



KONGSBERG

Seapath[®] 320

User Manual

About this document

Rev	Date	Written by	Checked by	Approved by
Rev. 1	2010-02-22	FOS		FOS
	First issue of this manual			
Rev. 2	2010-06-25	FOS		FOS
	Description of serial port extender and minor changes in the text			

Copyright

© 2010 Kongsberg Seatex AS. All rights reserved. No part of this work covered by the copyright hereon may be reproduced or otherwise copied without prior permission from Kongsberg Seatex AS.

Disclaimer

The information contained in this document is subject to change without prior notice. Kongsberg Seatex AS shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this document.

Kongsberg Seatex AS

Pirsenteret
N- 7462 Trondheim
Norway

Telephone: +47 73 54 55 00
Telefax: +47 73 51 50 20
Duty phone + 47 73 50 21 11
www.km.kongsberg.com/seatex
E-mail: km.support.seatex@kongsberg.com



KONGSBERG

Table of contents

1	PRODUCT DESCRIPTION	1
1.1	Purpose and application	1
1.2	System components.....	2
1.2.1	The Processing Unit.....	3
1.2.2	The HMI Unit	4
1.2.3	The MRU 5	5
1.2.4	The GNSS antennas and antenna bracket	6
1.3	Networked architecture	7
1.4	GNSS systems.....	8
1.4.1	GPS - Global Positioning System.....	8
1.4.2	GLONASS - Global Navigation Satellite System	9
1.4.3	Differential GPS (DGPS) and differential GLONASS (DGLONASS).....	10
1.4.4	SBAS system description	11
2	TECHNICAL DESCRIPTION	15
2.1	Design principles.....	15
2.1.1	System architecture.....	15
2.1.2	Main data flow	16
2.1.3	Heading determination.....	16
2.1.4	Roll and pitch determination	17
2.1.5	Position and velocity determination	17
2.1.6	Real-time heave computation	18
2.1.7	Delayed heave output	22
2.1.8	High speed data in real-time	22
3	OPERATING INSTRUCTIONS	23
3.1	Screen sections views.....	23
3.1.1	Switch and select views	24

3.2	Top bar	25
3.3	Sky view.....	27
3.4	DGNSS views	28
3.5	Integrity view	30
3.6	Compass view	31
3.7	Motion Data view.....	32
3.8	Time Series view.....	33
3.9	View menu	35
3.9.1	Display mode	35
3.9.2	View.....	36
3.9.3	Display format	37
3.9.4	Bars.....	38
3.10	Alarm menu.....	39
3.10.1	Alarm history view	40
3.11	Tools menu.....	41
3.11.1	Utilities	41
3.11.2	Diagnostics	44
3.11.3	Log.....	49
3.12	System menu	49
3.12.1	Configuration.....	49
3.12.2	Operator software configuration.....	50
3.12.3	Information	57
3.12.4	System control	58
4	MAINTENANCE	61
4.1	Periodic maintenance	61
4.1.1	Software upgrades	61
4.1.2	Cleaning of air inlet	61
4.1.3	Recalibration of the Antenna Bracket.....	62
4.1.4	Recalibration of the MRU	62
4.1.5	Changing the internal lithium battery	63
4.2	Repairs and modifications.....	63
4.2.1	Exchange of GNSS antenna cable	63
4.2.2	Exchange of GNSS antenna.....	63

4.2.3	Repair of Processing and HMI Unit	64
4.2.4	Installation of spare Processing Unit	64
4.2.5	Installation of spare HMI Unit.....	65
4.2.6	Repair of the MRU	65
4.2.7	Repair of the MRU junction box	66
4.3	Troubleshooting	66
4.3.1	No mouse cursor.....	66
4.3.2	External output problems.....	67
4.3.3	All data quality status are black.....	67
4.3.4	All data invalid "four red data quality indicators"	67
4.3.5	Invalid position/velocity indicator	67
4.3.6	Reduced position/velocity indicator	68
4.3.7	Invalid heave and roll/pitch indicators	68
4.3.8	Reduced heave and roll/pitch data indicators	69
4.3.9	Invalid heading indicator	69
4.3.10	Reduced heading indicator	69
4.3.11	Problems with the MRU	70
4.3.12	Reduced roll or pitch performance	71
4.3.13	Reduced heave performance.....	72
5	PART LIST	73
	APPENDIX A LCD DISPLAY AND KEYBOARD	75
A.1	Navigation.....	75
A.2	Main menu	76

List of figures

Figure 1	Typical information shown to the user.....	2
Figure 2	System architecture	3
Figure 3	Front panel of Processing Unit.....	4
Figure 4	Rear panel of Processing Unit.....	4
Figure 5	Front panel of HMI Unit	4
Figure 6	Rear panel of HMI Unit	5
Figure 7	The MRU 5	5
Figure 8	MRU 5 functional modules	6
Figure 9	Antenna Bracket.....	7
Figure 10	Side view of GNSS antenna installation	7
Figure 11	Differential GPS/GLONASS (DGPS/DGLONASS) concept	10
Figure 12	Orbit and clock concept	11
Figure 13	SBAS coverage	12
Figure 14	System sketch.....	15
Figure 15	Processing Unit with the NavEngine software	16
Figure 16	Relative heave residual in percentage of amplitude.....	20
Figure 17	Heave step response with corresponding settling time	21
Figure 18	Relative heave residual as percentage of amplitude – average heave period 10 s 22	
Figure 19	Integrated LCD display and keyboard	23
Figure 20	Main view sections.....	24
Figure 21	Top bar	25
Figure 22	Sky view.....	27
Figure 23	Satellite colours.....	27
Figure 24	Satellites with two signal-to-noise bars.....	28
Figure 25	Tooltip for GPS satellite with corrections.....	28
Figure 26	Tooltip for GLONASS satellite with corrections	28
Figure 27	DGNSS status view.....	29
Figure 28	DGNSS age view	30
Figure 29	Integrity view	31
Figure 30	Compass view	32
Figure 31	Motion Data view.....	33

Figure 32	Times Series view showing data for roll, pitch, heave and heading	34
Figure 33	View menu	35
Figure 34	Dusk mode	36
Figure 35	Day black mode	36
Figure 36	Browse views with the F2 key	37
Figure 37	Switch views with the F3 key	37
Figure 38	Alarm menu.....	39
Figure 39	Export alarm log view	39
Figure 40	Alarm history view – Status tab	40
Figure 41	Alarm log view – History tab.....	41
Figure 42	Tools menu.....	41
Figure 43	Satellite Prediction	42
Figure 44	Adding sector into the Satellite Prediction Sky view.....	43
Figure 45	Track plot	43
Figure 46	Close up of satellite prediction graphs	44
Figure 47	DGNSS Monitor, RTCM stations	46
Figure 48	DGNSS Monitor, SBAS	47
Figure 49	Data Viewer application.....	48
Figure 50	System menu	49
Figure 51	The NavEngine Configuration menu	49
Figure 52	Operator software configuration - View	50
Figure 53	Operator software configuration - Alarms	51
Figure 54	Operator software configuration - Data source	52
Figure 55	Operator software configuration - Compass	53
Figure 56	Operator software configuration – Position Integrity	54
Figure 57	Operator software configuration - Sky view	54
Figure 58	Selection of correction satellites to display.....	55
Figure 59	Correction satellite tooltip.....	55
Figure 60	Sky view with correction satellites, signal strength bar, track plots and shadow sector	56
Figure 61	Operator software configuration - UTM options	57
Figure 62	Quick Help dialog	58
Figure 63	Change system mode options.....	58

Figure 64 Restart options.....59

Figure 65 Stop options.....59

Figure 66 Start Operator SW60

Figure 67 Shutdown options.....60

Figure 68 Integrated display and keypad.....75

Figure 69 Arrow symbols indicate possible navigation direction76

Figure 70 Main menu76

List of tables

Table 1 PRN for geo-stationary satellites.....14

Abbreviations

AP	Aft Perpendicular. The vertical intersection of the design waterline at the stern, alternatively the centerline of the rudder stock.
BL	Base Line. Is the same as the keel for a vessel with horizontal keel line.
C/A	Coarse/Acquisition
CEP	Circular Error Probability
CG	Centre of gravity. The mass centre of a vessel. This is normally the location with least linear acceleration, and hence the best location for measurements of roll and pitch.
CL	Centre Line. Is the longitudinal axis along the centre of the ship
DGLONASS	Differential GLONASS
DGNSS	Differential Global Navigation Satellite System
DGPS	Differential GPS
ED50	European Datum of 1950
EGNOS	European Geostationary Navigation Overlay System (SBAS-Europa)
EPE	Estimated Position Error
GLONASS	GLObal Navigation Satellite System. A Russian system
GNSS	Global Navigation Satellite System
GPS	Global Positioning System. The American NAVSTAR system.
GPS Time	The time in the GPS system. The GPS time is within UTC time ± 180 nsec (95 per cent) plus leap second
GUI	Graphical User Interface
HMI	Human Machine Interface
HP	High Precision
IALA	International Association of Lighthouse Authorities
IMU	Inertial Measurement Unit
LED	Light Emitting Diode
LGND	Logic Ground
LOA	Length OverAll
MMSI	Maritime Mobile Service Identity
MP	Monitoring Point

MRU 5	Motion Reference Unit, model 5. This is the IMU within the Seapath measuring dynamic linear motion and attitude. A MRU consists of gyros and accelerometers.
MSAS	Multifunctional transport Satellite-based Augmentation System (SBAS-Japan)
NAD27	North American Datum of 1927
NMEA	National Marine Electronics Association. NMEA 0183 is a standard for interchange of information between navigation equipment.
NRP	Navigation Reference Point. The reference point for all measurements in Seapath. The recommended used NR is the vessel CG or rotation centre.
PGND	Power Ground
PPS	Pulse Per Second
PRN	Pseudorandom Noise
PSS	Physical Shore Station
RAIM	Receiver Autonomous Integrity Monitoring
RMS	Root Mean Square
RTCM	Radio Technical Commission of Maritime Services
SA	Selective Availability
SBAS	Satellite Based Augmentation System
SL	Speed Along Ship
SNR	Signal/Noise Ratio
SOG	Speed Over Ground
SRRD	Seatex Rescue and Restore Disk
ST	Speed Transverse Ship
SW	Software
UTC	Universal Time Co-ordinated. This is the official time in the world and has replaced GMT (Greenwich Mean Time) as the official time.
UTM	Universal Transverse Mercator
WAAS	Wide Area Augmentation System (SBAS-USA/Canada)
WEEE	Waste Electrical and Electronic Equipment
WGS84	World Geodetic System of 1984

Terminology

Alignment	Is the process of adjusting the current internal navigation frame in the instrument to the true external frame.
Antenna bracket	Is the arrangement for mounting the GPS antennas.
Antenna holder	Is the arrangement on board the vessel for mounting the antenna bracket to.
Attitude	The orientation relative to the vertical axis of a vehicle. Heading is not included. If heading is included the word "orientation" is used for the vehicle.
Beam	The maximum width of the vessel at Main Deck level (B. mld).
GPS Time	The time in the GPS system. The GPS time is within UTC time ± 180 nsec (95 per cent) plus leap second.
Heading	The direction of the main axis (bow direction) of the vehicle as opposed to course, which is the direction of motion of the vehicle. Yaw angle as defined here is the same as heading.
Heave	The vertical dynamic motion of a vehicle and defined positive down. Heave position and velocity are dynamic motion variables oscillating around a mean value, typically zero.
Height	The height in the Seapath product is defined as the vertical position relative to the WGS84 datum (rotational ellipsoid).
Host system	In this manual defined as Navigation computers, Dynamic Positioning Systems, etc., receiving data from Seapath.
Origin	The zero point in the coordinate system. The origin is the intersection point between AP, BL and CL.
P-axis	This axis is fixed in the vehicle, and points in the starboard direction horizontally when the roll angle is zero. Positive rotation about this axis is bow of the vehicle up.
Pitch	A rotation about the pitch axis is positive when the bow moves up. Normally, pitch means the dynamic pitch angle motions.
R-axis	This axis is fixed in the vehicle, and points in the forward direction horizontally when the pitch angle is zero. Positive rotation about this axis is starboard side of the vehicle down.
Roll	A rotation about the roll axis is positive when starboard side of the vehicle moves down. Normally, roll means the dynamic roll angle motion.
Starboard	When looking in the bow direction of a vehicle, this is the right hand side of the vehicle.

Surge	The alongship dynamic motion of a vehicle and defined positive forward.
Sway	The athwartship dynamic motion of a vehicle and defined positive starboard.
Y-axis	This axis is fixed in the vehicle and points in the downward direction when the vehicle is aligned horizontally. Positive rotation about this axis is turning the bow of the vehicle to starboard.
Yaw	A rotation about the vertical axis is positive when turning Eastward (Clockwise) when the vehicle cruises in North direction. Normally, yaw means the dynamic yaw motion.

References

- [1] M300-62, Seapath 320 Installation Manual
- [2] NMEA 0183 Standard for Interfacing Marine Electronic Devices, Version 3.00
- [3] RTCM Recommended Standards for Differential Navstar GPS Services, Version 2.3

Health, environment and safety warnings

All electrical and electronic components have to be disposed of separately from the municipal waste stream via designated collection facilities appointed by the government or local authorities. The correct disposal and separate collection of your old appliance will help prevent potential negative consequences for the environment and human health. It is a precondition for reuse and recycling of used electrical and electronic equipment. For more detailed information about disposal of your old appliance, please contact your local authorities or waste disposal service.

Until further notice is given regarding reuse, disassembly or disposal, the equipment at end-of-life, could be returned to Kongsberg Seatex AS if there is no local WEEE collection.

The equipment is marked with this pictogram.



Restrictions in export

Export of the MRU 5 component within the Seapath product to other countries than EU countries or Argentina, Australia, Canada, Iceland, Japan, New Zealand, Switzerland, South-Korea, Turkey, Ukraine and USA, requires an export license.

Notice to Importer: The MRU product specified in this document has been shipped from Norway in accordance with The Ministry of Foreign Affairs' Official Notification on Export Control and may be subject to restrictions if re-exported from your country.

Restrictions in guarantee

The liability of Kongsberg Seatex is limited to repair of the Seapath system only under the given terms and conditions stated in the sales documents. Consequential damages such as customer's loss of profit or damage to other systems traceable back to Seapath malfunctions are excluded. The warranty does not cover malfunctions of the Seapath resulting from the following conditions:

- 1 The MRU is not shipped in the original transport box.
- 2 The MRU has been exposed to extreme shock and vibrations.
- 3 The MRU housing has been opened by the customer in an attempt to carry out repair work.
- 4 Over-voltage or incorrect power connection.
- 5 Shorting of GNSS antenna cable during operation of the Seapath systems.

Restrictions in use

The Seapath function is based on GNSS signals and requires free sight to the sky, minimum four visible satellites, PDOP value less than 6 and otherwise normal conditions to operate. It is designed for use on board marine surface operated vehicles with linear acceleration less than $\pm 30 \text{ m/s}^2$ ($\pm 3g$) and an angular rate range less than $\pm 150^\circ/\text{s}$.

Only relative dynamic heave position is calculated.

1 PRODUCT DESCRIPTION

The Seapath 320 is a positioning, attitude and heading sensor. The product combines inertial technology together with GPS and GLONASS satellite signals. Core components in the product are the MRU 5 inertial sensor, the two combined GPS/GLONASS receivers, the Processing and HMI Unit.

1.1 Purpose and application

The product is developed specifically for hydrographic and other high precision applications where heading, position, roll, pitch, heave and timing are critical measurements.

The Seapath 320 offers the best possible combination of GNSS signals and inertial measurements for demanding operations in challenging environments. The possibility to use GLONASS in addition to the GPS satellites significantly increases satellite availability, provides robust integrity monitoring and results in more precise solutions, particularly in highly obstructed environments.

The combination of GNSS signals and inertial data enables much better performance than each of the signals alone, with a high output data rate (up to 200 Hz), zero delay on output data, data available in up to eight different monitoring points and a total of eight configurable serial lines and Ethernet ports.

This Seapath product is a two-module solution with a Processing and an HMI Unit connected via Ethernet. The Processing Unit runs all critical computations independent of the user interface on the HMI Unit to ensure continuous and reliable operation. Several HMI Units can be connected to the same Processing Unit in a networked architecture. The HMI Units present the vessel motion in a simple and easy-to-understand format to ensure that the decision making based on the available data is as efficient as possible.

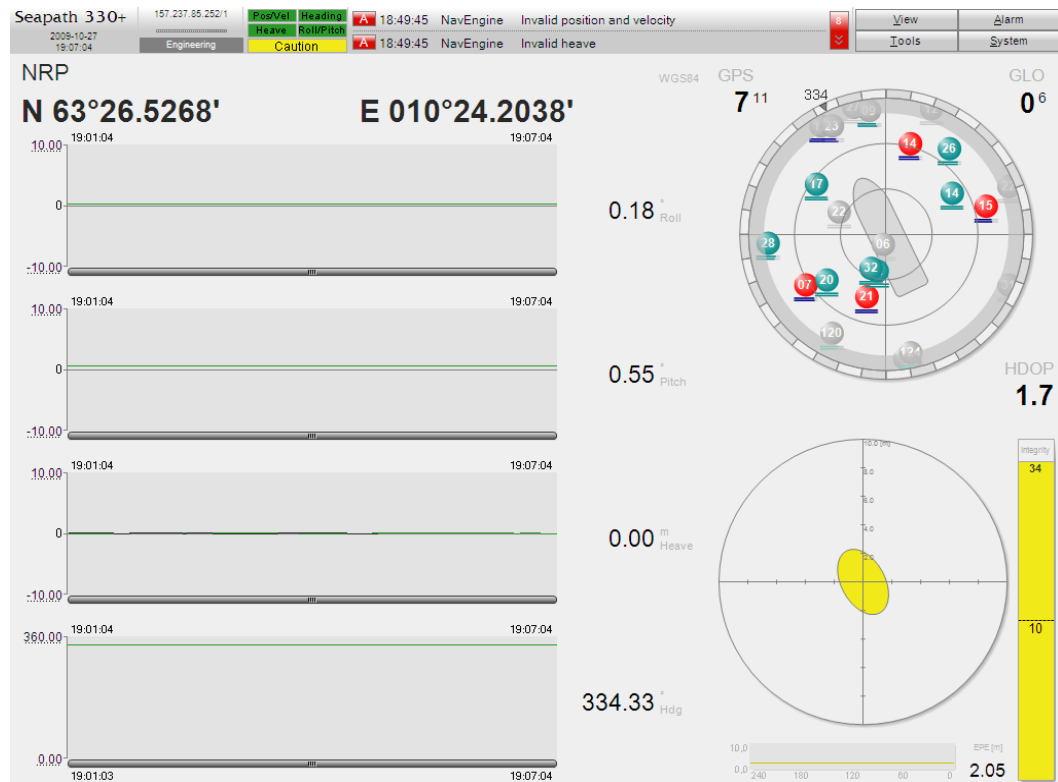


Figure 1 Typical information shown to the user

1.2 System components

The Seapath 320 comprises the following main components, which are physically separated:

- A Processing Unit for I/O and calculations.
- An HMI Unit with MONITOR, keyboard and PC mouse.
- An MRU 5 inertial sensor.
- An MRU wall mounting bracket.
- An MRU junction box with three metres of cable for interfacing to the MRU.
- An Antenna Bracket with two GNSS antennas.

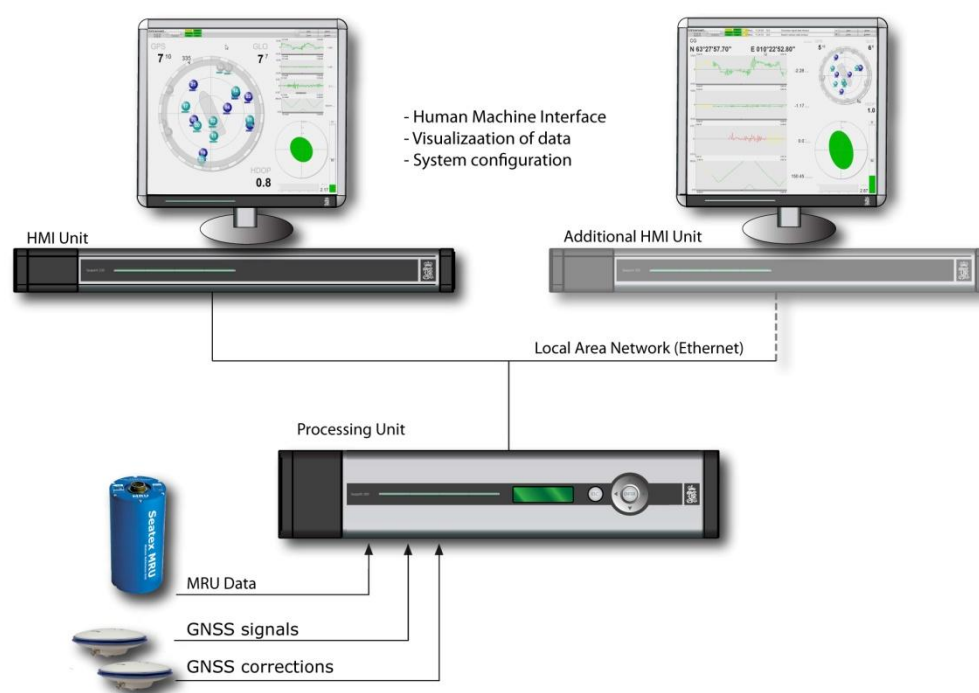


Figure 2 System architecture

1.2.1 The Processing Unit

The Processing Unit is designed to fit standard 19-inch racks and is typically installed on the bridge or in the instrument room. The Processing Unit comprises the following main parts:

- Hard disk
- Serial I/O board, Ethernet and computer main board
- Power supply
- Two GNSS receivers

The power on/off switch, LAN port and USB connection are located under the lid on the left part of the front panel.





Figure 3 Front panel of Processing Unit

The rear panel of the Processing Unit contains communication interface ports for interfacing to external sensors. These ports are individually galvanically isolated.

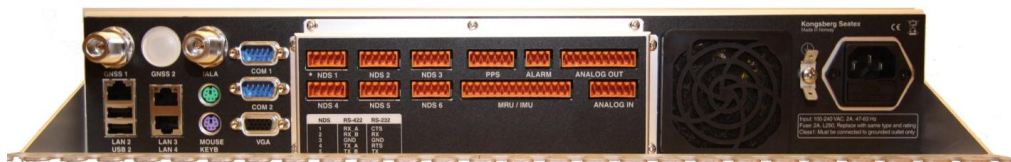


Figure 4 Rear panel of Processing Unit

1.2.2 The HMI Unit

The HMI Unit is designed to fit 19-inch racks and is typically installed on the bridge or in the instrument room. The 1U-height HMI Unit comprises the following main parts:

- Flash disk
- Serial I/O board, Ethernet and computer main board
- Power supply

The power on/off switch and USB connection are located under the lid on the left part of the front panel.



Figure 5 Front panel of HMI Unit



Figure 6 Rear panel of HMI Unit

1.2.3 The MRU 5

The Seatex MRU 5 is specifically designed for motion measurements in marine applications. The unit incorporates 3-axis sensors for linear acceleration and angular rate, along with complete signal processing electronics and power supply. The MRU 5 outputs absolute roll and pitch. Dynamic acceleration in the MRU axes direction as well as velocity and relative position, are also provided. The MRU achieves high reliability by using sensors with no rotational or mechanical wear out parts.



