Seatex MRU 5 & H

Installation Manual

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Revision log

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hs-016-b	MRU-M-MB3 bracket, Hydrographic version	1	1
hs-024-a	Subsea bottle MRU-M-SB5, Dimensions	0	1
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1. INTRODUCTION

1.1 About this manual

This manual is designed to provide the user with sufficient information to correctly install the MRU 5 & H motion sensors. For all other product information, please consult the *User's Manual*.

Note The guidelines for installation presented here must be regarded as a basis for detailed plans prepared by the installation shipyard or company.

This manual is organised into the following chapters:

Chapter 1 **Introduction** - A brief presentation of the MRU 5 & H Installation Manual with references and abbreviations.

Chapter 2 **Specifications** - A description of the physical dimensions, required power, environmental and cable specifications.

Chapter 3 **Installation** - Procedures to be followed for a typical ship installation with recommendation for best location of the unit, mechanical and electrical installation and configuration of the Motion Reference Unit (MRU).

Chapter 4 **Installation drawings** - Contains outline drawings showing the mechanical dimensions of the MRU and the mounting bracket.

In this manual the following remarks are used:

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.

Note A note text has this format and is used to draw the user's attention to special features or behaviour of the equipment.

1.2 References

[1] MRU-D-007 *Digital Interface Programming*, rev. 2

1.3 Abbreviations

ADCP	Acoustic Doppler Current Profiler.
CG	Centre of Gravity. The mass centre of a vessel. This is normally the location with the least linear acceleration and hence the best location for measurements of roll and pitch.
EMI	Electromagnetic Interference.
HPR system	Hydroacoustic Positioning Reference system.
MP	Measurement Point.
MRC	Special software delivered with all MRU units. Running on a PC under Microsoft Windows. With this software, the user can set up the MRU according to his application by use of the delivered configuration cable. The MRC software is used to change the configuration parameters, to check the internal status, etc.
MRU	Motion Reference Unit. Measures dynamic linear motion and attitude.
NMEA	National Marine Electronics Association. NMEA 0183 is a standard for interchange of information between navigation equipment.
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 facing upward.
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 facing downward.
ROV	Remotely Operated (underwater) Vehicle.
Token	This is a marker in a message to identify the message.
UTC	Universal Time Co-ordinated. This is the official time in the world and has replaced GMT (Greenwich Mean Time) as the official time.
Y-axis	This axis is fixed in the vehicle and points in the downward direction when the vehicle is aligned horizontally. Positive rotation about this axis is turning the bow of the vehicle to starboard.

2. SPECIFICATIONS

2.1 Physical dimensions

MRU

Height: ..... 204 mm
Diameter: ..... 105 mm
Weight: ..... 2.5 kg
Colour: ..... Blue

MRU-M-MB3 Mounting Bracket

Length: ..... 265 mm
Width: ..... 119 mm
Height: ..... 119 mm
Weight: ..... 1.6 kg
Colour: ..... Black
Material: ..... POM-H

MRU-E-JB1 Junction Box

Length: ..... 226 mm
Width: ..... 126 mm
Height: ..... 90 mm
Weight: ..... 2.0 kg
Colour: ..... Black
Material: ..... Aluminium
Enclosure protection: IP-65

2.2 Power

Voltage input: ..... 12 to 30 Volts DC
Recommended voltage: ..... 24 Volt DC
Power consumption, MRU 5 models (power up surge): ..... Max. 11 Watts
Power consumption, MRU 5 models (max. at -5°C operation temp): ..... 9 Watts
Power consumption, MRU 5 models (max. at +50°C operation temp. or above): ..... 5 Watts
Power consumption, MRU H: ..... Max. 6 Watts
Power rise speed: ..... Not critical
Batteries: ..... None; connection to UPS recommended

2.3 Environmental

MRU

Enclosure material: ..... Anodised aluminium
Enclosure protection: IP-66
Operating temp. range: ..... -5 to +55ºC
Operating humidity (max.): ..... Sealed, no limit
Storage temp. range: ..... -20 to +70ºC
Storage humidity: ..... Sealed, no limit
Max. allowed vibration operational (10 - 2000 Hz continuous): ..... 0.5 m/s^2
Max. allowed vibration non-operational (0 - 2000 Hz continuous): ..... 20 m/s^2
Max. shock non-operational (10 ms peak): ..... 1000 m/s^2

2.4 Cable

Cable MRU-E-CS1

Type: ..... Heavy duty screened, Habia Aquatherm RTFR 14x2x0.25 mm^2
Length: ..... 3 m
Diameter: ..... 13.5 mm
Weight: ..... 0.27 kg/m
Flame retardation: ..... IEC 332-1
Insulation: ..... ETFE
Screen: ..... Cu-braid

3. INSTALLATION

3.1 General information

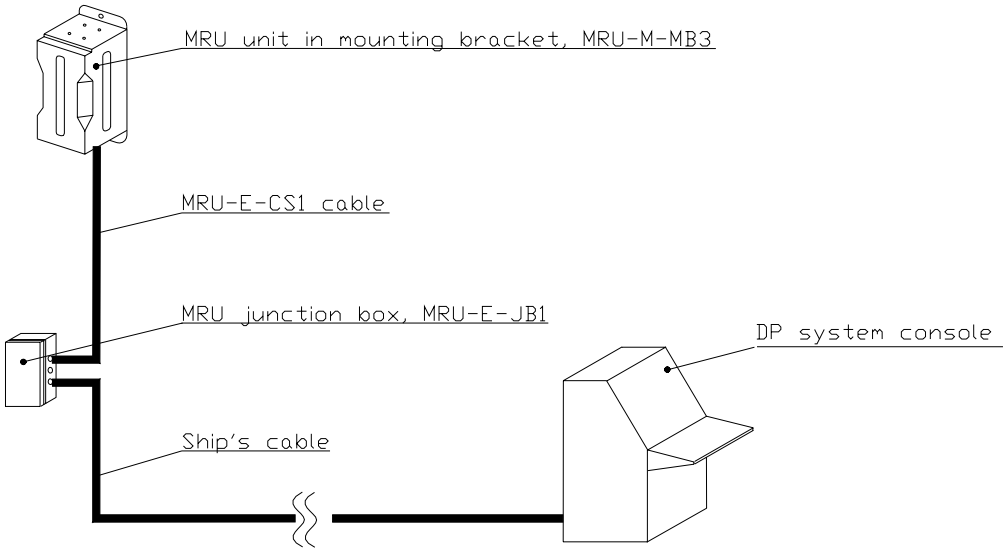
This chapter describes a typical ship installation of the MRU 5 or H for use together with an HPR system, for example. There is also a section in this chapter that describes a subsea installation of the MRU.

The MRU unit is shipped in a specially designed transportation container. Keep the MRU 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 MRU 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-CS1 cable with the MRU connector at one end and marked conductors at the other.
- The MRU-M-MB3 wall-mounting bracket complete with four M4.0 screws, three M6.0 screws and one sticker.
- The MRU-E-JB1 junction box for connecting the MRU output signals to the HPR system and to supply the MRU with 24 VDC power. A ship cable to be supplied for connecting the MRU junction box with the HPR system. This cable can be delivered by Seatex, although normally it is delivered by the HPR system supplier, the shipyard, or others.



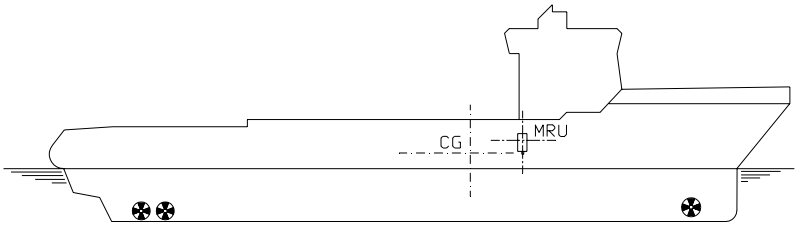
3.2 Location of the unit

Take the following into consideration when searching for a suitable place to mount the MRU:

- The unit is designed for installation in an indoor environment and for operation within the temperature range.

- For best roll, pitch, surge and sway measurements, place the MRU as close to the centre of gravity (CG) of the ship as possible. Alternately, try to mount it along the R-axis of the ship as close to the CG as possible. Roll usually is the most dominant angular motion; avoid mounting the MRU high up or out to the side of the ship.

- For best heave measurement, mount the MRU as close as possible to where the heave is to be measured.



Be aware of the following:

- **Vibrations**. Direct mounting onto the main hull structure is preferable.

Note The least desirable mounting positions are thin walls that may resonate 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 200 Hz. Such vibrations should not exceed 0.5 m/s^2 in any direction. If required, the MRU-M-MB1 mounting bracket can be delivered with an MRU-M-MB2 vibration damper extension.

- **Temperature changes**. For optimum accuracy, locate the MRU where the temperature is relatively low and temperature changes are slow. A location directly on the hull far away from the heat of the machinery, heaters and air conditioning systems is preferable.

- **Corrosion problems**. Avoid locations that may come in contact with seawater.

3.3 Logistics

Safety: None.

Personnel qualifications: Trained electricians.

Minimum number of personnel: 1.

Equipment location: Mount at the ship's CG or near the system to be compensated.

Special tools required: None.

3.4 Procedures

The installation is performed in two steps:

1. Mechanical installation of the mounting bracket, the MRU and the junction box.

2. 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.

A third part is added to the procedure if the MRU is to be installed in the MRU subsea bottle. In addition, the user can modify the standard MRU configuration.

3.4.1 Mechanical installation

3.4.1.1 Mounting orientation for the MRU

The default mounting position is defined with the MRU connector facing downward, the R-axis pointing forward and the P-axis pointing starboard. Please see Figure 1 for the mounting orientation of the +R and +P indexes at the top of the MRU according to the axes of the ship. Please see Figure 2 for the default mounting position. The directions marked on the MRU housing (R,P,Y) should be aligned with the ship axes in the following way:

- The R-axis (+R arrow) points in the bow (forward) direction of the ship.
- The P-axis (+P arrow) points horizontally and starboard.
- The Y-axis points in the downward direction.

The MRU is best mounted with the logical axes in the direction described 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 and the ship axes are simply entered in the MRU configuration software, MRC. See "Appendix N - MRU configuration" for a description on how to configure the MRU and set the mounting angles. In chapter 3.4.4 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.

Note Mounting of the MRU with the +R arrow pointing up or down should be avoided since the automatic setup of mounting angles in the MRC software then cannot be used in these orientations.

Seatex utilises the NATO standard for the MRU axis orientation as illustrated in Figure 2.

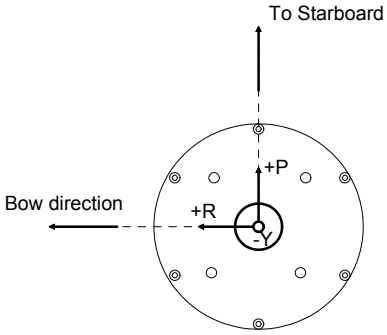


Figure 1 Top view of the MRU with +R, +P and -Y directions shown

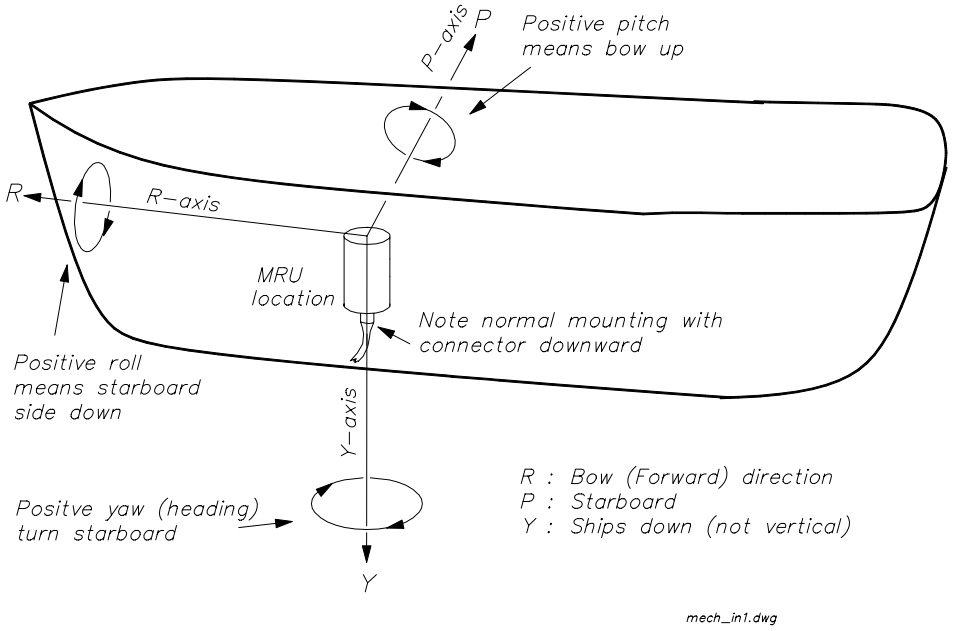


Figure 2 Default mounting position for the MRU

Positive (+) output signals from the MRU include:

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

3.4.1.2 Axis directions for surge, sway and heave measurements

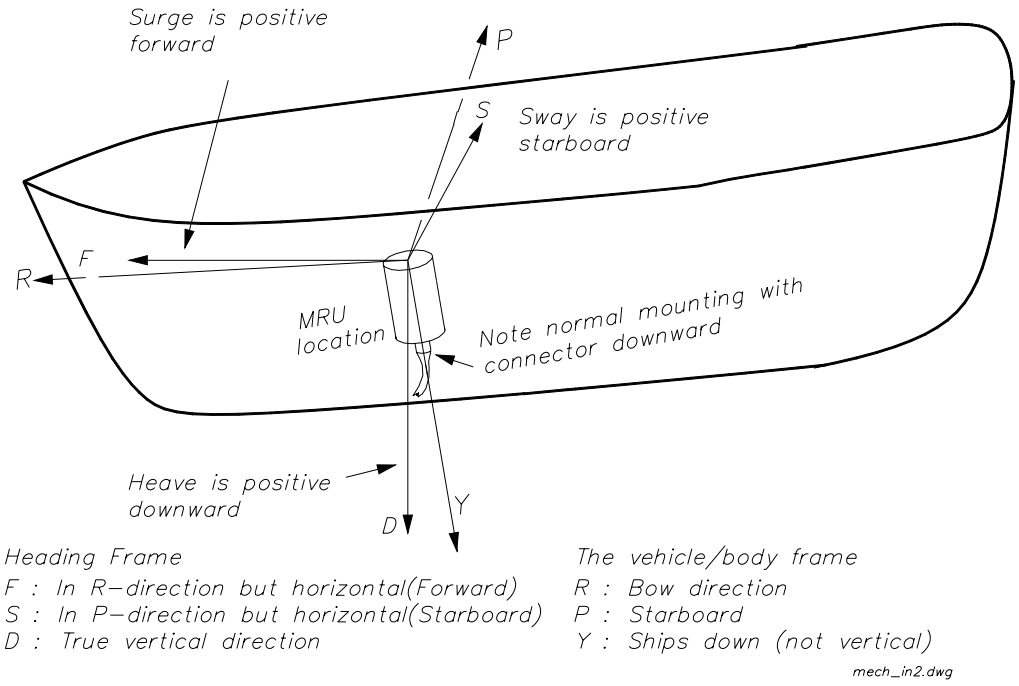


Figure 3 Axis directions for surge, sway and heave

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).

3.4.1.3 The use of lever arms

Setting up lever arms in the MRU configuration simplifies the installation of some applications like heave compensation of cranes. The MRU can then be located some distance away from the location of the measurement point. A lever arm vector up to 60 metres from the MRU to the location of the measurement point (MP) can be used without degrading the MRU linear position output accuracy significantly. The MRU 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 MRU at precisely the CG, it is possible to compensate for this and

achieve the same roll and pitch accuracy as if the MRU were mounted at the vessel's CG by inputting the lever arm CG vector in the MRU configuration.

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

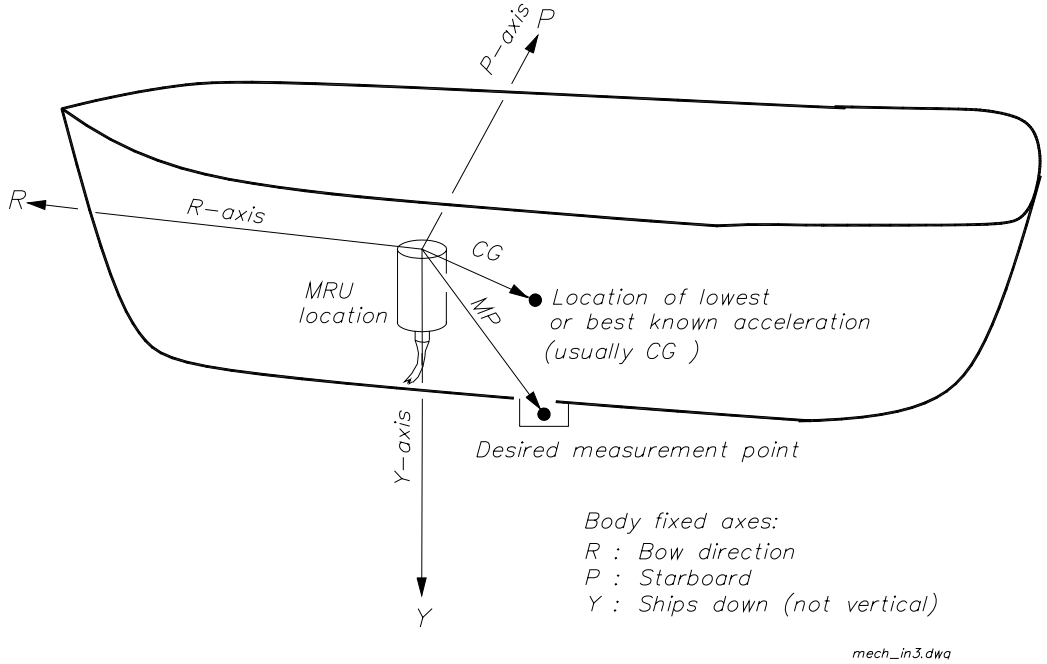


Figure 4 Locations of the MRU, CG and MP on the vessel

- **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 MRU to the vessel's Centre of Gravity (CG). The components must be measured in metres from the MRU location with an accuracy better than one metre.

- **Definition of the user Measurement Point lever arm (MP).** This is the vector (R,P,Y) from the MRU to the desired MP, as illustrated in Figure 4. The components must be measured in metres from the MRU location with an accuracy better than 0.1 metre. In systems where the MP is not a fixed point relative to the MRU location (crane, for instance), the MRU is designed to receive input co-ordinates for the lever arm MP from a computer through the MRU digital interface. The MRU command **Set Lever Arm Vector** is used to continuously update the MRU with the correct MP values. See reference [1] for more information on this command.

See "Appendix N - MRU configuration" for additional details on how to configure the MRU and set up the CG and MP lever arms. Typical locations of the CG, the MRU position, and the measurement point are shown in Figure 4.

Note The MRU 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 MRU position.

When using long lever arms, any vessel vibration sensed by the MRU 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 MRU. Incorrect use of lever arms will result in degraded performance..

3.4.1.4 Installation procedures

The MRU must be handled with care during installation. Keep the unit within the transportation container until the mounting bracket is fastened on the wall and ready for installation.

The mechanical installation of the MRU is done in the following steps:

1. When the best mounting location for the MRU has been identified, place the MRU mounting bracket in the preferred orientation and make screw holes in the foundation. If the orientation of the bracket can be freely selected, mount the bracket on the longitudinal or transversal bulkheads of the ship with the opening pointing downward, as shown in Figure 5. This will ensure easy and accurate orientation of the MRU according to the longitudinal axis. Reserve sufficient space below the bracket to allow insertion of the MRU from below.

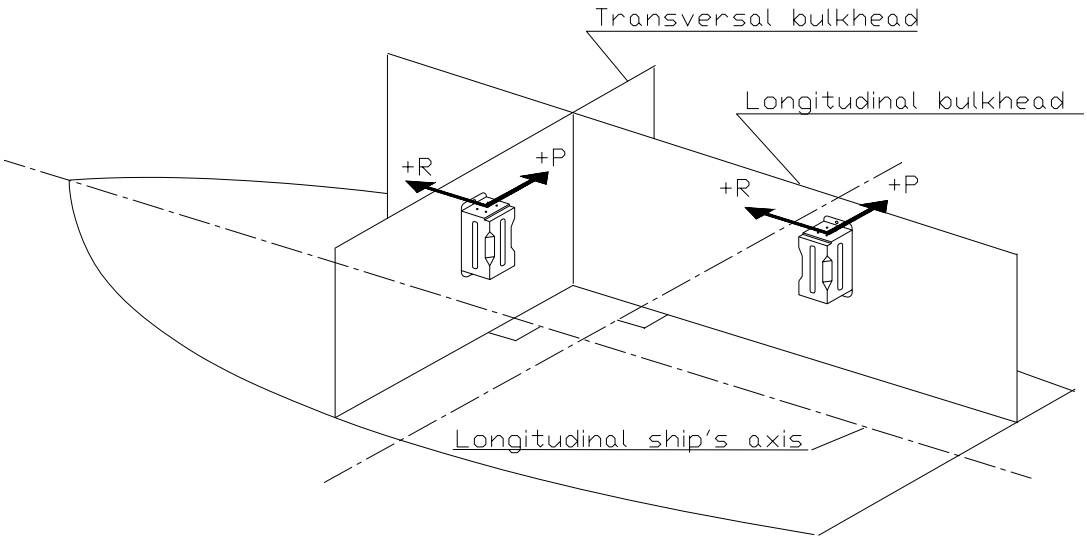


Figure 5 Recommended orientation of the MRU mounting bracket

2. Mount the MRU bracket on the wall, preferably with the opening pointing down, as shown in Figure 6. Mark and drill an M6 hole for the top screw (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 (2) and insert and securely tighten all three screws, using washers or self-locking nuts.

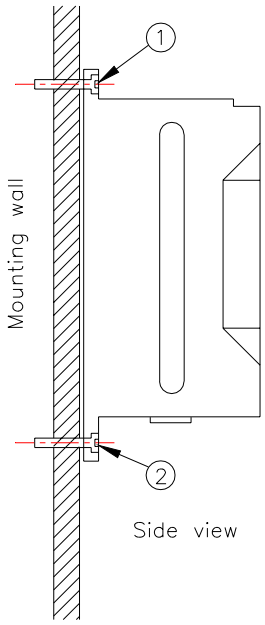


Figure 6 Wall mounting of the bracket with the MRU connector pointing down

3. Insert the MRU into the bracket. In order to achieve the orientation as shown in Figure 5, the MRU must be rotated in the bracket. Apply Loctite 242 glue or equivalent on the four MRU screws (3).

Note The MRU R+ arrow must always point in the bow direction unless the default mounting orientation of the unit is modified in the MRU configuration.

4. Apply the sticker (4) onto the bracket according to the actual mounting direction of the MRU, as shown in Figure 7. In this way, the actual mounting direction is identified in case the unit is to be exchanged or removed temporarily.

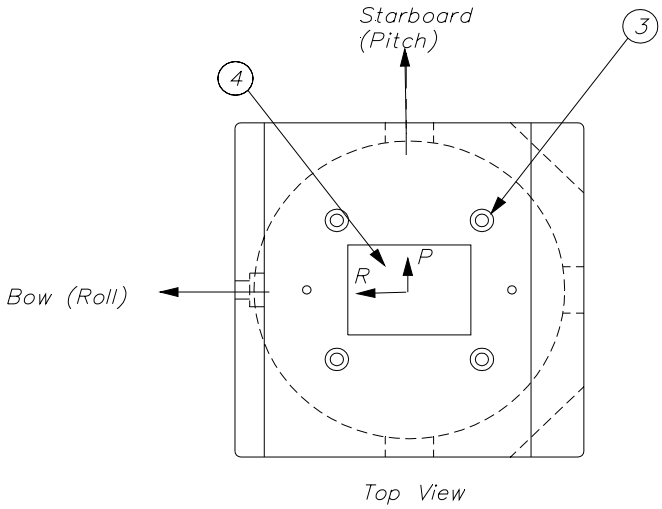


Figure 7 Sticker (4) shall indicate actual mounting orientation of MRU within bracket

Note If the MRU is mounted correctly in the bracket, the +R arrow on the top of the MRU will point in the bow direction of the ship and the same direction as the R-axis of the sticker. If uncertain whether the MRU R-axis is pointing in the bow

direction, look under the MRU and check that the +R arrow label is pointing in the bow direction. Precise MRU orientation is important to ensure that high quality and accurate measurements are available to the host system.

