

Installation manual



KONGSBERG

MRU H

Motion Reference Unit - 5th generation





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Motion Reference Unit
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MRU-D-204 /5.0

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Rev. 2.0	26.10 2012	Updated to correspond with MRC+ version 5.03.00. Description of the MRU binary protocol is included in this version.
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Rev. 5.0	17.11 2014	Updated to correspond with MRU sw. version 5.02.00 and MRC+ version 5.04.00. Appendix A Digital Interface is updated with new UDP ports

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Kongsberg Seatex AS disclaims any responsibility for damage or injury caused by improper installation, use or maintenance of the equipment.

Comments

To assist us in making improvements to the product and to this manual, we welcome comments and constructive criticism.

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Glossary

Abbreviations

AHRS	Attitude and Heading Reference System
AP	Aft perpendicular. The vertical intersection of the design waterline at the stern, alternatively the center line of the rudder stock.
BL	Base Line. Is the same as the keel for a vessel with horizontal keel line.
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.
CGND	Communication ground.
CL	Centre line. Is the longitudinal axis along the centre of the ship.
CRP	Common Reference Point.
GA	General Arrangement drawing.
GGND	The MRU ground.
GNSS	Global Navigation Satellite System
GUI	Graphical user interface
HPR	Hydroacoustic Positioning Reference system.
IMU	Inertial Measurement Unit
INS	Intertial Navigation System.
LGND	Logic ground
MEMS	Micro-Electro-Mechanical-Structure.
MP	Monitoring Point
MRC	MRU configuration software. Runs on a PC under Microsoft Windows.
MRU	Motion Reference Unit. A MRU consists of gyros and accelerometers.
NMEA	National marine electronics association. NMEA 0183 is a standard for interchange of information between navigation equipment.
PGND	Power ground
PPS	Pulse per second
RMS	Root mean square
UDP	User Datagram Protocol
UTC	Universal Time Coordinated. This is the official time in the world and has replaced GMT (Greenwich Mean Time) as the official time.

WEEE Waste Electrical and Electronic Equipment

Definitions

Alignment	Is the process of adjusting the current internal navigation frame in the instrument to the true external frame.
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.
Heave	The vertical dynamic motion of a vehicle and defined positive down. Heave position and velocity are dynamic motion variables calculated for a selected average heave period.
Origin	The zero point in the coordinate system. The origin location can be configured by the user. Typical origin locations are CRP in a survey report, CG, MRU or 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.
Y-axis	Yaw axis. This axis is fixed in the vehicle (b-frame), 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.

1 Introduction

1.1 About the reader

This installation manual is intended as a reference manual for the personnel installing the MRU and it contains the necessary information to install and set up the equipment on a vessel.

1.2 Notations used in this manual

The following notations are used in this manual:

Bold text is used for all menu names. A series of menu selections is indicated by **File**→**New**

Italics is used for manual names and for information that needs your attention.

Note

A note is used to draw attention to special features or behaviour of the equipment.

Caution

Caution is used to make the user aware of procedures and operational practice which, if not followed, may result in degraded performance or damage to the equipment.

WARNING

Warning is used when it is necessary to warn personnel that risk of injury or death exists if care is not exercised.

1.3 Product restrictions

1.3.1 Restrictions in export

Export of the MRU 5+, 5, E, H and 2 models to other countries than EU countries or Argentina, Australia, Canada, Iceland, Japan, New Zealand, Switzerland, South-Korea and USA, requires an export license.

Note

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 US EAR. The MRU may be subject to restrictions if re-exported from your country.

1.3.2 Restrictions in guarantee

Changes or modifications to the product not explicitly approved by Kongsberg Seatex AS will void the guarantee.

The liability of Kongsberg Seatex AS is limited to repair of this 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 this system's malfunctions, are excluded. The warranty does not cover malfunctions of the system resulting from the following conditions:

- The sensor unit is not shipped in the original transport box.
- The sensor unit has been exposed to extreme shock and vibrations.
- The sensor unit housing has been opened by the customer in an attempt to carry out repair work.
- Over-voltage or incorrect power connection.

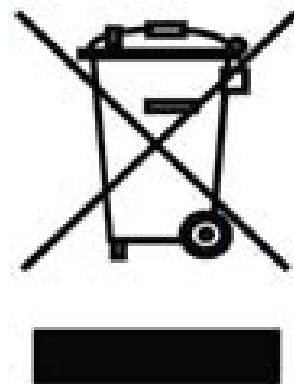
1.3.3 Restrictions in use

The MRU function is based on an inertial sensor 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 $\pm 100^\circ/\text{s}$.

Only relative dynamic heave position is calculated.

1.4 Disposal

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.



The equipment may be returned to Kongsberg Seatex AS if there is no local WEEE collection. The equipment is marked with this pictogram.

1.5 Equipment handling

Observe the following when handling the equipment:

- All units must be handled with care.
- The case containing the unit 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 equipment must be preserved and stored in such a way that it does not constitute any danger to health, environment or personal injury.
- The unit must, whenever possible, be stored and transported in its original transportation box.
- The transportation box must not be used for any purpose for which it was not intended.
- The storage area's mean temperature must not be lower than $-25\text{ }^{\circ}\text{C}$ and not warmer than $+70\text{ }^{\circ}\text{C}$.
- Once unpacked, the equipment must be kept in a dry, non-condensing atmosphere, free from corrosive agents and isolated from sources of vibration.

Note

After the installation please save the transportation container. To maintain warranty validity, the sensor unit must be shipped in this container for service or repair.

2 Product description

This manual describes the 5th generation MRU products. This generation motion sensing products is both mechanically and electrically compatible with the previous MRU generations. The 5th generation MRU products are identified by serial numbers above 20000, titanium coloured housing and Ethernet communication.

2.1 Purpose and application

The MRU H contains 3–axis angular rate sensors and 3–axis acceleration sensors.

This MRU provides no absolute north information and the measurement drifts slowly in yaw, except when external heading is input to the MRU H.

The MRU H is specially designed for motion measurements in marine applications requiring highly accurate heave measurements in environments with extreme horizontal accelerations. The MRU H is an ideal sensor for roll, pitch and heave compensation of offshore cranes and echo sounders. The MRU H can also be used on typical ship motions monitoring applications such as helideck motion monitoring, hydroacoustic positioning systems, as well as hull stress monitoring.

The MRU H outputs roll, pitch and yaw angles and corresponding angular rate vectors fixed to the vehicle frame. The unit outputs relative (dynamic) heave position, velocity and acceleration in adjustable frames.

2.2 System components

The MRU models are supplied with the following standard parts:

- The MRU motion sensor.
- Three-metre Ethernet configuration cable for connection to a PC.
- Power supply 24 V for Ethernet configuration cable.
- USB memory stick including the MRU configuration software MRC+, manuals, configuration and calibration file.
- Transportation box.

In addition comes a mounting bracket, a junction box and cables according to the customer's requirements.



3 Technical specifications

3.1 Performance data

3.1.1 Orientation output

Angular orientation range	$\pm 180^\circ$, unlimited
Resolution in all axes	0.001°
Static accuracy ^[1] roll, pitch	0.04° RMS
Dynamic accuracy ^[1] roll, pitch (for a $\pm 5^\circ$ amplitude)	0.05° RMS

3.1.2 Angular rate sensors

Number of rate sensors	3
Angular rate range	$\pm 100^\circ/\text{s}$
Angular rate noise ^[2] roll, pitch, yaw	$0.1^\circ/\text{s}$ RMS
Scale factor error	0.2 % RMS

3.1.3 Acceleration sensors

Number of sensors	3
Acceleration range all axes	$\pm 30 \text{ m/s}^2$
Acceleration noise ^[1]	0.002 m/s^2 RMS
Acceleration accuracy	0.01 m/s^2 RMS
Scale factor error	0.02 % RMS

-
1. When the MRU is exposed to a combined two-axis sinusoidal angular motion with 10 minutes duration.
 2. When the MRU is stationary over a 30-minute period.

3.1.4 Heave motion output

Output range	±50 m
Periods (real-time)	0 to 25 s
Periods (delayed)	0 to 50 s
Heave accuracy (real-time)	5 cm or 5 % whichever is highest
Heave accuracy (delayed)	3 cm or 3 % whichever is highest

3.1.5 Internal processing

Main processing cycle frequency	200 Hz
Orientation erection time (from power on)	Max 15 minutes

3.2 Physical dimensions

3.2.1 MRU Unit

Type	5 th generation MRU
Height	140 mm (5.525")
Diameter	105 mm (4.134")
Weight	2.4 kg
Colour	Titanium
Connector	Souriau 851-36RG 16-26S50 (MIL. spec.)

3.2.2 MRU floor mounting bracket

Type	MRU-M-MB5
Length	160 mm
Width	140 mm
Height	26.7 mm
Weight	0.8 kg
Colour	Black
Material	Aluminium

3.2.3 MRU wall mounting bracket

Type	MRU-M-MB4
Length	123.5 mm
Width	110 mm
Height	140 mm
Weight	0.8 kg
Colour	Black
Material	Aluminium

3.2.4 MRU protected mounting bracket

Type	MRU-M-MB6
Length	134.5 mm
Width	130 mm
Height	300 mm
Weight	2.4 kg
Colour	Black
Material	Aluminium

3.2.5 MRU junction box

Type	MRU-E-JB3
Length	226 mm
Width	126 mm
Height	90 mm
Weight	2.0 kg
Colour	Black
Material	Aluminium
Enclosure protection	IP-65

3.2.6 Subsea bottle 4000-metre

Type	MRU-M-SB9
Height	275 mm incl. protection caps, 297.5 mm incl. connectors
Diameter	129 mm, 132.9 mm incl. protection cap
Dry weight	10.3 kg including MRU

Submerged weight	6.9 kg including MRU
Colour	Titanium
Depth	4000 metres
Connectors	2, 8-pin Seacon

3.2.7 Subsea bottle 1000-metre

Type	MRU-M-SB10
Height	275 mm incl. protection caps, 297.5 mm incl. connectors
Diameter	129 mm, 132.9 incl. protection cap
Dry weight	7.6 kg including MRU
Submerged weight	4.2 kg including MRU
Colour	Anodised aluminium
Depth	1000 metres
Connectors	2, 8-pin Seacon

3.2.8 Subsea bottle 50-metre

Type	MRU-M-SB11
Height	209 mm, 240.5 mm incl. connectors
Diameter	120 mm
Dry weight	7.8 kg including MRU
Submerged weight	5.4 kg including MRU
Colour	Stainless steel
Depth	50 metres
Connectors	2, 8-pin Seacon

3.3 Power

3.3.1 MRU Unit

Voltage input	10 to 36 V DC
Recommended voltage	24 V DC
Power consumption	Max 12 Watts (typical 8 Watts)

Power rise speed	Not critical
Batteries	None; connection to UPS recommended

3.3.2 MRU junction box

Type	MRU-E-JB3
Voltage input	85 to 264 V AC
Voltage output	15 Watt 24 V DC Mains power

3.4 Environmental specification

3.4.1 MRU Unit

Enclosure material	Anodised aluminium
Enclosure protection	IP-66
Operating temperature range	-5 °C to +55 °C (all MRU models except MRU E)
Operating humidity (max)	Sealed, no limit
Storage temperature range	-25 °C to +70 °C
Storage humidity	Sealed, no limit
Electromagnetic compatibility (immunity/emission)	IEC 60945/EN 60945
Vibration	IEC 60945/EN 60945
Max shock non-operational (10 ms peak)	1000 m/s ²
MTBF (computed)	50000 h

3.4.2 MRU junction box

Type	MRU-E-JB3
Enclosure material	Aluminium
Operating temperature range	-25 °C to +70 °C
Storage temperature	-25 °C to +70 °C
Ingress protection	IP 65

3.5 External interfaces

Serial ports	COM1: Bidirectional RS-422 COM2: Bidirectional RS-232. From junction box user configurable RS-232/RS-422 COM3&4: Input only. User configurable RS-232/RS-422
Baud rate	Max. 115200 Baud
Ethernet UDP/IP (3 output ports and one input port)	10/100 Mbps
Data output variables	Max. 24 (serial line or Ethernet port)
Data output rate	Max. 200 Hz
Analog output channels (from junction box only)	4, ± 10 V with 14 bits resolution
Timing accuracy	1 ms
Data delay	Typical 3.5 ms plus transmission delay
Data output	Cyclic output of data or by request from host computer

3.6 Data outputs

Output protocols	MRU Normal. The MRU proprietary binary format NMEA Proprietary Sunder Simrad EM3000 Atlas Fansweep TSS1 Seapath binary 23 Seapath binary 25 (Raw IMU) Seapath binary 26 PFreeHeave RDI ADCP
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3.7 Data inputs

Input protocols	MRU commands NMEA format HDT, HDM, VBW, VHW, VTG, ZDA
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3.8 MRU cable

Type	MRU-E-CS8, Heavy duty screened, 14 x 2 x 0.25 mm ²
Length	3 m
Diameter	13.5 mm
Weight	0.27 kg/m
Flame retardation	IEC 60332–1
Insulation	ETFE
Screen	Cu-braid

3.9 LED indicator MRU

A LED indicator is located next to the connector on the sensor unit. This LED indicates status on operation, software and configuration. The LED function is described with a sequence of colours. Each second is divided into 4 slots.

- **Time sync**: the first slot in the sequence shows information about time synchronisation.
- **Blank**: the second slot is always blank.
- **Aiding**: the third slot in the sequence shows status on external inputs.
- **Status**: the fourth slot in the sequence shows the sensor unit status.

The meaning of the colour in each slot is illustrated in the table.

Note

One column in the table represents one second.

1 second flash per column			
Time sync	Blank	Aiding	Status
NO PPS		NO AID	OK
PPS OK		HEAD AID	
PPS & DATE OK		SPEED AID	
		HEAD & SPEED	

If default IP is selected, every 4th second the LED is yellow.



If there is something wrong with the sensor unit, a flashing red light flashing at 4 Hz is observed.



Pressing the **ALERT** button changes the light to blue. By holding the ALERT button for more than 8 seconds, a red light indicates that the unit is reset to default IP.



3.10 Power requirements

The sensor unit is to be powered by a clean 10 to 36 V DC source. However, the recommended power source is 24 V DC which is also the design power source. The sensor unit power lines are galvanically isolated from the signal circuits inside the unit. The maximum isolation voltage inside the sensor unit is 200 V DC.

The sensor unit should be protected by an external slow fuse rated at 2 A. There is a fuse in the MRU-E-JB3 junction box.

Caution

Permanent damage to the sensor unit may occur if power is applied to the Ethernet or digital conductors. Therefore, it is imperative to check the power connection by measuring the power voltage at the connector before the sensor unit is connected. Damage resulting from incorrect connection and power is not covered by the Kongsberg Seatex AS warranty.

3.11 Cable lengths

If a long ship cable (> 30 m) is used, please consider the following:

- At 24 V DC, the maximum allowable DC resistance in the cable (sum of the forward and back resistance) is $R_{DC} < 10 \Omega$. This means max. 200 m cable at 0.75 mm^2 .

3.12 Cable wiring schematics

The wiring schematics for the MRU-E-CS8 heavy duty cable.

Table 1 Cable wiring schematics

Souriau 26-pin		Signal description	Conductor	
Signal conn.			Pair no.	Colour
PWR+	R	Power supply (+24 V)	1a	White
PWR-	B	Power supply (0 V)	1b	Blue
COM1_OUT_B	C	RS-422B+ output data from MRU	2a	White
COM1_OUT_A	T	RS-422A- output data from MRU	2b	Orange
COM1_IN_B	S	RS-422B+ input data to MRU	3a	White
COM1_IN_A	P	RS-422A- input data to MRU	3b	Green
RJ_1	G	TD+, Ethernet	4a	White
RJ_2	H	TD-, Ethernet	4b	Brown
ALERT	X	MRU alert	5a	White

Table 1 Cable wiring schematics (cont'd.)

Souriau 26-pin		Signal description	Conductor	
Signal conn.			Pair no.	Colour
GGND	A	MRU ground	5b	Grey
RJ_3	J	RD+, Ethernet	6a	Red
RJ_6	K	RD-, Ethernet	6b	Blue
COM2_IN	c	RS-232 data to MRU	7a	Red
COM2_OUT	M	RS-232 data from MRU	7b	Orange
COM3_IN_A	E	RS-422A- or RS-232 input signal to MRU	8a	Red
COM3_IN_B	Y	RS-422B+ or RS-232 return signal to MRU	8b	Green
COM4_IN_A	V	RS-422A- or RS-232 input signal to MRU	9a	Red
COM4_IN_B	L	RS-422B+ or RS-232 return signal to MRU	9b	Brown
CGND	a	Communication ground	10a	Red
XIN	U	Signal to MRU, 5 Volt or RS-232 level	10b	Grey
XOUT	b	Signal from MRU, 5 Volt level	11a	Black
EXT0	F	Signal from MRU, 5 Volt level	11b	Blue
	Z	Internal control, do not connect	12a	Black
	W	Internal control, do not connect	12b	Orange
	D	Internal control, do not connect	13a	Black
5V	N	5 Volt out, max. 20 mA	13b	Green
		Not connected	14a	Black
		Not connected	14b	Brown

3.13 RS-422 A and B signal definition

According to the following standard the signal state definitions are:

- IEC 61162-1. The idle, marking, logical 1, OFF or stop bit states are defined by a negative voltage on line A with respect to line B. The active, spacing, logical 0, ON or start bit states are defined by a positive voltage on line A with respect to line B. It should be noted that the above A with respect to B levels are inverted from the voltage input/output requirements of standard UARTs and that many line drivers and receivers provide a logic inversion.

3.14 Hardware I/O description

The digital communication lines COM1_OUT, COM1_IN, COM2_OUT, COM3_IN, COM4_IN, XIN, XOUT and EXT0 share a common ground (CGND) and are isolated from the sensor unit power system.

The Ethernet connection pins RJ_1, 2, 3 and 6 are isolated from the sensor unit power system.

COM1

Is an RS-422 input and output line. Transmit is on OUT and receive on IN.

COM2

Is an RS-232 input and output line. Transmit is on OUT and receive on IN. In the MRU-E-JB3 junction box this signal is also available as RS-422.

COM3

Is an RS-422 or RS-232 input line.

COM4

Is an RS-422 or RS-232 input line.

XIN and XOUT lines

These lines are general purpose I/O lines, programmable by the MRU software.

- XIN. The XIN accepts RS-232 levels. The line is considered HIGH if left open or driven by 3 to 15 V, and LOW for 0 to -15 V.
- XOUT. Sensor unit ready/not ready. Zero or 5 V out.

EXT0 line

Internal use only. In use for output of analog signals from the MRU junction box and to activate the relay when analog data are valid.

Ethernet ports

Through the Ethernet connection, three output ports and one input port are available in the MRC+ configuration software for I/O setup.

4 Installation

This chapter describes a typical ship installation of the MRU for use together with, for example, an Hydroacoustic Positioning Reference system (HPR).

There is also a section in this chapter which describes a subsea installation of the MRU.

The sensor unit is shipped in a specially designed transportation container. Keep the sensor unit in this container until ready to install the unit in the mounting bracket.

Note

After the installation, please save the transportation container. To maintain warranty validity, the sensor unit must be shipped in this container for service or repair.

In addition to the MRU unit itself, the following additional equipment is required for installation:

- The heavy duty screened **MRU-E-CS8 cable** with the MRU connector at one end and marked conductors at the other.
- The **MRU-M-MB5 floor-mounting bracket** or the **MRU-M-MB4 wall mounting bracket** complete with four M4.0 screws and three M6.0.
- The **MRU-E-JB3 junction box** for connecting the MRU output signals to the HPR system and to supply the MRU with 24 V DC power. A ship cable to be supplied for connecting the MRU junction box with the HPR system. This cable can be delivered by Kongsberg Seatex AS, although normally it is delivered by the HPR system supplier, the shipyard or others.

4.1 Logistics

Safety

None.

Personnel qualifications

Trained electricians.

Minimum number of personnel

1.

Special tools required

A PC.

4.2 Location of MRU Unit

When installing the MRU, note the following:

- The unit is designed for installation in an indoor environment and for operation within the temperature range.
- For units that outputs heave it is important to mount the unit close to the user equipment of which it is supposed to measure the motion. This is to avoid errors in alignment with the user equipment and to eliminate errors due to ship hull torsion.
- For best roll, pitch, surge and sway measurements, place the MRU as close to the centre of gravity (CG) of the ship as possible, unless lever arm from the MRU location to the CG location is entered in the MRC configuration program. Alternately, try to mount it along the R-axis of the ship, low in the ship and amidships. Roll is usually the most dominant angular motion; avoid mounting the MRU high up or out to the side of the ship.

Caution

Be aware of vibrations. Direct mounting onto the main hull structure is preferable.

The worst mounting positions are thin walls that may come in resonance with vibrations driven by machinery, propellers, pumps or motors. Avoid mounting the MRU close to hydraulic pumps and valves where there are high frequency vibrations. The MRU function may be disturbed if strong vibrations around 14 kHz are present. It is some sensitivity to vibrations around sequences of 100 Hz (100, 200, 300 Hz and so on). Such vibrations should not exceed 0.5 m/s² in any direction.

Caution

Be aware of temperature changes. For safe mounting of the sensor unit, place the unit in a location where the temperature is low and where changes in temperature are slow. A location directly on the hull far away from the heat of the machinery, heaters and air conditioning systems is preferable.

Caution

Be aware of corrosion problems. Place the sensor unit in a location where no direct splashing sea water is present.

4.3 Survey of sensors on vessels

In order to achieve the specified accuracy of the sensor unit, the installation has to be surveyed.

The reference systems in use for this system are:

- The vessel reference system
- The MRU sensor point and axes system

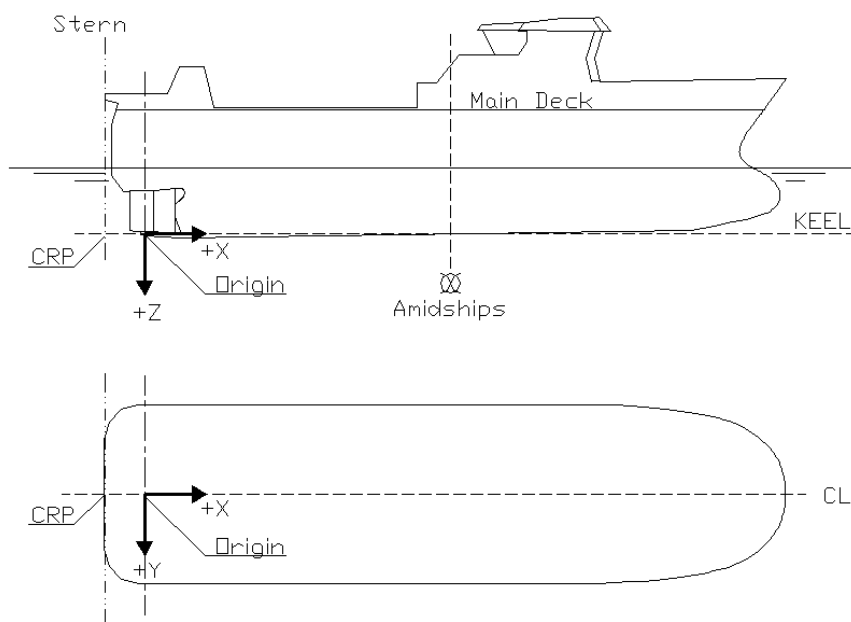
A survey has to be performed to determine the offsets in angle and position from the vessel reference system to the sensor unit.

4.3.1 Vessel reference system

The following has to be surveyed:

- All vessels have a defined Cartesian coordinate system that all sensors can be referenced to. In this right hand system, the X-axis is positive forwards, which is parallel to the centre line of the vessel, the Y-axis, positive towards starboard, and the Z-axis, which is positive downward.
- The origin in the vessel reference system is typically frame 0 at keel level or the surveyed origin in a survey report, i.e. where X, Y and Z are all 0.
- The coordinate reference point (CRP) is defined to be in the intersection between stern, longships center line and keel. In case the keel is not parallel with the base line, the reference for CRP is where the keel crosses the vertical section amidships. The location of CRP vs the origin is configurable, and is typically set based on the survey report.
- The reference plane in this system must be well defined and described. This can be a Best Fit Plane on main deck, or a Best Fit Plane through the draught marks on the hull. This is particularly important on a floating vessel, as it is not possible to project the horizontal plane from land.
- The chosen convention must be made clear to all parties involved, both survey personnel performing the survey and the users of the survey results. Any deviation from the defined coordinate system, shown in the figure *Definition of Origin on vessel and positive X, Y and Z axes directions* on page 27, should be well described in both text and drawings to avoid common misunderstandings.

Figure 1 Definition of Origin on vessel and positive X, Y and Z axes directions



4.3.2 MRU

Figure 3 Sensor point on the wall mounting bracket

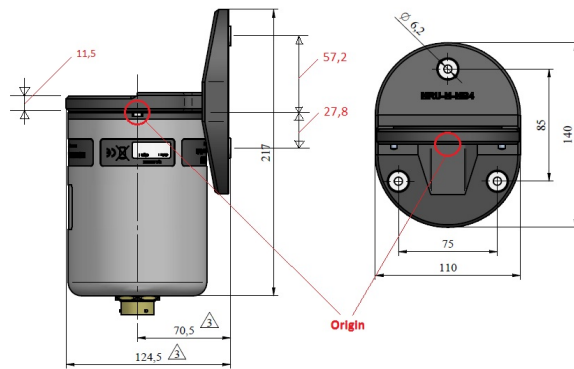
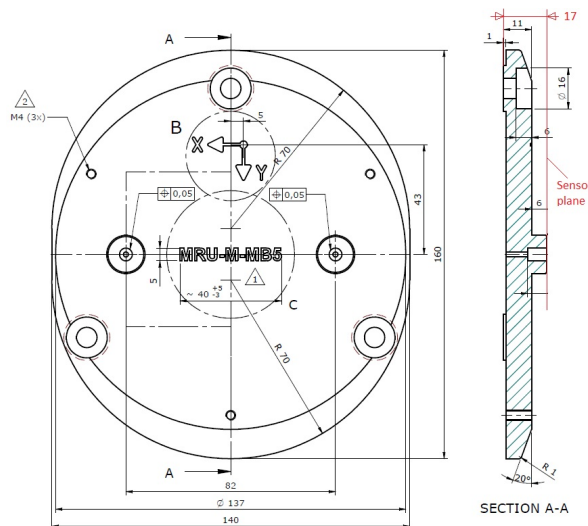


Figure 2 Sensor point and position (0, 0, 0) for all MRU units



Figure 4 Sensor plane on the floor mounting bracket over the deck



For the sensor unit the following should be surveyed:

- Position (X,Y,Z) of sensor point. The axis cross centre on the MRU top.
- Mounting angles in Roll, Pitch and Yaw (heading).

Pitch and Roll mounting angles should be checked for correctness against sensor unit readings after configuration of the offset angles values found during survey, for instance during Gyro calibration.

4.3.3 Survey accuracy

The MRU product must be surveyed to the following accuracy level. If not, the performance of the product will be degraded.

- Distance vector from the Origin to MRU (X, Y, Z): <0.1 metre

- Distance vector from the Origin to the user defined monitoring points (X, Y, Z): <0.1 metre
- Distance vector from the Origin to the Centre of Gravity (CG) location (X, Y, Z): <1 metre
- Yaw misalignment angles with the vessel axes: < 0.5°
- Misalignment angles (Roll, Pitch) with the vessel axes: < 0.1°

4.4 MRU mounting orientation

The default mounting position is defined with the MRU connector facing downward, the x-axis pointing forward and the y-axis pointing starboard. The illustrations show the mounting orientation of the x, y and z indexes at the top of the MRU according to the axes of the ship as well as the default mounting position. The directions marked on the MRU housing (x, y, z) should be aligned with the ship axes in the following way:

- The x-axis (x arrow) points in the bow (forward) direction of the ship.
- The y-axis (y arrow) points horizontally and starboard.
- The z-axis points in the downward direction.

Figure 5 Top view of MRU with x, y and z direction

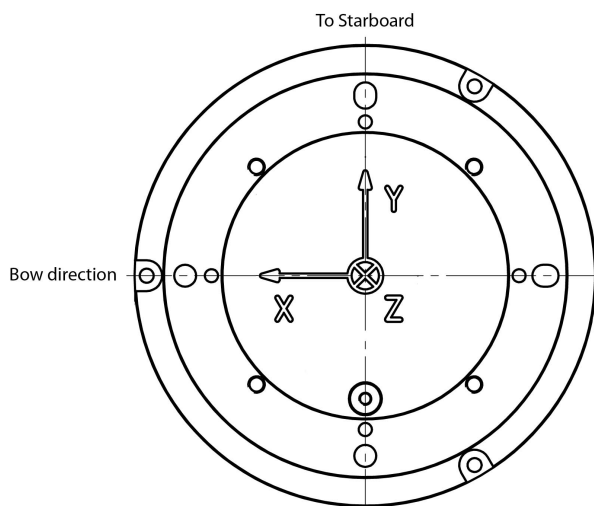
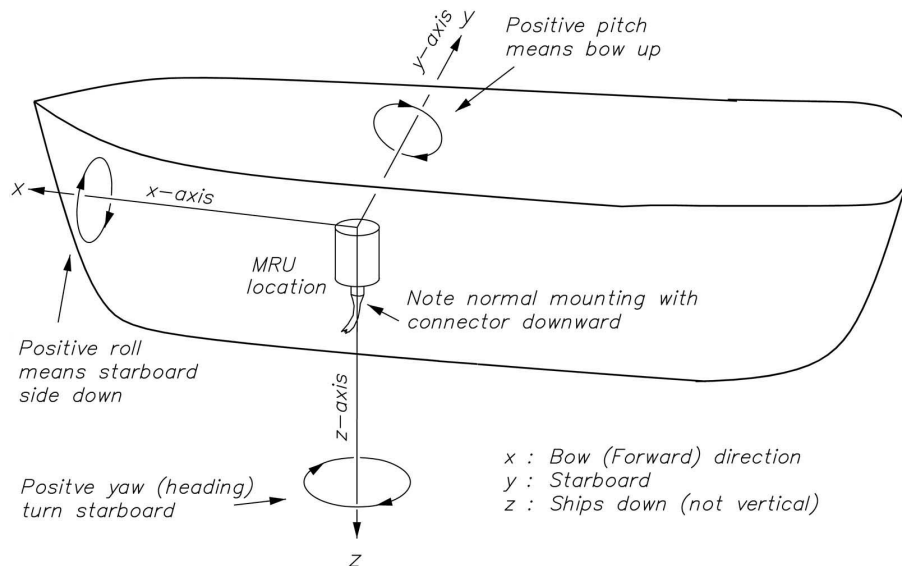


Figure 6 Default MRU mounting position



Positive (+) output signals from the MRU include:

- Positive pitch means bow up, or a clockwise rotation about the y-axis.
- Positive roll means starboard (right) side facing downward, or a clockwise rotation about the x-axis.
- Positive yaw (heading, azimuth) means a turn to starboard (right), or a clockwise rotation about the z-axis.

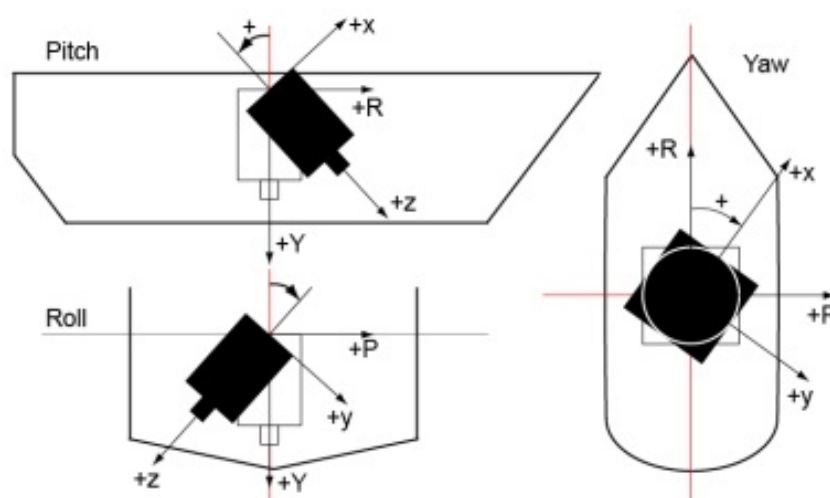
The MRU is best mounted with the logical axes in the direction described above to avoid confusion and problems with the definition of the roll, pitch, yaw output angles. However, the MRU can be mounted in any orientation relative to the above mentioned logical axes. In this case, the offset angles between the MRU axes (x, y, z) and the ship axes (R, P, Y) are simply entered in the MRU configuration software, MRC+. See *Configuration tab* on page 61 for a description on how to configure the MRU and set the mounting angles.