Figure 7 The MRU 5

When the MRU is used within the Seapath product, only raw angular rate and linear acceleration data is output from the unit. All processing of these signals to roll, pitch, heave and velocity measurements is performed in the Kalman filter in the Processing Unit. The analog output channels from the MRU, as indicated in Figure 8, are therefore not used when the MRU is used within the Seapath product.

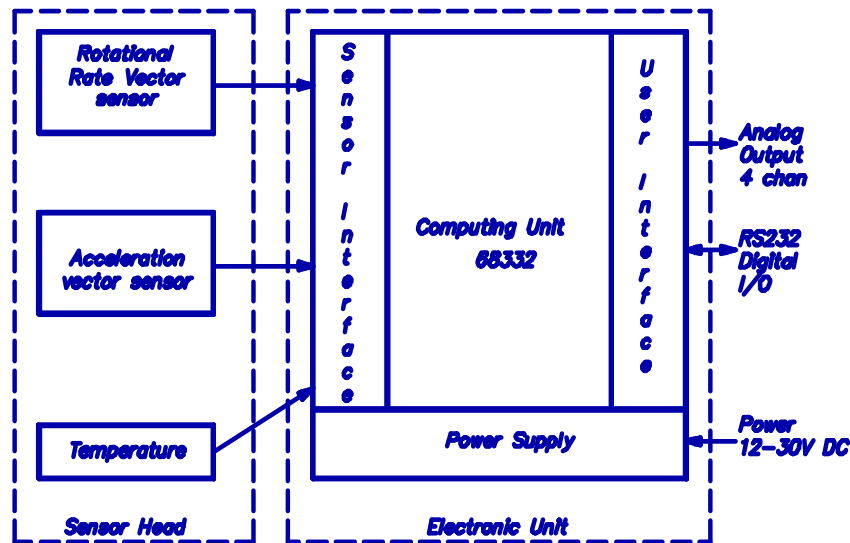


Figure 8 MRU 5 functional modules

The interior of the MRU is divided into two sub-assemblies consisting of an electronic unit and a sensor unit. The electronic unit consists of plug-in circular multi-layer boards. Extensive use is made of surface mounted components. The unit is divided into nine separate mechanical parts, which may be exchanged very quickly by plug in boards when the housing cylinder has been removed. The housing cylinder should, however, not be removed by anyone else than Kongsberg Seatex.

The MRU is integrated in Seapath, and all digital data are routed through the Processing Unit.

1.2.4 The GNSS antennas and antenna bracket

In a standard Seapath delivery, the Antenna Bracket is 2.5 metres. The Antenna Bracket is delivered in aluminium. However, maximum heading accuracy is achieved with 4-metre antenna separation. For antenna separations greater than 2.5 metres it is recommended to mount each antenna separately on a rigid structure.

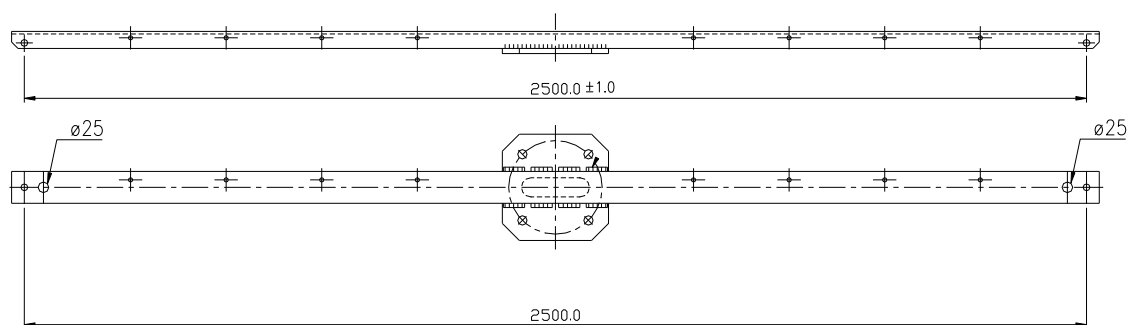


Figure 9 Antenna Bracket

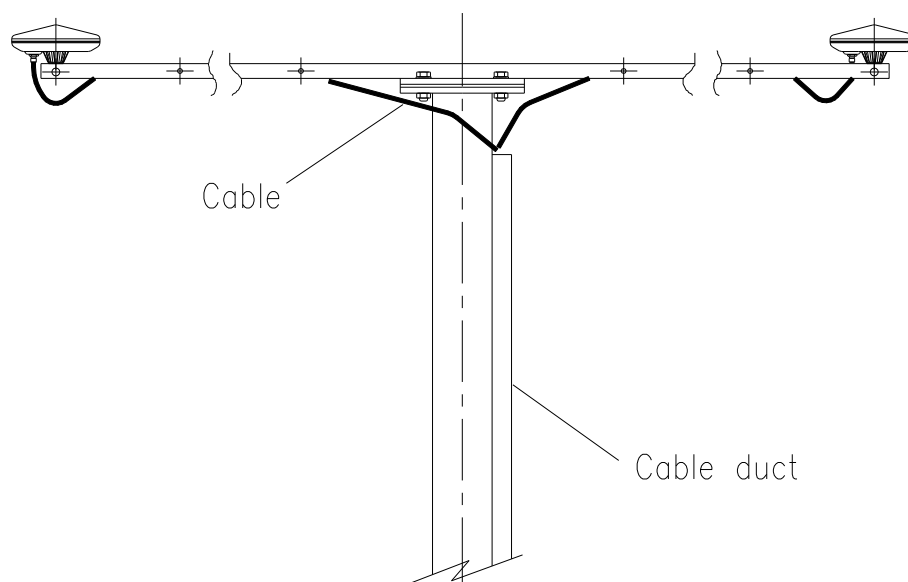


Figure 10 Side view of GNSS antenna installation

1.3 Networked architecture

The Navigation Engine runs all critical computations independent of the HMI Unit to ensure continuous and reliable operation. Navigation Engine runs in a safe mode protected from unintended user operations. Several HMI Units can be connected to the same Navigation Engine in a networked architecture.

1.4 GNSS systems

GNSS (Global Navigation Satellite System) is a generic term for satellite navigation systems providing autonomous geo-spatial positioning with global coverage. GPS is the only GNSS with full constellation. However, GLONASS is operable and plan to have full constellation within 2010. Galileo is a third GNSS which is in the development phase and scheduled to be operational in 2013.

1.4.1 GPS - Global Positioning System

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of satellites placed into orbit by the U.S. Department of Defence. GPS was originally intended for military applications but in the 1980's the government made the system available for civilian use.

GPS provides a highly accurate and continuous navigation service. It provides 24-hour, all weather and global coverage.

The system is divided into the following three segments:

Space segment	This segment consists of at least 24 satellites (21 active plus 3 operating spares) in 12-hour circular orbits. At an altitude of 20200 km, each satellite is transmitting orbital and clock parameters.
Control segment	This segment comprises Ground Control Stations geographically spread for monitoring, up-loading and control of the satellite transmitted characteristics.
User segment	This segment comprises GPS receivers installed onboard ships, aircraft etc. to track satellite signals and transform them into position, velocity and time.

Each GPS satellite transmits radio signals at two microwave frequencies in the L band, 1575.43 MHz (L1) and 1227.6 MHz (L2).

The L1 signal is modulated by a precise (P) code for Precise Positioning Service (PPS) and a course/acquisition (C/A) code for Standard Positioning Service (SPS). The P code is for military and authorised personnel only and is encrypted before broadcast to GPS users. The C/A code is for civil users. Until 1 May 2000 the accuracy of the C/A code was degraded to 100 m (2DRMS) horizontal positioning by the use of Selective Availability (SA). However, SA is now switched off and the position accuracy of the system is about 16 metres 95% CEP.

The fundamental technique for GPS is one-way ranging from the satellites.

Triangulation, based on ranging from the satellites, is the basis of the system. In order to triangulate, the GPS measures distance using the travel time of a radio message. To measure travel time, timing is crucial. GPS therefore needs very accurate clocks. The transmission is referred to highly accurate atomic frequency standards onboard the satellites, which are in synchronisation with the GPS system time base.

The time difference from when the signal leaves the satellites until it is received at the GPS receiver, is measured. The distance is computed by multiplying with the speed of light. Once the distance to a satellite is known, the satellite's position in space must be found. The GPS satellites are launched into very precise orbits and their position is transmitted to the user. Knowing the satellites' position and the distance to the user receiver, the user position can be computed. Three perfect measurements can solve a three-dimensional point in space.

However, the crystal clocks in the GPS receivers are drifting, and the position is therefore inaccurate. To calculate a three dimensional position, four unknowns have to be solved (latitude, longitude, height and receiver clock offset). To solve this equation with four unknowns it is necessary with range measurements from four or more satellites.

The geometry, and hence the accuracy of the position calculation, varies with the number of satellites available and their location.

Using differential corrections from one or more GPS Reference Stations significantly reduces all major error sources. This principle is called differential GPS (DGPS).

1.4.2 GLONASS - Global Navigation Satellite System

The Global Navigation Satellite System (GLONASS) is a Russian satellite based navigation/positioning system.

The GLONASS system is based on the same segments as the GPS system with a space segment, a control segment and a user segment.

A fully operational GLONASS constellation consists of 24 satellites, with 21 used for transmitting signals and three for on-orbit spares, deployed in three orbital planes.

In contrast to the GPS system where all satellites transmit on the same frequency, each GLONASS satellite transmits on its own frequencies. Each GLONASS satellite transmits radio signals at two microwave frequencies in the L band.

In order to calculate a three-dimensional position based on both GPS and GLONASS, five unknowns have to be solved (latitude, longitude, height and two receiver clock offsets). Tracking five or more satellites solves this equation.

One of the primary advantages of GPS+GLONASS is the increased satellite coverage. With satellites from the combined GPS and GLONASS constellations, there are many more visible satellites available for position computation. A combined GPS+GLONASS system is therefore extremely beneficial in obstructed operating environments.

By using GPS+GLONASS, users benefit from the integrity of two independently operated satellite positioning systems. With more satellites available, the constellation geometry is significantly improved, providing the user with added confidence in the accuracy of the positioning solutions.

1.4.3 Differential GPS (DGPS) and differential GLONASS (DGLONASS)

Position accuracy from both GPS and GLONASS may be enhanced by using the differential technique. This can be achieved by using either traditional DGPS or by clock and orbit corrections.

1.4.3.1 Traditional DGPS/DGLONASS (RTCM)

The DGPS/DGLONASS system improves the position accuracy by using the differential technique. This is accomplished by accurately surveyed GPS/GLONASS reference stations which calculate pseudo-range corrections for all the satellites tracked by the reference station's GPS/GLONASS receiver.

The DGPS/DGLONASS system also uses a communication link for transmission of correction data from the Reference Station to the vessel.

Each GPS/GLONASS reference station compares the measured distance to a satellite with the one calculated based on the satellites' and the reference station's known co-ordinates. The resultant range difference is the correction data, which are broadcast from the GPS/GLONASS reference stations to the Differential GPS/GLONASS correction receiver(s) on board the vessel(s). The correction data can also be broadcast via satellite, e.g. an Inmarsat satellite.

At the vessel, these pseudo-range corrections are applied to correct the pseudo-ranges received by the vessel's GPS receiver, prior to using them for the calculation of a three-dimensional navigation solution. The concept of a differential GPS/GLONASS (DGPS/DGLONASS) real-time system is illustrated in Figure 2.

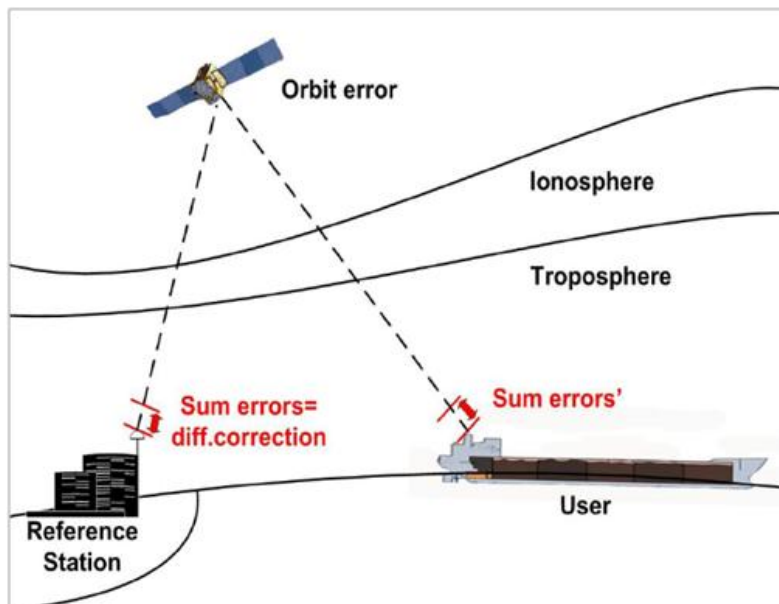


Figure 11 Differential GPS/GLONASS (DGPS/DGLONASS) concept

1.4.3.2 Clock and orbit corrections

In contrast to having a unique set of satellite corrections specific to each reference site, the orbit and clock concept consists of one set of corrections for the satellites, which is valid globally.

The orbit and clock concept, Figure 12, uses reference stations with a worldwide spread to calculate the orbit and the clock value of each GPS/GLONASS satellite more accurately than the broadcast GPS/GLONASS ephemeris. Orbit and clock corrections to the broadcast GPS/GLONASS ephemeris are then transmitted to the user. The correction data can be used at any location, regardless of distance to any reference station, making the system truly global. Local ionospheric errors are corrected at the user end by using a dual frequency receiver. Use of orbit and clock corrections improves the accuracy from metre level to decimetre level.

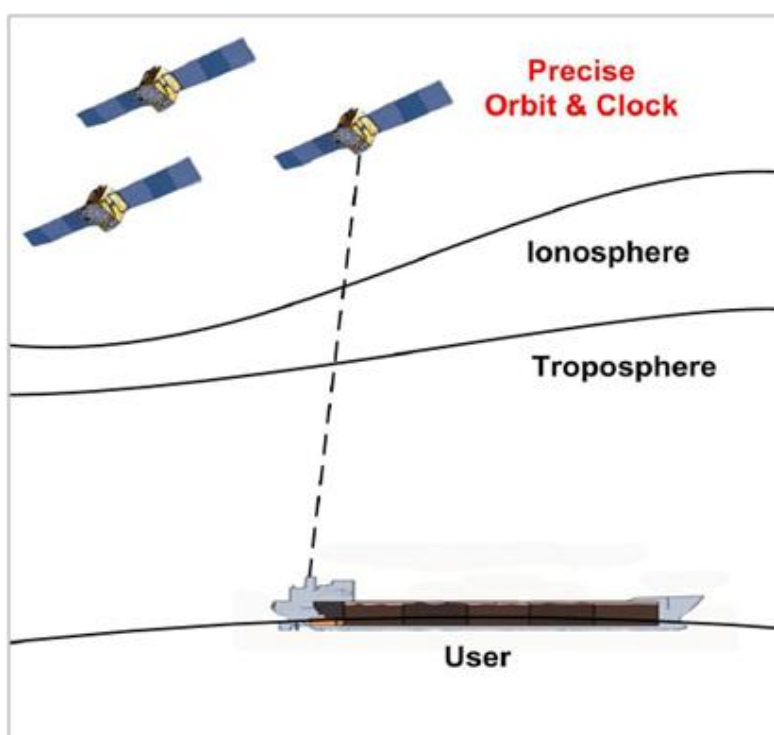


Figure 12 Orbit and clock concept

1.4.4 SBAS system description

SBAS, Satellite Based Augmentation System, is a generic term for GPS augmentation systems such as WAAS, EGNOS, MSAS and GAGAN, which use geostationary satellites to broadcast information to users over a large geographical area. SBAS shall provide additional accuracy and reliability for the GPS system. The systems are independent but based on the same principles. The systems are fully interoperable and compatible.

1.4.4.1 WAAS

WAAS, Wide Area Augmentation System, is an American GPS based assistance to air traffic, built and operated by the FAA, Federal Aviation Administration.

WAAS is designed to improve the accuracy and ensure the integrity of information coming from GPS satellites. The signals from GPS satellites are received at a network of ground based reference stations. Measurements from the reference stations are routed to master stations, which generate and send the correction messages to Geostationary Earth Orbit (GEO) satellites. These GEO satellites broadcast the WAAS message to the users on the same frequency as GPS.

The FAA commissioned WAAS in July 2003 throughout the continental United States and most of Alaska. The next segment of WAAS was completed in 2008 and will expand service coverage to all of the continental United States, most of Alaska and significant regions of Canada and Mexico.

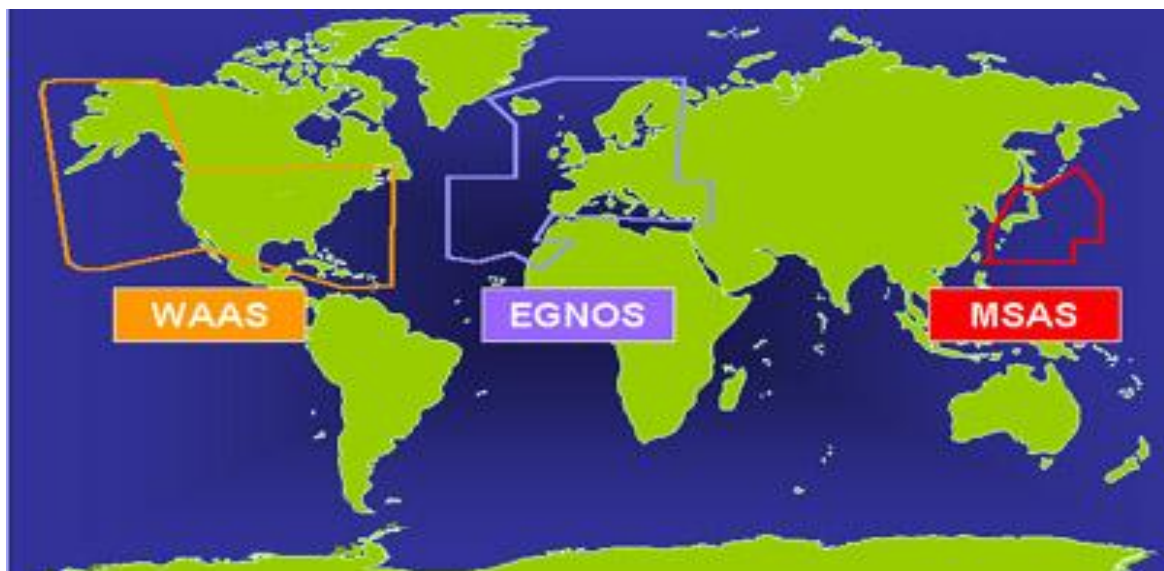


Figure 13 SBAS coverage

1.4.4.2 EGNOS

EGNOS, European Geostationary Navigation Overlay Service, is the European SBAS and is being deployed to provide regional satellite based augmentation services to aviation, maritime and land-based users in Europe. EGNOS is the first step in the European Satellite Navigation strategy that leads to Galileo, the future European satellite navigation system which will complement GPS. EGNOS will become fully operational in 2010.

The EGNOS architecture is highly redundant, generating wide area differential corrections and alerting users within six seconds if a malfunction occurs in GPS. Thirty-four reference stations are deployed to monitor the satellites used for navigation. Each satellite has to be monitored by multiple stations before correction and integrity messages are generated. Four Mission Control Centers process data received from these stations to generate the corrections and the integrity messages for each satellite. Satellite up-link stations upload the corrections and integrity messages to the EGNOS satellites for onward broadcasting to the users.

1.4.4.3 MSAS

MSAS, Multifunctional transport Satellite-based Augmentation System, is a Japanese augmentation system, implemented by the Japanese Civil Aviation Bureau.

MSAS generates GPS augmentation information by analyzing signals from GPS satellites received by monitor stations on the ground. This augmentation information consists of GPS-like ranging signals and correction information on GPS errors caused by the satellites themselves or by the ionosphere.

MSAS was commissioned in September 2007.

1.4.4.4 GAGAN

GAGAN is an Indian Space Based Augmentation System. The system is being developed jointly by the Airports Authority of India (AAI) and the Indian Space Research Organization (ISRO).

GAGAN is planned operable in 2010.

1.4.4.5 Signal distribution

SBAS signals are distributed by geostationary satellites. The broadcasting frequency of the signals is the same as GPS (L1, 1575.42 MHz).

The following PRNs have been allocated to the SBAS satellites:

Geo satellite	Service	PRN	Position
AOR-W	WAAS	122 (phased out)	142° W
POR	WAAS	134 (phased out)	178° E
PanAmSat Galaxy	WAAS	135	133° W
Telesat Anik	WAAS	138	107.3° W
AOR-E	EGNOS	120	15.5° W
Artemis	EGNOS	124	21.5° E
IOR-W	EGNOS	126	25° E
IOR-E	EGNOS	131 (phased out)	64° E

Geo satellite	Service	PRN	Position
MTSAT-1	MSAS	129	140° E
MTSAT-2	MSAS	137	145° E
GSAT-4	GAGAN	127	82° E

Table 1 PRN for geo-stationary satellites

2 TECHNICAL DESCRIPTION

2.1 Design principles

2.1.1 System architecture

The product is a two-module solution with a Processing and an HMI Unit connected via Ethernet. The Processing Unit runs the navigation software (NavEngine) which handles all critical computations independent of the user interface on the HMI Unit to ensure continuous and reliable operation. The Processing Unit runs in a safe mode protected from unintended user operations. Multiple HMI Units can be connected to the same Processing Unit in a networked architecture.

The product is operated through the operator software installed on one or more HMI Units. This software is used for performance monitoring and configuration of the system. For performance monitoring the software includes a number of views that can be adjusted to different operations. On each HMI Unit the operator can select the views which fit his operation (one HMI Unit at the bridge, one at the operation room).

The product is by standard delivered with an HMI Unit for 19-inch rack mounting and monitor, keyboard and mouse for desktop mounting.

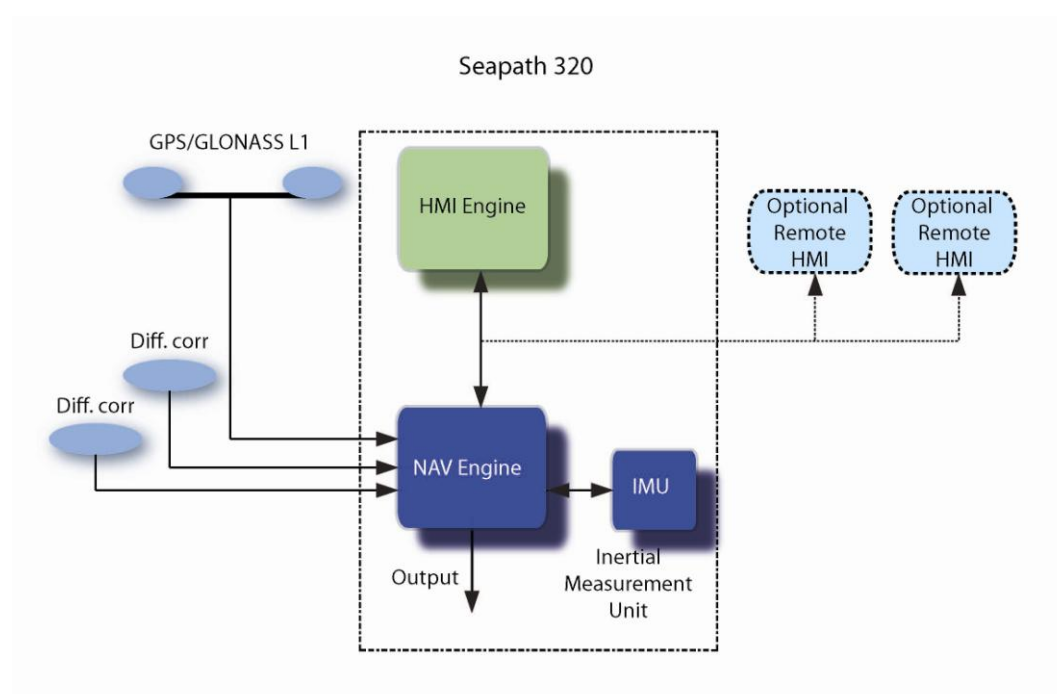


Figure 14 System sketch

2.1.2 Main data flow

The main data flow to and from the Processing Unit is shown in Figure 15.