5. Mount the junction box on the wall in a suitable location within the length of the 3-metre MRU-E-CS1 cable, as shown in Figure 8. The screws for mounting the junction box should be secured with washers or self locking nuts.

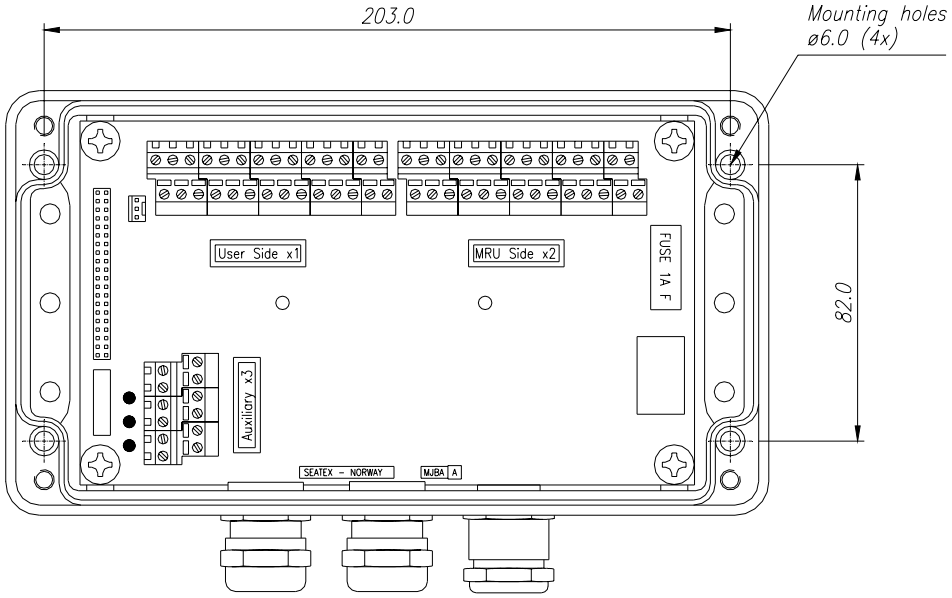


Figure 8 Junction box mounting

3.4.2 Electrical installation

3.4.2.1 Power requirements

The MRU is to be powered by a 12 to 30 VDC source. The MRU power lines are galvanically isolated from the signal circuits inside the unit. The maximum isolation voltage inside the MRU is 200 VDC.

If the power voltage has significant ripple, ensure that the minimum voltage is higher than 12 VDC at all times. The MRU internal power will not tolerate short transient drops in the power supply below 12 VDC.

The MRU must be protected by an external fast fuse rated at 1 A (or must be connected to a foldback power supply rated at 1 A). The MRU will short circuit an incorrect polarity power voltage and blow the fuse without damage to the MRU. The same fuse also protects against over-voltage damage. This fuse is installed in the MRU-E-JB1 junction box.

CAUTION

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

Note Transient drops in the power voltage should be avoided. If the power supply for the MRU is shared by other devices running on 24 VDC, a short, temporary drop in the MRU power supply may occur when these devices are switched on. If the voltage drops below 12 VDC, even for a short time, the MRU will restart and the performance will be degraded for a period of about 15 minutes.

3.4.2.2 Cable lengths

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

- At 24 VDC, 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.
- When using an analog cable up to 200 metres, each pair should have its own screen and the square should be 0.22 mm^2 or higher. A differential input A/D converter must be used and connected as shown in Figure 9.

Note The screen in the analog cable should not be connected to ground on the host receiver side, only on the MRU/transmit side.

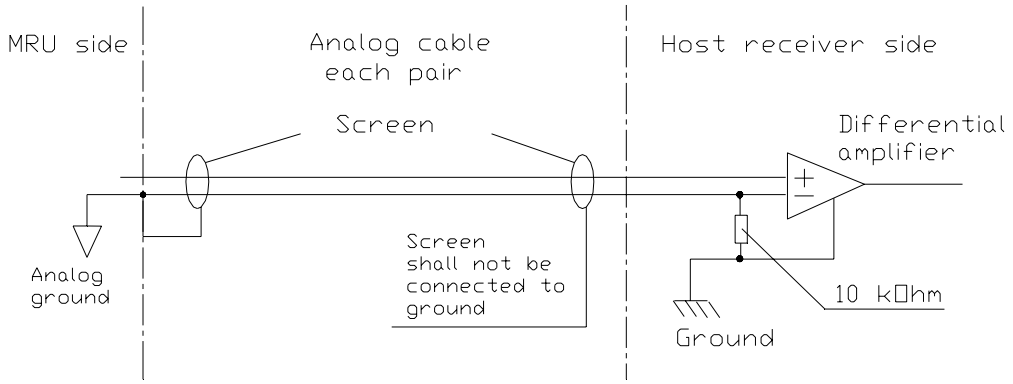


Figure 9 Cable connections to drive the analog signal through 200 metres of cable

3.4.2.3 Cable wiring schematics

The wiring schematics for the MRU-E-CS1 heavy duty cable are as follows:

Souriau 26 pin Signal Conn.		**Signal Description**	**Conductor**	
			Pair No.	**Colour**
SHIELD	**A**	Cable screen, connected to MRU housing		**Screen**
PWR+	**R**	Power supply (+24 V)	**1**	**Blue**
PWR-	**B**	Power supply (0 V)	**1**	**Black**
TX+	**C**	Sysport serial from MRU, RS-232 or RS-422 level	**2**	**Orange**
TX-	**T**	Return	**2**	**Black**
RX+	**S**	Sysport serial to MRU, RS-232 or RS-422 level	**3**	**Green**
RX-	**P**	Return	**3**	**Black**
AN0+	**G**	Analog channel 0, out ± 10 Volt	**4**	**Brown**
AN0-	**X**	Return	**4**	**Black**
AN1+	**H**	Analog channel 1	**5**	**Blue**
AN1-	**X**	Return	**5**	**White**
AN2+	**J**	Analog channel 2	**6**	**Orange**
AN2-	**X**	Return	**6**	**White**
AN3+	**K**	Analog channel 3	**7**	**Green**
AN3-	**X**	Return	**7**	**White**
AUX1RX+	**E**	Aux serial to MRU, RS-232 level, isolated	**8**	**Brown**
AUX1RX-	**Y**	Return	**8**	**White**
AUX2RX+	**V**	Aux serial to MRU, RS-232 level, isolated	**9**	**Grey**
AUX2RX-	**L**	Return	**9**	**White**
AUX3RX+	**Z**	Aux digital to MRU, RS-232 or TTL level, isolated	**10**	**Blue**
AUX3RX-	**W**	Return	**10**	**Red**
AUX4TX	**M**	Unused	**11**	**Orange**
AUX4RX	**c**	Unused	**11**	**Red**
XIN	**U**	To MRU, RS-232 level	**12**	**Green**
LGND	**a**	Ground XIN,XOUT,EXT0,AUX4RX,TX,RX,Shutoff	**12**	**Red**
XOUT	**b**	From MRU, 5 V CMOS level	**13**	**Brown**
EXT0	**F**	From MRU, 5 V CMOS level	**13**	**Red**
SHUTOFF	**D**	Shutoff MRU or RS-232/422 selection	**14**	**Grey**
L5V	**N**	5 V out, max. 20 mA	**14**	**Red**

3.4.2.4 Hardware I/O description

The digital communication lines TX, RX, XIN, XOUT, AUX4TX, AUX4RX, EXT0 and Shutoff share a common ground (LGND) and are isolated from the MRU power system. The AUX1RX, AUX2RX and AUX3RX lines are isolated from all other.

The analog lines are not isolated from the internal MRU power system.

RS-232 compatible mode on Sysport. The default mode for the Sysport lines is a RS-232-compatible TX and RX line. When the Sysport is in the RS-232 mode, transmit is on TX+ and receive is on RX+. The TX- and RX- are connected to LGND internally in the MRU.

- LGND (alternatively TX- or RX-) is connected to "PC RS-232 GND".
- RX+ is connected to "PC RS-232 TX".
- TX+ is connected to "PC RS-232 RX".

RS-422 compatible mode on Sysport. RS-422 compatible lines are optional, see "Appendix K – RS-422 Communication with the MRU" on how to establish RS-422 communication on the Sysport lines.

The AUX1 and AUX2 lines. They are RS-232 compatible serial input lines with optical isolation.

The AUX3 line. It is a general purpose RS-232 compatible (discrete) input line that is optically isolated, but it is not a serial input line.

The 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**. MRU ready/not ready. Zero or 5 V out.

The EXT0 line. This line is a combined I/O-line used to send a pulse each time new analog data are output from the MRU. Zero or 5 V out.

The Shutoff line. This is a dual function input line:

- Shutoff is driven high. If the Shutoff is driven high, above 5 V, the MRU is shut off.
- Shutoff connected to LGND or drive is negative. The Sysport levels are then RS-422 compatible (optional).
- Shutoff is left floating. The Sysport levels are then RS-232 compatible (default).

Note Applications already using the Shutoff line based on MRU hardware before the blue third generation MRU, can obtain compatibility with old schemes by adding a series diode on the line connected to the Shutoff input.

3.4.2.5 Installation procedure

The electrical installation of the MRU is done in the following steps:

1. Insert the connector on the MRU-E-CS1 cable into the MRU and insert the other end of the cable into the junction box. 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.

Insert each of the cable wires into the correct terminal on the MRU side (x2) within the box.

|----------MRU side x2----------|

pin	signal	pair	wire colour
1	PWR+	1	blue
2	PWR-	1	black
3	TX+	2	orange
4	TX-	2	black
5	RX+	3	green
6	RX-	3	black
7	AN0+	4	brown
8	AN0-	4	black
9	AN1+	5	blue
10	AN1-	5	white
11	AN2+	6	orange
12	AN2-	6	white
13	AN3+	7	green
14	AN3-	7	white

pin	signal	pair	wire colour
15	AUX1RX+	8	brown
16	AUX1RX-	8	white
17	AUX2RX+	9	grey
18	AUX2RX-	9	white
19	AUX3RX+	10	blue
20	AUX3RX-	10	red
21	AUX4TX	11	orange
22	AUX4RX	11	red
23	XIN	12	green
24	LGND	12	red
25	XOUT	13	brown
26	EXT0	13	red
27	SHUTOFF	14	grey
28	L5V	14	red

2. Insert the ship cable and the power cable through one of the free nipples on the junction box. 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 MRU power and EMC requirements. The cable shield must be connected to earth only on one end (open in the other). It is recommended to connect the cable shield in the MRU end to pin 1 (Chassis) on the Auxiliary Contact (x3) side in the MRU junction box or ensure that the shield is in contact with the junction box nipple.

Note 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.

Insert each of the cable wires into the correct terminal on the User side (x1) within the box.

|----------User side x1----------|

pin	signal	description
1	PWRIN+	power +
2	PWRIN-	power gnd
3	TX+	from MRU
4	TX-	-"-
5	RX+	to MRU
6	RX-	-"-
7	AN0+	analog ch0
8	AN0-	-"-
9	AN1+	analog ch1
10	AN1-	-"-
11	AN2+	analog ch2
12	AN2-	-"-
13	AN3+	analog ch3
14	AN3-	-"-

pin	signal	description
15	AUX1RX+	to MRU
16	AUX1RX-	-"-
17	AUX2RX+	-"-
18	AUX2RX-	-"-
19	AUX3RX+	-"-
20	AUX3RX-	-"-
21	AUX4TX	from MRU
22	AUX4RX	to MRU
23	XIN	-"-
24	LGND gnd ref aux.+dig	
25	XOUT	from MRU
26	EXT0	-"-
27	SHUTOFF	of MRU
28	L5V	5V out

3. If a ready signal for the MRU analog output signals is required, insert the ship cable wires for this signal into the terminals on the Auxiliary Contact (x3) side within the box. This is done by feeding +24 VDC into pin 2 and running a wire back into the host system from pin 3. This will give the host system a +24 VDC signal from pin 3 when MRU analog output signals are ready.

|----------Auxiliary Contact x3----------|

pin	signal
1	CHASSIS ⊥
2	MRU READY
3	MRU READY
4	
5	
6	

pin	signal
7	
8	
9	
10	
11	
12	

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

4. When all cable wires are connected, power up the MRU. The LED1 light diode in the junction box should then shine green indicating that the MRU receives power. A yellow light in LED2 indicates that digital data are sent from the MRU on TX+ and/or AUX4TX.

A red light in LED3 indicates that analog signals are sent out from the MRU on the analog channels.

5. If the lights in the LED's are according to your connections, the installation is now finished, unless the standard configuration delivered with the MRU needs to be modified for the specific installation. An MRU 5 or H unit is normally delivered with the following standard setup:

Sensor \ Geometry:

Mounting Angles Set to (0.0°, 0.0°, 0.0°).

Sensor \ Heave Config:

Filter Mode Set to **Automatic**.

Data Interface \ Digital:

System Port Setup The baud rate for the digital communication is set to **4800** and the parity to **8 data no parity**.

Verbose mask The mask is set to **Silent**.

XIN pin control The logical CMOS input line to the MRU is set to **Not used**.

XOUT pin control The logical CMOS output line from the MRU is set to **Low**.

Data Protocol The protocol for output of data from the unit is set to the binary format **MRU normal**.

Digital channels The number of output variables is set to **4** channels and the output variables are roll (var. no. 63), pitch (var. no. 64), heave (var. no. 105, PosMonD) and heave velocity (var. no. 115, VelMonD).

Interval The sample interval of output variables is set to **100** (100 ms), providing a sample rate of 10 Hz.

Data Interface \ Auxiliary:

Serial Input AUX1 The auxiliary input line 1 to the MRU is set to **Enabled** for a 4800 baud rate and an **8 data no parity** mode.

Serial Input AUX2 The auxiliary input line 2 to the MRU is set to **Enabled** for a 4800 baud rate and an **8 data no parity** mode.

Logical Input AUX3 The auxiliary input line 3 to the MRU for discrete data is set to **Not used**.

Ext. heading age The age on the external heading signal is set to **20** ms.

Data Interface \ Analog:

Analog enabled The analog output variables are disabled (turned off) by the default setting **No**.

Special Options \ Magnetic conditions:

Latitude Default set to **0**. The actual latitude where the unit is to be used has to be input.

Magnetic deviation The magnetic deviation is default set to **0**.

Fluxgate usage The heading erection due to the internal magnetic fluxgate compass is set to **Disabled** for an MRU 5 or H.

If this standard configuration needs to be changed, the MRU configuration software MRC must be used to select the correct settings. Installation and use of the MRC software is described in "Appendix N - MRU configuration".

3.4.3 Subsea installation

3.4.3.1 Subsea bottle versions

As an option, the MRU may be delivered mounted in one of three different subsea bottles depending on water depth rating:

The 4000-metre bottle, MRU-M-SB5
This subsea bottle, made of titanium, is designed for use down to 4000 metres. The dry weight of this bottle, including the MRU, is 11.6 kg and the submerged weight including the MRU is approximately 7.4 kg. 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 two mounting holes (M8) on each 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 digital communication and one for analog output channels.

The 1000-metre bottle, MRU-M-SB6
This subsea bottle made of black anodised aluminium and designed for use down to 4000 metres has exactly the same exterior and interior design as the 4000-metre bottle MRU-M-SB5. The dry weight of the bottle, including the MRU, is 8.5 kg and the submerged weight including the MRU is approximately 4.3 kg. 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 two mounting holes (M8) on each 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

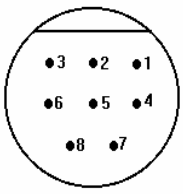
cover plate to protect the bottle from damage and for help during alignment. The bottle is delivered with two 8-pin Seacon connectors, one for digital communication and one for analog output channels.

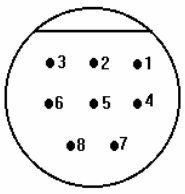
The 10-metre bottle, MRU-M-SB7
This subsea bottle, made of black anodised aluminium, is designed for use down to 10 metres. The dry weight of this bottle, including the MRU, is 4.0 kg and the submerged weight including the MRU is approximately 1.2 kg. Within the bottle the MRU is mounted on a steering plate. Outside each cover plate there are four mounting holes (M6). The mounting direction of the MRU within the bottle is indicated on the bottom cover plate. The bottle is delivered with one 8-pin Seacon connector for digital communication.

3.4.3.2 Connector and cable

All the bottles are delivered with one 8-pin Seacon connector for digital communication (Connector A). In addition the bottles MRU-M-SB5 & 6 are delivered with a second connector for analog output channels (Connector B). The part number for the Seacon connectors is 5506-1508 (male). Seacon pigtails for the customer's own application can be delivered as an option.

The default pin configuration for the two connectors are as follows:





CONNECTOR A

Pin	Signal
1	Power - (0 V)
2	Power + (24 V)
3	RX – To MRU
4	RX + To MRU
5	TX + From MRU
6	TX – From MRU
7	Magnetic Free run - (LGND)
8	Magnetic Free Run + (XIN)

CONNECTOR B

Pin	Signal
1	Analog ch0 +
2	Not connected
3	Analog ch1 +
4	Analog ch2 +
5	Analog ch3 +
6	Analog GND
7	AUX1 RX + To MRU
8	AUX1 RX – To MRU

Please be aware of the following:

- Short between 7 and 8 on connector A makes MRU enter free run mode (MRU 4 & 6 only)
- Pin 2 on connector B is not connected to avoid damage from power when using wrong connector.
- AUX1 RX +/- is auxiliary serial input no. one for entering external speed and heading information to MRU.

3.4.3.3 Corrosion protection

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

a) Coat all the cover screw holes with silicone grease to avoid pitting corrosion.

b) Do not connect the bottle housing galvanically to any steel structures or other conducting materials.

c) For long term submerged operations, connect a zinc anode cover to the bottle.

d) If not using the screws provided in the kit, be sure that the replacement screws are made of stainless steel.

3.4.3.4 Mounting procedure of the MRU within MRU-M-SB7

If the MRU is taken out of this subsea bottle, follow the procedure below in order to precisely mount the MRU back into the bottle again:

1) Unscrew the six screws on the top lid (the cover plate with the connector on) of the empty bottle, if not already done.

2) Put a screwdriver into the trace at the top of the cylinder, between the top lid and the cylinder, in order to separate the top lid from the cylinder.

3) Insert the MRU into the empty bottle with the connector side of the MRU pointing out. When inserting the MRU into the steering pin plate in the bottom of the subsea bottle, ensure that the orientation of the MRU (the +R arrow) is pointing in exactly the same direction as the +R arrow on the bottom cover plate of the subsea bottle. The steering pins on the plate inside the bottle will aid this positioning. If the orientation of the MRU within the bottle is not correct, the MRU performance will be degraded.

4) Apply silicon of type DC4/MS4 or similar to the o-ring part of the cylinder and the o-rings on the top lid.

5) Insert the connector on the inside of the top lid into the MRU.

6) Apply nitrogen gas into the bottle before closing the top lid. Press the top lid onto the cylinder with the same orientation of the top cover plate as shown in the subsea bottle drawings in chapter 4. Mount the six screws on the top cover plate again.

7) The subsea bottle should be pressure tested before subsea installation.

3.4.3.5 Mounting procedure of the MRU within MRU-M-SB5 & 6

How to install the MRU unit into an empty bottle of these types (to remove MRU unit is reverse of this description):

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 is now removable 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) The MRU is put on 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).
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) Flush the main cylinder with nitrogen and then slide the whole arrangement with the connector lid 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 and pressure test the subsea bottle before subsea installation. Remember always to mount dummy connector on connectors not used during pressure test and subsea operation.

3.4.4 Calibration

After the mechanical installation is completed, the MRU R, P and Y axes must be calibrated 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. For multibeam echo sounder applications an accuracy better than 0.1 degrees is required to ensure satisfactory performance.

A typical calibration consists of calibrating the MRU axes to an external reference. Type of reference must be determined according to the required accuracy.

The reference for roll and pitch calibration must be carefully selected depending on the intended application. It may be the hull, or a sensor like a multibeam echo sounder or a USBL acoustic system. Some sensors have internal calibration routines, and accurate calibration of the MRU is not required. In "Appendix N - MRU configuration", the MRU mounting wizard is described, which includes an automatic procedure for obtaining the roll and pitch mounting angles.

An accurate alignment of the MRU +R 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 easiest way to ensure a correct yaw orientation of the MRU is to mount the unit on the vessel's longitudinal or transversal bulkheads. Figure 10 illustrates that a misalignment of 1 degree of the MRU in yaw will result in a roll error of ±0.09 degrees if the vessel is pitching ±5 degrees. To calibrate the misalignment of the MRU axis to an accuracy of 0.5 degrees or better is not an easy task and requires use of an accurate external reference.