In the MRC+ a mounting wizard is available to assist in determining the MRU mounting angles. This mounting wizard starts with applying the main rotation which means to change the mounting angles in steps of 90° for each axis. After applying the main rotation of the MRU, the bracket offset angles are defined as the remaining offset angles of the MRU axes (x, y, z) relative to the ship axes (R, P, Y). The roll and pitch bracket offset angles can be interpreted as the bracket's tilt angles relative to the ship deck plane (horizontal plane). Be aware that these angles are not exactly the same as the MRU roll and pitch mounting angles. The MRC+ mounting angle wizard will convert the measured offset bracket angles into the corresponding roll, pitch and yaw mounting angles (Euler angles) that are used in the MRU. The bracket offset angles are defined as:

- Roll offset angle. The angle between the ship Y-axis and the projection of the MRU z-axis in the ship's PY-plane.

- Pitch offset angle. The angle between the ship Y-axis and the projection of the MRU z-axis in the ship's RY-plane.
- Yaw offset angle. The angle between the ship R-axis and the projection of the MRU x-axis in the ship's RP-plane.

Figure 7 MRU bracket misalignment offset angles. Positive roll offset angle if the bracket tilts to starboard. Positive pitch offset angle if the bracket tilts to stern. Positive yaw offset angle if bracket is rotated clockwise



Note

Mounting of the MRU with the x-axis (x arrow) pointing up (90, 0, 0) or down (-90, 0, 0) should be avoided due to that there is a singularity in the Euler angle representation for a 90 degree pitch angle. Therefore, the wizard for mounting angles in the MRC+ software doesn't support these orientations.

Note

If the bracket offset angles exceed 45°, another main rotation should be selected.

In *Calibrating the MRU axis* on page 51 it is described to which accuracy the mounting angles have to be calibrated to ensure that the MRU functions are according to specifications. The MRU software automatically corrects the mounting angles back to the default orientation when these angles are set in the MRC+ software.

See *MRU User Manual* in *References* on page 102 for details on the different frames which are used, like the MRU/sensor frame (x, y, z), ship/body frame (R, P, Y), heading frame (F, S, D) and geographical frame (N, E, D).

Related topics

- *Configuration tab* on page 61

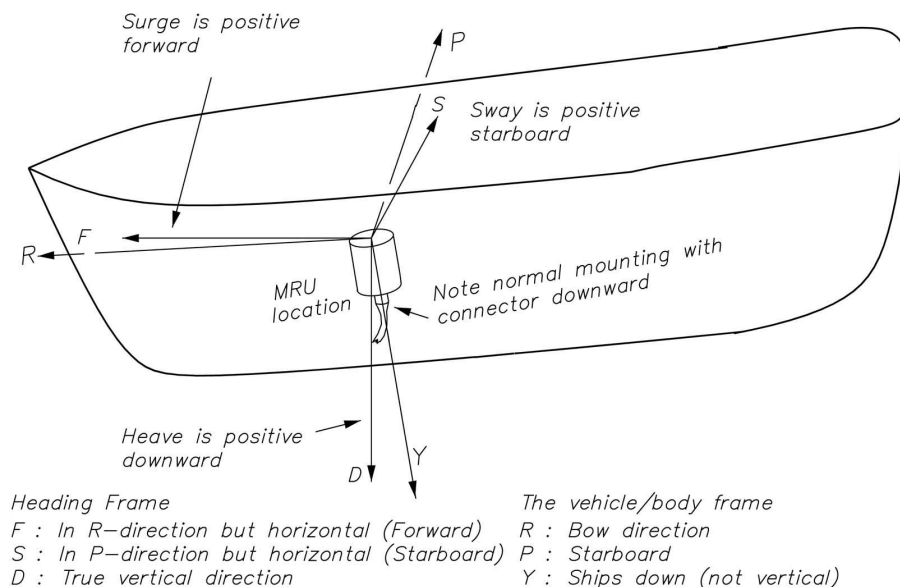
- *Calibrating the MRU axis on page 51*

4.5 Axis direction for surge, sway and heave measurements

The default axis directions for the linear motion are defined as follows:

- Surge is defined positive in a horizontal axis direction pointing forward (F-axis).
- Sway is defined positive in a horizontal axis direction pointing starboard (S-axis).
- Heave is defined positive pointing downward (D-axis).

Figure 8 Axis directions for surge, sway and heave



4.6 Use of lever arms

Setting up lever arms in the MRC+ configuration software simplifies the installation of some applications like heave compensation of cranes. The sensor unit can then be located some distance away from the location of the monitoring points.

Lever arm vectors up to 40 metres from the sensor unit to the location of the monitoring points (MP) can be used without significantly degrading the sensor unit linear position and velocity output accuracy.

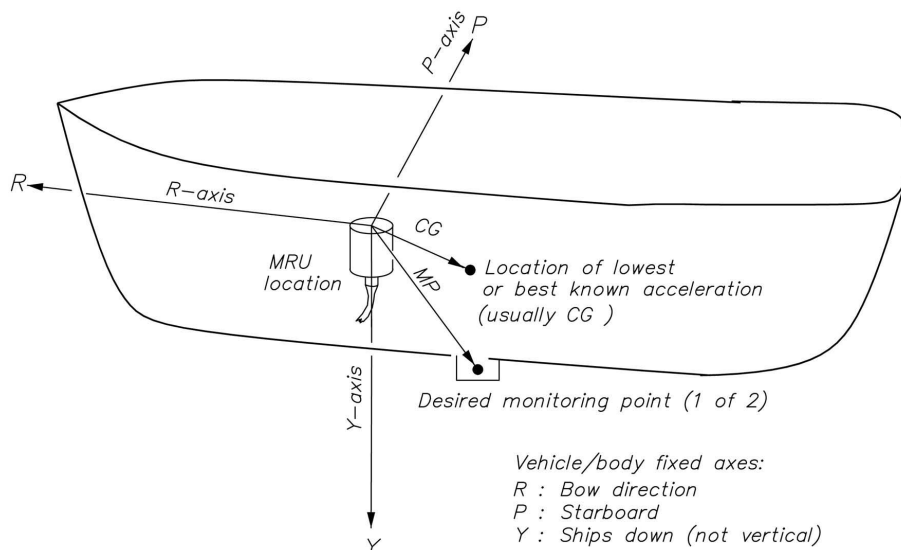
Note

The sensor unit linear acceleration measurements can only be transferred a few metres else the accuracy of these measurements will be degraded.

The sensor unit achieves its best roll and pitch accuracy when the unit is mounted at the vessel's centre of gravity (CG). Although it is often not possible to mount the sensor unit at precisely the CG, it is possible to compensate for this and achieve the same roll and pitch accuracy as if the sensor unit was mounted at the vessel's CG by inputting the lever arm CG vector in the sensor unit configuration.

When lever arm corrections are used, the following lever arm co-ordinates must to be defined in the MRC+ configuration software:

Figure 9 Location of MRU, CG and MPs on vessel



Definition of the Centre of Gravity (CG) lever arm

This is the lever arm vector (the components along the R, P, Y axes) from the sensor unit to the vessel's Centre of Gravity (CG). The components must be measured in metres from the sensor unit location with an accuracy better than one metre.

Definition of the Monitoring Point lever arm (MP)

In the sensor unit two individually configurable monitoring points are available. Typical vector (R, P, Y) from the sensor unit to a desired MP is illustrated. The components must be measured in metres from the sensor unit location with an accuracy better than 0.1 metre. In systems where the MPs are not a fixed point relative to the sensor unit location (crane, for instance), the sensor unit is designed to receive input co-ordinates for the lever arm MP from a computer through the digital interface. The command Set Lever Arm Vector is used to continuously update the sensor unit with the correct MP values. See *MRU binary protocol* on page 104 for more information on this command.

Note

The sensor unit position is the origin of the co-ordinate system from which the CG and MP lever arms are to be measured. A component is positive when moving in the positive axis direction from the sensor unit position. Be aware that the vertical axis is positive down. Use the graphical view in MRC+ to ensure the MPs are correctly positioned.

When using long lever arms, any vessel vibration sensed by the sensor unit will increase the noise level of the measurements, because angular velocity and numerically derived angular acceleration are used in these computations.

Caution

Use caution when selecting a location for the sensor unit. Incorrect use of lever arms will result in degraded performance.

Related topics

- See *Configuration tab* on page 61 for additional details on how to configure the sensor unit and set up the CG and MP lever arms.

4.7 Installation procedures

The installation is performed in two steps, or three steps if the MRU is installed in the MRU subsea bottle:

- Mechanical installation of the mounting bracket, the MRU and the junction box.
- Electrical installation of the MRU cable connectors and power to the junction box at one end, and cable connectors for the HPR system at the other end.
- Installation of the MRU in the subsea bottle.

In addition, the user can modify the standard MRU configuration.

4.8 Mechanical installation

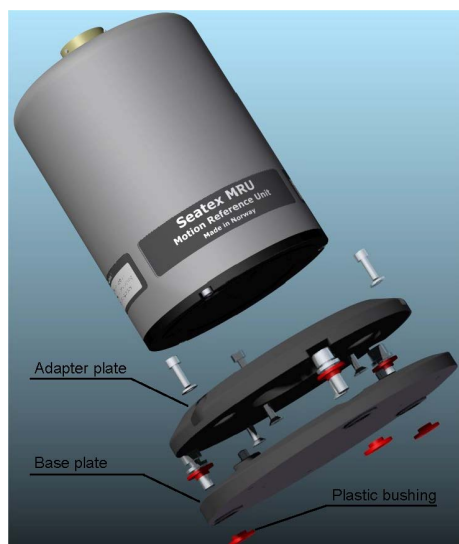
The MRU can be mounted on board by use of the **floor mounting bracket** (MRU-M-MB5), the **wall mounting bracket** (MRU-M-MB4) or the **protected mounting bracket** (MRU-M-MB6). Choose the appropriate installation procedure for the Bracket delivered with your product.

How to install the MRU — floor mounting bracket

- 1 Identify the best mounting location for the MRU. The best location is on the floor or on a steel table.
- 2 When the mounting location has been identified, place the mounting base plate in the preferred orientation. If the orientation of the bracket can be freely selected, mount the base plate with the x arrow pointing in the bow direction. The figure

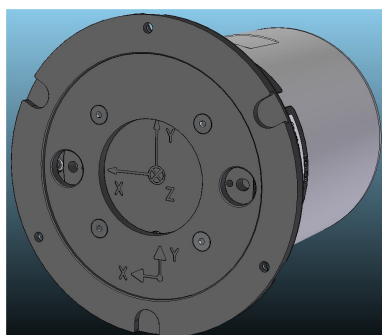
MRU with floor mounting bracket on page 35 shows the different components for mounting the MRU on the floor.

Figure 10 MRU with floor mounting bracket



- 3 Mark and drill three M6 holes in the foundation for the base plate screws.
- 4 Place a plastic bushing between the floor and the base plate for each of the three holes. This is done for electrical and mechanical insulation of the MRU from the foundation due to earthing and to prevent corrosion.
- 5 For each base plate hole, enter a plastic bushing, then a washer and finally enter the M6 screw. In the other end, enter a nut for each screw. The nut should be secured with a washer or by using a self-locking nut.
- 6 Mount the adapter plate to the MRU, as shown in the figure *Adapter plate mounting on MRU* on page 35. Ensure that the x and y arrow directions are the same on the adapter plate and the MRU. Enter the four M4 screws and fasten the adapter plate to the MRU. It is recommended to apply Loctite 242 glue or equivalent on the four MRU screws.

Figure 11 Adapter plate mounting on MRU



- 7 Place the MRU with the adapter on top of the base plate, as shown in the figure *MRU mounted in bracket* on page 36. Ensure that the MRU enters the steering pins on the

base plate properly and that the orientation of the MRU is the same as indicated (x and y arrows) on the base plate, as shown in the figure *Base plate* on page 36.

- 8 Enter the three M4 screws with washers from the adapter plate to the base plate. It is recommended to apply Loctite 242 glue or equivalent on these three screws.

The base plate has steering pins and x and y arrow indication.

Figure 12 Base plate

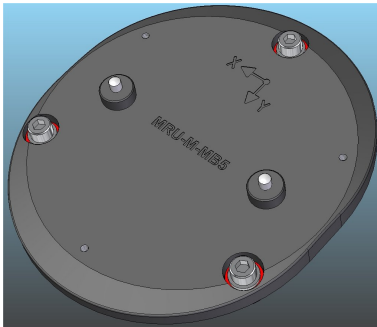


Figure 13 MRU mounted in bracket

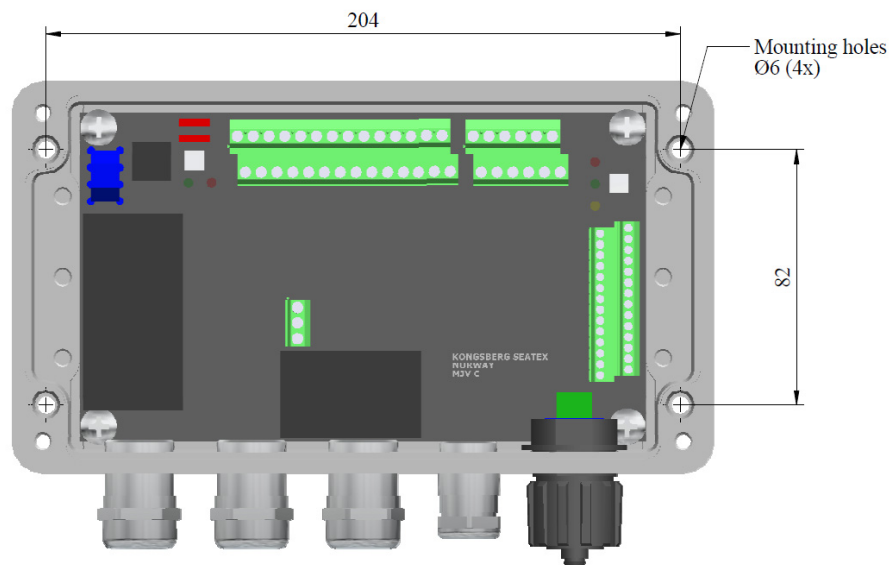


Note

The MRU mounting angles have to be modified by use of the MRU configuration to correspond with the actual mounting orientation of the MRU in the Bracket. Precise MRU orientation is important to ensure that high quality and accurate measurements are available to the host system.

- 9 Mount the junction box on the floor or wall in a suitable location within the length of the 3-metre MRU-E-CS8 cable, as shown in the figure *MRU junction box mounting* on page 37.
- 10 The screws for mounting the junction box should be secured with washers or self-locking nuts.

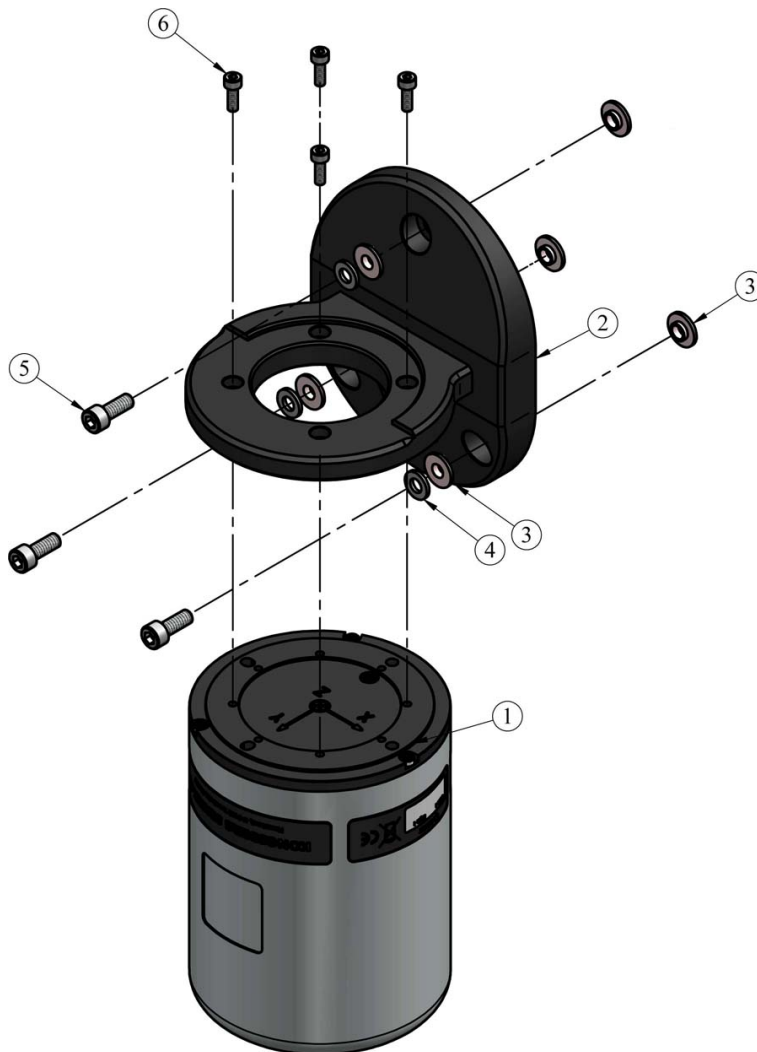
Figure 14 MRU junction box mounting



How to install the MRU with wall mounting bracket

- 1 Identify the best mounting location for the MRU. Preferably mount the Bracket on longitudinal or transversal bulkheads of the hull structure, this to assist alignment and to prevent vibration.
- 2 Preferably mount the MRU with the opening pointing downwards, as illustrated.
- 3 Reserve sufficient space below the Bracket for the MRU and the cable.
- 4 Mount the Bracket to the wall with the screws, pos. 5, before the MRU is mounted to the Bracket.
- 5 Clean the surface between the MRU and the Bracket carefully prior to assembly. Connecting surfaces between MRU and Bracket must in no way be damaged before mounting.
- 6 Mount the MRU to the Bracket with the screws, pos. 6.

Figure 15 MRU with wall mounting bracket

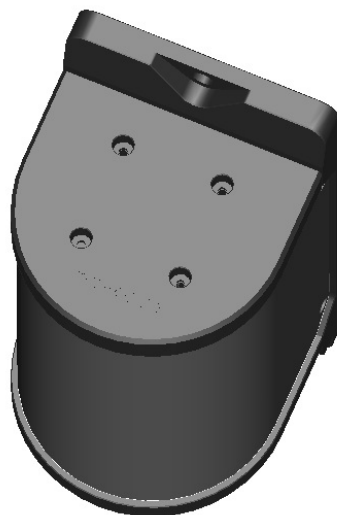


- 7 When disassembling the MRU from the Bracket for service purposes, only remove the screws, pos. 6. Do not remove the Bracket from its position.

How to install the MRU with protected mounting bracket

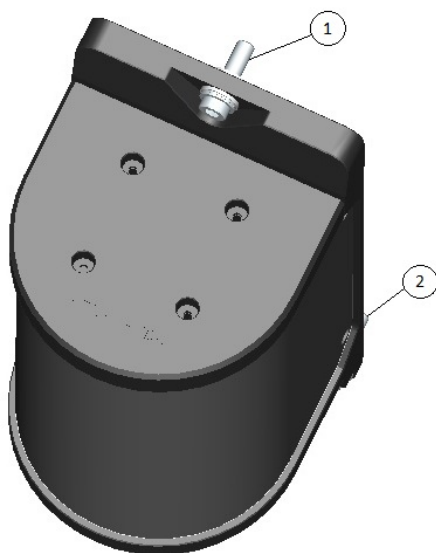
- 1 Identify the best mounting location for the MRU on the wall. Preferably mount the Bracket on longitudinal or transversal bulkheads of the hull structure, this to assist alignment and to prevent vibration.
- 2 Mount the Bracket with the opening pointing downwards, as illustrated. Reserve sufficient space below the Bracket for the MRU and the cable.

Figure 16 Wall mounting with the Bracket opening pointing down



- 3 Mark and drill an M8 hole for the top screw, pos. 1, and enter the screw without tightening it completely. Align the bracket vertically using its own weight or by aligning it in relation to the wall. Drill two holes for the lower screws, pos. 2, and insert and securely tighten all three screws, using lock washers and nuts.

Figure 17 Wall mounting with the Bracket opening pointing down



- 4 Unscrew the cover on the bottom of the Bracket, as illustrated.

Figure 18 Bracket with cover



Figure 19 Bracket without cover



- 5 Fasten the MRU cable (MRU-M-CS8) to the MRU connector and insert the MRU into the bracket.

Figure 20 Bracket with the MRU and cable inserted



Note

The MRU mounting angles have to be modified by use of the MRU configuration to correspond with the actual mounting orientation of the MRU in the Bracket. Precise MRU orientation is important to ensure that high quality and accurate measurements are available to the host system.

- 6 Fasten the MRU to the Bracket with the four M4 screws, pos. 1, with lock washers and push down the cover caps , pos. 2, at the top of the screw holes, as illustrated, to ensure that water is not entering the holes.

Figure 21 The four mounting screws for the MRU

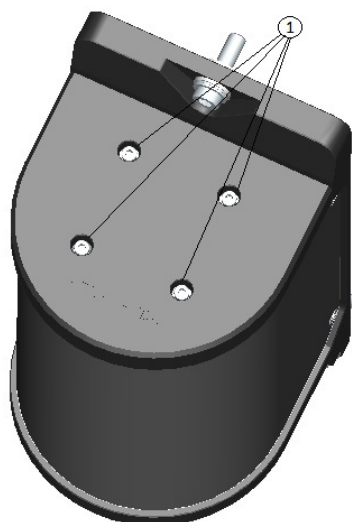
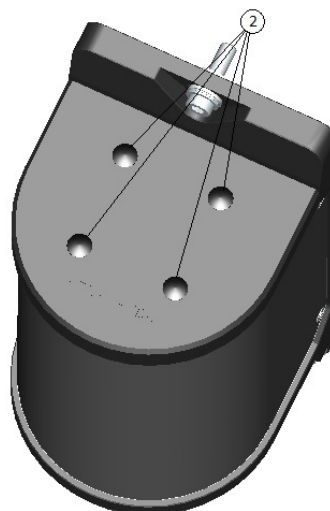


Figure 22 The cover caps entered above the screws



- 7 Mount the cover on the bottom of the Bracket with the three M4 screws, as illustrated.

Figure 23 MRU with wall mounting bracket



- 8 When disassembling the MRU from the Bracket for service purposes, do not remove the Bracket from its position only the MRU inside.

4.9 Electrical installation

Follow the procedure in order to carry out the electrical installation of the MRU.

How to carry out the electrical installation

- 1 Insert the connector on the MRU-E-CS8 cable into the sensor unit and insert the other end of the cable into the junction box.
- 2 Ensure that the cable shield is in contact with the nipple for grounding before the cable is fastened to the box. Use the required number of clips to fasten the cable to the wall.
- 3 Insert each of the cable wires into the correct terminal on the P1 side (sensor unit) within the box.

MRU P1							
Pin	Signal	Pair	Wire colour	Pin	Signal	Pair	Wire colour
1	PWR+	1	White	15	Com3_In_A	8	Red
2	PWR-	1	Blue	16	Com3_In_B	8	Green
3	Com1_Out_B	2	White	17	Com4_In_A	9	Red
4	Com1_Out_A	2	Orange	18	Com4_In_B	9	Brown
5	Com1_In_B	3	White	19	CGND	10	Red
6	Com1_In_A	3	Green	20	XIN	10	Grey
7	RJ_1	4	White	21	XOUT	11	Black
8	RJ_2	4	Brown	22	EXT0	11	Blue
9	ALERT	5	White	23	Internal	12	Black
10	GGND	5	Grey	24	Internal	12	Orange
11	RJ_3	6	Red	25	Internal	13	Black
12	RJ_6	6	Blue	26	5V	13	Green
13	Com2_In	7	Red	27	Not used	14	Black
14	Com2_Out	7	Orange	28	Not used	14	Brown

- 4 Insert the ship cable and the power cable through one of the free nipples on the junction box.
- 5 Ensure that the cable shield is in contact with the nipple for grounding before the cable is fastened to the box. Use the required number of clips to fasten the cable to the wall.

Note

Cable with shield has to be used in order to fulfil the sensor unit power and EMC requirements. The cable shield must be connected to earth only on one end (open in the other).

Fill the nipples not used with self-bounding tape. Press the self-bounding tape together as ball and fill it into the nipple. Screw in the nipples properly afterwards to ensure it is watertight. This to fulfil the enclosure protection specification.

The junction box housing is grounded to earth through the screws for mounting the box to the wall or floor. Please note that if the foundation on which the junction box is mounted is NOT connected to earth, one of the junction box mounting screws has to be connected to earth by connecting a wire from the screw to an object that is connected to earth.

- 6 Insert each of the cable wires into the correct terminal on the P2 side (user) within the box.

User P2					
Pin	Signal	Description	Pin	Signal	Description
1	PWR+	Power+	15	Com3_In_A	
2	PWR-	Powergnd	16	Com3_In_B	
3	Com1_Out_B		17	Com4_In_A	
4	Com1_Out_A		18	Com4_In_B	
5	Com1_In_B		19	Com2_In_A	
6	Com1_In_A		20	Com2_In_B	
7	AN0+	Analog ch0	21	Com2_Out_A	
8	AN0-	Analog ch0	22	Com2_Out_B	
9	AN1+	Analog ch1	23	XIN	To MRU
10	AN1-	Analog ch1	24	CGND	
11	AN2+	Analog ch2	25	XOUT	From MRU
12	AN2-	Analog ch2	26	EXT0	From MRU
13	AN3+	Analog ch3	27	CGND	
14	AN3-	Analog ch3	28	L5V	5V out

- 7 Check that the DIP switches in the upper left corner of the junction box are in the correct position according to the communication on COM3 and COM4. For RS-422 the DIP switch should be in the right position and a termination resistant of 120 Ohm will then be connected.

Correct position of these DIP switches are only important with RS-422 communication when using long cables.

Figure 24 DIP switch position for RS-422 communication (default)

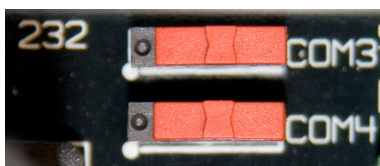
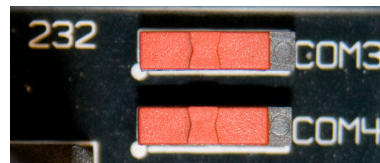


Figure 25 DIP switch position for RS-232 communication



- 8 If a ready signal for the analog output signals is required, insert the ship cable wires for this signal into the terminals on the P3 side within the box. This is done by feeding +24 V DC into RL_C pin and running a wire back into the host system from RL_NO pin. This will give the host system a +24 V DC signal from RL_NO pin when analog output signals are ready.

User P3					
Pin	Signal		Pin	Signal	
29	CGND		35	Com2_In	
30	Not in use		36	Com2_Out	
31	RJ_1	TD+	37	RL_NO	
32	RJ_2	TD-	38	RL_C	
33	RJ_3	RD+	39	RL_NC	
34	RJ_6	RD-	40	CHASSIS	⊥

Note

After finishing the wiring of the junction box, ensure that the unused nipples are watertight by inserting Duct tape into these nipples.

- 9 Optional, insert the power cable with 100 to 240 V AC into the terminal on the P4 side within the box if 24 V DC is not available.

User P4		
Pin	Signal	Wire colour
1	Ground	Yellow
2	L	Brown
3	N	Blue

Note

It is possible to input both 24 V DC on User P2 side and 100 to 240 V AC on the User P4 side simultaneously.

- 10 When all cable wires are connected, apply power to the junction box.
- The MRU PWR light diode in the junction box should then shine green indicating that the sensor unit receives power.
 - The AC PWR will shine red if AC power is connected to the AC 100 - 240 V terminal; else AC PWR light diode is off.
 - The COM light diode will flash red if digital data are sent from the sensor unit on COM1.
 - The MRU light diode will shine green if the sensor unit is running, else off.
 - The DAC diode will shine yellow if analog output is used, else off.

- 11 If the lights in the LEDs are according to your connections, the installation is now finished, unless the standard configuration delivered with the sensor unit needs to be modified for the specific installation.

4.10 Subsea installation

As an option the MRU can be delivered mounted in a subsea bottle.

4.10.1 MRU mounted in 4000-metre bottle

This subsea bottle is made in titanium and designed for use down to 4000 metres. Inside the bottle the MRU is mounted within an inner cylinder with steering plate.

Correct installation and orientation of the MRU within the bottle is ensured by the design of this inner cylinder. The mounting orientation of the MRU within the bottle is indicated on the bottom cover plate.

On the outside there are four mounting holes (M8) on the bottom cover plate. The user must design his own mounting arrangement for the bottle based on these four mounting holes (M8). In addition, there is a protection cap on each cover plate to protect the bottle from damage and for help during alignment.

The bottle is delivered with two 8-pin Seacon connectors, one for serial and one for Ethernet communication.



4.10.2 MRU mounted in 1000-metre bottle

This subsea bottle is made in anodised aluminium and designed for use down to 1000 metres. Inside the bottle the MRU is mounted within an inner cylinder with steering plate.

Correct installation and orientation of the MRU within the bottle is ensured by the design of this inner cylinder. The mounting orientation of the MRU within the bottle is indicated on the bottom cover plate.

On the outside there are four mounting holes (M8) on the bottom cover plate. The user must design his own mounting arrangement for the bottle based on these four mounting holes (M8). In addition, there is a protection cap on each cover plate to protect the bottle from damage and for help during alignment.

The bottle is delivered with two 8-pin Seacon connectors, one for serial and one for Ethernet communication.

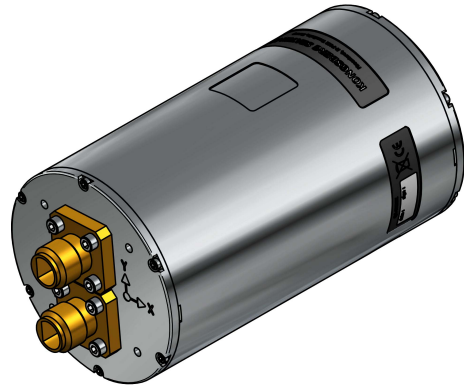


4.10.3 MRU mounted in 50-metre bottle

This subsea bottle is made in stainless steel and designed for use down to 50 metres. Inside the bottle the MRU is mounted on a steering plate.

On the outside there are four mounting holes (M6) on both cover plates. The mounting direction of the MRU within the bottle is indicated on the bottom cover plate.

The bottle is delivered with two 8-pin Seacon connectors, one for serial and one for Ethernet communication.



4.10.4 Connector and pin configuration

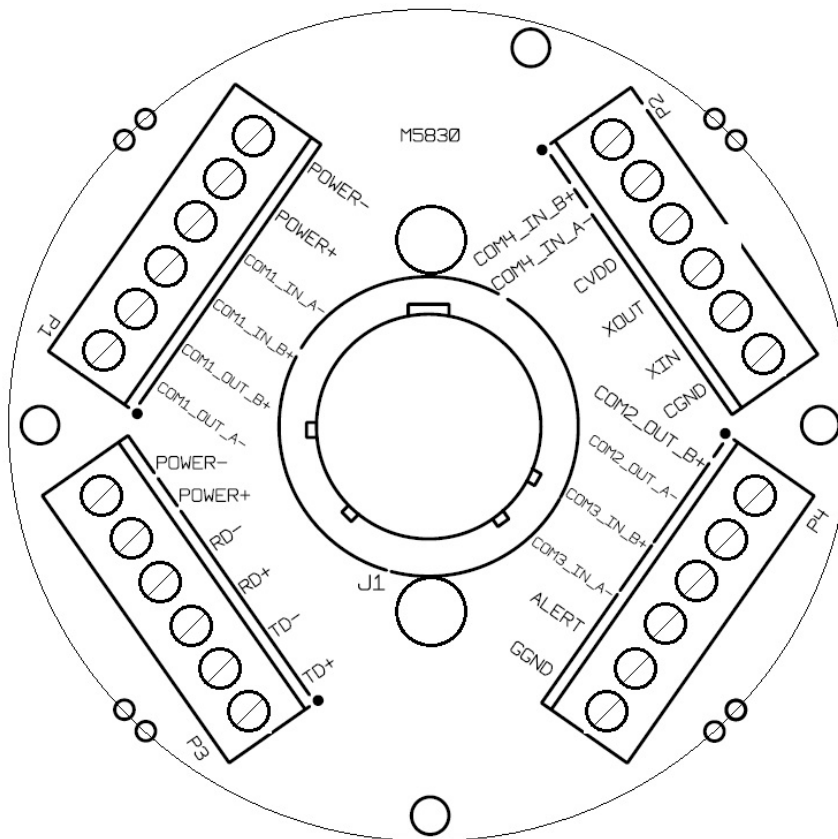
The bottle includes two 8-pin Seacon connectors. The part number for the Seacon connector is 5506-1508 (male). A Seacon pigtail for the customer's own application can be delivered as an option (part no MRU-E-PT8).

