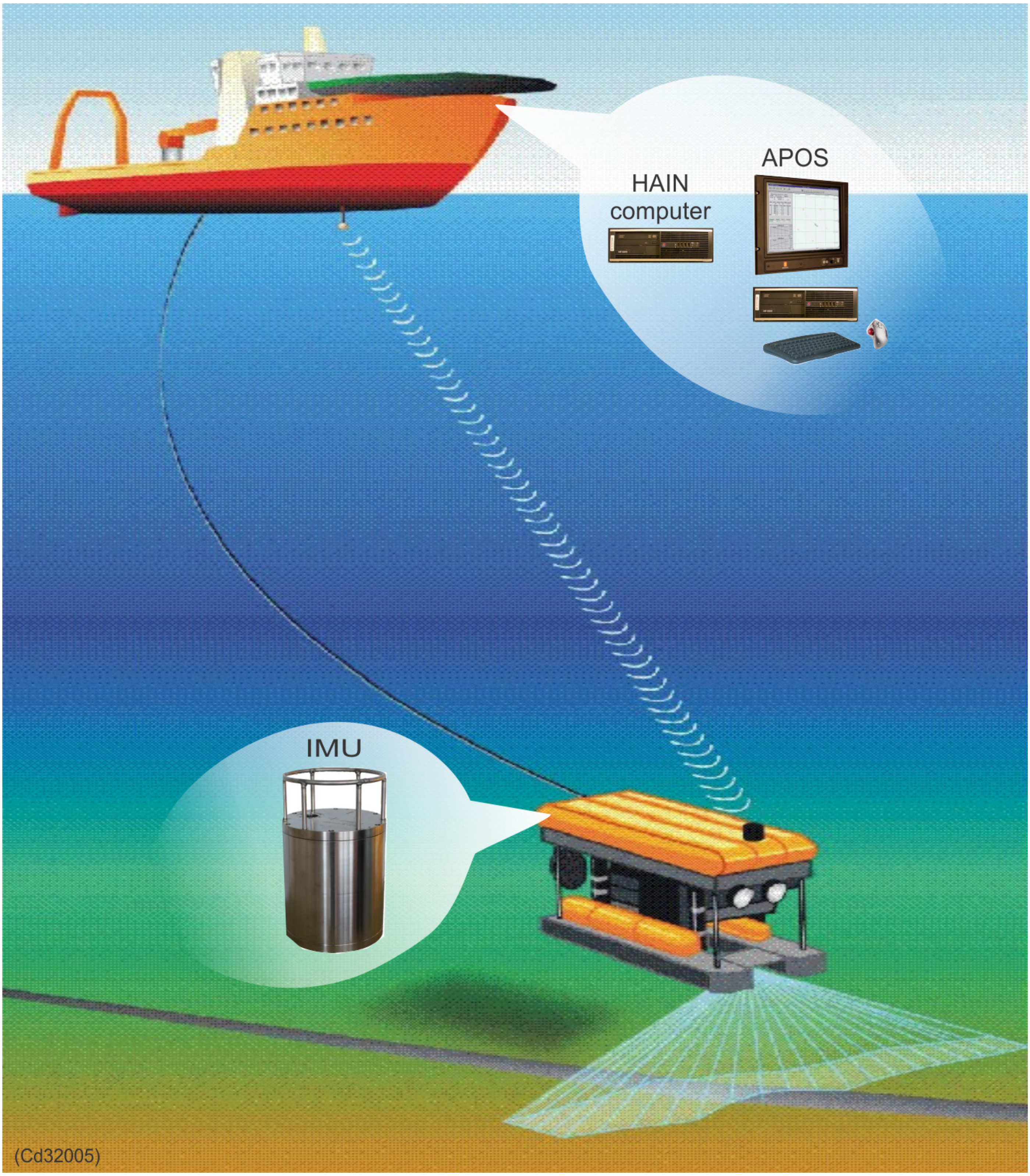
Instruction manual

KONGSBERG

HAIN Subsea
Hydroacoustic Aided Inertial Navigation



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Document history

Rev	Date	Written by	Checked by	Approved by
A	13 February 2012	ABW/IJG	TRE	ABW
	First issue.			
B	03 Sept 2012	ABW	IJG	ABW
	Added comments on HainController.			
C	15 April 2014	ABW	TRE	ABW
	Improved description of sensor biases.			

Disclaimer

Kongsberg Maritime endeavors to ensure that all information in this document is correct and fairly stated, but does not accept liability for any errors or omission.

Warning

The equipment to which this manual applies must only be used for the purpose for which it was designed. Improper use or maintenance may cause damage to the equipment and/or injury to personnel. The user must be familiar with the contents of the appropriate manuals before attempting to operate or work on the equipment. Kongsberg Maritime disclaims any responsibility for damage or injury caused by improper installation, use or maintenance of the equipment.

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Remarks

The reader

The installation information in this manual is intended for the design and installation engineers at the shipyard performing the installation. The information is supplied as the basis for the shipyard's own installation drawings applicable to the vessel. On completion of the installation, this manual must be kept on the vessel for reference purposes during system maintenance.

The operator information in this manual is intended to be used by the system operator. He/she should be experienced in the operation of positioning systems, or should have attended a Kongsberg Maritime training course.

The maintenance information in this manual is intended to be used by a trained maintenance technician or engineer, with experience of electronic and digital circuitry, computers and electromechanical design. The level of information is based on Kongsberg Maritime's maintenance philosophy: The onboard technical personnel shall, with the help of the documentation and the system's built-in test functions, be able to identify malfunctions, locate the fault, and replace major parts, modules and components on the "Line Replaceable Unit" (LRU) level. He/she will however not attempt to repair the LRUs.

HIGH VOLTAGE SAFETY WARNING

The voltages used to power this equipment are potentially lethal. Even 110 volts can kill.

Whenever possible, the following precautionary measures should be taken before any work is carried out inside the equipment:

- Switch off all high-voltage power supplies.
- Check the operation of any door interlocks and any other safety devices.
- Completely discharge all high-voltage capacitors.

It should be noted that interlocks and safety devices are normally located only at regular access points, and high voltages may be exposed during dismantling.

Caution *Never work alone on high-voltage equipment! Refer to general safety procedures.*

Table of contents

1 ABOUT THIS MANUAL

This manual describes the Hydroacoustic Aided Inertial Navigation (HAIN) product.

Abbreviations

Abbreviations used in this manual:

APOS	Acoustic Positioning Operator Station
COS	Common Operator Station
DP	Dynamic Positioning
dGPS	differential Global Positioning System
DVL	Doppler Velocity Log
GPS	Global Positioning System
HAIN	Hydroacoustic Aided Inertial Navigation
HiPAP	High Precision Acoustic Positioning
HPR	Hydroacoustic Position Reference
IMU	Inertial Measurement Unit
INS	Inertial Navigation System
LBL	Long Base Line
MULBL	Multi-User Long Base Line
ROV	Remotely Operated Vehicle
SSBL	Super Short Base Line
SSLBL	Super Short and Long Base Line

2 SYSTEM DESCRIPTION

This chapter gives an overall description of the HAIN Subsea system.

Topics

HAIN computer

The HAIN units consist of a computer without a monitor and the IMU (Inertial measurement unit) installed on a bracket together with a power supply.

The computer executes the navigation algorithm, which consists of Strap-down navigation equations and a Kalman filter. The unit is interfaced with an IMU (Inertial Measurement Unit) and APOS (Acoustic Positioning Operator Station).

The computer receives the aiding positions (latitude/longitude) from the APOS and it limits the position-drift that is inherent in inertial navigation systems. Vessel position, attitude, speed and expected accuracy are sent back to the APOS at 1 Hz update.

Figure 1 HAIN computer

Inertial Measurement Unit - IMU

The IMU consists of three accelerometers and three gyros that measures the vehicle's accelerations and rotation in three axes.

SIU 1

Figure 2 SIU 1

Operator station - APOS

The HAIN system is operated from the APOS and has the following main functions:

- Controls the HAIN system
- Displays position and sends position and status data

The information received from the HAIN computer is displayed and sent to external computer(s). APOS can request status information in the HAIN computer to be displayed which helps the operator to check the system in real-time.

HAIN Subsea system layout

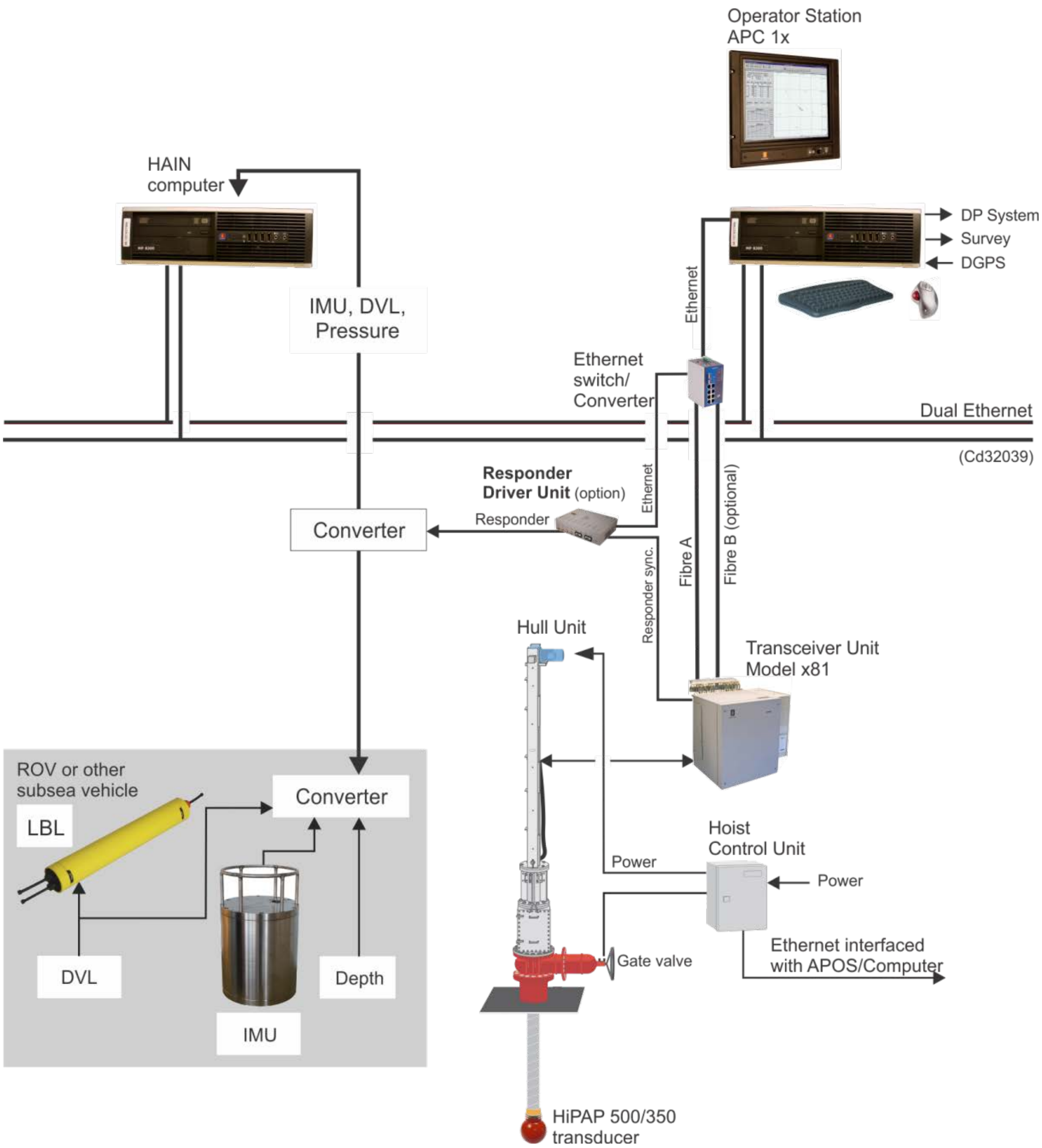


Figure 3 HAIN Subsea system layout

3 INTRODUCTION TO HAIN

Topics

Introduction

The HAIN system is an extension to the High Precision Acoustic Positioning (HiPAP) or Hydroacoustic Position Reference (HPR) systems. HAIN uses acoustic position measurements and inertial navigation to get more precise, accurate, reliable, and frequent position measurements. In addition, HAIN will provide accurate measurements of the vehicle’s velocity and orientation.

HAIN is operated from APOS.

The following two systems are available:

- HAIN Reference
  - Supplying accurate position, orientation and velocity of surface vessels. Typically for vessels running Dynamic Positioning (DP).
- HAIN Subsea
  - Supplying accurate position, orientation and velocity of tethered underwater vehicles. Typically used in survey applications.

Advantages of HAIN

- Increased accuracy
- Increased smoothness
- Increased robustness
- Increased reliability
- Increased update rate

- Positioning during acoustic drop out
- Optimal combination of several sensors’ measurements
- Log of vehicle’s motion

Inertial navigation

The base of inertial navigation is the inertial measurement unit (IMU) which measures the acceleration and angular rate in all three dimensions. This is normally done by having three perpendicular gyroscopes and accelerometers.

Navigation on inertial measurement is based on knowing the initial values of position, orientation, and velocity, and integrating the measurements from the IMU from these initial values. This means:

- Angular rates are integrated to give orientation
- Accelerations are integrated to give velocities
- The calculated velocities are integrated to give position

Drift

The inertial sensors as any other sensor have errors. The integration effectively removes most of the rapid noise, but it also makes the effects of longer term errors increase with time. The errors in inertial navigation system will therefore grow with time. This is usually called drift, as the navigation system slowly drifts off from the correct values. After a while the drift will reach unacceptable levels.

Aiding

The solution to drift is aiding, meaning external sensors that provide input (corrections) to the navigation system. HAIN has support for aiding of the following type of measurements:

- Horizontal position – HiPAP SSBL or LBL
- Vertical position – Depth or pressure sensor
- Heading – Magnetic or gyro compass
- Velocity – DVL

The external measurements are compared to the estimates of the navigation system and the estimates are then updated accordingly. This will in general control the drift.

In HAIN a Kalman Filter is used to make the combination of external measurements and the estimates into an optimal updated estimate.

Acoustic and inertial positioning principles in combination are ideal, since they have complementary qualities. Acoustic positioning is characterised by relatively high and evenly distributed noise and no drift in the position, whilst inertial positioning has very low short-term noise and relatively large drift in the position over time.

Gyrocompassing

The inertial navigation system will gyrocompass, provided that the orientation, latitude and velocity is fairly correct and that the angular rate measurements are of sufficient quality.

For many applications though, the initial orientation is not known and some method of determining the initial orientation. This can be achieved by gyrocompassing, which means using the inertial measurements in a slightly different manner together with some knowledge of velocity and latitude to obtain heading, roll, and pitch estimates. These estimates are then initial values for the navigation system to start with.

HAIN uses another orientation sensor, the IMU’s internal gyrocompassing algorithm, or its own gyrocompassing algorithm for initialization.

Post-processing

The logged HAIN data are very well fit to be post-processed with NavLab. Post-processing of inertial navigation data gives significantly smoother and more accurate estimates. NavLab also allows you to reprocess the data with different settings, should something have gone wrong online. NavLab post-processing is also good for quality assurance and control, and identifying problems.

In addition HAIN calculates HainPP, which are estimates that have been post-processed over a short interval. The latency of this output is the post-processing period. These estimates are smoother and more accurate than those available from HAIN real-time, but due to the shorter post-processing interval, the smoothness and accuracy are not as good as doing a complete post-processing of the entire data set.