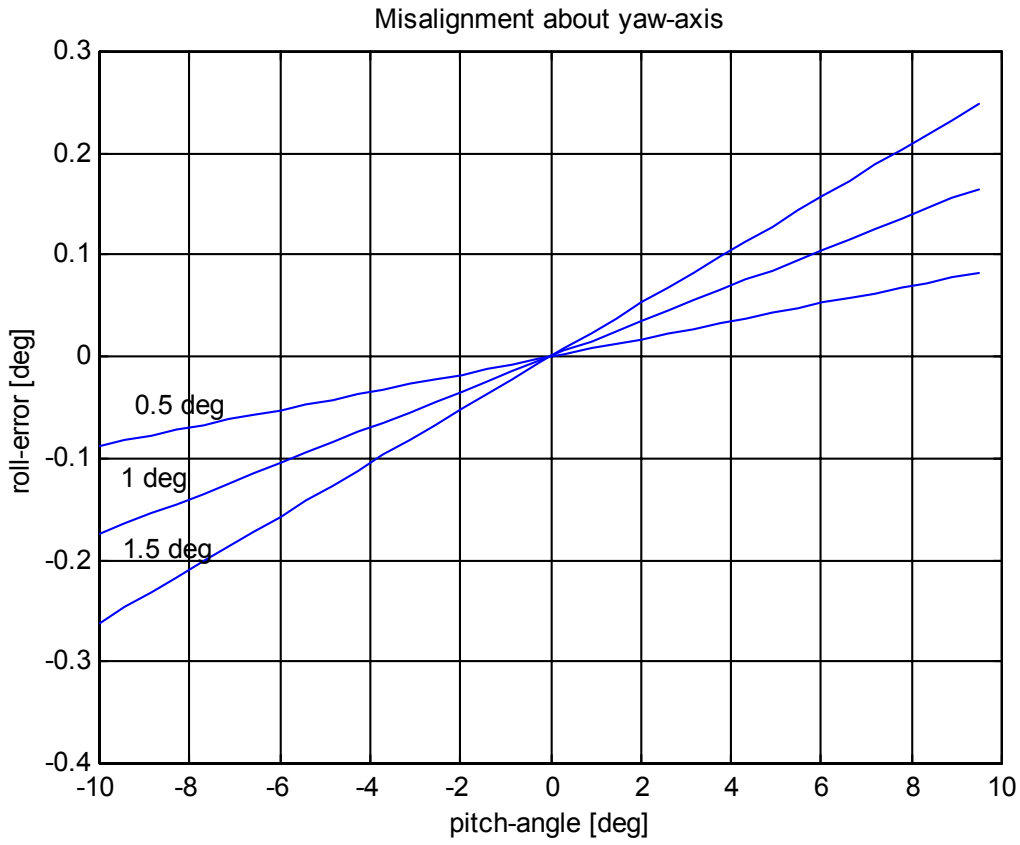


Figure 10 Value of roll error as function of vessel pitch angle, displayed at 0.5°, 1° and 1.5° MRU yaw misalignment

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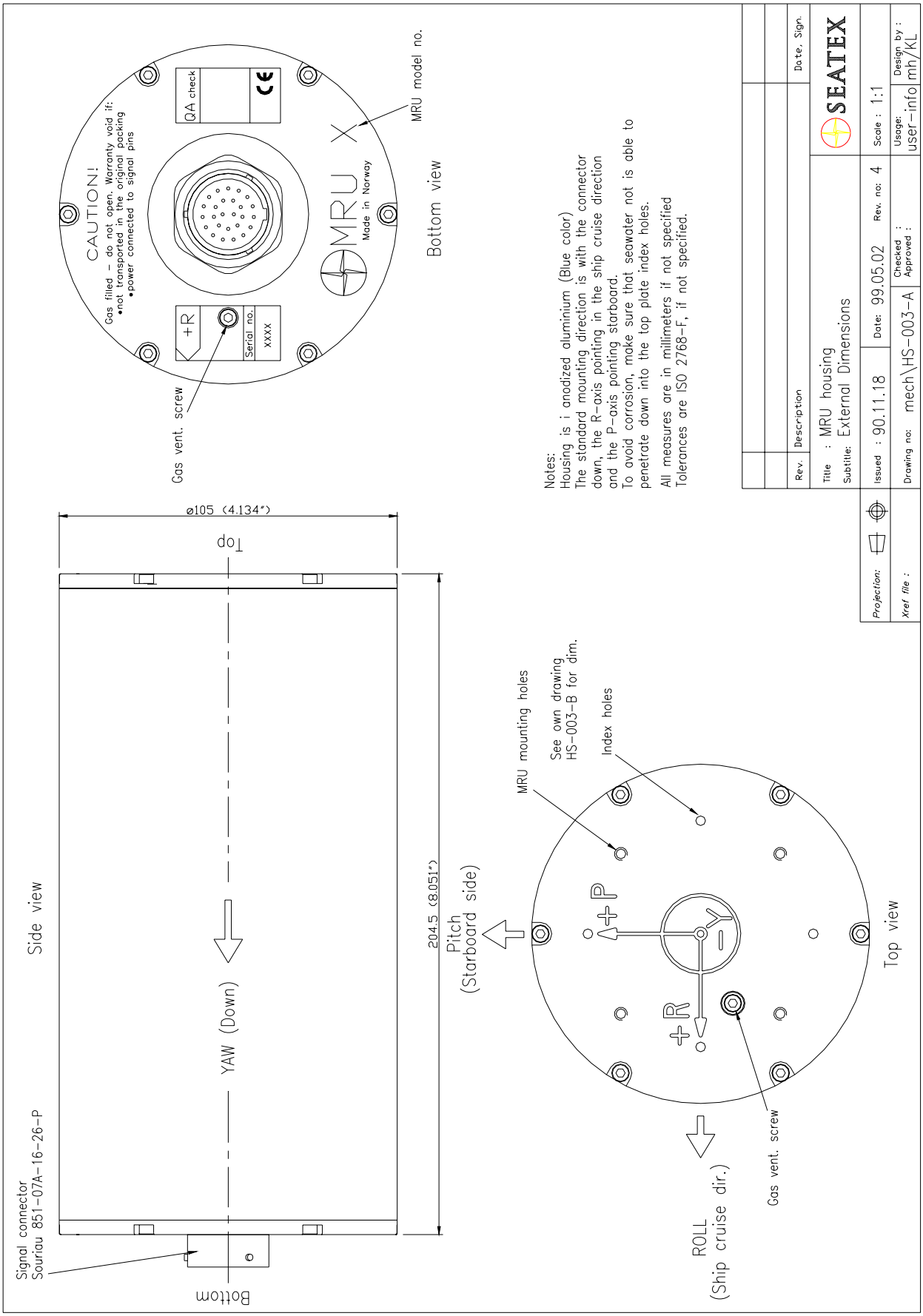
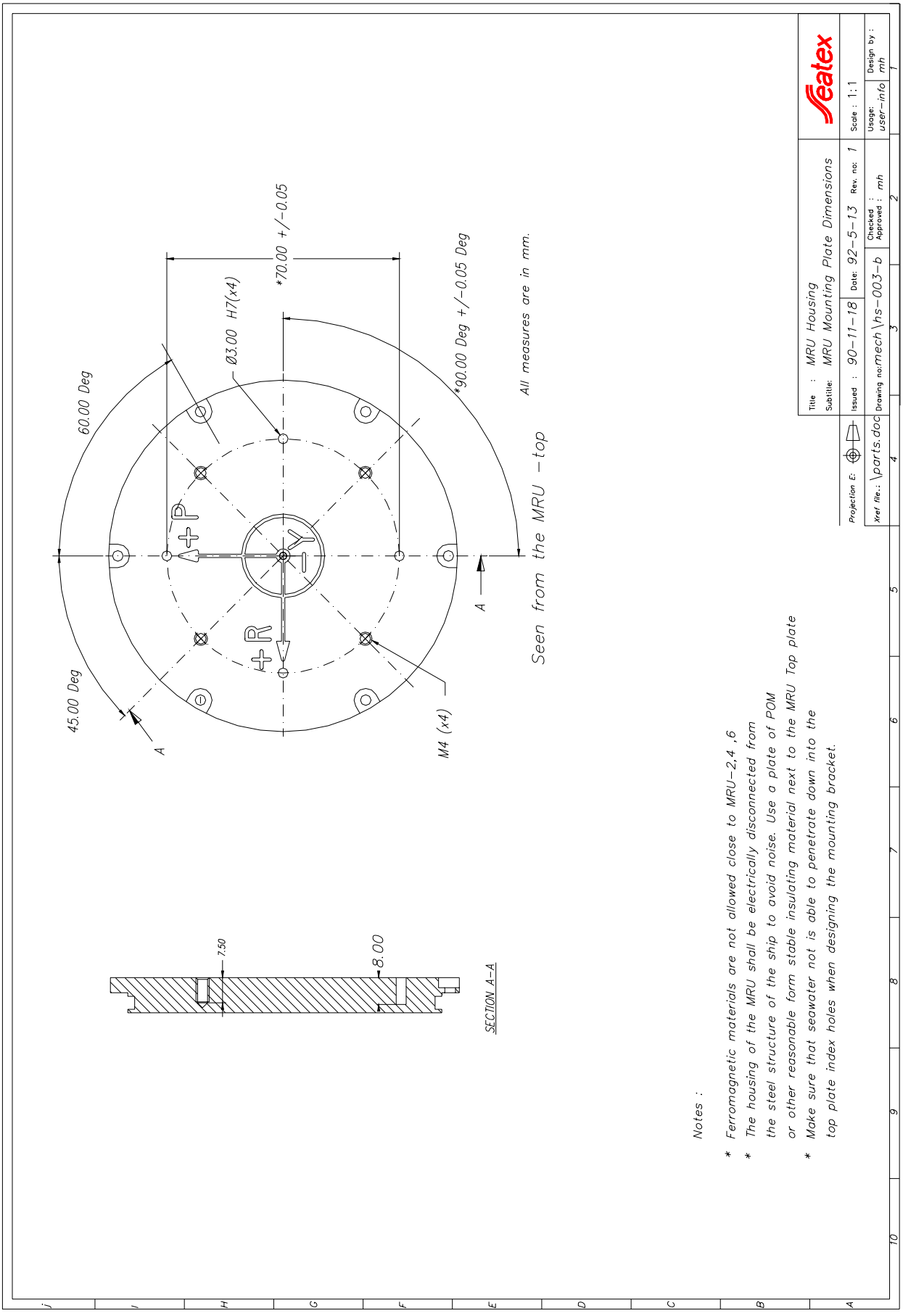
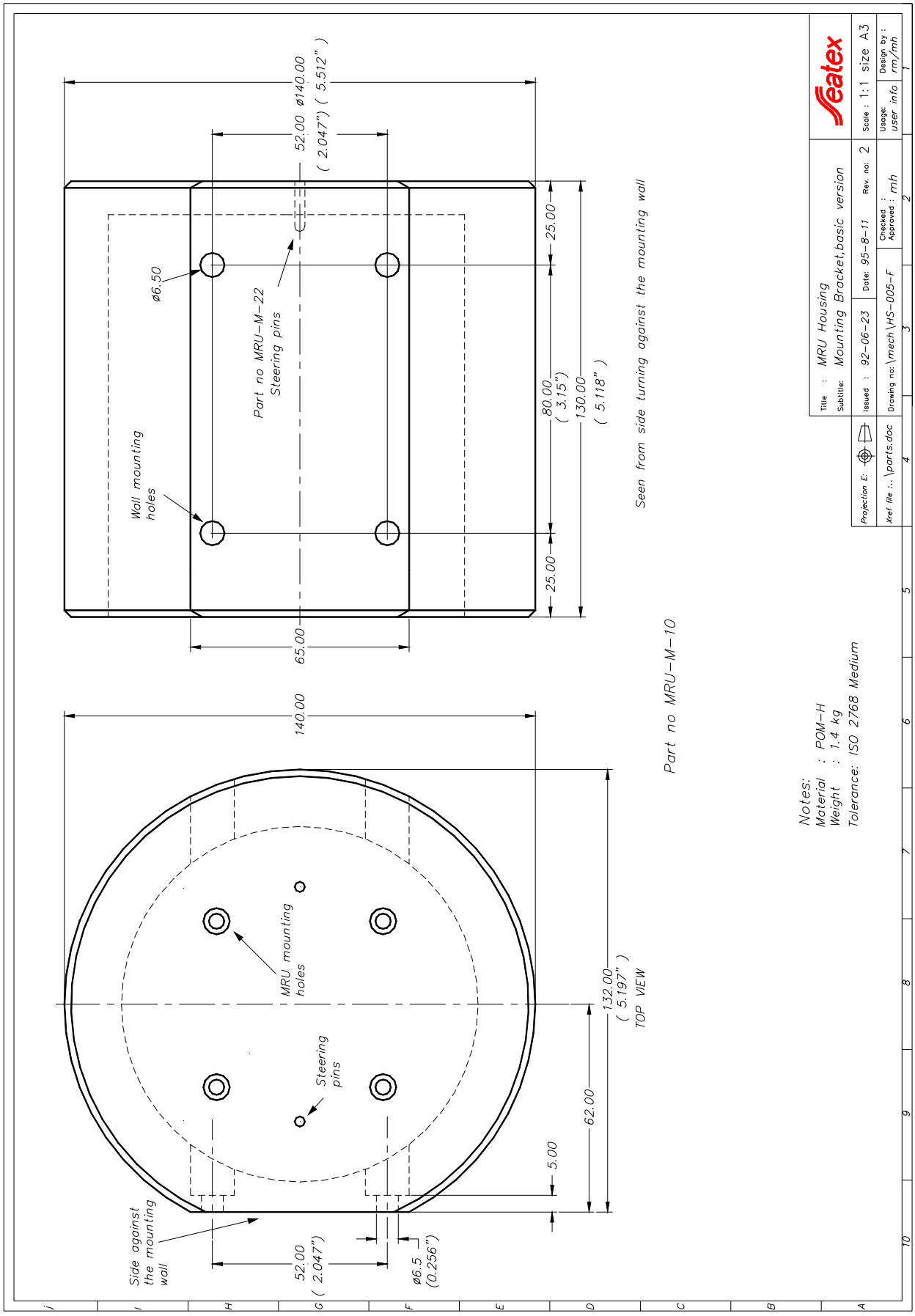
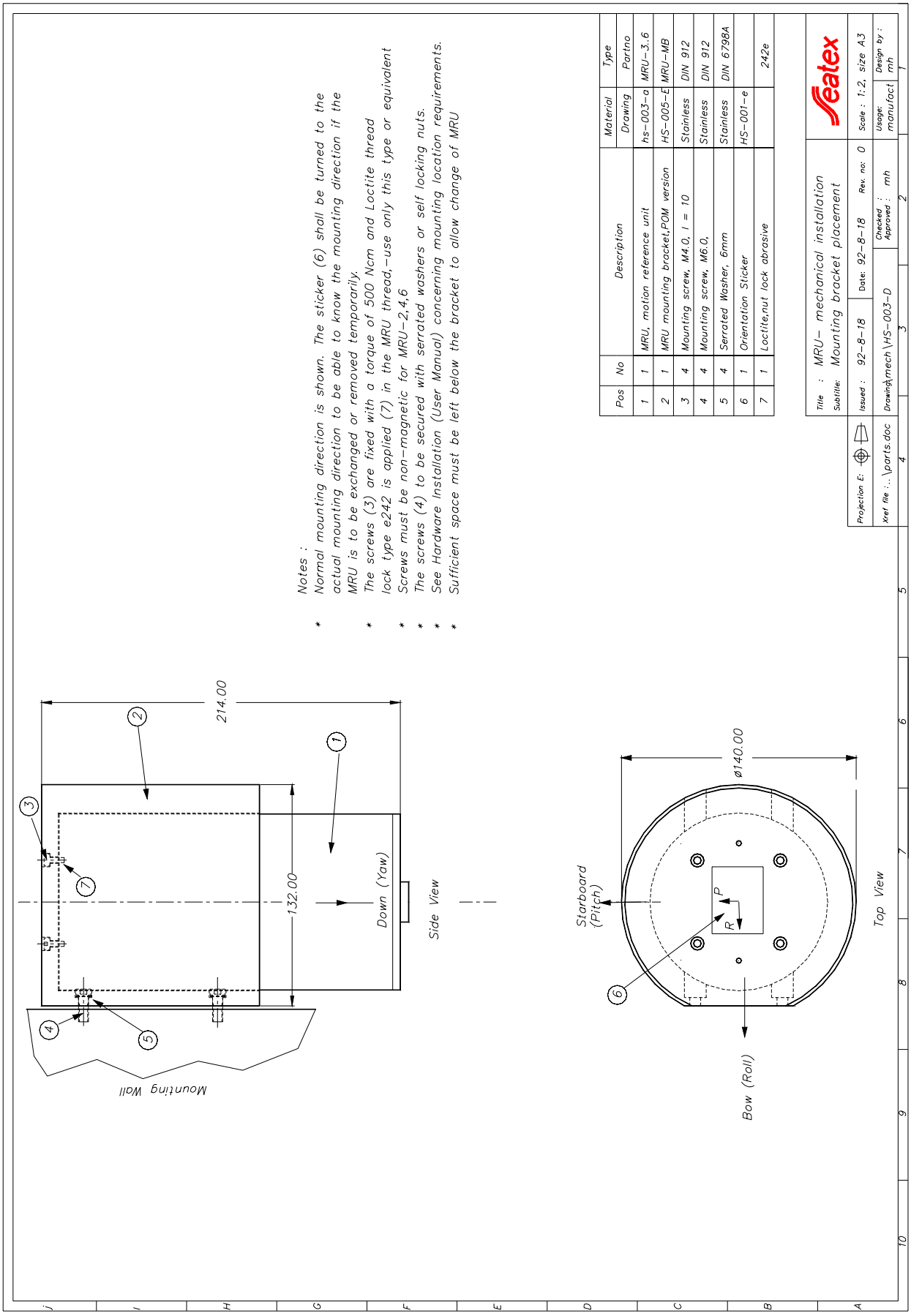
4. INSTALLATION DRAWINGS

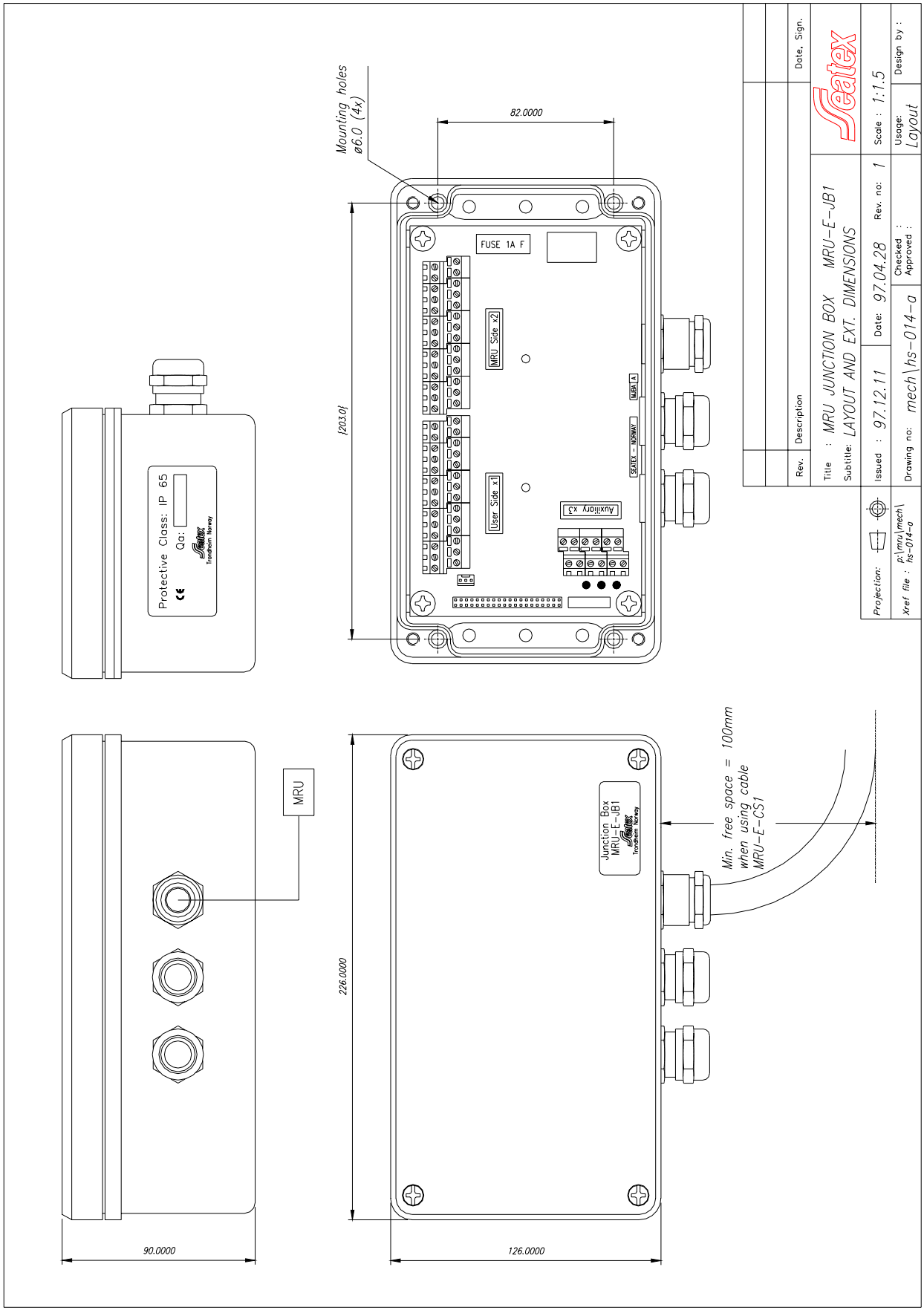
This section contains outline drawings showing the mechanical dimensions of the MRU, the mounting bracket, the junction box and the subsea bottles. The drawings are not to scale. To scale drawings are available upon request.

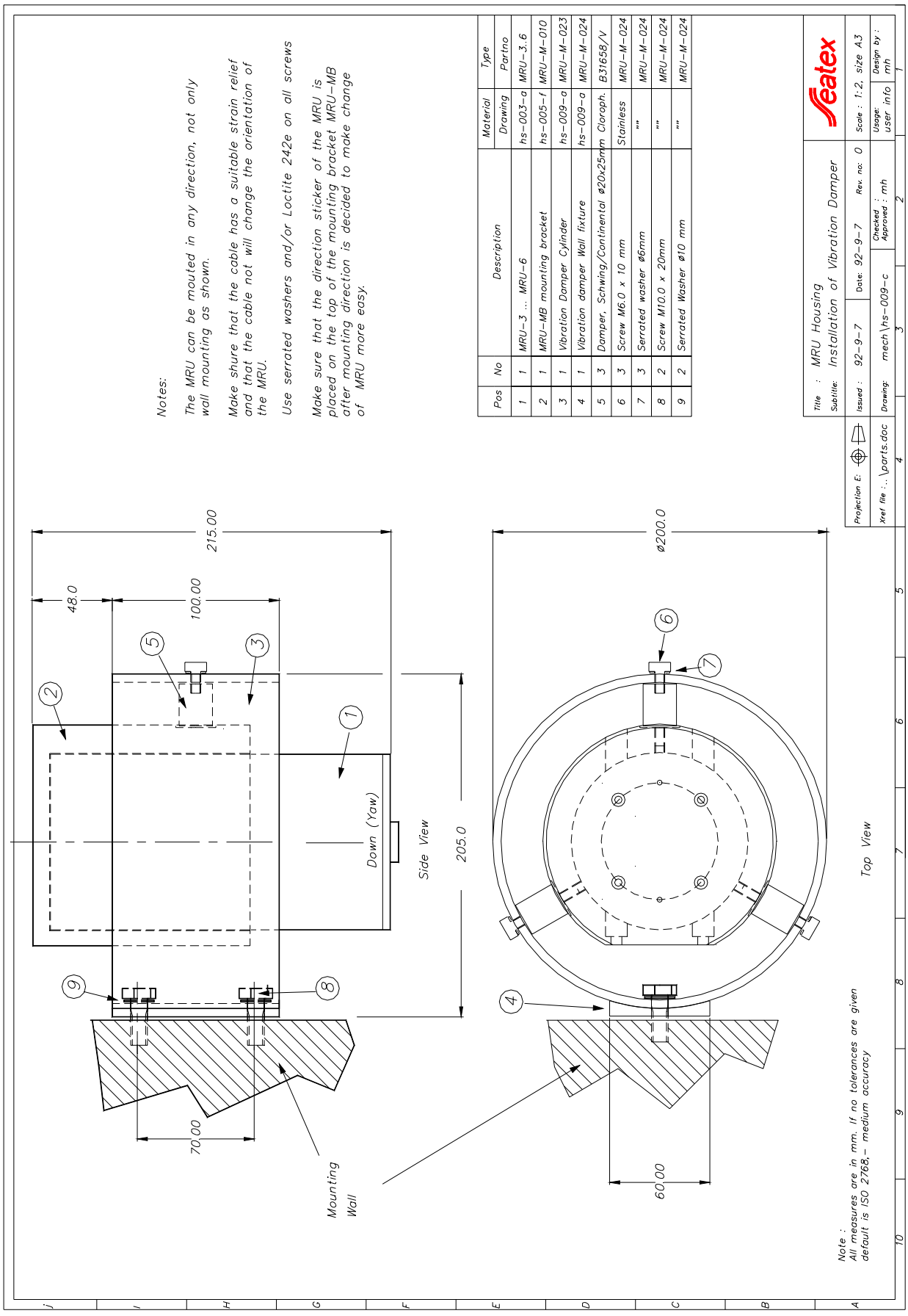

CAUTION!
Gas filled – do not open. Warranty void if:
•not transported in the original packing
•power connected to signal pins
QA check
CE
+R
Serial no.
XXXX
MRU
Made in Norway
MRU model no.
Gas vent. screw
Bottom view
Notes:
Housing is i anodized aluminium (Blue color)
The standard mounting direction is with the connector down, the R-axis pointing in the ship cruise direction and the P-axis pointing starboard.
To avoid corrosion, make sure that seawater not is able to penetrate down into the top plate index holes.
All measures are in millimeters if not specified
Tolerances are ISO 2768-F, if not specified.
Rev. Description Date. Sign.
Title : MRU housing
Subtitle: External Dimensions
SEATEX
Projection:
Issued : 90.11.18
Date: 99.05.02
Rev. no: 4
Scale : 1:1
Xref file :
Drawing no: mech\HS-003-A
Checked
Approved :
Usage: user-info
Design by : mh/KL
ø105 (4.134")
Top
Side view
YAW (Down)
204.5 (8.051")
Bottom
Signal connector
Souriau 851-07A-16-26-P
Pitch
(Starboard side)
MRU mounting holes
See own drawing
HS-003-B for dim.
Index holes
+P
+R
Top view
ROLL
(Ship cruise dir.)
Gas vent. screw