Inside the bottle is a connector board where the wires from the Seacon connectors are terminated to the MRU connector pins. The user can modify which signals that are input/output on the Seacon connector by reconnect the wires from the Seacon connector. The connector board is mounted on the connector plate of the subsea bottle.

Note

Even though the COM2 output from the MRU is RS-232, the output from the subsea bottle will always be RS-422 on COM2 since the signal is converted from RS-232 to 422 on the connection board.

Figure 26 Layout of the connector board with the different terminals



Connector A: Default pin configuration, Seapath 200/300 compatible

Pin	Signal (Seapath compatible)
1	POWER -
2	POWER +
3	COM1_IN_A-
4	COM1_IN_B+
5	COM1_OUT_B+
6	COM1_OUT_A-
7	CGND (ground ref for XIN)
8	XIN (Seapath 1PPS)

The user can reconfigure the pin configuration for his application. An alternative pin configuration for serial communication with serial output on COM1 and input of speed or heading on COM3 or 4 is (to be modified by the user):

Pin	Signal (general serial communication)
1	POWER -
2	POWER +
3	COM3_IN_A-
4	COM3_IN_B+
5	COM1_OUT_B+
6	COM1_OUT_A-
7	COM4_IN_A-
8	COM4_IN_B+

Connector B: Default pin configuration, Ethernet communication

Pin	Signal (Ethernet communication)
1	POWER -
2	POWER +
3	RD- (RJ_6)
4	RD+ (RJ_3)
5	TD- (RJ_2)
6	TD+ (RJ_1)
7	GGND
8	ALERT

4.10.5 Corrosion protection, 1000-metre bottle

The following steps should be taken into consideration to protect the subsea bottle from corrosion during installation:

- Coat all the cover screw holes with silicone grease to avoid pitting corrosion.
- Do not connect the bottle housing galvanically to any steel structures or other conducting materials.
- For long term submerged operations, connect a zinc anode cover to the bottle.
- If not using the screws provided in the kit, be sure that the replacement screws are made of stainless steel.

4.10.6 MRU mounting procedure within MRU-M-SB9 & 10

How to carry out installation of the MRU into an empty bottle

- 1 Remove the polycarbonate protection cap at the connector end of the bottle by unscrewing the four M5 screws holding the cap. Unscrew the six M3 screws holding the connector lid on to the main cylinder.

- 2 Carefully jack up the connector lid by inserting a couple of large screwdrivers into the traces at the top of the cylinder and bend gently and evenly. This may be easier if the bottle is placed horizontally so that the weight of the interior is not preventing the opening.
- 3 The connector lid including inner support cylinder and steering plate can now be removed from the rest of the bottle.
- 4 The connector lid is placed upside down on a table and the inner cylinder is removed by unscrewing four M3 screws along the edge facing down towards the connector lid.
- 5 Attach the MRU to the connector board in the connector lid by gently turning it on the connector until it slides down in position (the coding of the connector fits). Make sure that the adapter with o-ring is between the MRU and the connector board. Reassemble the inner cylinder with steering plate and make sure that the direction is correct by looking into the inspection holes in the steering plate. One should here see the same markings on the MRU as indicated in the steering plate. Fasten the MRU to the inner cylinder steering plate with the four M4 screws supplied with the cylinder. Press the inner cylinder down and fasten the four M3 screws to the connector lid.
- 6 Inspect and apply silicon grease to the o-ring part of the main cylinder and the o-rings on the connector lid. Observe that the PTFE support ring is ok and in position.
- 7 Before entering the MRU into the main cylinder it is recommended to flush it with nitrogen or at least make sure that the air inside is dry (humidity < 30 % and no water inside). Then slide the whole arrangement with the connector lid and the MRU back into the main cylinder and rotate it until steering pin engages with bottom lid. Press down and mount the six M3 screws holding the connector lid.
- 8 Mount the protection cap. For the 1000-metre bottle, MRU-M-SB10, mount a zinc anode on it. Then pressure test the subsea bottle before subsea installation. Remember always to mount dummy connector on connectors not used during pressure test and subsea operation.

4.10.7 MRU mounting procedure within MRU-M-SB11

How to carry out installation of the MRU into an empty bottle

- 1 Unscrew the six M3 screws holding the connector lid on to the main cylinder.
- 2 Carefully jack up the connector lid by inserting a couple of large screwdrivers into the traces at the top of the cylinder and bend gently and evenly. This may be easier if the bottle is placed horizontally so that the weight of the interior is not preventing the opening.
- 3 The connector lid can now be removed from the rest of the bottle.
- 4 Attach the MRU to the connector board in the connector lid by gently turning it on the connector until it slides down in position (the coding of the connector fits). Make sure that the adapter with o-ring is between the MRU and the connector board.
- 5 Inspect and apply silicon grease to the o-ring part of the main cylinder and the o-rings on the connector lid. Observe that the PTFE support ring is ok and in position.

- 6 Before entering the MRU into the main cylinder it is recommended to flush it with nitrogen or at least make sure that the air inside is dry (humidity < 30 % and no water inside). Then slide the whole arrangement with the connector lid and the MRU back into the main cylinder and rotate it until steering pins engages with bottom lid. Press down and mount the six M3 screws holding the connector lid.
- 7 Pressure test the subsea bottle before subsea installation. Remember always to mount dummy connector on connectors not used during pressure test and subsea operation.

4.11 Calibrating the MRU axis

After the mechanical installation is completed, the MRU x, y and z axes must be aligned to the corresponding vessel axes or the axes of the system to be compensated. To achieve the MRU's specified roll and pitch accuracy, any misalignment of the MRU axes with the vessel axes must be precisely calculated and accounted for. The MRU axes, and particularly the yaw axis, must be aligned with the vessel axes with an accuracy better than 0.5 degrees to ensure that the MRU functions are according to specifications.

WARNING

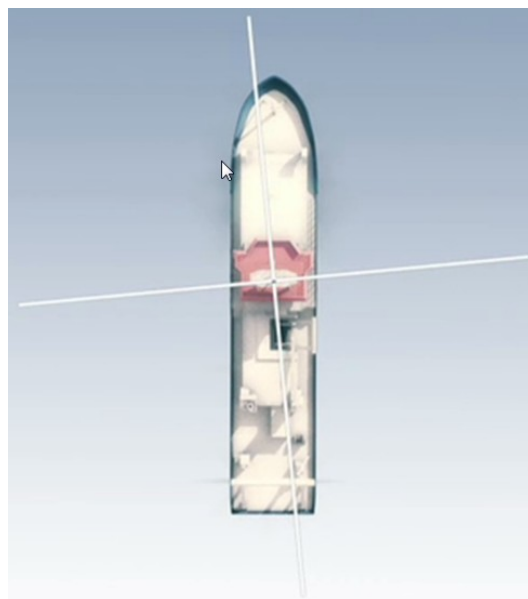
If the MRU is not calibrated and corrected for misalignment in yaw, the performance of the product will be degraded.

A typical alignment process consists of aligning the MRU axes to an external reference. Type of reference must be determined according to the required accuracy.

The reference for roll and pitch alignment must be carefully selected depending on the intended application. It may be the hull, a sensor such as a multibeam echo sounder or a USBL acoustic system. Some sensors have internal alignment routines, and accurate alignment of the MRU is not required.

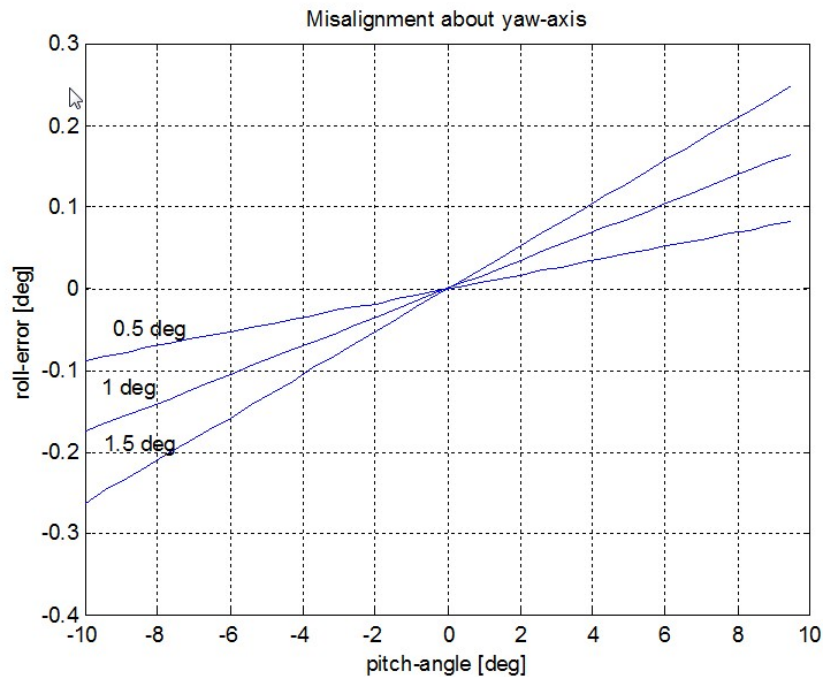
An accurate alignment of the MRU x arrow towards the vessel's longitudinal axis (yaw orientation) is of special importance. If not properly aligned, the performance of the roll and pitch measurements from the MRU will be degraded. The plot illustrates that a misalignment of 1 degree of the MRU in yaw will result in a roll error of ± 0.09

Figure 27 Alignment of MRU yaw axis to vessel longitudinal axis



degrees if the vessel is pitching ± 5 degrees. To determine the misalignment of the MRU axis to an accuracy of 0.5 degrees or better is not easy and requires use of an accurate external reference.

Figure 28 Value of roll error as a function of vessel pitch angle, displayed at 0.5°, 1° and 1.5° MRU yaw misalignment



Related topics

- *Mounting wizard* on page 67

5 Configuration

The configuration software, **MRC+**, is used to set configuration parameters in the sensor unit. It runs under Microsoft Windows XP, Vista and 7 (32 and 64 bit). The **MRC+** communicates with the sensor unit through the Ethernet.

The **MRC+** software is a part of the standard delivery. The software has the following main functions:

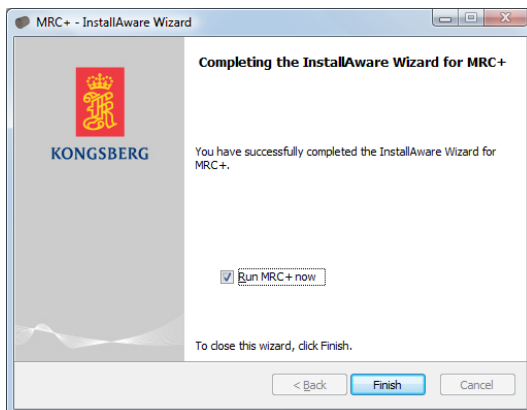
- Configure the sensor unit for specific applications
- Check the internal status of the sensor unit (status log file)
- Load new software to the sensor unit
- Plot data to the screen and log data on file

5.1 MRC+ installation

Follow the procedure to install the **MRC+** software on the local PC (standard Windows procedure).

How to install the MRC+ software

- 1 Insert the memory stick with the software in the USB port on the local PC.
- 2 Start up the Explorer program if not already done.
- 3 Open the Removable Disk drive to which the memory stick is connected.
- 4 Open the file `MRC+setup.exe` in the **SW\MRC** folder .
- 5 Follow the instructions on the screen in order to complete the installation of the **MRC+** program.
- 6 Observe that the window illustrated appears when the installation of files is finished.

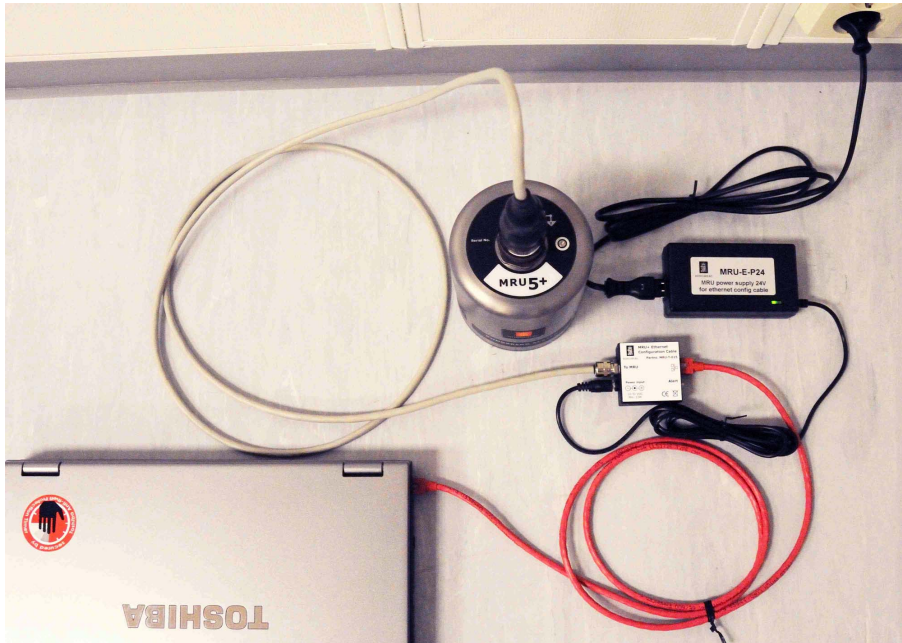


- 7 It is recommended to select the **Run MRC+ now** check box.
- 8 Click **Finish** and the setup is completed.
- 9 Terminate the Explorer program and remove the USB memory stick from the local PC.

5.2 Starting the MRC+ configuration program

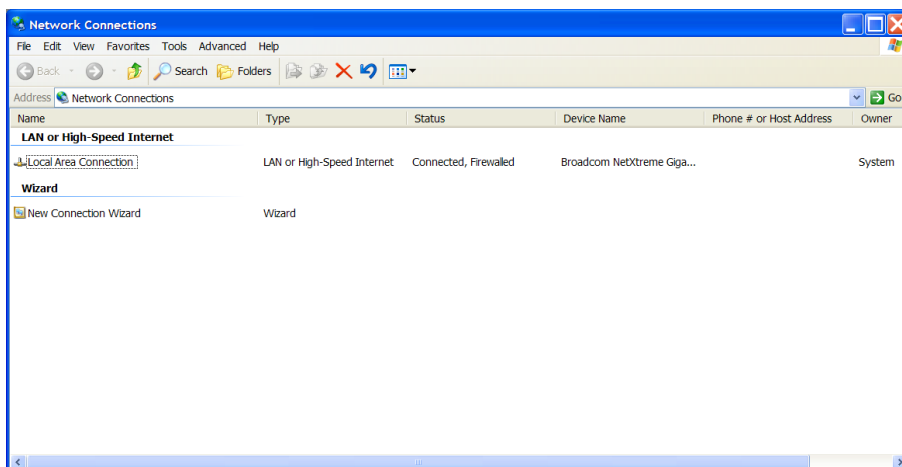
How to start the software

- 1 Power up the PC with the MRC+ installed if not already running.
- 2 Connect a cable from a free Ethernet port or switch on the PC to the Ethernet connector on the MRU-T-015 box. Connect the Ethernet configuration cable MRU-T-015 to the sensor unit. Normally, the Ethernet configuration cable MRU-T-015 and MRU-E-CE1 are delivered with the sensor unit for this purpose. Insert the power connector on the power inlet on the MRU-T-015 box. Use the delivered power supply MRU-E-P24 to supply the sensor unit with 24 V DC. Alternatively, connect the sensor unit to the junction box MRU-E-JB3 and an Ethernet cable between the PC and the junction box.

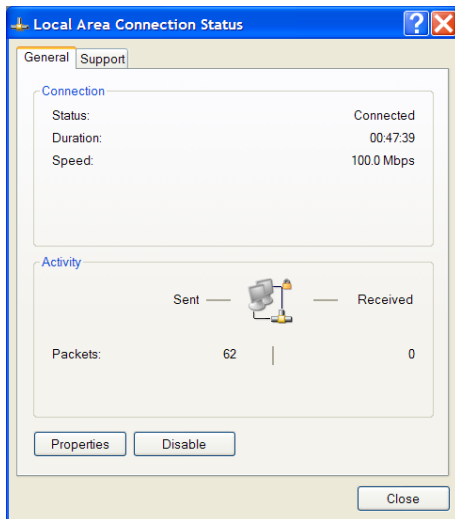


- 3 The LED on the sensor unit will start flashing green and blue indicating that the sensor unit is powered and its software is running.
- 4 The sensor unit is set up with a default Ethernet address 192.168.1.20. Then the PC with the MRC+ installed has to be set up with the address in the range 192.168.1.xx, except for the same address as the sensor unit. For instance if the sensor unit has the Ethernet address 192.168.1.20 (default), then the address on the PC could be set to 192.168.1.10.

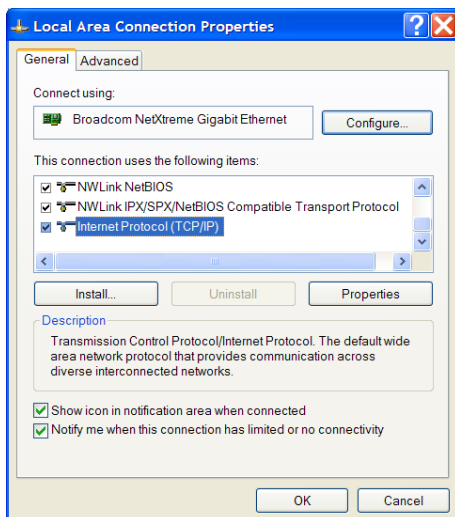
To configure the PC to use local area connection, enter **Settings** and **Network Connections** on the PC. Observe that the **Network Connections** dialog box appears.



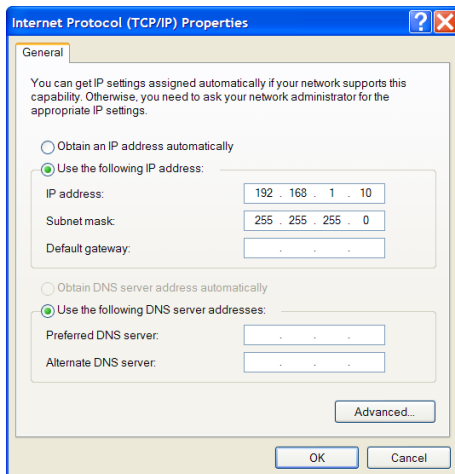
- 5 Click on the **Local Area Connection** and select the **Properties** button in the **General** tab.



- 6 In the **Local Area Connection Properties** dialog box select the **Internet Protocol (TCP/IP)** item in the list of items and click on **Properties** button.



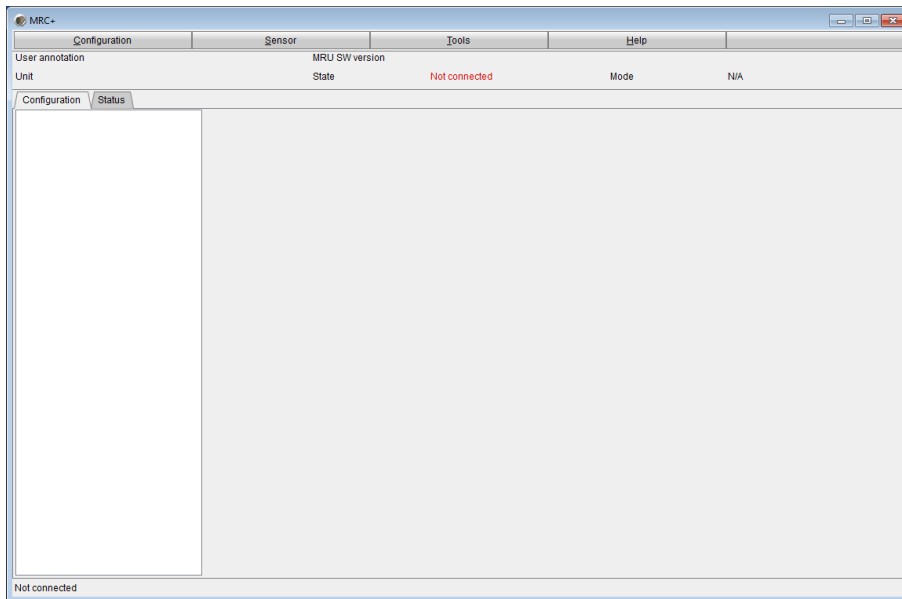
- 7 In the **Internet Protocol (TCP/IP) Properties** dialog box select the **Use the following IP address** and **Use the following DNS server addresses** option buttons exactly as illustrated. Click **OK** to exit the dialogues.



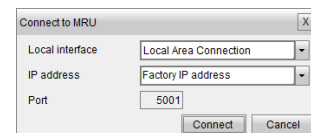
- 8 When the LED is flashing green, start up the MRC+ software by double-clicking the **MRC+** icon. First time the MRC+ is started the Windows Firewall dialogue appears. Ensure to select both **Private** and **Public** networks as illustrated.



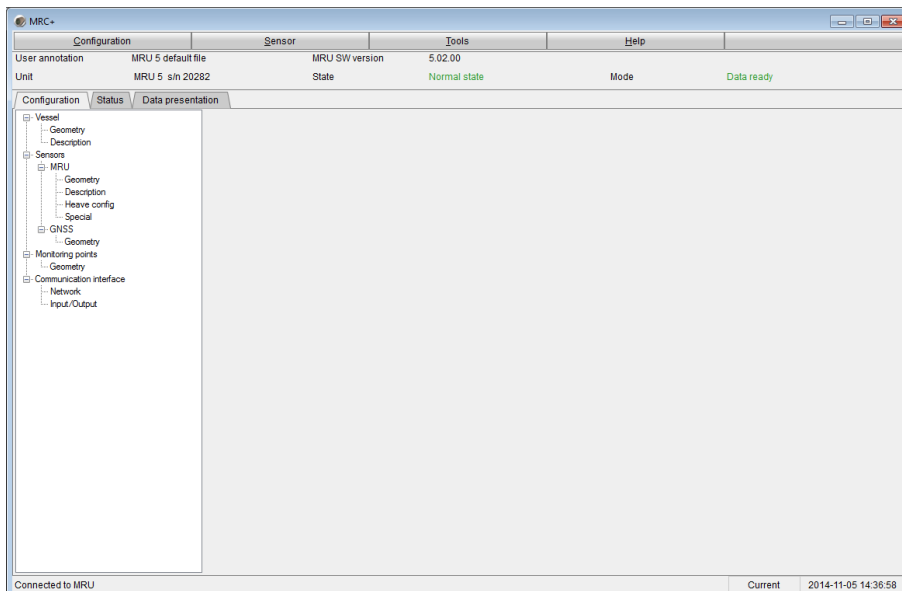
- 9 After allowing access from the firewall the MRC+ will start up.



- 10 Click on the **Sensor** menu and select **Connect**. Enter the IP address and port number and click the **Connect** button. The selection **Factory IP address** includes the default sensor unit IP address (192.168.1.20).



- 11 The MRC+ receives configuration from the sensor unit and observe that a **Configuration** tab appears on the screen. You are now connected and are free to configure according to your purpose.



- 12 If connection with the sensor unit is not establish, check if the IP address and port number are correct.

To get back to the default IP and port number for the sensor unit, press the small connector pin in the connection box on the configuration cable. Hold it in until the

blue light turns red. A yellow flash will then appear on the LED indicating that default IP is used. Repeat the connection from step 10 above.

5.3 General user interface

The MRC+ software consists of a top bar with application menus and information bar. The menus have sub-menus offering various operational options.

5.3.1 Top bar

The top bar consists of the following menus and information:



Configuration

Includes sub-menus for handling of configuration information, such as Open, Save, Revert and Send configuration file to sensor unit.

Sensor

Includes sub-menus to connect to the sensor unit, restart the sensor unit, send calibration file, synchronize clock and to upgrade software.

Tools

At the moment empty.

Help

Includes help and system details.

Info bar

Includes sensor unit type, serial number, software version, user annotation, status and mode.

Windows size/Exit

To scale the MRC+ size and to exit the software.

5.3.2 Configuration menu

The **Configuration** menu includes the following sub-menus:

Open

Opens a configuration from file.

Save

Saves the configuration to file.

Revert changes

Reverts all changes performed since the file was open.

Send to sensor unit

The edited configuration parameters in the MRC+ screen are sent to the connected sensor unit.

Exit

Exits the software.

5.3.3 Sensor menu

The **Sensor** menu includes the following sub-menus:

Connect

Connects MRC+ to the sensor unit.

Restart sensor unit

Restarts the sensor unit. The alignment time after a restart is approximately 15 minutes.

Send calibration set

Opens a calibration file and sends it to the connected sensor unit.

Demo

Runs MRC+ without a sensor unit connected.

Synchronize clock

Synchronises the clock within the sensor unit to local or UTC time.

Upgrade software

Sends new MRU software to the unit.

5.3.4 Tools menu

The **Tools** menu includes so far no sub-menus.

5.3.5 Help menu

The **Help** menu includes the following sub-menus:

MRC+ Help

A PDF-file with description of how to configure the unit with MRC+ is available.

Compatibility

Lists the MRU SW versions that can be used with this MRC+ version.

Legacy Source IDs

Lists the variables that have been given new Source IDs in the 5th generation MRU.

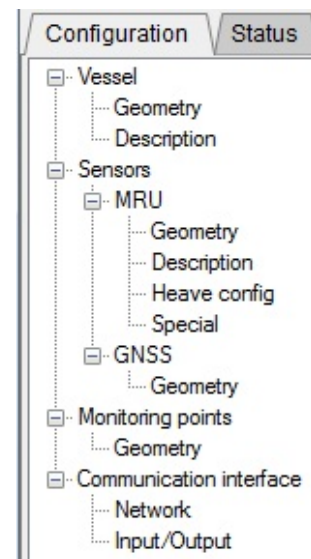
About MRC+

List MRC+ SW version, contact information and details on this software.

5.4 Configuration tab

The following parameters can be set in the Configuration tab:

- Vessel geometry and description
- Sensor data, including
 - MRU geometry, description, heave configuration and special
- Monitoring points geometry
- Communication interface, including:
 - Network
 - Input/output



5.5 Vessel configuration

Vessel configuration consists of two views: Geometry and Description.

Geometry

For later configuration of sensor and monitoring point locations it is an advantage that the background vessel (vessel shape) is as equal as possible to the vessel on which the system is installed. The background vessel is scaled on the screen to be equal to the installed vessel. To scale the vessel shape on the screen, the actual vessel dimensions have to be input.

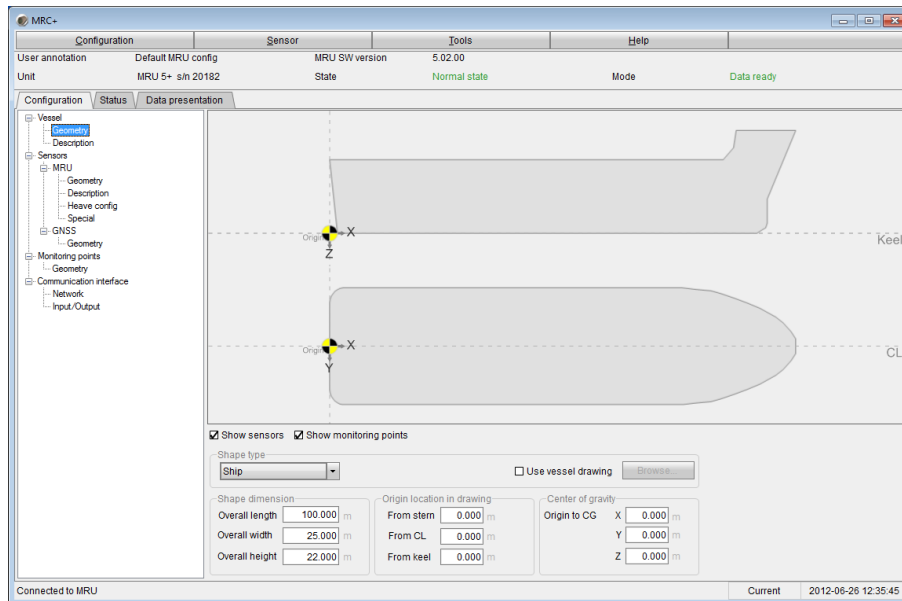
Description

Vessel data for the specific installation.

5.5.1 Vessel geometry

In the **Vessel Geometry** view, information for help to specify correct location of sensor unit and monitoring points on a vessel is entered. The drawing has to be correctly scaled based on the vessel dimensions to ensure correct indication of the various points.

Figure 29 Vessel geometry view — default vessel shape



Select the check boxes **Show sensors** or **Show monitoring points** to display objects defined in other views.

Shape type

The **Shape type** section defines the shape of the vessel hosting the system. The list contains some general shape outlines: Ship, Rig, Jackup (3 leg) and Jackup (4 leg). These are all scaled according to the dimensions given in the **Shape dimension** section.

The general shape outline can be overridden by an actual shape defined in a drawing file. Supported file extensions are **Vessel models (*.svm)**, **Vessel vector images (*.svi)** and **Old vessel images (*.txt)**. This file can be created or edited in a text editor. Select the **Use vessel drawing** check box, and browse for the wanted drawing file by clicking the **Browse** button. When a valid drawing file has been loaded, the dimensions are defined by the loaded shape and the **Shape dimension** fields are locked.

Shape dimensions

In the **Shape dimensions** section it is possible to set the following parameters:

Overall length

The overall length of the vessel, i.e. from stern to bow.

Overall width

The overall width of the vessel.

Overall height

The distance from the highest point of the vessel to the keel.

Origin location in drawing

All point locations in the configuration refer to the origin. The location of the origin is defined using distance from stern, center line and keel (often referred to as the CRP (coordinate reference point) in survey reports).

From stern

The distance from the aft point of the ship to origin along the X axis.

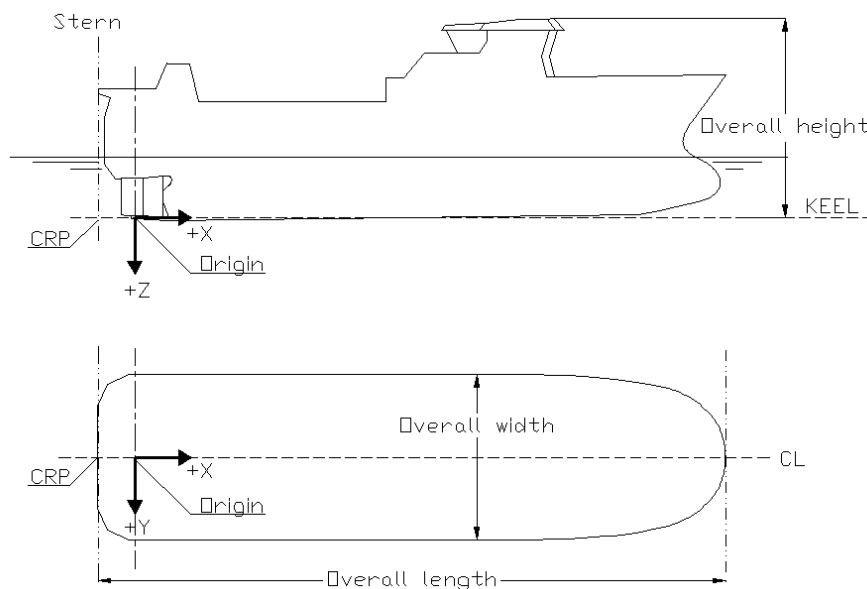
From CL

The distance from the vessel's centre line, positive towards starboard.

From keel

The distance from the keel, positive downwards.

Figure 30 Different dimensions and location of Origin



Centre of gravity

The **Origin to CG** fields in the **Centre of gravity** section defines the location of CG related to origin. The CG is the center of rotation in the vessel.

Related topics

- *Vessel shape from file* on page 64.

5.5.2 Vessel shape from file

The pre-defined scalable vessel shapes represent the actual vessel outline only in rare cases. In order to configure the accurate location of various sensors, equipment and monitoring points, it is recommended to load a separate vessel model from file.