→ *See APOS online help for more details.*

4 TECHNICAL SPECIFICATION

This chapter lists the main technical specification for the HAIN units.

Topics

HAIN computer

The HAIN computer is the same computer that is used for the HiPAP system.

Weight:	7.6 kg
Dimensions (WxDxH):	338 x 379 x 100 mm

Power specifications

Voltage:	110/220 VAC 50/60 Hz autosensing 240 W 85+ autosensing power

Connections

Parallel port:	1 x HP Parallel Port Adapter
Serial port:	COM1 8 port Bluestorm card
USB:	8 x USB 2.0
VGA:	1 x VGA – implemented on motherboard
Display port:	1 x Display port – implemented on motherboard Display port adapter (HP Display port to DVI-D Adapter)

Audio:	1 x Audio in 1 x Audio out Integrated High Definition audio with AD1884 codec
Others:	2 x PS2 1 x Headphone/line-out 1 x Microphone in

HAIN computer connections

All connections to and from the computer are made on the rear of the unit.

- A: VHDC1-68 connector, PORT 1 to 8 for serial line cable (split cable; W-U010a,… W-U010h).
- Ethernet connectors for NET A and Net B
- Ethernet connector - connection to the transceiver unit
- USB ports
- B: HDMI connector to display
- D: VGA connector for display
- Trackball (mouse)
- Keyboard PS/2 style connector
- C: Power input

The computer rear panel may look like the following figure:

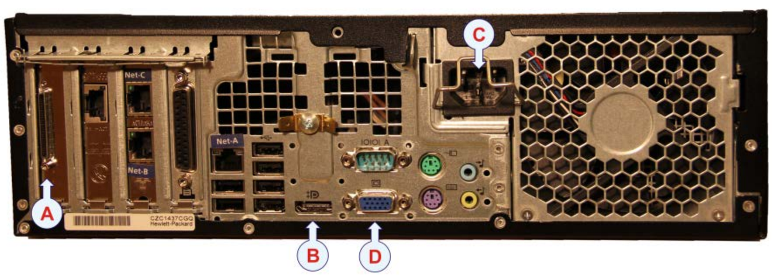


Figure 4 Computer rear panel

IMU

HAIN Subsea may use different types of IMUs. They could be both Kongsberg Maritime and third-party products. For accurate and up-to-date information on the others, see the manual accompanying the product. Specifications of Kongsberg Maritime housing of IMU 90 is shown in Appendix.

Currently HAIN Subsea supports these IMUs

- SIU 1 Kongsberg Maritime
- IMU120 IXSEA
- IMU90 IXSEA/(Kongsberg Maritime)
- Orion TSS
- HG9848 Honeywell
- HG1700 Honeywell
- Mini-RLG2 CDL
- Mini-POS2 CDL

SIU 1

Weight in air:	Approx. 30 kg
Weight in water:	Approx. 17 kg

→ *Outline dimensions – see drawings in Drawing file on page 67*

Degree of Protection	IP68
Operation depth:	4000 m
Housing material:	Titanium

DVL

This is a third-party product. See the accompanying manual. HAIN Subsea supports input from DVLs on Teledyne RDI’s telegrams PD0 and PD3.

Pressure sensor

This is a third-party product. See the accompanying manual. HAIN Subsea supports Digiquartz and Winson pressure/depth inputs.

5 MECHANICAL INSTALLATION

This chapter includes the basic information required to install the HAIN units.

Topics

→ *IMU on page 17*

→ *DVL on page 18*

→ *Depth/Pressure sensor on page 20*

→ *HAIN Computer on page 20*

Related topics

→ *Equipment handling on page 54*

→ *Drawings in the Drawing file chapter from page 65*

IMU

For further details see the product's accompanying manual.

Unit location

The unit should be placed on a rigid frame, which also holds the other aiding sensors, and any type of equipment the HAIN outputs are used with, such as multibeam echosounders, sonars, cameras etc.

Lever arm

The performance of the HAIN system is affected by how accurate the physical position of the IMU reference point relative to the vessel reference point (datum) is entered in the HAIN configuration in APOS. The position must be measured forward/aft, starboard/port and up/down

Caution — *The error of measured IMU location must be less than 5 % of expected output accuracy to be negligible.*

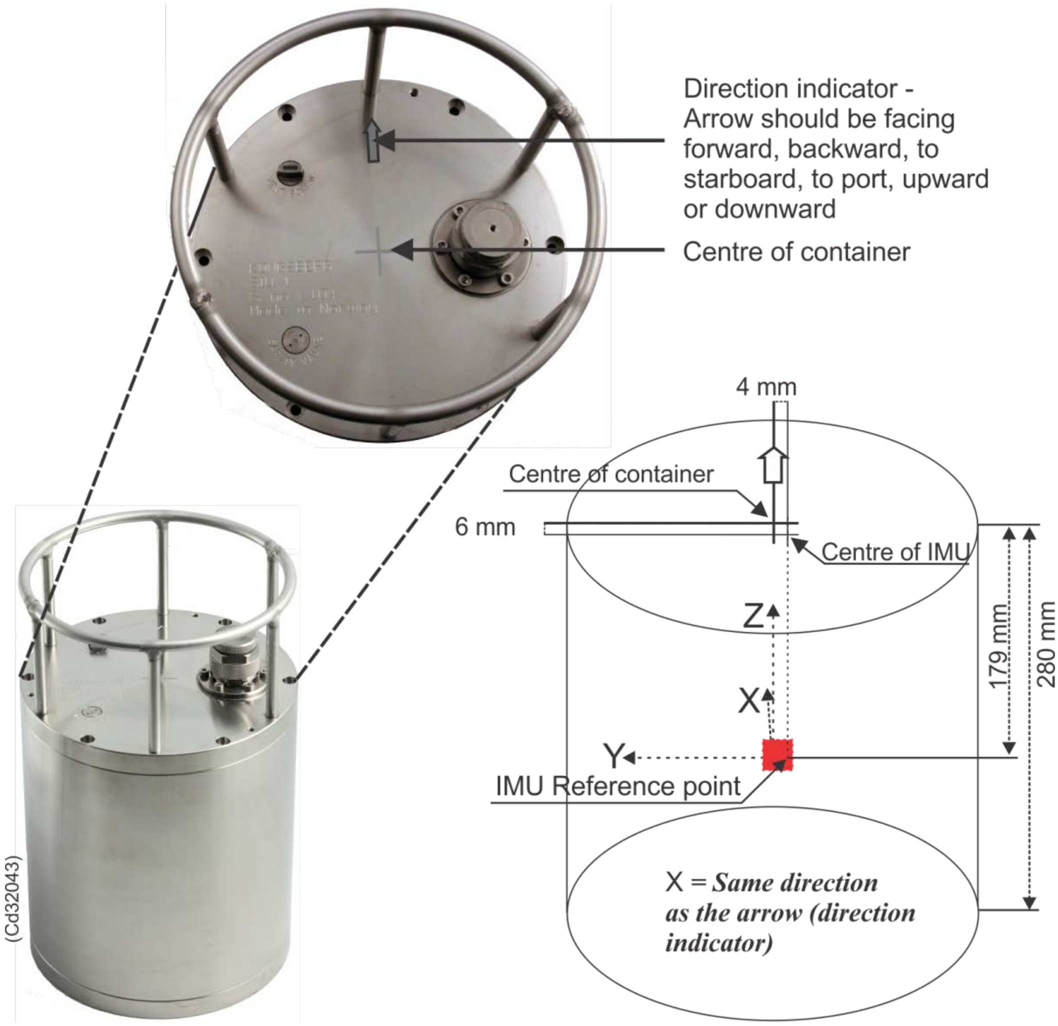


Figure 5 SIU 1 Reference point

DVL

This section gives information on what is important for integration of DVL into HAIN. For information on what is important to get the best performance of the DVL and how to install it, see its accompanying manual.

It is important that the connection between DVL and IMU are rigid, meaning they should be mounted on the same fixed structure.

Location

In general best performance is achieved if the DVL and IMU are mounted close to each other. In most situations good performance is also achieved when they are mounted a meter or two apart.

Lever arm

The performance of the HAIN system is affected by how accurate the physical position of the DVL's reference point relative to the vessel reference point (datum) is entered in the HAIN configuration in APOS. The position must be measured forward/aft, starboard/port and up/down.

Calibration (including alignment)

After installation a proper DVL calibration should be performed.

Calibration is best performed with NavLab. Kongsberg Maritime can, at an extra charge, perform the actual calibration calculations. This service requires that you have already performed a calibration run of HAIN data.

In order to get the best DVL calibration the calibration run should have:

- 20-30 minutes or more of data,
- DVL bottom track always,
- well performing aiding sensors (such as pressure sensor and dGPS-HiPAP and DVL),
- frequent changes in velocity,
- include motion in all directions (up-down, port-starboard, forward-aft),
- include turns and rotations,
- include a figure-8.

However, a proper calibration can most often be achieved by using a regular survey run.

A new calibration should be performed whenever the IMU or DVL is dismounted and re-mounted.

During post-processing increased performance can often be achieved by performing a DVL calibration on the data set before processing it for output.

Depth / pressure sensor

This section gives information on what is important for integration of the pressure sensor into HAIN. For information on what is important to get the best performance of the pressure sensor and how to install it, see its accompanying manual.

It is important that the connection between DVL and IMU are rigid, meaning they should be mounted on the same fixed structure.

Location

The location of the pressure sensor is not important for HAIN performance, if it is well known.

Lever arm

The performance of the HAIN system is affected by how accurate the physical position of the pressure sensor's reference point relative to the vessel reference point (datum) is entered in the HAIN configuration in APOS. The position must be measured forward/aft, starboard/port and up/down.

HAIN Computer

The HAIN computer is supplied without a monitor and a keyboard.

Unit location

The HAIN computer must be easily accessible during operation of the system.

Logistics

Safety - Refer to the safety warning in the front of this manual.

Personnel - Minimum 2 trained mechanical/electrical fitters.

Special tools - None.

19" rack installation

The HAIN computer can be supplied with a rail kit for rack mounting.

Procedure

1. Mount the rails and brackets onto the unit. Use the bolts and washers provided.
2. Follow the procedure provided by the rack manufacturer and mount the unit into the rack.
3. Connect the cables.

Desktop installation

The HAIN computer must be placed on a suitable desk or shelf and secured in position using the mounting brackets provided.

- Ensure that the desk/shelf is strong enough to support the weight of the unit(s).
- Check that you can operate the system comfortably before securing the unit(s) in position.

6 SOFTWARE SET-UP

Topics

HAIN Computer

The HAIN SW is installed by running the installation file. Follow the on-screen wizard.

APOS

Install and start the HAIN computer before you start to set-up HAIN in APOS.

You need to be logged in as user service to create the HAIN object in APOS.

→ *See the APOS online help for details about how to perform this.*

It is important that you get the parameters in the “HAIN properties” in APOS correct.

The HAIN properties can also be controlled locally on the HAIN computer by the HainController application: \HAIN\Bin\HainController.exe.

HAIN Clock synchronization

All measurements are time stamped by the computer reading the measurements.

- The acoustic positions are time stamped by the APOS/HiPAP system.

- The GPS positions are time stamped by the GPS.
- The HAIN sensor readings are time stamped by the HAIN computer.

The timestamp information is fully exploited in the calculations.

APOS transmits the position aid to the HAIN computer with the timestamp based on the clock in the APOS. It also adds an age parameter in the telegram, telling how old the position aid measurement is. The HAIN computer subtracts the age from its clock, and thereby gets a timestamp with the HAIN computer clock. The other measurements are read by the HAIN computer and time stamped with the HAIN computer clock. It is therefore irrelevant whether or not computer clocks involved are synchronized.

HAIN installation and NTP

The HAIN installation wizard asks the operator if the NTP program shall be started together with the HAIN programs. Tick the radio button **Start NTP (Network Time Synchronization)** in the wizard if it shall be started, and **No NTP** if it shall not be started.

In the first case the NTP program will be started before the HAIN programs are started. This requires that the ntp.conf file is set up properly (see separate subsection). NTP may be started for HAIN Subsea installations, although Kongsberg does not recommend it. Kongsberg recommends that the clock in the HAIN computer is free running and that the timestamps are corrected in the post-processing, as described in the NavLab User Guide, doc. no 165152 version e and newer

In the latter case the HAIN clock will be free-running.

Crude clock synchronization

The NTP works best when it fine-adjusts the clock in the HAIN computer. It does so by just tuning the clock frequency, which causes no discontinuity in the timestamp of the IMU measurements. NTP may wait long before it sets the client clock to a new value.

The operator at the HAIN computer may set the clock in the HAIN computer approximately equal to the APOS clock.
This is done by:

1 Right-click the HAIN icon.

2 Click the Synchronize Time command.

- The event view on the APOS shows how the HAIN computer clock is adjusted.

The crude clock synchronization cannot be done when the HAIN positioning is active.

NTP for HAIN subsea

NTP is Network Time Protocol. APOS and the HAIN computer may use NTP to synchronize their clocks.

NTP in the APOS is the time server, and the NTP in the HAIN computer is a time client. If two or more APOS computers are connected in a Master/Slave configuration, the NTP in one of them must be the time server, and the other(s) must be time client(s).

The APOS operator stations are often clock synchronized with other Kongsberg Maritime computers (as the DP computers) on the vessel. This is done with the OSKTimeSynch program. This program must be stopped on the APOS(es) that are NTP clients. It shall execute on the APOS time server with the 1 PPS and ZDA connected, in order to synchronize the other Kongsberg Maritime computers. If, however, one of the DP computers in the network also is synchronized to the GPS clock, the OSK time synch in the APOS with the NTP server should be stopped.

The NTP is configured by the ntp.conf file. Each computer running NTP has a ntp.conf file. One computer is configured as a NTP time server. All other NTP units are configured as time clients. The IP address of the time server has to be entered in the ntp.conf file of the time clients.

When the system is switched on, we normally recommend starting the NTP server first and letting it run for some time. Then the clients can be started. They will normally synchronize time to the server within 10 - 15 minutes. The accuracy of the time synchronization will improve over time. Our observation is that after 24 hours, the time difference between computers is below 10 milliseconds. It is important that the time is relative similar on the computers to be synchronized before NTP is started.

Note *As default, NTP will not synchronize time, if time difference is more than 1000 seconds.*

You may also check that the computer time zone is set correct. NTP synchronizes on the computer UTC time.

ntp.conf

The lines in the ntp.conf starting with # are just comments. Before you start the system, you must check/edit the line starting with server followed by an IP address. There are three different IP-addresses to use.

IP address line	Used when
server 127.127.1.0	The computer is the time server.
server 127.127.28.2 prefer	The computer is the time server, and it is synchronized with the GPS receiver. This line shall be set in addition to the time server line in the previous row.
server nnn.nnn.nnn.nnn	The computer is a NTP client. nnn.nnn.nnn.nnn is the IP address of the time server.

- In the APOS, the ntp.conf is located in the APOS\bin folder.
- In the HAIN computer, the ntp.conf is located in the HAIN\bin folder.

NTP is a often used standard for clock synchronization.