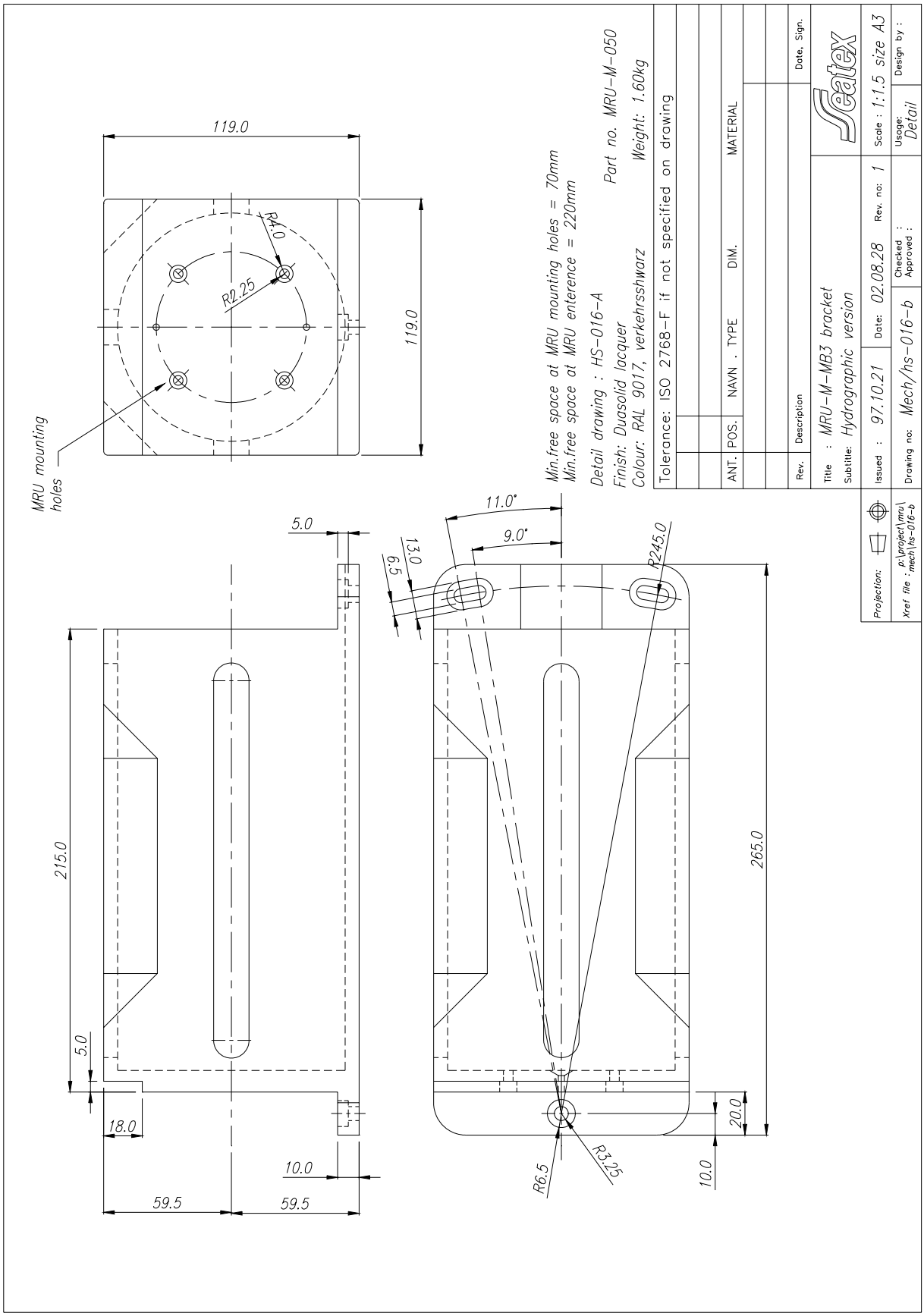

60.00 Deg
45.00 Deg
Ø3.00 H7(x4)
*70.00 +/-0.05
*90.00 Deg +/-0.05 Deg
M4 (x4)
+P
+R
+Y
A
A
Seen from the MRU -top
All measures are in mm.
7.50
8.00
SECTION A-A
Notes :
* Ferromagnetic materials are not allowed close to MRU-2,4 ,6
* The housing of the MRU shall be electrically disconnected from the steel structure of the ship to avoid noise. Use a plate of POM or other reasonable form stable insulating material next to the MRU Top plate
* Make sure that seawater not is able to penetrate down into the top plate index holes when designing the mounting bracket.
Title : MRU Housing
Subtitle: MRU Mounting Plate Dimensions
Issued : 90-11-18
Date: 92-5-13
Rev. no: 1
Scale : 1:1
Projection E:
Xref file:: \parts.doc
Drawing no:mech\hs-003-b
Checked Approved : mh
Usage: user-info
Design by : mh
Seatex

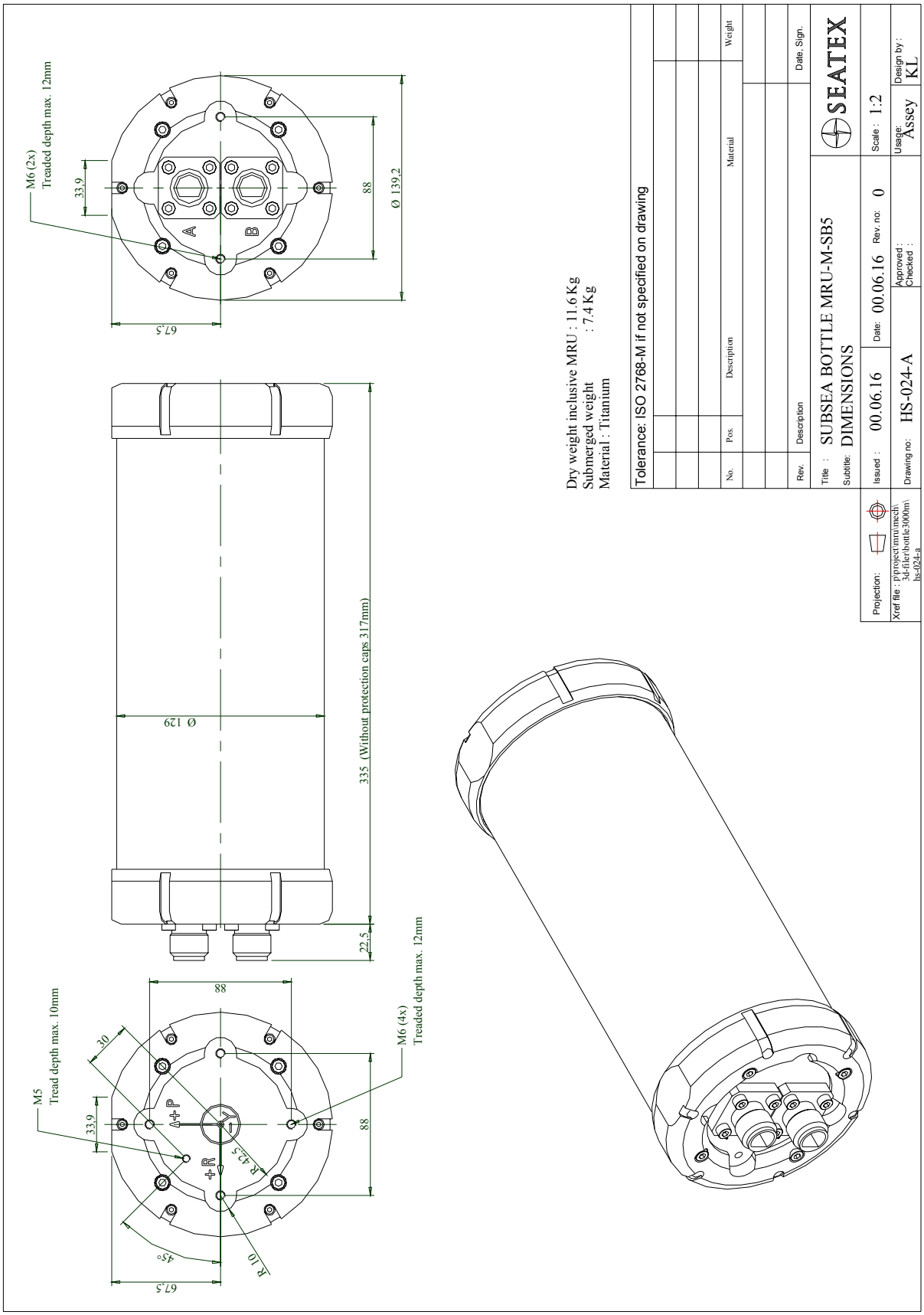

52.00 ø140.00
(2.047") (5.512")
ø6.50
Part no MRU-M-22
Steering pins
Wall mounting holes
25.00
80.00
(3.15")
130.00
(5.118")
25.00
65.00
Seen from side turning against the mounting wall
Part no MRU-M-10
140.00
MRU mounting holes
Steering pins
132.00
(5.197")
TOP VIEW
62.00
5.00
Side against the mounting wall
52.00
(2.047")
ø6.5
(0.256")
Notes:
Material : POM-H
Weight : 1.4 kg
Tolerance: ISO 2768 Medium
Title : MRU Housing
Subtitle: Mounting Bracket,basic version
Issued : 92-06-23
Date: 95-8-11
Rev. no: 2
Drawing no: \mech\HS-005-F
Checked
Approved : mh
Scale : 1:1 size A3
Usage: user info
Design by : rm/mh
Projection E:
Xref file :.. \parts.doc

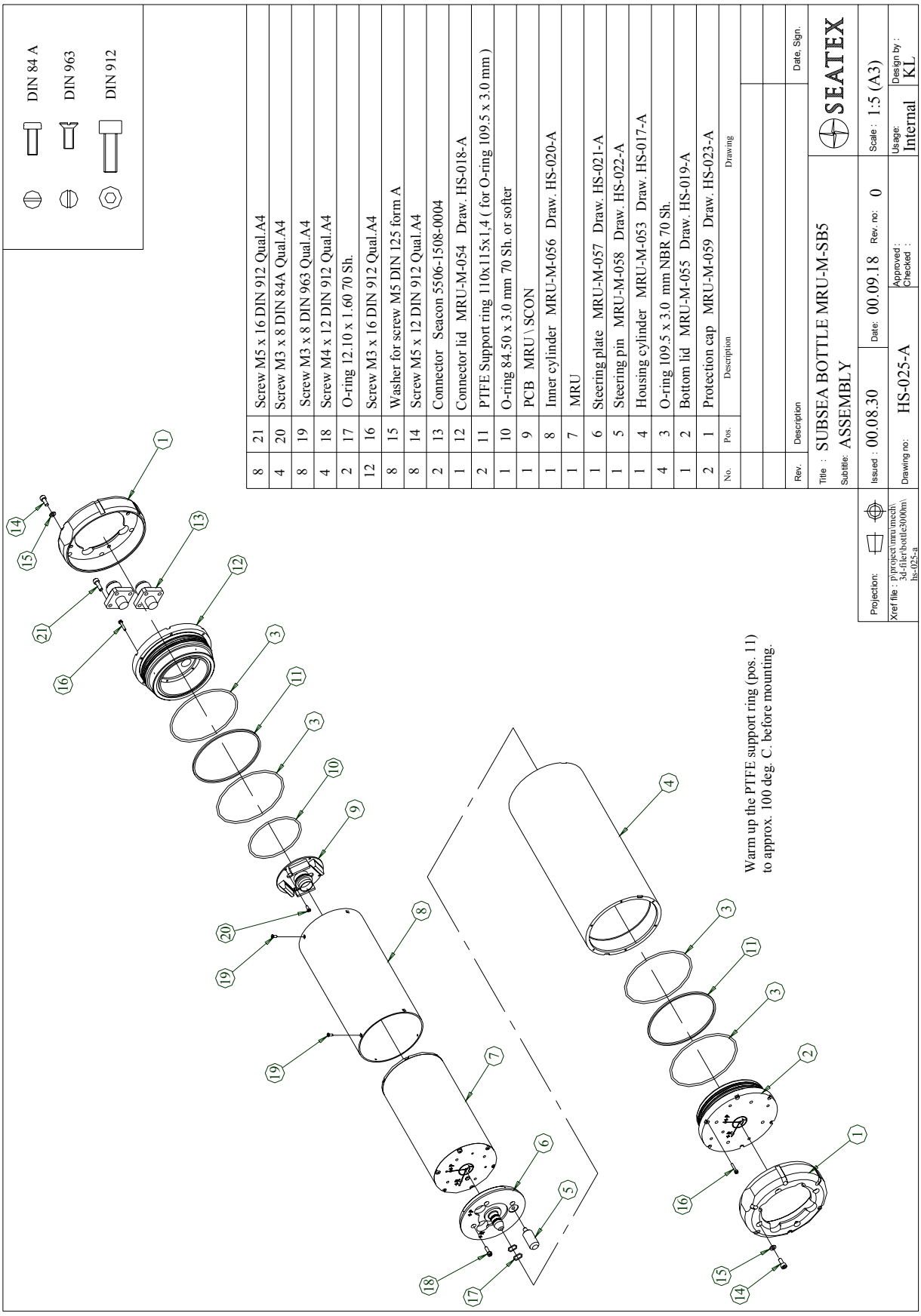

Notes :
* Normal mounting direction is shown. The sticker (6) shall be turned to the actual mounting direction to be able to know the mounting direction if the MRU is to be exchanged or removed temporarily.
* The screws (3) are fixed with a torque of 500 Ncm and Loctite thread lock type e242 is applied (7) in the MRU thread,-use only this type or equivalent
* Screws must be non-magnetic for MRU-2,4,6
* The screws (4) to be secured with serrated washers or self locking nuts.
* See Hardware Installation (User Manual) concerning mounting location requirements.
* Sufficient space must be left below the bracket to allow change of MRU
Pos No Description Material Type
Drawing Partno
1 1 MRU, motion reference unit hs-003-a MRU-3.6
2 1 MRU mounting bracket,POM version HS-005-E MRU-MB
3 4 Mounting screw, M4.0, l = 10 Stainless DIN 912
4 4 Mounting screw, M6.0, Stainless DIN 912
5 4 Serrated Washer, 6mm Stainless DIN 6798A
6 1 Orientation Sticker HS-001-e
7 1 Loctite,nut lock abrasive 242e
Title : MRU- mechanical installation
Subtitle: Mounting bracket placement
Seatex
Projection E: Issued : 92-8-18 Date: 92-8-18 Rev. no: 0 Scale : 1:2, size A3
Xref file : ..\parts.doc Drawing\mech\HS-003-D Checked : mh Approved : Usage: manufact Design by : mh
214.00
132.00
Down (Yaw)
Side View
Mounting Wall
Ø140.00
Starboard (Pitch)
Bow (Roll)
Top View
P
R


Mounting holes
ø6.0 (4x)
82.0000
203.0
FUSE 1A F
MRU Side x2
User Side x1
Auxiliary x3
SEATEX - NORWAY
Protective Class: IP 65
Qa:
MRU
Junction Box
MRU-E-JB1
Min. free space = 100mm
when using cable
MRU-E-CS1
226.0000
90.0000
126.0000
Rev.
Description
Date. Sign.
Title : MRU JUNCTION BOX MRU-E-JB1
Subtitle: LAYOUT AND EXT. DIMENSIONS
Issued : 97.12.11
Date: 97.04.28
Rev. no: 1
Scale : 1:1.5
Drawing no: mech\hs-014-a
Checked :
Approved :
Usage: Layout
Design by :
Projection:
Xref file : p:\mru\mech\hs-014-a


Notes:
The MRU can be mouted in any direction, not only wall mounting as shown.
Make shure that the cable has a suitable strain relief and that the cable not will change the orientation of the MRU.
Use serrated washers and/or Loctite 242e on all screws
Make sure that the direction sticker of the MRU is placed on the top of the mounting bracket MRU-MB after mounting direction is decided to make change of MRU more easy.
Pos | No | Description | Material / Drawing | Type / Partno
1 | 1 | MRU-3 ... MRU-6 | hs-003-a | MRU-3..6
2 | 1 | MRU-MB mounting bracket | hs-005-f | MRU-M-010
3 | 1 | Vibration Damper Cylinder | hs-009-a | MRU-M-023
4 | 1 | Vibration damper Wall fixture | hs-009-a | MRU-M-024
5 | 3 | Damper, Schwing/Continental ø20x25mm | Cloroph. | B31658/V
6 | 3 | Screw M6.0 x 10 mm | Stainless | MRU-M-024
7 | 3 | Serrated washer ø6mm | "" | MRU-M-024
8 | 2 | Screw M10.0 x 20mm | "" | MRU-M-024
9 | 2 | Serrated Washer ø10 mm | "" | MRU-M-024
Title : MRU Housing
Subtitle: Installation of Vibration Damper
Seatex
Projection E:
Issued : 92-9-7
Date: 92-9-7
Rev. no: 0
Scale : 1:2, size A3
Xref file : ..\parts.doc
Drawing: mech\hs-009-c
Checked : mh
Approved :
Usage: USER info
Design by : mh
215.00
48.0
100.00
205.0
Down (Yaw)
Side View
ø200.0
Top View
70.00
60.00
Mounting Wall
Note :
All measures are in mm. If no tolerances are given default is ISO 2768, - medium accuracy


119.0
119.0
R4.0
R2.25
MRU mounting holes
Min.free space at MRU mounting holes = 70mm
Min.free space at MRU enterence = 220mm
Detail drawing : HS-016-A
Finish: Duasolid lacquer
Colour: RAL 9017, verkehrsshwarz
Part no. MRU-M-050
Weight: 1.60kg
Tolerance: ISO 2768-F if not specified on drawing
ANT. POS. NAVN . TYPE DIM. MATERIAL
Rev. Description Date. Sign.
Title : MRU-M-MB3 bracket
Subtitle: Hydrographic version
Seatex
Projection:
Issued : 97.10.21
Date: 02.08.28
Rev. no: 1
Scale : 1:1.5 size A3
Xref file : p:\project\mru\mech\hs-016-b
Drawing no: Mech/hs-016-b
Checked :
Approved :
Usage: Detail
Design by :
5.0
11.0°
9.0°
13.0
6.5
R245.0
215.0
265.0
5.0
18.0
10.0
59.5
59.5
R6.5
R3.25
20.0
10.0


M6 (2x)
Treaded depth max. 12mm
33.9
88
Ø 139.2
67.5
A
B
Ø 129
335 (Without protection caps 317mm)
22.5
88
M5
Tread depth max. 10mm
30
33.9
M6 (4x)
Treaded depth max. 12mm
88
R 42.5
R 10
45°
67.5
Dry weight inclusive MRU : 11.6 Kg
Submerged weight : 7.4 Kg
Material : Titanium
Tolerance: ISO 2768-M if not specified on drawing
No. Pos. Description Material Weight
Rev. Description Date, Sign.
Title : SUBSEA BOTTLE MRU-M-SB5
Subtitle: DIMENSIONS
SEATEX
Issued : 00.06.16
Date: 00.06.16
Rev. no: 0
Scale : 1:2
Drawing no: HS-024-A
Approved :
Checked :
Usage: Assey
Design by : KL
Projection:
Xref file : p:\project\mru\mech\3d-file\bottle3000m\hs-024-a



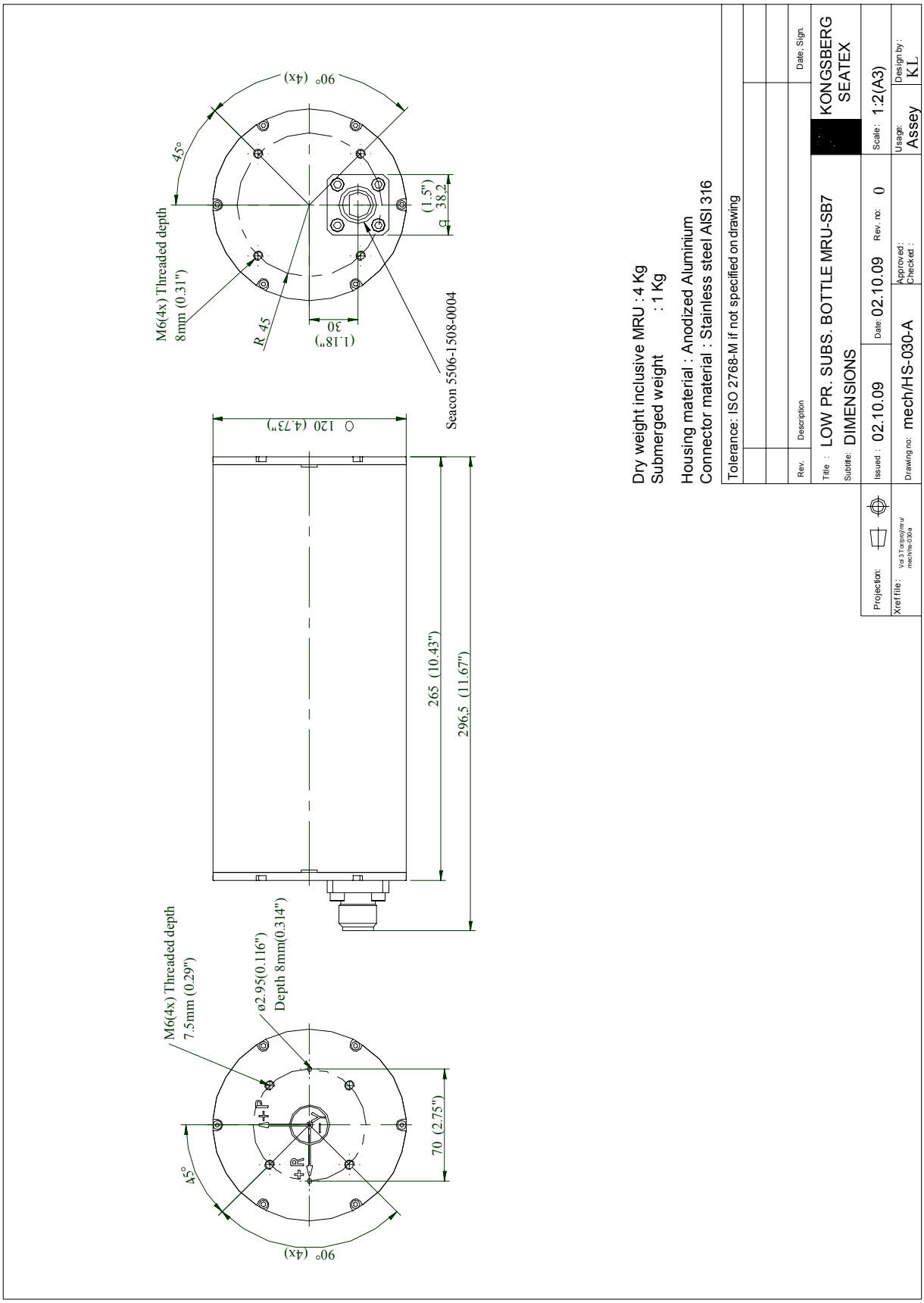
No.	Pos.	Description
8	21	Screw M5 x 16 DIN 912 Qual.A4
4	20	Screw M3 x 8 DIN 84A Qual.A4
8	19	Screw M3 x 8 DIN 963 Qual.A4
4	18	Screw M4 x 12 DIN 912 Qual.A4
2	17	O-ring 12.10 x 1.60 70 Sh.
12	16	Screw M3 x 16 DIN 912 Qual.A4
8	15	Washer for screw M5 DIN 125 form A
8	14	Screw M5 x 12 DIN 912 Qual.A4
2	13	Connector Seacon 5506-1508-0004
1	12	Connector lid MRU-M-054 Draw. HS-018-A
2	11	PTFE Support ring 110x115x1,4 (for O-ring 109.5 x 3.0 mm)
1	10	O-ring 84.50 x 3.0 mm 70 Sh. or softer
1	9	PCB MRU \ SCON
1	8	Inner cylinder MRU-M-056 Draw. HS-020-A
1	7	MRU
1	6	Steering plate MRU-M-057 Draw. HS-021-A
1	5	Steering pin MRU-M-058 Draw. HS-022-A
1	4	Housing cylinder MRU-M-053 Draw. HS-017-A
4	3	O-ring 109.5 x 3.0 mm NBR 70 Sh.
1	2	Bottom lid MRU-M-055 Draw. HS-019-A
2	1	Protection cap MRU-M-059 Draw. HS-023-A

Rev.	Description	Date. Sign.