Select the **Use vessel drawing** check box, then click the **Browse...** button to browse for an image file. Three file types are available: **Vessel models (*.svm)**, **Vessel vector images (*.svi)** and **Old vessel images (*.txt)**.

The system supports two types of two dimensional outlines: side view (towards starboard) and top view.

The vessel image file has to obey the following requirements:

- 1 The vessel data have to be in an ASCII file generated by Excel, Notepad or similar tools.
- 2 The file head includes Overall length (LOA), Overall width, Overall height and Stern to Origin data in metres.
- 3 Profile (side view) data in X and Z coordinates in metres, related to the origin. Coordinates are specified clockwise from a point aft of the origin, and the last coordinate has to equal the first coordinate to form a closed polygon.
- 4 The top view data in X and Y coordinates in metres. The first coordinate has to be aft of the origin along the centre line. Successive coordinates are specified clockwise, and the last coordinate has to equal the first to form a closed polygon.

Vessel image files may be created by Kongsberg Seatex AS upon customer request. GA drawings or similar is required to create vessel image files.

A typical example of a vessel data file is illustrated.

Figure 31 Example GA drawing of multi-purpose vessel

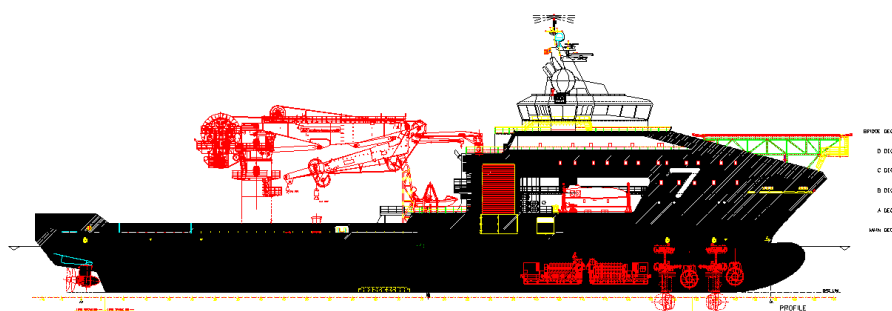


Figure 32 Example of vessel shape in user text file

```

mpv.svi - Notepad
File Edit Format View Help
%Vessel Data [m]
%LOA = 120.70
%Width = 23.00
%Height = 32.20
%Aft to AP = 7.00

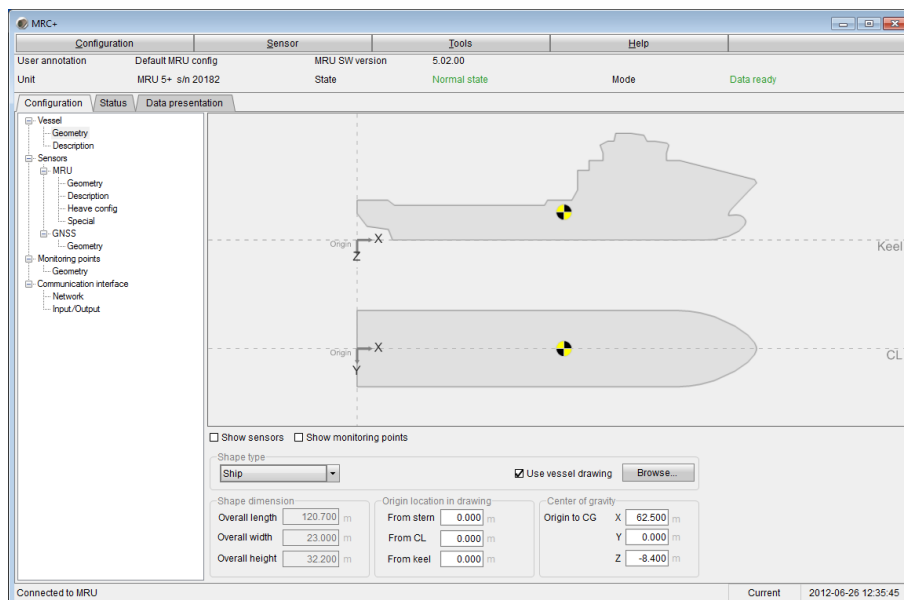
%Profile coordinates in (X,Z) [m]
0.00,-3.55
2.44,-3.19
3.69,0.00
98.60,0.00
101.00,-0.14
105.20,-1.12
108.36,-2.70
110.09,-4.51
110.35,-5.20
110.40,-5.43
110.40,-5.69
.
.
.
63.10,-24.00
63.10,-21.00
59.60,-21.00
59.62,-15.13
57.87,-12.99
49.65,-10.50
4.25,-10.50
2.31,-12.00
-7.00,-12.00
-7.00,-8.00
-4.00,-4.11
0.00,-3.55

%Profile cutout
-23.20,-36.48
-23.20,-10.24
23.20,-10.24
23.20,-36.48
-23.20,-36.48

%Top view coordinates in (X,Y) [m]
-7.00,0.00
-7.00,11.50
90.30,11.50
.
.
.
113.60,0.57
113.70,0.00

```

Figure 33 Example vessel shown in Vessel Geometry view

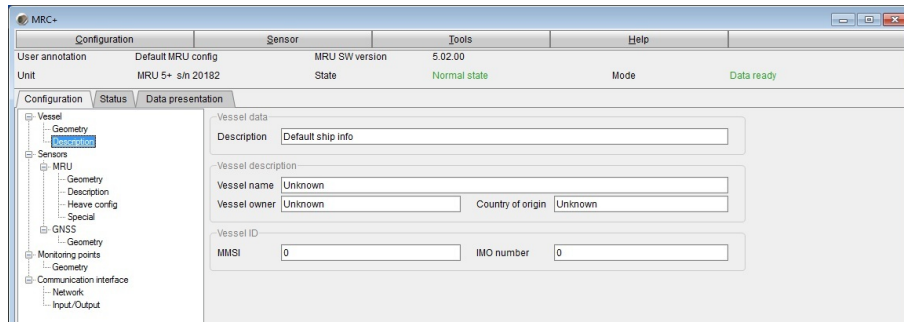


In the example, only the port side of the vessel top view is defined in the file. Symmetry is assumed, so this is sufficient to draw a symmetric vessel shape. If the vessel is *not* symmetric, use the section code %Top view coordinates in (X,Y) [m] Complete and give the coordinates along the complete shape, defined clockwise.

It is possible to define cutouts within the profile or top view polygons. For profile cutout, use %Profile cutout n , where n identifies the cutout.

5.5.3 Vessel description

The Vessel Description view contains information about the vessel needed for identification purposes, for example finding the correct configuration file at a later stage.



Vessel name

The name of the vessel. An empty name field is not allowed. The default value is **VESSEL**.

Vessel owner

The name of the vessel owner (optional).

Country of origin

The name of the vessel's country of origin (optional).

MMSI

The MMSI assigned to the vessel. Default value is 0.

IMO Number

The IMO ID assigned to the vessel. Default value is 0.

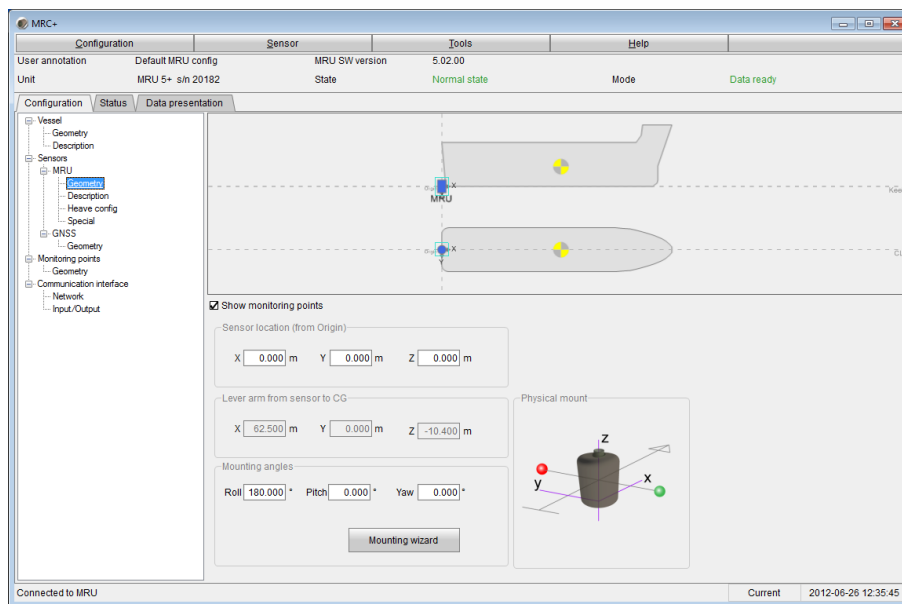
5.6 Sensors configuration

5.6.1 MRU geometry

The lever arm vector from the Origin to the MRU location has to be measured or calculated based upon drawings or previously measured points, and entered into the software. Look at the sketch of the MRU geometry on the screen in order to enter correct

signs on the co-ordinates. Check also that the MRU has been located on the expected spot in the vessel shape. If not, check the signs and the co-ordinates input for the MRU, the vessel dimension, the entered location of Origin and CG.

The sensor unit mounting angles can either be input manually or determined by use of the **Mounting wizard**.



Sensor location

Enter the position of the MRU in X, Y, Z coordinates from Origin. The sensor unit location has to be measured or calculated based upon drawings or previously measured points. The default location of the sensor unit is in the vessel Origin. If a survey report is available the vessel Origin should be located in the CRP used in the report.

Lever arm from sensor to CG

The section is for information only and shows the relative position between the sensor unit and CG. It is recommended that none of the coordinates in this exceeds more than 150 metres, else the sensor unit measurements can be unstable and start to oscillate.

Mounting angles

The mounting angles of the sensor unit in roll, pitch and yaw have to be input to the sensor unit. The mounting wizard can be used to determine these mounting angles.

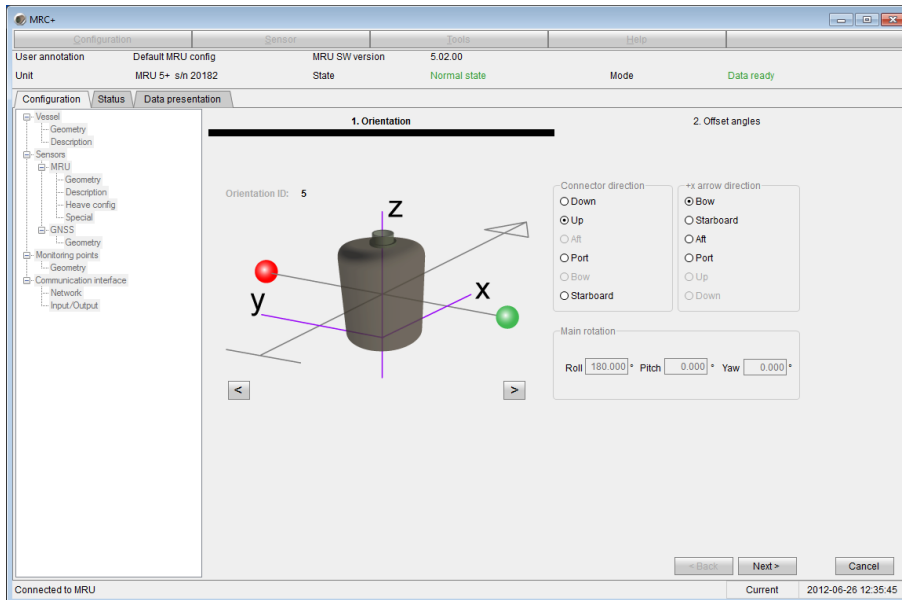
5.6.2 Mounting wizard

How to use the mounting wizard

- 1 Press the **Mounting wizard** button in the Geometry view.
- 2 In Step 1 Orientation, click the << or >> buttons in the lower left part of screen to turn the sensor unit around in 90-degree steps, axis by axis. Click until correct

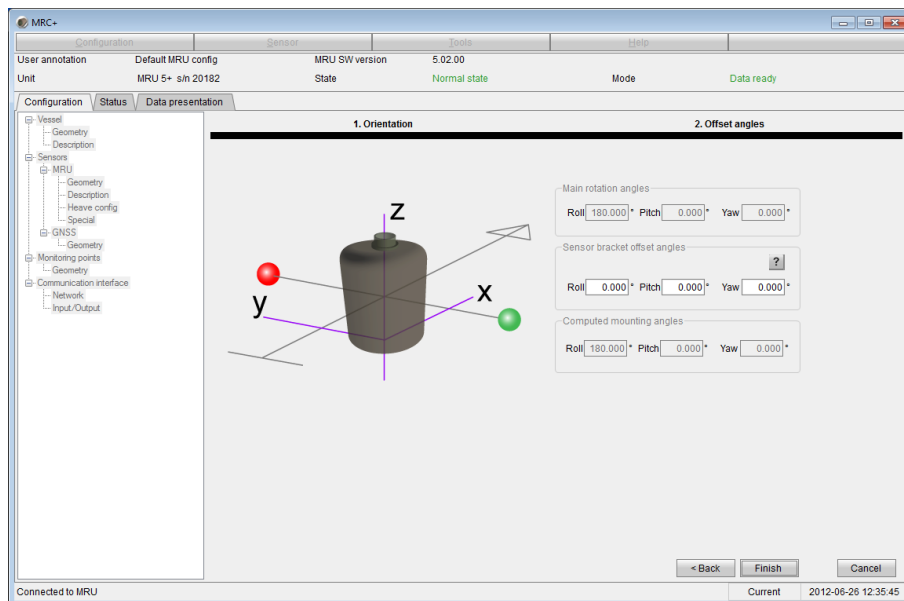
mounting orientation of the sensor has been found. The right part of this dialog box is automatically updated with the actual main rotation of the unit. Click **Next** to proceed to Step 2.

Figure 34 Step 1 Sensor unit axis orientation



- 3 At the top right in the window the main rotation angles of the sensor unit are displayed. Enter the offset angles for Roll, Pitch and Yaw from the main rotation angles. Click the **Help** button (question mark) to get more help on the sign of the offset angles. A positive offset angle rotation is:
 - a Positive roll offset means starboard (right) side facing downward, or a clockwise rotation about the x-axis.
 - b Positive pitch offset means bow up, or a clockwise rotation about the y-axis.
 - c Positive yaw offset (heading, azimuth) means a turn to starboard (right), or a clockwise rotation about the z-axis.

Figure 35 Step 2 Offset angle inputs



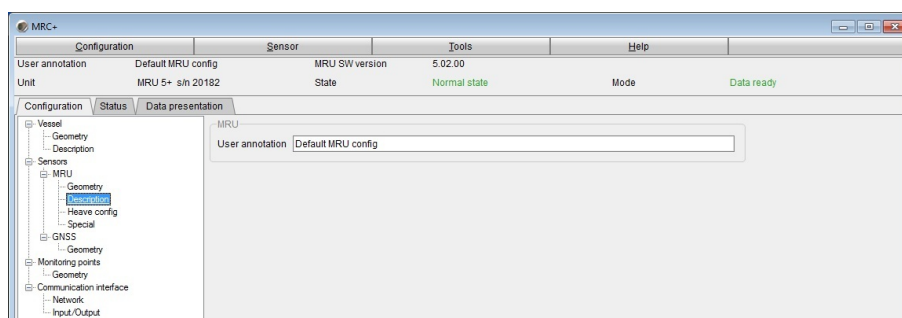
- 4 Click **Finish** to finish the setting of the MRU axis.

Note

The new MRU mounting angles are only valid in the MRU after entering the **Configuration** menu and selecting **Send to MRU**.

5.6.3 Description

The Description view includes user annotation. This information is helpful to identify the correct configuration file at a later stage. The user annotation should be a text describing the specific configuration for a vessel or installation. This text will be displayed in the **Top bar** and on status information



5.6.4 Heave configuration

When using real-time heave measurements, it is important to tune the heave parameters (heave period and damping) to the vessel motion characteristics for the actual weather conditions. The default settings for heave period and damping have to be tuned for the

actual vessel and weather conditions in order to achieve optimum heave performance. Therefore, before a survey and/or during operation check the heave performance and tune the heave parameters until the best heave performance is achieved. An alternative is to select *Automatic* and let the system automatically choose the best settings.

The following should be considered when selecting the different heave filter modes and parameters:

Option for filter mode

- **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 system is to be used for heave compensation of echo sounders and offshore crane systems.

- **Automatic**

To be selected when the vessel is operating in various sea states or when the average heave period is unknown. The *Automatic* filter mode estimates the average heave period and automatically sets the filter period in real time during operation. The *Automatic* filter mode uses the *Hydrographic survey* filter structure.

- **General purpose**

Is selected when the heave phase is of no importance. This mode is typically selected when the system is to be used for measuring the heave height and period on oceanographic buoys.

Period

- An expected average heave period has to be set to the heave filter. This period can be determined by measuring the time between two wave-tops by using a watch.
- 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 long heave period, the settling time will be slower than it has to. 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

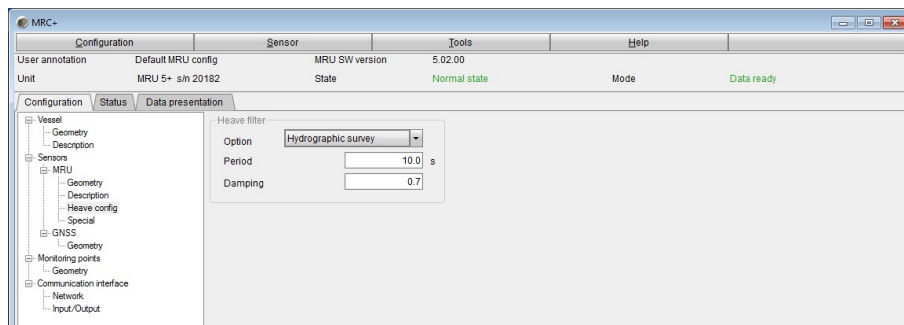
- The heave damping factor is usually set to 0.7. Only for special occasions should this parameter be changed.

For more details on selection of heave filter mode and parameters, see the *User Manual* referred in *References* on page 102.

How to select the heave configuration

- 1 Enter the settings for heave filter in the **Heave config** dialog box.

The **Option** drop-down menu has the following options; Automatic, Hydrographic survey or General purpose. In *Hydrographic survey* and *General purpose* mode, the filter parameter for Period can be set to a value between 1 and 25 seconds, and the Damping value between 0.3 and 1.3.



5.6.5 Special

The Special view includes configuration of the following parameters:

External Heading Age

A parameter for correction of delay in the external heading signal input to the sensor unit. This parameter should be set to 0 [ms] unless a more precise value is available.

Latitude Angle

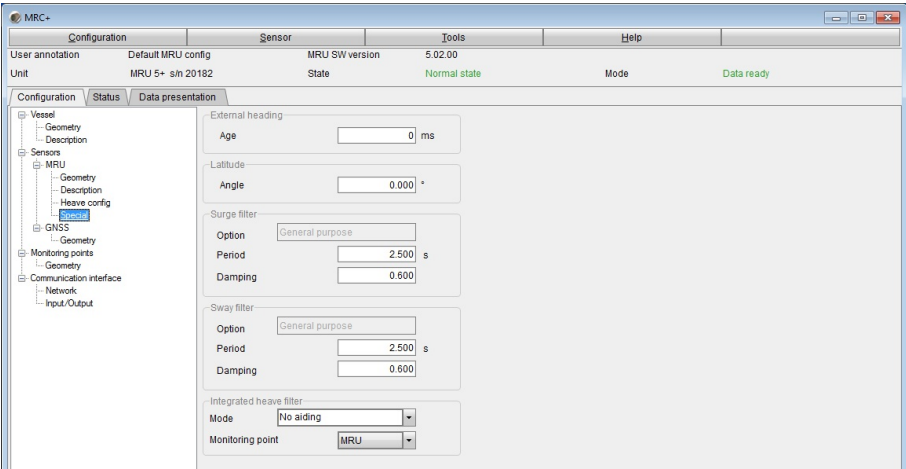
The approximate latitude for operation of the MRU is positive north, zero at equator and negative south. This parameter influences the built-in gravity estimation model of the MRU. A correct setting will slightly improve the performance on roll and pitch of an MRU. Accuracy in the latitude parameter of approximately 5 degrees is sufficient.

Surge and sway filter

For these filters the option is fixed to *General purpose*. The user can set the **Period** in the range 1 to 25 seconds. The recommended period for surge and sway motion is in the range 2 to 4 seconds. The default value is 2.5 seconds. The damping factor can be selected in the range 0.3 to 1.3 by adjusting the **Damping** parameter. This parameter influences the phase and amplitude response of the motion measurements. A low damping factor of 0.3 to 0.45 improves the phase and amplitude response when the motion frequency is close to the cutoff frequency in surge/sway, but oscillations in position and velocity may occur. The damping factor should normally be set to 0.6.

Integrated heave filter

For this filter the user can select between *No aiding* or *Height aiding* mode. In addition the user have to select in which **Monitoring point** the heave shall be output. In *Height aiding* mode the height is input from the GNSS receiver.



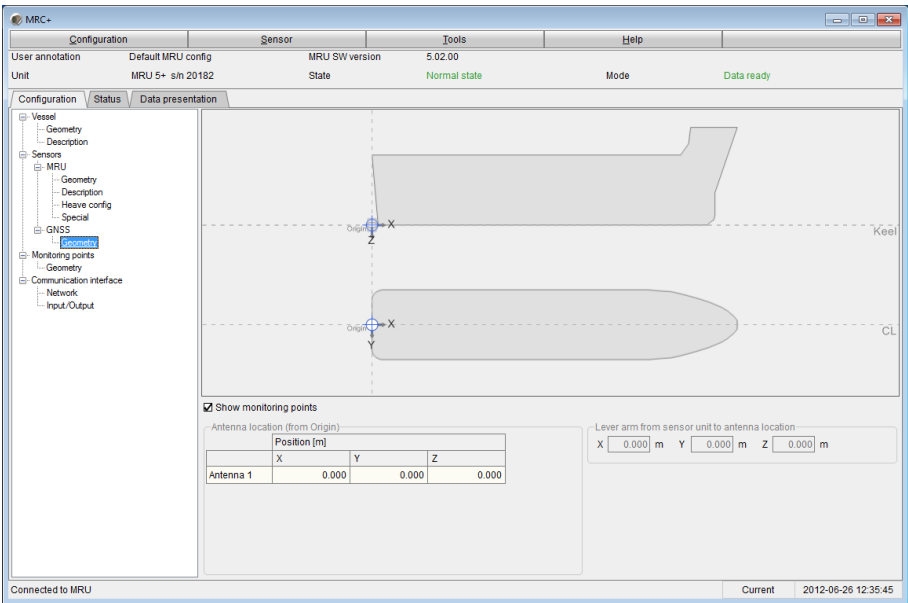
5.6.6 GNSS geometry

The lever arm vector from the Origin to the GNSS antenna has to be measured or calculated based upon drawings or previously measured points, and entered into the configuration.

How to set up antenna location

- 1 Set the antenna location coordinates for the GNSS antenna.
- 2 Check that the antenna has been located on the expected spot in the vessel shape.

If not, check the signs and the co-ordinates entered for the GNSS antenna, the vessel dimensions and the entered location of Origin.

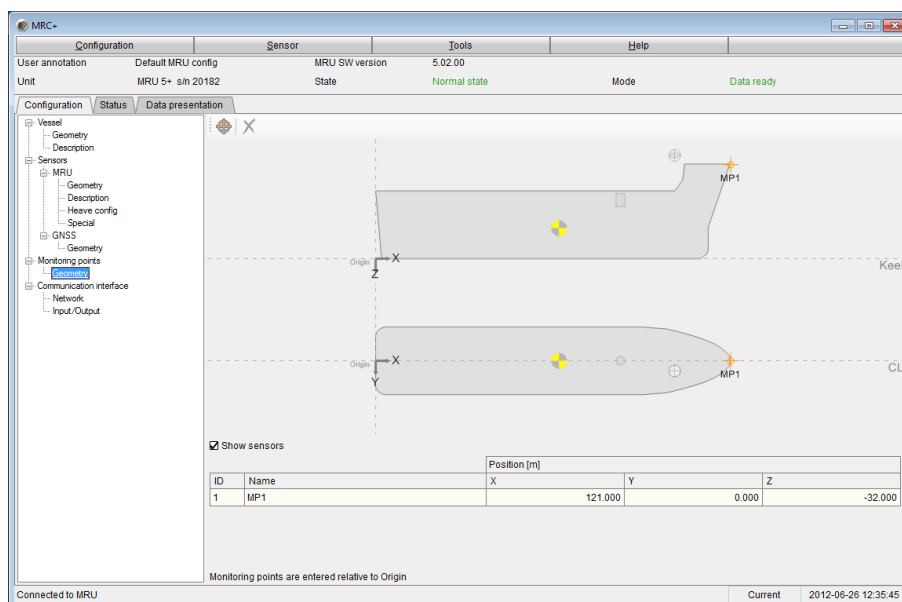


5.7 Monitoring points configuration

The system supports up to two user definable monitoring points. These are defined in the Monitoring Points view.

As soon as a monitoring point has been defined, its location is indicated in the vessel outline for easy visual verification. The monitoring points are given relative to Origin (positive forward, towards starboard and down). The position of a monitoring point relative to the Origin is indicated in the drawing when the cursor is over the monitoring point.

If a monitoring point appears incorrect, check the signs and the coordinates input for each monitoring point, the vessel dimensions and the entered location of Origin.



To add a monitoring point, select the **Add** button in the upper left corner of the view and drag the symbol to the correct location on the vessel. The selected monitoring point coordinates are shown at the bottom of the view.



To get exact coordinates from Origin to each monitoring point, each monitoring point has to be measured or calculated based upon drawings or previously measured points, and entered into the software manually. To delete a point, select the wanted point in the list and then press the **X** button in the top left corner.

When the **Add** button is clicked, red lines will be displayed on the screen to help placing the new point. Co-ordinates will also be displayed to help placing the monitoring point. The position and name of the added point may be adjusted by writing the co-ordinates into the table below the vessel drawing.

Note

No more than two monitoring points can be added

Figure 36 Adding MP, defining X and Z co-ordinates

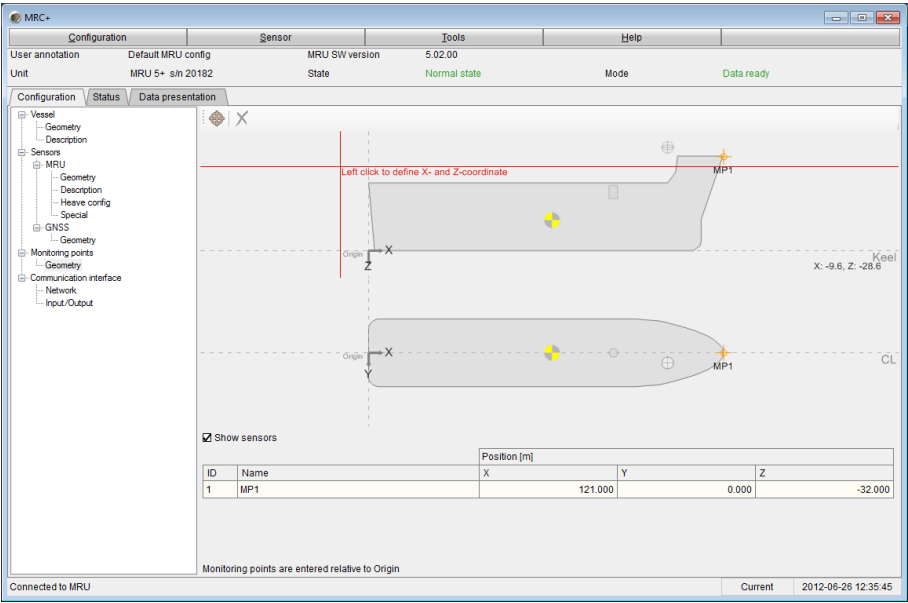


Figure 37 Adding MP, defining Y co-ordinate

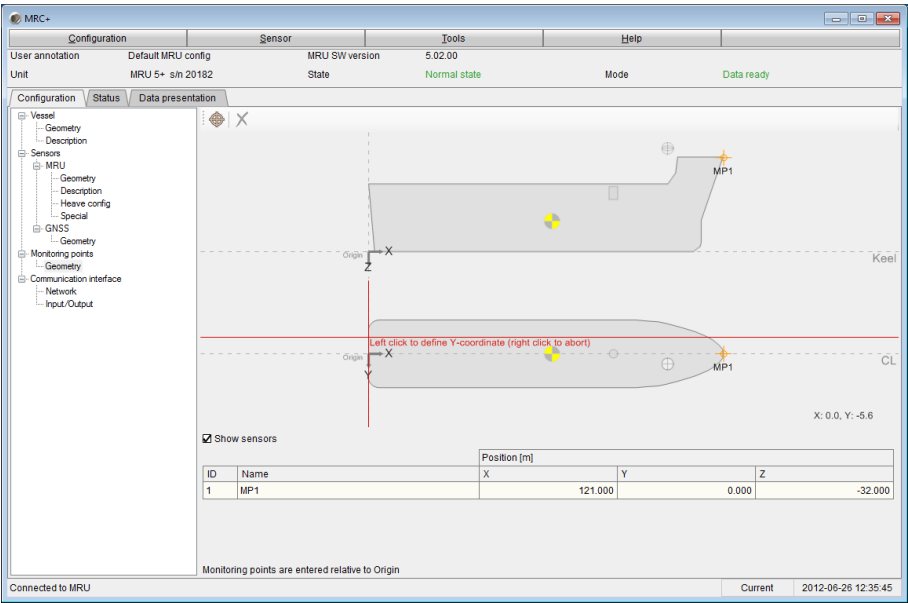
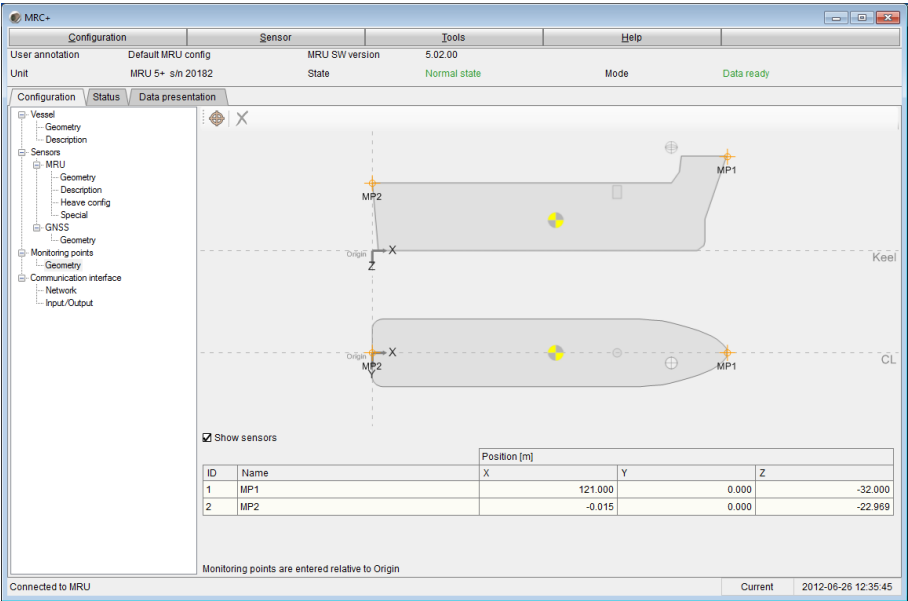
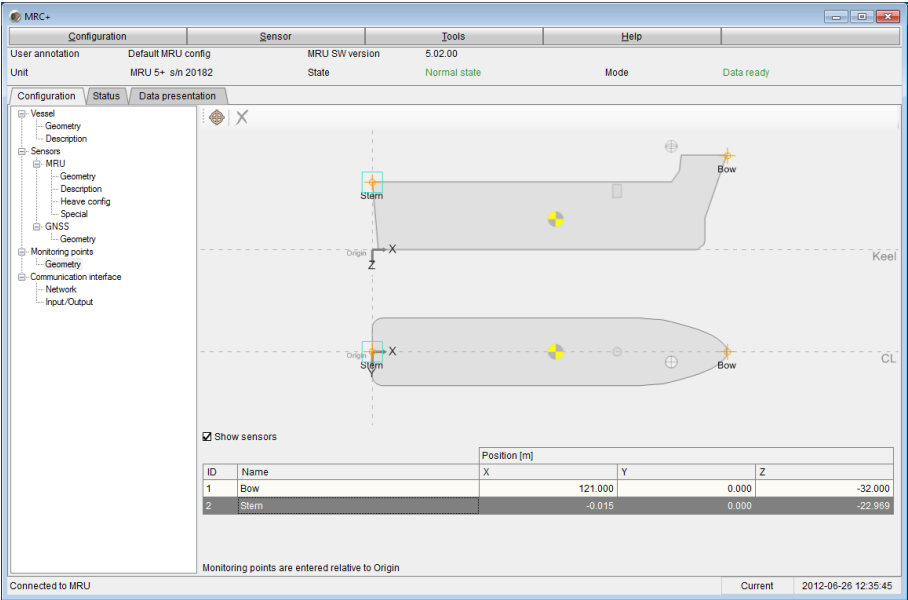


Figure 38 New monitoring point added



The new monitoring point may be renamed by entering the new name directly into the table.