→ *See http://www.ntp.org/ for more information.*

Example of time synchronisation Master ntp.config

```
# NTP configuration file (ntp.conf)
# for APOS
# server 157.237.11.192 # Change to match your server IP address (APOS computer)
server 127.127.28.2 prefer shared memory clock driver. Use this for IoServer!!!
server 127.127.1.0 # local clock driver. Use always when master!!
# multicastclient  224.237.1.1
```

Example of Slave ntp.config

```
# NTP configuration file (ntp.conf)
# for APOS
server 157.237.11.192 # set IP time synchronisation Master
# server 127.127.28.2 prefer
# shared memory clock driver. Use this for IoServer!!!
# server 127.127.1.0 # local clock driver. Use alway when master!!
```

multicastclient 224.237.1.1

NTP display

The NTP writes information to its DOS command window. The command window on the NTP client shows the difference between the client clock and the server clock, as decided by the NTP. An example is shown in the

Figure 6 on page 26.

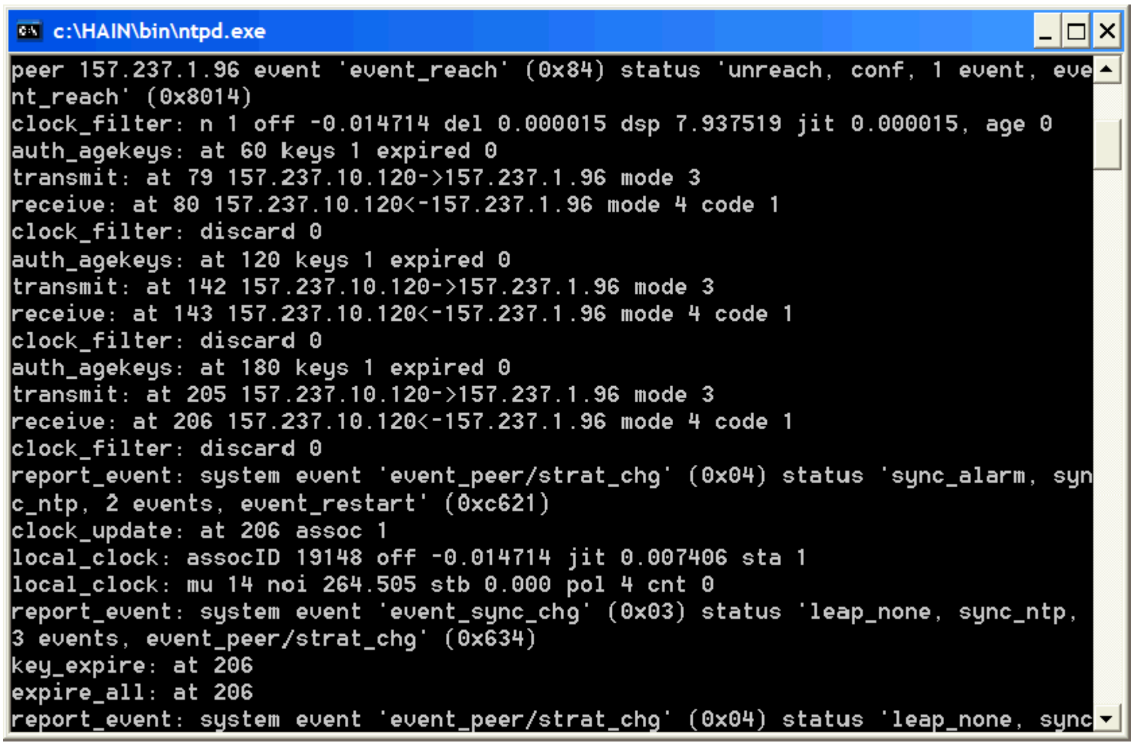


Figure 6 NTP Display

The NTP client has IP address 157.237.10.120. You can see that there is a two-way communication with the time server running at 157.237.1.96. Check that there is a similar two-way communication on your HAIN computer.

The NTP client decides that there is a difference of 14.7 ms between itself and the time server as seen after the *off* in the screen above.. The NTP client will minimize this difference by adjusting its clock frequency.

GPS UTC

HAIN subsea with the acoustic aiding positions derived from SSBL, depends on the GPS readings, because it combines the GPS positions and the SSBL positions to calculate the position aid in latitude longitude. Then the clocks in the APOS must be synchronized with the UTC in the GPS receiver. This synchronization requires both a time sentence (ZDA, UTC or similar) and a 1PPS from the GPS receiver to the APOS. APOS handles this via an IoServer.

→ *See APOS online help for information about this synchronization.*

The APOS that is synchronized with the GPS must execute the NTP time server. The APOS IoServer communicates with the NTP server via shared memory. The NTP must be started before the IoServer. This is automatically taken care of by the APOS. When the APOS has the HAIN option set, it starts the NTP program before it starts the IoServer.

The APOS starts the NTP server regardless of the HAIN computer shall be clock synchronized with the APOS or not.

The serial port used can be either an RS 232 or an RS 422. The 1 PPS pulse should be connected to the CTS (Clear To Send) input on the port. However in both cases the 1 PPS pulse must be compliant with the RS232 or RS422 signal levels. The following table describes the pin numbers used on the port.

RS 232 Function	Pin No
Rx	2
Gnd.	5
CTS	8

RS 422 Function	Pin No
Rx +	1
Rx -	4
Gnd.	5
CTS +	9
CTS -	6

IMU

See the sensors own manual for details on how to set up.

Configuration

See the product's accompanying manual how to configure this.

For serial IMUs it is advantageous to use RS-422 over RS-232 if possible.

HAIN require the following inputs from the different types of IMUs.

IMU	Type	Datarate Hz	Parity	Databits	Stopbits	Baudrate kbs
SIU 1	ethernet	300	-			-
IMU120	serial	100	N	8	1	115200
IMU90	serial	100	N	8	1	115200
Orion	serial	100	O	8	1	115200
HG1700	serial	100	N	8	1	115200
MiniRLG2/ MiniPOS2	serial	100	O	8	1	115200
HG1700 HG9848 HG9900	SDLC					

IMU90 in Kongsberg Maritime's housing

We recommend the configuration of the IMU90 serial ports as shown in the table:

Com port	Configured for
A	Tx: IMU raw measurements,
B	Tx: Simrad EM3000 telegram with the Octans heading and attitude. Rx: The gga sentence with latitude.
C	

Enabling HAIN output in MiniPOS / MiniRLG

CDL delivers a combined MiniPos and MiniRLG unit. It must be programmed to operate either as a MiniPos or as a MiniRLG.

To operate as a MiniRLG, you must:

- Turn the Fast Test messages "on".

To operate as a MiniPos, you must:

- Turn the Fast Test messages "off".
- Slow Test messages "on".

The procedure to turn these messages "on" and "off" is given below. Beware that, depending on the firmware of the unit the menus may look differently than depicted here, hence also the options to choose may be different.

1 Access the RLG via a terminal program.

2 Hit <Esc> to enter the menu system

3 Hold down the Alt key and press '241' (these have to be on the number keypad – on a laptop use the function key for these numbers).

- This gives you access to CDL's hidden menu system.

4 Choose 3 – "Config gyro" (Figure 7).

5 Choose 2 – "Config Boresight angles, alignment time and test messages" (Figure 8).

6 Set option 5 to "True". (Figure 9).

7 Up one menu level - backspace. (Figure 10).

8 Choose 5 – "Update RLG" (Figure 8)

9 Select Option 7 to update RLG eeprom

10 Wait a few seconds then power cycle the unit.

```
**************** Ser No 02164 ******************
* CDL RLG2 Firmware Rev 3.12 - RLG mode = 0x09 *
************************************************

MiniRLG Menu
============
1       Config Port 1
2       Config Port 2
3       Config Gyro
4       (Re)start Alignment
5       Set Latitude ... +59.99999999
6       Config Aux 1
7       Config Aux 2
8       Reset factory defaults
9       Configuration Dump
BkSp    Up one menu level
Esc     Main Menu
X       Exit Menu and Save
Q       Quit Without Saving
```

Figure 7 MiniRLG menu

```
MiniRLG Config RLG Menu
======================
1       Config Alignment
2       Config Boresight Angles, Alignment Time and Test Messages
3       Config GPS Lever Arm
4       Config DVL Lever Arm
5       Update RLG
BkSp    Up one menu level
Esc     Main Menu
X       Exit Menu and Save
Q       Quit Without Saving

Info ... when all changes have been made to Boresight and GPS/DVL Lever Arm
select Update RLG to save the settings and power cycle the RLG. The new
settings to take effect when the RLG starts up again.
```

Figure 8 MiniRLG Config RLG Menu

```
MiniRLG Config Boresight Menu
=============================
1       Roll Angle ... +0.0000
2       Pitch Angle ... +0.0000
3       Azimuth Angle ... +0.0000
4       Set Alignment Time ... 10 mins
5       Enable Fast Test Messages ... False
6       Enable Slow Test Messages ... True
BkSp    Up one menu level
Esc     Main Menu
X       Exit Menu and Save
Q       Quit Without Saving
```

Figure 9 MiniRLG Config Boresight Menu

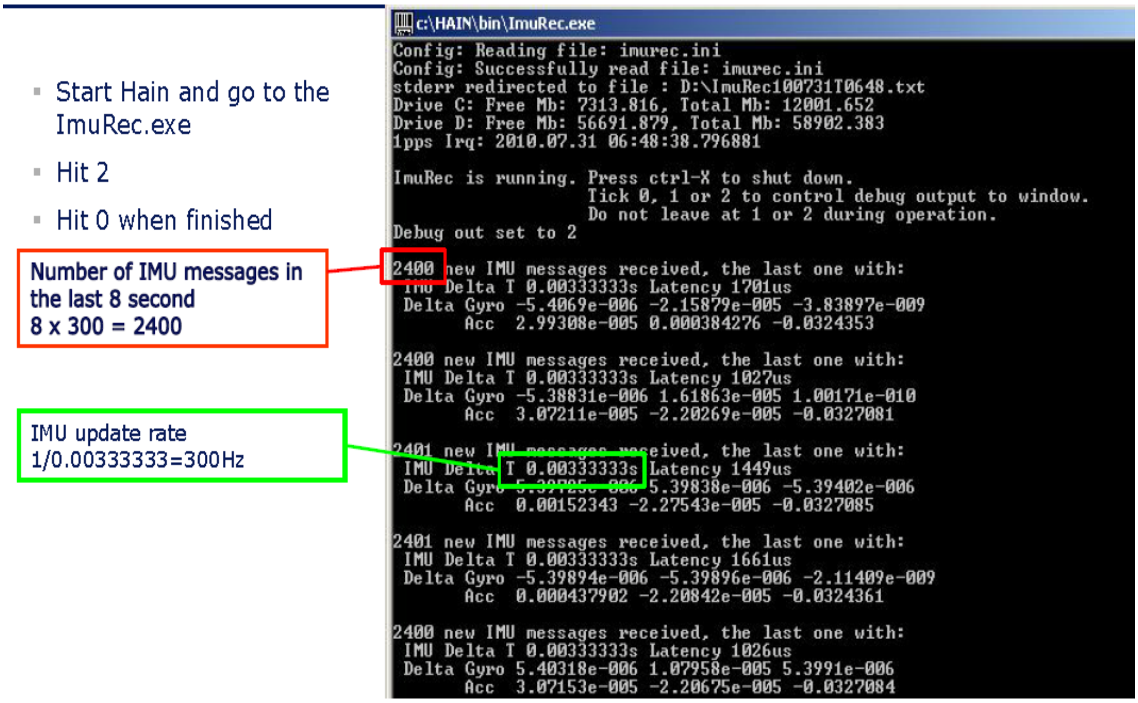
```
MiniRLG Config Boresight Menu
=============================
1       Roll Angle ... +0.0000
2       Pitch Angle ... +0.0000
3       Azimuth Angle ... +0.0000
4       Set Alignment Time ... 10 mins
5       Enable Fast Test Messages ... True
6       Enable Slow Test Messages ... False
BkSp    Up one menu level
Esc     Main Menu
X       Exit Menu and Save
Q       Quit Without Saving
```

Figure 10 MiniRLG Config Boresight Menu - test messages true

Testing

If computer is running with ImuRec.exe, you can examine the ImuRec.exe window. This is typically the case when running HAIN with gyrocompassing.

1 Open the ImuRec.exe window on the HAIN computer and press to in order to see debug output.



The configuration of IMU and cabling can be tested using the IMU test programs on the HAIN computer, located in \HAIN\Bin\.

2 Close any open HAIN programs before running the test programs.

3 Open the program and select the appropriate serial port.

- If the HAIN computer is able to receive on that port you will see what it is receiving in the window.
- If the computer is unable to receive the IMU messages you will see no changes in the window.

IMU	Program
SIU 1	See manual
IMU120	-
IMU90	ImuTestSerial.exe
Orion	ImuTestTssorion.exe
HG1700	-
MiniRLG2/ MiniPOS2	ImuTestRLG.exe
HG1700 HG9848 HG9900	ImuTest9900.exe

Figure 11 Example of RLG Test

Ensure that there are no “Missing msg” as this could indicate multiplexer problems on the ROV

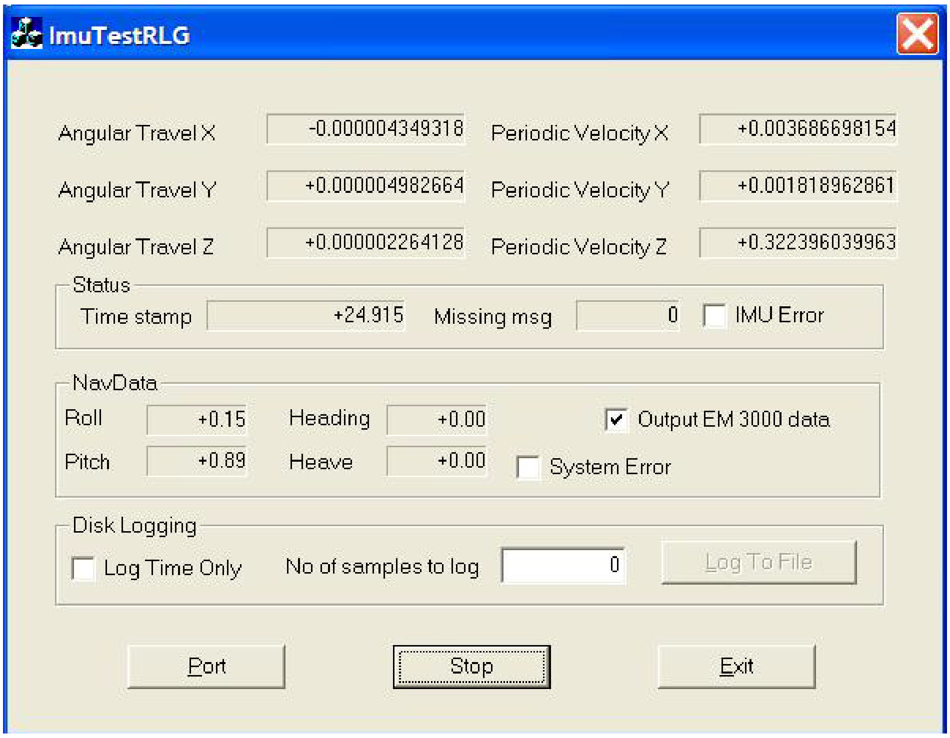


Figure 12 ImuTestRLG

DVL

→ *See the sensors own manual for details on how to set up.*

Configuration

- RS232/422
- PD0 or PD3 (RDI Workhorse Navigator)[1]
- Up to 57600 baud

The DVL is usually configured by the customer or by the surveyors. The DVL readings are often used by both the HAIN system and other systems onboard. HAIN does not configure the DVL, but the operator must know the DVL setup in order to set the HAIN parameters correctly.