Title : SUBSEA BOTTLE MRU-M-SB5
Subtitle: ASSEMBLY

SEATEX

Projection:
Issued : 00.08.30
Date: 00.09.18
Rev. no: 0
Scale : 1:5 (A3)
Xref file : p:\project\mru\mech\3d-filer\bottle\8000m\hs-025-a
Drawing no: HS-025-A
Approved :
Checked :
Usage: Internal
Design by : KL


90° (4x)
45°
M6(4x) Threaded depth
8mm (0.31")
R 45
30
(1.18")
(1.5")
38.2
Seacon 5506-1508-0004
120 (4.73")
265 (10.43")
296.5 (11.67")
M6(4x) Threaded depth
7.5mm (0.29")
ø2.95(0.116")
Depth 8mm(0.314")
70 (2.75")
45°
90° (4x)
Dry weight inclusive MRU : 4 Kg
Submerged weight : 1 Kg
Housing material : Anodized Aluminium
Connector material : Stainless steel AISI 316
Tolerance: ISO 2768-M if not specified on drawing
Rev.
Description
Date, Sign.
Title : LOW PR. SUBS. BOTTLE MRU-SB7
Subtitle: DIMENSIONS
KONGSBERG SEATEX
Projection:
Issued : 02.10.09
Date: 02.10.09
Rev. no: 0
Scale: 1:2(A3)
Xref file: Vol.3 Tr/proj/mru/mech/hs-030a
Drawing no: mech/HS-030-A
Approved :
Checked :
Usage: Assey
Design by : KL

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5. APPENDIX A - OTHER PROTOCOLS FOR MRU DATA OUTPUT

The recommended way to obtain data from the MRU is to utilise the MRU proprietary protocol ref. [1], since this is the fastest and most accurate protocol. However, it is possible to select other protocols for the MRU data output. These other protocols are an NMEA proprietary sentence, a SOUNDER sentence, the SIMRAD EM1000/950 and EM3000 protocols, the SUBMETRIX format, the RD Instrument PRDID format, the Hippy 120 digital format and the Atlas output format.

5.1 MRU NMEA sentence

The MRU NMEA sentence follows NMEA 0183 version 2.00 specification 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 more 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 protocol, all other messages remain as normal MRU protocol messages. As the NMEA protocol is ASCII based, as opposed to the MRU binary message, more than twice as many bytes are used to transfer a six-variable sentence by NMEA than MRU binary. 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 normal MRU protocol can transmit 35 messages per second under the same conditions.

The following is a Seatex proprietary MRU NMEA data message:

```
$PSXN,10,xx,x.xx,x.xx,x.xx,x.xx,x.xx,x.xx*hh<CR><LF>
   |       |  |    |    |       |    |    |    |___ data field 6
   |       |  |    |    |       |    |    |
   |       |  |    |    |       |    |    |___ data field 5
   |       |  |    |    |       |    |
   |       |  |    |    |       |    |___ data field 4
   |       |  |    |    |       |
   |       |  |    |    |       |___ data field 3
   |       |  |    |    |
   |       |  |    |    |___ data field 2
   |       |  |    |
   |       |  |    |___ data field 1
   |       |  |
   |       |  |___user defined token (10..100)
   |       |
   |       |___MRU message identifier (11 if data unstable)
   |
   |___ Seatex A.S id (SeateX Norway)
```

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:

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
      |  |   |       |       |       |       | |  |_checksum
      |  |   |       |       |       |       | |_empty fields
      |  |   |       |       |       |__Tue Jun 14 1994 12:53:47
      |  |   |       |       |___HEAVE
      |  |   |       |__ PITCH
      |  |   |__ ROLL
      |  |__ token
      |__ Message number, data stable
```

5.2 SOUNDER sentence

The next adjustable protocol is the SOUNDER sentence which is the most commonly used interface format for heave compensation of single beam echo sounders. By selecting this protocol 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:

:aabbbb shhhhxsrrrr spppp<CR><LF>

where:

- aa is a 2 char hex number with SWAY acceleration, in 0.03835 m/ss units.
  bbbb is a 4 char hex number with HEAVE acceleration, in 0.000625 m/ss units.

- hhhh is a 4 char decimal number with HEAVE position in centimetres, positive up
  s is 1 character of sign: <SPACE> if positive "-" if negative.

- x is warning character. <SPACE> if OK, "?" if data unstable.

- rrrr is a 4 char decimal number with ROLL angle in hundreds of a degree.
  s is 1 character of sign: <SPACE> if positive, "-" if negative.

- pppp is a 4 char decimal number with PITCH angle in hundreds of a degree.
  s is 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

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

Example:

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

5.3 Binary format, Simrad EM1000/950 compatible

The Simrad EM1000 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
Header		Unsigned	1	00 Hex
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. Invalid data are indicated by values outside the specified ranges.

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

$$roll_{EM1000} = \arcsin\left[\sin(roll_{Euler}) \cdot \cos(pitch_{Euler})\right]$$

5.4 Binary format, Simrad EM3000/Hipap compatible

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.

5.5 SUBMETRIX format

The SUBMETRIX format is in the pure unsigned binary form and includes the following messages:

Byte No.	Byte Description	Units
1	Message Start Byte ':'	---
2	IMU Status Byte	---
3	Raw Depth, MSB	m
4	Raw Depth, LSB	
5	Compass Output, MSB	degrees
6	Compass output, LSB	
7	Est Roll - Phi, MSB	rad
8	Est Roll - Phi, LSB	
9	Est Pitch - Theta, MSB	rad

10	Est Pitch - Theta, LSB	
11	Est Heading - Psi, MSB	degrees
12	Est Heading - Psi, LSB	
13	Est PhiDot, MSB	rad/s
14	Est PhiDot, LSB	
15	Est PsiDot, MSB	rad/s
16	Est PsiDot, LSB	
17	Est Vert Disp Zest, MSB	m
18	Est Vert Disp Zest, LSB	
19	Est Vert Rate Zdot, MSB	m/s
20	Est Vert Rate Zdot, LSB	
21	Mean Axial Displ, MSB	m
22	Mean Axial Displ, LSB	
23	Mean Lateral Displ, MSB	m
24	Mean Lateral Displ, LSB	
25	IMU Block Temperature	degC
26	Checksum Byte	

The various IMU (Inertial Measurement Unit) status byte characters have the following meaning:

Status character	Description
N	**Unaided mode and stable data**. The MRU is operating without external input data.
n	**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 five minutes.
S	**Speed aided mode and stable data**. The MRU is operating with external input of speed data.
s	**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.
C	**Heading aided mode and stable data**. The MRU is operating with external input of heading data.
c	**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.
M	**Internal magnetic heading available and stable data.** The MRU is operating with use of the internal magnetic compass.
m	**Internal magnetic heading available but unstable data.** The MRU is operating with use of the internal magnetic compass, but the data from the unit are unstable most likely due to alignment after power on or restart.

B	**Speed aided, internal magnetic heading available and stable data.** The MRU is operating with external input of speed data and the internal magnetic compass is in use.
b	**Speed aided, internal magnetic heading available but unstable data.** The MRU is operating with external input of speed data and the internal magnetic compass is in use, but the data from the unit are unstable most likely due to alignment after power on, restart or input of external speed data.
A	**Full aided mode and stable data**. The MRU is operating with external input of both speed and heading data.
a	**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.

5.6 RDI ADCP format

The RDI format is a proprietary ASCII text format used when connecting RD Instrument ADCP equipment. This format is output in two versions from the MRU:

- **ADCP RDID**. Then the MRU will output the format **$RDID,***pitch*,*roll*,*head term*
- **ADCP PRDID**. Then the MRU will output the format **$PRDID,***pitch*,*roll*,*head term*

Explanation:

pitch	Pitch, degrees in 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 in 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 in format ddd.dd, with leading zeroes where appropriate.
term	CR-LF (2 bytes, values 13 and 10).

5.7 Hippy 120 digital format

The MRU can emulate the Hippy 120 digital format. Only parts of the Hippy interface is implemented. By sending an **O** command to interrogate the MRU, the MRU will respond by sending out roll, pitch and heave measurements in the following format:

Element	Unit	Resolution
RollHippy	[-1 1]	0.0005
PitchHippy	[-1 1]	0.0005
Heave	[m]	0.5 cm
Heave	[m]	0.5 cm

The fourth element in the output string is heave and not delayed heave which is normal from the Hippy 120. Roll is positive with port side up. Pitch is positive with stern up. Heave is positive up.

5.8 ATLAS format

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.

Packet format is:

DLE RrPpHhQ *DLE*

The description of each field is:

Field	Definition	Units
DLE	Start character - ASCII 10 Hex	
R	Roll - MSB	Horn scaling 2π = 2**16
r	Roll - LSB	
P	Pitch - MSB	Horn scaling 2π = 2**16
p	Pitch - LSB	
H	Heave - MSB	1 mm per increment
h	Heave - LSB	
Q	Status code 0 to 7 inclusive. Below is a description of the various codes.	
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.
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.

5.9 TSS1 sentence

The next adjustable protocol is the TSS1 sentence which is a modified version of the SOUNDER sentence with aiding MRU status information. By selecting this protocol, 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:

:aabbbb shhhhxsrrrr spppp<CR><LF>

where:

- aa is a 2 char hex number with SWAY acceleration, in 0.03835 m/ss units.
  bbbb is a 4 char hex number with HEAVE acceleration, in 0.000625 m/ss units.

- hhhh is a 4 char decimal number with HEAVE position in centimetres, positive up
  s is 1 character of sign: <SPACE> if positive, "-" if negative.

- x is a status character. Below is a description of the various characters.

- rrrr is a 4 char decimal number with ROLL angle in hundreds of a degree.
  s is 1 character of sign: <SPACE> if positive, "-" if negative.

- pppp is a 4 char decimal number with PITCH angle in hundreds of a degree.
  s is 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:

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

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:

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

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6. APPENDIX B - OTHER PROTOCOLS FOR COMMANDS TO MRU

The recommended way to send commands to the MRU is to use the MRU proprietary protocol. The MRU will, however, accept several NMEA 0183 sentences carrying appropriate MRU information if enabled through the auxiliary serial lines 1 or 2 in the MRU configuration. These sentences can be interleaved with other proprietary commands using the same baud rate, parity etc. The following sentences are recognised:

True Heading

$--HDT,x.x,T*hh<CR><LF>
|_____ heading degrees

Magnetic Heading

$--HDM,x.x,M*hh<CR><LF>
|_____ heading degrees

Dual Ground/Water Speed

$--VBW,x.x,x.x,A,x.x,x.x,A*hh<CR><LF>
|_____ longitudinal speed knots

Water Speed

$--VHW,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
| |_____ speed Km/hr
|_____ speed knots

Track Made Good and Ground Speed

$--VTG,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
| |_____ speed Km/hr
|_____ speed knots

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7. APPENDIX C - EXTERNAL SPEED AND HEADING INPUT

7.1 Introduction

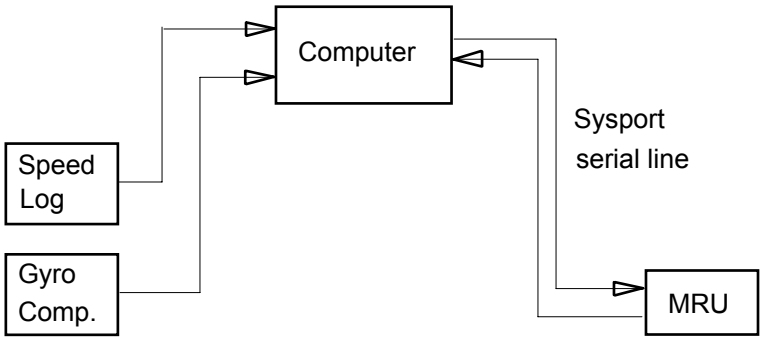
Seatex has designed the MRU Z, H, 4, 5 and 6 models to generate data of the highest precision for marine applications. Key factors in achieving this level of precision involve the external input of speed data (from a speed log) and heading data (from a gyro compass). These features are particularly important for operations that include frequent turns, changes in heading and/or accelerations.

External input of speed and heading data eliminates the roll, pitch and heave measurement drift caused by turning and accelerations, so the MRU can accurately measure roll and pitch angles even while turning and/or accelerating. Inputting speed data is particularly important in operations involving frequent turns. It ensures high quality roll and pitch measurements during these manoeuvres. Only a high quality heading signal must be used. If the quality of the heading signal is uncertain, it is better to simply refrain from sending it to the MRU. Some types of Echo Sounders (e.g., Simrad EM3000) receive heading data through the MRU, and in these cases it is convenient to input gyro compass heading data to the MRU.

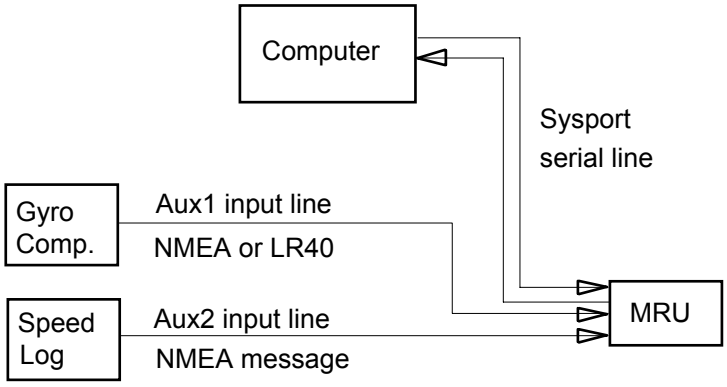
7.2 Interface possibilities

The interface possibilities of speed and heading to the MRU are as follows:

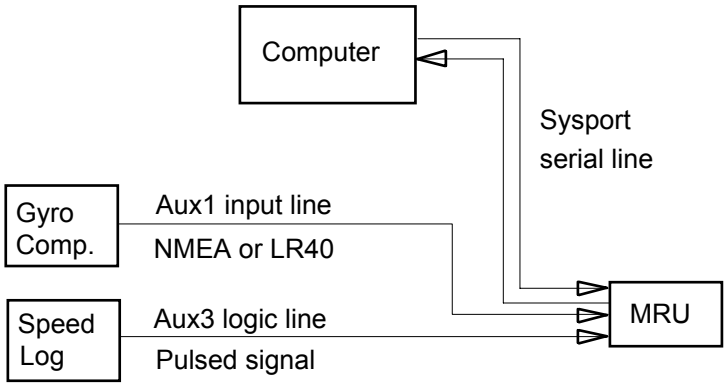
a) Speed and heading data may be input to the MRU from a host computer through the MRU Sysport, the main RS-232 communication line, by sending the information as a standard MRU protocol command or as an NMEA message.



b) Speed and heading data may be input as auxiliary serial data to the MRU directly from the sources through the Aux1 and 2 lines as an NMEA HDT, HDM, VTG or LR40 format.



c) Heading data may be sent to the MRU on the auxiliary input line, Aux1 or Aux2, and the speed as a pulsed signal on the logic input line, Aux3. The MRU accepts 200 pulses per nautical mile as a discrete speed signal.



7.2.1 Default settings

The MRU is delivered with the following default settings on the input signals:

- Sysport baud rate of 4800 baud and **8 data no parity** mode.
- Aux1 and 2 set to accept serial data input at a rate of 4800 baud and **8 data no parity** mode.
- Aux3 set to **Not used**.

These default settings can be changed by using the MRU configuration software MRC. The baud rate on the Sysport can be set within the range 1200 to 57600. For the Aux1 and 2 ports the baud rate can be selected in the range 1200 to 19200.

7.2.2 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, because doing so may overload the MRU computer.

If speed data are not received by the MRU for three seconds, external speed changes will be considered not available. If heading data are not received by the MRU within three to 40 seconds, the heading will drift based on estimated parameters from the period when heading data were available. If heading data are not received by the MRU after 40 seconds, the heading reference will be considered the value of the last reference received or the MRU then automatically switches to the internal magnetic compass (MRU 4 & 6) as the heading reference.

7.3 The heading signal

The MRU Z, H, 4, 5 and 6 models accept external heading information sent to the unit by using the standard MRU protocol commands, the NMEA or LR40 format. 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 (gyro or magnetic) 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 set up, 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) more than approximately one second to avoid errors in turns.

7.3.1 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 ±π 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_lsb**>

delay Unsigned byte given time delay in 10 ms units since data were captured (default 0, maximum 2.55 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 -π to π. Values outside these limits will result in an unacceptable message.

7.3.2 Heading input through the NMEA interface

The MRU will accept NMEA 0183 formatted messages for heading data. These are sent directly into the unit on the Sysport or one of the auxiliary serial input lines, Aux1 or Aux2. The NMEA message can be interleaved with other MRU messages. Cyclic data messages from the MRU may continue while NMEA messages are written to the MRU.

The following NMEA sentences are acceptable for heading input to the MRU:

- HDT Heading - True

  $--HDT,x.x,T*hh<CR><LF>
  |_____ heading degrees

- HDM Magnetic Heading

  $--HDM,x.x,M*hh<CR><LF>
  |_____ heading degrees

7.3.3 Heading input through the LR40 interface

The MRU will also accept heading data in the digital Gyro Repeater format LR40 (Lehmkuhl/ScanRepeater). These heading data are sent directly into the unit through the auxiliary serial input line, Aux1 or Aux2. This message can be interleaved with other MRU messages.

7.4 The speed log signal

The MRU Z, H, 4, 5 and 6 models accept external speed information sent to the unit using standard MRU protocol commands, the NMEA format or as a pulsed log signal. The speed data must be of high quality in order to achieve the expected improvement of the MRU performance. Only a quality speed data source should be used (real-time signal, vessel speed in CG).

Note The GPS speed data input to the MRU must be lever arm compensated down to CG (essential when the GPS 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.

An internal MRU orientation estimator filters external speed log data. 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.

7.4.1 Speed input through the standard MRU protocol

The most efficient way to input speed log information to the MRU is by using the standard MRU protocol commands. By using these software commands, the user can send speed information to the MRU 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_lsb**>

delay Unsigned byte giving time delay in 10 ms units since data were captured (default 0, maximum 2.55 seconds) until the message is entered into the MRU (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.

7.4.2 Speed input through the NMEA interface

The MRU will accept NMEA 0183 formatted messages for speed data. These data are sent directly into the unit on the Sysport or one of the auxiliary serial input lines, Aux1 or Aux2. The NMEA message can be interleaved with other MRU messages. Cyclic data messages from the MRU may continue while NMEA messages are written to the MRU.

The following NMEA sentences are acceptable for speed input to the MRU:

- VTG Track Made Good and Ground Speed

  $--VTG,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
  | |_____ speed, km/hr
  |_____ speed, knots

- VHW Water Speed and Heading

  $--VHW,x.x,T,x.x,M,x.x,N,x.x,K*hh<CR><LF>
  | |_____ speed, km/hr
  |_____ speed, knots

- Dual Ground/Water Speed

  $--VBW,x.x,x.x,A,x.x,x.x,A*hh<CR><LF>
  |_____ longitudinal speed, knots

7.4.3 Input of pulsed speed signal

A speed log pulsed signal can be input to the MRU through the logic auxiliary input line, Aux3. In this case, the MRU must be configured with the selection **Speed log pulse input** on the Aux3 line in the MRU configuration software, MRC. The MRU Aux3 line will accept 200 pulses per nautical mile as input. The pulses must be at least 10 ms high and 10 ms low. When no pulses are received, the speed is set to zero.

7.5 Remarks

When external input is used, please verify the following:

- The status of <Ext head> and <Ext speed> appears in the MRU Info Bar in the MRC configuration software as shown in Figure 11. This verifies that the external input information is correctly received by the MRU. If not, the MRU has not accepted the messages you tried to send. If there are problems, then output the variables ExtSpeed (var.no. 160) and ExtHead (var.no. 162) from the MRU in order to monitor the external signals received by the MRU.

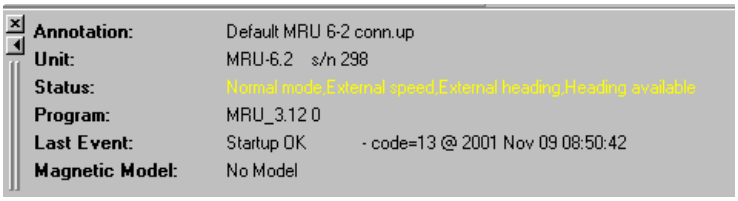


Figure 11 MRU Info Bar

- When speed data from GPS 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.

- Always use heading data from a gyro compass. Do not use GPS heading data with the MRU.

- A delay in the external heading signal of more than one second will degrade the MRU's ability to compensate for centrifugal force. Be aware that external delays can occur when a computer is connected between the gyro compass and the MRU.

- It is essential that heading and speed data sent to the MRU are of the specified quality; otherwise, MRU system accuracy will be diminished.

8. APPENDIX D - TIME SYNC INPUT

It is possible to synchronise the MRU internal clock/calendar to an external one second time pulse (typical from GPS or other high accuracy time source). To do this, the user must select **Time sync input, 1 sec** for the **XIN pin control** or the **Logical Input AUX3** line under the configuration folder **Data Interface \ Digital** in the MRC configuration program. A 5 Volt CMOS level signal carrying the one second time pulse must be applied to the **XIN pin control** or **Logical Input AUX3** line (LGND is the ground reference). The pulse signal must have a 10 ms minimum high period and a 10 ms minimum low period. The MRU internal clock/calendar will synchronise itself to advance by seconds on the negative edge of the time sync signal.

Click the **Synchronize clock** button under the MRC bar **Status** to change the MRU clock/calendar to the desired values, preferably UTC time.

This time sync facility will allow the internal MRU clock to be synchronised both in phase and period with a global clock system. Data from the MRU can be stamped with the MRU's own clock. The clock/calendar information can be output as one (or two) of the parameters in the MRU data packet, normally the output variables 188 and 189 are used for this.

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9. APPENDIX E - STATUS MESSAGES FROM THE MRU

These are unrequested messages from the MRU. The user configuration parameter **Verbose mask** controls which messages are transmitted. The following settings are available:

0: Silent; no messages transmitted
1: Status report
2: Events report
3: Status + Events report

Status Change Report Message

This message is sent after every MRU status change if enabled through **Verbose mask** in the MRU configuration.

<'c'><6><9><0><s_0><s_1><s_2><s_3><chk>

s_0,1,2,3 32 bit MRU status, see "Appendix G - MRU status bits"

Event Message

This message is sent on every MRU event (i.e., change of normal operation in the MRU if enabled through **Verbose mask** in the MRU configuration).

<'c'><10><9><event><t_0><t_1><t_2><t_3><c_0><c_1><0><0><chk>

event MRU event number + 16, see "Appendix H - MRU event numbers"

t_0,1,2,3 32 bit date of event occurrence, number of seconds since 1 Jan 1970 00:00:00

c_0,1 16 bit code connected to event (only for internal use)

Welcome Message

This message is sent at startup.

<'c'><20><8><'MRU VV.RR'><type><vers><v_0><v_1><s_0><s_1><0><mode><opt><0><chk>

MRU VV.RR is a 10 byte string with software version and revision level

type MRU type: 1..7
bit 7=1 if emulation of other MRU type

vers hardware version
'0', '1', '2', 'd' and 'e' hardware version identification

v_0,1 16 bit software number multiplied with 100 (version 3.20 will then be 320)

s_0,1 16 bit MRU serial number

mode MRU modus
1: Normal
2: Abnormal

opt N/A

Abnormal Mode Message

This message is sent every two seconds if the MRU is in an abnormal mode (i.e., some error has occurred). If the user configuration in the MRU is okay, the message is transmitted at user specified baud rate and settings. Otherwise, the default setting of 4800, N, 8, 1 is used.

<'c'><6><9><1><h_0><h_1><h_2><h_3><chk>

h_0,1,2,3 32 bit MRU HW report status, see "Appendix I - MRU HW report status bits".

10. APPENDIX F - OUTPUT VARIABLE LIST

The output variables available from the MRU are listed below.

Source no.	Variable	Unit	Default Format	Scaling Long	Scaling Short	Scaling Char	Description
0	Off						Disable output signals from this channel
1	VelAngR	[rad/s]	[float]	1e6	1e3	10	Roll angular velocity
2	VelAngP	[rad/s]	[float]	1e6	1e3	10	Pitch angular velocity
3	VelAngY	[rad/s]	[float]	1e6	1e3	10	Yaw angular velocity
11	AccMruGR	[m/ss]	[float]	1e6	1e3	10	Linear acceleration in the MRU R-axis
12	AccMruGP	[m/ss]	[float]	1e6	1e3	10	Linear acceleration in the MRU P-axis
13	AccMruGY	[m/ss]	[float]	1e6	1e3	10	Linear acceleration in the MRU Y-axis
17	AccMonRawF	[m/ss]	[float]	1e6	1e3	10	Unfiltered linear acceleration at the user monitoring point in Forward direction.
18	AccMonRawS	[m/ss]	[float]	1e6	1e3	10	Unfiltered linear acceleration at the user monitoring point in Starboard direction.