Figure 39 Rename monitoring point



Here, **Stern** is highlighted and entered instead of the name **MP2**. Press **Enter** to apply the new name.

5.8 Communication interface configuration

5.8.1 Network

In order to input and output data on the Ethernet connector as an UDP (User Datagram Protocol) diagram the following parameters have to be set:

IP address

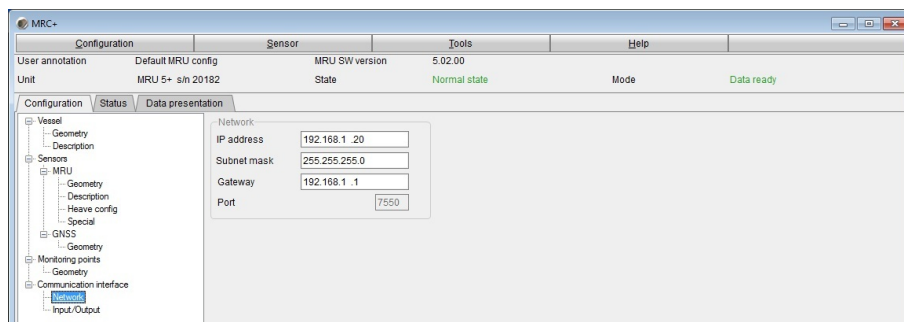
The Internet protocol (IP) network address. Default is 192.168.1.20.

Subnet mask

The Internet protocol (IP) sub-network mask. Default is 255. 255. 255. 0.

Gateway

The Gateway address. Default is 192. 168. 1. 1.



Check with the network administrator on board the vessel for the correct selection of network address and mask.

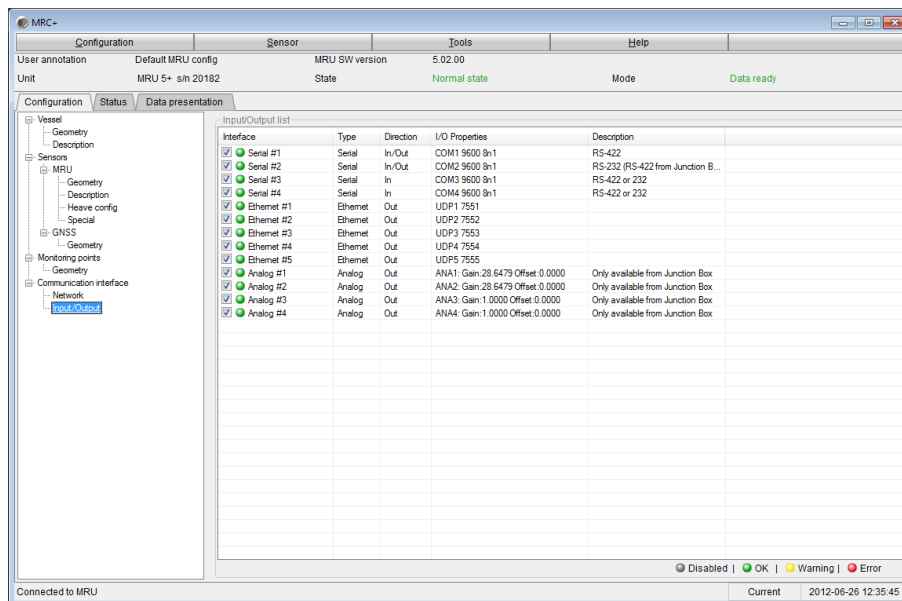
Note

Changes in the IP Address, Mask and Gateway will only take effect after a restart of the sensor unit

5.8.2 Input/output communication

The default view for the Input/Output communication shows all available input/output ports before any interface is selected.

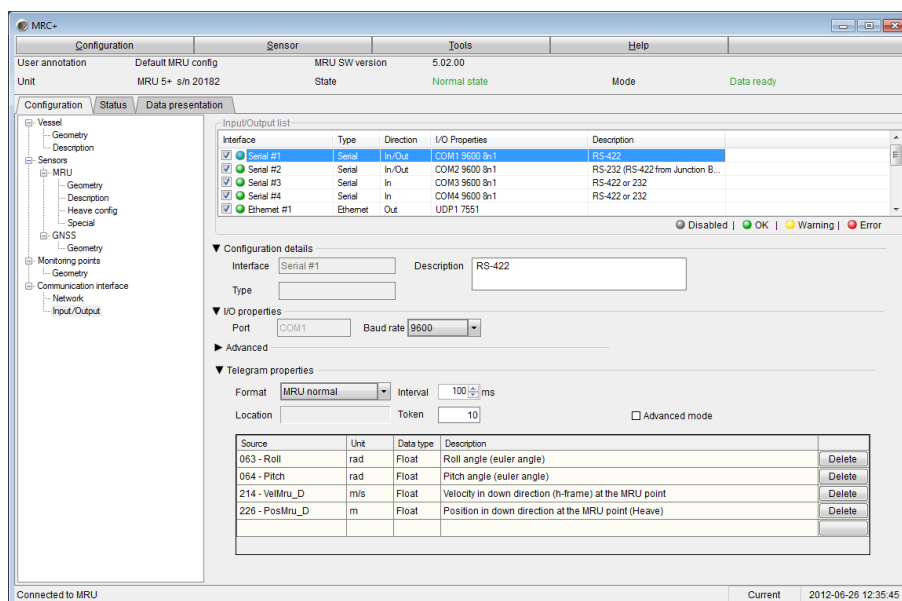
Figure 40 Input/output view with available communication sources



The Input/Output view consists of configuration details for the interface selected in the list. The configuration details vary between the different interfaces. By clicking on one of the interfaces, the screen is divided into two parts, one with the **Input/Output** list and one with **Configuration details**.

Analog outputs are available from the sensor unit if the junction box is connected.

Figure 41 Input/output configuration view



The Configuration details view is divided into four sections:

- an interface selection section

- an I/O properties section
- details on serial line or Ethernet setup
- and a telegram properties section

5.8.2.1 Configuration details

In the Communication details section the following is shown and can be configured:

Interface

Shows the communication line type and number selected in the **Input/Output list**.

Description

Input of a text to describe which equipment this communication line is connected to. This helps to remember which equipment this interface is connected to.

Type

Shows the type of communication interface selected, Serial, Ethernet or Analog. Optionally also analog output channels are available if the junction box is connected.

Direction

Shows the direction of the communication interface selected, In/Out, In or Out.

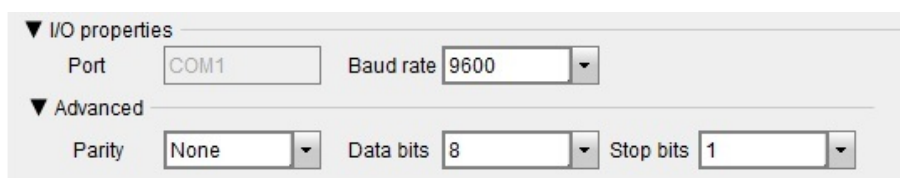
5.8.2.2 I/O properties

The parameters displayed in the I/O Properties properties views are dependent on what **Type** of interface is selected in the Configuration details section.

5.8.2.2.1 Serial interface

The default view for the serial port interface is illustrated. Click the arrow next to **I/O Properties** section to hide or show the information.

Figure 42 I/O Properties when serial interface is selected



The screenshot shows a configuration window titled 'I/O properties' with a dropdown arrow. It contains two sections: 'Port' and 'Advanced'. The 'Port' section has a 'Port' dropdown set to 'COM1' and a 'Baud rate' dropdown set to '9600'. The 'Advanced' section has a 'Parity' dropdown set to 'None', a 'Data bits' dropdown set to '8', and a 'Stop bits' dropdown set to '1'.

Port

Shows the serial line number (COM1 to 4).

Baud rate

The baud rate can be set from 1200 to 115200.

The baud rate required depends on the required number of digital output channels, the sample rate and the format selected. For the **MRU Normal** format each digital output channel requires approximately 40 bits, including transmission overhead. For a complete message, an overhead of approximately 40 bits is necessary independent of the message length.

Example 1 Calculation of minimum baud rate with the MRU Normal format

4 channels out at a sample rate of 20 Hz (50 ms): $(4\text{ch} * 40 + 40) * 20$
Hz = 4000 Baud (minimum)

In real time applications, take into account that data are not available before the end of the message. Do not select a higher baud rate than needed. A high baud rate will load down the computer with interrupts, resulting in possible transmission errors if using long lines.

Under the collapsible **Advanced** group box, less used properties are placed:

Parity

Select parity (None, Even or Odd) on the serial line selected.

Data bits

Select the number of data bits on the serial line selected.

Stop bits

Select the number of stop bits on the serial line selected.

5.8.2.2.2 Ethernet interface

The default view for the Ethernet interface is illustrated. Click the arrow next to **I/O Properties** section to hide or show the information.

Figure 43 I/O Properties when Ethernet interface is selected



▼ I/O properties

☒ Broadcast ☐ Unicast ☐ Multicast

Local interface

Port

Protocol

The UDP protocol. Options are Broadcast, Unicast or Multicast.

Local interface

Automatic is the only option and cannot be changed.

IP address

The target IP address.

Port

The number of the port to which the client listens.

5.8.2.3 Telegram properties

In the telegram properties section the following is shown and can be configured:

Format

This parameter selects the data output format. When selecting the **MRU Normal** and **NMEA propr** formats, the user can select the number of variables and variable number (source) which is to be a part of this format.

Location

Selecting the location for output of the linear measurements (MRU, CG, MP1 or MP2). This selection is only available for other output formats than MRU Normal and NMEA proprietary.

Interval

Time interval for cyclic auto transmit of data. The interval must be selected in steps of 5 milliseconds. Be aware of possible data overruns if the interval is too short. 0 ms == Auto Transmit OFF. Set interval in milliseconds.

Token

User selected numbers are associated with the selected format. This is a unique message marking byte with a value in the range 10 to 100.

Advanced mode

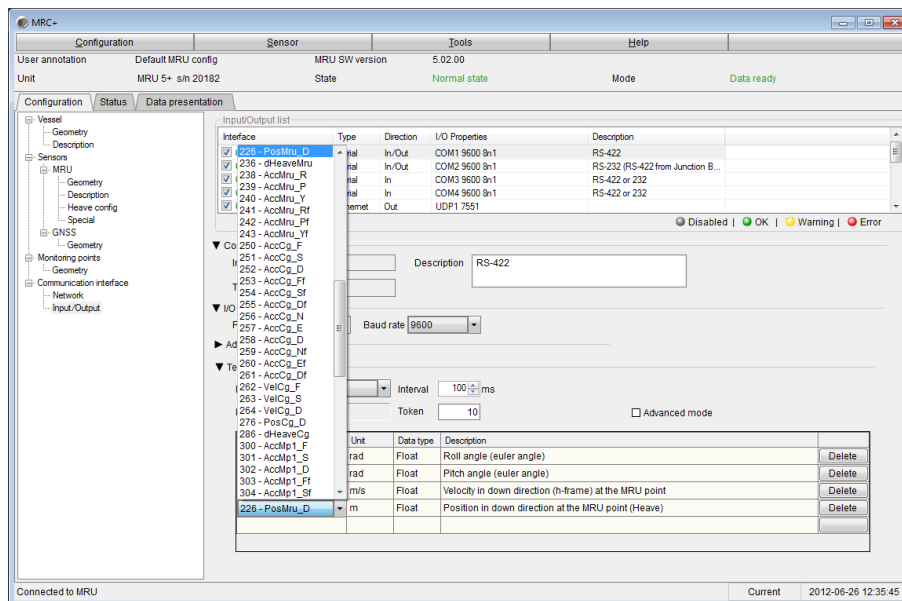
Enable or disable. If enabled, the more advanced source IDs will be listed.

Source

The number of output variables for each communication channel is limited to a maximum of 24. The actual output variables for each communication channel can be selected freely between a number of sources. Formats other than **MRU Normal** may limit the maximum number for output variables and/or the chosen time interval. The number of channels and the variables are defined in the format.

Many output variables are available from the sensor unit. By activating the drop-down menu, a list of the most frequently used output variables is shown, as illustrated. To list the more advanced variables **Advanced mode** has to be selected before the drop-down menu has been activated.

Figure 44 List of sources



Related topics

- *Digital interface* on page 103
- *Output variable list* on page 133

5.8.2.4 Analog output

Four analog output channels are available from the sensor unit when the junction box (part no MRU-E-JB3) is connected. The same output variable list is valid for the analog channels as for the digital communication. For each of the analog channels, the user must specify the gain and offset. The limit on the output signal is fixed to ± 10 Volt.

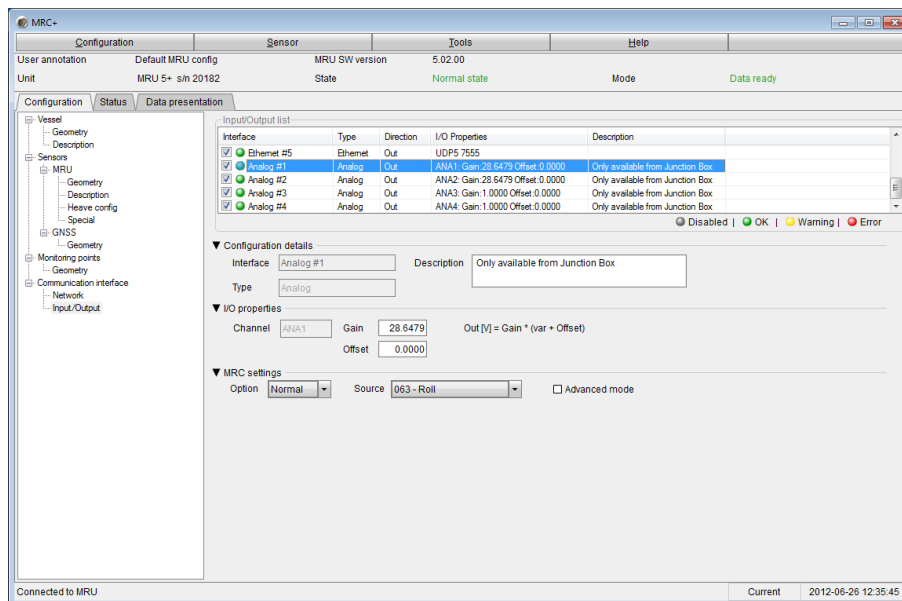
Gain is set according to the formula:

- $[\text{Voltage out in Volts}] = \text{Gain} * [\text{Selected Variable} + \text{Offset}]$

The gain therefore has scaling volts per physical unit (for instance, volts/metre). Note that the variables in the sensor unit are given in standard SI units.

Example 2 Gain calculation

Requirement: ± 10 V shall give ± 0.5236 radians (± 30 degrees). The gain factor must then be; $\text{Gain} = \text{volts/radians} = 10/0.5236 = 19.0986 \text{ v/rad}$.



5.9 Status tab

The Status tab include the views Status and Events:

Info

This part shows following information.

- **System program**
Shows the current MRU software version on which the unit is operating.
- **Unit**
Lists the current sensor unit model and its hardware revision, like "v".
- **S/N**
Shows the serial number (s/n) of the sensor unit connected.
- **Calibration**
Shows the serial number of the sensor unit for which the calibration file is generated and the calibration date.
- **Last startup**
Shows the date and time for the last start-up of the sensor unit.
- **No. of startups**
Shows the number of start-ups the sensor unit has had since it was manufactured.
- **Accumulated run time [hours]**
Shows the number of hours the sensor unit has been in operation since it was manufactured.

System status

This part shows the following status.

- **External velocity**
Shows status and source on external velocity input; "Available" or "Not available".
- **External heading**
Shows status and source on external heading input; "Available" or "Not available".
- **External time**
Shows status and source on external time input; "Available" or "Not available".
- **Timesync**
Shows status and source on external time synchronisation input; "Available" or "Not available".

Data status

Shows status of the sensor data output; "Not available", "Reduced" or "Normal".

General status

This part shows the following status.

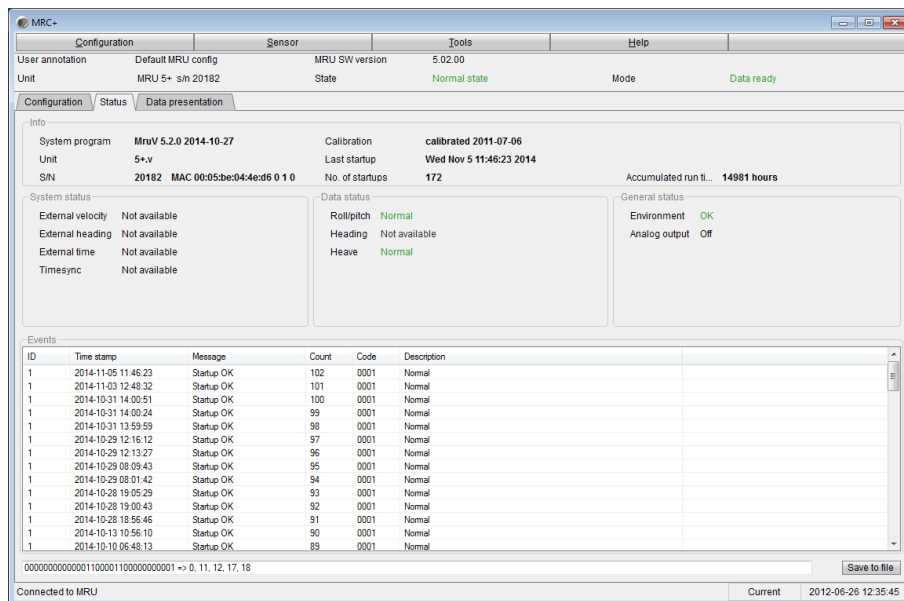
- **Environment**
Shows status on the environment like temperature level; "OK" or "Not OK".
- **Analog output**
Shows on the analog output. "On" if a junction box is connected and analog outputs are configured else "Off" .

Events

This part shows the original event messages generated.

Save

Click the **Save** button to save the status information to a text file.



5.10 Data presentation tab

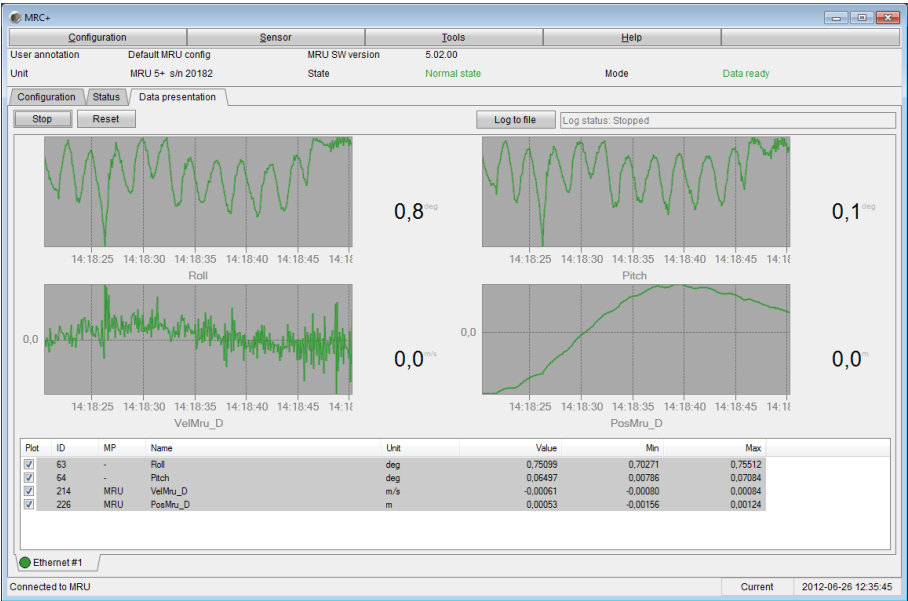
The Data presentation tab includes the following functionality:

- Presents the output variables configured on Ethernet port #1, #2, #3, #4 or #5 on the screen and the possibility to log data on file. Remember to configure the outputs on Ethernet port #1, #2, #3, #4 or #5 and sending the configuration to the sensor unit, before entering the data presentation tab.
- Maximum six variables can be plotted on the screen simultaneously. The other output variables are displayed numerically. Click the check box in the Plot column to select the variables to be plotted. Green colour on the curves indicates that the sensor unit operates in normal mode. Yellow colour indicates that the sensor unit outputs data with reduced accuracy.
- Use the **Start/Stop** and **Reset** button to control the data presentation and logging to file.
- Click on the **Log to file** button to log data to file. The data are saved in an ASCII file with the output variables stored as floats in columns. The file contains a header with the name of the variables, number of samples and the sample time. The file can easily be modified by the user in a text editor to adjust to other, similar formats. The default file name is *.tsa.

Note

Outputs to Ethernet port #1, #2 or #5 have to be configured and sent to the sensor unit before the data presentation tab is entered. Else now data will be presented

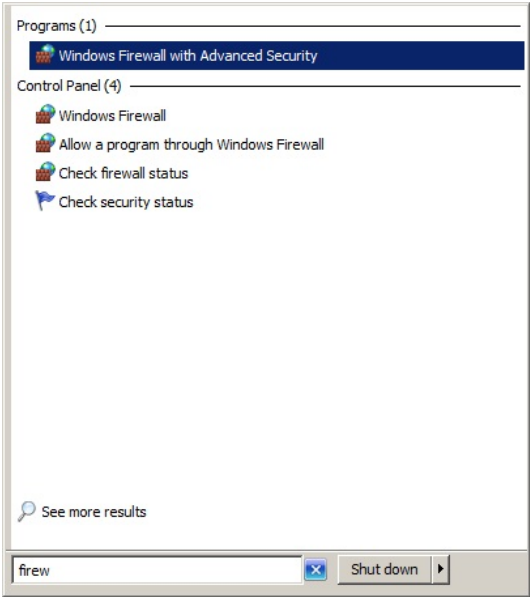
The outputs on COM1 and 2 are not presented in this data presentation tab. This since the MRC+ only has connection to the sensor unit through Ethernet and not through serial line.



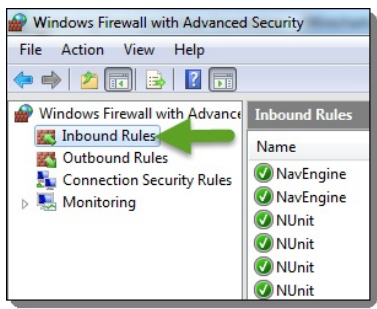
If you always have red light before the Ethernet port you may have problems with the MRC+ installed outside the firewall. Proceed as follows to get the correct firewall settings:

Change firewall settings

- 1 Click the **Start** button in Windows and type `firewall` in the search field as illustrated and click **Windows Firewall with Advanced Security**.



- 2 Click **Inbound Rules** as illustrated.



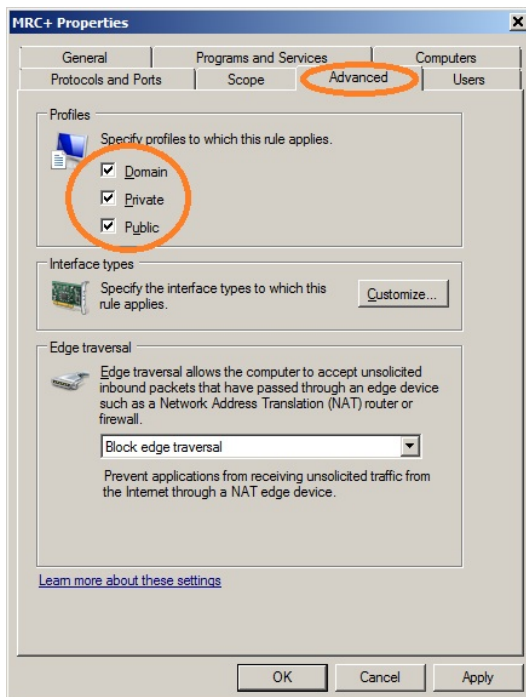
- 3 Scroll down the list to MRC+ and check what is written. In the figure below the MRC+ is blocked in **Privat domain** and this has to be solved.

MRC+	Public	Yes	Block	No	D:\dev\svn\edc...
MRC+	Domain, Private	Yes	Allow	No	D:\dev\svn\edc...
MRC+	Domain, Private	Yes	Allow	No	D:\dev\svn\edc...
MRC+	Public	Yes	Block	No	D:\dev\svn\edc...

- 4 Click line 2 in the figure (the line with UDP). Right-click and click **Properties**.

Microsoft Visual Studio 2008	Domain	Yes	Allow	No	C:\program...	Any	Any	TCP
MRC+	Public	Yes	Block	No	D:\dev\svn\...	Any	Any	TCP
MRC+	Domain, Private	Yes	Allow	No	D:\dev\svn\...	Any	Any	UDP
MRC+	Domain, Private	Yes	Allow	No		Any	Any	TCP
MRC+	Public	Yes	Block	No		Any	Any	UDP
NavEngine	Domain	Yes	Allow	No		Any	Any	TCP
NavEngine	Domain	Yes	Allow	No		Any	Any	UDP
NetBIOS Datagram Service	F Domain	Yes	Allow	No		Any	Any	UDP
NetBIOS Name Service	F Domain	Yes	Allow	No		Any	Any	UDP
NetBIOS Session Service	F Domain	Yes	Allow	No		Any	Any	TCP
Netlogon Service (NP-In)	N All	No	Allow	No		Any	Any	TCP
Network Discovery (LLMNR-UDP-In)	N Public	No	Allow	No	%SystemRo...	Any	Local subnet	UDP

- 5 In the **Advanced** tab select the profiles for **Domain**, **Private** and **Public**.



- 6 Click **Apply** and **OK** when finished.

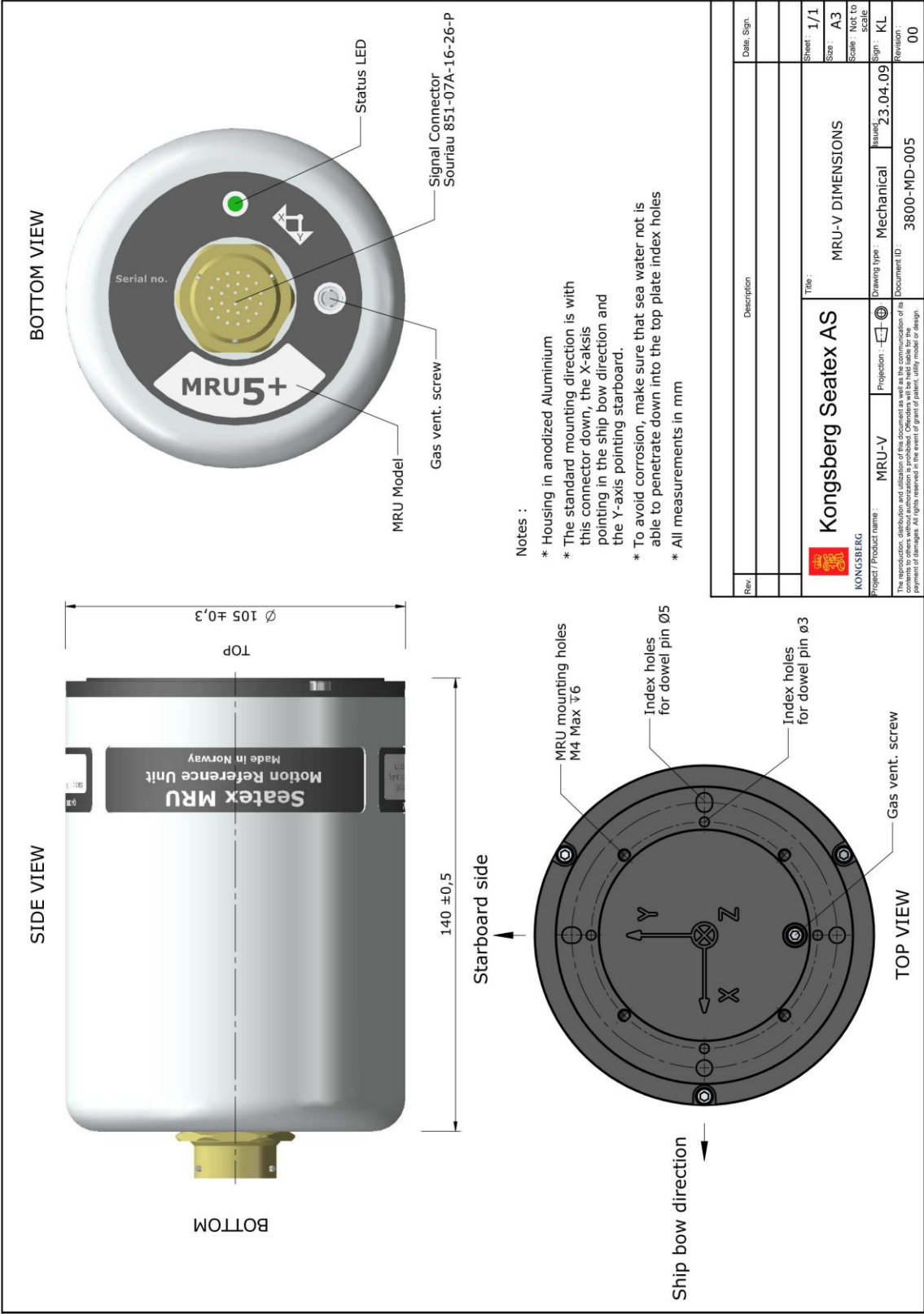
6 Drawings

This chapter contains outline drawings showing mechanical dimensions of the MRU, the mounting bracket, the junction box and the subsea bottle.