Sometimes the HAIN engineer must configure the DVL. The following commands/settings were given to the RDI DVL 600 kHz Workhorse. The RDI Self Contained ADCP Application terminal program was used.
The settings below are just an example:

1	CR1	Reset to factory settings
2	EA00000	No alignment values inserted.
3	EP00000	
4	ER00000	
5	BP1	1 ping per ensemble
6	BK0	water mass off
7	CF11110	
8	EX10011	
9	ST0	
10	ECxxxx	Sound velocity at seabed area. Value in m/s.
11	EZ0000000	Clears bit (6), DVL not to calc speed of sound
12	(BM 7	For 1200KHz only tracking down to 20cm)
13	PD0	Output telegram
14	CS	Start continuous output
15	CK	Save setup in non-volatile memory

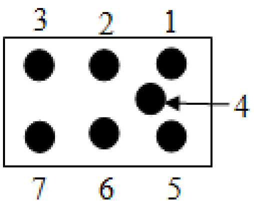
The EA, ER and EP all have 00000 as parameter, because we do all the rotations in the HAIN. The EX command allows 3-beam solution.

1 HAIN will automatically adapt to the supplied format.

The c bit in the EZ command is zero, telling the DVL to use the manually set sound of speed. If either the DVL has a depth sensor or the depth is sent continuously to it, the bits in EZ should be set and the DVL will calculate the speed of sound.

→ *Refer to the RDI manual for details.*

Doppler



Pin	Function
1	RS232 in
2	RS232 out
3	+24 V
4	0 V RS232
5	422 + (trigger)
6	422 - (trigger)
7	0 V

Looking into whip;
Type 9 pin impulse LPMIL-7-FS

Figure 13 Teledyne RDI Workhorse navigator pin-outs

Note *Use the commands above just as an example.*

Testing

During operation observe that the DVL light in the APOS Position Status view is green.

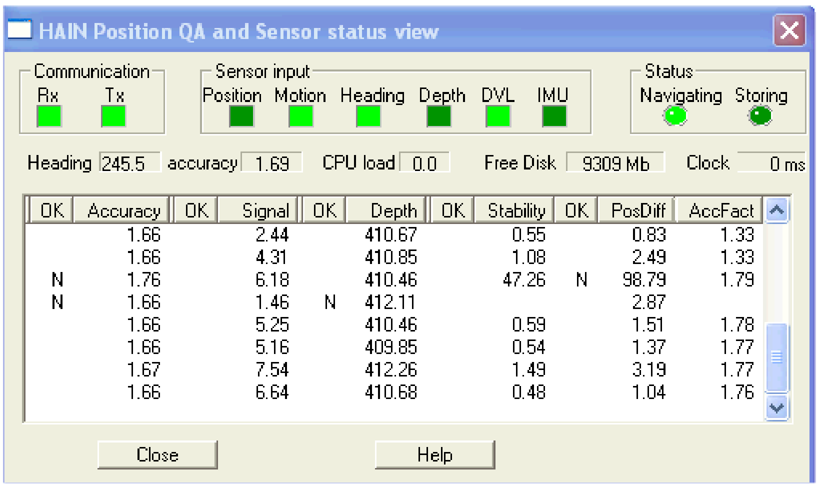
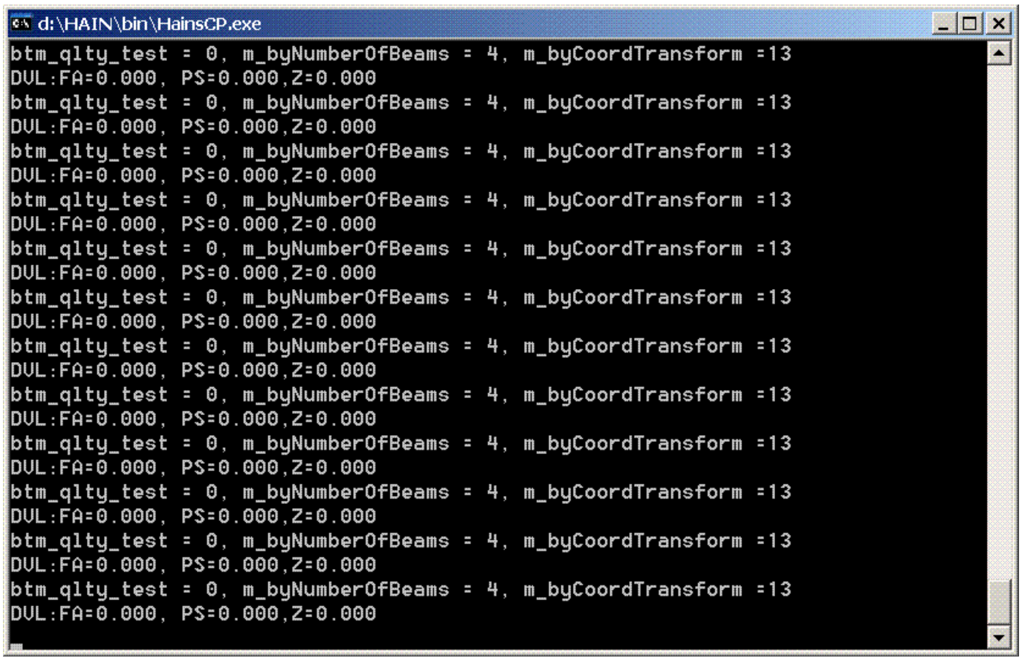


Figure 14 Position Status View

If Debug is ticked in the HAIN Properties/HainController → Advanced

In the HainCP window with the ROV on deck FA (Fore Aft) PS (Port Starboard) and Z should all read zero.




```
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
btm_qlty_test = 0, m_byNumberOfBeams = 4, m_byCoordTransform =13
DVL:FA=0.000, PS=0.000,Z=0.000
```

Figure 15 Example of DVL debug output

Depth / pressure sensor

See the sensors own manual for details on how to set up.

It is also possible to have the acoustic positioning provide depth, but this is generally a lot less accurate than a pressure sensor. This is available directly from APOS with no extra set up.

Configuration

- RS232/422
- Available formats
  - Winson raw
  - Digiquartz standard format
- Up to 57600 baud

The depth value in the Winson raw telegram may be either the depth in mm or the pressure in psi * 100000. The HAIN decoding is decided by the SeaKingProtocol parameter in HainConfig.ini. The pressure is converted to bar using the Pressure to bar factor in the APOS HAIN Properties/HainController dialog.

The Digiquartz telegrams start with *00nn followed by the pressure. The pressure is converted to bar using the Pressure to bar factor in the APOS HAIN Properties/HainController dialog.

Testing

During operation observe that the Depth light in the APOS Position Status view is green.

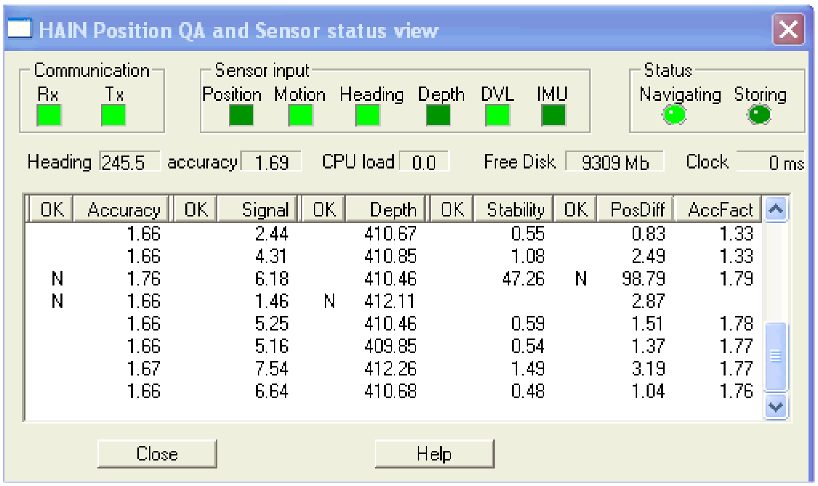


Figure 16 Position Status View

If Debug is ticked in the HAIN Properties/HainController > Advanced

In the HainCP window with the below is for the standard digiquarz

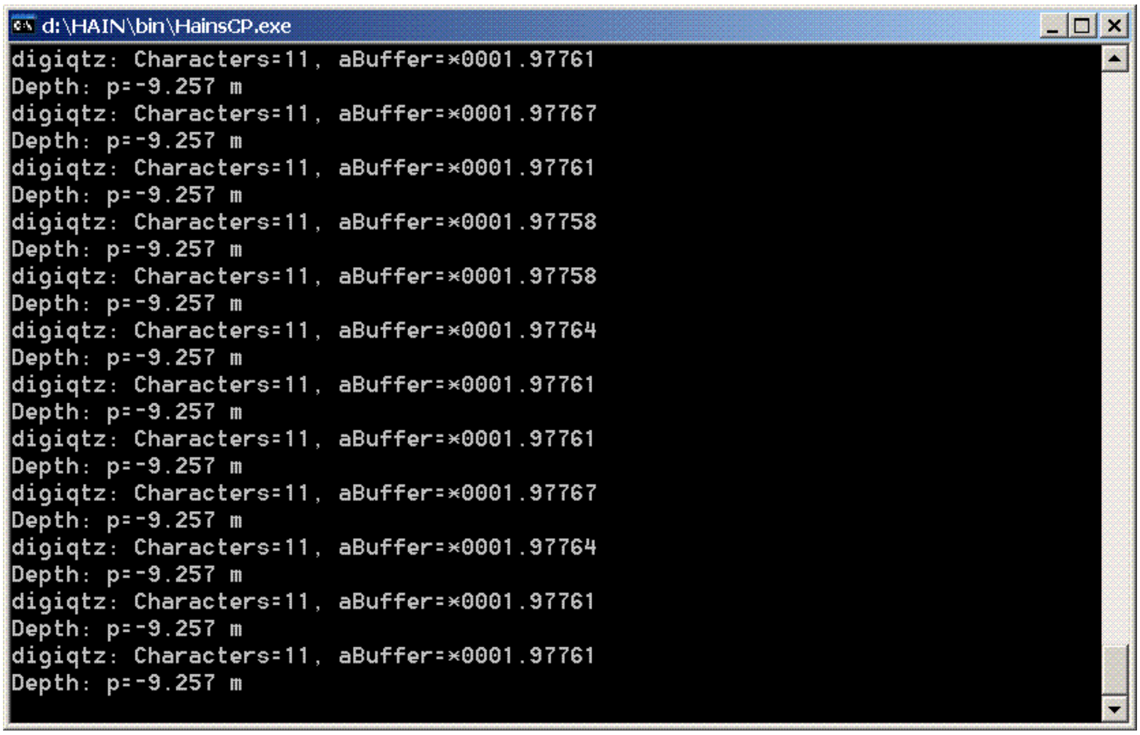


Figure 17 Pressure sensor debug output

HyperTerminal and depth

Winson Raw should look like below:

```
%D0074042701-
102000009777682+003300003023926000235361 7+000003739
9+009413486214885+0000000000055+000005731917232202
```

Motion and heading sensor

Motion and Heading sensor is normally an integral part of the IMU.

→ *See the sensors own manual for details on how to set up.*

Configuration

- RS232/422
- Available formats
  - Octans std
  - Simrad EM3000
- Up to 57600 baud

Testing

No testing possible to see if this sensor is providing correct input to HAIN. The only test is during operation observe that the Depth light in the APOS Position Status view is green.

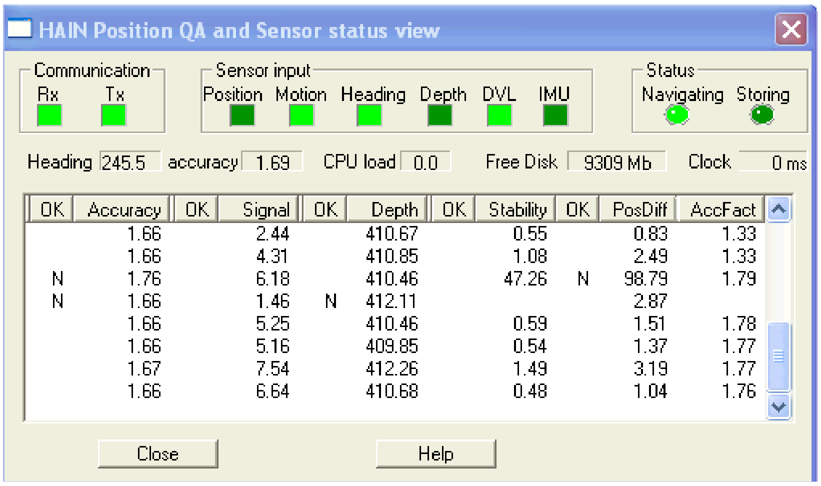


Figure 18 Position Status View

Outputs

→ *See APOS on-line help on how to configure traditional APOS outputs (NMEA, BCD, etc) based on HAIN.*

In addition HAIN has the outputs described in this section going directly from the HAIN computer.

Simrad EM3000

This is output of heading, roll, pitch and heave on serial line or UDP port. This is controlled from the HAIN Properties/HainController.

→ *See the APOS/HainController online help for details.*

This can be both based on all sensory input or just the raw IMU data (gyrocompassing).

This is generally used for roll-pitch-heading compensation of acoustic instruments such as HiPAP, MBE etc.

UDPNavDataOut

This is output of HAIN navigation data and estimated accuracies on a proprietary Kongsberg Maritime format. The data are sent as UDP messages. This is set up by manually editing the HAIN configuration files on the HAIN computer.

→ *See page 74 for details on the format.*

UDPNavDataOut is controlled by config.ini and specifically the section.

```
[UDPNavDataOut]
TxPort          = 0
IpAddress       = 127.0.0.1
AdapterAddress  = 127.0.0.1
Decimation      = 4
```

- If this section is missing in the running config.ini or the TxPort is set to 0, the output is turned off.

TxPort	- The UDP port to output on
IpAddress	- The IP-address to transmit to
AdapterADdress	- The IP-address of the network card sending
Decimation	- # of IMU-samples per output

- If decimation is set to 4 on 100 Hz IMU, UDPNavDataOut is transmitted at 25 Hz, meaning every fourth IMU sample.

1 You set it up by editing both the \HAIN\DefaultIni\config.ini and the \HAIN\Bin\config.ini on the HAIN computer.

2 This is done by double-clicking the files.

- If the above section is not present in the files you can add it, otherwise change it according to the requirements at hand.

7 OPERATION

Topics

Note *The dialog boxes and their details change when new SW releases are delivered. The APOS online help is always up-to-date.*

General

APOS is the operator station for the HAIN. The philosophy for the operation is the same as for the other navigation functions in the APOS.

APOS operation is described in general terms in the APOS Instruction manual.

APOS detailed operation, also for the HAIN, is described in the APOS online help, integrated into the APOS.

The APOS online help is integrated with APOS SW, but it may also be executed stand-alone on a PC. It is delivered as a chm file (WinHPR.chm).

To run it stand-alone:

1 Copy it to your PC and double click on it.

- The Windows Explorer will start and you have the online help available.
- To make changes on HAIN you generally are required to be logged in as service.

Create the HAIN object

You must create the HAIN positioning object in APOS, just as you create other APOS positioning objects.

You must be logged in as service and have enabled HAIN positioning in your APOS to do follow the procedure below:

1 Select Positioning → HAIN Positioning in the main menu.

- The dialog box is explained in the APOS online help *Positioning → Hain Positioning → Hain Positioning*.