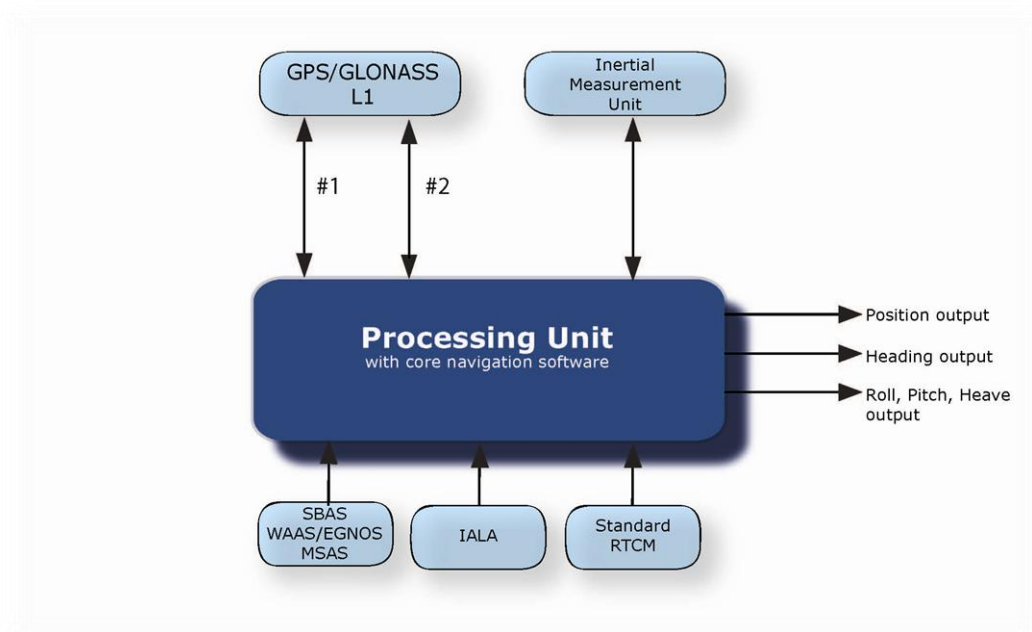


Figure 15 Processing Unit with the NavEngine software

The NavEngine software runs on the Processing Unit. This software combines the GNSS signal and the inertial measurements to determine accurate position, heading, attitude and heave signal. The NavEngine software utilises Kongsberg Seatex advanced true multi-reference algorithms for real-time parallel processing of all available correction signals including:

- SBAS (WAAS, EGNOS, MSAS)
- IALA
- Standard RTCM corrections (DGPS/DGLONASS)

There is no practical limitation to the number of correction signals/reference stations handled by the NavEngine.

2.1.3 Heading determination

True heading is provided by integrating the best signal characteristics of the MRU yaw rate and differential carrier phase measurements between two GNSS antennas. On rare occasions where GNSS heading may be unavailable due to poor GNSS conditions, an external gyro compass can be used as a secondary heading reference to increase reliability.

The GNSS part of the system measures direction from antenna no. 1 to antenna no. 2. In order to output ship's heading from Seapath, the angular offset between the Antenna Bracket and the ship's centre line is entered as a parameter. The angular offset is determined during calibration by comparing heading measured by GPS with ship's heading measured by a reference system.

In order to maximise heading performance, Seapath continuously calibrates gyro compass versus GNSS heading. This gives the best result, if gyro heading must be used, because the GNSS heading is more accurate and does not need re-calibration regularly. Seapath calculates a long-term gyro bias, which is the average difference between the gyro compass and the GNSS heading since system start-up. Assuming that Seapath has been correctly calibrated, the long-term bias can be used directly as a calibration value for the gyro compass. In addition, a short-term gyro bias is calculated as a filtered value of the difference between the gyro compass and the GNSS heading with a 15-minute time constant. The intention with the short-term bias is to measure dynamic errors in the gyro, e.g. after manoeuvres. When gyro compass heading is used in Seapath, the short-term bias is applied as correction to the gyro heading. If GNSS heading for some reason is missing for a longer period, the short-term bias converges towards the long-term bias with a 15-minute time constant. As a result, the best available correction is always used for the gyro heading.

Gyro re-calibration can be done at any time without affecting the use of a gyro compass as a backup heading sensor in Seapath, because of the continuous calibration routine in Seapath. The Seapath heading does not need re-calibration unless the Antenna Bracket has been moved.

2.1.4 Roll and pitch determination

Roll and pitch output from Seapath is based on highly accurate linear accelerometer data and angular rate sensor data from the MRU. By tightly integrating these MRU data in the Kalman filter with data from the GNSS receivers, Seapath provides accurate roll and pitch under all conditions. With this feature, horizontal accelerations are observable, making the run-ins needed to stabilise conventional vertical reference systems unnecessary.

2.1.5 Position and velocity determination

The two, fixed baseline GNSS antennas and their receivers are used as redundant GNSS position and velocity sources. In case of missing data from one GNSS receiver, the other (remaining) receiver provides position and velocity. The Seapath is robust against GNSS dropouts by using the MRU for dead reckoning navigation in order to provide position, velocity and also heading measurements when GNSS is not available.

Position and velocity are measured by differential GNSS using phase-smoothed pseudo-range and Doppler observations. Seapath is capable of providing position and velocity data with the best possible accuracy by combining all available GNSS signals and a multitude of differential correction data. NavEngine is capable of simultaneous integration of the free-of-charge SBAS (e.g. WAAS, EGNOS, MSAS), IALA/USCG corrections, and a multitude of subscription based corrections services.

The MRU measurements effectively bridge gaps in the satellite constellation caused by physical obstructions or ionospheric activity, and at the same time all available GPS and GLONASS signals will remove bias or drift in MRU measurements. Because of the tight integration, the MRU will directly assist the GNSS receiver in optimising signal tracking under the most challenging conditions.

RAIM (Receiver Autonomous Integrity Monitoring) extended by data from the MRU provides ultimate reliability of the position and velocity data under difficult GNSS conditions.

Seapath has a built-in autonomous real-time quality control feature continuously monitoring the quality of the calculated position. Alarms and warnings are activated if critical tolerances are exceeded or if position quality degrades.

The GNSS data are lever arm compensated to the user selected Navigation Reference Point on the vessel (usually close to the centre of gravity). Acceleration data from the MRU are also lever arm compensated to the Navigation Reference Point and integrated with the GNSS data in a Kalman filter.

The resulting position, velocity and heave measurements are then compensated for the lever arm from the Navigation Reference Point to the user monitoring points before output.

2.1.6 Real-time heave computation

Heave is the vertical position or height relative to a zero mean level and positive downwards. The vertical acceleration is high pass filtered and integrated twice over time to heave position. Heave velocity is computed with one integration over time of filtered vertical acceleration. The heave filter removes static and slowly varying errors.

The user must tune this filter according to user requirements. The heave filter parameters should be selected according to the expected average wave period T_0 for the vessel. The expected average wave period T_0 can be selected in the range 1 to 20 seconds. If a too long period is selected, the velocity and position outputs will have a slowly varying error. If a too short period is chosen, the estimated heave will have a phase error for long period motions.

A low damping factor ε reduces the short-term error for long period motions close to the selected average period T_0 , since the phase error is reduced. However, ringing in the output at T_0 may cause some problems. The damping factor ε can be set in the range 0.3 to 1.0.

In the software two different types of filter structures are implemented. The filter mode "General purpose" is implemented to achieve optimal amplitude performance, whereas the "Hydrographic survey" mode provides optimal phase performance. For the "Automatic" filter mode the hydrographic survey filter structure is used. This algorithm estimates the sea conditions by computing the dominating period of the waves seen from ship or vehicle and automatically sets the average heave period T_0 in real time during operations.

2.1.6.1 Selection of heave filter mode

The following selections are available in the Seapath configuration in order to achieve the optimal heave performance:

- **Heave filter mode.** Selection between different filter structures.
- **Period.** The average heave period for the vessel, T_0 .
- **Damping.** The heave damping factor ε to be used in the filter.

The heave filter damping and average period should be chosen in order to obtain the best possible correspondence between the estimated heave motion and the real heave motion. These parameters can be set to a constant value or the automatic adaptive filter may be chosen in case of varying sea states. The following should be considered when selecting the different heave filter modes and parameters:

Heave filter mode:

- **Automatic.** To be selected when the vessel is operating in various sea states or when the average heave period is unknown.
- **General purpose.** Is selected when optimal heave amplitude is to be measured and the heave phase is of no importance. This mode is typically selected when the Seapath is to be used for measuring the heave height and period on oceanographic buoys.
- **Hydrographic survey.** To be selected when the heave phase and amplitude have to be output correctly in real time. This mode is typically selected when the heave output signal from the Seapath is to be used for heave compensation of echo sounders, hydro acoustic positioning systems and offshore crane systems.

Period:

- An expected average heave period has to be set to the heave filter.
- The settling time for the heave measurements from power-on or after a turn will be about 10 times the selected period, T_0 . By selecting an unnecessary high heave period, the settling time will be longer than optimal. For vessels performing surveys with frequent turns, the period should be set as low as possible to minimise the heave settling time after turns.

Damping:

- The heave damping factor shall usually be set to 0.7. Only for particular operations should this parameter be changed. In operations with heave periods of more than 25 seconds, the damping factor should be reduced to 0.6 in order to achieve correct phase measurements. In operations with heave periods of less than 2 seconds, the damping factor should be increased to 0.8.

Figure 16 and Figure 17 below should be used as a guideline for selecting the correct average heave period (T_0) in the "Hydrographic survey" filter.

Figure 16 illustrates the relative heave residual in percentage of amplitude for the "Hydrographic survey" filter with damping 0.7 and various average heave periods of 5, 10, 15 and 20 seconds.

Figure 17 illustrates the heave step response with corresponding settling time for the "Hydrographic survey" filter with damping 0.7 and various average heave periods of 5, 10, 15 and 20 seconds.

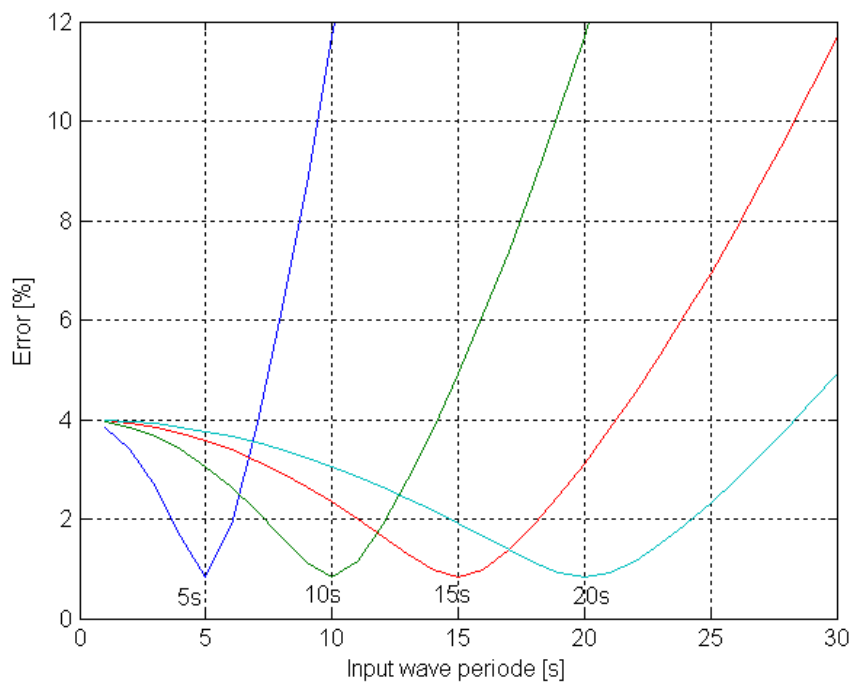


Figure 16 Relative heave residual in percentage of amplitude

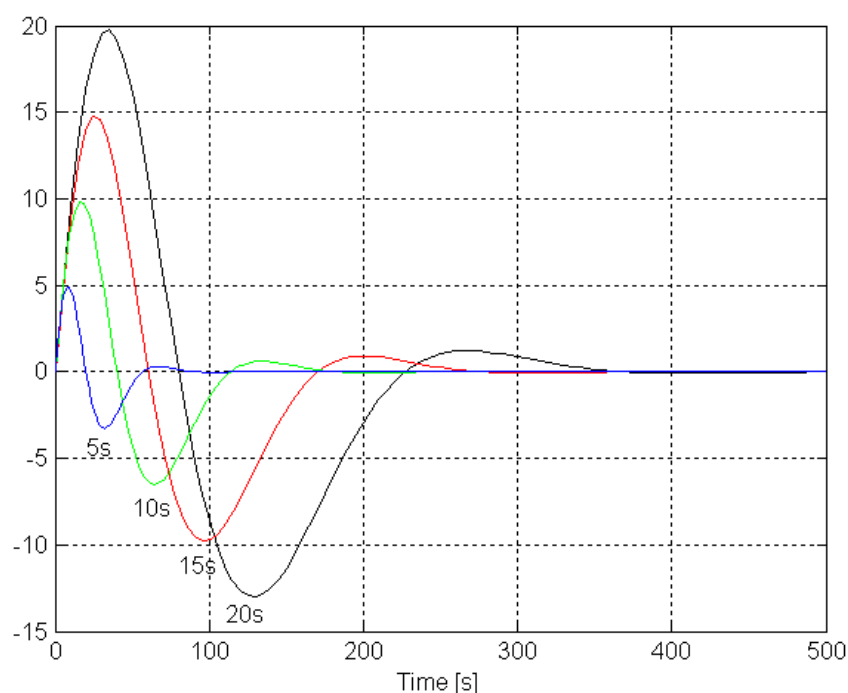


Figure 17 Heave step response with corresponding settling time

The selection of heave filter settings is a trade-off between low heave error over a wide range of heave periods and the settling time after an occurrence introducing a step response in the heave filter.

For an MRU without external input we recommend the following selections:

- The selection $T_0 = 5$ or lower is recommended for vessels performing surveys with a lot of turning on rivers or within harbours. The settling time in heave will be about 50 seconds.
- The selection $T_0 = 10$ is the default setting for this heave mode and covers most surveys, unless long period heave motions.
- The selection $T_0 = 20$ is recommended used for vessels operating in oceans with deep waters or vessels that frequently operate with following sea.

Figure 18 shows the change in the "Hydrographic survey" filter performance when changing the damping factor. We recommend that the damping factor is set to 0.7.

The figure illustrates the relative heave residual as a percentage of the amplitude for the "Hydrographic survey" filter with average heave period set to 10 seconds with various damping factors of 0.5, 0.6, 0.7, 0.8 and 0.9.

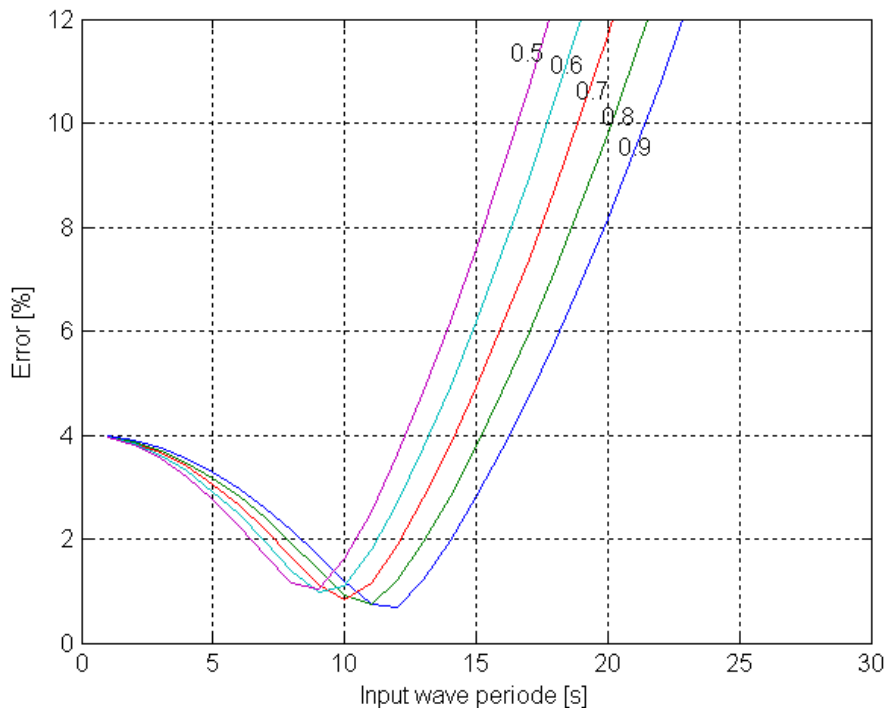


Figure 18 Relative heave residual as percentage of amplitude – average heave period 10 s

2.1.7 Delayed heave output

The new developed PFreeHeave[®] algorithm uses past measurements to output a correct and phase-free heave from Seapath. PFreeHeave[®] has an advantage in long swell conditions and for applications that can utilise a heave signal that is delayed some minutes, typical seabed mapping applications. The PFreeHeave[®] signal can be output on serial line or Ethernet (UDP/IP) together with the real-time heave signal.

To take advantage of this new functionality, the Seapath user has to post-process the echosounder recordings together with the motion sensor recordings. The application of delayed heave has to be performed in post-processing software delivered from QPS, CARIS, EIVA, HYPACK, Kongsberg Maritime and others. These software packages are able to read the PFreeHeave[®] format. See the *Installation Manual* for details on the PFreeHeave[®] format.

2.1.8 High speed data in real-time

By the integration of motion data with GNSS positions in the Kalman filter, a 200 Hz update rate of heading, roll, pitch and position is achieved. All Seapath data are output in real-time, including the position data, due to internal processing by use of accelerometer measurements between each GNSS position. This eliminates delays due to processing.

3 OPERATING INSTRUCTIONS

The Seapath will start automatically after power on and it is operated through the operator software installed on one or more HMI Units. The software is used for performance monitoring, configuration and system troubleshooting.

Normally, the system outputs signals on the serial lines, analog channels and Ethernet ports without any involvement from the user. After power on, up to 30 minutes is needed to obtain full accuracy on all data. Since there normally is no reason to turn off Seapath, it should be left running continuously.

The Processing Unit include an integrated LCD display and keypad for accessing the internal menu system for review of system status. For more details on the LCD display functionality, see APPENDIX A.



Figure 19 Integrated LCD display and keyboard

In the following chapters, the various display pages comprising the operator software will be described for better understanding of the displayed parameters.

3.1 Screen sections views

The main application window of the system is divided into four sections: **Top bar**, **View 1**, **View 2** and **View 3**. The size and position of the sections are fixed.

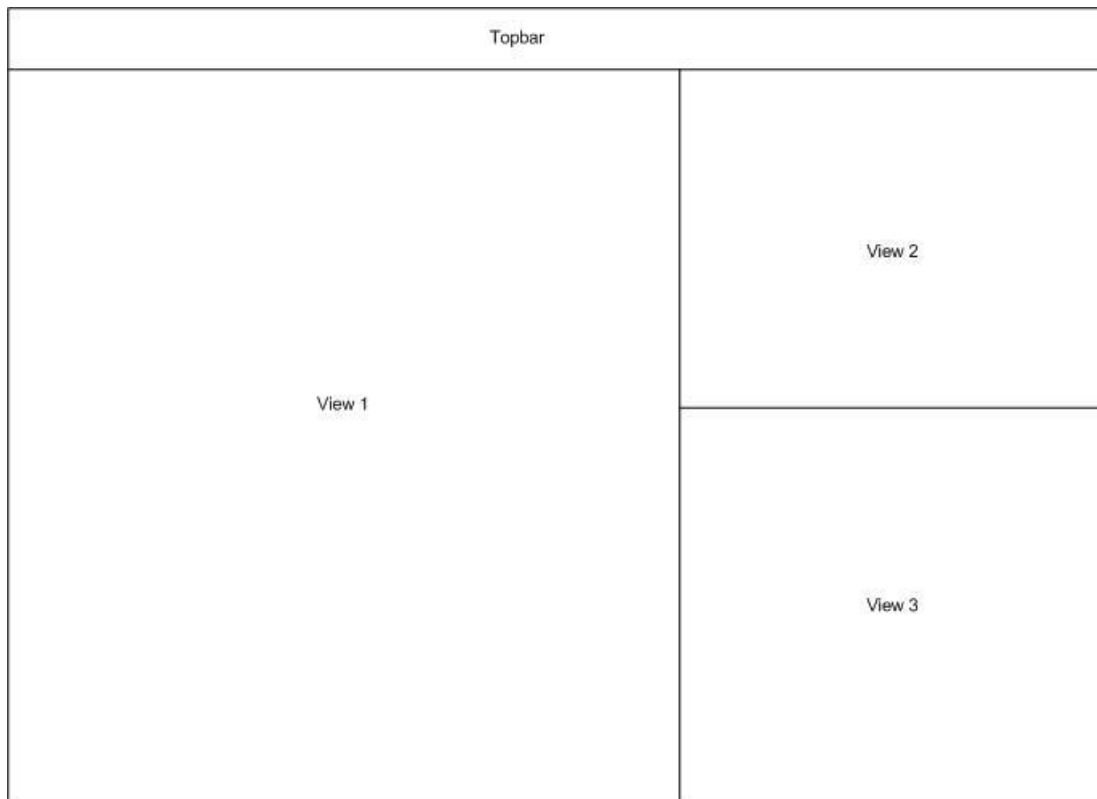


Figure 20 Main view sections

3.1.1 Switch and select views

The operator may select between the following views:

- Combined view
- Sky view
- DGNSS age view
- DGNSS status view
- Position integrity
- Compass
- Motion data
- Time Series view

Press **F2** to browse to the next available view in View 2.

Press **Shift+F2** to browse to the next available view in View 3.

Press **F3** to switch the contents of View 1 and View 2.

Press **Shift+F3** to switch the contents of View 1 and View 3.

Press **F5** to let View 1 cover the whole screen.

3.2 Top bar

The **Top bar** includes the following information:

- Type of system
- Current date and time (UTC)
- Data source
- System mode
- Data quality status
- System status
- Event message list including type of event and time tag for the event
- Application menu

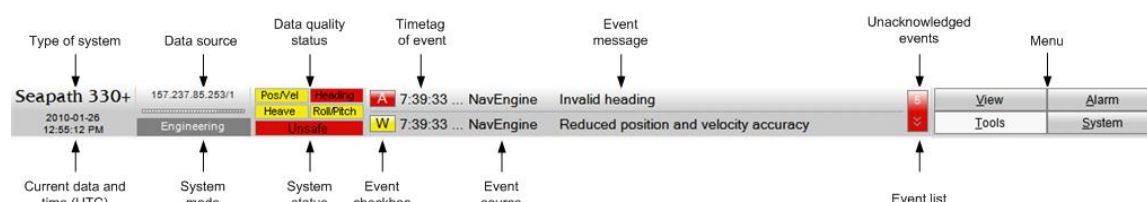


Figure 21 Top bar

System modes

Seapath has three system modes, indicated in the System mode field of the **Top bar**:

Operation mode This is the default mode. In this mode it is not possible to launch any external applications, diagnostic tools or reconfigure the system. A password is not required to switch to this mode.