19	AccMonRawD	[m/ss]	[float]	1e6	1e3	10	Unfiltered linear acceleration at the user monitoring point in Down direction.
21	MagR	[Tesla]	[float]	1e12	1e9	1e6	Linear magnetic field in the MRU R-axis
22	MagP	[Tesla]	[float]	1e12	1e9	1e6	Linear magnetic field in the MRU P-axis
23	MagY	[Tesla]	[float]	1e12	1e9	1e6	Linear magnetic field in the MRU Y-axis
27	MagN	[Tesla]	[float]	1e12	1e9	1e6	Linear magn. field according to geographic North.
28	MagE	[Tesla]	[float]	1e12	1e9	1e6	Linear magn. field according to geographic East.
29	MagD	[Tesla]	[float]	1e12	1e9	1e6	Linear magn. field according to geographic Down.
31	T.sensor house	[Deg.C]	[float]	1e6	1e2	1	Temperature in sensor house
49	q_bg_sinf*11	[-1 1]	[float]	1e8	1e4	1e2	The quaternion of C_bg
50	q_bg_sinf*12	[-1 1]	[float]	1e8	1e4	1e2	The quaternion of C_bg
51	q_bg_sinf*13	[-1 1]	[float]	1e8	1e4	1e2	The quaternion of C_bg
52	q_bg_cosf	[-1 1]	[float]	1e8	1e4	1e2	The quaternion of C_bg
60	AccAngR	[rad/ss]	[float]	1e6	1e3	10	Estimated roll angular acceleration
61	AccAngP	[rad/ss]	[float]	1e6	1e3	10	Estimated pitch angular acceleration
62	AccAngY	[rad/ss]	[float]	1e6	1e3	10	Estimated yaw angular acceleration
63	Roll	[rad]	[float]	2^{31}/Pi	2^{15}/Pi	2^{7}/Pi	Roll angle
64	Pitch	[rad]	[float]	2^{31}/Pi	2^{15}/Pi	2^{7}/Pi	Pitch angle
65	Yaw	[rad]	[float]	2^{31}/Pi	2^{15}/Pi	2^{7}/Pi	Yaw angle
66	RollHippy	[-1 1]	[float]	1e8	1e4	1e2	Datawell Hippy compatible roll angle
67	PitchHippy	[-1 1]	[float]	1e8	1e4	1e2	Datawell Hippy compatible pitch angle
68	Heading	[rad]	[float]	2^{31}/Pi	2^{15}/Pi	2^{7}/Pi	Heading angle

69	Tilt,cosine	[-1 1]	[float]	1e8	1e4	1e2	Cosine to the tilt angle α. Cos(α)=Cos(φ)*Cos(θ) where φ=roll and θ=pitch
76	AccMonN	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) according to geographic North.
77	AccMonE	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) according to geographic East.
78	AccMonD	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) according to geographic Down.
86	AccMonF	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point in Forward direction.
87	AccMonS	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point in Starboard direction.
88	AccMonD	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point in Down direction.
96	AccMonR	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) in the MRU R-axis direction.
97	AccMonP	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) in the MRU P-axis direction.
98	AccMonY	[m/ss]	[float]	1e6	1e3	10	Linear acceleration at the user monitoring point (MP) in the MRU Y-axis direction.
100	PosMonN	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) according to geographic North.
101	PosMonE	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) according to geographic East.
102	PosMonD	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) according to geographic Down.
103	PosMonF	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in Forward direction.
104	PosMonS	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in Starboard direction.
105	PosMonD	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in Down direction.
106	PosMonR	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in the MRU R-axis direction.
107	PosMonP	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in the MRU P-axis direction.
108	PosMonY	[m]	[float]	1e6	1e3	10	Linear position at the user measurement point (MP) in the MRU Y-axis direction.
109	LA PosMonD	[m]	[float]	1e6	1e3	10	Lever arm compensated heave position. The mean position depends on the vessel tilt.
110	VelMonN	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) according to geographic North.
111	VelMonE	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) according to geographic East.
112	VelMonD	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) according to geographic Down.

113	VelMonF	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in Forward direction.
114	VelMonS	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in Starboard direction.
115	VelMonD	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in Down direction.
116	VelMonR	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in the MRU R-axis direction.
117	VelMonP	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in the MRU P-axis direction.
118	VelMonY	[m/s]	[float]	1e6	1e3	10	Linear velocity at the user measurement point (MP) in the MRU Y-axis direction.
119	LA VelMonD	[m/s]	[float]	1e6	1e3	10	Lever arm compensated heave velocity. The mean velocity depends on the vessel tilt.
129	Heave period	[s]	[float]	1e6	1e3	10	Estimated heave period.
160	ExtSpeed	[m/s]	[float]	1e6	1e3	10	Externally entered speed log signal
162	ExtHead	[rad]	[float]	2^{31}/Pi	2^{15}/Pi	2^{7}/Pi	Externally entered heading signal
168	SampleTime.s	[sec]	i32	1	16 lsb	8 lsb	The point of time when the raw data measurements are sampled internally in the MRU.
169	SampleTime.n	[nano]	i32	1	16lsb	8lsb	Nano seconds part ditto
176	Time ticks	[5.00ms]	i32	1	16 lsb	8 lsb	Time from power on in time increment 4.39ms
177	Idle index		i32	1	16 lsb	8 lsb	Shows RT-kernel idle time
178	Test square	[0,1]	i32	1	16 lsb	8 lsb	Test signal switching between 0 and 1 at 1 Hz
188	Date_time.s	[sec]	i32	1	16 lsb	8 lsb	Seconds since 1970.01.01 00:00.00 UTC
189	Date_time.n	[nano]	i32	1	16 lsb	8 lsb	Nano seconds part ditto

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11. APPENDIX G - MRU STATUS BITS

MRU status bits in a 32 bit status:

stat 32 bit status, made up of the following bit fields:

runtime modus: bit 0..3
- bit 0 Normal mode
- bit 1 Abnormal mode

model status: bit 8..15
- bit 8 Kalman initialise
- bit 9 Sensor overrange
- bit 10 Data unreliable
- bit 11 Sensor clipping

system status: bit 16..31
- bit 16 Break detected
- bit 17 Overload, too many output variables selected
- bit 18 Configuration changed, need to restart to take effect
- bit 19 Magnetic erection off
- bit 20 Gravity erection off
- bit 21 External velocity
- bit 22 External speed
- bit 23 External yaw
- bit 24 External magnetic
- bit 25 External position ref
- bit 26 Emulating
- bit 27 Bad environment
- bit 28 Time sync
- bit 29 Transmit buffer overflow

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12. APPENDIX H - MRU EVENT NUMBERS

MRU event numbers:

1: Start-up OK
2: Start-up Error
3: Last Stop
4: Receive Frame Error
5: Transmit Queue Full
6: Receive Message Error
7: Kernel Error
8: Desc. Version Error
9: Transient Pwr Off/On
10:
11:
12: Bad Temperature
13: Bad Pressure
14: Rate Sensor Overrange
15: Accelerometer Sensor Overrange
16: Magnetic Sensor Overrange
17: Heavy Load
18: Overload Data Output
19: Improper Power Down
20: Spurious NMI
21: Kalman Overrange
22: Bad External Data
23:
24:
25:
26:
27:
28: Arithmetic Overflow
29: Hardware Error
30: Orientation Initialisation Error
31: System Restart

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13. APPENDIX I - MRU HW REPORT STATUS BITS

MRU HW report status bits in a 32 bit status:

bit 0: 332 error
bit 1: Board configuration error
bit 2: SW descriptor error
bit 3: HW descriptor error
bit 4: Board error
bit 5: SW level error

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14. APPENDIX J – USE OF THE MRU SERVICE CABLE

The MRU units can optionally be delivered with the service cable MRU-T-022 for configuration of the unit through the service port in the MRU junction box.

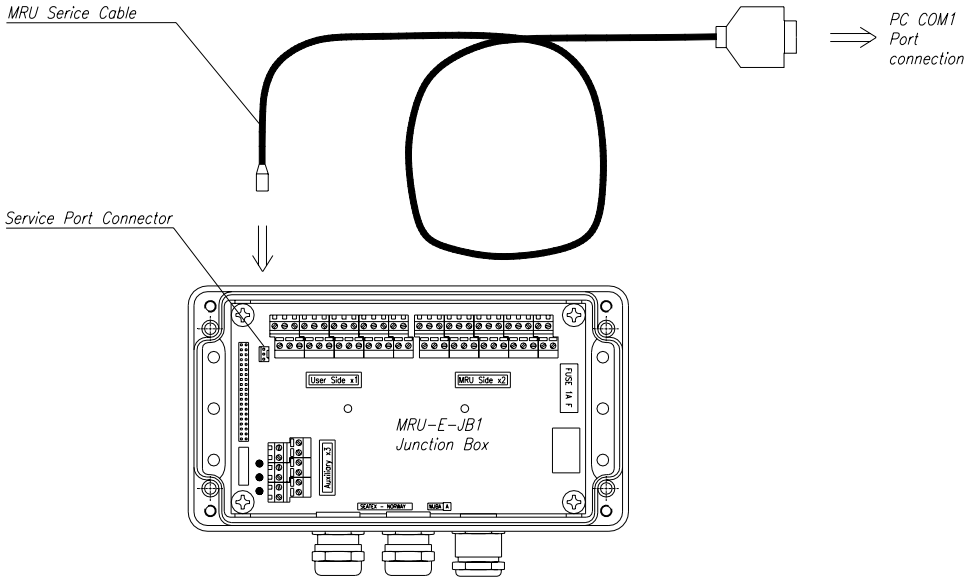

Figure 12 Connection of the service cable to the MRU junction box and the PC

The general procedure to start the MRU from the MRC software by use of the service cable, is as follows:

1. Connect the 9-pin DSUB part of the service cable to the COM1 port on the PC.

2. Connect the other end of the service cable to the service port connector in the MRU junction box as shown in Figure 12.

3. Ensure that the junction box and the MRU is powered with 12 to 30 VDC before starting up the MRC software from the PC. Wait at least 10 seconds after connecting the MRU and the junction box to the power source, before starting the MRC software.

4. The MRC now starts to establish contact with the MRU. After contact is made, the MRC reads the user configuration and some status information from the MRU. The user is now free to use the MRC commands.

Be aware of the following limitations when configuring the MRU by use of the service cable through the service port in the junction box:

- The MRU has to be of hardware version 2, D or E or newer (i.e. MRU-5-2, MRU-H-D or MRU-5-E). MRU units with earlier hardware versions have to be configured by use of the standard configuration cable MRU-T-013.

- The cable MRU-E-CS1 has to be used between the MRU and the junction box. Other cables do not have the required number of pairs to also connect the MRU service port (AUX4).

- The baud rate between the MRU and the PC running the MRC software will always be 9600 even though the MRU **Sysport** baud rate is set to a different value. This is because the MRU utilises another serial line, the MRU AUX4 line, when configuring the MRU by use of the service cable. This serial line is always set to 9600 baud.

- The MRC software has to be of version 3.00 or later, preferably 3.12 or later.

15. APPENDIX K – RS-422 COMMUNICATION WITH THE MRU

With the 3rd generation MRU models coloured blue (serial number above 1149) it is possible to change the standard RS-232 communication to 422 on the system port.

The default mode for the Sysport lines is a RS-232 compatible TX and RX. However, in the new generation MRU models the Sysport lines can be switch to an RS-422 compatible TX+, TX- and R+, RX- by connecting the Shutoff line to LGND or drive it negative. As long as the Shutoff line is left floating, the Sysport levels are then RS-232 compatible (default).

15.1 Procedures for achieving RS-422 communication

The electrical installation of the MRU is done in the following steps:

1. Insert the connector on the MRU-E-CS1 cable into the MRU and insert the other end of the cable into the junction box, if not already done. 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. Insert each of the cable wires into the correct terminal on the MRU side (x2) within the box, if not already done

2. Insert the ship cable and the power cable through one of the free nipples on the junction box. 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.

   Insert each of the cable wires into the correct terminal on the User side (x1) within the box.

3. Insert an isolated wire between pin 24 (LGND) and pin 27 (Shutoff) on the user side (x1) in the junction box. By connecting these two pins together the communication with the MRU will switch from RS-232 to RS-422.

|----------User side x1----------|

pin	signal	description
1	PWRIN+	power +
2	PWRIN-	power gnd
3	TX+	from MRU
4	TX-	-"-
5	RX+	to MRU
6	RX-	-"-

pin	signal	description
24	LGND	gnd ref.aux.+dig
27	SHUTOFF	of MRU

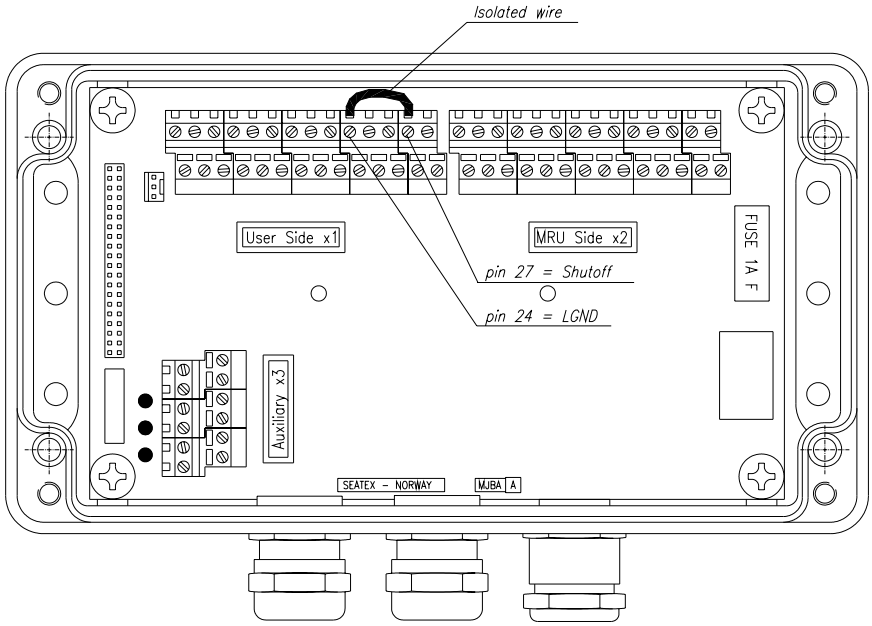

Figure 13 Modifications required in the Junction Box to achieve RS-422 communication on the 3rd generation MRU models

16. APPENDIX L - ADDITIONAL BOARD IN JUNCTION BOX

This appendix describes the installation of the additional board MRU-E-JBRS in the MRU junction box with the following features:

- Galvanically isolated input and output lines for MRU serial numbers less than 1150.
- RS-422 output line from the MRU.
- A converter of RS-422 lines to RS-232 and vice versa.

The wiring schematics for the Auxiliary Contact (x3) in the junction box with the MRU-E-JBRS board inserted, is as follows:

X3 side pin Signal Conn.		**Signal Description**
RLGND	**1**	Chassis (earth) connection for the junction box
RL+	**2**	One of the contacts to the relay
RL-	**3**	The other contact to the relay
AUX232	**4**	RS-232 output signal from RS-422/232 converter
AUX422+	**5**	RS-422+ input signal to RS-422/232 converter
AUX422-	**6**	RS-422- input signal to RS-422/232 converter
TX422+	**7**	RS-422+ output signal from MRU main port (Sysport)
TX422-	**8**	RS-422- output signal from MRU main port (Sysport)
RX422+	**9**	RS-422+ input signal to MRU main port (Sysport)
RX422-/RX	**10**	RS-422- input signal to MRU main port (Sysport) and input signal for isolated RX (RS-232) on main port.
TX	**11**	RS-232 output signal for isolated TX from main port (Sysport)
GND	**12**	Earth connection for all serial lines on the JBRS board

16.1 Installation procedures

The installation of the additional board is performed in the following steps:

1. Turn off the power to the junction box.

2. Unscrew the cover of the junction box and insert the additional board from above into the connector on position P1 in the junction box main board, as shown in Figure 14. Insert the delivered foam strip inside the box cover in such a way that it pushes on to the top wings of the additional board. This to ensure the positioning and vibration damping of the board.

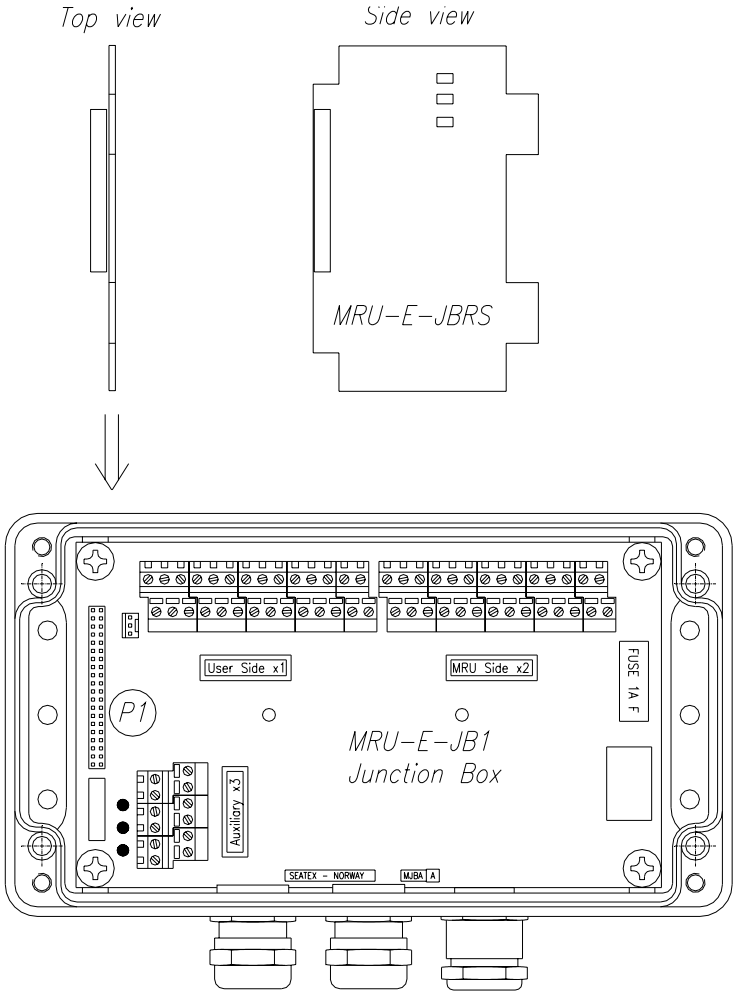

Figure 14 Installation of the additional board in the MRU junction box

3. The following connections are performed in order to achieve:

- **Galvanically isolated RS-232 input and output lines to/from the MRU**. This is achieved by inserting the ship cable wires for the RS-232 communication to pin 10 (RX), pin 11 (TX) and pin 12 (GND) on the Auxiliary Contact (x3) instead of connecting the wires to pin 3 (TX+), pin 4 (TX-), pin 5 (RX+) and pin 6 (RX-) on the User side (x1). Pin 12 (GND) on the Auxiliary Contact (x3) is used for earth connections for the isolated RS-232 lines.

|----------Auxiliary Contact x3----------|

pin	signal
1	
2	
3	
4	
5	
6	

pin	signal
7	
8	
9	
10	RX
11	TX
12	GND

Note It is not possible to use the RX+/RX- and TX+/TX- on the User side (x1) when the additional board is mounted.

- **Galvanically isolated RS-422 input and output lines to/from the MRU**. This is achieved by inserting the ship cable wires for the RS-422 communication to pin 9 (RX422+), pin 10 (RX422-), pin 7 (TX422+) and pin 8 (TX422-) on the Auxiliary Contact (x3). Pin 12 (GND) on the Auxiliary Contact (x3) is used for earth connections for the isolated RS-232 lines.

|----------Auxiliary Contact x3----------|

pin	signal
1	
2	
3	
4	
5	
6	

pin	signal
7	TX422+
8	TX422-
9	RX422+
10	RX422-
11	
12	GND

Note It is not possible to use the RX+/RX- and TX+/TX- on the User side (x1) when the additional board is mounted.

- **Converting an external RS-422 input signal for the MRU to RS-232**. This possibility is useful when an external input signal from a gyro compass or speed log is only available as an RS-422 signal and needs to be converted to RS-232 before it is sent to the MRU. With the additional board installed this is achieved by inserting the signal cable wires from the external sensor to pin 5 (AUX422+) and pin 6 (AUX422-) on the Auxiliary Contact (x3). Then connect the output RS-232 signal from this additional board pin 4 (AUX232) to pin 15 (AUX1RX+) or pin 17 (AUX2RX+) on the User side (x1) by an additional wire. In the same way, connect the RS-232 ground signal pin 12 (GND) to either pin 16 (AUX1RX-) or pin 18 (AUX2RX-) on the User side (x1) by an additional wire.

|----------Auxiliary Contact x3----------|

pin	signal
1	
2	
3	
4	AUX232
5	AUX422+
6	AUX422-

pin	signal
7	
8	
9	
10	
11	
12	GND

4. When the connections are completed, turn on the power and check that everything works as expected. Finally, screw the junction box cover on again.

17. APPENDIX M - PINOUT FOR MRU CONNECTOR

Souriau 26 pin Signal Conn.		Signal Description
SHIELD	**A**	Cable screen, connected to the MRU housing
PWR+	**R**	Power supply (+24 V)
PWR-	**B**	Power supply (0 V)
TX+	**C**	Sysport serial from MRU, RS-232 or RS-422 level
TX-	**T**	Return
RX+	**S**	Sysport serial to MRU, RS-232 or RS-422 level
RX-	**P**	Return
AN0+	**G**	Analog channel 0, out ± 10 Volt
AN0-	**X**	Return
AN1+	**H**	Analog channel 1
AN1-	**X**	Return
AN2+	**J**	Analog channel 2
AN2-	**X**	Return
AN3+	**K**	Analog channel 3
AN3-	**X**	Return
AUX1RX+	**E**	Aux serial to MRU, RS-232 level, isolated
AUX1RX-	**Y**	Return
AUX2RX+	**V**	Aux serial to MRU, RS-232 level, isolated
AUX2RX-	**L**	Return
AUX3RX+	**Z**	Aux digital to MRU, RS-232 or TTL level, isolated
AUX3RX-	**W**	Return
AUX4TX	**M**	Unused
AUX4RX	**c**	Unused
XIN	**U**	To MRU, 5 V CMOS level
LGND	**a**	Ground XIN,XOUT,EXT0,AUX4RX,TX,RX,Shutoff
XOUT	**b**	From MRU, 5 V CMOS level
EXT0	**F**	From MRU, 5 V CMOS level
SHUTOFF	**D**	Shutoff MRU or RS-232/422 selection
L5V	**N**	5 Volt out, max. 20 mA

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18. APPENDIX N - MRU CONFIGURATION

The MRU configuration software **MRC** is used to set configuration parameters in the MRU. It runs under Microsoft Windows 98, Me, 2000, NT 4.0 and XP. The MRC communicates with the MRU through a serial line.

The MRC requires that the MRU operates on software version 3.12 or newer. If the version is 3.00 or newer, the user is asked to upgrade to a newer version. Then a newer MRU version must be available. If the MRU operates on software version 2.53 or earlier, a version 3 software has to be downloaded to the MRU. This has to be done by use of the DOS version of the MRC prior to connecting this Windows version of the MRC to the MRU unit.

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

- Configures the MRU for specific applications.
- Checks the internal status of the MRU (error log file).
- Loads new software versions to the MRU.
- Plots data to the screen and logs data on file.

18.1 Software installation

Follow the procedure below to install the MRC software on the local PC (standard Windows procedure):

1. Insert the MRU memory stick in the USB port on the local PC.

2. Start up the Explorer program if not already done. Then enter the FlashDisk drive into which the MRU memory stick is connected. In the WinMRC403 folder open the file "MRCSetup.exe". Then follow the instructions on the screen in order to complete the installation of the MRC program.

3. In the **Select Components** window shown in Figure 15, select Standard mode. The other selection, Hydrographic mode, is for those who want to select the digital interface from the predefined list of echo sounders.

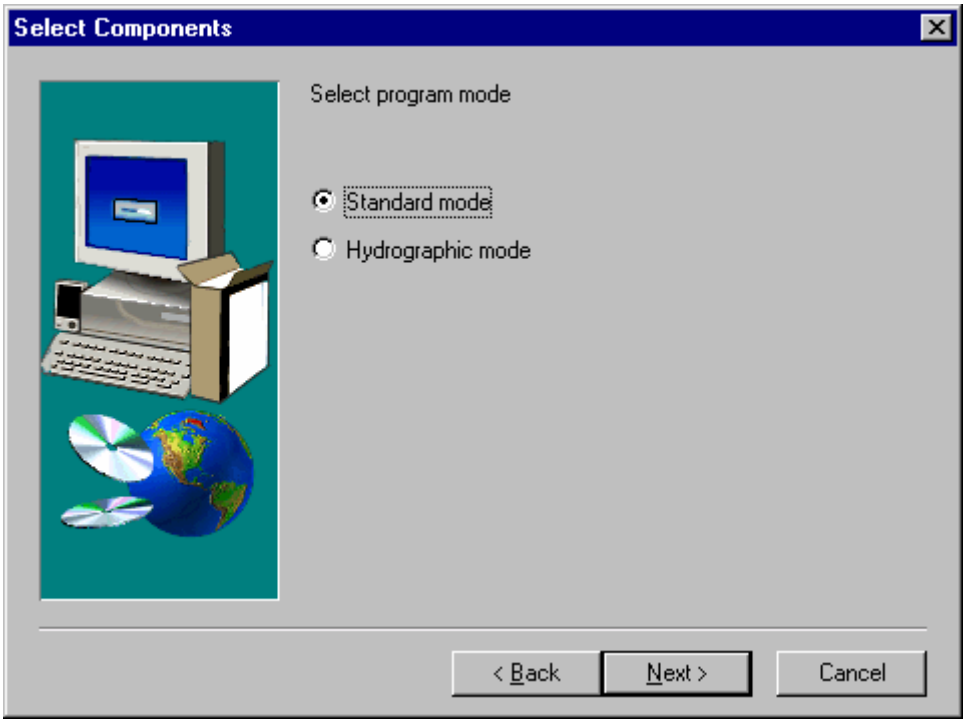

Figure 15 Selection of program mode to install

4. When the installation of files is finished, the window shown in Figure 16 appears. Choose to restart the computer now or later. Click **Finish** and the setup is complete. Terminate the Explorer program and remove the MRU USB memory stick for the local PC.

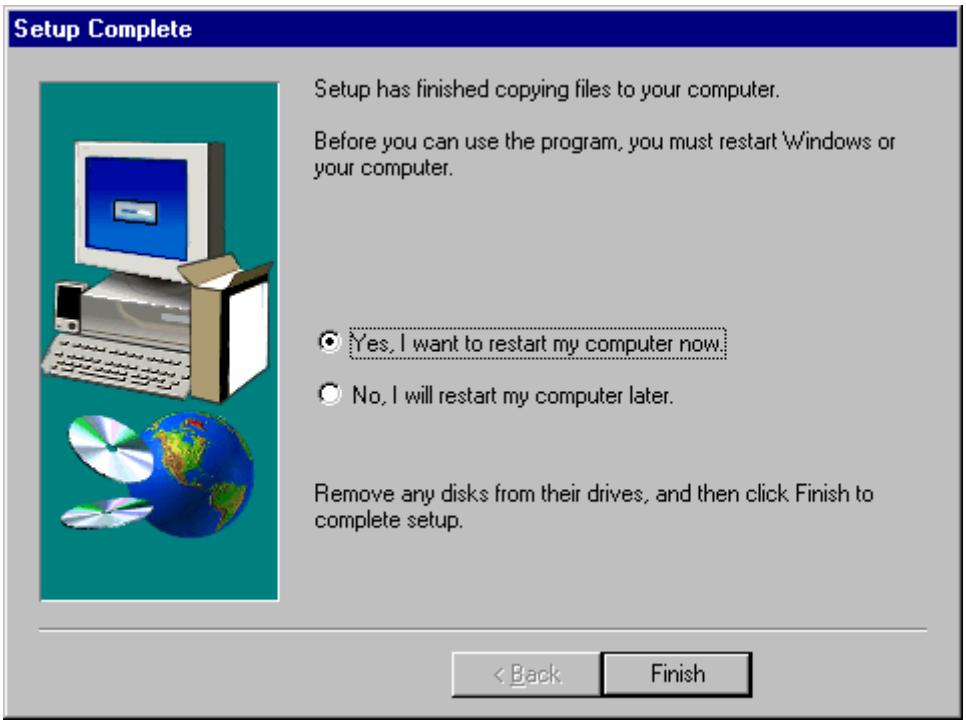

Figure 16 Installation Complete

In order to start the **MRC** application in an easy way, place a shortcut button in the tool line on the screen. Start **Windows NT Explorer** by use of the **Start** menu and **Programs**. Click the folder where the software is installed, like **D:\Program Files**. Place the mouse pointer on the icon to the file **MRC.exe** and move the icon to the tool line. The shortcut button is now in position. To start the application, just click the MRC icon.

18.2 How to get started

18.2.1 Starting the program

Power up the PC if not already running. Connect a cable from a free serial port on the PC (com1: or com2:) to the connector on the MRU. Normally, the test cable MRU-T-013 is delivered with MRU for this purpose.

The general procedure to start the MRU from the MRC software is as follows:

a) Connect the MRU to the PC by the MRU-T-013 cable and to a power supply of 12 to 30 VDC. If a fuse is not installed on one of the power leads to the MRU, then include a 1.0 A (fast) fuse on one of them. It is preferable to use the com1 port, which is the default port for the software.

Note The red banana connector is positive.

b) Approximately 10 seconds after connecting the MRU to the power supply the user can start the MRC software from Microsoft Windows by double clicking on the **MRC** icon.

c) To continue, click one of the buttons:

1. **Connect** - System tries to establish communication with MRU. If connection fails, Figure 18 is shown. Go to chapter 18.2.1.1 for information.
2. **Offline -** System opens for preparation of the configuration parameters in the local PC, see Figure 23.
3. **Exit -** Application is closed.

d) The user is now free to use the MRC commands.

Figure 17 MRU Configuration Window

18.2.1.1 Connection failed

When the **Connection Status** field shows failed connection, check the following:

- COM port connection and that the baud rate is selected correctly.
- Power supply and voltage supplied to the MRU.
- Cabling between the MRU and the PC.
- The 10-second wait: wait at least 10 seconds after supplying the MRU with voltage before starting the MRC from Windows. The MRU does not respond to requests on the serial line due to internal self-check during the first 10 seconds.

Click the **Retry connection** button to re-establish connection with the MRU.

Alternatively, **Go Offline** and prepare parameter settings in the local PC, see Figure 23, or **Exit** to close the application.