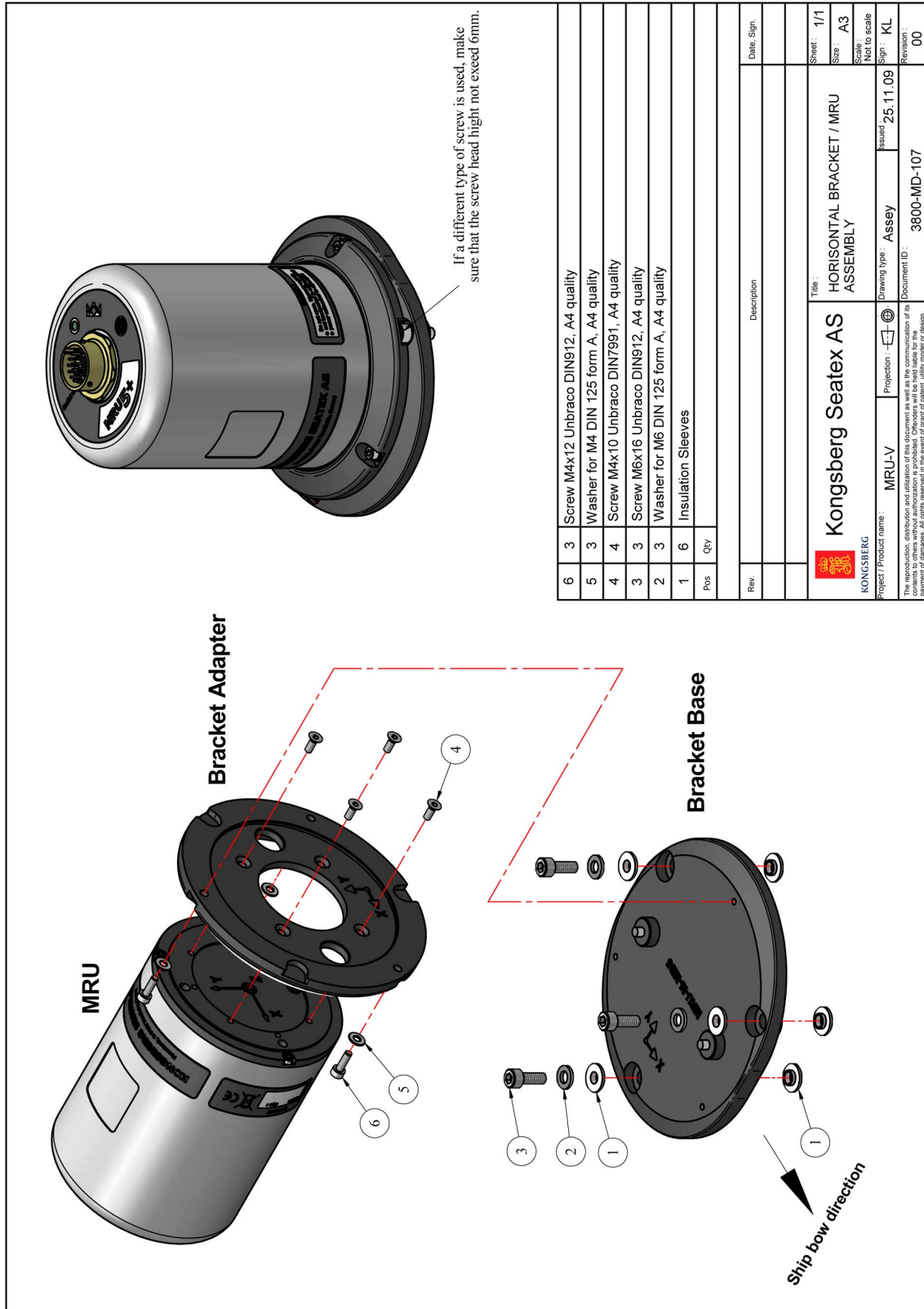
Note

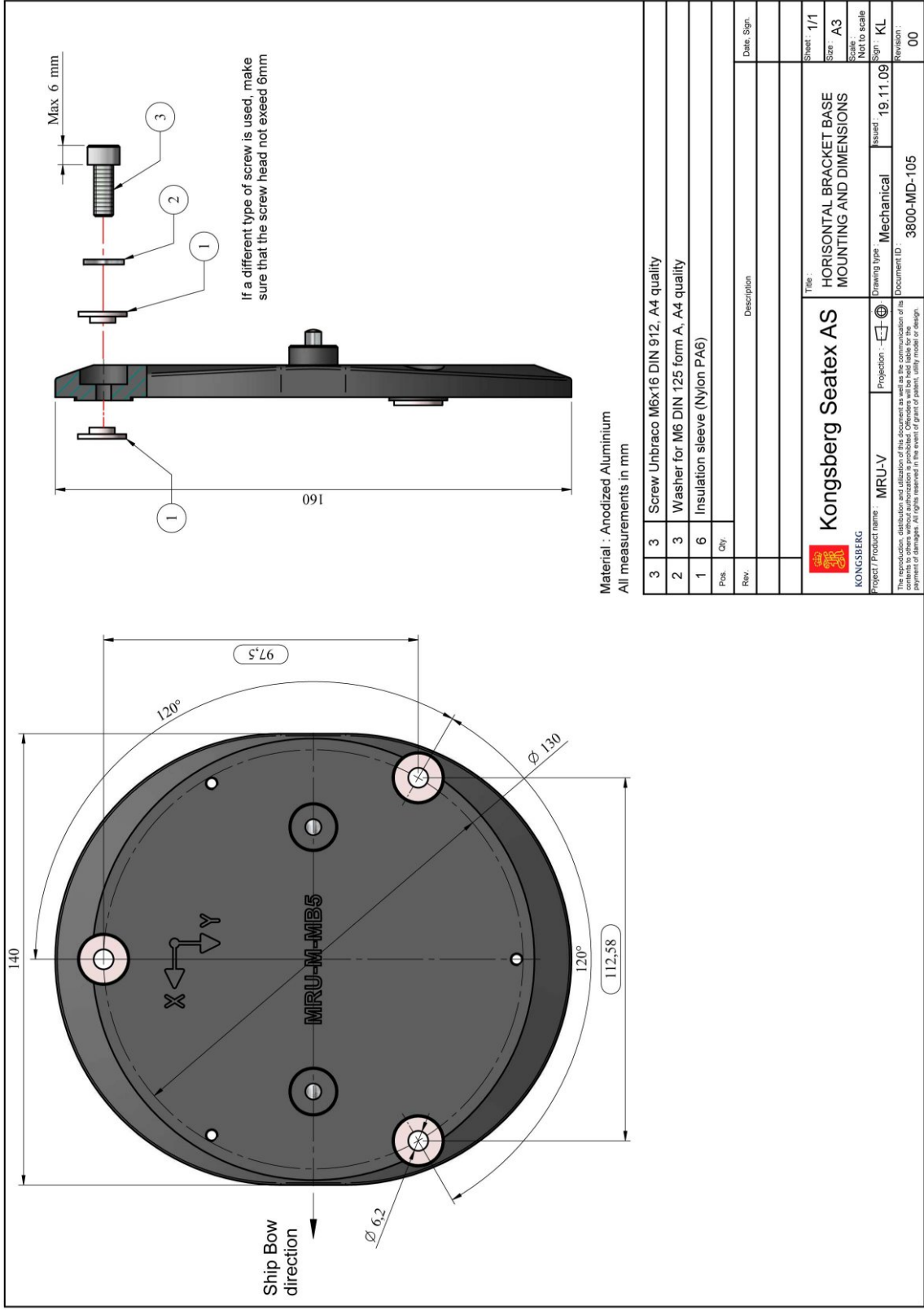
The drawings in this manual are not to scale. To scale drawings are available upon request.

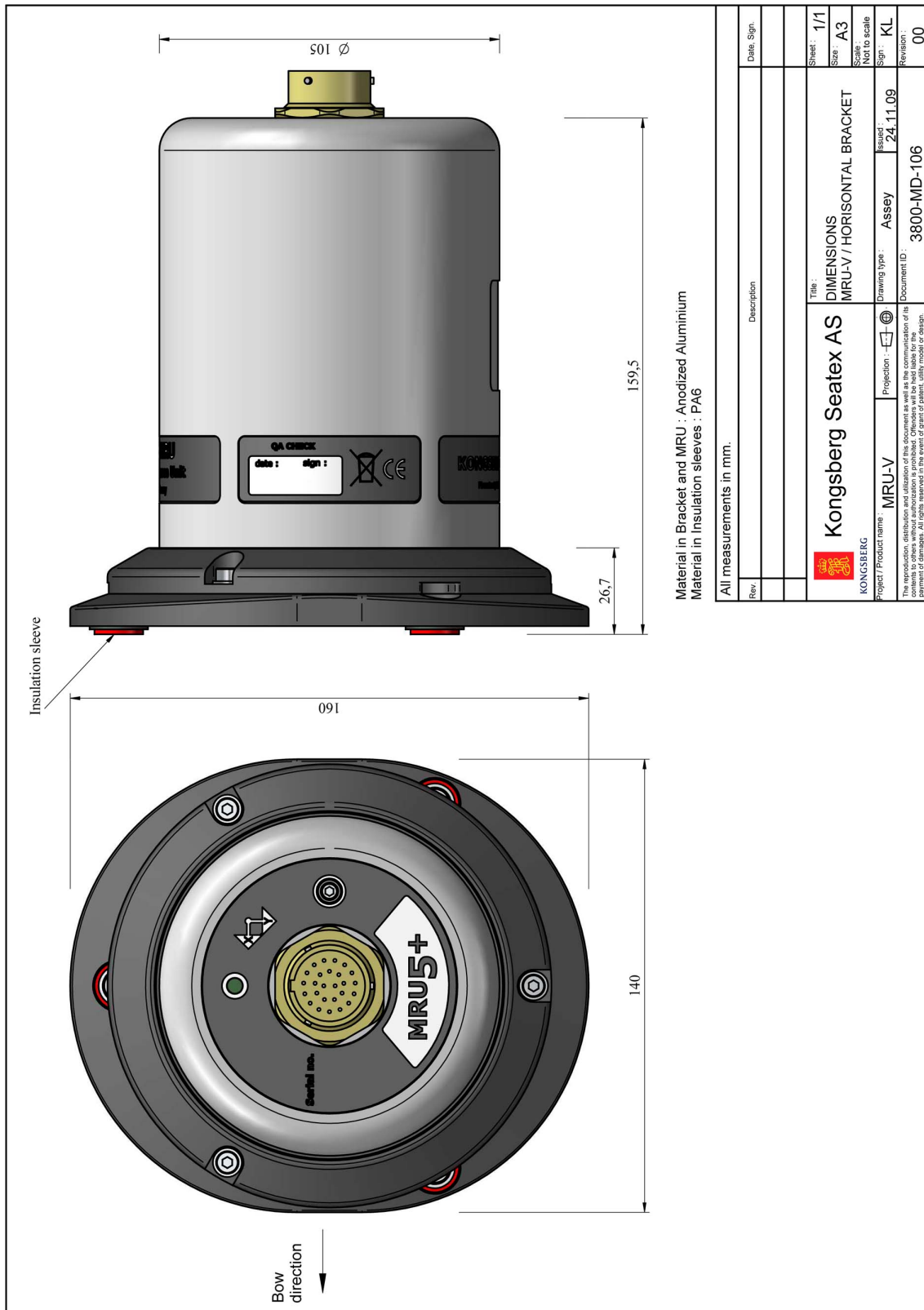
6.1 MRU mechanical dimensions



6.2 MRU floor mounting bracket







6.3 MRU wall mounting bracket

Note:
Clean the surface between MRU and Bracket carefully before assembly
Connecting surfaces between MRU and Bracket should
in no way be damaged before mounting
It is preferable that the bracket is attached to the hull structure
to prevent vibrations.
The Bracket (pos 2.) must be mounted with the screws pos.5
before the MRU is mounted to the Bracket.
To disassembly the MRU from the Bracket, remove the
screws pos.6. Do not remove the Bracket from its position.

Exploded view diagram showing the assembly of the MRU wall mounting bracket. The diagram includes the MRU unit (1), the bracket (2), and the mounting hardware (3, 4, 5, 6). Dimensions are provided for the bracket and the MRU unit.

Top view of the MRU wall mounting bracket. Dimensions: 140 (width), 85 (height), 75 (height), 110 (height), 140 (width), 85 (height).

Side view of the MRU wall mounting bracket. Dimensions: 217 (width), 124.5 (height), 70.5 (height).

WALL BRACKET MRU+

6	4	Screw Unbraco M4x12, DIN 912, A4 quality
5	3	Screw Unbraco M6x20, DIN 912, A4 quality
4	3	Washer for M6 DIN 125 form A, A4 quality
3	6	Insulation sleeves
2	1	Bracket MRU-M-MB4
1	1	MRU+

Pos Qty

Tolerance : ISO 2768-M if not specified on drawing :

Rev	Description	Date	Sign.
3	Changed dimensions	27.09.12	
4	Information of pos 5 & 6 corrected	09.12.13	

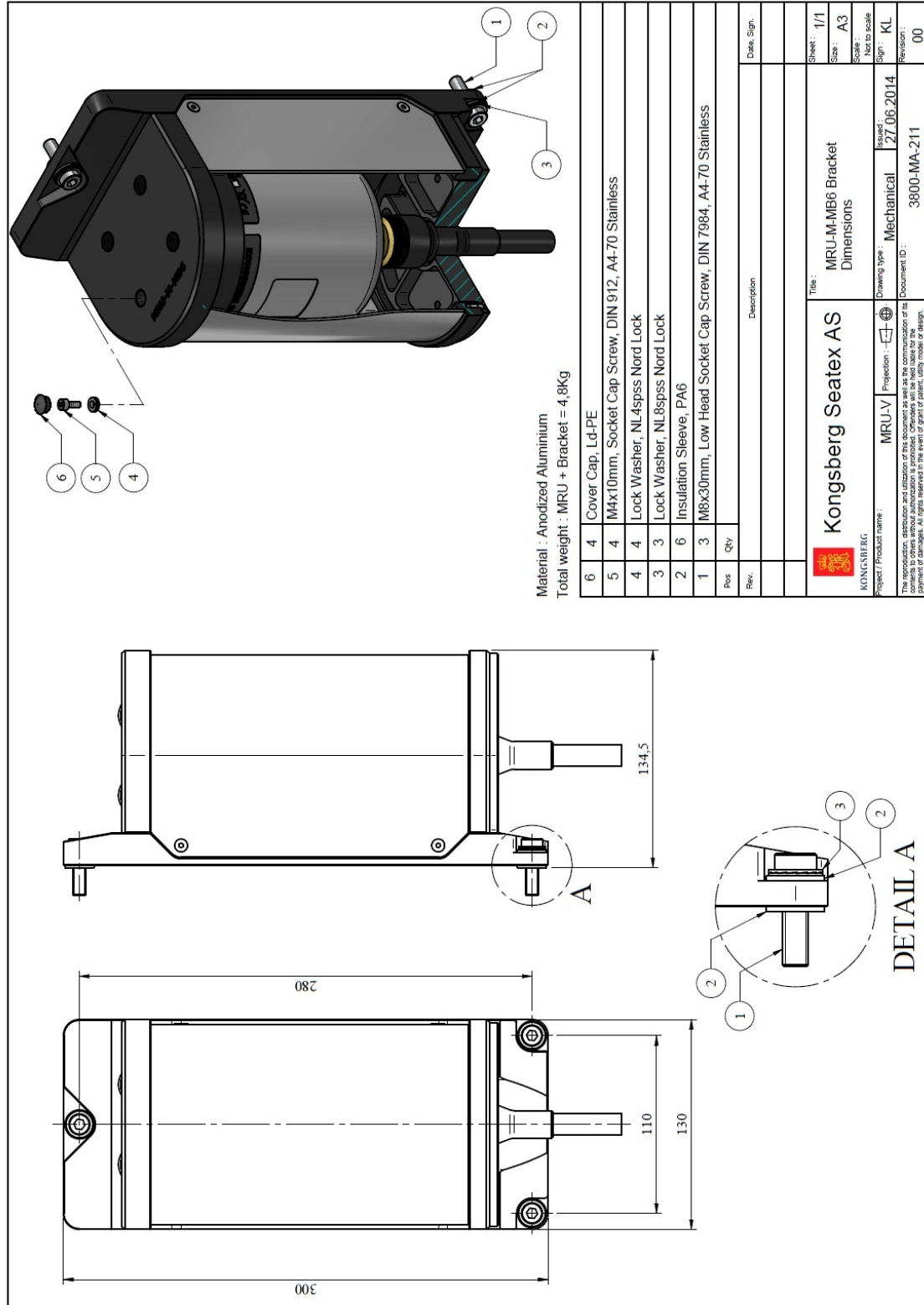
Sheet : 1/1
Size : A3
Scale : Not to scale
Sign : KL
Revision : 04

Kongsberg Seatex AS
KONGSBERG

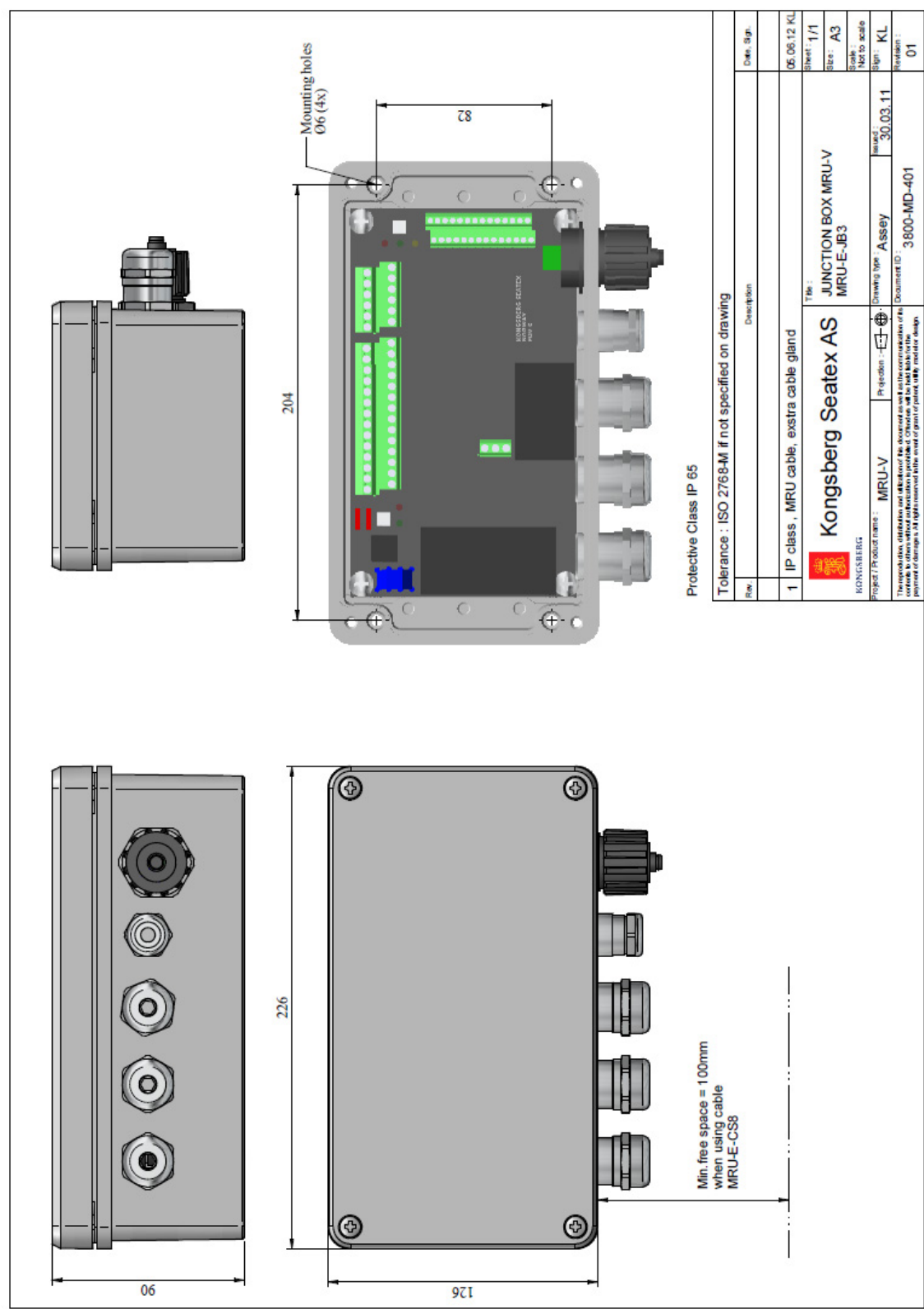
Project / Product name : MRU
Revision : 03.05.2011
Drawing type : Mechanical
Document ID : 3800-MD-009

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6.4 MRU protected mounting bracket

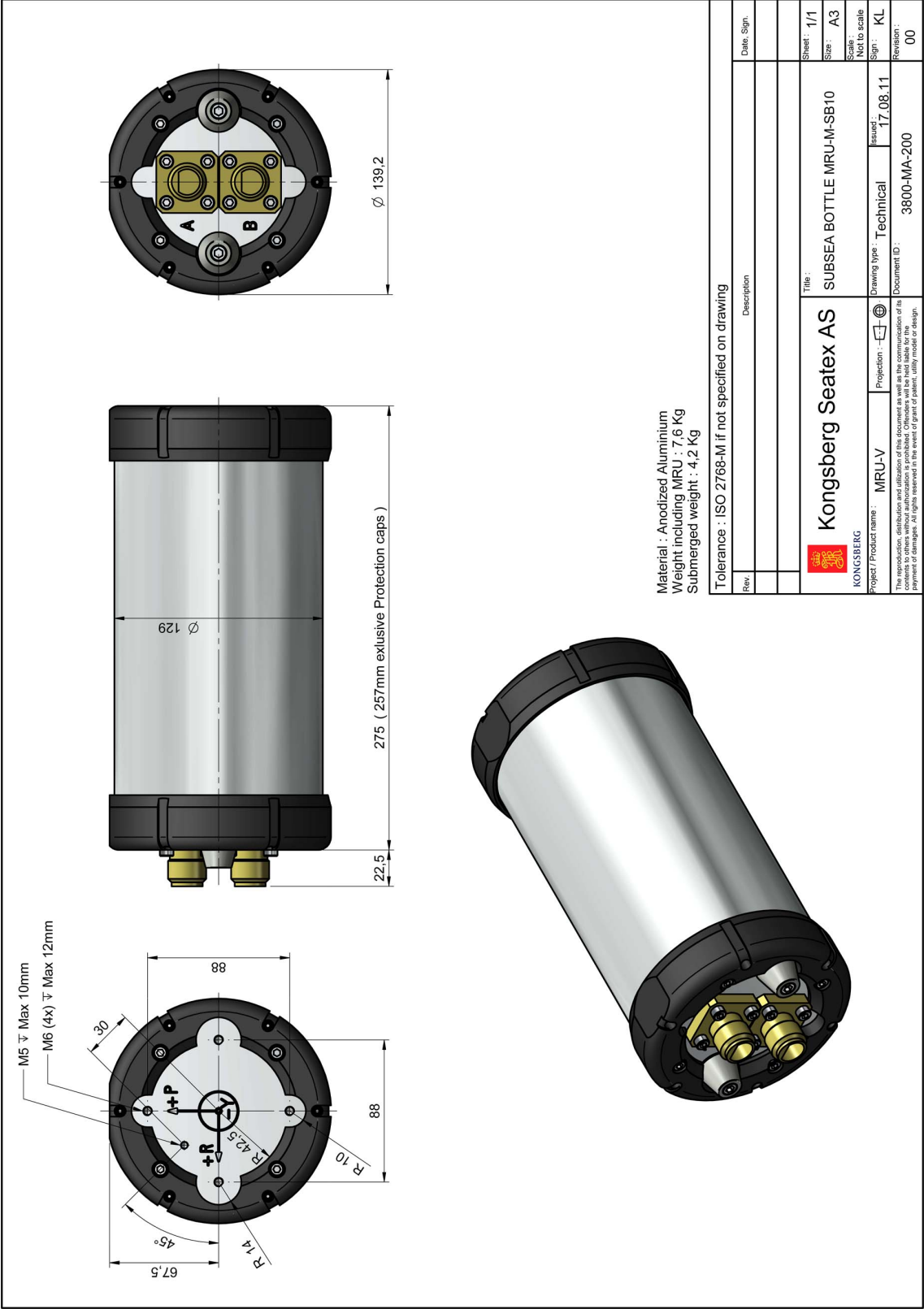


6.5 MRU junction box dimensions

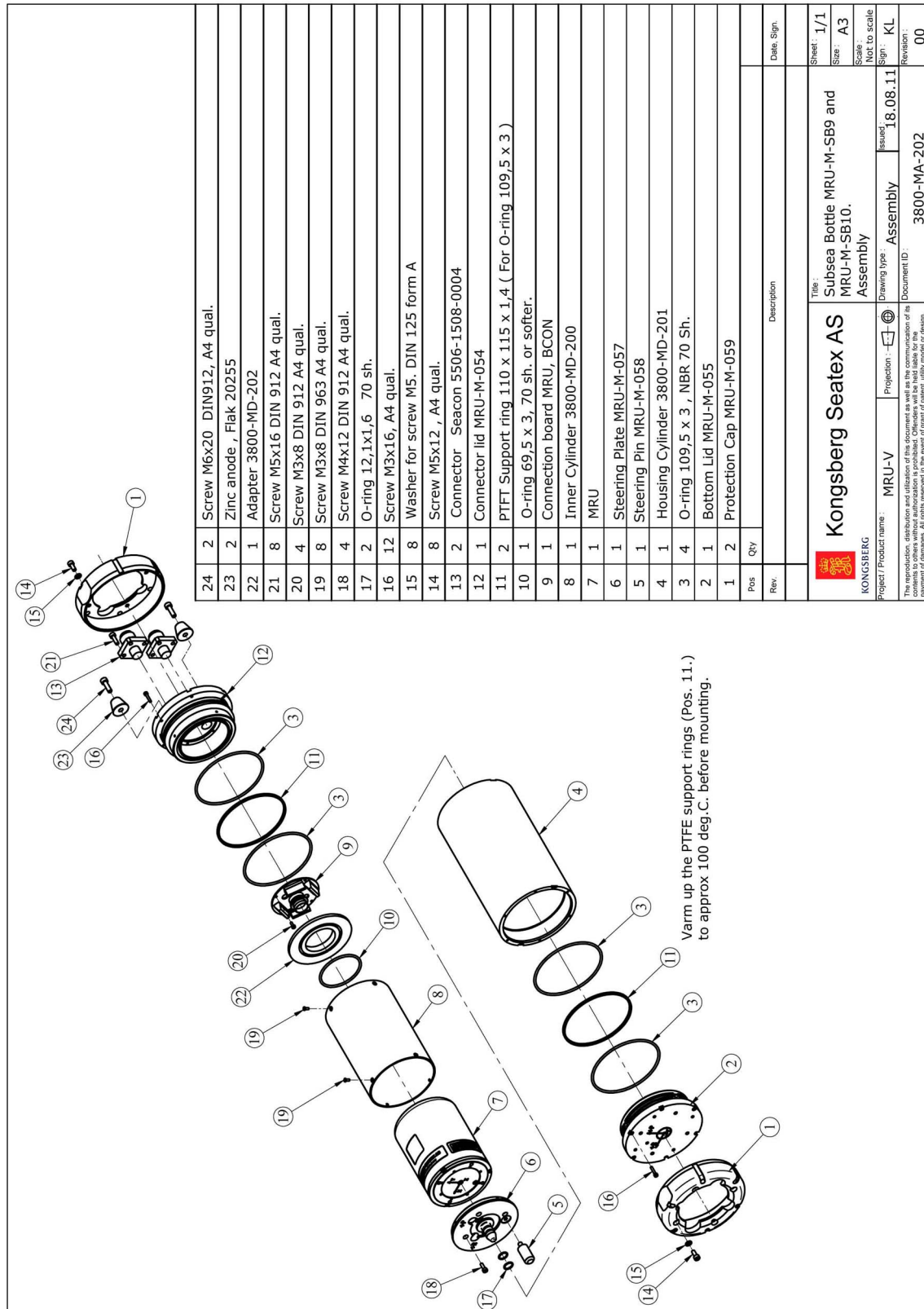


Tolerance : ISO 2768-M if not specified on drawing			
Rev.	Description	Date	Sign.
 Kongsberg Seatex AS KONGSBERG		Sheet: 1/1 Size: A3 Scale: Nati to scale	
Project / Product name: MRU-V		Drawing type: Technical Issued: 17.08.11	
Projection: 		Document ID: 3800-MA-201	
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Revision		00	

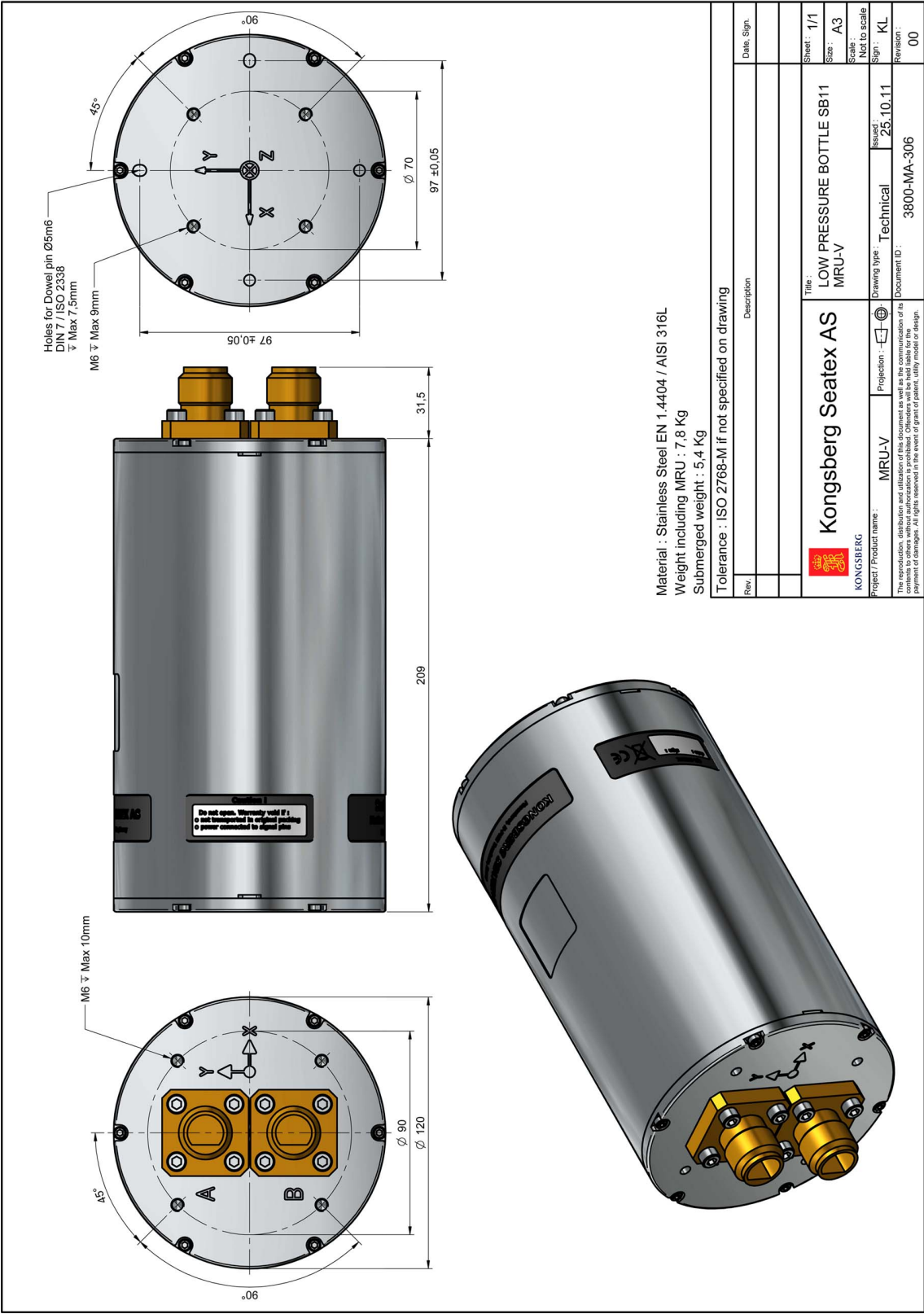
6.7 MRU subsea bottle 1000-metre



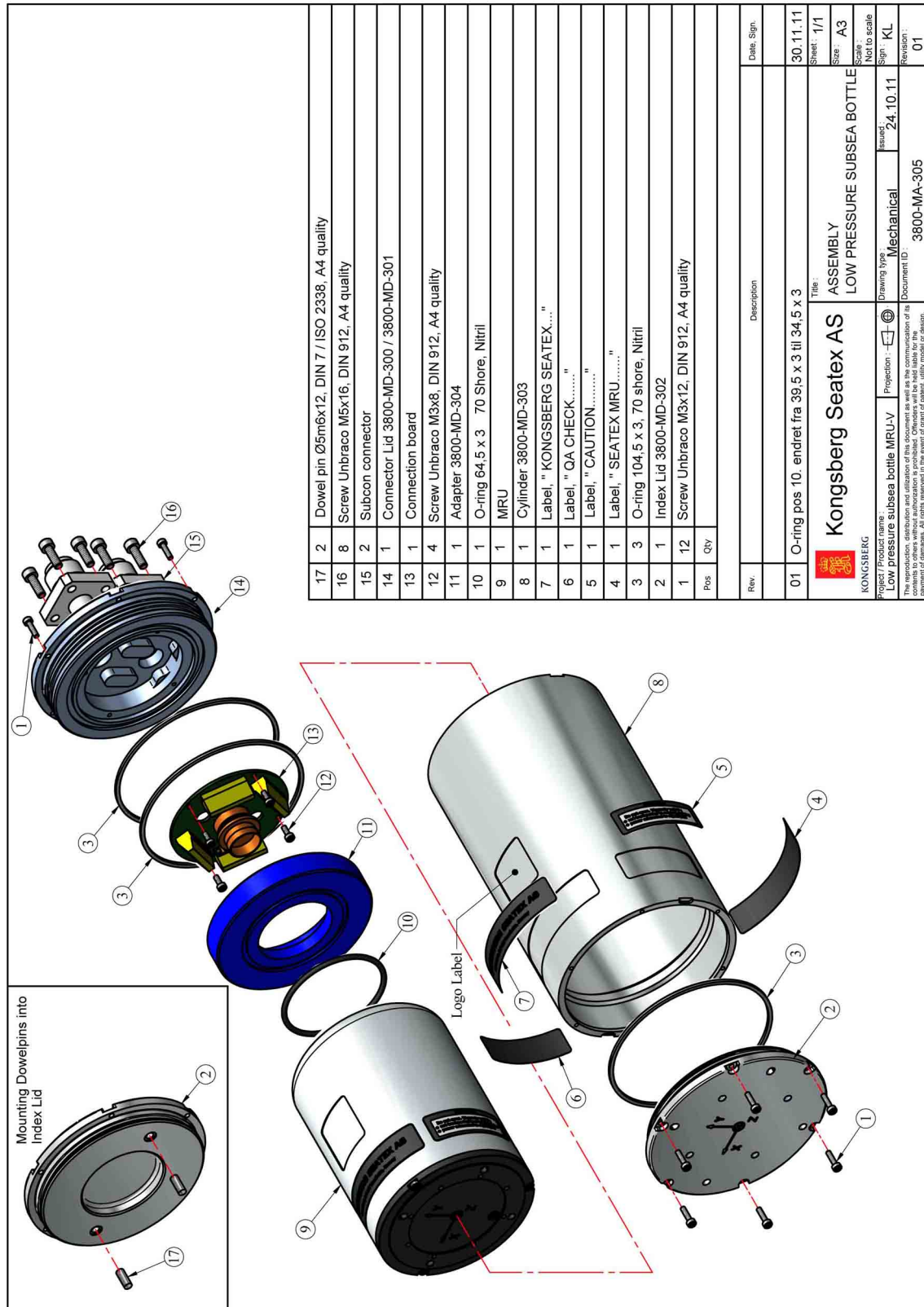
6.8 Assembly drawing for 1000 and 4000-metre subsea bottle



6.9 MRU subsea bottle 50-metre



6.10 Assembly drawing for 50-metre subsea bottle



7 Parts list

The MRU basic packet consists of:

Part no.	No.	Description
MRU-H-V	1	The sensor unit.
MRU-T-015	1	Three metres Ethernet configuration cable for connection to a PC.
MRU-E-P24	1	Power supply 24 VDC for Ethernet configuration cable.
MRU-E-CE1	1	One metre Ethernet cable of type crossover.
MRU-SW-ED	1	USB memory stick including the MRU configuration software, manuals, configuration and calibration file.
MRU-M-SC1	1	Transportation box.