Configuration mode In this mode it is possible to change settings related to the connected sensors, applications and system-wide settings.

Engineering mode This mode is primarily intended for field engineers during initial installation, fault diagnostics and system-wide reconfiguration.

A password is required to switch from Operation to Engineering or Configuration mode. The password is "stx" and it is not possible to change. The system will return to Operation mode after 3 minutes of user inactivity.

Data quality status

The Seapath has the following four data quality status indicators:

- Horizontal position and velocity
- Heave
- Roll and pitch
- Heading

The colour codes are:

- Green; normal
- Orange; reduced performance
- Red; invalid data

The quality status information output on serial lines or Ethernet is the same as indicated on the data quality status indicators.

System status

Seapath has three system states. The system status describes the position integrity level, and is indicated in the status field of the **Top bar**. The background colour of this field helps indicate the system status. The system states are:

Safe	
Caution	
Unsafe	

→ *For more information about integrity, see section 3.5*

Events

Three types of events may appear:

- Information messages
- Warnings
- Alarms

An event message is acknowledged by clicking in the **Event** check box. When an event is acknowledged, it disappears from the **Event list**. However, the event can still be viewed in **Alarm history** under the **Alarm** menu.

Application menu

The four menu buttons located to the far right on the **Top bar** constitute the application menu:

- View
- Alarm
- Tools
- System

The various menus have a drop-down list offering various operational and visual options.

3.3 Sky view

The **Sky view** display shows which satellites the system is tracking and using in the position computation. The satellites are presented according to satellite geometry. The grey outer circle represents the elevation mask. Satellites under the set elevation mask are marked grey. The satellite azimuth angle is according to the north-south axis.

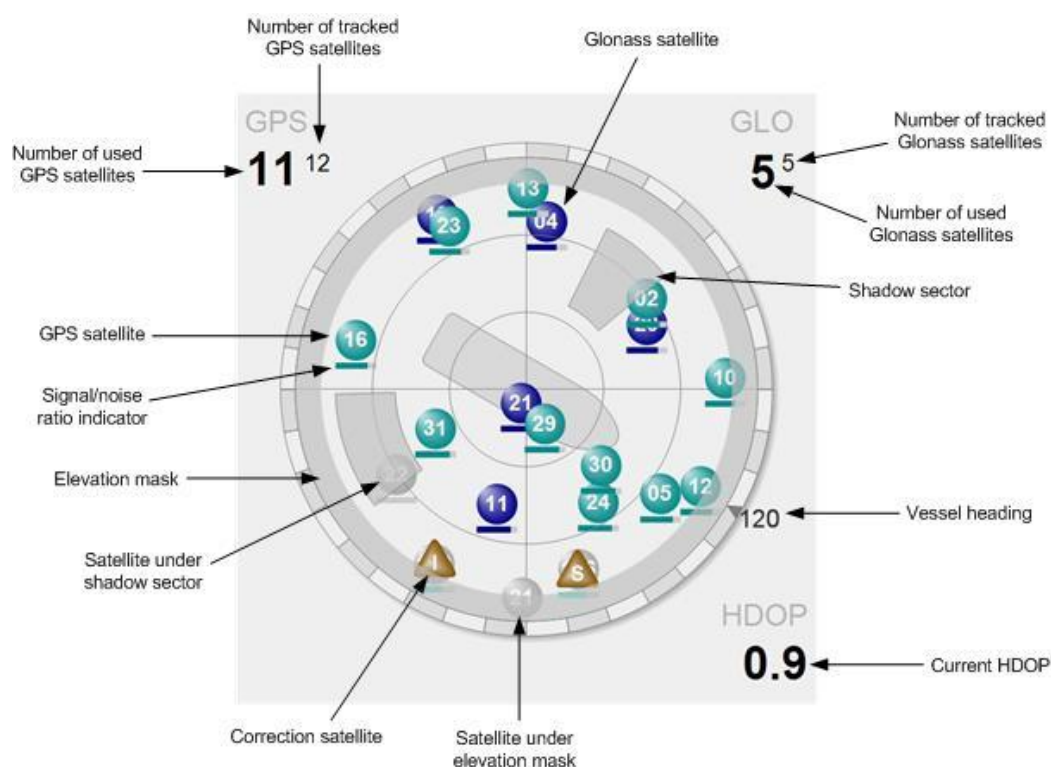


Figure 22 Sky view

In the upper left corner, the number of GPS satellites tracked and used in the position solution is presented. In the upper right corner, the number of GLONASS satellites tracked and used in the position solution, is presented.

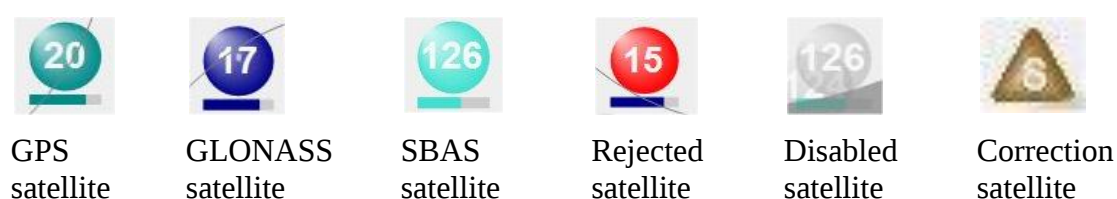


Figure 23 Satellite colours

Satellites marked grey are disabled as they are not used directly in the position fix, e.g. satellites under the elevation mask or satellites under a shadow sector.

The bar(s) at the bottom of each satellite represents the signal-to-noise level for the satellite, and the longer the bar, the stronger the signal.

The upper bar represents the L1 signal-to-noise level, while the lower bar represents the L2 signal-to-noise level.

When the mouse cursor hovers over a satellite symbol, a tooltip will appear with the status of the satellite including azimuth, elevation, L1/L2 signal-to-noise ratio and differential correction availability.

If the vessel has a gyro interfaced, the display shows the vessel's true heading.

The shadow sectors have no effect on calculations but will assist in explaining why some satellites are not used in the position fix.

The **Sky view** is configured in the **Sky view** tab in the **Operator software configuration** dialog. It is possible to enable or disable the correction satellites, the signal bars, the track plot and the shadow sectors.

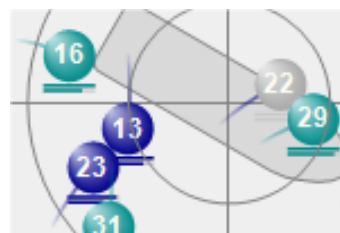


Figure 24 Satellites with two signal-to-noise bars

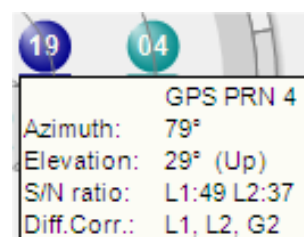


Figure 25 Tooltip for GPS satellite with corrections

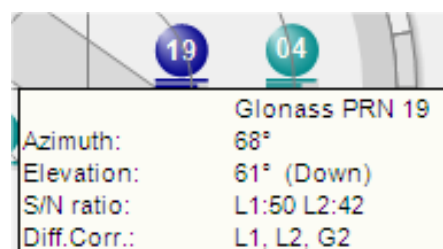


Figure 26 Tooltip for GLONASS satellite with corrections

3.4 DGNSS views

There are two DGNSS views, **DGNSS age** view and **DGNSS status** view. Both views indicate the status of the available correction links.

All links are indicated using green colour if correction data are received, red if *no* data are received through that link, or light grey if the link has been disabled for some reason.

Status of up to 9 correction links may be displayed. Each link is identified by its name as defined in the Configuration file. The number of reference stations used in the position calculation and the number of reference stations available are indicated for each correction link.

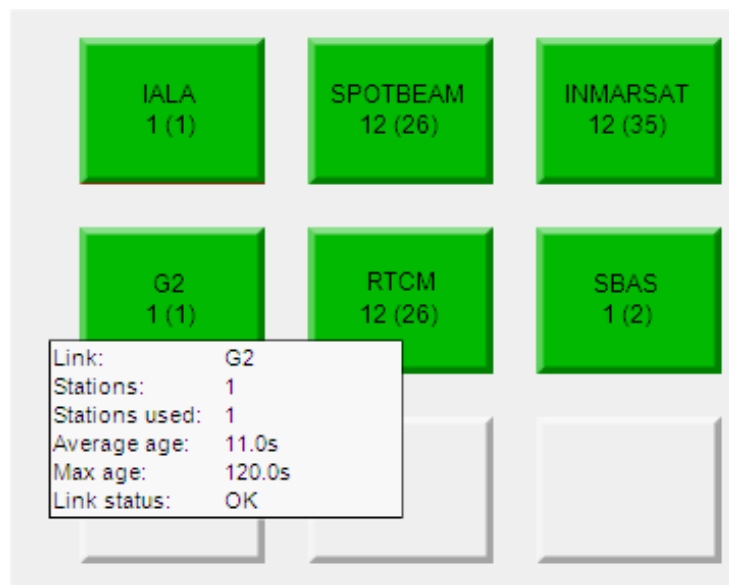


Figure 27 DGNSS status view

A tooltip is displayed when dragging the mouse over a correction link. The tooltip displays information on the specific correction link, as seen in Figure 27.

The **DGNSS age** view, as seen in Figure 28, presents each link as a circular button and presents a bar that indicates the quality as the age of the corrections received through that link. If a bar is filled green, the correction signals are newer. The older the signals are, the shorter the bar is.

If the bar is grey, the age of the corrections has exceeded the maximum age, and the corrections from the link are not in use. The maximum age for using differential corrections is set in the **Configuration** view.

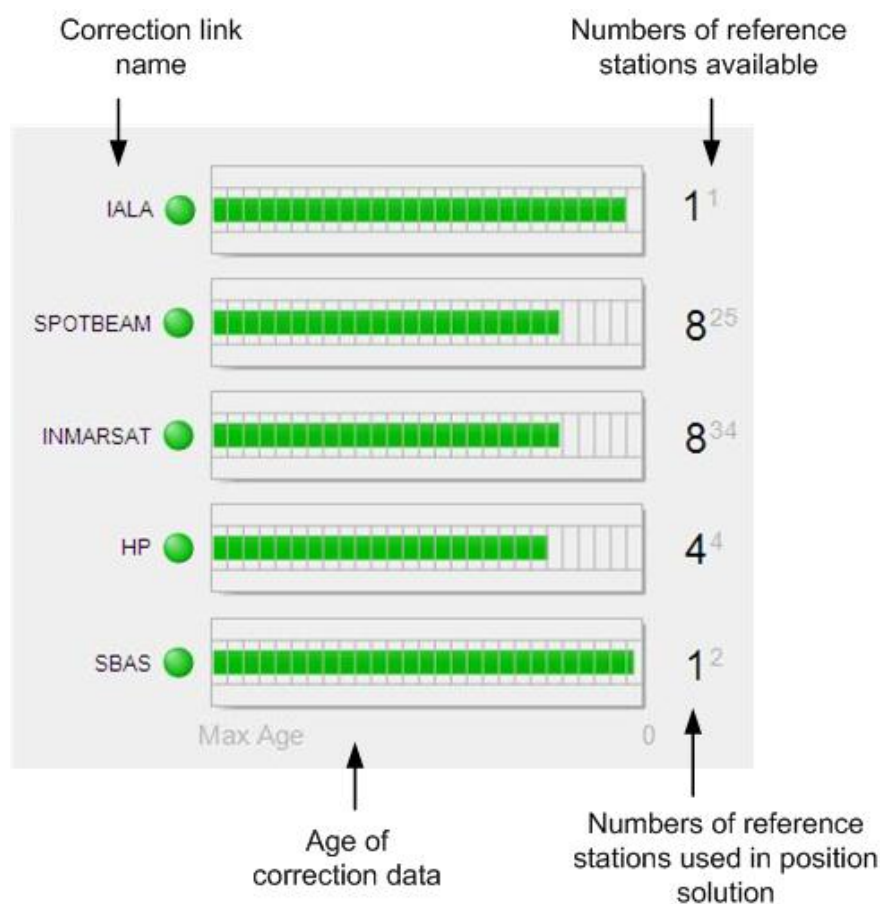


Figure 28 DGNSS age view

When clicking on one of the link buttons, the **DGNSS Monitor** appears. This view lists details of all available reference stations from all correction links.

3.5 Integrity view

The **Integrity** view indicates the position integrity of the system position according to the IMO requirements to positioning equipment based on the RAIM exclusion and detection algorithm implemented. The integrity indication for different position accuracy levels is expressed in three states (Safe, Caution and Unsafe) according to the requirements. The different states are indicated with colours (green, yellow and red) on the vertical bar in the view.

Part of the view is also an error ellipse that describes the position quality and the geometry of the position solution. The position accuracy level is configurable from the setup file (the value is displayed as the outer circle on the axis). Default value is 10 m.

The system integrity value is often referred to as the horizontal external reliability. It gives an indication of how large a horizontal position error might be, at the condition of an arbitrary undetected satellite failure.

Safe (green) indicates that the system accuracy is below the selected accuracy level and that a single satellite failure cannot make the actual horizontal position error exceed the selected integrity limit (95 % confidence level).

Caution (yellow) indicates that the system accuracy is below the selected position accuracy level but a single satellite failure might not be detected. If such a satellite failure is detected, the actual horizontal position error might exceed the selected integrity limit (95 % confidence level). With only four satellites (three when height aiding is chosen), there is no way to detect a satellite failure, and the system will always be in the state Caution or Unsafe. The expected accuracy and HDOP might still be reasonably low.

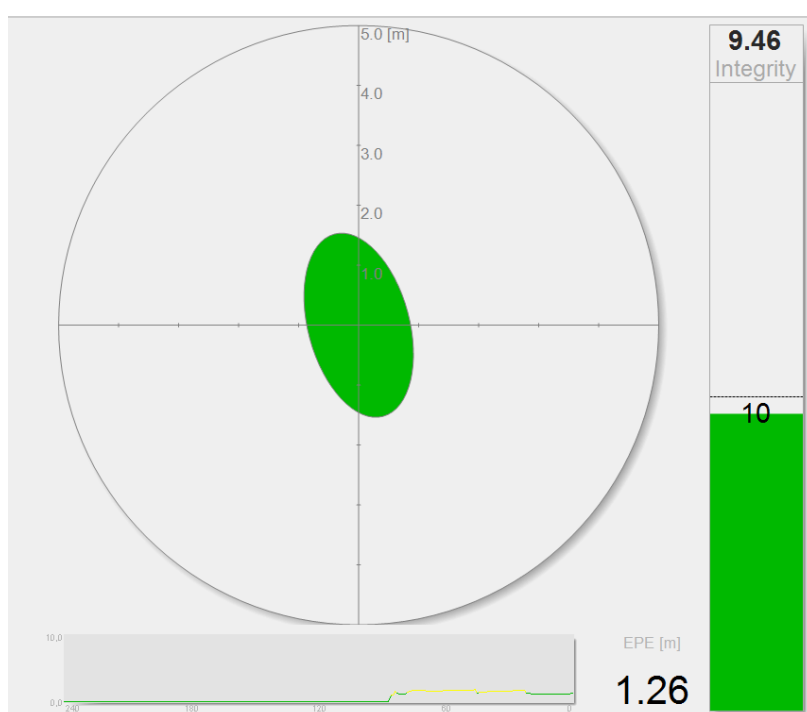


Figure 29 Integrity view

Unsafe (red) indicates that the system accuracy is above the selected accuracy level (95 % confidence level).

3.6 Compass view

The **Compass** view shows the position of the vessel at NRP, the vessel heading, COG and SOG.

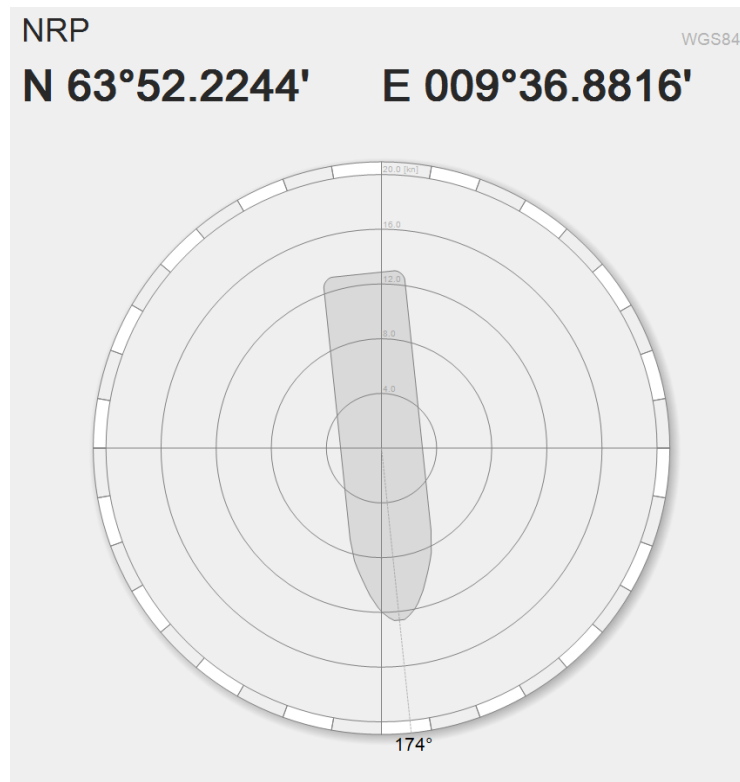


Figure 30 Compass view

3.7 Motion Data view

The main function of the **Motion Data** view is to give information about the speed and heading of the vessel.

Longitudinal and transversal speed (SL and ST) are presented together with arrows indicating forward/aft and port/starboard directions. The arrows and the vessel's course over ground (COG) are not displayed if the speed over ground (SOG) is less than 0.1 m/s.

Also the vessel roll, pitch, heave and rate of turn (ROT) are shown in this view.

Note *The displayed speed values apply to the NRP only even if the position is displayed for other measurement points.*

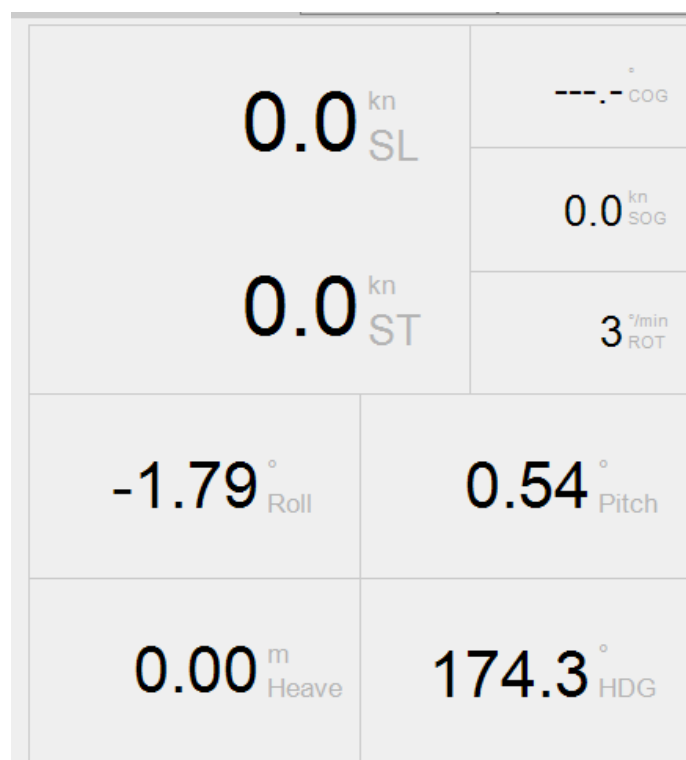


Figure 31 Motion Data view

3.8 Time Series view

This view plots roll, pitch, heave and heading as time series. The user may zoom in parts of each plot. The colour of the time series indicates the data quality. In the heave time series both real-time heave and delayed heave are presented in the same time series. Therefore the heave time series is always 2 minutes delayed in time in order to be able to present both measurements in the same curve and for the same sample.

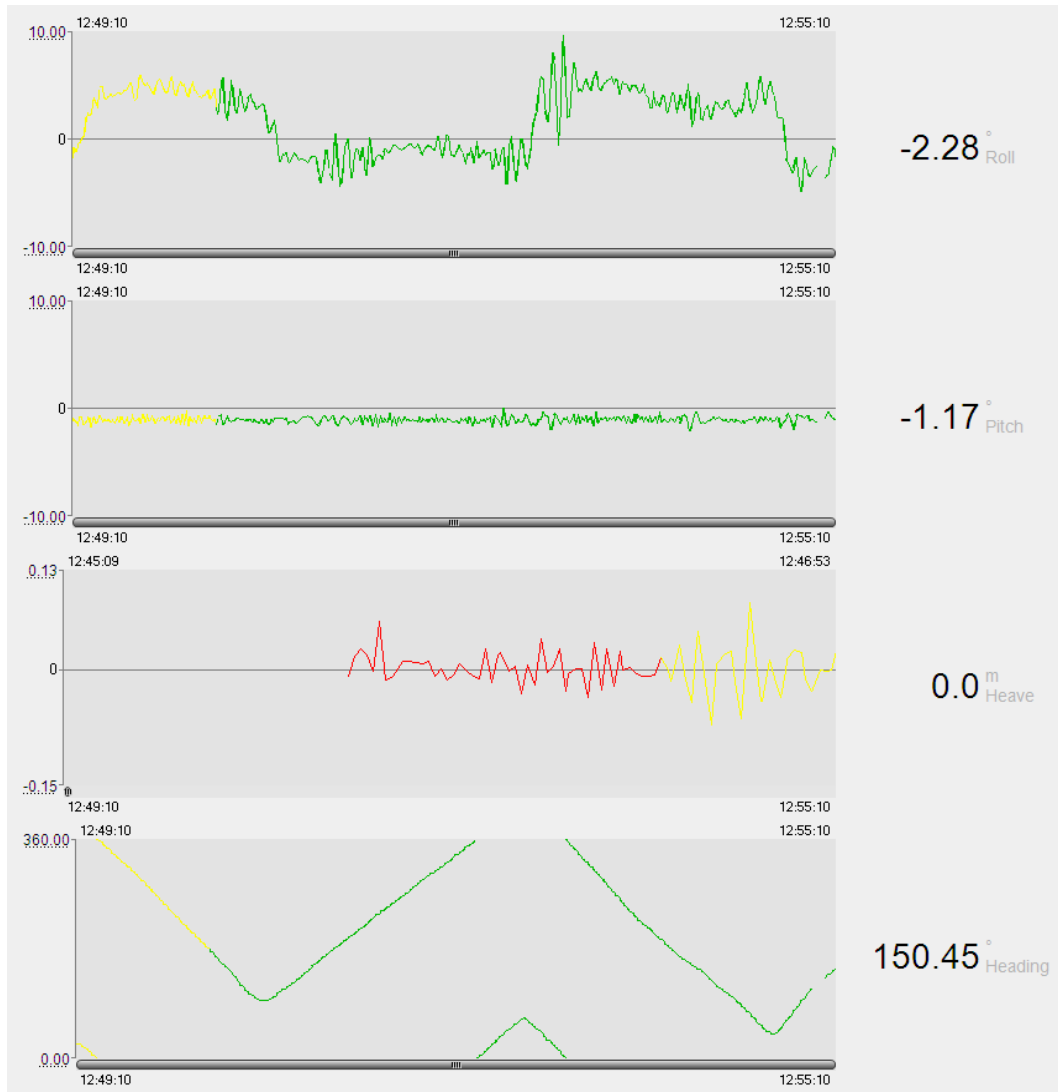


Figure 32 Times Series view showing data for roll, pitch, heave and heading

3.9 View menu

The **View** menu is a part of the Application menu located to the far right on the **Top bar** and holds the Display mode, View, Display format and Bars features.