2 Right click on the HAIN icon in APOS to reach the context sensitive menu.

Monitoring

This topic is covered best in the APOS online help.

HAIN Sensor biases

Sensor biases... is a command in the context sensitive menu of the HAIN icon.

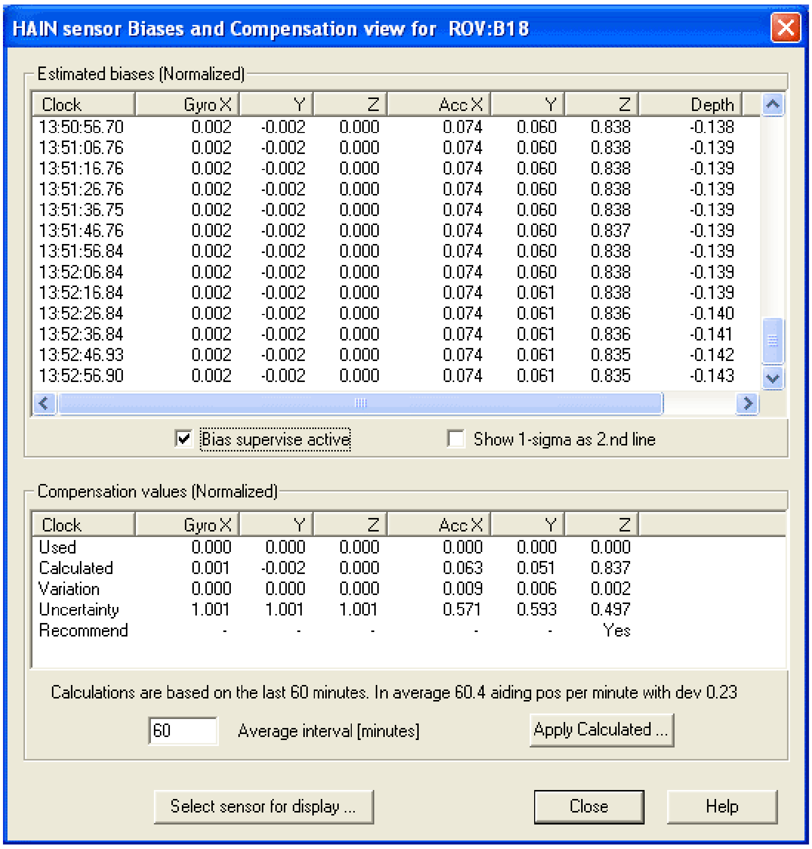


Figure 19 HAIN sensor biases

– The dialog box is explained in the APOS online help *Positioning → Hain Positioning → Hain Sensor Biases.*

The main purpose of the dialog box is to observe the bias estimates. The values are normalized with their QA parameters set up for the sensors in your system. So a value less than 1.0 means that the estimated bias is less than its 1-sigma QA parameter.

If the biases are consistently greater than 1, it may be an indication of systematic errors, which may deteriorate HAIN performance. Please retrieve at least 1 hour of HAIN data (APOS right click HAIN icon choose Retrieve HAIN data) and e-mail this together with a short description of the issue to km.support.hpr@kongsberg.com for support. If the HAIN log files are too large for e-mailing they can be uploaded to https://ftp.km.kongsberg.com.

If the Bias automatic supervise function is active, the HAIN will restart the positioning if one or more of the biases are consistently greater than 3.

It is recommended to check the sensor biases at daily basis, unless there are recurring restarts caused by bias supervise.

If Sensor biases are consistently running at some level, it may stem from a fixed offset. You can then use the Apply Calculated button, to remove this fixed offset from the measurements directly.

HAIN Position Status view

HAIN Position Status vies... is a command in the context sensitive menu of the HAIN icon.

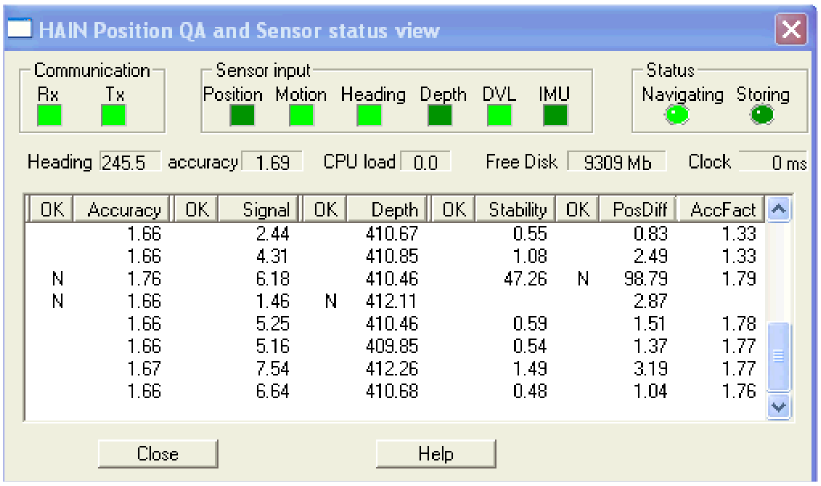


Figure 20 Position status view

Note — *It is recommended to keep the status view visible in APOS when running HAIN.*

You should look for two things:

- If any of the lights become red, there is an indication of a problem with that sensor.
- If many position measurements have N on their OK status, this is an indication of problems with the position measurements.

Avoiding full disk - Tidy

You avoid filling the disk with HAIN data by using the Tidy program.

The program performs the following

- Automatically delete old log files.
- Automatically delete old event files.
- Perform backup of the .in- files located at the NavData.
- Automatically delete earliest file in search area if free disk space is less than 50 MB.

The following directories/files are handled by Tidy:

- ?\Logdata*\NavData*.log
- ?\Logdata*\EventLog*.txt
- ?\navptest*.txt
- ?\ImuRec*.txt
- ?\GP*.txt
- ?\Logdata*\NavData*.ini

"?" is the drive letter where Tidy is installed, typically D. If you log to a drive different than the installation Tidy will not perform these operations and you risk running out of disk space.

If more than one file has to be deleted, a file will be deleted each second.

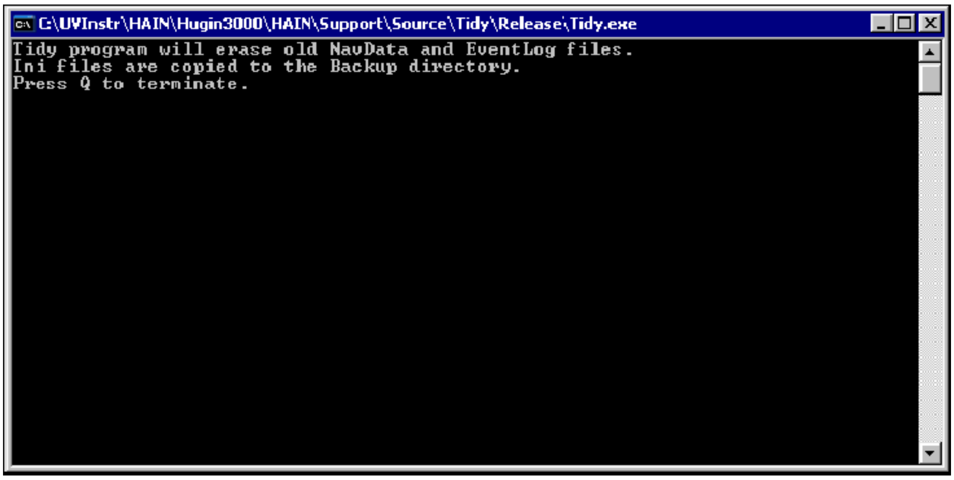


Figure 21 Tidy window

Operation

Tidy is automatically started when HAIN is started.

Normally you shall not stop Tidy, but it can be stopped using keyboard commands in one of the following ways:

- Press **Q** or **q**.
- Press the **Ctrl-C**

Advanced information

Tidy is started from the Start_HAIN.bat file in the \HAIN folder. By default, the line that starts Tidy, reads:

```
start /MIN %1bin\tidy.exe
```

You may edit this line. Be careful when doing so, and make a backup of the file first. The Start_HAIN.bat file is overwritten the next time you install the HAIN program, also when you select the Upgrade option in the install program.

- You edit the file by right-click on the file in the Explorer and select Edit, and the bat file is opened in Notepad.
- You prevent the program from starting, by inserting REM followed by a space before start. Tidy will not be started.
- By default, Tidy deletes log files older than 48 hours in the unnamed folder. The limit may be changed by adding a space followed by a number at the end of the line.

Example:

When Tidy is started with the line:

```
start /MIN %1bin\tidy.exe 120
```

- it will erase log files older than 5 days.

Examine log files - Extract program description

This section describes the purpose and functionality of the Extract.exe program to be used as a part of the HAIN product.

Extract.exe is a separate running program located in the \HAIN\bin folder.

The purpose of the program is to convert binary data located in the HAIN-generated .log files to text and/or binary files for further processing. These text and binary files contain one type of data each. See 70

Starting the program

The Extract.exe program is started by double clicking on the file name in Windows Explorer.

When the program is started, the following window appears:

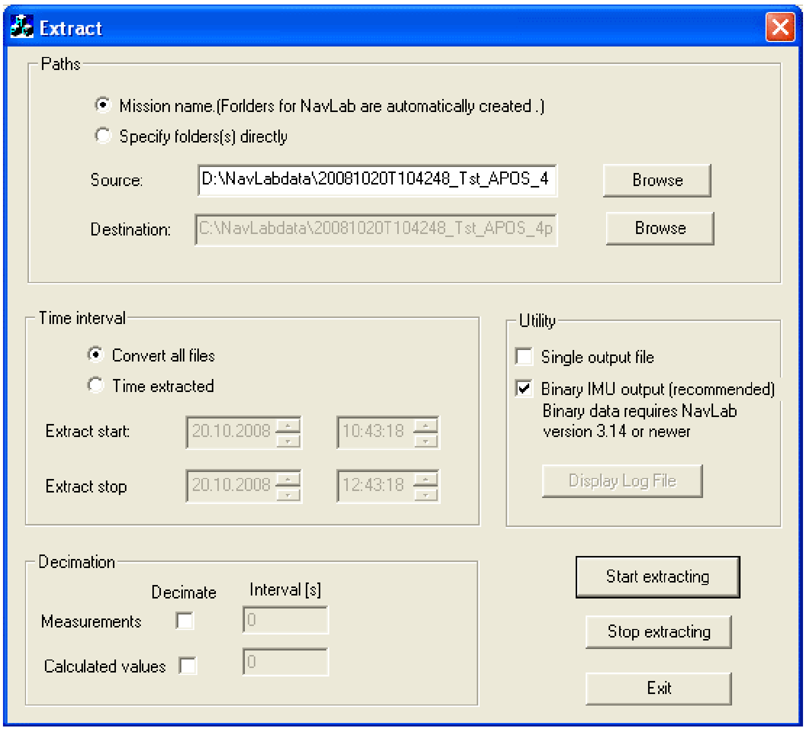


Figure 22 Extract

Operation

Path

You may specify either the mission name folder or the folders directly. When you specify the mission name folder, the extracted files are written to the subfolder NavP\NavData in the mission name folder. The subfolder is created if it does not exist.

1 Select the Browse button.

2 Navigate in the Browse for folder that is displayed.

3 When you have has navigated to the wanted directory → press OK.

Mode

The Mode is describes as the following functionality:

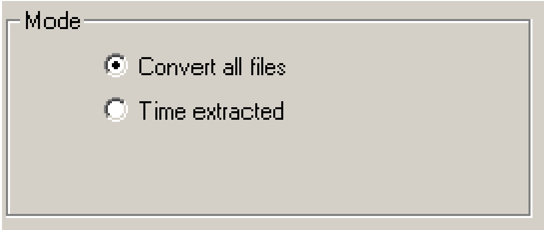


Figure 23 Extract mode

Convert all files - When the radio button is checked, all information located in the log files at the source directory will be extracted. The Time settings will be disabled, since the information is unnecessary.

Time extracted - When the radio button is checked, only the logdata inside the Extract Start and Extract Stop time interval will be extracted from log files. The Time settings are therefore enabled for this selection.

Time settings

The Time settings have the following selections:

Note ***Time extracted mode*** *has to be selected.*

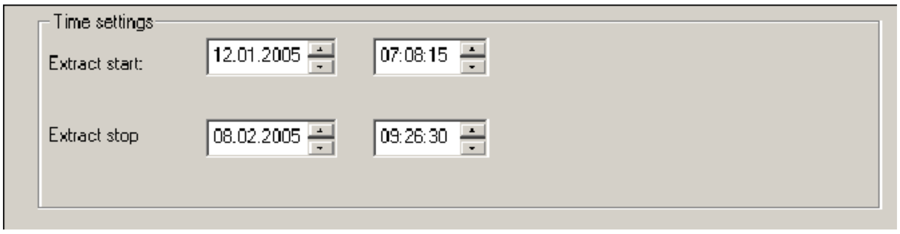


Figure 24 Extract time settings

Note *The initialised values for the Extract Start date/time are calculated from the oldest data located at the Source directory. The Extract Stop date/time are calculated from the last stored data.*

Extract start - The Date and Time for the oldest data to be extracted from log files.

Extract stop - The Date and Time for newest data to be extracted from log files.

Utility

Single output file - Normally each binary log file is extracted to one set of text and binary files. If you tick this checkbox, all the log files are extracted to one set of these files.

Binary IMU output - Tick this checkbox to generate binary files with the IMU data. This is strongly recommended, both due to speed, storage requirements and accuracy. Text files shall only be generated for very special purposes.

Display Log File - The button is enabled after an extracting sequence. Selecting the button will open Notepad for examination the Log.txt file- This file contain status information for the last extracting sequence.

Command buttons

The following command buttons are available:

Figure 25 Extract command buttons

Start Extracting - The command will start the extraction of data from the Source directory.

When the button is pressed, the following dialog appears:

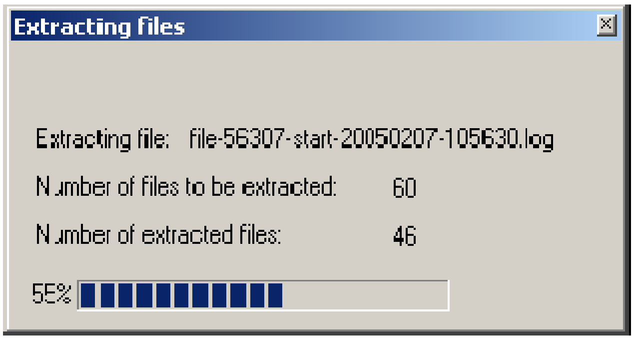


Figure 26 Extract progression bar

The dialog is used for presentation of the progress of the extraction. The following information is shown:

- Name of the currently extracted file.

- Total number of file to be extracted.
- Number of extracted files
- Progress of current extraction

Stop Extraction - The command will stop the extracting sequence when the currently extraction is finished.

Exit - The program will be terminated.

8 MAINTENANCE

This chapter describes the maintenance routines the various parts of the system.

- The maintenance personnel are expected to replace faulty Line Replaceable Units (LRUs), and have access to standard electronic instruments, such as oscilloscopes and multimeters.

Warning ***Kongsberg Maritime accepts no responsibility for any damage or injury to the system or personnel caused by drawings, instructions and procedures not prepared by Kongsberg Maritime.***

Neither Kongsberg Maritime nor our dealers will accept responsibility for damage or injury to the system or personnel resulting from incorrect maintenance performed on the system.