The MRU package with junction box and wall mounted bracket consists of:

Part no.	No.	Description
MRU-H-V	1	The motion sensor.
MRU-M-MB4	1	MRU 5 th generation wall mounting bracket
MRU-E-JB3-CS81	1	MRU junction box with three meter communication cable.
MRU-E-CE1	1	One metre Ethernet cable of type crossover.
MRU-SW-ED	1	USB memory stick including the MRU configuration software, manuals, configuration and calibration file.
MRU-M-SC1	1	Transportation box.

The MRU can be delivered with the following additional equipment:

Part no.	Description
MRU-M-MB4	MRU 5 th generation wall mounting bracket
MRU-M-MB5	MRU 5 th generation floor mounting bracket
MRU-M-MB6	MRU 5 th generation protected mounting bracket
MRU-M-SB9	MRU 5 th generation subsea bottle with two 8 pin connector, 4000 m depth (Titanium house)
MRU-M-SB10	MRU 5 th generation subsea bottle with two 8 pin connector, 1000 m depth (Aluminum house)

Part no.	Description
MRU-M-SB11	MRU 5 th generation subsea bottle with two 8 pin connector, 50 m (Stainless steel house)
MRU-E-JB3	MRU 5 th generation junction box with serial communication, analog output channels, Ethernet and AC power input
MRU-E-CS8	MRU 5 th generation cable (four serial lines, Ethernet & power) type heavy-duty screened cable with MRU connector.

8 References

Reference documents

- *MRU 5th Generation User Manual*, Kongsberg Seatex AS

Appendix A

Digital interface

A.1 Interfacing philosophy

The host computer communicates with the sensor unit by the use of duplex serial line (COM 1 or COM 2) or Ethernet. The sensor unit is standardised on the simplest possible interface and protocol which provides the desired performance.

Serial communication speed is programmable from 1200 to 115200 baud. 1 start bit, 8 data bits (LSB first), programmable none, odd or even parity, and 1 stop bit is used.

UDP telegrams are used to transmit messages on Ethernet. Each telegram contains one sensor unit message.

Communication with the sensor unit uses a proprietary efficient binary protocol.

The sensor unit will also recognize some NMEA sentences carrying relevant information.

A.2 Formats

The sensor unit can transmit data telegrams in many formats:

- MRU normal: default, most versatile, most efficient
- NMEA proprietary: ASCII based
- Sounder
- Simrad EM3000
- ATLAS
- TSS1
- Seapath Binary 23
- Seapath Binary 25: Raw IMU output (not documented)
- Seapath Binary 26
- PFreeHeave
- RDI ADCP format, PRDID

A.3 MRU binary protocol

A.3.1 Communication scheme

A.3.1.1 Message format

Communication is based on byte messages with arbitrary length <250 bytes. The same communication format is used for messages to and from the sensor unit. The general communication format is as follows:

Format

<header><length>[<datan>] .. <checksum>

where each <xx> denotes a binary byte.

Format description

- 1 <header> = Start of message and defines message type. ASCII character.
- 2 <length> = Number of data-bytes in transmission. The maximum number is 245.
- 3 <datan> = One of the data-bytes in the transmission. This byte may be a command or parameter connected to one of the commands.
- 4 <checksum> = Is the modulo 256 sum of all **datan** bytes.

Note

<token> shall be part of the checksum calculation if part of the format.

Example 3 MRU protocol

Format

<'C'><2><31><3><34>

Header 'C' (ASCII 67), length 2, command number 31, operand 3, checksum $31 + 3 = 34$. The checksum is a modulo of 256. If the sum of all data and bytes becomes for instance 257, then the checksum is 1 ($257 - 256 = 1$). The data consists of a command number followed by zero to 'n' operands or byte values. These bytes will be interpreted as ASCII characters, 16 bit words, 32 bit integers, IEEE single precision floats etc. depending on actual command. Data types consisting of multiple bytes are transmitted with MSB first. All valid commands to the sensor unit will respond with some kind of answer, either an asked for message, or a general acceptance message in the form:

<'a'><2><status><command><checksum>

where status takes one of the following values:

- 2 = unable to execute command
- 0 = OK
- -1 = bad command number

Example 3 MRU protocol (cont'd.)

- -2 = parameter error
- -3 = all error
- -4 = header error

command is assumed command number.

A.3.1.2 Message synchronisation on serial communication

No handshake is used in the communication. The sensor unit can always receive short messages. The user is responsible for using a buffer of suitable length (>256 bytes) to pick up the messages of limited lengths from the sensor unit (at the selected baud rate).

There are no boundaries between messages, i.e. messages can follow each other without synchronisation. This implies that an error may occur where the transmitter and the receiver are out of phase. To help overcome this problem some precautions have been taken with the sensor unit, and some caution must be taken when writing the driver:

- Successive bytes in a message sent to the sensor unit must follow each other within a minimum of approximately 200 ms. If too much time has past, a new message (i.e. a header byte) is expected by the sensor unit. Be aware of this when transmitting data to the sensor unit over a multiplexed system.
- If data from the sensor unit is requested by the command 'Get current data set', stop requesting data if received data are lost. Empty the input buffer and wait until all data coming from the sensor unit have been received.
- If the sensor unit is set up to output data cyclically, search for the known heading until a match with heading and checksum is found. Because the data are binary, there is a chance of losing a few samples of data. This is usually due to a false start message. Note that if an acceptable header is found, but the checksum is wrong, it will be necessary to search for a new header from the same point in the input data as the last incorrect header found. Do not start from the point where the checksum was found.

A.3.2 Defined sensor unit commands

All currently defined messages sent to the sensor unit have a 'C' header, and the following command numbers are valid:

- 1 = Get current data set
- 2 = Suspend auto transmit of data
- 7 = Get unit info
- 8 = Get software version string
- 9 = Get system status
- 12 = Enter external speed
- 13 = Enter external yaw angle
- 15 = Set lever arm vector

- **16** = Get lever arm vector
- **17** = Set clock
- **19** = Change digital output variables
- **20** = Get digital output variables

Note

In the following description, the checksum byte is omitted for clarity.

A.3.2.1 Get current data set

The format for the getting current data set is as follows:

Format

<'C'><1><1>

or

<'C'><2><1><ch>

Selected data from the sensor unit are transferred back in a message formatted according to setup for current channel (COM1 or COM2), or selected channel if **ch** is used.

Channel **ch** maps as follows:

0 = COM1, 1 = COM2, 5 = UDP1, 6 = UDP2, 7 = UDP3, 8 = UDP4, 9 = UDP5,

See *Data message formats* on page 111 for description of data message formats.

A.3.2.2 Suspend auto transmit of data

The format for suspending auto transmit of data:

Format

<'C'><5><2><time_msb><time_1><time_2><time_lsb>

Format description

- 1** **time_x** = 32 bit delay time, in seconds. Auto transmit of digital data will be disabled for time seconds. This is used during the set-up and configuration of the sensor unit to avoid unwanted messages.

A.3.2.3 Get unit info

Requests for general info on unit:

Format

<'C'><1><7>

Answer back is (same as Welcome Message) :

Format

<'c'><36><7><'MruV v.r.n yyyy-mm-dd'><type><vers><v_0><v_1>

<n_0><n_1><s_0><s_1><s_2><s_3><opt><0><chk>

Format description

- 1 **MruV v.r.n yyyy-mm-dd** = 22 characters with software version.
- 2 **type** = Sensor unit type: 11..25 11== '2', 12=='D', 13=='3', 14=='H', 15=='5+', 16=='5', 17=='E', 25=='R3'
- 3 **vers** = hardware version : 'v', 'x'.. hardware version identification.
- 4 **v_0,1** = 16 bit software number multiplied with 100 (version 5.1.1 will then be 511)
- 5 **n_0,1** = 16 bit sensor unit serial number (20000++)
- 6 **s_0,3** = 32 bit sensor unit status (see *Status bits* on page 139)
- 7 **opt** = N/A

A.3.2.4 Get software version string

Requests for software version string:

Format

<'C'><1><8>

Answer back is:

Format

<'I'><len>'MruV v.r.n yyyy-mm-dd'<0>

Format description

- 1 **len** = Length of string including terminating 0.
- 2 **v.r.n** = Version number (ASCII string). I.e 5.1.1 is version 5, release1, build 1.
- 3 **yyyy** = Year.
- 4 **mm** = Month.
- 5 **dd** = Date.
- 6 **0** = Terminating 0.

This is a legacy command. Preferably use command 7, Get Unit Info.

A.3.2.5 Get system status

Requests for system status:

Format

<'C'><2><9><code>

Format description

- 1 **code** = Specifies status type: 0: system runtime status.

Answer back for system runtime status is:

Format

<'c'><6><9><code><stat.msb><...><stat.lsb>

Format description

- 1 **stat** = 32 bit status. For listing of the MRU status bits see *Status bits* on page 139.

A.3.2.6 Enter external speed

This is input from a standard Doppler log or other single axis speed log providing the vessel's forward cruise speed. External speed input is used to improve attitude accuracy for the MRU 3, H, E, 5 and 5+.

The format for entering external speed vx_b:

Format

<'C'><6><12><delay><vx_b_msb><vx_b_1><vx_b_2><vx_b_lsb>

Format description

- 1 **delay** = Unsigned byte giving time in 10 ms units since data was captured (default 0, max 2.55 sec) until the message is entered into the MRU.
- 2 **vx_b_x** = IEEE single prec. float (unit m/s) specifying cruise speed. The speed is positive in the stem direction of the ship. Valid range ± 40 m/s.

Preferable update rates range from 0.25 to 2 Hz. Higher update rates are not recommended. Lower rates than 0.2 Hz might disconnect the speed log input.

The MRU will utilise speed data without any special user configuration as soon as data is sent to the MRU. If no valid data is received by the MRU for 3 seconds, external speed corrections will be considered zero.

A.3.2.7 Enter external heading (yaw angle)

External heading input is used to improve attitude accuracy for the MRU 3, H, E, 5 and 5+. This is ideal in cases where the vehicle will experience turns (ROVs, high speed crafts, etc.). The input can be taken from a gyro compass or magnetic compass.

The format for entering external yaw angle yx_bg:

Format

<'C'><6><13><delay><yx_bg_msb><yx_bg_1><yx_bg_2><yx_bg_lsb>

Format description

- 1 **delay** = Unsigned byte giving time in 10 ms units since data was captured (default 0, max 2.55 sec) until the message is entered into the MRU.
- 2 **yx_bg_x** = IEEE single prec. float (unit radians) specifying heading (yaw)-angle. The heading is zero at North and increases when turning starboard. Values must be in the range 0 to 2π or $-\pi$ to π . Values outside this will result in a "not accepted" message.

Preferable update rates range from 0.25 to 2 Hz. Higher update rates are not recommended. Lower rates than 0.2 Hz might disconnect the external heading input.

The MRU will use external heading data without any special user configuration as soon as data are sent to the MRU. If no data are received by the MRU for 3 seconds, the MRU will use its internal sensors only, and leave *Heading Aided* mode.

A.3.2.8 Set lever arm vector

The format for setting lever arm vector lav[n]:

Format

```
<'C'><14><15><n>  
<lav[0]_msb><lav[0]_1><lav[0]_2><lav[0]_lsb>  
<lav[1]_msb><lav[1]_1><lav[1]_2><lav[1]_lsb>  
<lav[2]_msb><lav[2]_1><lav[2]_2><lav[2]_lsb>
```

Format description

- 1 **n** = Monitoring point: 1 = MP1, 2 = MP2.
- 2 **lav[n]_x** = Floats (m) specifying level arm vector (R,P,Y), valid range ± 1000 m.

Note

The parameters changed with this command are temporarily modified and will be reset to configuration values after a reboot of the sensor unit.

A.3.2.9 Get lever arm vector

The format for getting lever arm vector lav[n]:

Format

```
<'C'><2><16><n>
```

Answer back is:

Format

```
<'c'><14><16><n>  
<lav[0]_msb><lav[0]_1><lav[0]_2><lav[0]_lsb>  
<lav[1]_msb><lav[1]_1><lav[1]_2><lav[1]_lsb>  
<lav[2]_msb><lav[2]_1><lav[2]_2><lav[2]_lsb>
```

Format description

- 1 **n** = Monitoring point: 1 = MP1, 2 = MP2.
- 2 **lav[n]_x** = Floats (m) specifying level arm vector (R,P,Y).

A.3.2.10 Set MRU clock

The format for setting sensor unit internal calendar\clock:

Format

<'C'><6><17><option><time_msb><time_1><time_2><time_lsb>

Format description

1 **time** = 32-bit number of seconds since 1 January, 1970 GMT 00:00:00.

A.3.2.11 Change digital output variables

The format for selecting digital output variables:

Format

<'C'><len><19>'setup_string'<0><chk>

The string contains words separated by one or more spaces. The setup-string is defined as follows:

- If CHAN is an UART channel (COM1 or COM2):

'CHAN BAUD MODE FORMAT INTERVAL TOKEN VAR1 VAR2..VARn'

- If CHAN is an UDP channel (UDP1 to UDP5):

'CHAN PORT IP_ADDR FORMAT INTERVAL TOKEN VAR1 VAR2..VARn'

Format description

- 1** **CHAN** is one of COM1, COM2, UDP1, UDP2, UDP3, UDP4 and UDP5.
- 2** **PORT** is UDP port number (default 7551-5).
- 3** **IP_ADDR** is destination IP address (default broadcast on subnet (x.x.x.255)).
- 4** **BAUD** is baud rate 9600 to 115200.
- 5** **MODE** is parity, normally 8N1 i.e no parity, 8 bits, 1 stop bit.
- 6** **FORMAT** is one of MRUBIN, NMEAP, NMEAN, SOUND, TSS1, EM3000, ATLAS, BIN23,BIN25, BIN26, PFREE, PRDID, LISTEN.
- 7** **INTERVAL** is interval in milliseconds between each auto transmitted data message (0, 5 to 32000).
- 8** **TOKEN** is a tag number selected by user 10..100 for current setup.
- 9** **VARn** is variable number, optional appended letter W for 16 integer, or L for 32 bit integer. Default (no letter) is float.

TOKEN and VARn are not used for all FORMATS.

Example 4 Setup-string

'COM1 9600 8n1 NMEAP 250 71 63 64 214 226'

'UPD2 7551 192.168.1.255 MRUBIN 10 78 63 64 226 220
173L'

A.3.2.12 Get digital output variables

The format for getting digital output variables:

Format

<'C'><len><20>'string'<0><chk>

Where string is one of CHAN set by command 19, with a '?' appended.

Example 5 MRU command to get digital output variables

<'C'><len><'COM1?'><0><chk>

will return the following:

<'C'><len><20>'COM1 9600 8n1 NMEAP 250 71 63 64
214 226'<0><chk>

A.3.3 Legacy MRU commands

The 5th generation MRU will respond correctly to the following two previous generations commands; Set Digital Output Format and Get Digital Output Format.. If the MRU receives one of these old command, the MRU will respond as if it was an older generation MRU with the previous source IDs.

A.4 Data message formats

A.4.1 MRU normal format

The default format for data messages is the proprietary binary format *MRU binary protocol* on page 104

Format

<'q'><len><token><data0>...<dataN>

Format description

- 1 <'q'> = Message header.
- 2 <token> = The users token associated with the selected format. This helps in parsing data message
- 3 <dataN> = Formatted data. Words, integers and floats are transferred with MSB first. Data are in the same succession as defined in the MRC+.

Note

If data is invalid, or unstable, the header is replaced with 'Q'. The rest of the message is unchanged. This is normally a transient situation, typically at start-up and at abrupt movements when in normal operation. The MRU status obtained through command 9 will give an indication of what caused the situation.

If the MRU is in auto transmit mode (see MRC+ configuration utility), this message will be transmitted without using the Get Current Data Set command.

Example 6 MRU data message out

There are two ways of getting digitally measured data from the MRU:

- Interrogated (user must ask for a data message).
- Automatic transmission at selected intervals. Selection can be made through the MRC configuration program.

If **automatic transmission** is selected, the MRU will begin transmission immediately after power on. If **interrogating** is selected, (time interval = 0) the user must send the command 'C 1' to obtain the data message.

Messages from the MRU containing measured data (roll, pitch, heave etc.) have the following format:

Format

<'q'><len><token><data0>...<dataN>

Format description

- 1 <'q'> = Header, replaced with 'Q' when data is unstable (i.e. at start-up).
- 2 <len> = Length of message (dataN bytes + token).
- 3 <token> = Token as set by user during configuration.
- 4 <data0> = Data bytes, msb first for 16 and 32 bits data.
- 5 <dataN> = Data message, data stable.

Example 7 Use MRC+ to configure the MRU

- Select 3 variables, 63 (Roll), 64 (Pitch) and 226 (PosMrud).
- Select Auto Transmit Asynchronous.
- Select Interval = 100 (milliseconds).
- Associate this configuration with a token you select, for example 47 (hex 2f).

After configuration, the MRU will transmit a message every 100 milliseconds:

Format

<71><0d><2f> <3d><50><e5><60> <bd><50><e5><60>
<3f><90><f3><b6> <cb>

Format description

- 1 <71> = Header ('q'), replaced with 'Q' when data is unstable (i.e. at start-up).
- 2 <0d> = Length is 3 * size of (float) + 1 (token) = 3* 4 + 1 = 13 = hex 0d
- 3 <2f> = User selected token (associated with this configuration)
- 4 <3d> to <60> = Roll = 0x3d50e560 IEEE float → 0.051 rad
- 5 <bd> to <60> = Pitch = 0xdb50e560 IEEE float → -0.051 rad

Example 7 Use MRC+ to configure the MRU (cont'd.)

- 6 <3f>to <b6> = PosMruD = 0x3f9df3b6 IEEE float → 1.234 m
- 7 <cb> = Check

A.4.2 NMEA Proprietary

The NMEA Proprietary format follows the NMEA 0183, version 2.00, specifications with the exception that the baud rate may be set to other than 4800. The string is designed to output up to six variables from the MRU variable list, together with a user selected token (10..100) accompanying the selections. If less than six variables are selected, empty fields are put in the NMEA string. It is possible to output more than six variables (maximum 16 variables) with this string, but then the length of the string will be longer than the standard 80 characters which is the NMEA standard.

Float data are written as floats (C print format %8.3e) and integers as integers (C print format %d). Only the MRU data out message is changed when using the NMEA format, all other messages remain as MRU Normal format messages. As the NMEA format is ASCII based, as opposed to the MRU Normal format, more than twice as many bytes are used to transfer a six-variable sentence by NMEA than MRU Normal. This feature will reduce the number of messages per second for a given baud rate (i.e., for a six-variable NMEA sentence, up to 12 messages per second at 9600 baud can be achieved). The MRU Normal format can transmit 35 messages per second under the same conditions.

Format

\$PSXN,10,xx,x.xx,x.xx,x.xx,x.xx,x.xx,x.xx*hh<CR><LF>

Format description

- 1 \$PSXN = Seatex A.S. id (SeateX Norway)
- 2 10 = MRU message identifier (11 if data unstable)
- 3 xx = User defined token (10..100)
- 4 x.xx = Data field 1
- 5 x.xx = Data field 2
- 6 x.xx = Data field 3
- 7 x.xx = Data field 4
- 8 x.xx = Data field 5
- 9 x.xx = Data field 6
- 10 *hh = Checksum

The manufacturer mnemonic code SXN is NOT an NMEA approved mnemonic.

The message number is 10 for normal MRU data and 11 if data are unstable (at power-on and other restarts). The token value is a user adjustable number associated with the current format configuration.

Float data fields are written with "scientific notation" formats (i.e., 1.234e3 or -3.456e-12) and integers as decimal numbers (i.e. -12345 or 859). The asterisk "*" denotes a checksum feature, and "hh" is the hexadecimal checksum according to the NMEA standard.

Example 8 Typical NMEA Proprietary string

4 variables ROLL = 0.051 rad, PITCH = -0.051 rad, HEAVE = 1.234 metres, DATE in seconds since 1 January 1970 00:00:00; token is 19, data stable.

```
$PSXN,10,019,5.100e-2,-5.100e-2,1.234e+0,771598427,,*61
```

- 1 **\$PSXN**
- 2 **10** = Message number, data stable
- 3 **019** = Token
- 4 **5.100e-2** = Roll
- 5 **-5.100e-2** = Pitch
- 6 **1.234e+0** = Heave
- 7 **771598427** = TueJun14 1994 12:53:47
- 8 **,,** = Empty fields
- 9 **x.xx** = Data field 6
- 10 ***61** = Checksum

A.4.3 Sounder

The Sounder format is a proprietary ASCII text format used when connecting to Simrad EA500 and other echo sounders. By selecting this format the number of MRU variables is fixed and there is no token associated with it. However, the baud rate and output interval may be changed as required.

The format is ASCII based, with fixed length and terminated with CR and LF.

Format

:aabbbbshhhhxsrrrrspppp<CR><LF>

Format description

- 1 **aa** = 2 char hex number with SWAY acceleration, in 0.03835 m/ss units
- 2 **bbbb** = 4 char hex number with HEAVE acceleration, in 0.000625 m/ss units
- 3 **hhhh** = 4 char decimal number with HEAVE position in centimetres, positive up
- 4 **s** = 1 character of sign: <SPACE> if positive "-" if negative
- 5 **x** = warning character. <SPACE> if OK, "?" if data unstable
- 6 **rrrr** = 4 char decimal number with ROLL angle in hundreds of a degree
- 7 **s** = 1 character of sign: <SPACE> if positive, "-" if negative
- 8 **pppp** = 4 char decimal number with PITCH angle in hundreds of a degree

9 s = 1 character of sign: <SPACE> if positive, "-" if negative

The definition of the attitude angles in this format is different from the Euler angles definition used elsewhere. The difference appears in the roll angle, where:

$$roll_{echo-sounder} = \arcsin[\sin(roll_{Euler}) \cdot \cos(pitch_{Euler})]$$

Example 9 Typical Sounder string

If the SWAY acceleration is 1.0 m/ss = 26 * 0.03835 = 0x1a * 0.03835, the HEAVE acceleration is 8.750 m/ss = 14000 * 0.000625 = 0x36b0 * 0.000625, the HEAVE is -2.54 metres, the ROLL is -0.87 degrees and the PITCH is 3.78 degrees.

Data is OK. The message is then:

:1a36b0 -0254 -0087 0378<CR><LF> (total 27 characters).

A.4.4 Simrad EM3000

The Simrad EM3000 format consists of a fixed-length message using single-byte unsigned, 2-byte unsigned and 2-byte two-complement integer data elements. For the 2-byte elements, the least significant byte is transmitted first.

Format

Element	Scaling	Format	Bytes	Value
Status byte		Unsigned	1	
Header		Unsigned	1	90 Hex
Roll	0.01 degrees	Integer	2	-17999 to 17999
Pitch	0.01 degrees	Integer	2	-17999 to 17999
Heave	1 cm	Integer	2	-999 to 999
Heading	0.01 degrees	Unsigned	2	0 to 35999

Roll is positive with port side up. Pitch is positive with bow up. Heave is positive up.

The status byte can have the following values:

Value	Interpretation
90 Hex	Normal
91 Hex	Reduced performance
A0 Hex	Invalid data

Invalid data are also indicated by values outside the specified ranges. When the status is A0, the values which are within specified ranges can be assumed to have valid, but reduced quality.

A.4.5 ATLAS

This is the default digital output format from a motion sensor that is to be interfaced with an Atlas Fansweep echo sounder. Each field in the output packet is a 16-bit 2's complement number expressed as two binary-coded digits.

Format

DLE RrPpHhQ DLE

Format description

- 1 **DLE** = Start character - ASCII 10 Hex.
- 2 **R** = Roll – MSB. Unit: Horn scaling $2\pi = 2^{**}16$.
- 3 **r** = Roll – LSB.
- 4 **P** = Pitch – MSB. Unit: Horn scaling $2\pi = 2^{**}16$.
- 5 **p** = Pitch – LSB.
- 6 **H** = Heave – MSB. Unit: 1 mm per increment.
- 7 **h** = Heave – LSB.
- 8 **Q** = Status code 0 to 7 inclusive. Below is a description of the various codes.
- 9 **DLE** = Stop character - ASCII 10 Hex.

The various status codes have the following meaning:

Status code	Description
0	Unaided mode and stable data. The MRU is operating without external input data.
1	Unaided mode but unstable data. The MRU is without external input data, but the data from the unit are unstable most likely due to alignment after power on or restart. The alignment period from power on or restart is normally 5 minutes.
2	Speed aided mode and stable data. The MRU is operating with external input of speed data.
3	Speed aided mode but unstable data. The MRU is operating with external input of speed data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of speed data
4	Heading aided mode and stable data. The MRU is operating with external input of heading data.
5	Heading aided mode but unstable data. The MRU is operating with external input of heading data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of heading data.

Status code	Description
6	Full aided mode and stable data. The MRU is operating with external input of both speed and heading data.
7	Full aided mode but unstable data. The MRU is operating with external input of both speed and heading data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of external data.

A.4.6 TSS1

The TSS1 format is a modified version of the SOUNDER format with aiding MRU status information. By selecting this format, the number of MRU variables is fixed, and there is no token associated with it. However, the baud rate and output interval may be changed as required.

The format is ASCII based, with a fixed length and terminated with CR and LF.

Format

:aabbbb shhhxsrrrr spppp<CR><LF>

Format description

- 1 **aa** = 2 char hex number with SWAY acceleration, in 0.03835 m/ss units
- 2 **bbbb** = 4 char hex number with HEAVE acceleration, in 0.000625 m/ss units
- 3 **hhhh** = 4 char decimal number with HEAVE position in centimetres, positive up
- 4 **s** = 1 character of sign: <SPACE> if positive, "-" if negative
- 5 **x** = status character. Below is a description of the various characters
- 6 **rrrr** = 4 char decimal number with ROLL angle in hundreds of a degree
- 7 **s** = 1 character of sign: <SPACE> if positive, "-" if negative
- 8 **pppp** = 4 char decimal number with PITCH angle in hundreds of a degree
- 9 **s** = 1 character of sign: <SPACE> if positive, "-" if negative

The definition of the attitude angles in this format is different from the Euler angles definition used elsewhere. The difference appears in the roll angle, where:

$$roll_{echo-sounder} = \arcsin[\sin(roll_{Euler}) \cdot \cos(pitch_{Euler})]$$

The various status characters have the following meaning:

Status character	Description
U	Unaided mode and stable data. The MRU is operating without external input data.
u	Unaided mode but unstable data. The MRU is without external input data, but the data from the unit are unstable most likely due to alignment after power on or restart. The alignment period from power on or restart is normally 5 minutes.
G	Speed aided mode and stable data. The MRU is operating with external input of speed data.
g	Speed aided mode but unstable data. The MRU is operating with external input of speed data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of speed data.
H	Heading aided mode and stable data. The MRU is operating with external input of heading data.
h	Heading aided mode but unstable data. The MRU is operating with external input of heading data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of heading data.
F	Full aided mode and stable data. The MRU is operating with external input of both speed and heading data.
f	Full aided mode but unstable data. The MRU is operating with external input of both speed and heading data, but the data from the unit are unstable most likely due to alignment after power on, restart or input of external data.

Example 10 Typical TSSI string

If the SWAY acceleration is 1.0 m/ss = $26 * 0.03835 = 0x1a * 0.03835$, the HEAVE acceleration is 8.750 m/ss = $14000 * 0.000625 = 0x36b0 * 0.000625$, the HEAVE is -2.54 metres, the ROLL is -0.87 degrees and the PITCH is 3.78 degrees.

Data are unaided and stable. The message is then:

:1a36b0 -0254U-0087 0378<CR><LF> (total 27 characters).

A.4.7 RDI ADCP

The RDI format is a proprietary ASCII text format used when connecting RDI ADCP equipment.

Format:

\$PRDID,pitch,roll,head term

Explanation:

- pitch** Pitch, degrees on format sddd.dd. s is the sign character, "+" or "-". ddd.dd is a decimal number with leading zeroes where appropriate. Positive with bow up.
- roll** Roll, degrees on format sddd.dd. s is the sign character, "+" or "-". ddd.dd is a decimal number with leading zeroes where appropriate. Positive with port side up.
- head** Heading, degrees true on format ddd.dd, with leading zeroes where appropriate.
- term** CR-LF (2 bytes, values 13 and 10).

A.4.8 Seapath Binary 23

This binary format consists of a fixed-length message using 1, 2 and 4-byte signal and unsigned integers. The signed integers are represented as two-complement numbers. For the multi-byte elements, the most significant byte is transmitted first. The total number of bytes is 44.

This format is mainly implemented in the MRU for Doppler correction in FM mode for the EM710 and EM2040 multi-beam echo sounders. For best possible results the following is required:

- Speed and heading input to the MRU. The speed input has to be on the NMEA VTG format and output in the vessel CG. The MRU uses the course over ground and heading information in the VTG message to de-compose the speed input vector in North and East direction as required for FM mode correction.
- Both the speed and heading input have to be on high update rate, preferably 10 Hz or more.
- The delays on the speed and heading input have to be at a minimum, less than 5 ms.

When this format is output from the MRU the following elements are set to zero:

- Latitude and Longitude
- Height

Format

Element	Scaling	Format	Bytes	Value
Header		Unsigned	1	AA Hex
Header		Unsigned	1	51 Hex
Time, seconds	seconds	Integer	4	
Time, fraction of second	0.0001 second	Unsigned	2	0 to 9999
Latitude	$2^{30} = 90$ degrees	Integer	4	$-2^{30} - 2^{30}$
Longitude	$2^{30} = 90$ degrees	Integer	4	$-2^{31} - 2^{31}$

Element	Scaling	Format	Bytes	Value
Height	centimetres	Integer	4	
Heave	centimetres	Integer	2	
North velocity	centimetres/second	Integer	2	
East velocity	centimetres/second	Integer	2	
Down velocity	centimetres/second	Integer	2	
Roll	$2^{14} = 90$ degrees	Integer	2	$-2^{15} - 2^{15}$
Pitch	$2^{14} = 90$ degrees	Integer	2	$-2^{15} - 2^{15}$
Heading	$2^{14} = 90$ degrees	Unsigned	2	$0 - 2^{16}$
Roll rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Pitch rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Yaw rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Status word		Bit-fields	2	
Checksum		Unsigned	2	

Checksum is calculated as a 16-bit Block Cyclic Redundancy Check of all bytes between, but not including the Header and Checksum fields. The CRC algorithm is described in a separate section. Time is divided in an integer seconds part and a fractional second part. The integer seconds part of time is counted from 1970-01-01 UTC time. For accurate time value the sensor unit require input of ZDA message and 1PPS signal.

The status word consists of 16 single bit flags numbered from 0 to 15, where 0 is the least significant bit.