3.9.1 Display mode

The Display mode controls the selection of colours used by the HMI. Click a menu item to select the desired mode.

Day bright	Will give the brightest colour combination.
Day white	This is the recommended colour combination for daylight use.
Day black	This colour combination uses bright colours, but has a dark background.
Dusk	This colour combination is intended for use during dusk or dawn.
Night	This is a special palette with very low contrast on black background, intended to be used during night without weakening the night sight of the system operators.

Display mode	
☐ Day bright	F7
☒ Day white	
☐ Day black	
☐ Dusk	
☐ Night	F8
View	
Maximize main view	F5
Browse top views	F2
Browse bottom views	Shift+F2
Toggle top view	F3
Toggle bottom view	Shift+F3
Display format	
◀ Date format	
◀ Time format	
◀ Position format	
◀ Datum	
◀ Unit system	
Bars	
☐ Link status	

Figure 33 View menu

Press **F8** to enter Night mode.

Press **F7** to browse through the non-night colour palettes. If clicked when in **Night** mode, **Dusk** will be selected.



Figure 34 Dusk mode



Figure 35 Day black mode

3.9.2 View

Maximise main view Click to let View 1 cover the whole screen. This has the same effect as pressing the F5 .

Browse top views Click to browse to the next available view in View 2. This has the same effect as pressing the F2 key.

Browse bottom views Click to browse to the next available view in View 3. This has the same effect as pressing Shift plus the F2 key.

Toggle top views Click to switch the contents of View 1 and View 2. This has the same effect as pressing the F3 key.

Toggle bottom views Click to switch the contents of View 1 and View 3. This has the same effect as pressing Shift plus the F3 key.

Browsing or switching views using **F2** and **F3** is not stored. The only way to ensure that the selected contents is displayed every time the operator software starts, is to make the selection as described in the View tab in the Operator software configuration dialog.

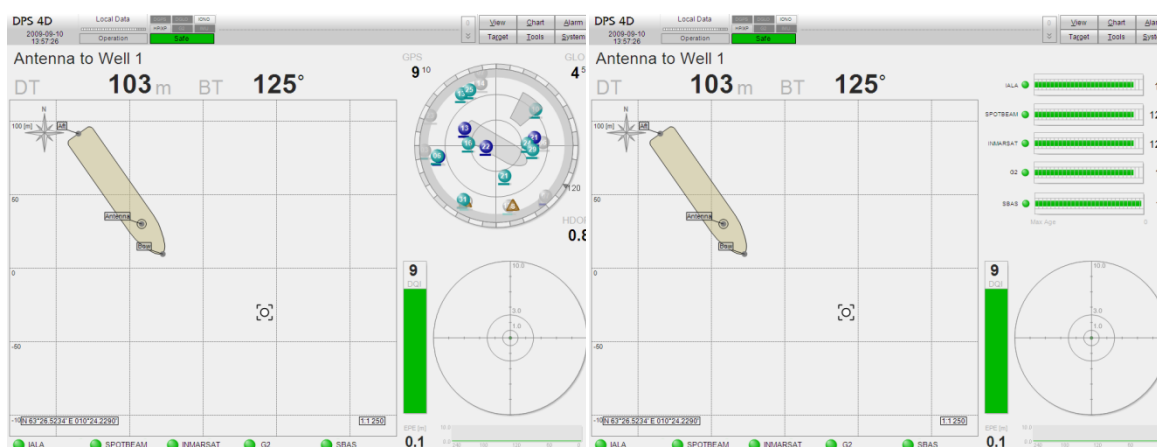


Figure 36 Browse views with the F2 key

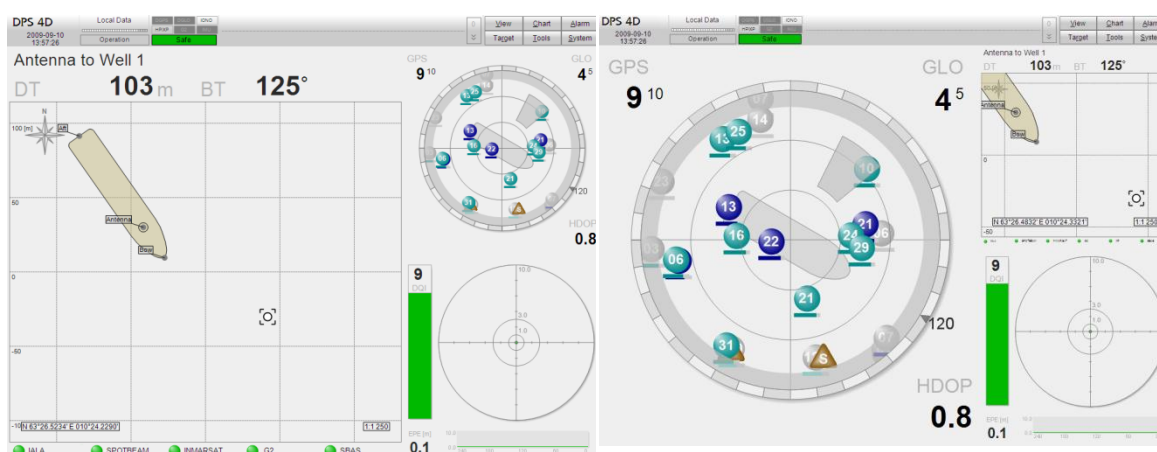


Figure 37 Switch views with the F3 key

→ For more information about View, see section 3.12.2.1.

3.9.3 Display format

The display format group provides alternatives for modifying the presentation of various data types. When clicking a view menu item in this group, or hovering the mouse cursor over it, a sub-menu will appear to the left, containing radio items for selecting the wanted format.

Date format

Select between various date formats. The selected format is used in displayed fields presenting date information, e.g. the date part of the **Top bar**.

Time format	Select between AM/PM and 24-hour display of time values. Influences all displayed fields presenting time information, e.g. current date and time and event fields of the Top bar .
Position format	Select between decimal seconds (e.g. N 63°26'31.92"), decimal minutes (e.g. N 63°26.5320') and UTM. All positions displayed in the various views and dialogs will follow this selection.
Datum	Select datum in which positions are presented. Available selections are WGS84, ED50 and NAD27.
Unit system	Select the length and speed units used in the various views. Two types of unit system selections are available: Fixed units and Auto-scaling units. Each alternative indicates the distance unit, then the speed unit. Auto-scaling units will change from short range unit to long range unit (indicated in parenthesis) when the number of digits in the displayed value exceeds a certain limit. Available fixed units: NM, knots m, m/s ft, ft/s Available auto-scaling units: M (km), km/h m (NM), knots ft (NM), knots

3.9.4 Bars

Click on the **Link status** mode to turn On/Off the desired mode.

Link status	When this mode is active, a link status bar will appear at the bottom of the screen.
--------------------	--

3.10 Alarm menu

The **Alarm** menu appears when the Alarm menu button is clicked.

Acknowledge alarm Selecting this item or pressing **F10** will acknowledge the topmost event viewed in the **Top bar**. Has the same effect as clicking the **Event** check box in the **Top bar**.

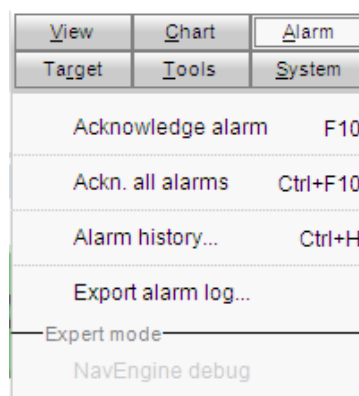


Figure 38 Alarm menu

The option is disabled if no alarms are available in the **Top bar**. Acknowledged alarms are still available in the alarm log, but removed from the **Top bar** view.

Ackn. all alarms Selecting this item or pressing **Ctrl+F10** will acknowledge all events viewed in the **Top bar**. The option is disabled if no alarms are available in the **Top bar**.

Acknowledged alarms are still available in the alarm log, but removed from the **Top bar** view.

Alarm history... Selecting this item opens a dialog for investigating the alarm history.

→ See section 3.10.1 for Alarm history view.

Export alarm log This item is disabled as long as the **Alarm history** is empty. When clicking this item, the dialog shown in Figure 39 is displayed. Select the wanted destination directory. The available space on the target drive is displayed. Make sure there is sufficient available space before clicking the **OK** button.

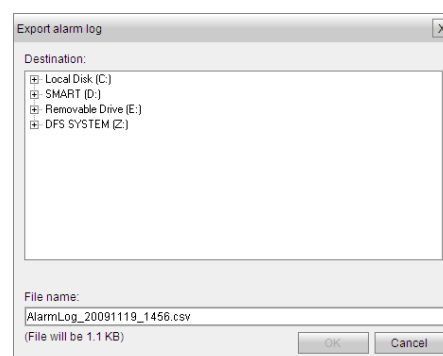


Figure 39 Export alarm log view

3.10.1 Alarm history view

In the **Alarm history** view there are two tabs, **Status** and **History**. The **Status** tab displays the active alarms, while the **History** tab displays all alarm history within a selected period or a maximum number which is set in the **Operator software configuration** dialog 3.12.2.2. All alarm changes are inserted as a new entry in the **History** tab.

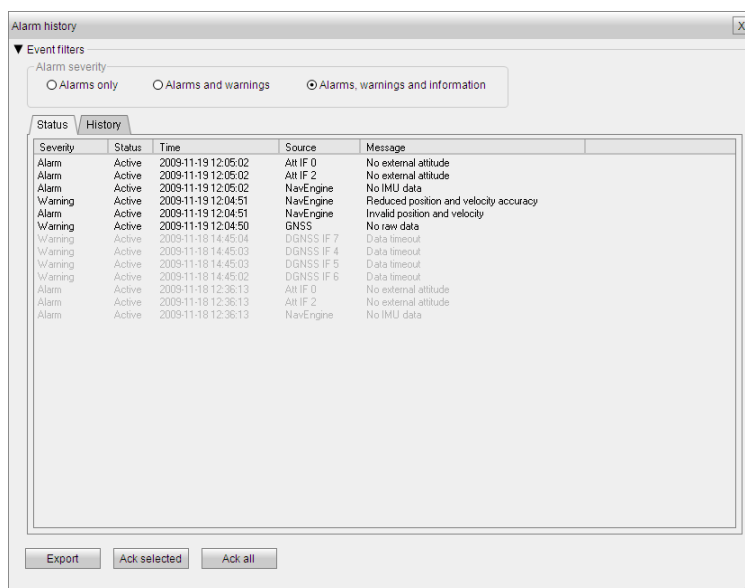


Figure 40 Alarm history view – Status tab

The option buttons at the top of the dialog provide some simple message filtering: if **Alarms only** is selected, only events with the Alarm severity level are displayed, if **Alarm and warnings** is selected, events with Alarm or Warning severity level are displayed and if **Alarm, warnings and information** is selected, all events are displayed.

From the Status tab it is possible to acknowledge alarms. Pressing **Ack. selected** acknowledge the selected alarms, while **Ack. all** will acknowledge all alarms in the view. When an alarm is acknowledged and active, the alarm message text will be grey. The alarm message will only be removed from the Status tab when it becomes inactive.

It is also possible to export alarms from the Alarm history view. Pressing **Export** enables the **Export alarm log** view, see Figure 39.

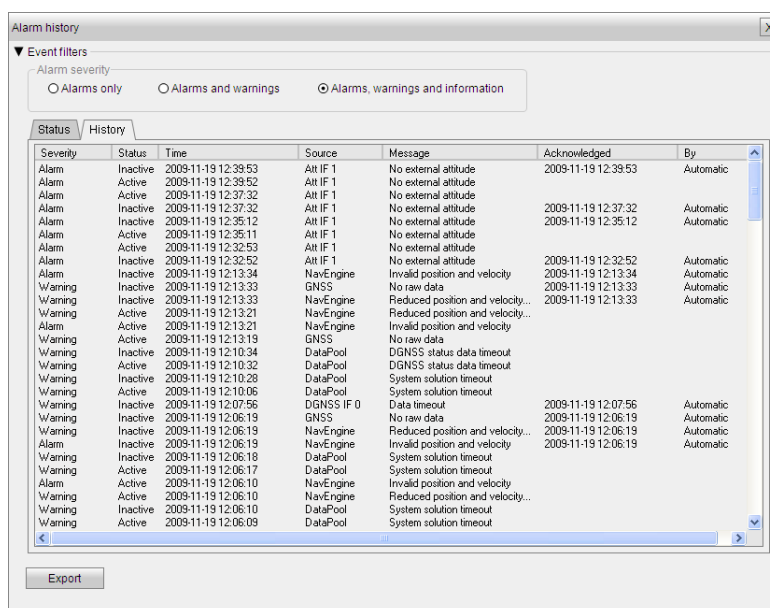


Figure 41 Alarm log view – History tab

3.11 Tools menu

The **Tools** menu shows a configurable list of tools serving various diagnostic purposes.

This manual describes a typical set of tools defined for Seapath, and is subject to change without notice.

3.11.1 Utilities

Satellite Prediction A tool which displays number of satellites and satellite geometry for a defined position and period, see section 3.11.1.1.

Copy Configuration A tool that copies all relevant configurations into a zip archive.

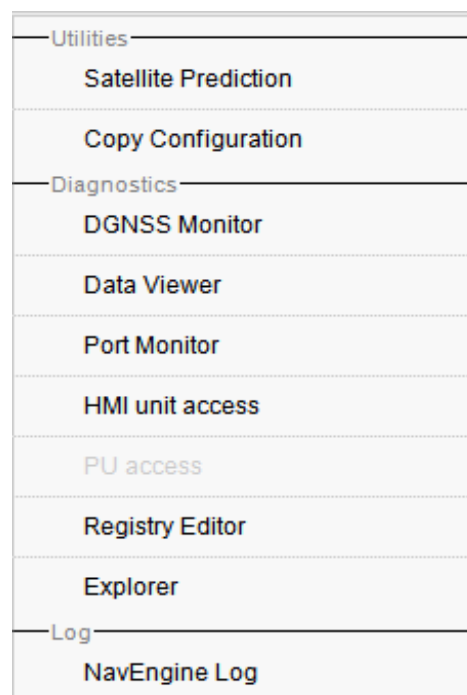


Figure 42 Tools menu

3.11.1.1 Satellite Prediction

During some periods the satellite coverage over some areas is rather poor and in addition, operations close to large equipment will often result in shadowed satellites and decrease the number of satellites available. This is a major risk for safety operations.

The **Satellite Prediction** application is a helpful tool to plan an operation where good accuracy throughout the operation is necessary and it will help the operator to plan when a safety operation could take place and to identify periods of poor satellite geometry.

The satellite prediction is based on the satellite's almanac data received from the GNSS receiver.

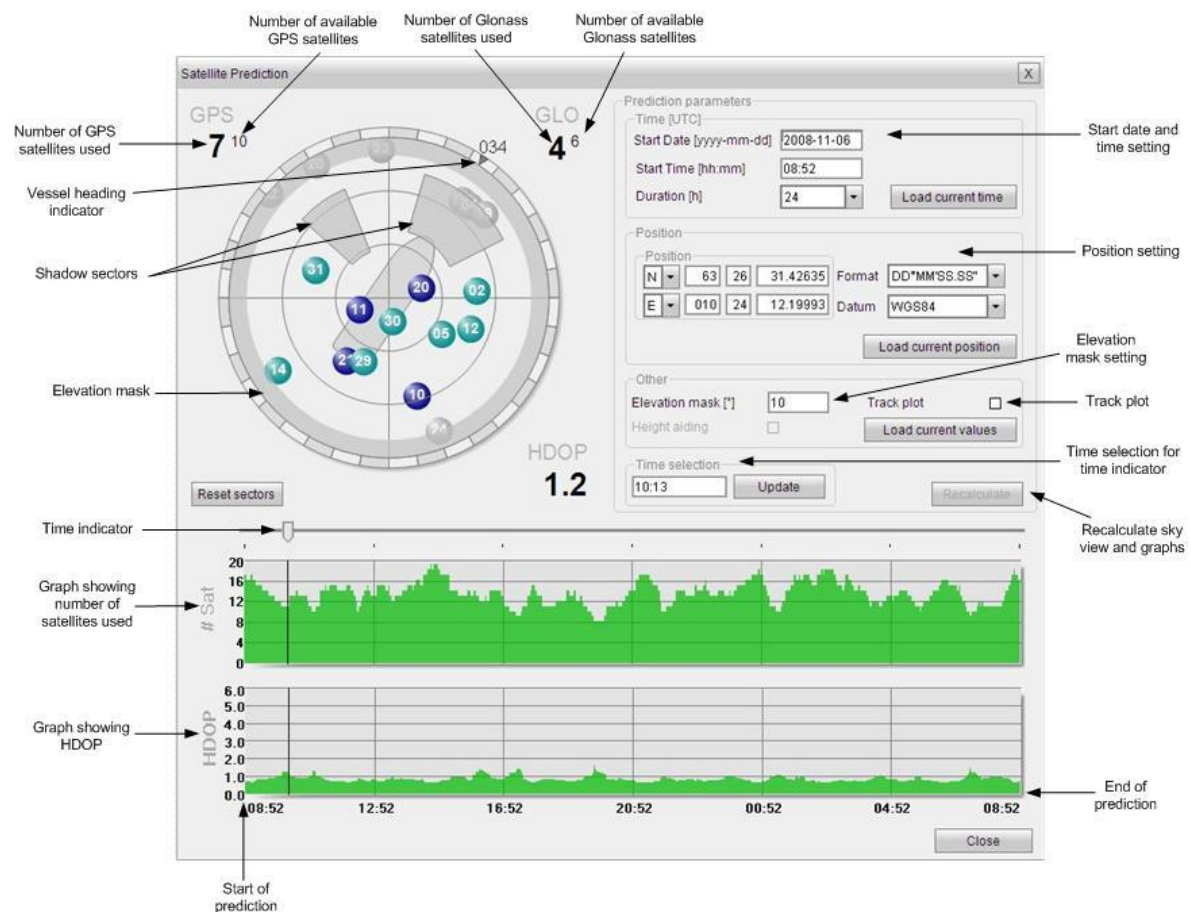


Figure 43 Satellite Prediction

When opening the **Satellite Prediction** application, the current date, time and position is set as start values. In addition, shadow sectors are drawn as inserted in the **System settings** dialog, while the elevation mask is drawn as set in the Configuration file. The default duration of the prediction is set to 24 hours but may be changed to 1, 2, 4, 8 and 12 hours. To change start values, insert new values and press the **Recalculate** button to update the graphs and sky view.

The vessel heading is displayed in the satellite prediction application identical to the heading input to the DPS. However, it is possible to drag the heading indicator to any heading and see how this affects the graphs.

It is possible to add shadow sectors. Right-click on the mouse over the **Sky view** area, press **Add sector** and a new sector is enabled. The new sector is edited by dragging and placing it in the correct place. Also the default sectors may be edited. After adding and editing sectors, press the **Recalculate** button to update the graphs. Press the **Reset sectors** button to delete the added sectors. Only the sectors drawn in the **System settings** dialog will remain.

To remove a sector, right-click on the mouse over the current sector and select **Remove sector**. In the **Satellite Prediction** application it is possible to disable satellites. In the sky view, right-click on the mouse over a satellite and select **Disable**. The satellite will become grey and the graphs will display number of satellites and HDOP where this satellite is omitted. To enable the satellite, right-click on the mouse over a satellite and select **Enable**.

By dragging the **Time indicator** with the mouse, the satellite constellation will change according to the time shown by the Time indicator and the **Time selection**. PageUp and PageDown or the left and right arrow keys on the keyboard also operate the Time indicator.

When using the PageUp and PageDown keys, the Time indicator will jump in greater intervals than if using the arrow keys. To set the satellite constellation to a specific time, input time in the **Time selection** box and press **Update**.

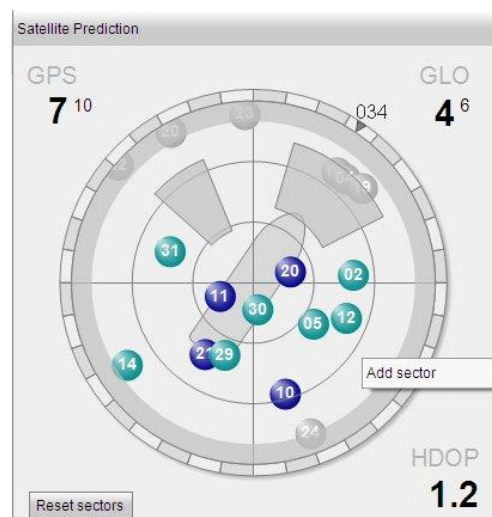


Figure 44 Adding sector into the Satellite Prediction Sky view

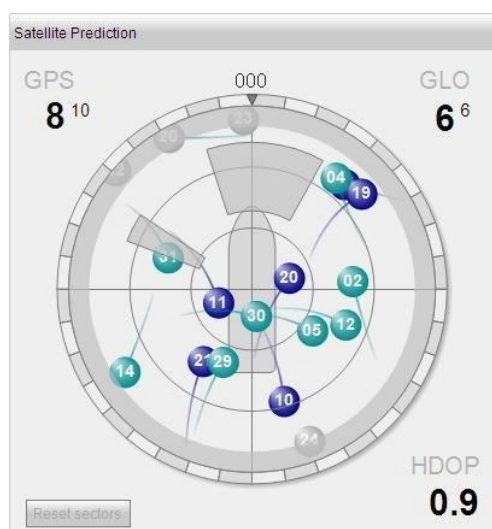


Figure 45 Track plot

If the **Track plot** option is enabled, the satellites orbit will be plotted when dragging the time indicator. The track plot assists in determining if a satellite is rising or falling in elevation. The length of the track plot is the same as in the **Sky view** tab in the **Operator software configuration** dialog.

The colours used in the Number of satellites (# Sat) graph, indicate the status of the satellite constellation.

Green: ≥ 5 satellites visible.

Yellow: 4 satellites visible.

Red: ≤ 3 satellites visible.

The colours of the HDOP graph indicate the satellite geometry (default values):

Green: HDOP < 2.5.

Yellow: $2.5 < \text{HDOP} < 4$.

Red: HDOP > 4.



Figure 46 Close up of satellite prediction graphs

The colours of the satellites in the sky view indicate the following:



GPS satellite.



GLONASS satellite.



The satellite is under the elevation mask or hidden by a shadow sector.



The satellite is rejected by the DPS position calculation algorithms or is reported unhealthy from the almanac. Red satellites are not included in the calculations.

→ For more information on Sky view, see 3.12.2.6.

3.11.2 Diagnostics

A tool which shows information about available reference stations.

DGNSS Monitor

A tool which shows information about available reference stations; see section below for more information.

Data Viewer	An application for providing raw data views to ease system verification and diagnostics.
Port Monitor	An application which displays the data traffic on all serial and net ports.
HMI Unit Access	Opens the Windows command shell on the HMI Unit.
PU Access	Opens a MSDOS window on the Processing Unit
Registry Editor	Opens the Windows Registry Editor.
Explorer	Opens the Windows Explorer view

3.11.2.1 DGNSS Monitor

The **DGNSS Monitor** shows information about available reference stations. The dialog presents three tabs, one per supported correction type.

By default, the reference station list is sorted in ascending order based on the distance from the vessel to the reference station. Click a column header to change sort criteria. Only ascending order is provided.