Note *Static electricity will damage sensitive electronic components. Ensure the work bench has a conductive surface and is connected to the vessel/platform ground. Wear an grounding bracelet while working on electronic racks.*

Topics

→ *Safety on page 51*

→ *Before you start on page 51*

→ *Maintenance philosophy on page 51*

→ *Maintenance schedule on page 53*

→ *Preventive maintenance on page 53*

Related topics

→ *Drawings in the Drawing file chapter from page 65*

→ *Spare parts on page 64*

Safety

Refer to standard company/vessel safety procedures before commencing maintenance work.

→ *See also High voltage safety warning on page II in this manual.*

Note *After any maintenance work, the system must be checked to ensure it works correctly. Refer to the procedure in the Test and alignment procedures.*

Before you start

Before you start performing any maintenance, the power must be switched off, and it must be kept off while the maintenance is being carried out.

Warning ***The maintenance engineer MUST wear a grounding bracelet, which is securely connected to the vessel's ground, at all times when performing maintenance on the units.***

1 Switch off all power to the HAIN system and other systems connected to the HAIN.

2 For the other systems, remove the fuses if possible and label the fuse panels with tags stating that maintenance is being carried out on the system.

Maintenance philosophy

The maintenance philosophy recommended by Kongsberg Maritime is:

- On-board maintenance should be carried out by a maintenance engineer, with the assistance of the operator. The maintenance should include the following:
  - Calibrations
  - Simulations
  - Functional tests
  - Traditional troubleshooting based on a good knowledge of the system.

- Replacement of faulty parts should be limited to the line replaceable units (LRUs) recommended in the spare parts list.

Note *To reduce the number of spare boards required, standard circuit boards without software may be provided. In the event of a replacement becoming necessary, the software on the faulty circuit board must then be transferred to the new board. Any links and switches on the new circuit board must also be set as on the old board.*

Whenever a faulty unit has been replaced, the unserviceable unit should be sent to Kongsberg Maritime, or an appointed dealer, for repair.

Error detection

If a fault is detected, the operator should call the maintenance engineer at the earliest opportunity. The operator should be issued with a standard procedure detailing how he/she is to respond to system errors or faults. This procedure should contain the following (as a minimum):

Whenever an error message appears:

- Write down any Alarm message.
- Write down the parameters currently set in the system.
- Write down a brief description of the actions currently being carried out.
- Write down the commands being executed (if any) when the error appeared.
- Write down the controls carried out (if any) when the error message appeared.
- Write down any other information that might be valuable to the maintenance engineer during troubleshooting. This also includes events not directly connected to the system (for example bad weather, excessive temperature in operations room etc.).

Verification

The first action to be performed by the maintenance engineer on receipt of a fault message must be fault verification. If the system has been closed down, it should be powered up again (unless the fault has caused serious damage to the system), and an attempt made to make the fault reappear.

- Verify the fault during continued operation.

Maintenance schedule

Maintenance routines must be performed regularly and effectively to ensure that the equipment is kept in top condition.

The chart below states the **maximum** recommended intervals at which the various routines should be performed - the intervals should be decreased if the system is used excessively.

Maintenance chart

Unit	Weekly	1-3 Month	6 Months	Reference
All units - exterior	Clean/ Check	-	-	-
All cable connections	Check	-	-	-
HAIN Computer filter	-	-	Check/Clean	*HiPAP 501/451/351/101 Instruction Manual*

Preventive maintenance

After retrieving the unit from salt water, it should be thoroughly rinsed with fresh water as usual with this kind of equipment.

When you rinse this kind of equipment, note these general considerations:

Rinse or soak thoroughly with fresh water, the longer the better. Lukewarm water is preferable if available. Pay particular attention to nooks and crannies (around bolt heads, connectors, etc).

If a connector has been disconnected for open face rinsing, leave it to dry properly before reconnecting.

- Replace sacrificial anodes as necessary.

- Make sure pins and threads on connectors are kept clean and greased with suitable lubricants.Equipment handling

This chapter describes how to transport, pack and unpack, clean, preserve and store electronic, electro-mechanical and mechanical units supplied by Kongsberg Maritime.

The units may be supplied as spare parts, or as parts of a delivery.

Topics

Transportation

Unless otherwise stated in the accompanying documentation, electronic, electro-mechanical and mechanical units supplied by Kongsberg Maritime can be transported using all methods approved for delicate equipment; (by road, rail, air or sea). The units are to be transported in accordance with general or specific instructions for the appropriate unit(s), using pallets, transport cases, or carton boxes as appropriate.

Note *Special local restrictions concerning air transportation may be applied to units containing certain types of batteries. The units should be checked and the regulations investigated by the packer/shipper before the unit is dispatched.*

Local transportation

All local transportation must be carried out according to the same specifications as for the initial delivery. In general, all units must be handled with care. The carton/case containing the equipment must be kept dry at all times, and must be sheltered from the weather. It must not be subjected to shocks, excessive vibration or other rough handling.

The carton /case will normally be marked with text or symbols, indicating which way it is to be placed. You must follow the instructions given, and ensure that the carton /case is always placed with its “top” uppermost.

The carton/case must not be used for any purpose for which it was not intended (step, table, etc.), and in the absence of other information, no other cartons/cases must be stacked on top of it.

Lifting

A heavy crate will normally be marked with its weight, and the weights of other cartons or crates will normally be entered on the packing list.

- You must always check the weight of a crate before attempting to lift it.
- You must always use lifting apparatus that is certified for the load.

Heavy units may be equipped with lifting lugs for transportation by crane within the workshop or installation area. Before a crane is used, check:

- You must check the applicable weight certificate for the crane.
- You must check the security of the lifting lugs.

Ensure that all available lifting lugs are used. Ensure the unit remains under control during the operation to avoid damage to the unit, equipment or personnel.

Heavy units may be transported using a fork-lift truck. Special attention must then be paid to the position of the unit’s centre of gravity. The units must be properly secured to the truck.

Storage prior to installation or use

When a system, a unit or a spare part has been delivered to the customer, it may be subject to long-time storage prior to installation and use. During this storage period, certain specifications must be met. The equipment must be preserved and stored in such a way that it does not constitute any danger to health, environment or personal injury.

- The equipment must be stored in its original transportation crate.
- Ensure that the units are clearly separated in the shelves and that each unit is easily identifiable.

- The crate must not be used for any purpose for which it was not intended (e.g. work platform etc.).
- The crates must not be placed on top of each other, unless specific markings permit this.
- The crates must not be placed directly on a dirt-floor.
- Do not open the crate for inspection unless special circumstances permit so.
- “Special circumstances” may be suspected damage to the crate and its content, or inspections by civil authorities.
- If any units are damaged, prepare an inspection report stating the condition of the unit and actions taken. Describe the damage and collect photographic evidence if possible. Re-preserve the equipment.
- If the units are not damaged, check the humidity absorbing material. If required, dry or replace the bags, then repack the unit(s) according to the packing instructions.
- If the crate has been opened, make sure that is it closed and sealed after the inspection.
- Use the original packing material as far as possible.

→ *Refer to information on page 61.*

Ambient temperature and humidity

- The storage room/area must be dry, with a non-condensing atmosphere. It must be free from corrosive agents.
- The storage area’s mean temperature must not be lower than -30 °C, and not warmer than +70 °C.
- If other limitations apply, the crates will be marked accordingly.

Note *Transducers must not be stored in temperatures below -30 °C, or higher than +55 °C.*

- The crate must not be exposed to moisture from fluid leakages.
- The crate must not be exposed to direct sunlight or excessive warmth from heaters.

Shock and vibration

Caution — *The crate must not be subjected to excessive shock and vibration.*

ESD precautions

→ *Refer to the information on page 62.*

Batteries

If the unit contains normal batteries, these may have been disconnected/isolated before the unit was packed. These must only be reconnected before the installation starts. Units containing batteries are marked.

Caution — *Units containing lithium or alkaline batteries must be handled separately and with care. Such units are marked accordingly. Do not attempt to recharge such batteries, open them or dispose of them by incineration. Refer to the applicable product data sheets.*

Inspection

An inspection must be carried out immediately after the unit(s) has arrived at their destination.

- Check all wooden or cardboard boxes, plastic bags and pallets for physical damage. Look for signs of dropping, immersion in water or other mishandling.
- If damage is detected externally, you will have to open the packaging to check the content.
  - Request a representative of the carrier to be present while the carton is opened, so any transportation damage can be identified.
- If any units are damaged, prepare an inspection report stating the condition of the unit and actions taken. Describe the damage and collect photographic evidence if possible. Send the inspection report to Kongsberg Maritime as soon as possible.
- If the units are not damaged, check the humidity absorbing material. If required, dry or replace the bags, then repack the unit(s) according to the packing instructions.

Unpacking

Caution	*The IMU sensor is very delicate. Take precaution during unpacking and installation. Do not drop or hit the unit.*

Normal precautions for the handling, transportation and storage of fragile electronic equipment must be undertaken.

Note	*If the unit is not to be prepared for immediate use, you may consider storing it unopened in its original packing material. However, it may be useful to open the case to check its content for damage and retrieve any accompanying documentation.*

- Check the carton before opening it to ensure it shows no signs of dropping, immersion in water or other mishandling.
  - If the carton shows signs of such damage, refer to the paragraph covering Inspection on receipt.
- Place the carton on a stable work bench or on the floor with the top of the carton uppermost.
- In the absence of other instructions, always open the top of the carton first. Its content will normally have been lowered into the carton from above, so this will usually be the easiest route to follow.
  - Care must be used when opening the carton to ensure the contents are not damaged.

Caution	*Do not use a knife to open cardboard cartons - the content may lie close to the surface, and may be damaged by the blade.*

- If the carton has been closed using staples, remove the staples from the carton as you open it. This will reduce the possibilities of scratch injury to yourself and damage to the content.
- If a wooden crate has been closed using screws, always remove them using a screw-driver. Do not attempt to prise the lid off with a crow-bar or similar.
- Once the carton is open, carefully remove all loose packing and insulation material. Check for manuals and other documents that may have been added to the carton during

packing, and put these to one side. Check also for special tools, door keys etc.

Electronic and electro-mechanical units

Caution *Beware of the dangers of Electro-Static Discharge (ESD) both to yourself and to the equipment, when handling electronic units and components. Refer to the ESD precautions starting on page 62.*

Electronic and electro-mechanical units will normally be wrapped in a clear plastic bag. Lift the unit, in its bag, out of the carton and place it in a stable position on the floor/work bench.

Inspect the unit for damage before opening the plastic bag.

Note *Cables must **never** be used as carrying handles or lifting points.*

Note *Do not break the seal to open a circuit board package before the board is to be used. If the board package is returned to the manufacturers with the seal broken, the content will be assumed to have been used and the customer will be billed accordingly.*

Assuming all is well, open the bag and remove the unit.

Open the unit and check inside. Remove any packing and desiccant material that may be inside.

Mechanical units

Mechanical units may be heavy. Using a suitably certified lifting apparatus, lift the unit out of the crate and place it in a stable position on the floor/work bench.

Inspect the unit for damage and remove any packing material that may be inside the unit.

Re-packing

If the unit is not to be installed immediately, re-pack it in its original packing material to prevent damage in the intervening period.

→ *Refer to the information on page 61.*

Storage after unpacking

The unit must whenever possible be stored in its original transportation crate until ready for installation. The crate must not be used for any purpose for which it was not intended (e.g. work platform etc.).

Once unpacked, the equipment must be kept in a dry, non condensing atmosphere, free from corrosive agents and isolated from sources of vibration.

Note *Do not break the seal to open a circuit board package before the board is to be used. If the board package is returned to the manufacturers with the seal broken, the content will be assumed to have been used and the customer will be billed accordingly.*

The unit must be installed in its intended operating position as soon as possible after unpacking.

If the unit contains normal batteries, these may have been disconnected/isolated before the unit was packed. These must then be reconnected during the installation procedure. Units containing batteries are marked.

Caution *Units containing lithium or alkaline batteries must be handled separately and with care. Such units are marked accordingly. Do not attempt to recharge such batteries, open them or dispose of them by incineration. Refer to the applicable product data sheets.*

After use storage

If a unit is removed from its operating location and placed into storage, it must be properly cleaned and prepared before packing.

Cleaning cabinets

If a cabinet has been exposed to salt atmosphere while it was in use, it must be thoroughly cleaned both internally and externally to prevent corrosion.

- Wipe the cabinet externally using a damp cloth and a little detergent. Do not use excessive amounts of water as the unit may not be water tight. On completion, dry the unit thoroughly.

- All surfaces must be inspected for signs of corrosion, e.g. flaking/bubbling paint, stains etc. Damaged or suspect areas must be cleaned, prepared and preserved using the correct preservation mediums for the unit. The mediums to be used will usually be defined in the units' maintenance manual.
- All surfaces must be inspected for signs of corrosion, e.g. flaking/bubbling paint, stains etc. Damaged or suspect areas must be cleaned, prepared and preserved using the correct preservation mediums for the unit.
- Open the unit, and using a vacuum cleaner, remove all dust etc. from the unit. Great care must be taken to ensure the circuit boards and modules are not damaged in the process.

Cables

Wipe clean all exposed cables, and check for damage. If a cable shows signs of wear or ageing, contact Kongsberg Maritime for advice.

Dehumidifier

Place a suitably sized bag of desiccant material (silica gel or similar) into the unit to keep the electronic components as dry as possible.

Coatings

Spray the unit externally with a corrosion inhibitor (e.g. a light oil) before packing.

Re-packing

The unit should be stored and transported in its original packing material and/or crate. In the event that this material is not available, proceed as follows:

- Small units must be protected from damp by being placed within a plastic bag at least 0.15 mm thick. An appropriate quantity of desiccant material should be placed inside this bag, and the bag sealed. The sealed unit must then be placed in an appropriate carton or crate, and supported in the container by appropriate shock-absorbing insulation (polystyrene foam chips etc.).
- Large units must be placed in a suitable cardboard box or wooden crate. The unit must be protected against physical

damage by means of shock-absorbing insulation mats. The box must be clearly marked with its content, and must be stored in a dry and dust-free area.

ESD precautions

What is ESD?

Electro-Static Discharge (ESD) is the transfer of an electrostatic charge between two bodies at different electrostatic potentials, caused either by direct contact or induction by an electrostatic field.

The passing of a charge through an electronic device can cause localised overheating, and it can also “puncture” insulating layers within the structure of the device. This may deposit a conductive residue of the vaporised metal on the device, and thus create a short circuit. This may result in a catastrophic failure, or degraded performance of the device.

ESD Protection during transport and storage

Sensitive electronic equipment must be transported and stored in protective packing bags, boxes and cabinets. The circuit boards must not be transported or stored close to strong electrostatic, electro-magnetic or radioactive fields.

If it is necessary to open and touch the circuit board inside the protective bag, then the following precautions must be taken:

- The working area must be covered by an approved conductive service mat that has a resistance of between 50 kW and 2 MW, and is connected directly to a reliable earth point via its earthling cord
- The service personnel involved must wear a wrist-band in direct contact with the skin, connected to the service mat.
- Printed circuit boards and other components should be placed on the conductive service mat during installation, maintenance etc.

Caution *If, for any reason, it is necessary to move the circuit board or components from the conductive service mat, they must be placed in an approved anti-static transportation container (e.g. static shielding bag) before transportation.*

- During installation and servicing, all electrical equipment (soldering irons, test equipment etc.) must be grounded.