A 1 value (true) means:

Bit no.	Interpretation
0	Reduced horizontal position and velocity performance.
1	Invalid horizontal position and velocity data.
2	Reduced heave and vertical velocity performance.
3	Invalid heave and vertical velocity data.
4	Reduced roll and pitch performance.
5	Invalid roll and pitch data.
6	Reduced heading performance.
7	Invalid heading data.

The remaining bits in the status word are reserved for future expansion.

A.4.9 Seapath Binary 26

This binary format consists of a fixed-length message using 1, 2 and 4-byte signal and unsigned integers. The signed integers are represented as two-complement numbers. For the multi-byte elements, the most significant byte is transmitted first. The total number of bytes is 52.

Format

Element	Scaling	Format	Bytes	Value
Header		Unsigned	1	AA Hex
Header		Unsigned	1	53 Hex
Time, seconds	seconds	Integer	4	
Time, fraction of second	0.0001 second	Unsigned	2	0 to 9999
Latitude	$2^{30} = 90$ degrees	Integer	4	$-2^{30} - 2^{30}$
Longitude	$2^{30} = 90$ degrees	Integer	4	$-2^{31} - 2^{31}$
Height	centimeters	Integer	4	
Heave, real-time	centimeters	Integer	2	
North velocity	centimeters/second	Integer	2	
East velocity	centimeters/second	Integer	2	
Down velocity	centimeters/second	Integer	2	
Roll	$2^{14} = 90$ degrees	Integer	2	$-2^{15} - 2^{15}$
Pitch	$2^{14} = 90$ degrees	Integer	2	$-2^{15} - 2^{15}$
Heading	$2^{14} = 90$ degrees	Unsigned	2	0 - 2^{16}
Roll rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Pitch rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Yaw rate	$2^{14} = 90$ degrees/second	Integer	2	$-2^{15} - 2^{15}$
Delayed heave time, seconds	seconds	Integer	4	
Delayed heave time, fraction of second	0.0001 second	Unsigned	2	0 to 9999
Heave, delayed	centimeters	Integer	2	
Status word		Bit-fields	2	
Checksum		Unsigned	2	

Checksum is calculated as a 16-bit Block Cyclic Redundancy Check of all bytes between, but not including the Header and Checksum fields. The CRC algorithm is described in a separate section. Time is divided in an integer seconds part and a fractional second part. The integer seconds part of time is counted from 1970-01-01 UTC time. For accurate time value the sensor unit require input of ZDA message and 1PPS signal.

Latitude is positive north of the Equator. Longitude is positive east of Greenwich. Height is above the ellipsoid. Heave is positive down. Roll is positive with port side up. Pitch is positive with bow up.

The status word consists of 16 single bit flags numbered from 0 to 15, where 0 is the least significant bit.

A 1 value (true) means:

Bit no.	Interpretation
0	Reduced horizontal position and velocity performance.
1	Invalid horizontal position and velocity data.
2	Reduced heave and vertical velocity performance.
3	Invalid heave and vertical velocity data.
4	Reduced roll and pitch performance.
5	Invalid roll and pitch data.
6	Reduced heading performance.
7	Invalid heading data.
8	Invalid delayed heave data

The remaining bits in the status word are reserved for future expansion.

A.4.10 PFreeHeave

This PFreeHeave® format consists of a fixed-length message using 1-, 2- and 4-byte signed and unsigned integers. The signed integers are represented as two-complement numbers. For the multi-byte elements, the most significant byte is transmitted first. The total number of bytes is 13.

The PFreeHeave output is delayed by a few minutes due to processing. The time fields contain time of validity for the data.

Format

Element	Scaling	Format	Bytes	Value
Header		Unsigned	1	AA Hex
Header		Unsigned	1	52 Hex
Time, seconds	Seconds	Integer	4	

Element	Scaling	Format	Bytes	Value
Time, fraction of second	0.0001 second		2	0 to 9999
Heave	Centimetres	Integer	2	
Status word		Bit-fields	1	
Checksum		Unsigned	2	

Checksum is calculated as a 16-bit Block Cyclic Redundancy Check of all bytes between, but not including the Header and Checksum fields. The CRC algorithm is described in a separate section. Time is divided in an integer seconds part and a fractional second part. The integer seconds part of time is counted from 1970-01-01 UTC time. For accurate time value the sensor unit require input of ZDA message and 1PPS signal.

Heave is positive down. The status field is zero if heave is valid, non-zero if heave is invalid.

A.4.11 Cyclic redundancy check algorithm

The 16-bit Block Cyclic Redundancy Check algorithm used to calculate the checksum in some formats is described in C and Fortran source code below.

C code

```
#define POLY 0x8408
unsigned short blkcrc(
    unsigned char *bufptr,      /* message buffer */
    unsigned long len           /* number of bytes */
)
{
    unsigned char i;
    unsigned short data;
    unsigned short crc = 0xffff;

    if (len == 0L) {
        return ~crc;
    }

    do {
        for (i=0, data = (unsigned short) (0xff & *bufptr++);
            i < 8;
            i++, data >>= 1) {
            if ((crc & 0x0001) ^ (data & 0x0001)) {
                crc = (crc >> 1) ^ POLY;
            } else {
                crc >>= 1;
            }
        }
    } while (--len);

    crc = ~crc;
    data = crc;
    crc = (crc << 8) | ((data >> 8) & 0xff);

    return crc;
}
```

Fortran code

```
SUBROUTINE blkcrc(inbuffer, len, crc)

INTEGER*2 len, i , bit
INTEGER*4 crc, data, poly
CHARACTER inbuffer*(*)

poly = 16#8408
crc = 16#FFFF
data = 0

IF (len.EQ.0) THEN
    crc = 0
    RETURN
END IF

DO i = 1, len
    data = ICHAR(inbuffer(i:i))
    DO bit = 1, 8
        data = IAND(data,16#FF)
        IF (IAND(crc,16#01).EQ.(IAND(data,16#01))) THEN
            crc = ISHL(crc,-1)
        ELSE
            crc = ISHL(crc,-1)
            crc = IEOR(crc, poly)
        END IF
        data = ISHL(data,-1)
    END DO
END DO

data = IEOR(crc,16#FFFF)
crc = IOR(ISHL(data,8),IAND(ISHL(data,-8),16#FF))

END
```

A.5 Other messages

A.5.1 Get current data set message

In addition to the binary C 1 command, the following ASCII command can be used for data message interrogation:

Format

\$PSXN, ?<cr><lf>

or

\$PSXN, ?**n**<cr><lf>

Data from the sensor unit is transmitted in a message formatted according to setup for current channel (COM1 or COM2), or selected channel **n** if **n** is used.

Channel **n** maps as follows:

0 = COM1, 1 = COM2, 5 = UDP1, 6 = UDP2, 7 = UDP3, 8 = UDP4, 9 = UDP5

A.5.2 Welcome message

This message is sent at start-up on COM1 and UDP.

Format

```
<'c'><36><7><'MruV v.r.n yyyy-mm-dd'><type><vers><v_0><v_1>  
<n_0><n_1><s_0><s_1><s_2><s_3><opt><0><chk>
```

Format description

- 1 **MruV v.r.n yyyy-mm-dd** = 22 characters with software version.
- 2 **type** = MRU type: 11..20 11== '2', 12=='D', 13=='3', 14=='H', 15=='5+', 16=='5', 17=='E', 25=='R3'
- 3 **vers** = hardware version : 'v', 'x'.. hardware version identification.
- 4 **v_0,1** = 16 bit software number multiplied with 100 (version 5.1.1 will then be 511)
- 5 **n_0,1** = 16 bit MRU serial number (20000++)
- 6 **s_0,3** = 32 bit MRU status
- 7 **opt** = N/A

A.5.3 Abnormal mode message

When in *Abnormal* mode, the MRU transmits a text message on COM1 and UDP every second:

Format

```
MRU-V.v,ser.no nnnnn,sw MruV v.r.n yyyy-mm-dd, status  
xxxx\n
```

Format description

- 1 **status xxxx** = Hex value, showing why abnormal mode was entered:
 - Bit_1: Abnormal mode
 - Bit_8: HW error
 - Bit_9: HW config error
 - Bit_10: Board error
 - Bit_11: SW level error
 - Bit_12: Config file error
 - Bit_13: Calibration error

The MRU LED flashes red at 4 Hz when in *Abnormal* mode.

A.6 External speed and heading input

The MRU 3, H, E, 5 and 5+ models are designed to generate data of the highest precision for marine applications. Key factors in achieving this level of precision involve the external input of speed data (from a speed log) and heading data (from a gyro compass). These features are particularly important for operations that include frequent turns, changes in heading and/or accelerations.

External input of speed and heading data reduces the roll, pitch and heave measurement drift caused by turning and accelerations. In this way the MRU can accurately measure roll and pitch angles even while turning and/or accelerating. Both input of speed and heading data are particularly important in operations involving frequent turns. It ensures high quality roll and pitch measurements during these manoeuvres. Only a high quality speed and heading signal must be used. If the quality of the external inputs are uncertain, it is better to simply refrain from sending it to the MRU. Heading input eliminate the influence from earth rotation and speed input on changes on vessel acceleration.

Note

To check that correct input of external speed and heading to the MRU is used, the output variable numbers 161 (external speed signal) and 162 (external heading signal) are available.

A.6.1 Interface possibilities

These are the interface possibilities of speed and heading input to the MRU.

- Speed and heading data may be input to the MRU from a host computer through the combined RS-422 input/output port COM 1. The baud rate and parity then have to be the same on both the input and output signal. Input data can be sent as a standard MRU protocol command or as an NMEA protocol.
- Speed and heading data may be input to the MRU directly from the source through the RS-422/232 lines COM 3 and/or COM 4 as a standard MRU protocol command or as an NMEA protocol.
- Heading data may be sent to the MRU on the RS-422/232 lines COM 3 and/or COM 4.
- Speed and heading data may be input to the MRU through Ethernet (UDP/IP) UDP1 port as a standard MRU protocol command or as an NMEA protocol.

A.6.2 Default settings

These are the default settings on the input signals.

- COM 1 and 2 are set to 9600 baud and 8 data no parity mode.
- COM 3 and 4 are set to accept serial data input at 9600 baud and 8 data no parity mode.

These default settings can be changed by using the MRC+ configuration software.

A.6.3 Input data rate

The preferred update rate for external speed and heading data is 2 Hz. Under no circumstances should this rate be set to exceed 10 Hz, in order not to overload the MRU computer unnecessarily.

If speed and heading data are not received by the MRU for three seconds, external input will be considered not available. Hence, the input rate must be higher than 0.33 Hz.

A.6.4 Heading signal

The MRU 3, H, E, 5 and 5+ models accept external heading information sent to the unit by using the standard MRU protocol commands and as NMEA sentence. Heading data must be of high quality (better than 100°/s in follow-up rate and a real-time signal) in order to achieve the specified accuracy of the MRU. Only a high quality compass should be used.

External heading data must be calibrated to the standard vessel heading (heading the bow direction). In this way the MRU mounting misalignment, as calculated and keyed in during the setup, will apply to the heading data.

The heading signal can be sent whenever wanted. However, the data must not be delayed (compared to real time) to avoid errors in turns. If the heading signal sent as NMEA HDT or HDM message has a known delay, this can be compensated for by inputting this as a parameter in the MRU configuration **External heading age**.

Heading input through the standard MRU protocol

The most efficient way of inputting heading information to the MRU is by using the standard MRU protocol commands. By using these software commands, the user can send heading information to the MRU as data containing an IEEE single precision floating point number directly in the physical units (given as 0 to 2 radians, or $\pm\pi$ radians). The direction must be positively defined as the ship turns from north to east.

The following is the format for entering external yaw angle `yx_bg`:

`<'C'><6><13><delay><yx_bg_msb><yx_bg_1><yx_bg_2><yx_bg_1sb>`

- **delay** = Unsigned byte given time delay in 10 ms units since data were captured (default 0, maximum possible delay is set to 2 seconds) until the message is entered into the MRU.
- **yx_bg_x** = IEEE single precision float (given in radians) specifying heading (yaw) angle. The heading is zero at north and increases when turning starboard; values must be in the range 0 to 2π or $-\pi$ to π . Values outside these limits will result in an unacceptable message.

Heading input through the NMEA interface

The MRU will accept NMEA 0183 sentences for heading data. These are sent directly into the unit on the COM ports 1, 3 or 4 or on the Ethernet UDP1 port. The NMEA sentence can be interleaved with other MRU messages. Cyclic data messages from the MRU may continue while NMEA sentences are written to the MRU.

NMEA sentences acceptable for heading input to the MRU:

HDT heading — true

\$--HDT, **x.x**, T*hh<CR><LF>

- **x.x** = heading degrees

HDM magnetic heading

\$--HDM, **x.x**, M*hh<CR><LF>

- **x.x** = heading degrees

Note

*If the heading signal has a known delay, it can be compensated for by inputting this as a parameter in the MRU configuration **External heading age**. Note that this setting only has effect when the NMEA interface is used. For the standard MRU protocol the heading delay is a part of the heading input format. Maximum possible delay is set to 2000 milliseconds, default is 200 ms.*

A.6.5 Speed log signal

The MRU 3, H, E, 5 and 5+ models accepts external speed information sent to the unit using standard MRU protocol commands, the NMEA sentence or as a pulsed log signal. The speed data must be of high quality in order to achieve the expected performance. Only a quality speed data source should be used (real-time signal, vessel speed in CG).

Note

The GNSS speed data input to the MRU must be lever arm compensated down to CG (essential when the GNSS antenna is high up in the mast) and only include speed in the vessel longitudinal axis.

The speed signal can be sent whenever wanted. However, speed data should not be delayed (compared to real time) more than approximately 0.1 second to avoid errors in turns.

The MRU software filters external speed log data in an internal filter. The user does not need to perform additional filtering of the data. However, speed log data must be checked for validity before being input into the MRU.

Speed input through the standard MRU protocol

The most efficient way to input speed log information to the sensor unit is by using the standard MRU protocol commands. By using these software commands, the user can send speed information to the sensor unit as data containing an IEEE single precision floating point number directly in the physical units (given in m/s).

The speed information can be taken from a standard Doppler log or other scalar speed log that provides the forward cruise speed of the vessel in the longitudinal axis. The following format is used for entering external speed vx_b:

<'C'><6><12><delay><vx_b_msb><vx_b_1><vx_b_2><vx_b_1sb>

- **delay** = Not in use.
- **vx_b_x** = IEEE single precision float (given in m/s) specifying cruise speed. The speed is positive in the bow direction of the ship.

Speed input through the NMEA interface

The sensor unit will accept NMEA 0183 sentences for speed data. These are sent directly into the unit on the COM ports 1, 2, 3 or 4 or on the Ethernet UDP port. The NMEA sentence can be interleaved with other MRU messages. Cyclic data messages from the sensor unit may continue while NMEA sentences are written to the sensor unit.

NMEA sentences acceptable for speed input:

VTG — Track made good and ground speed

\$--VTG, x.x, T, x.x, M, x.x, N, x.x, K*hh<CR><LF>

- **x.x** = speed knots
- **x.x** = speed km/h

VHW — Water speed

\$--VHW, x.x, T, x.x, M, x.x, N, x.x, K*hh<CR><LF>

- **x.x** = speed knots
- **x.x** = speed km/h

VBW — Dual ground/water speed

\$--VBW, x.x, x.x, A, x.x, x.x, A*hh<CR><LF>

- **x.x** = longitudinal speed knots

A.7 External time and time synchronisation input

The MRU can be synchronized to an external 1PPS signal, typical from a GNSS receiver. This is done by applying a logic level signal to XIN with minimum 2.5 Volt referred to CGND (the communication ground reference). The pulse signal must have minimum 2 ms high and low periods. The MRU seconds will be synchronized to negative edge of the 1PPS signal. Synchronization state will be reported in the MRU status bit field.

The MRU date can be set by use of the NMEA ZDA message. When a valid ZDA message is received on any MRU input channel, the MRU date is changed on the next new MRU second. Max valid change is ± 120 seconds used together with 1PPS. A valid change of seconds will appear in MRU event log.

NMEA sentences acceptable for time/data input is:

ZDA — Time and date

\$--ZDA,hhmmss.ss,xx,xx,xxxx,xx,xx*hh<CR><LF>

- hhmmss.ss = UTC
- xx = Day, 01 to 31, UTC
- xx = Month, 01 to 12, UTC
- xxxx = Year, UTC
- xx = Local zone hours, 00 to ± 13 hrs
- xx = Local zone minute, 00 to +59

A.8 External height input

Height information like from GPS RTK can be used to aid the integrated heave filter with external height information. The external height signal can be input as NMEA GGA message at 1 Hz with quality indicator set to 4 (RTK quality).

Note

The GNSS height input must be lever arm compensated down to CG. When configuring the lever arm from the GNSS antenna to the origin in the MRC+ configuration software the MRU will perform this lever arm compensation to CG itself.

NMEA sentence acceptable for height input is:

GGA — Global positioning system fix data

Format

\$--GGA,hhmmss.ss,llll.ll,a,yyyy.yy,a,x,x.x,x.x,M,x.x,M,x.x,xxxx*hh<CR><LF>

Format description

- 1 hhmmss.ss = UTC of position fix
- 2 llll.ll = Latitude, E/W
- 3 yyyy.yy = Longitude, E/W
- 4 x = GPS quality indicator
- 5 xx = Number of satellites in use, 00–12
- 6 x.x = Horizontal dilution of precision
- 7 x.x = Altitude re: mean sea level, M
- 8 x.x = Geoidal separation, M
- 9 x.x = Age of DGPS data
- 10 xxxx = DGPS station ID

A.9 Remarks

When external input is used, please verify the following:

- The status of <OK> appears in the MRC+ **Status** tab when the sensor unit accepts the external input signals. If not, the sensor unit has not accepted the sent messages.
- If there are problems with speed and heading input, then output the variables ExtSpeedUser (var.no. 161) and ExtHeadUser (var.no. 162) from the MRU in order to monitor the external signals received by the MRU. For control it is possible to monitor the internal estimated speed signal in the MRU by outputting var.no. 160 and the heading signal from the MRU by outputting var.no. 68.
- When speed data from GNSS is used, the speed data must be lever arm compensated down to the CG (essential when the GPS antenna is high up in the mast) and only include speed in the vessel longitudinal axis.
- It is essential that speed data sent to the sensor unit are of the specified quality; otherwise the system accuracy will be diminished.
- If there are problems with height input, then output the variable **IntHeight** (var. no. 93) from the sensor unit in order to monitor the external signal received by the sensor unit.

A.10 Simple software driver

Assumption: The MRU is set up by the MRC software to output data in a given data format. The MRU is set up for interrogate mode. The baud rate is set so that the transmission time is lower than the needed sample time. The software in the host consists of a cyclically running task.

The driver must:

- Send the `Get Current Data` command to the MRU.
- Pick up data from the MRU as arrived.
- Decode the picked up data according to decided fixed format.

No special checking on data is required, except parity and checksum for serial communication. If those data are bad, keep the last sample. If data are not received from the MRU, then an alarm message is given, and inputs from the MRU are set to "safe" default values.

Some properties:

- The job must wait for the MRU transmission: this wastes CPU time.
- Correspondence with actual format loaded in the MRU is not known.

Appendix B

Output variable list

The output variables available are listed below:

No.	Variable name	Unit	Description
1	AngRate_R	[rad/s]	Angular rate in roll axis (b-frame)
2	AngRate_P	[rad/s]	Angular rate in pitch axis (b-frame)
3	AngRate_Y	[rad/s]	Angular rate in yaw axis (b-frame)
11	AccM_Rf	[m/s ²]	Low pass filtered measured acceleration in the roll axis in the MRU point (gravity not subtracted)
12	AccM_Pf	[m/s ²]	Low pass filtered measured acceleration in the pitch axis in the MRU point (gravity not subtracted)
13	AccM_Yf	[m/s ²]	Low pass filtered measured acceleration in the yaw axis in the MRU point (gravity not subtracted)
31	T.sensor house	[DegC]	Sensor house temperature
60	AngAcc_R	[rad/s ²]	Angular acceleration in roll axis (b-frame)
61	AngAcc_P	[rad/s ²]	Angular acceleration in pitch axis (b-frame)
62	AngAcc_Y	[rad/s ²]	Angular acceleration in yaw axis (b-frame)
63	Roll	[rad]	Roll angle (euler angle)
64	Pitch	[rad]	Pitch angle (euler angle)
65	Yaw	[rad]	Yaw angle (euler angle)
66	RollHippy	[-1 1]	Sine of roll angle relative horizontal plane, Datawell Hippy compatible
67	PitchHippy	[-1 1]	Negative pitch angle sine, Datawell Hippy compatible
68	Heading	[rad]	Heading (Yaw angle represented in the interval from 0 to 2*pi)
90	IntHeave	[m]	Heave in configured measurement point. Integrated heave solution
91	IntHeaveVel	[m/s]	Heave velocity in configured measurepoint. Integrated heave solution
92	HeaveUnrel		Heave transient indicator for integrated heave solution
93	IntHeight	[m]	Height in configured monitoring point. Integrated heave solution

No.	Variable name	Unit	Description
129	AutomaticPeriod	[s]	Heave period used in the automatic heave filter
159	HeavePeriod	[s]	Estimated heave period
160	ExtSpeed	[m/s]	Speed estimated from external speed input
161	ExtSpeedUser	[m/s]	External speed input from user
162	ExtHeadUser	[degrees]	External heading input from user
167	SampleTime.ms	[ms]	Seconds since 1970, millisecond fraction
168	SampleTime.s	[s]	Seconds since 1970.01.01 00:00.00 UTC
169	SampleTime.n	[nano]	Seconds since 1970, nanosecond fraction
173	Status	[]	MRU status bit that indicates its internal status
176	SampleTime	[ms]	Sample time in milliseconds since power on
Linear motion variables in the MRU location (variable200 to 250):			
200	AccMru_F	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in forward direction (h-frame)
201	AccMru_S	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in starboard direction (h-frame)
202	AccMru_D	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in down direction (h-frame)
203	AccMru_Ff	[m/s ²]	Low pass filtered acceleration at MRU point in forward direction (h-frame)
204	AccMru_Sf	[m/s ²]	Low pass filtered acceleration at MRU point in starboard direction (h-frame)
205	AccMru_Df	[m/s ²]	Low pass filtered acceleration at MRU point in down direction (h-frame)
206	AccMru_N	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in north direction (g-frame)
207	AccMru_E	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in east direction (g-frame)
208	AccMru_D	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in down direction (g-frame)
212	VelMru_F	[m/s]	Linear velocity at MRU point in forward direction (h-frame)
213	VelMru_S	[m/s]	Linear velocity at MRU point in starboard direction (h-frame)
214	VelMru_D	[m/s]	Linear velocity at MRU point in down direction (h-frame)
224	PosMru_F	[m]	Linear position at MRU point in forward direction (h-frame)
225	PosMru_S	[m]	Linear position at MRU point in starboard direction (h-frame)
226	PosMru_D	[m]	Linear position at MRU point in down direction (h-frame)

No.	Variable name	Unit	Description
230	PosMru_N	[m]	Linear position at MRU point in north direction (g-frame)
231	PosMru_E	[m]	Linear position at MRU point in east direction (g-frame)
232	PosMru_D	[m]	Linear position at MRU point in down direction (g-frame)
234	dSurgeMru	[m]	Delayed surge output at MRU point in north direction (g-frame). Output delayed 33 seconds from real-time
235	dSwayMru	[m]	Delayed sway output at MRU point in east direction (g-frame). Output delayed 33 seconds from real-time
236	dHeaveMru	[m]	Delayed heave output at MRU point in down direction (g-frame). Output delayed 132 seconds from real-time
238	AccMru_R	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in R-direction (b-frame)
239	AccMru_P	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in P-direction (b-frame)
240	AccMru_Y	[m/s ²]	Linear acceleration (raw/unfiltered) at MRU point in Y-direction (b-frame)
241	AccMru_Rf	[m/s ²]	Low pass filtered acceleration at MRU point in R-direction (b-frame)
242	AccMru_Pf	[m/s ²]	Low pass filtered acceleration at MRU point in P-direction (b-frame)
243	AccMru_Yf	[m/s ²]	Low pass filtered acceleration at MRU point in Y-direction (b-frame)
244	VelMru_R	[m/s]	Linear velocity at MRU point in R-direction (b-frame)
245	VelMru_P	[m/s]	Linear velocity at MRU point in P-direction (b-frame)
246	VelMru_Y	[m/s]	Linear velocity at MRU point in Y-direction (b-frame)
247	PosMru_R	[m]	Linear position at MRU point in R-direction (b-frame)
248	PosMru_P	[m]	Linear position at MRU point in P-direction (b-frame)
249	PosMru_Y	[m]	Linear position at MRU point in Y-direction (b-frame)
Linear motion variables in CG (variable 250 to 300):			
250	AccCg_F	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in forward direction (h-frame)
251	AccCg_S	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in starboard direction (h-frame)
252	AccCg_D	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in down direction (h-frame)
253	AccCg_Ff	[m/s ²]	Low pass filtered acceleration at CG in forward direction (h-frame)
254	AccCg_Sf	[m/s ²]	Low pass filtered acceleration at CG in starboard direction (h-frame)
255	AccCg_Df	[m/s ²]	Low pass filtered acceleration at CG in down direction (h-frame)

No.	Variable name	Unit	Description
256	AccCg_N	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in north direction (g-frame)
257	AccCg_E	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in east direction (g-frame)
258	AccCg_D	[m/s ²]	Linear acceleration (raw/unfiltered) at CG in down direction (g-frame)
262	VelCg_F	[m/s]	Linear velocity at CG in forward direction (h-frame)
263	VelCg_S	[m/s]	Linear velocity at CG in starboard direction (h-frame)
264	VelCg_D	[m/s]	Linear velocity at CG in down direction (h-frame)
274	PosCg_F	[m]	Linear position at CG in forward direction (h-frame)
275	PosCg_S	[m]	Linear position at CG in starboard direction (h-frame)
276	PosCg_D	[m]	Linear position at CG in down direction (h-frame)
286	dHeaveCg	[m]	Delayed heave output at Cg in down direction (g-frame)
Linear motion variables in monitoring point 1, MP1 (variables 300 to 350):			
300	AccMp1_F	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in forward direction (h-frame)
301	AccMp1_S	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in starboard direction (h-frame)
302	AccMp1_D	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in down direction (h-frame)
303	AccMp1_Ff	[m/s ²]	Low pass filtered acceleration at the first monitoring point in forward direction (h-frame)
304	AccMp1_Sf	[m/s ²]	Low pass filtered acceleration at the first monitoring point in starboard direction (h-frame)
305	AccMp1_Df	[m/s ²]	Low pass filtered acceleration at the first monitoring point in down direction (h-frame)
306	AccMp1_N	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in north direction (g-frame)
307	AccMp1_E	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in east direction (g-frame)
308	AccMp1_D	[m/s ²]	Linear acceleration (raw/unfiltered) at the first monitoring point in down direction (g-frame)
312	VelMp1_F	[m/s]	Linear velocity at the first monitoring point in forward direction (h-frame)
313	VelMp1_S	[m/s]	Linear velocity at the first monitoring point in starboard direction (h-frame)
314	VelMp1_D	[m/s]	Linear velocity at the first monitoring point in down direction (h-frame)

No.	Variable name	Unit	Description
323	LA_VelMp1_D	[m/s]	Velocity in down direction (g-frame) at MP1, lever arm compensated from CG. The mean velocity depends on vessel tilt
324	PosMp1_F	[m]	Linear position at the first monitoring point in forward direction (h-frame)
325	PosMp1_S	[m]	Linear position at the first monitoring point in starboard direction (h-frame)
326	PosMp1_D	[m]	Linear position at the first monitoring point in down direction (h-frame)
335	LA_PosMp1_D	[m]	Lever arm compensated linear position relative to Cg in the first monitoring point in down direction (g-frame). The mean position depends on vessel tilt
336	dHeaveMp1	[m]	Delayed heave output at the first monitoring point in down direction (g-frame)
Linear motion variables in monitoring point 2, MP2 (variables 350 to 400):			
350	AccMp2_F	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in forward direction (h-frame)
351	AccMp2_S	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in starboard direction (h-frame)
352	AccMp2_D	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in down direction (h-frame)
353	AccMp2_Ff	[m/s ²]	Low pass filtered acceleration at the second monitoring point in forward direction (h-frame)
354	AccMp2_Sf	[m/s ²]	Low pass filtered acceleration at the second monitoring point in starboard direction (h-frame)
355	AccMp2_Df	[m/s ²]	Low pass filtered acceleration at the second monitoring point in down direction (h-frame)
356	AccMp2_N	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in north direction (g-frame)
357	AccMp2_E	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in east direction (g-frame)
358	AccMp2_D	[m/s ²]	Linear acceleration (raw/unfiltered) at the second monitoring point in down direction (g-frame)
362	VelMp2_F	[m/s]	Linear velocity at the second monitoring point in forward direction (h-frame)
363	VelMp2_S	[m/s]	Linear velocity at the second monitoring point in starboard direction (h-frame)
364	VelMp2_D	[m/s]	Linear velocity at the second monitoring point in down direction (h-frame)
373	LA_VelMp2_D	[m/s]	Lever arm compensated linear velocity relative to Cg in the second monitoring point in down direction (g-frame). The mean velocity depends on vessel tilt, see the <i>User Manual</i> [2] for details.

No.	Variable name	Unit	Description
374	PosMp2_F	[m]	Linear position at the second monitoring point in forward direction (h-frame)
375	PosMp2_S	[m]	Linear position at the second monitoring point in starboard direction (h-frame)
376	PosMp2_D	[m]	Linear position at the second monitoring point in down direction (h-frame)
385	LA_PosMp2_D	[m]	Lever arm compensated linear position relative to Cg in the second monitoring point in down direction (g-frame). The mean position depends on vessel tilt, see the <i>User Manual</i> [2] for details.
386	dHeaveMp2	[m]	Delayed heave output at the second monitoring point in down direction (g-frame)

Appendix C

Status bits

The status bits in a 32 bit status.

Message	Bit	Description
SYS_NORM	0	Normal mode
SYS_ABNORM	1	Abnormal mode
SYS_TIMESYNC	4	True if PPS1 signal is input to sensor unit
SYS_CLOCKSYNC	5	Date set by ZDA, NTP or TSC
SYS_ANA_ON	6	Analog output of data on (require junction box)
SYS_DELHEAVE_UNREL	7	Delayed heave output unreliable
SYS_KALMAN_INIT	8	Kalman filter initialization
SYS_HEAD_INIT	9	Heading calculation initialization
SYS_MODEL_UNREL	10	Output data unreliable
SYS_HORIZ_UNREL	11	Horizontal position unreliable
SYS_HORIZ_REDUCED	12	Horizontal position has reduced accuracy
SYS_HEAVE_UNREL	13	Heave data unreliable (heave transient present)
SYS_HEAVE_REDUCED	14	Heave data has reduced accuracy
SYS_ROLLP_UNREL	15	Roll and pitch unreliable
SYS_ROLLP_REDUCED	16	Roll and pitch data have reduced accuracy
SYS_HEAD_UNREL	17	Heading data unreliable
SYS_HEAD_REDUCED	18	Heading data has reduced accuracy
SYS_SPEED_AIDED	19	True if sensor unit is speed aided
SYS_HEAD_AIDED	20	True if sensor unit is heading aided
SYS_EXTPOS	21	True if external position input is detected
SYS_EXTVEL	22	True if external velocity input is detected
SYS_EXTYAW	23	True if external heading input is detected
SYS_POS_AIDED	24	True if sensor unit is position aided
SYS_HEIGHT_AIDED	25	True if sensor unit is height aided
SYS_BAD_ENV	27	Bad environment, like with to high temperature
SYS_NAVMODE	30	Gyrocompass or integrated navigation mode

Appendix D

Event numbers

The event and warning numbers.

No.	Message	Description
1	EV_STARTUP_OK	Date and time at last startup (power on)
2	EV_STARTUP_ERR	Error during startup
6	EV_PARSE_ERR	Parsing error
7	EV_MESSAGE_ERR	Message error
8	EV_SETCLOCK	Set sensor unit clock
10	EV_INFO	Information on program or configuration change
11	EV_MSTATE	Change of model state (reliable to unreliable)
12	EV_BAD_TEMP	To high internal temperature
19	EV_IMPROP_PWRDOWN	Improper power down or unexpected restart
22	EV_EXT_VAL_BAD	Bad validation of external input data
23	EV_INTERNAL_SYS	Internal system information
24	EV_SENSOR_INTEGRITY	Sensor integrity

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