The column headers of the **DGNSS Monitor** show the following:

ID	The reference station's identification number.
Link Name	The name of the correction link that receives data from the reference station.
Type	The type of corrections received from the reference station, GPS L1, GPS L2, GLO L1 or GLO L2.
#SV	The number of satellites tracked by the reference station.
Dist [km]	The distance between the vessel and the reference station in kilometres.
Age [s]	This column shows the age of the correction data.
Health code	This column shows the reference station health status. Health code = 0: the reference station is working OK. Health code = 6: the reference station transmission is not monitored. Health code = 7: the reference station is not working.
Used	This column shows if the reference station data are used in the position computation (Yes, No, Timed out).
Name	The name of the reference station.

DGNSS Monitor									
RTCM SBAS HPX/P/G2									
		No. of stations	Stations in use	Age limit		Range limit			
GLO		7	4	120.0 s		2000.0 km			
GPS		41	20	120.0 s		2000.0 km			
ID	Link Name	Type	#SV	Dist (km)	Age (s)	Health code	Used	Name	
632		GLO L1	4	0.1	37.7	5	YES	Trondheim_Norway_SGH	
632		GLO L1	4	0.1	37.7	5	YES	Trondheim_Norway_SGH	
632		GPS L1	10	0.4	14.9	5	YES	Trondheim_Norway_SGH	
632		GPS L1	10	0.4	14.9	5	YES	Trondheim_Norway_SGH	
580		GPS L1	10	567.4	14.9	5	YES	Rogaland_Norway_SGH	
580		GPS L1	10	567.4	14.9	5	YES	Rogaland_Norway_SGH	
690		GPS L1	10	788.1	14.9	5	YES	Tromso_Norway_SGH	
690		GPS L1	10	788.1	14.9	5	YES	Tromso_Norway_SGH	
620		GPS L1	11	888.8	14.9	5	YES	Torshavn_Faroes_SGH	
620		GPS L1	11	888.8	14.9	5	YES	Torshavn_Faroes_SGH	
571		GLO L1	4	976.9	56.9	5	YES	Aberdeen_Scotland_SGH	
571		GLO L1	4	976.9	56.9	5	YES	Aberdeen_Scotland_SGH	
571		GPS L1	11	977.1	14.9	5	YES	Aberdeen_Scotland_SGH	
571		GPS L1	11	977.1	14.9	5	YES	Aberdeen_Scotland_SGH	
700		GPS L1	9	1109.3	14.9	5	YES	Kirkenes_Norway_SH	
700		GPS L1	9	1109.3	14.9	5	YES	Kirkenes_Norway_SH	
521		GPS L1	9	1311.6	14.9	5	YES	Leidschendam_Netherlands_SGH	
521		GPS L1	9	1311.6	14.9	5	YES	Leidschendam_Netherlands_SGH	
530		GPS L1	10	1641.0	14.9	5	YES	Shannon_Ireland_SGH	
530		GPS L1	10	1641.0	14.9	5	YES	Shannon_Ireland_SGH	

Figure 47 DGNSS Monitor, RTCM stations

The upper field of the **RTCM** tab presents the number of RTCM stations available and the number of RTCM stations used by the system. In addition, the Age limit and Range limit set in the Configuration file are displayed. A reference station further away than the range limit, will not be used in the position calculations. If the age of the data received from a reference station exceeds the Age limit, the data from the station will not be used.

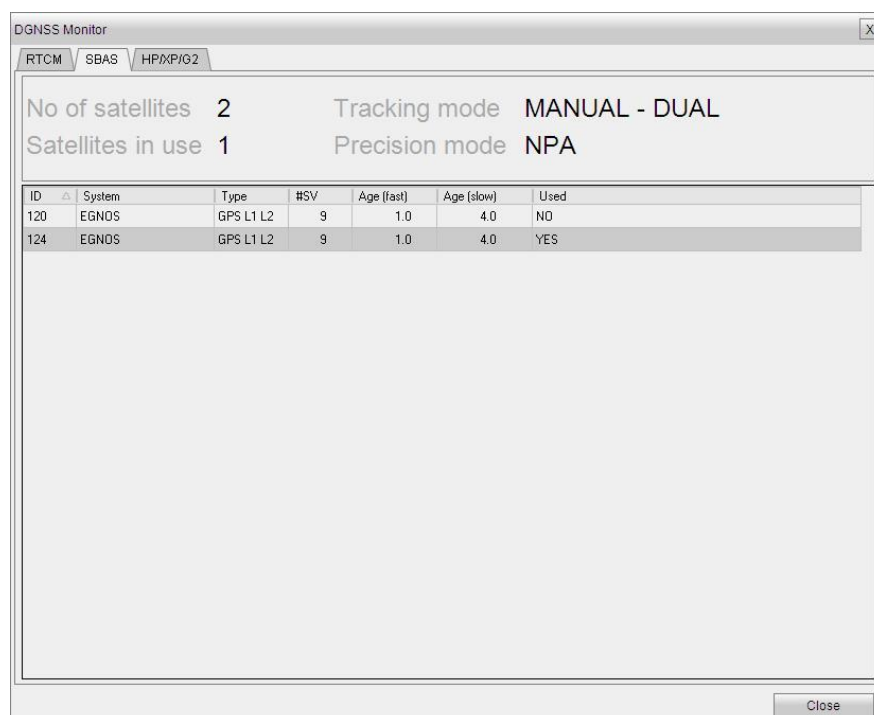


Figure 48 DGNSS Monitor, SBAS

The **SBAS** tab shows SBAS satellites as correction links and the status of corrections received from the satellites via the GNSS receiver. The upper field of the tab presents the number of SBAS satellites tracked by the GNSS receiver and how many of the satellites are used in the position solution. Tracking mode indicates how many SBAS satellites that are enabled in the Configuration file.

Tracking mode parameters:

- Manual – Single** One specific SBAS satellite is enabled in the Configuration file.
- Manual – Dual** Two specific SBAS satellites are enabled in the Configuration file.
- Disabled** SBAS disabled in the Configuration file.
- Automatic** No specific SBAS satellite is selected and the system will select and use data from the best of the available satellites.

Precision mode parameters:

- NPA** Non Precision Approach Mode.
- PA** Precision Approach Mode.

3.11.2.2 Data Viewer

The **Data Viewer** shows raw data information about satellites tracked by the receiver, position fix information, SBAS information and hardware platform status. The application is a helpful tool for system verification and diagnostics.

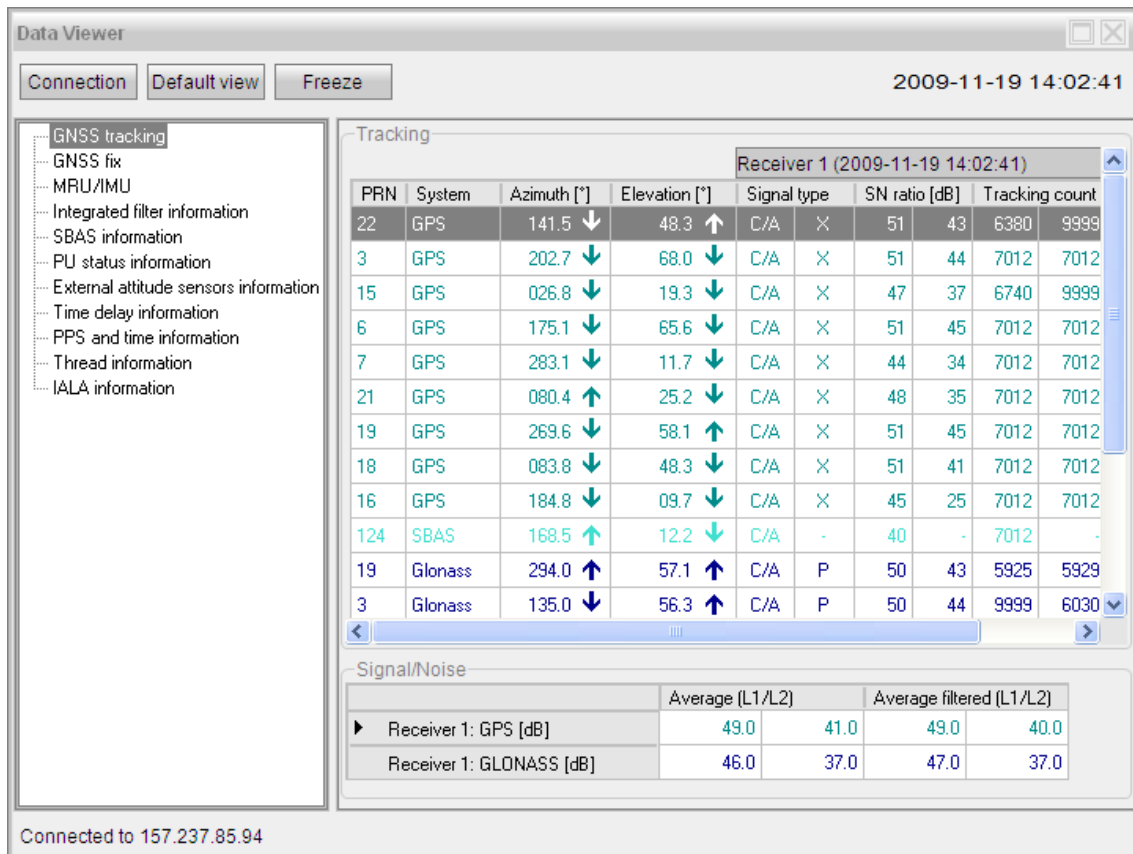


Figure 49 Data Viewer application

3.11.3 Log

NavEngine log Opens the Windows Explorer in the root folder for the NavEngine log data.

3.12 System menu

The items of the **System** menu are described below.

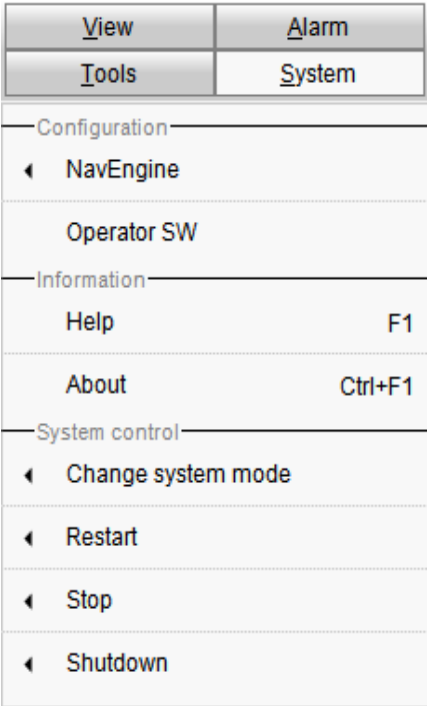


Figure 50 System menu

3.12.1 Configuration

The **Configuration** section contains two items – **NavEngine** and **Operator SW**.

Selecting **NavEngine** enables a sub-menu where **Standard** or **Advanced** configuration may be selected.

Consult the *Installation Manual* ref [1] for a description on how to configure the NavEngine.

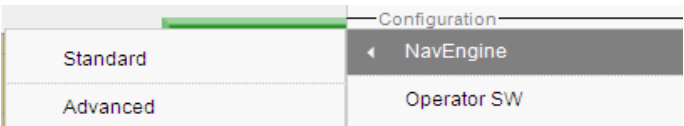


Figure 51 The NavEngine Configuration menu

3.12.2 Operator software configuration

The **Operator software configuration** view appears when clicking the **System** menu and **Operator SW**.

The settings are grouped in several tab pages, and each of these is described in the following sections.

3.12.2.1 View

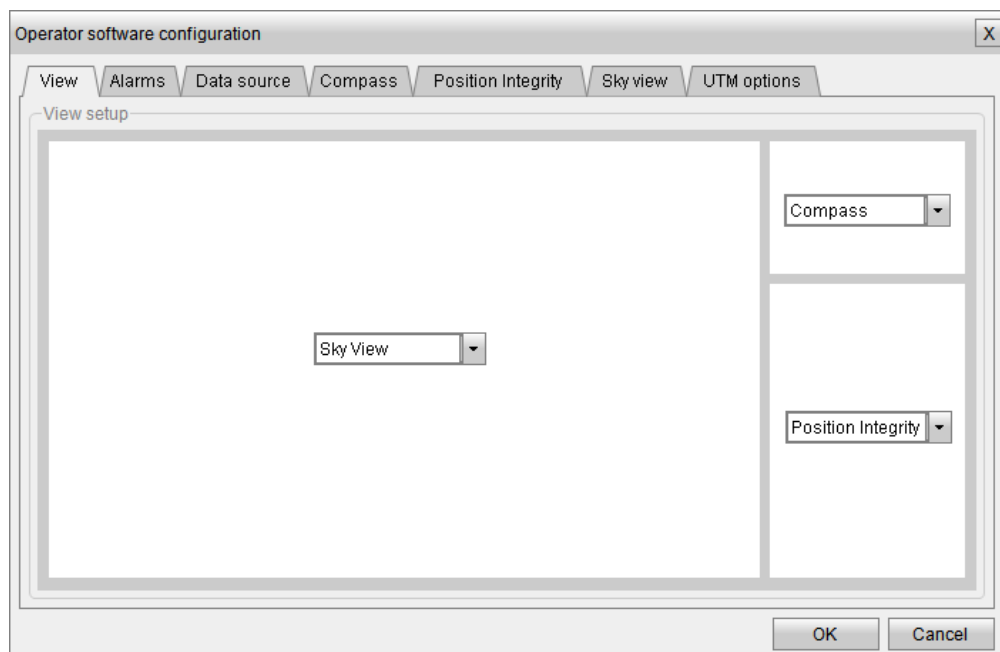


Figure 52 Operator software configuration - View

The **View** page specifies the contents of each view to be used when the GUI application starts up. The drop-down list controls indicate the contents, and the user may select from the available list in View 1 and View 2.

Click **OK** to apply the selection.

3.12.2.2 Alarms

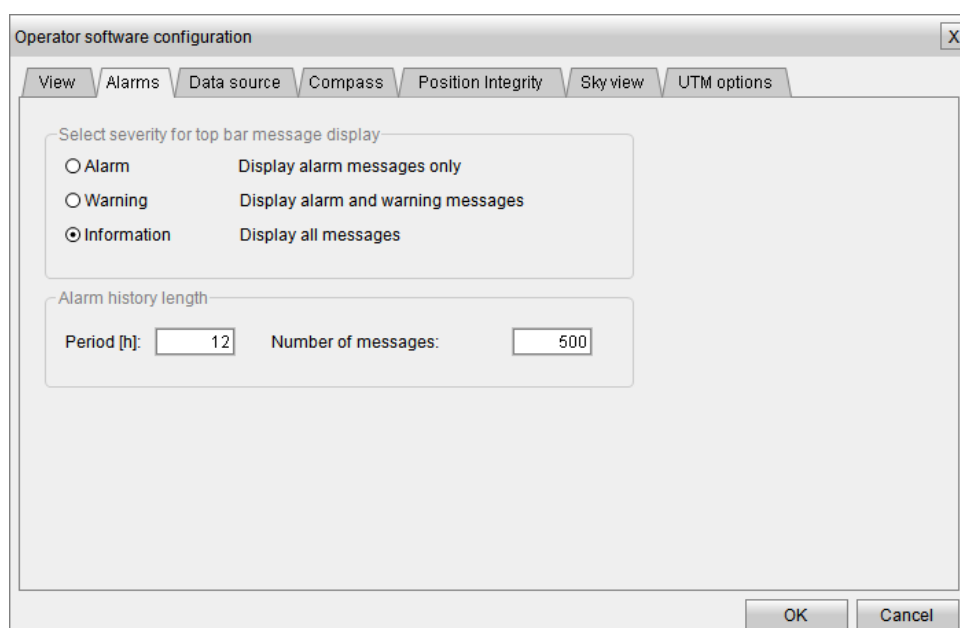


Figure 53 Operator software configuration - Alarms

The **Alarms** page is divided into two sections.

The first section controls the minimum severity for alarms displayed in the **Top bar**.

Alarm	Only messages with alarm severity are displayed.
Warning	Messages with alarm and warning severity are displayed.
Information	All messages are displayed.

The second section controls the **Alarm history length** in the **Alarm history** view.

Period	Sets the period for the inactive alarms to be displayed in the History tab in the Alarm history view. If a period of 12 hours is selected, the last 12 hours inactive alarms will be displayed. [h]
Number of messages	Sets a maximum numbers of inactive alarms which shall be displayed in the History tab in the Alarm history view. If 500 are selected, the last 500 inactive alarms will be displayed.

Note *If the Operator SW is stopped, restarted or shutdown, most of the alarm history will be deleted. Only the active alarms generated from NavEngine sw will be available.*

3.12.2.3 Data source

The Seapath GUI does not need to run on the same CPU as the NavEngine service. By entering the multicast group and port used by the wanted NavEngine instance in the **Data Source** page, remote data become available.

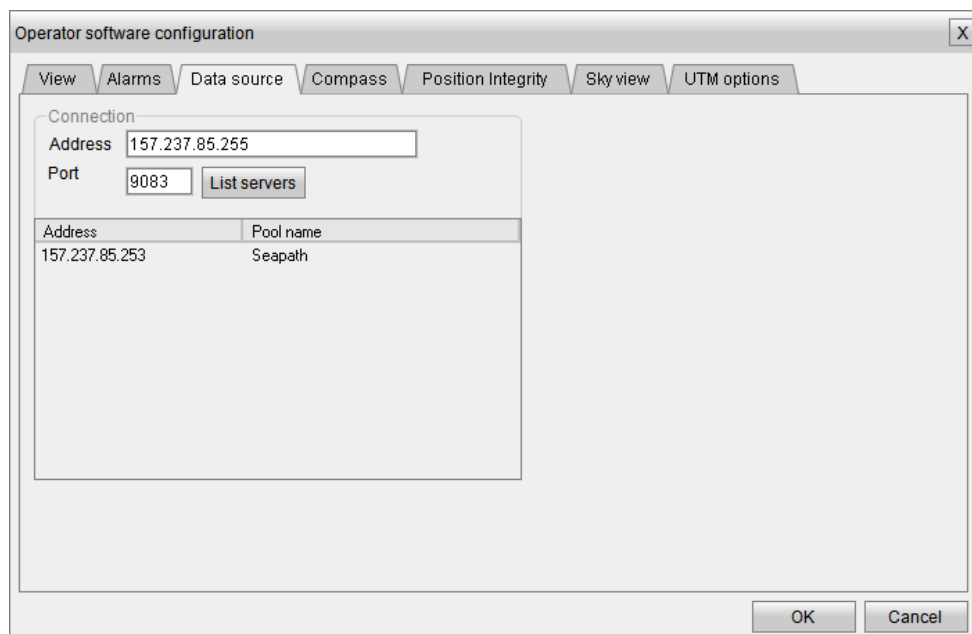


Figure 54 Operator software configuration - Data source

Address The address on which the Operator software receives data.

Port The port on which the Operator software receives data.

Note *If the Operator software should receive data from NavEngine, the Address and Port must match the UDP address and UDP port entered in the NavEngine configuration, see the Installation Manual [1].*

3.12.2.4 Compass

In the **Compass** page the following can be adjusted:

Max speed The maximum vessel speed to be shown.

Number of speed ticks The resolution of graphical presentation of the speed in the compass (number of circles).

Speed limit Set the lower limit for when COG, SOG and SL data shall be shown in the Compass view (filter out noise in the presentation of data).

It is also possible to select whether heading shall be presented as true heading or COG.

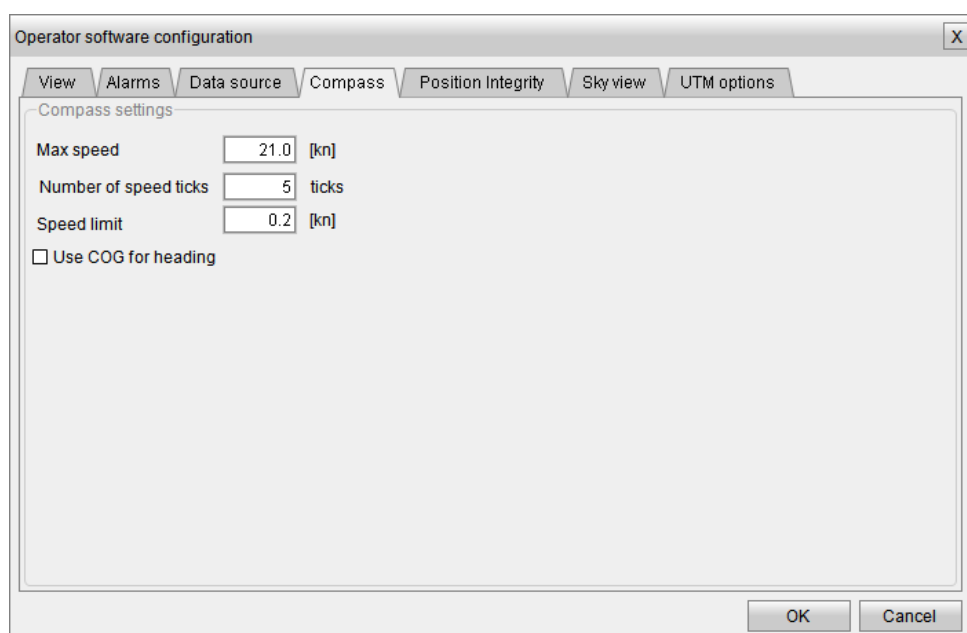


Figure 55 Operator software configuration - Compass

3.12.2.5 Position Integrity

In this view the following can be adjusted:

- | | |
|------------------------|---|
| Max ellipse EPE | The maximum EPE of the ellipse. |
| Resolution | The resolution of graphical presentation. |

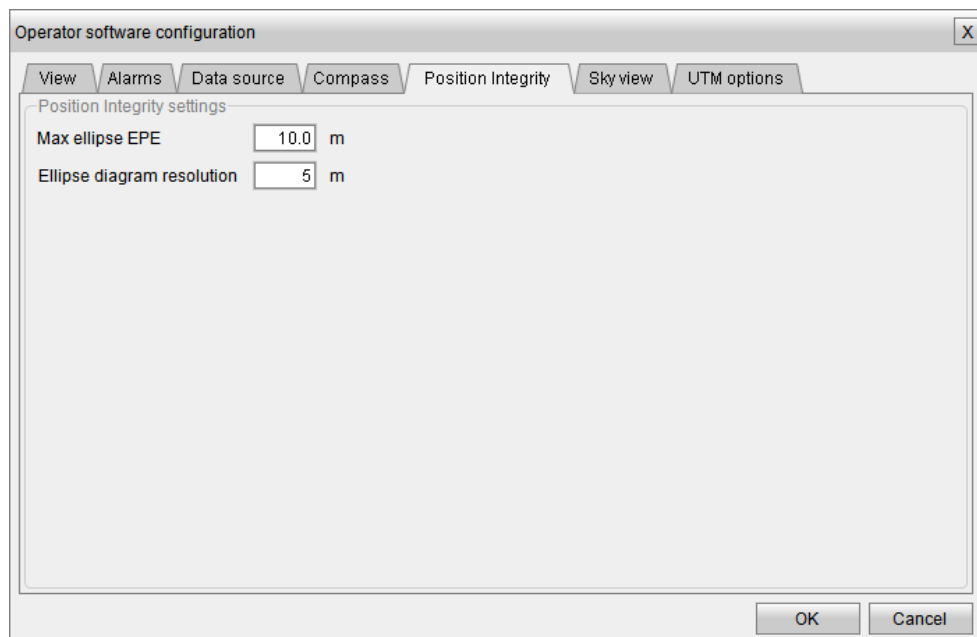


Figure 56 Operator software configuration – Position Integrity

3.12.2.6 Sky view

The **Sky view** page defines the appearance of the Sky view. It is possible to select the following options: Display correction satellites, Signal strength, Shadow sectors and Satellites track plot length.