Temperature protection

If the unit must be protected against extremes of temperature, the carton/crate must be lined on all walls, base and lid with 5 cm thick polyurethane or polystyrene foam.

These units will be identified as delicate in the applicable documentation.

The package must then be clearly marked.

Caution *Must not be transported or stored in temperatures below -5 degrees Celsius.*

Other units can normally be stored in temperatures between -30 °C and +70 °C, refer to the system’s technical specifications for details.

9 SPARE PARTS

This chapter lists the parts and modules defined by Kongsberg Maritime as *Line Replaceable Units (LRUs)*. The required mounting components (such as nuts, bolts, washers etc.) are identified on the diagrams, but have not been allocated order numbers as we regard these items as standard commercial parts available from retail outlets around the world.

Units

KM P/N	**Units**	**Comments**
Computer		
364602	Computer	
337533	Bluestorm serial interface card	
368464	Power supply unit	
367360	Hard disk	
368465	DVD-Recorder	

10 DRAWING FILE

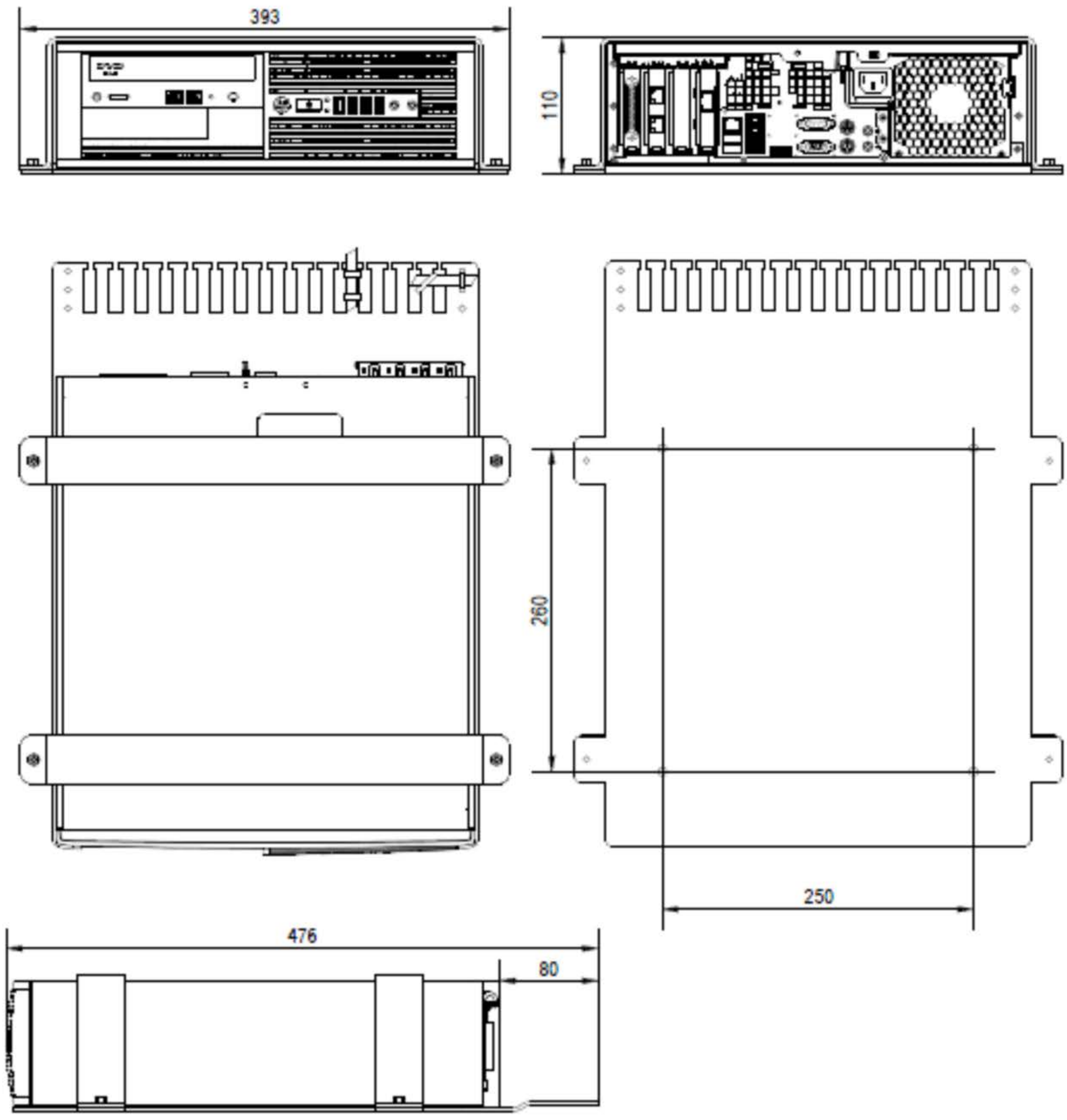
This chapter holds illustrations referred to in various sections in this manual. The illustrations are based on the original system drawings and wiring diagrams.

- The original drawings are available in electronic format on request.
- Unless otherwise noted, all measurements are in millimetres.
- The illustrations are not in scale.
- The drawings of third party units in this section may be outdated. Please refer to the manual accompanying the product for up-to-date information.

Drawings

Draw. No.	Rev.	Description	Ref.
Outline dimensions/mounting			
365290	B	Computer desktop	on page 66
371591	B	Computer rack	on page 67
345820	A	SIU 1 Titanium – Outline dimensions Page 1	on page 68
345820	A	SIU 1 Titanium – Outline dimensions Page 2	on page 69

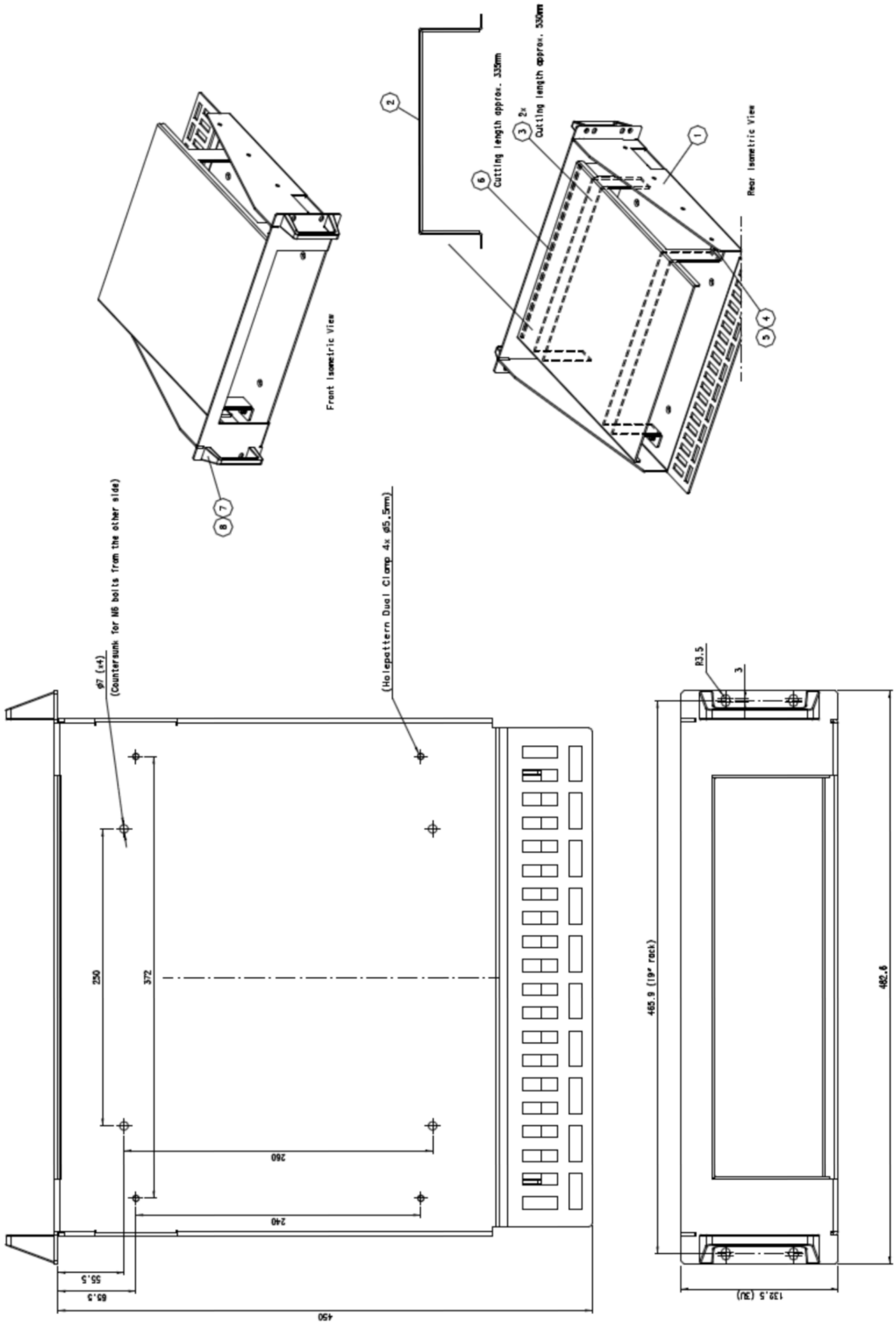
Computer - desktop mounting and outline dimensions



Note:
The drawing is not in scale.

Cd31249 Page 1
365290 Rev. B

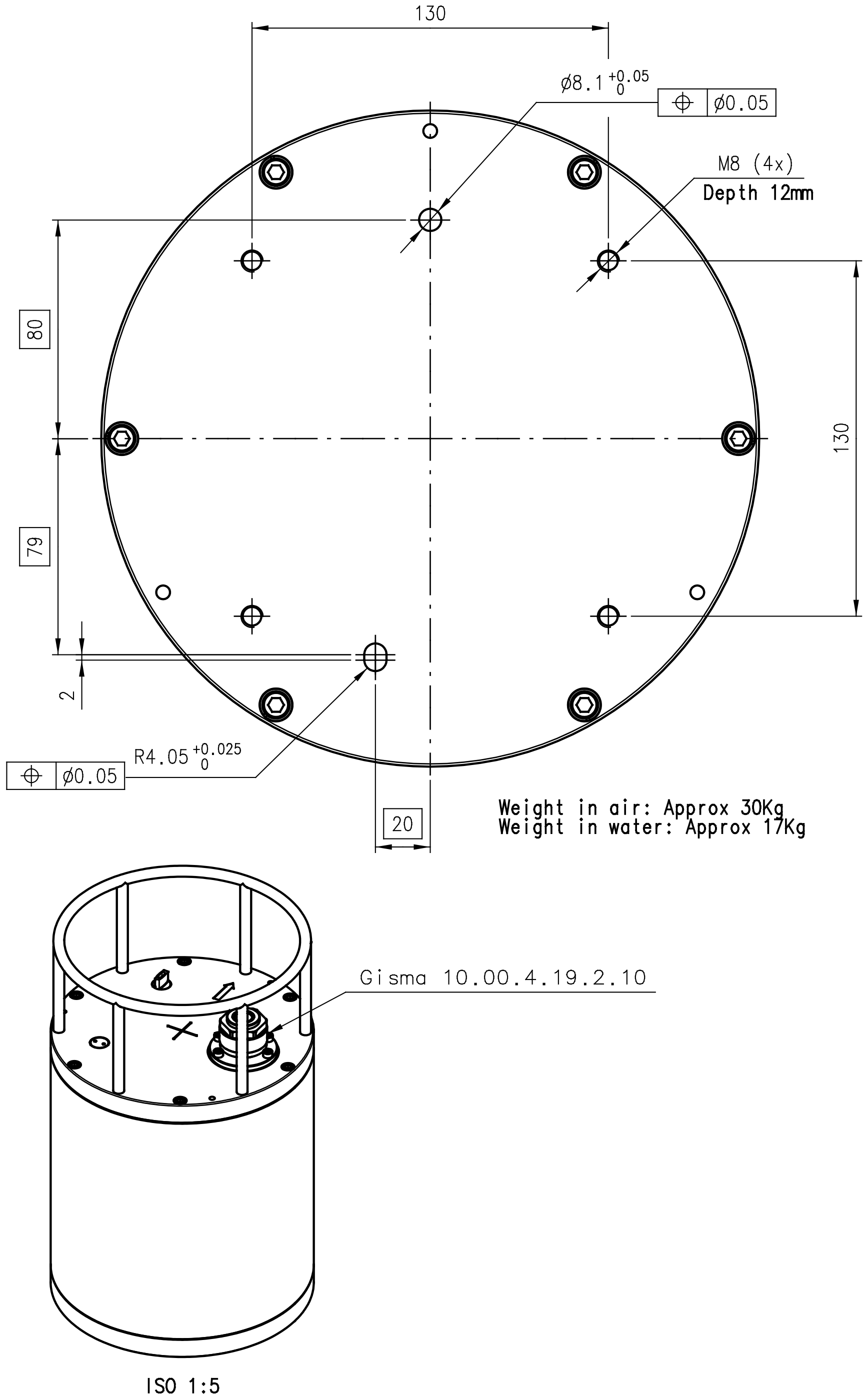
Computer - rack mounting and outline dimensions



Note:
The drawing is not in scale.

Cd31250 Page 1
371591 Rev. B

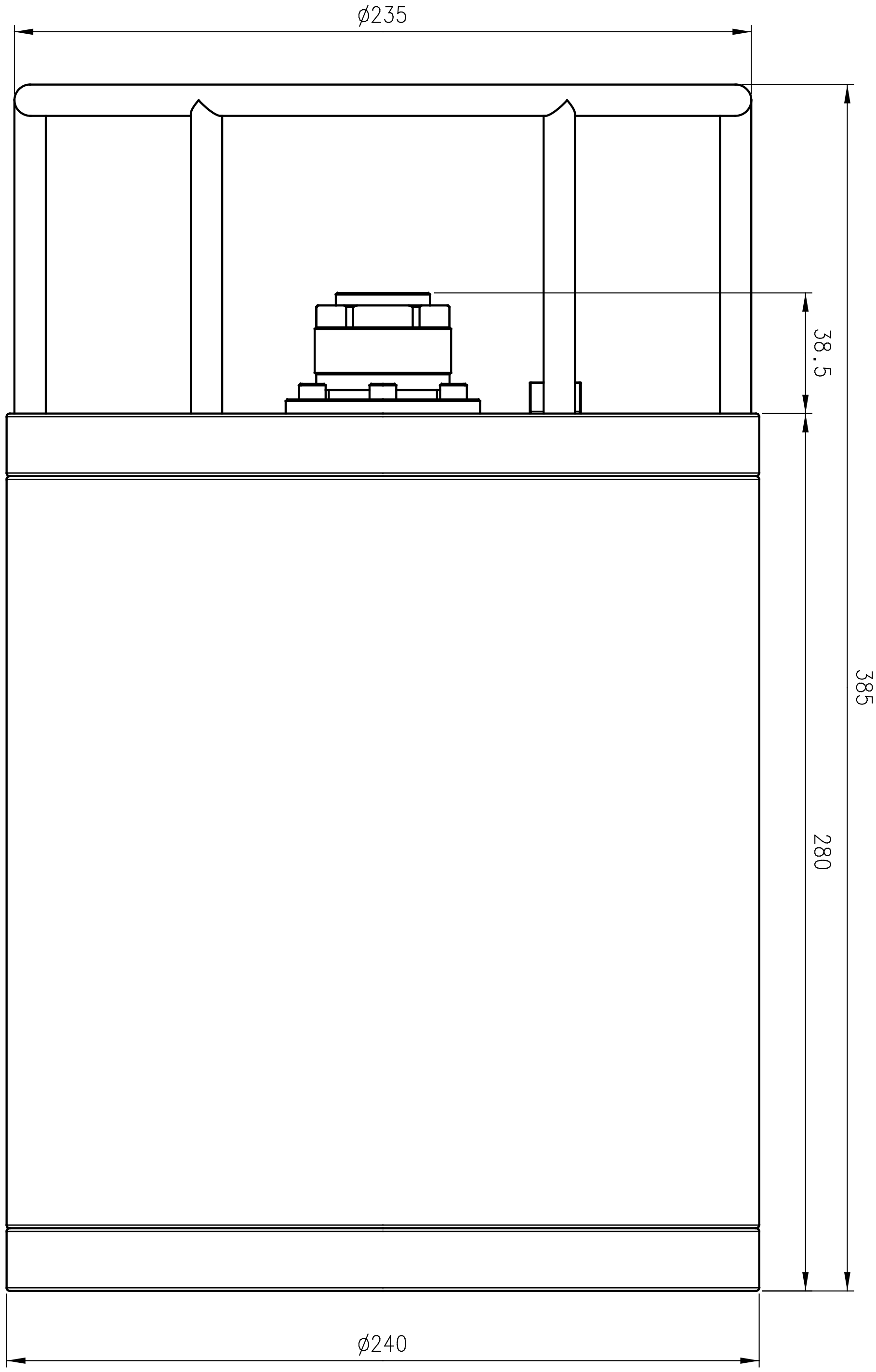
SIU 1 Titanium - Outline dimensions Page 1



Note:
All measurements are in mm.
The drawing is not in scale.

Cd371009 Page 1 of 2
345620 Rev. A

SIU 1 Titanium - Outline dimensions Page 2



Note:
All measurements are in mm.
The drawing is not in scale.

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11 APPENDIX

HAIN measurements on files

See description of Extract on page 45 on how to extract information from the log files.

The HAIN operator sets the mission name in an APOS dialog box, when he starts to log the HAIN measurements.

A folder with the mission name is generated in the LogData folder on the HAIN computer. The mission name has the prefix yyyymmddThhmmss.

The HAIN log files are written to the NavData sub-folder in the MissionName folder. There is up to 15 minutes of data on each log file.

They are named **File-xxxx-start-yyyymmdd-hhmmss.log.**

xxxx - is a sequence number.

yyyymmdd-hhmmss - is the UTC date and time when the log file is initiated.

The ini files are written to a subfolder in the mission name folder, with name **NavSettings\ yyyymmddThhmmss**. The log files are usually transferred to another computer for analysis and post-processing. This requires a 100 Mbit/s TCP/IP net. The sub-folder structure is the same on this computer, with the .log files in the NavData folder.

The program **Extract.exe** reads the binary log files, and creates text and binary files from each .log files. The text and binary files are placed in a data folder at the same level as the NavData folder. Some of these files contain HAIN details for Kongsberg Maritime debug purposes. Other files contain all the HAIN raw measurements, as they are read from the sensors. These files are documented here.

SI Units

All data is in SI-units. The ASCII files have one sample per row and one variable per column.

Driver status

Sensor status data has been standardized by defining the DriverStatusType. It enables the system to treat all sensors in an uniform way. In addition a sensor typically has a SensorStatus which is sensor specific and contains more details.

NotPresent	= 0
SensorOK	= 1
ReducedQuality	= 2
Calibrating	= 3
NoData	= 4
HwError	= 5
InvalidData	= 6
ComError	= 7
ComFailure	= 8
ConfigError	= 9

ASCII files with raw measurements

Below there is one subsection for each file type. The file name is the same as the subsection name followed by a four digit sequence number and .txt. Each file contains up to 15 minutes of data. The four digit sequence number is the same as on the binary log file from which the data is extracted.

Example:

The IMUInertialData0021.txt file contains IMU measurements extracted from the log file
File-0021-start-20030709-083436.LOG.

0021 - is the sequence number

20030709-083436 - is the UTC date and time when the file was initiated.

IMUInertialData

This file contains the gyro and the accelerometer readings from the IMU.

1 TimeStamp, microsecs since the 1.st of January 1970

2 Status Word 1

3 Status Word 2

4 X_DeltaRotationBody rad.

5 Y_DeltaRotationBody "

6 Z_DeltaRotationBody "

7 X_DeltaVelocityBody m/s

8 Y_DeltaVelocityBody "

9 Z_DeltaVelocityBody "

DVLData

This file contains the readings from the DVL. Normally only the bottom track is used.

1 Timestamp, microsecs since the 1.st of January 1970

2 Forward Btm Velocity, m/s

3 Starboard Btm Velocity, m/s

4 Down Btm Velocity, m/s (positive down) (body axis)

5 Forward Wtr Velocity, m/s

6 Starboard Wtr Velocity, m/s

7 Down Wtr Velocity, m/s

8 Beam1BtmTrkQlty

9 Beam2BtmTrkQlty

10 Beam3BtmTrkQlty

11 Beam4BtmTrkQlty

12 Beam1WtrTrkQlty

13 Beam2WtrTrkQlty

14 Beam3WtrTrkQlty

15 Beam4WtrTrkQlty

16 DVLStatus

17 Btm Velocity DriverStatus

18 Wtr Velocity DriverStatus

PressureData

This file contains the readings from the pressure sensor

1 Timestamp, microsecs since the 1.st of January 1970

2 Pressure, absolute pressure (included atmosphere) in bar

3 SensorStatus

4 DriverStatus

DepthData

This file contains the readings from the depth sensor.

1 Timestamp, microsecs since the 1.st of January 1970

2 Depth in meters

3 SensorStatus

4 DriverStatus

HeadingData

This file contains the heading and attitude readings.

1 Timestamp, microsecs since the 1.st of January 1970

2 Heading, rad

3 Roll, rad

4 Pitch, rad

5 Heave, m/s

6 SensorStatus

7 DriverStatus

MotionSensorData

This file contains the attitude and heading.

1 Timestamp, microsecs since the 1.st of January 1970

2 Roll, rad

3 Pitch, rad

4 Heading, rad

5 Roll rate, rad/s Not used in HAIN

6 Pitch rate, rad/s - “ -

7 Yaw rate, rad/s - “ -

8 Surge acceleration, m/s^2 - “ -

9 Sway acceleration ,m/s^2 - “ -

10 Heave acceleration ,m/s^2 - “ -

11 SensorStatus

12 DriverStatus

DGPSHiPAPData

This file contains the position aid used by the HAIN.

1 Timestamp, microsecs since the 1.st of January 1970

2 Body Latitude, rad

3 Body Longitude, rad

4 Accuracy, 1-sigma white noise, m

5 Accuracy, 1-sigma coloured noise, m

6 DriverStatus

7 North variance

8 East variance

9 North east covariance

HiPAPLocalPositionData

This file contains the HiPAP local positions.

→ *See the NavLab manual for more details.*

1 Timestamp, microsecs since the 1.st of January 1970

2 North [m]

3 East [m]

4 Depth [m]

5 North variance [m2]

6 East variance [m2]

7 North east covariance [m2]

8 Stability factor

9 Heading [rad]

10 Roll [rad]

11 Pitch [rad]

12 DriverStatus

UDPNavDataOut

This sentence contains the HAIN position, orientation and speed and their estimated standard deviations. It is sent from the HAIN computer to a UDP port at an IP address. The IP address is normally in another address range than the Kongsberg net A and B addresses. The ascii sentence is terminated with carriage return - '\r' and linefeed - '\n'.

The sentence is sent at the IMU frequency divided with a decimation factor. As an example, a 100 Hz IMU and decimation factor 4 give the navigation sentence to be transmitted with 25 Hz.

The sentence fields have fixed length, causing the sentence length to be fixed at 309 characters. Each floating numeric field starts with a pluss or minus sign followed by leading zeroes if necessary. If a numerical value is too great for the reserved number of digits, it will be written as the max value (+999...) or the min value (-9999...).

The latitude and longitude numeric values have 9 digits in the decimal fraction. The other values have 6 digits in their decimal fraction. This ensures that the numeric resolution does not limit the accuracy, neither now or in the foreseeable future.

Space is the delimiter between the fields.

The status field is just a single character A or V. The other fields start with a 3 character identifier.

For HAIN Subsea the output position (latitude, longitude and depth) is that of the vehicle reference point.

The format is:

Name	**Example**	**Explanation**
Timestamp	Utc20090923125742.503547	The timestamp with year month day hour minute second and fraction of second.
Navigation Status	A	A for OK, V for not OK.
Sensor Status	Sns000011001	The sensors are bitcoded.
Latitude	Lat+59.379402707	The latitude and longitude of the HAIN position [°].
Longitude	Lon+010.457347527	
Depth	Dep+05327.589867	The Depth [m].
Heading	Hea+114.129040	The heading and the attitude [°]
Roll	Rol+00.388725	
Pitch	Pit-00.491741	

Name	Example	Explanation
Forwards velocity	Fwd-00.414652	The velocity in the Body co-ordinate system [m/s].
Starboard velocity	Stb+00.024042	
Down velocity	Dwn+05.577636	
North std	sLa+000.605144	The expected accuracy of the position [m].
East std	sLo+000.601049	
Depth std	sDe+001.017173	
Heading std	sHe+00.062022	The expected accuracy of the attitude and heading [°] .
Roll std	sRo+00.001528	
Pitch std	sPi+00.001606	
Forward velocity std	sFw+00.010010	The expected accuracy of the velocity [m/s]
Starboard velocity std	sSt+00.009551	
Down velocity std	sDw+00.010500	
Termination		CRLF

Navigation Status

The **Navigation Status** field is **A** when the sentence contains a valid navigation solution, i.e. that the HAIN computer managed to calculate the values in the sentence. The quality of the navigation solution is given by the standard deviations transmitted in the sentence. The Status may be A even when the expected accuracies are so bad that the values are useless for most practical reasons.

The Status field is **V** when the sentence contains no valid navigation solution. When the status is V, the sentence may be transmitted at a lower frequency than when the status is A.

The Navigation Status matches the Navigation light in the HAIN Status view in APOS. The status is A when the navigation lamp is green.

Sensor status

The **Sensor status** is shown in binary format with 9 bits. The bits match the Sensor lights in the HAIN Status view in APOS. A sensor bit is equal to 1 when the corresponding sensor lamp is green. The sensor bit is 0 when the input from the sensor has timed out.

Bit	0 set to 1 means that the		IMU measurements are OK.	
"	1	--------- " ------	DVL	--- "---
"	2	--------- " ------	pressure (depth)	--- "---
"	3	--------- " ------	Heading	--- "---
"	4	--------- " ------	Attitude	--- "---
"	6	--------- " ------	Position aid	--- "---

Be aware that a bit set only means that the input from the sensor has timed out. When navigation starts, status bit(s) may be set although no value is received from the sensor because the sensor input has not timed out. The same applies for the lamps in the status view on APOS.

IMU 90 in Kongsberg Maritime housing

Technical specifications

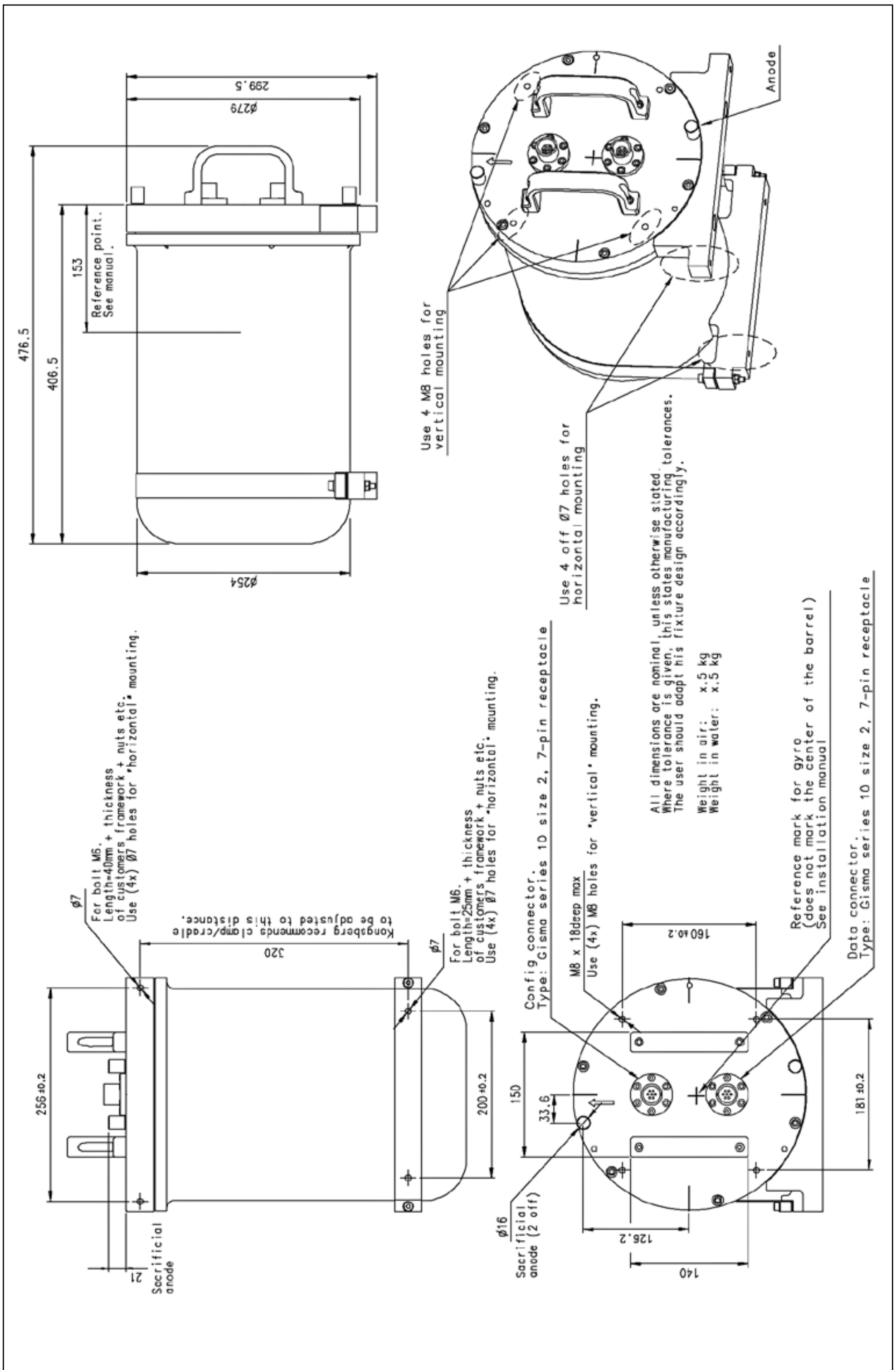
This product does not have its complete technical specifications accompanying the product.

Maximum depth rating	4000 m
Material	anodized aluminium
Length x width x height	(280 x 136 x 162) mm
Weight in air/water	31.5 Kg/13 kg
Tube/flange diameter	206 mm/248 mm
Overall length	460 mm
Power Requirements	24 Vdc
Power Consumptions	12 W

The dynamic range:

Gyro	± 500 °/s
Accelerometers	± 30 g

IMU 90 assembly and outline drawing



Page 1 of 1 (CD32011)	IMU 90 assembly and outline dimensions	830-220139 Rev. Preliminary

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