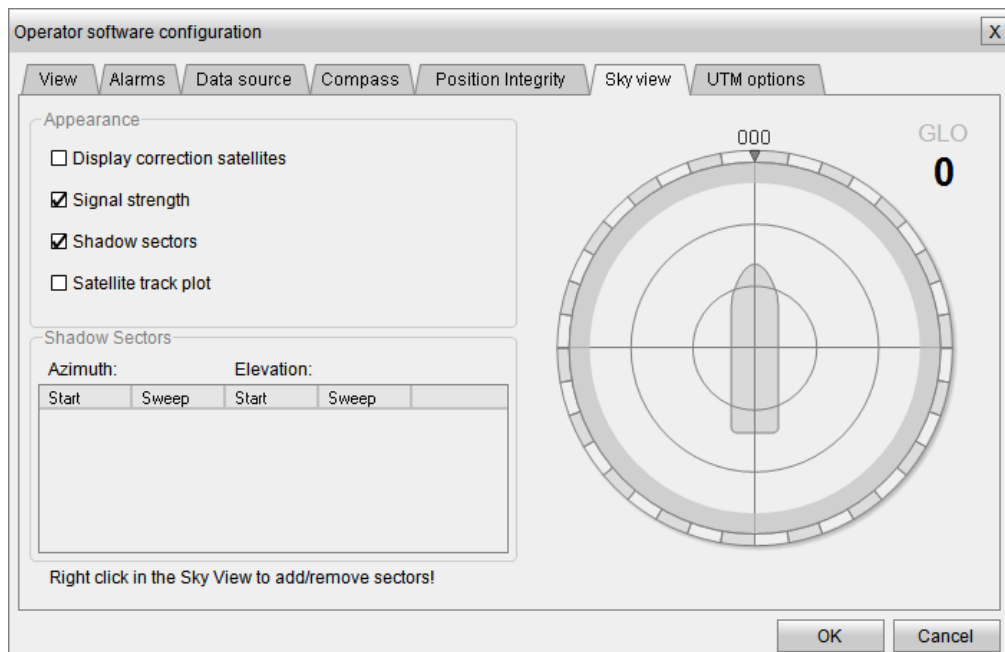


Figure 57 Operator software configuration - Sky view

The **Display correction satellites** option visualises correction satellites like Inmarsat and Spotbeam. The satellite positions are pre-defined in an xml-file. To select which correction satellites to display, press the **Individual...** button and select the satellites to use. The enabled satellites will appear in the Sky View as brown triangles. Spotbeam satellites are marked with an S while Inmarsat satellites are marked with an I.

When pointing with the mouse over a correction satellite, a tooltip with satellite name, azimuth, elevation and position will appear.

When enabling the **Signal strength** option, a signal bar is displayed under the satellites in the Sky view. The signal bar indicates the signal-to-noise ratio for the satellite, and the longer the bar, the stronger the signal. It is possible to select signal strength for both L1 and L2. When selecting for both L1 and L2, two signal bars are displayed.

To add a shadow sector, place the mouse over the sky view area, right-click on the mouse and select **Add sector**. By dragging the edges of the sector, the sector becomes larger or smaller. To move the sector, select the sector and drag it to the wanted position. To delete a sector, select a sector, right-click on the mouse and select **Remove sector**. The shadow sector refers to the vessel centre and will follow the vessel heading.

Azimuth start describes the starting angle of the sector in degrees (0 to 360) related to North. Azimuth sweep describes the size in degrees. Elevation start describes the starting angle of the sector in degrees (0 to 90) where 0 degrees is the horizon and 90 degrees is straight above the antenna.

Satellite track plot assists in determining if a satellite is rising or falling in elevation. The **Satellite track plot length** defines how long the length of the track plot should be. When Satellite Track plot is enabled, the track plot starts to increase. Maximum length of the track plot is 720 minutes.

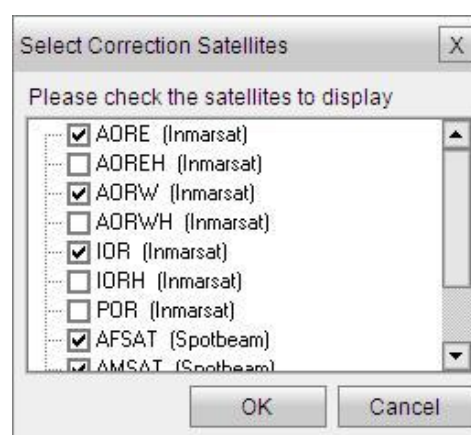


Figure 58 Selection of correction satellites to display

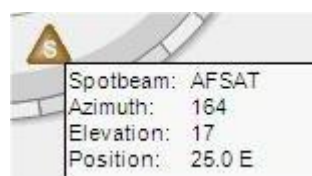


Figure 59 Correction satellite tooltip

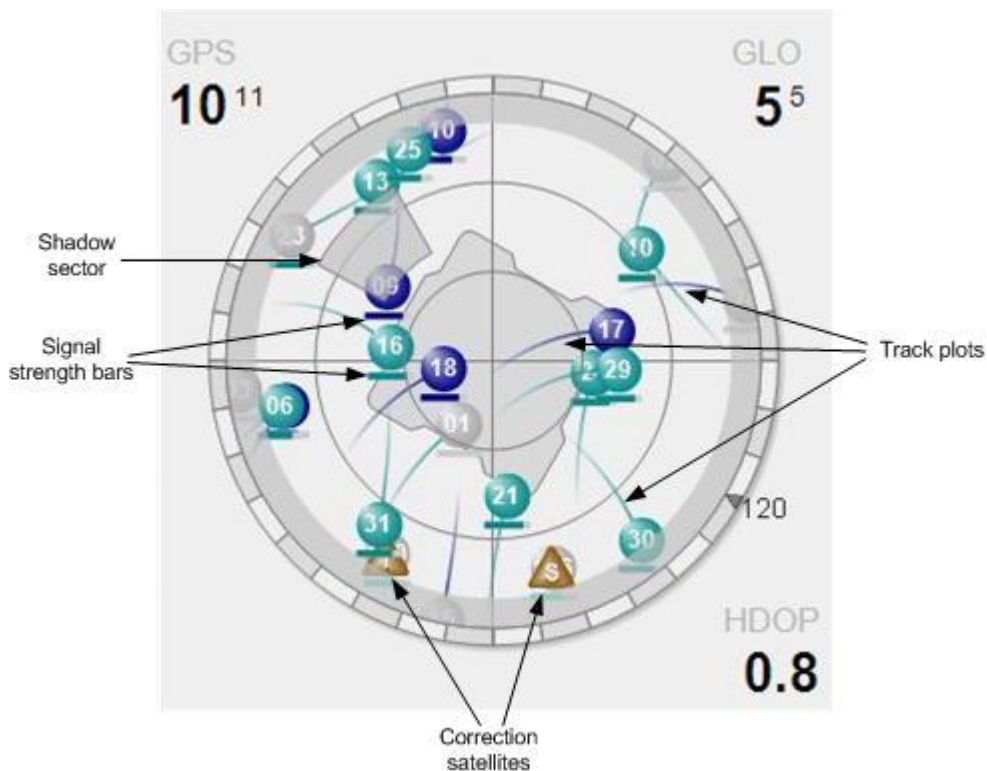


Figure 60 Sky view with correction satellites, signal strength bar, track plots and shadow sector

3.12.2.7 UTM options

The **UTM Options** page controls how UTM positions are treated by the Seapath application.

When selecting **False Northing**, positions south of the equator will always be presented positive. A fixed offset of 10 000 000 m is added to the northing value to avoid negative coordinates in the southern hemisphere. When selecting **False Easting**, a fixed offset of 500 000 m is added to the true easting value to avoid negative coordinates. The UTM standard uses false northing and false easting, i.e. the co-ordinates are never negative. In case negative northing or easting is wanted, uncheck the checkbox.

The UTM zone is automatically calculated by default. The **Auto extended** zone option is only applicable between 56 degrees to 64 degrees north and 3 degrees to 6 degrees east. The 32V zone is extended west to 3 degrees east, so when selecting the Auto extended zone in this area, zone 32V is used. When outside the current area and Auto extended zone is selected, the used zone is equal to the zone used when selecting **Auto** zone.

When selecting Auto zone, the system zone is automatically calculated in accordance with the inserted co-ordinates.

Selecting **Manual** zone makes it possible to define which Zone and Zone offset to use. The **Zone offset** option allows a fixed offset to be applied to the longitudinal degrees. The UTM zone can be offset up to ± 3 degrees. The Zone offset is typically used where the maps used have an offset. The Zone range is from 1 to 60.

Note *The position properties selected in the Operator software configuration dialog are only for display purposes. For position properties output on a port, see the Installation Manual [1].*

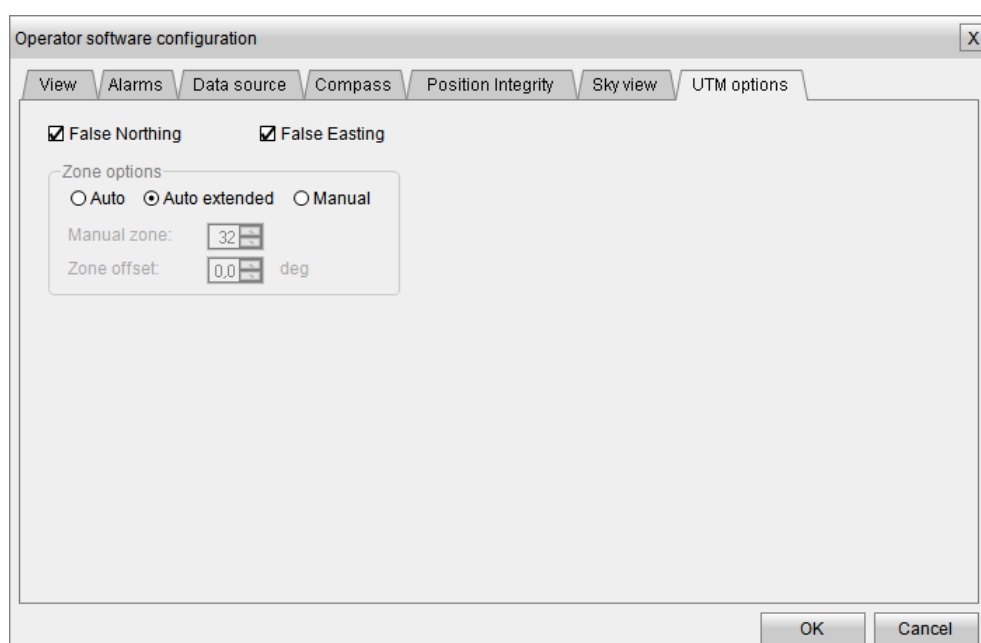


Figure 61 Operator software configuration - UTM options

3.12.3 Information

The Information section contains the Help and About dialogs.

Help Displays a Quick Help dialog presenting some basic help information.

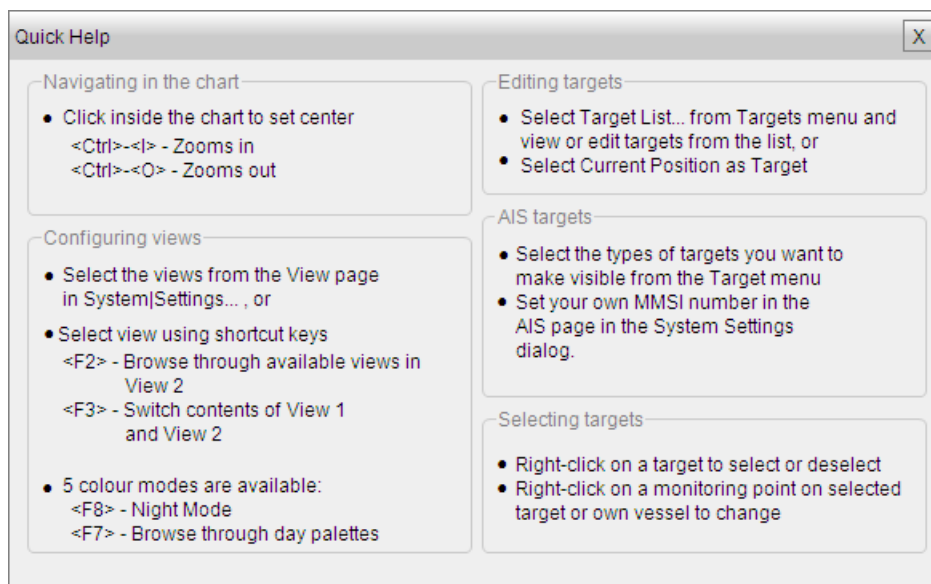


Figure 62 Quick Help dialog

About

Presents the **About** dialog which contains various information about the system such as contact, software version and equipment information.

3.12.4 System control

The **System control** part contains the **Change system mode** selection, the **Restart**, **Stop** and **Shutdown** options.

3.12.4.1 Change system mode

Via the **Change system mode** menu, the operator can change the system's operating mode. Switching to Configuration or Engineering mode requires a password. This password is always "stx" and is not possible to change.

The password is not case sensitive. The system will return to Operation mode after 3 minutes of user inactivity. Access to Engineering mode may also be gained by selecting **Ctrl+E** in the **TMV**. This opens the password dialog directly.

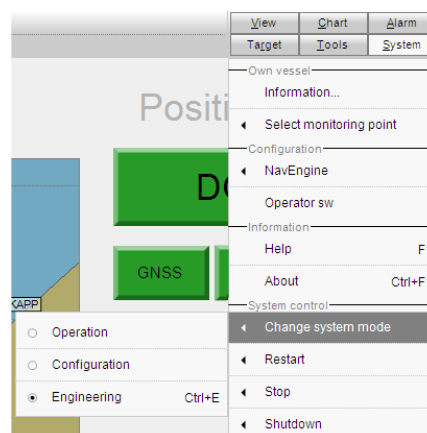


Figure 63 Change system mode options

3.12.4.2 Restart

From the **Restart** menu it is possible to stop and then immediately start the NavEngine, the Operator SW, the Processing Unit, the HMI Unit or the whole system.

When restarting the Processing Unit and/or the HMI Unit, the system will be restarted automatically and will resume operation within 2 minutes.

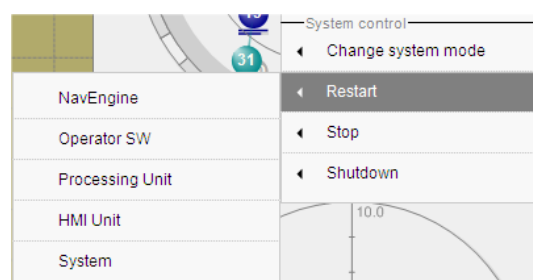


Figure 64 Restart options

When restarting the Operator SW, the application will terminate, and then automatically restart.

Caution *Restarting NavEngine, Processing Unit or System stops all processing, calculation and output from the system for about 2 minutes.*

Note *When restarting the Operator SW or the HMI Unit, the system will still calculate and output data.*

3.12.4.3 Stop

From the **Stop** menu it is possible to end the NavEngine and the Operator SW.

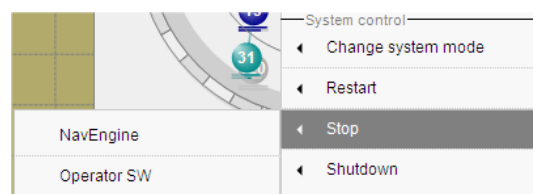


Figure 65 Stop options

Caution *Stopping NavEngine stops all processing, calculation and output from the system.*

Note *When stopping the Operator SW, the system will still calculate and output data.*

When stopping the Operator SW, the application will be terminated and the display will turn black.

To restart the Operator SW, press **Ctrl+Alt+Delete** and the **Task Manager** will appear. From the **Task Manager**, select **Shut Down** and then **Log Off DPS**. The standard Windows background and log in display will appear. Press **Enter**, and the Operator SW will restart.

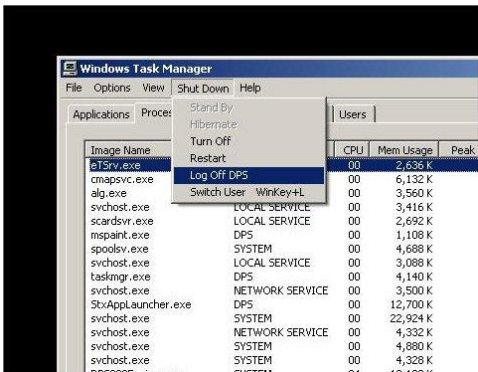


Figure 66 Start Operator SW

3.12.4.4 Shutdown

From the **Shutdown** menu it is possible to shutdown the Processing Unit, the HMI Unit or the System. Turn off the power on the Processing Unit or HMI Unit when the message "It is now safe to turn off your computer", appears.

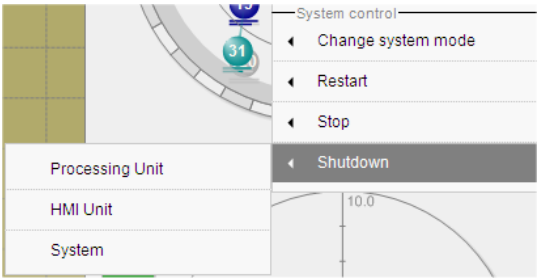


Figure 67 Shutdown options

Caution Shutting down the Processing Unit stops all processing, calculation and output from the system.

Note When shutting down the HMI Unit, the system will still calculate and output data.

Note Do not turn off power during the Windows XP shutdown sequence.

4 MAINTENANCE

Seapath consists of both software and hardware. The software part can be reinstalled or upgraded to the latest version in the field. Service of the Seapath hardware in the field can consist of:

- Exchange of damaged MRU and antenna cables.
- Exchange of failed GNSS antennas.
- Exchange of failed Processing Unit.
- Exchange of failed HMI Unit.
- Exchange of failed MRU.
- Checking fuse in the MRU junction box or exchanging the whole junction box.
- Checking fuse within the power connector on the Processing and HMI Units.

The Processing Unit, HMI Unit and the MRU are not designed for service in the field and opening the housing will result in damage or degradation of the units and void the warranty. A failed MRU unit has to be shipped back to Kongsberg Seatex in the original transportation box for service. The return address is provided in the first pages of this manual.

4.1 Periodic maintenance

4.1.1 Software upgrades

Kongsberg Seatex will regularly offer software upgrades for the system with improvements and new functionalities. It is up to the user to decide whether he will upgrade his unit to the latest version.

4.1.2 Cleaning of air inlet

The air inlet at the rear of the Processing Unit and HMI Unit needs to be cleaned regularly to avoid overheating of the units. The period between each cleaning is dependent on the air quality at the installation site. However, we recommend that the filter should be cleaned at least every six months.

2 U – Processing Unit

For the PU, remove the plastic cover and replace the filter or clean the filter either by washing with mild detergent or vacuuming.



With filter cover



Filter cover removed



Filter cover and filter

1 U – HMI Unit

Remove filter by sliding to the left with e.g. a small screw driver. Replace filter or clean by wasing with mild detergent or vacuuming.

4.1.3 Recalibration of the Antenna Bracket

The direction of the GNSS antenna baseline relative to the vessel's heading has to be recalculated only if the Antenna Bracket has been moved or dismounted from the Antenna Holder. Then the calibration procedures described in the Installation Manual [1] have to be followed for recalibration of the heading and antenna baseline.

4.1.4 Recalibration of the MRU

After two years in operation a recalibration of the MRU is recommended. A recalibration is recommended due to changes in the characteristics of the internal sensors over time and is therefore necessary in order to achieve the specified performance. Exactly when a recalibration is required, will depend on the use of the unit. An indication of required recalibration is oscillations in the roll, pitch and yaw measurements that cannot be related to the vehicle motions. The MRU has to be returned to Kongsberg Seatex for recalibration.

4.1.5 Changing the internal lithium battery

The lifetime of the internal lithium battery within the MRU should be at least 10 years, unless the unit has been stored unused for many years. An indication of a discharged battery will be that the MRU loses its configuration when the unit is unpowered. The MRU has to be returned to Kongsberg Seatex for changing of the lithium battery. A discharged battery will not have any influence on the MRU as long as it is connected to an external power source, like the Processing Unit.

4.2 Repairs and modifications

Repair of the Seapath consists of exchanging damaged GNSS antenna cables, the GNSS antennas, the Processing Unit, the HMI Unit, the MRU or the MRU junction box. These repairs can be carried out by a skilled electrician.

4.2.1 Exchange of GNSS antenna cable

- 1 Follow the Shut down procedure described in previous sections.
- 2 Dismount the damaged antenna cable. The new antenna cable must be as straight as possible. Do not crush or crimp the cable as this will affect the electrical properties of the cable.
- 3 Connect the antenna cable to the GNSS antenna.
- 4 The connection between the GNSS antenna and the antenna cable should be sealed against water penetration, preferably using waterproof self-vulcanizing tape.
- 5 Connect the antenna cable to the Processing Unit.

Caution *If the antenna cables are attached to the Processing Unit, do not attach the antenna cables to the GNSS antennas with the Processing Unit powered on. If the antenna cables are short-circuited with power on, the GNSS receivers within the Processing Unit will be damaged.*

4.2.2 Exchange of GNSS antenna

- 1 Follow the Shut down procedure described in previous sections.
- 2 Dismount the failed GNSS antenna.
- 3 Mount the new antenna on the mounting rod or similar.
- 4 Connect the antenna cable to the antenna.

- 5 The connection between the GNSS antenna and the cable should be sealed against water penetration, preferably by using waterproof self-vulcanizing tape.
- 6 Connect the antenna cable to the Processing Unit.

Caution *If the antenna cable is attached to the unit, do not attach the antenna cable to the antenna with the Processing Unit powered on. If the antenna cable is short-circuited with power on, the GNSS receiver within the unit can be damaged.*

4.2.3 Repair of Processing and HMI Unit

The Processing Unit and HMI Unit are not designed for customer maintenance. All repairs and modifications of these units, except changing the fuse in the power inlet, installation of new software versions and setup of the system, should be carried out by qualified personnel. A failed unit should be shipped back to Kongsberg Seatex or other agreed service point for repair.

4.2.4 Installation of spare Processing Unit

Use the following procedure to install the received spare unit if such a unit is available while your unit is being repaired:

- 1 Copy the Configuration files on the original unit to a USB memory stick, see **Copy Configuration** section 3.11.1.
- 2 If Fugro HP/XP/G2 is in use, copy the subscription files from /data/user/system folder to the USB memory stick.
- 3 Follow the Shut down procedure described in section 3.12.4.4.
- 4 Disconnect the unit to be repaired from its cables and the rack, and replace it with the spare unit.
- 5 Connect all cables as they were on the original unit.
- 6 Power up the unit.
- 7 Insert the USB stick into the spare unit and find the target folder where the copied configuration was stored. Copy the files under the Seatex folder on the USB stick to the /opt/seatex/nav/setup.cfg folder on the Processing Unit.
- 8 Copy the Fugro subscription files from the Seatex folder on the USB stick to the /data/user/system folder on the Processing Unit.
- 9 Restart the Processing Unit.

If the Compact Flash disk on the unit has failed, it is not possible to access the setup file.

4.2.5 Installation of spare HMI Unit

The SRRD USB stick delivered with your system contains a full image of the installed HMI Unit. The easiest way to install a working system on a spare HMI Unit is to restore the system from the SRRD.

Please follow the procedure below:

- 1 Shut down the system.
- 2 Plug in the SRRD.
- 3 Switch the HMI Unit on or press the **Ctrl+Alt+Delete** keys simultaneously to boot the system.
- 4 When the **Boot** menu appears, press the down arrow within 3 seconds to select **Seatex Rescue and Restore**. Press the **Enter** key.
- 5 Enter stx as password.
- 6 Wait while the system boots.
- 7 Select **Install System** from **Rescue and Restore Disk**, press the **Enter** key.
- 8 If this system is already installed on the disk you are about to install to, the program will automatically try to save the configuration files on this disk, and inform about the result of the operation. Note that the registry settings will not be saved.
- 9 If the new disk is not completely blank, you will be asked for permission to overwrite it. Confirm by pressing the left arrow key to select Yes, and then pressing the **Enter** key.
- 10 Wait until the installation completes.
- 11 Select **Shut down** from the menu, press **Enter**.
- 12 When the message System halted appears you may turn off the system or press the **Ctrl+Alt+Delete** keys simultaneously if you wish to start the system as normal.

4.2.6 Repair of the MRU

All repairs and modifications of the MRU except for installation of new software versions and user configuration, have to be carried out by Kongsberg Seatex.

Caution Opening the MRU housing will result in permanent damage and the user should under no circumstances make any attempt to do so.

4.2.6.1 Installation of spare MRU

If a spare unit is rented while your unit is in for repair, use the following procedure to exchange the units:

- 1 Follow the Shut down procedure described in previous sections.
- 2 Dismount the MRU cable and unscrew the unit from the mounting bracket.
- 3 Insert the spare MRU into the mounting bracket. Ensure that the MRU is mounted in the same orientation in the mounting bracket as the failed MRU. Connect the MRU cable to it and power on the Processing Unit.
- 4 Put the failed MRU in the MRU transportation container and ship it to Kongsberg Seatex for repair.

4.2.7 Repair of the MRU junction box

First check that the fuse within the box is not blown and replace it if it is. The fuse used is of type F1AH 250 V with size 5 x 20 mm. Second, check if any of the cable wires have loosened from the terminals. If the box is functioning correctly, the LED1 light diode should shine green indicating that the MRU receives power. A yellow light in LED2 indicates that digital data are sent from the MRU on TX+. The LED3 for analog signals from the MRU should not shine, since analog signals are not sent out of the MRU when used in this system. If the LED light diodes indicate that the junction box is still not working, the box has to be returned to Kongsberg Seatex for repair.

4.3 Troubleshooting

This part of the document is written for personnel with operator experience when a situation arises where assistance from service personnel may be required. The aim of this section is to identify the problem so that the appropriate action can be taken.

The error conditions in the system are usually observed by looking at the data quality status in the **Top bar** in the operator software or four LED indicators located on the front panel. For description of the LED indicators on the Processing and HMI Unit see the *Installation Manual* ref. [1].

The quality status information output on serial lines or Ethernet is the same as data quality status indicated in the **Top bar** in the operator software.

In the following pages a description of the different status and alarm situations is given.

4.3.1 No mouse cursor

The mouse cursor may hide important information. For maximum visibility, the mouse cursor is hidden after about one minute with no user activity. Simply move the mouse again to re-display the mouse cursor.

4.3.2 External output problems

Check the serial lines, net cables and cable connectors for mechanical damage if the external equipment receives no data from the Seapath. Check also that the connectors are connected to the correct output ports both on the Seapath equipment and on the external equipment. The layout of the rear panel of the unit is shown in the *Installation Manual* [1].

If the cable and connectors are OK, check that the external output configuration of the Seapath system is set up correctly. This is described in the *Installation Manual* [1].

4.3.3 All data quality status are black

During normal operation it takes a minute from the Processing Unit is powered on until the four data quality status indicators in the **Top bar** turn red. If all the indicators are still black after three minutes from power on, do as follows:

- Check the power connection to the Processing Unit. Is the Processing Unit supplied with 110 to 240 V AC power supply, see power specification in *Installation Manual*, ref. [1].
- Turn the power switch behind the lid on the front panel off and on two or three times in case of poor connection.

If the indicator lights are still not turning red, contact your nearest Kongsberg Maritime office.

4.3.4 All data invalid "four red data quality indicators"

During normal operation it can take up to 30 minutes from the Processing Unit is powered on until full accuracy on all data is obtained and the data quality indicators change colour from red. If all the indicator lights are still red after 30 minutes from power on, then do as follows:

- Check if the GPS GNSS cables and the MRU cable are properly connected to the Processing Unit. If not, switch off the power and connect the cables properly and power on the unit again.
- Check if the cable from the Processing Unit to the MRU junction box is properly terminated and if the cable from the junction box is connected to the MRU.
- Check if the fuse in the junction box is blown and replace it if it is.

If there are still four red lights, contact your nearest Kongsberg Maritime office.

4.3.5 Invalid position/velocity indicator

The problem occurs if the Processing Unit does not get data from any of the GNSS receivers. Do the following:

- Check that both GPS GNSS antenna cables are properly connected to the antenna ports on the Processing Unit. In the **Seapath Display Window** on **Show Other**,

Serial, data from the GPS GNSS antenna number 1 shall appear on Com11 and Com2 from antenna no. 2.

- Check that both GPS GNSS antennas are not damaged and their cables are properly terminated in the connectors. Replace the whole cable if necessary.
- Check that both GPS GNSS antennas are functioning properly by dismounting the antennas from their Antenna Brackets and inspecting them. Replace the antenna with a new one if necessary.

If it is still not working after checking all the above items, then the GPS GNSS receiver boards within the Processing Unit are most likely damaged and the Processing Unit has to be shipped to Kongsberg Seatex for repair.

4.3.6 Reduced position/velocity indicator

The possible reason for reduced position/velocity function could be one of the following:

- No differential corrections are input on the rear panel of the Processing Unit. If differential corrections are input to the Processing Unit, check that the link is properly set up in the **DgnssLink**, part of the **Input/Output** subfolder in the **NavEngine configuration**.
- You can be out of range to a radio reference station and the differential corrections are therefore missing. If the reference station is too far away or it is in the shadow of geographical obstructions or other equipment on board, reception may be unreliable or missing. The location of the reference stations connected to Seapath is shown in the **DGNSS Monitor** under the **Tools** menu.
- The reference station can be out of function. Check the status of the reference station with the authorities responsible for it, or contact the nearest Kongsberg Maritime office.
- The antenna or the MRU offset setup can be incorrect. Check the setup of the lever arms from NRP to antenna no. 1 and to the MRU once again. Check particularly that the sign for each of the vector components are correct by entering the **Geometry** subfolder under **Sensor\GNSS** and **MRU** in the **NavEngine configuration**.

Note Please note that the Seapath outputs position in WGS-84 Datum. If the position from Seapath differs from positions from other GNSS sensors onboard, check that all systems use the same Datum.

4.3.7 Invalid heave and roll/pitch indicators

The Processing Unit does not receive any data from the MRU. Do the following:

- Check that data is coming in to the MRU connector on the Processing Unit by selecting **MRU** on the **Port Monitor** in the **Tools** menu.

- Check that the cable from the MRU is properly connected to the MRU port on the rear panel of the Processing Unit. Also check that the MRU cable is properly terminated in the junction box and that the fuse in the box is not blown.
- If the above is OK, see the section below for troubleshooting of the MRU unit.

→ *For troubleshooting the MRU Unit, see section 4.3.11.*

4.3.8 Reduced heave and roll/pitch data indicators

These lights indicate that there are some problems with the MRU. The unit may for some reason be unstable. See the section below for troubleshooting of the MRU unit.

→ *For troubleshooting the MRU Unit, see section 4.3.11.*

4.3.9 Invalid heading indicator

If a gyro compass is not connected to the Processing Unit, the possible problem can be one of the following:

- Check that the antenna baseline setup parameters in GNSS Antenna Configuration in the operator software are properly configured, and if needed, re-measure and perform a new calibration of the antenna baseline.
- The Processing Unit is receiving no data from GNSS receiver no. 1 or 2. That can be verified by checking whether data appear on the **Port Monitor** in the **Tools** menu and by clicking on **GNSSA1** for GNSS antenna number 1 and **GNSSB1** for antenna no. 2. If no data are coming in, check that the cables from GNSS antenna no.1 and 2 are properly connected to the GNSS 1 and GNSS 2 connector on the Processing Unit. Check that the cables for GNSS antenna no. 1 and 2 are not damaged and that the cables are properly terminated in the connectors. Replace both cables if necessary.
- Check that GNSS antenna no. 1 and 2 are functioning properly by dismounting the antennas from the Antenna Bracket and inspecting them. Replace both antennas with new ones if necessary.

If a gyro compass is connected to the Processing Unit, check the items described above, and in addition check that data are coming in from the gyro compass. That can be verified by checking whether data appear on the **Port Monitor** in the operator software, and the communication line the gyro compass data is input on, normally Com9, works properly.

If it is still not working after checking all of the above items, then the GNSS receiver board within the Processing Unit is most likely damaged and the Processing Unit has to be shipped to Kongsberg Seatex for repair.

4.3.10 Reduced heading indicator

The reason for reduced heading performance could be one of the following:

- It may be a problem with the MRU. Check that by troubleshooting the MRU as described in the section below.
- Otherwise if the MRU is functioning OK, check that the antenna baseline setup parameters in the GNSS Antenna Configuration in the operator software are properly configured, and if needed, re-measure and perform a new calibration of the antenna baseline.
- The Processing Unit receives no data from GNSS receiver no. 1 or 2. That can be verified by checking whether data appear on the **Port Monitor** in the **Tools** menu and by clicking on **GNSSA1** for GNSS antenna number 1 and **GNSSB1** for antenna no. 2. If no data are coming in, check that the cables from GNSS antenna no.1 and 2 are properly connected to the GNSS 1 and GNSS 2 connector on the Processing Unit. Check that the cables for GNSS antenna no. 1 and 2 are not damaged and the cables are properly terminated in the connectors. Replace both cables if necessary.
- Check that the two GNSS antennas are of the same type and are mounted in the same orientation. If not, the heading could get unstable and it switches from normal to reduced heading performance frequently.
- Check that the GNSS antenna no. 1 and 2 are functioning properly by dismounting the antennas from the Antenna Bracket and inspecting them. Replace both antennas with new ones if necessary.

If it is still not working after checking all of the above items, then the GNSS receiver board within the Processing Unit is most likely damaged and the Processing Unit has to be shipped to Kongsberg Seatex for repair.

→ For troubleshooting the MRU Unit, see section 4.3.11.

4.3.11 Problems with the MRU

The tool available for troubleshooting the MRU is the **Data Viewer** and the **Port Monitor**. If the heave and roll/pitch indications show invalid "Red", then the Processing Unit most likely does not receive any data from the MRU. Then do the following:

- Check that data is coming in to the MRU connector on the Processing Unit by selecting **MRU** on the **Port Monitor** in the **Tools** menu.
- Check that the cable from the MRU is properly connected to the MRU port on the rear panel of the Processing Unit. Also check that the MRU cable is properly terminated in the junction box and that the fuse in the box is not blown. Replace it if it is.

Note *If the MRU 5 connected to the Seapath has been used in other applications before it is connected to the Seapath, it can take up to 10 minutes before communication between the MRU and the Processing Unit is established. If the MRU 5 has the Seapath configuration downloaded before it is*

connected to the Seapath, the communication is established within a minute or two.

If the heave and roll/pitch indications show reduced "Orange", then the data from the MRU are most likely unstable. Then do the following:

- Check if the Status in the **PPS and time information** window in the **Data Viewer** indicates "Sync". Then the Processing Unit is probably synchronized with GPS and probably also the MRU. In order to be sure, check also the **Time delay information** window in the **Data Viewer**. The time delay shown on the parameter "Raw IMU" should be 0.020 seconds or less. If the time delay is larger than 0.020, then the PPS signal from the Processing Unit is not properly connected. Check that the shield around each pair in the cable between the MRU and the Processing Unit is individually isolated in the MRU terminal. The outer shield is connected to pin 3 (screen) in the MRU terminal, which is an open end (not connected to earth). In the MRU junction box both the shield around each pair and the outer shield are terminated in pin 1 (chassis) on the x3 side.

If it is still not working after checking all of the above items, then the MRU has most likely failed and the MRU has to be shipped to Kongsberg Seatex for repair.

4.3.12 Reduced roll or pitch performance

Reduced roll or pitch performance may occur when:

- The MRU +R arrow is not properly aligned with the vehicle's longitudinal axis. A misalignment of only one degree will reduce the performance when exposed to heavy motions due to cross-coupled roll and pitch measurements. If not already done, ensure that the MRU yaw offset according to the vehicle's longitudinal axis is accurately measured and entered into the MRU configuration.
- It has been several years since the MRU was last calibrated. Contact Kongsberg Seatex to check whether the MRU needs recalibration.
- If DGPS corrections are input to the Seapath and range rate corrections are used, check that these corrections are not noisy. In **NavEngine Configuration** under subfolder **Sensors\GNSS\Processing** it is possible to enable/disable use of range rate corrections. The default configuration is with this functionality disabled. Disabling range rate corrections will reduce velocity and attitude noise when receiving DGNSS corrections from a reference station with noisy range rate.
- Depth errors in the outer beams on a multi-beam echo sounder may occur when:
- The oscillations in the depth of the outer beams are correlated with the pitch angle of the vessel. Check the mounting angle around the Y-axis. The MRU R-axis has to be parallel with the ship's longitudinal axis as long as the sounder transducer is aligned with the ship axes.

- The oscillations in the depth of the outer beams are correlated with the roll angle of the vessel. Check that the lever arm vector from the ship AP to the MRU is input correctly both when it comes to the length and the sign. Check also that the vector from AP to GNSS antenna no. 1 is input correctly both when it comes to the length and sign. Check specially the sign in the vertical direction, which always shall have a negative sign. Look at the background vessel in the **NavEngine Configuration** (part of the operator software) to check whether the arms and vector signs looks correct.

4.3.13 Reduced heave performance

Reduced performance in heave or depth errors in the centre beam of an echo sounder may occur when:

- There are oscillations in the depth of the centre beams. Check that the correct heave filter mode and heave period are selected in the subfolder **Sensors/MRU/Heave config** in the **NavEngine Configuration** (part of the operator software).

Note *Be aware that the Seapath outputs heave measurements in the Navigation Reference Point (NRP), and not in the transducer location, unless the vector from the NRP to the transducer head (Monitoring Point, MP) is entered into the operator software and defined on the output data string. Please note that the horizontal vector components from the NRP to MP are defined positive forward, to starboard and down.*

5 PART LIST

The basic Seapath 320 version (part no. M300-20) consists of:

Part no.	No.	Description
M300-23	1	Seapath 320 Processing Unit including NavEngine software
M320-21	1	Antenna Bracket in aluminium, 2.5-metre baseline
G060-24N	2	Antenna, GPS/GLONASS L1&L2
G071-91	4	Cable, Interconnection, N-M/N-F, 0.5 m
M300-04	1	Seapath HMI Unit (1U) with operator software
G071-28	2	Cable for power, Processing and HMI Unit, 2.5 m
G060-32	1	Monitor, 17" standard LCD, table mount
G062-11	1	Keyboard (US layout)
G062-16	1	PC mouse
MRU-5	1	The MRU 5 sensor
MRU-M-MB3	1	MRU wall mounting bracket
MRU-E-JB1	1	MRU junction box for flexible connection of MRU to Seapath
MRU-E-CS1	1	Cable, heavy duty screened cable with 14 twisted pairs, 3 m
MRU-M-SC1	1	MRU transportation box
M300-72	1	Seapath 320 Product Manuals

The Seapath 320 can be delivered with following optional equipment:

Part no.	Description
G070-01	Cable, GPS antenna, ½" Superflex or similar, length on request
G070-03	Connector kit for GPS antenna cable, ½" Superflex or similar
M310-41	Cable, flexible GPS antenna cable type RG214 Hiflex (max length 40 m)
M310-42	Connector kit for RG214 Hiflex cable
M310-62	Cable, PU to MRU junction box cable, length on request
G062-52	Keyboard with integrated mouse (US layout)
G071-21	Cabinet, height 6U
G071-97	Serial Port Extender, 8-Ports

APPENDIX A LCD DISPLAY AND KEYBOARD

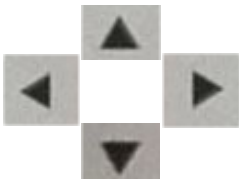
The Processing Unit includes an integrated LCD display and keypad for accessing the internal menu system. Use the menus and screens to review system status.



Figure 68 Integrated display and keypad

Because the display only provides 2 lines of 16 characters, the Processing Unit uses a number of menus and submenus to access the status configuration screens. All available status and configuration screens are described further on in this section.

A.1 Navigation

Button	Name	Function
	Escape	The Escape button shall be used to exit pages without changing the parameter and/or return to the previous menu level/move up one menu level. Hold the Esc button to return to the Home screen.
	Up Left / right Down	The arrow keys are also used for option scroll.
	Enter	The Enter button shall be used to start option scroll and for data entry/selection. Accept/store changes with Enter button.

[▲▶▼◀] Arrow symbols are used in the menu screens to indicate possible navigation direction, see figure below.



Figure 69 Arrow symbols indicate possible navigation direction

A.2 Main menu

The **Main** menu allows contrast and backlight adjustment in addition to displaying all available hardware states.

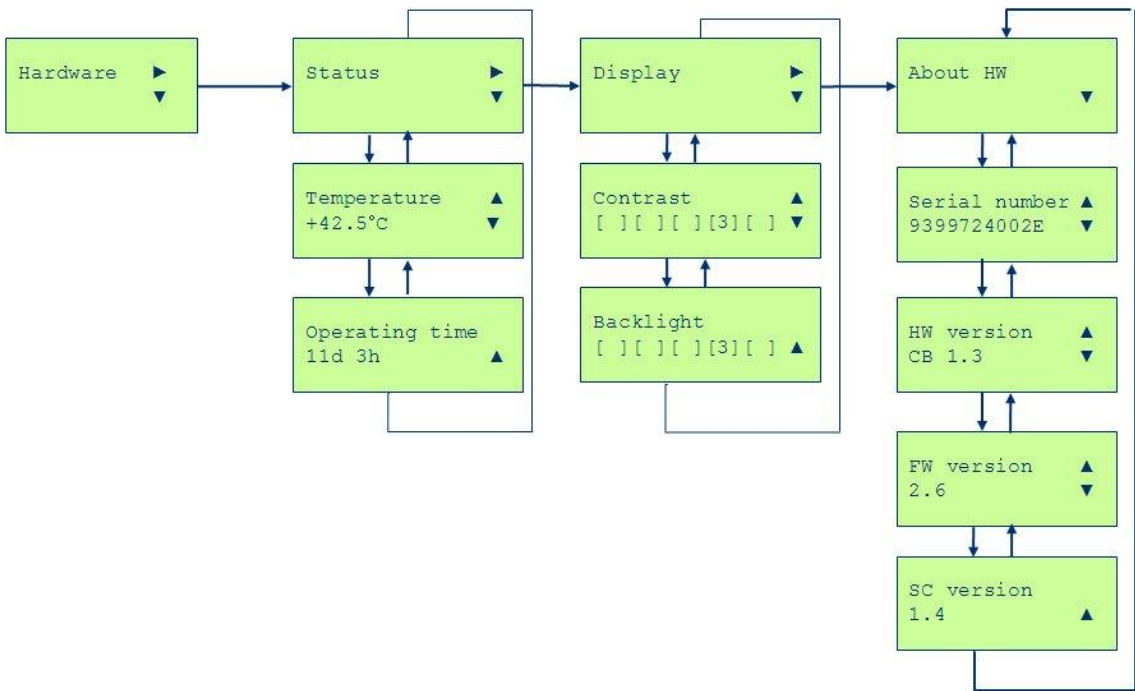
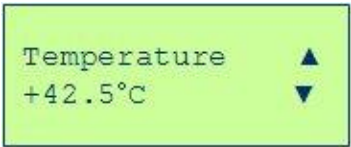


Figure 70 Main menu

Status

Temperature

The temperature inside the Processing Unit.
Normal temperature is 40 – 50 °C when the room temperature is 25 °C.

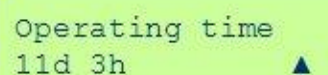


Temperature alarm

If the temperature exceeds 70 °C for more than 1 hour, the left most LED will start to blink.

Operating time

Total time in operation since first power on.



```
Operating time
11d 3h ▲
```

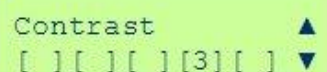
Display

Adjustment of the display contrast and backlight.

Contrast

Display contrast.

Five contrast levels are available. Change the value by pressing the **Enter** button, then use the right and left arrow keys to select the correct level before pressing the **Enter** button again to confirm the selection.



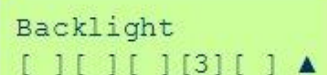
```
Contrast
[ ] [ ] [ ] [3] [ ] ▲▼
```

Backlight

Display backlight.

It is possible to change the intensity of the LEDs and the character display. Five backlight levels are available; 1 %, 3 %, 6 %, 25 % and 60 % of maximum intensity.

Change the value by pressing the **Enter** button, and then use the right and left arrow keys to select the correct level before pressing the **Enter** button again to confirm the selection.



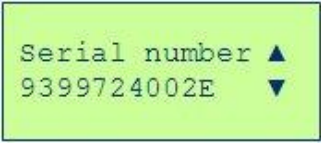
```
Backlight
[ ] [ ] [ ] [3] [ ] ▲
```

About HW

Information about hardware and current firmware versions.

Serial number

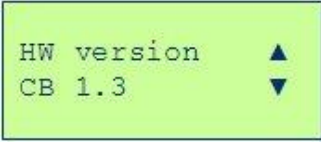
The serial number of the Processing Unit.



```
Serial number ▲  
9399724002E ▼
```

Hardware version

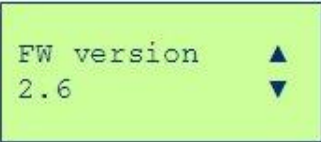
The hardware version of the Processing Unit.



```
HW version ▲  
CB 1.3 ▼
```

Firmware version

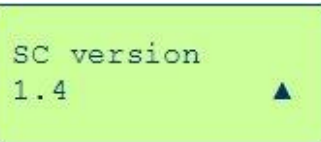
The firmware version of the FPGA.



```
FW version ▲  
2.6 ▼
```

Soft core version

The Soft Core version of the FPGA.



```
SC version ▲  
1.4 ▲
```

INDEX

A

alarm	39, 51
Alarm history view	40
Alarm menu	39
Auto extended zone	56

C

COG	32
Ctrl+F10	39

D

Data Viewer	48
datum	38
DGLONASS	10
DGNSS age view	28
DGNSS Monitor	45
DGNSS status view	28
DGPS	10
DRMS	8

E

ED50	38
EGNOS	12
events	26

F

F10	39
F2	24, 36
F3	24, 36
F5	24, 36
F7	35
F8	35

false easting	56
false northing	56

G

GAGAN	13
GLONASS	9, 27
GPS	8, 27

L

log	49
-----------	----

M

MSAS	13
------------	----

N

NAD27	38
Night mode	35

P

PRN	13
-----------	----

R

recalibration of the MRU	62
restart	59
RTCM stations	46

S

SA 8	
satellite prediction	42
SBAS	11, 27, 47
shutdown	60

sky view 54

Sky view 27

SL 32

SOG 32

ST 32

stop 59

system control 58

System mode 25

T

troubleshooting 66

U

UTM 38, 56

W

WAAS 12

WGS84 38

Z

zone offset 57