Cancel to close window without storing changes.

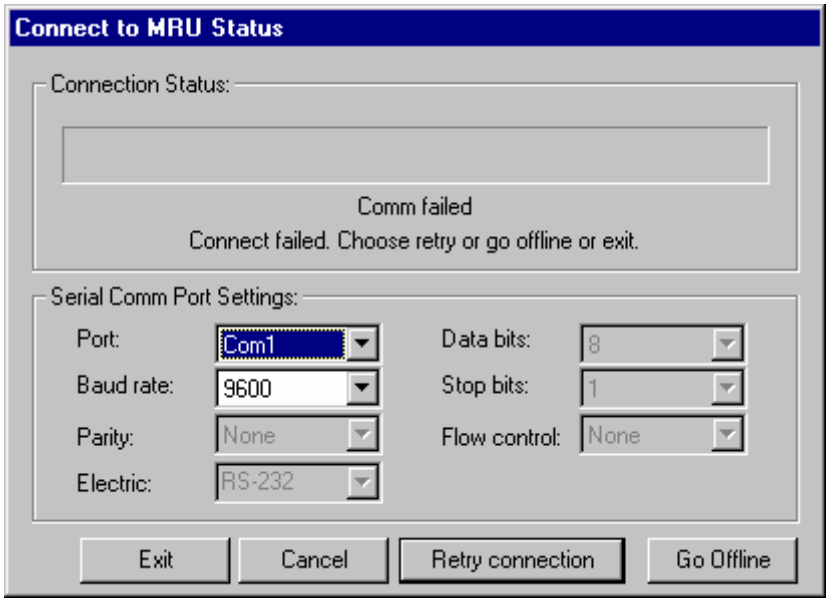

Figure 18 Connect to MRU Status

If the MRU operates on too old software (version 2.53 or earlier), the message "No valid answer from MRU (18)" will appear in the connection status field as shown in Figure 19.

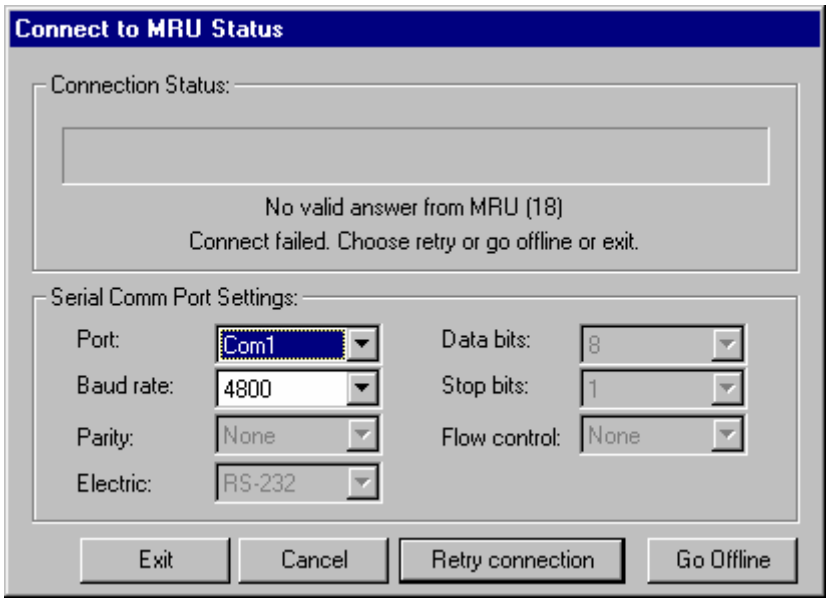

Figure 19 Connecting an MRU with old software version

The MRC requires that the MRU operates on software version 3.12 or newer. If the MRU operates on software version 2.53 or earlier, version 3 software has to be downloaded to the MRU. This has to be done by use of the DOS version of the MRC prior to connecting this Windows version of the MRC to the MRU unit.

If the MRC is used from a laptop PC operating on batteries, the power saving on the PC may have disconnected the com port in order to save batteries. Check the PC setup.

18.2.1.2 Download new software

The MRC software only supports MRU units that operate on software version 3.12 or later. To continue new software has to be downloaded to the MRU.

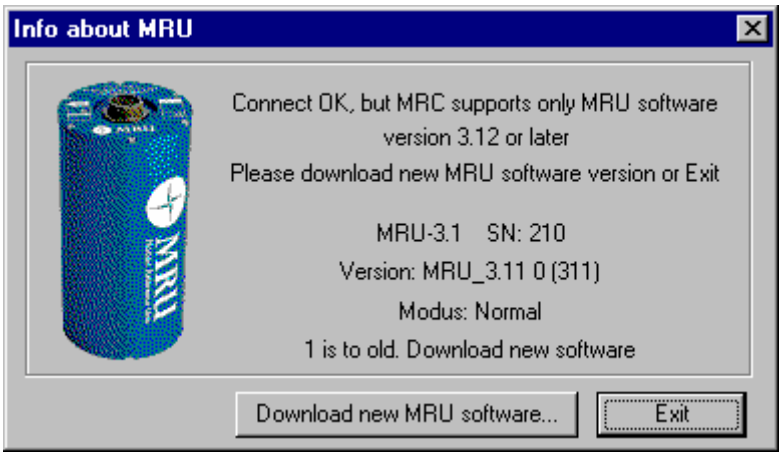

Figure 20 Download of new software

Click the **Download new MRU software** button if version 3.12 or later has been delivered by Seatex, but not been downloaded. Then select the location of the new software as shown in Figure 21. Otherwise, click **Exit** and contact Seatex to receive the latest version.

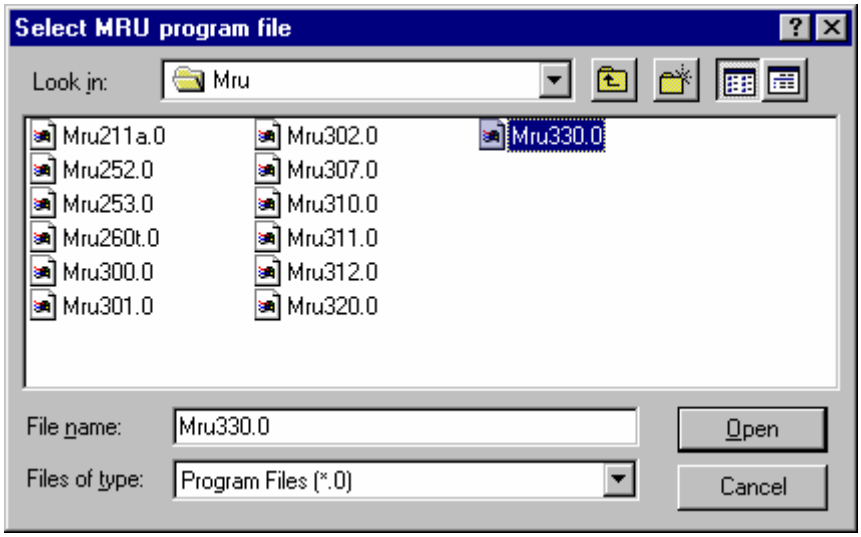

Figure 21 Location of MRU program files

18.2.1.3 Connection established

The window shown in Figure 22 appears when connection is established. This window contains information about the MRU and communication parameters. Activate the **Continue** button to proceed, and the MRU parameters are uploaded.

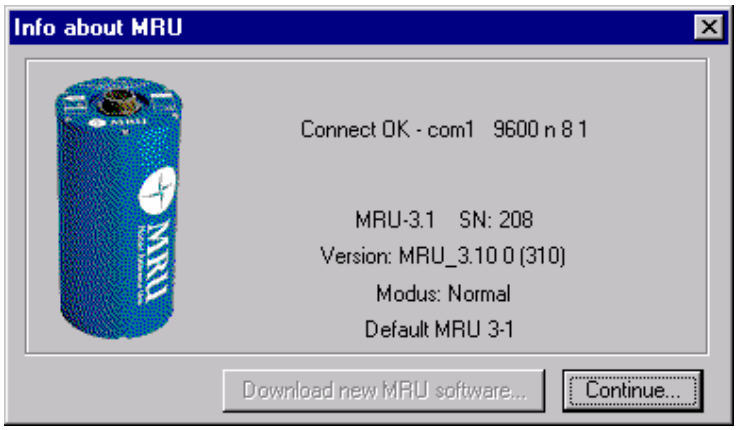

Figure 22 Information about MRU

The main window MRC – Configuration window is shown, see Figure 23, when uploading of MRU parameters are finished.

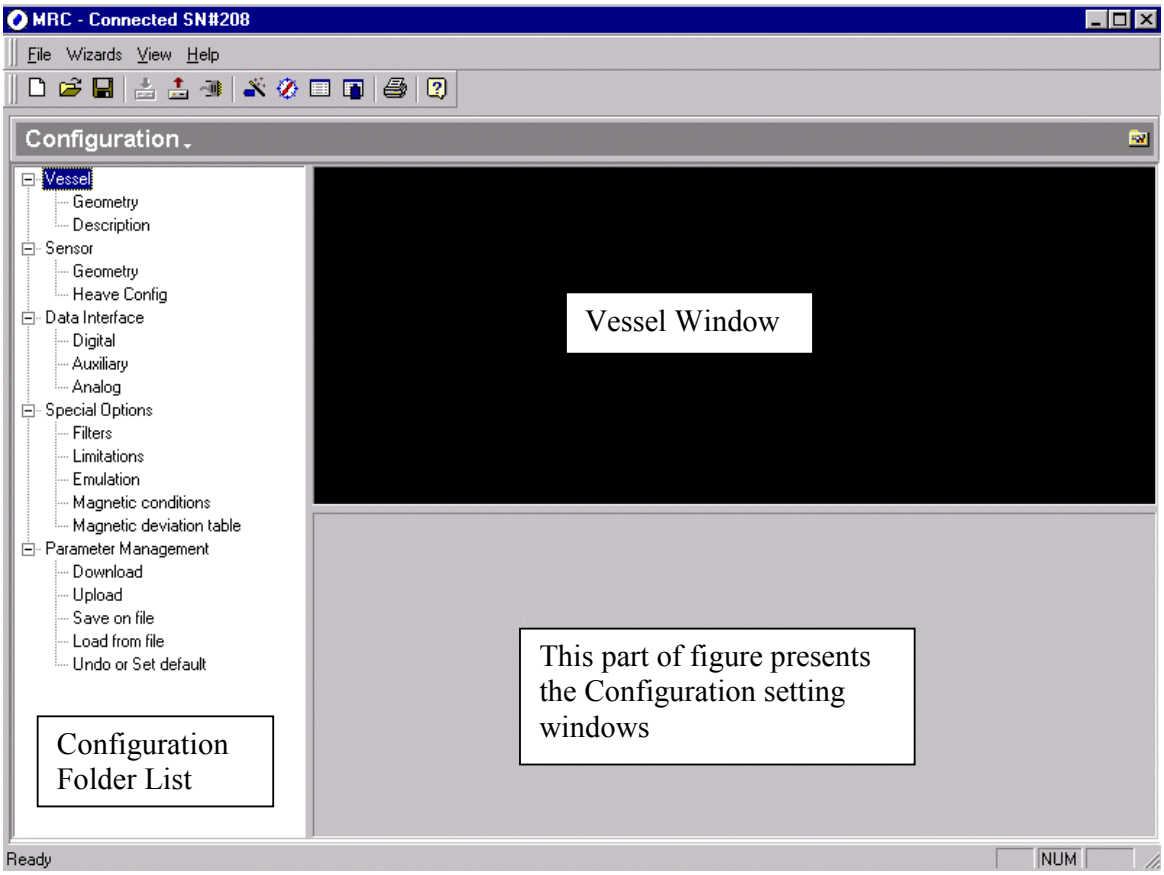

Figure 23 MRU configuration Window

18.2.2 Setting the serial port parameters

Click the **MRC-MRU Port Configuration** tool button, or pull down the **File** menu and select the **MRC to MRU Communication / Port Configuration** option. The dialogue box for communication setup appears (Figure 24), select port and baud rate. The baud rate must correspond to the baud rate setting in the MRU, unless the communication goes through modems or other equipment which changes the baud rate. Default baud rate is 9600. Normally, only the port selection has to be changed.

Click the **OK** button. The settings are saved and will remain unchanged until reconfigured. Click **Cancel** button to return to the main window without saving any changed settings.

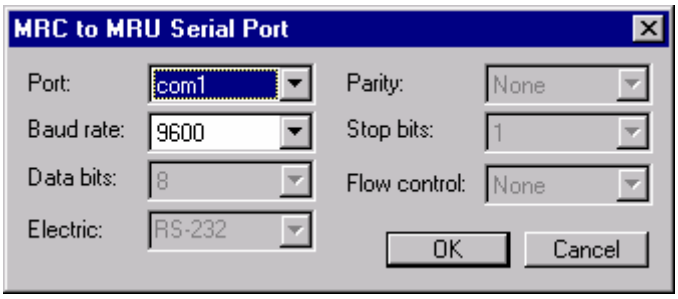

Figure 24 Communication Setup

18.2.3 Establishing connection

Click the **Connect to MRU** tool button, or pull down the **File** menu and select the **MRC to MRU Communication / Connect**. The **Connect to MRU Status** window becomes active, see Figure 18.

If the connection is not in order, an "error message" will appear after a few seconds. The two buttons **Retry connection** and **Go Offline** are highlighted. Choose **Go Offline** in order to close the connection attempt. Check that the MRU is powered on, that the connection cable is plugged into the correct connectors and that the correct baud rate has been selected. When connection is checked and corrected, try to establish connection again. If it is not possible to establish contact with the MRU, check chapter 18.2.1.1 for troubleshooting.

When connection is established, the system automatically downloads parameters from MRU to PC. A download can also be performed at any time, see chapter 18.4.5.2, "Upload" for information.

18.3 General user interface

18.3.1 File menu

In the **File** menu the following options are available:

- **New Configuration**. (Starts to prepare a completely new set of parameters).
- **Open Configuration.** (See description in chapter 18.4.5.4).
- **Save Configuration.** (See chapter 18.4.5.3).
- **Save AS Configuration.** (See chapter 18.4.5.3).
- **MRC to MRU Communication.**
    - **Connect** (Connects MRC to MRU).
    - **Disconnect** (Disconnects MRC from MRU).
    - **Port Configuration** (See chapter 18.2.2).
    - **Demo** (See chapter 18.3.1.1).
- **Print** (Self-explanatory).
- **Print Preview** (Self-explanatory).
- **Print Setup** (Self-explanatory).
- **Recent File** (Self-explanatory).
- **Exit** (See chapter 18.3.1.2).

18.3.1.1 Demo

Click on the **Demo** option and the system enters parameter examples into the different settings, making it possible to play with the application in offline mode.

18.3.1.2 Exit

To close down the application, pull down the **File** menu and click the **Exit** option. The connection to the MRU is shut down and the MRC program terminates. If parameters have been edited but not sent back to the MRU, the software will ask whether the configuration shall be downloaded to the MRU or saved to file before closing down the software.

18.3.2 Wizards menu

Pull down the **Wizards** menu. Two options are available:

- **MRU configuration**.
- **Magnetic Neutralisation.**

Proceed as follows to start one of these wizards:

- Click on the **MRU configuration** option or click on the tool button **MRU Configuration Wizard,** to activate the **MRU Axis Orientation** window. The configuration setting is described in chapter 18.4.2.1.

- Click on the **Magnetic Neutralization** option or click on the **Magnetic Neutralization Wizard** tool to activate the **Magnetic Neutralization** window. See chapter 18.4.6 on how to use the Magnetic Neutralization Wizard.

18.3.3 View menu

Pull down the **View** menu. Tick off or toggle to view the wanted options:

✓ **Toolbar** (See detailed information in chapter 18.3.5)
✓ **Status Bar** (Bottom line).
✓ **MRC Mode Select Bar**. (See Figure 25 Standard setup icons)
MRU Info Bar (Toggle Function). See chapter 18.3.5.1.

Click on the **MRC Mode Select Bar** and the **Standard Setup** icons below appear.

Figure 25 Standard setup icons

Click the **Configuration** icon to activate the MRU Configuration Folder List. Click the **Vessel 3D-View** icon to expand the "vessel" part of the configuration window to maximum size. Click the **Configuration** icon in order to return to the Configuration Folder List.

Click the **Status** icon to enter the **Status** window, see chapter 18.3.7.2. for details. Click the **Data Presentation** icon to enter the **Data Presentation** window. See chapter 18.3.7.3. for details.

18.3.4 Help menu

Pull down the **Help** menu. Click on the **About MRC** option and the window below appears. The window contains information about the company, software version and the software application.

Figure 26 About MRC

18.3.5 Tool buttons

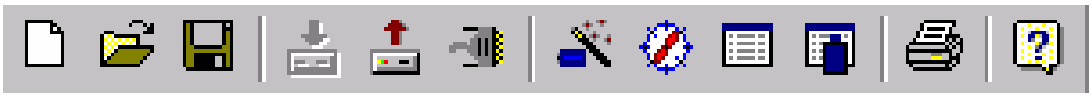

Figure 27 Tool buttons

Description of tool buttons (from left to right):

- New Configuration.
- Open Configuration (Self-explanatory).
- Save Configuration (Self-explanatory).
- Connect to MRU (Establishes data communication between MRC and MRU).
- Disconnect from MRU (Disconnects data communication between MRC and MRU).
- MRC-MRU Port Configuration (See chapter 18.2.2).
- MRU Configuration Wizard (See chapter 18.3.2).
- Magnetic Neutralization Wizard (see chapter 18.4.6, " Magnetic Neutralisation " for details).
- Toggle MRC Info Bar (see chapter 18.3.5.1).
- Toggle MRU Info Bar (see chapter 18.3.5.1).
- Print Configuration (see chapter 18.4.5.6,"Generate Report" for details).
- About (see chapter 18.3.4 for details).

18.3.5.1 Toggle MRC/MRU Info Bar

- Clicking on the toggle **MRU Info Bar** button shows information about the MRU unit. (Left part of Figure 28).
- Clicking on the toggle **MRC Info Bar** button shows information about the PC communication port. (Right part of Figure 28).

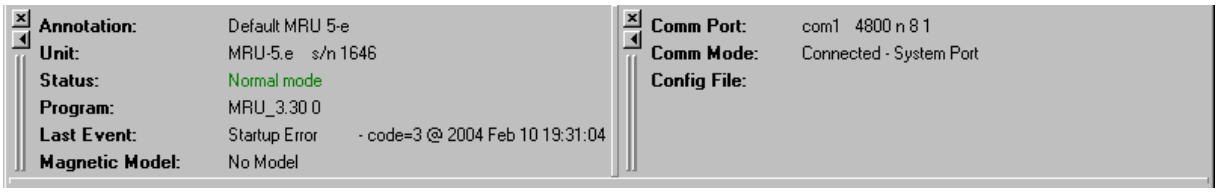

Figure 28 MRU/MRC information bar

MRU Info Bar

- **Annot.** User annotation for the current MRU configuration (e.g., name of ship).

- **Unit.** Lists the current MRU model, type of hardware options and the serial number (s/n). The various hardware options are:
  # *MRU-6 0* stands for an MRU 6 with digital channels only.
  # *MRU-6 1* stands for an MRU 6 with both analog and digital output channels.

MRU-6 2 stands for an MRU 6 with both analog and digital output channels and additional digital input serial lines.
MRU-6 d stands for an MRU 6 with isolated communication.
MRU-6 e stands for an MRU 6 with isolated communication and lower temperature drift errors.
MRU-5 1 E stands for an emulated MRU 5 from an MRU 6 unit and so on.

- **Status.** The MRU operational mode. This mode can be Normal, Abnormal or Unknown. In addition, the following status messages can be made available:
  # *Init* means that the MRU is in the initial mode during start-up.
  # *ModelUnrel* means that the roll, pitch and yaw data are not stable.
  # *HeaveUnrel* means that the heave data are not stable.
  # <*Ext head*>. Indicates that the MRU receives external heading data.
  # <*Ext speed*>. Indicates that the MRU receives external speed data.
  # <*Head avail*>. Indicates that magnetic heading information is available from the MRU.

- **Progr.** The current MRU software version.

- **Last Event.** Lists the last event within the MRU.

- **Magnetic Model.** Indicated whether a magnetic model is generated and available in the MRU or not.

MRC Info Bar

- **Comm Port**. The com port to which the MRU is connected on the PC together with baud rate and parity.

- **Comm Mode.** The communication mode Offline, Sys port or Service port

- **Config File.** The name of the saved configuration file and file location.

18.3.6 Mouse operation

The mouse operations for the 3D-View and the "vessel window" are as follows:

- Point and left click with the mouse pointer in the upper right "vessel window" and the mouse arrow changes into a rotation symbol. The "vessel model" can then be rotated in all directions.
- Press SHIFT and simultaneously point and left click with the mouse pointer in the upper right "vessel window" and the mouse arrow changes into a zoom symbol. The "vessel model" can then be zoomed both in and out.
- Press CTRL and simultaneously point and left click with the mouse pointer in the upper right "vessel window" and the mouse arrow changes into a move symbol. The "vessel model" can then be moved around within the window.

Point and right click with the mouse pointer in the upper right "vessel window" and a drop down menu with the below options appears. The options are self-explanatory. Tick off for wanted features.

Reset Viewpoint
Ghost Vessel
v Wireframe Vessel
Vessel Properties (NA)
Light properties (NA)
Show lights
Show OGL Axis
v Show Vessel Axis
Change FOV mode
Change Background Colour
Camera Properties

Figure 29 Vessel Drop Down Menu

18.3.7 Configuration folder list

The **Configuration** button is located below the other tool buttons. Click the button to see the folder list below.

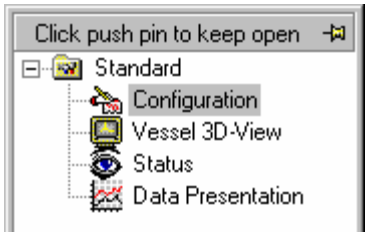

Figure 30 Keep Folder List Open

Click the pushpin in the upper right corner of the folder list to place this folder on the left side of the configuration folder. To remove the folder list and return to the original main window, click the **X** button in the upper right corner.

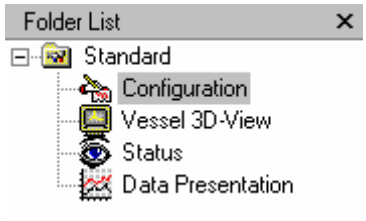

Figure 31 Close Folder List

18.3.7.1 Vessel 3D-view

Click the **Vessel 3D-View** button to show an expanded "vessel window". The "vessel window" will cover the whole screen like the figure below (here shown in Ghost mode. Right click in the window to activate menu for alternative view. Alternative to Ghost mode is Wireframe settings (see chapter 18.3.6 for more details). Click the **Vessel 3D-View** button and **Configuration** to return to the main window.

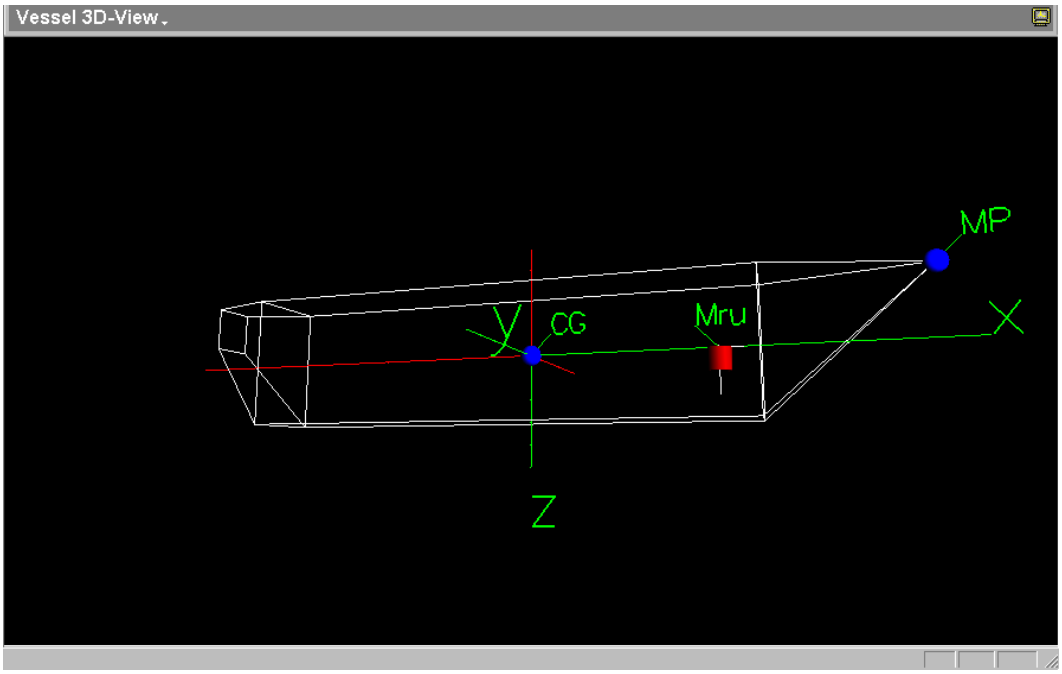

Figure 32 Vessel 3D-View, Ghost mode

18.3.7.2 Status

Click the **Status** button to see the MRU **Status** window.

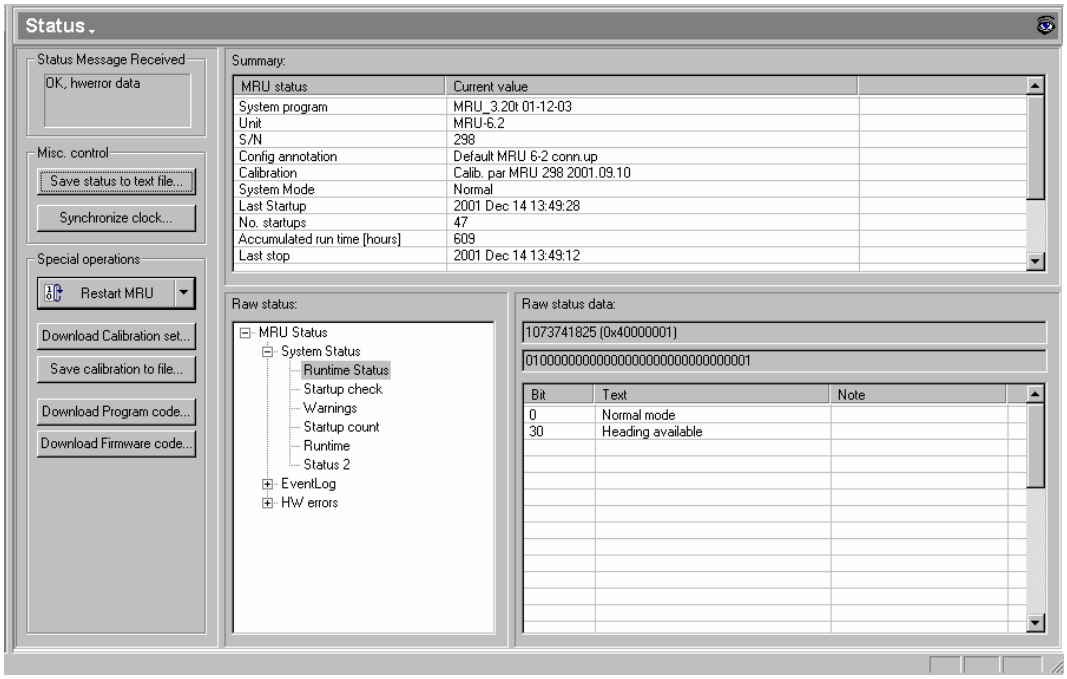

Figure 33 MRU Status window

The status window is divided into the following parts:

Status Message Received:

The status field shows the messages received from the MRU. A new message should be received every second.

Misc. control:

This field includes the following buttons and functionality:

- **Save status to text file**. Click the **Save status to text file** button and the standard **Save** window appears.
- **Synchronise clock**. Click this button to synchronise the clock within the MRU to local or UTC time.

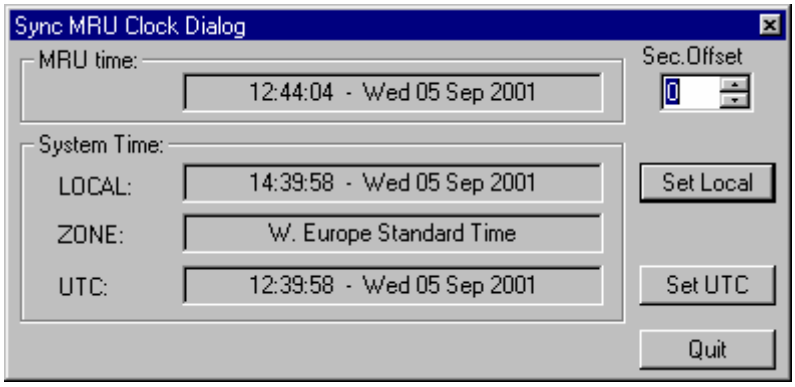

Figure 34 Synchronise the MRU clock

Special operations:

Below is a short description of each button:

- **Restart MRU**. Click the **Restart MRU** button to restart the MRU. Some changes in the user configuration take effect after rebooting, not when initially loaded into the MRU. The alignment time after a restart is approximately 15 minutes.

- **Download Calibration set.** Downloads new calibration data to the MRU. The MRC reads the calibration parameter file in the current directory and downloads the file.

- **Save Calibration to file**. Uploads the calibration within the MRU and saves the calibration to a file.

- **Download Program code**. Downloads a new MRU software version to the MRU. Before downloading new programs, make sure valid copies of the user configuration and MRU calibration are available on file. For more information, see chapter 18.2.1.2.

- **Download Firmware code**. Downloads a new firmware to the MRU.

Summary:

This part shows current value on the MRU status.

- **System Program**. Shows the current MRU software version on which the unit is operating.

- **Unit**. Lists the current MRU model and type of hardware options. The various hardware options are:
  # *MRU-6 0* stands for an MRU 6 with digital channels only.
  # *MRU-6 1* stands for an MRU 6 with both analog and digital output channels.
  # *MRU-6 2* stands for an MRU 6 with both analog and digital output channels and additional digital input serial lines.
  # *MRU-6 d* stands for an MRU 6 with isolated communication.

MRU-6 e stands for an MRU 6 with isolated communication and lower temperature drift errors.
MRU-5 1 E stands for an emulated MRU 5 from an MRU 6 unit and so on.

- **S/N**. Shows the serial number (s/n) of the MRU connected.

- **Config annotation**. Shows the user annotation for the current MRU configuration (e.g. name of ship). The text shown is the same as input under **Vessel Description** described in chapter 18.4.1.2.

- **Calibration**. Shows the serial number of the MRU for which the calibration file is generated and the calibration date.

- **System Mode**. Shows the MRU operational mode. This mode can be "Normal", "Abnormal" or "Unknown". In addition, the following status messages can be made available:
  # *Init* means that the MRU is in the initial mode during start-up.
  # *ModelUnrel* means that the roll, pitch and yaw data are not stable.
  # *HeaveUnrel* means that the heave data are not stable.

- **System Info**.

- **Last Startup**. Shows the date and time for the last start-up of the MRU.

- **No. startups**. Shows the number of start-ups the MRU has had since it was manufactured.

- **Accumulated run time [hours]**. Shows the number of hours the MRU has been in operation since it was manufactured.

- **Last stop**. Shows the date and time for the last time the MRU was powered off.

Raw status:

This part shows the original status and event messages that have generated the system mode and status elsewhere in the MRC software. Details on the following is available:

- System Status
- Event Log
- HW errors

Click the Configuration Folder List to return to the main window.

18.3.7.3 Data presentation

Proceed as follows to present or log data:

- Click the **Data Presentation** button to see the **Data Presentation** window.
- Click the **Run** button to start logging of motion data. Data OK is marked green if incoming data are OK. Click **Stop** button to stop logging of data.
- Click the **Graph Setup** in order to change scale and time span, see Figure 36.
- Click the **Log2File** button to log data on file. The MRC asks for the first sample to be logged on file (if the first sample is set to zero, the logging starts at once), the last sample, the description of the contents on file and the file name. The saved file is 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.

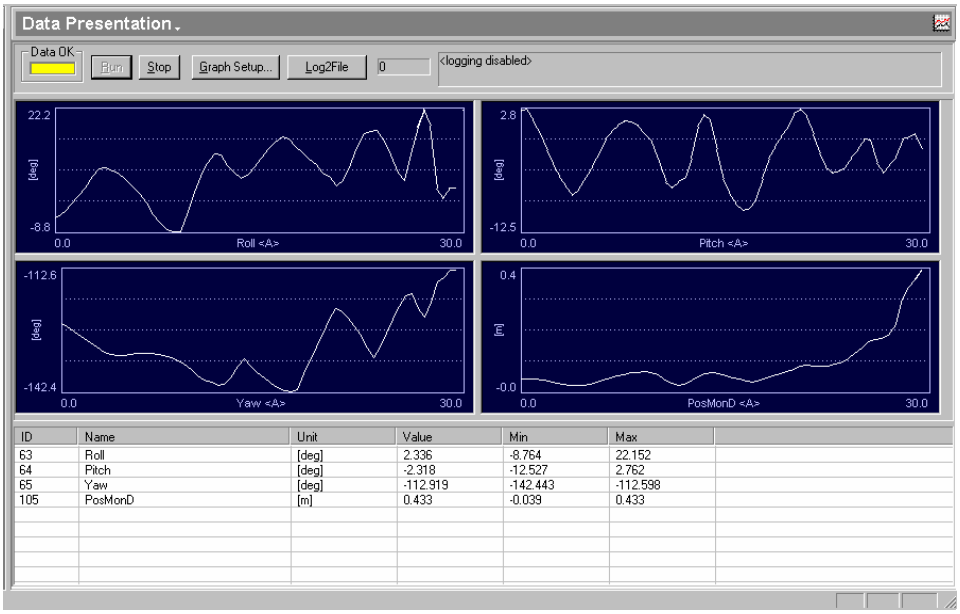

Figure 35 Data Presentation window

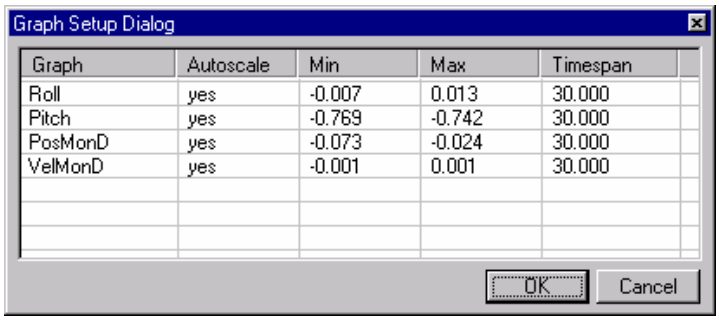

Figure 36 Graph Setup Dialog

Click the Configuration Folder List to return to the main window.

18.4 Editing parameter values

The flexible MRU design allows the unit to be configured for use in various applications. The configuration for a particular application is stored in the MRU after setup. The current configuration can be edited, saved on file and downloaded. It can easily be changed or transferred to another MRU.

When contact with the MRU is established, parameter values are loaded from the MRU into the local memory in the MRC computer where they can be inspected and modified. After editing the parameters are sent back to the MRU. No changes are effective until the parameters are sent and downloaded to the MRU.

The configuration data are kept in a file with the name "mruNNNN.cfu" where NNNN is the serial number of the MRU. This file is specific for each use of the MRU, but is not dependent on a specific MRU. The first part of the name can be chosen freely in the MRC software but the default is "mruNNNN". This file is delivered with each MRU and contains the requested configuration if specified by the customer when ordering. The file is used in the following way:

- The configuration can be read from a connected MRU.
- The configuration information can be read from a file by the MRC software and downloaded to the MRU.

In the main window, Figure 23, the different parameter groups to be edited are shown. Editing of parameter values is done by pointing to the parameter name in the Configuration Folder List and clicking the left mouse button. The Configuration Folder List contains the following parameter groups:

- The **Vessel** group contains settings for Vessel Geometry and Description.
- The **Sensor** group contains parameters to be edited for Geometry and Heave Configuration when installing and calibrating the MRU.
- The **Data Interface** group contains settings for Digital, Auxiliary and Analog interfaces.
- The **Special Options** group contains settings for Filters, Limitations, Emulation and Magnetic conditions.
- The **Parameter Management** group contains user features for loading and saving of configuration data.

Note For this new version of the MRC software, the sensor parameters for the MRU must be set from this software only.

Note Remember that the editing is done locally in MRC and has no immediate effect until the changes are downloaded to the MRU.

18.4.1 Vessel settings

18.4.1.1 Vessel geometry

In this folder the dimensions of the vessel and the location of the centre of gravity are entered. These inputs will influence the displayed location of the MRU and the Measurement Points in the "vessel window" and these values should therefore be as accurate as possible. Proceed as follows:

- In the Configuration Folder List, select **Vessel \ Geometry** and in **Vessel Dimension**:

  - Set vessel length (vessel length in meters from bow to stern).
  - Set vessel width (vessel width in meters from starboard to port).
  - Set vessel height (vessel height in meters from keel to main deck).

- In the **Centre of Gravity (CG) Location** field:

  - Set vessel CG-X position in meters relative to aft.
  - Set vessel CG-Y position in meters relative to centre line.
  - Set vessel CG-Z position in meters relative to keel.

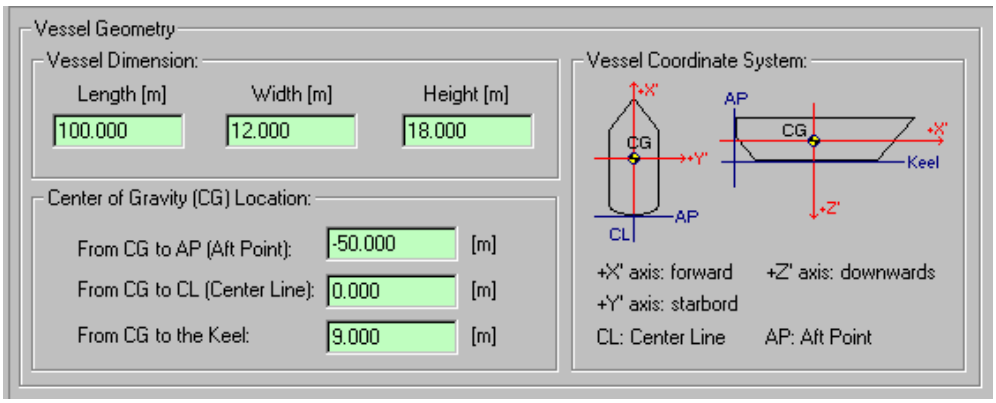

Figure 37 Vessel Geometry Settings

Note Look at the sketch of the vessel co-ordinate system in the menu in order to enter correct signs on the distance to CG.

18.4.1.2 Vessel description

In this folder vessel data for the specific MRU configuration file are entered. This information is helpful to identify the correct configuration file at a later stage. Proceed as follows:

- In the Configuration Folder List, select **Vessel \ Description**.

- Set general vessel data and management information. The **User Annotation** should be a text describing the specific configuration. This text will be displayed through the Status Folder List in the MRC program.

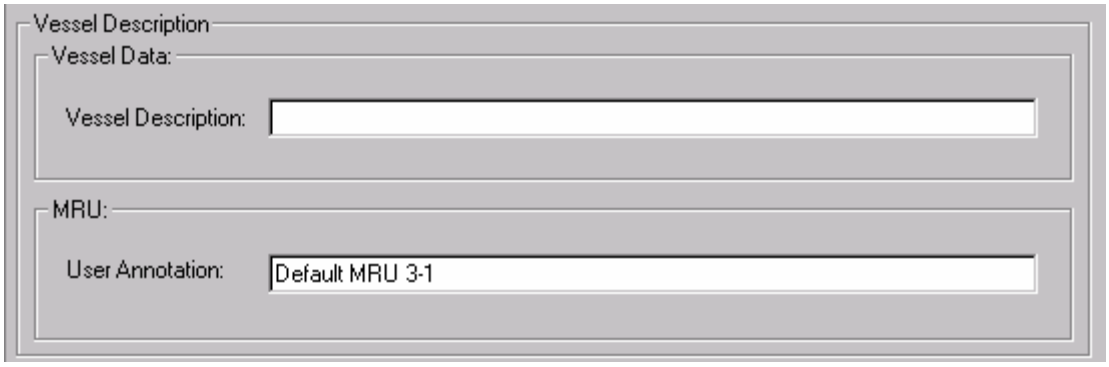

Figure 38 Vessel Description

18.4.2 MRU sensor settings

18.4.2.1 MRU geometry

The lever arm vectors have to be measured or calculated based upon drawings or previously measured points, and entered into the software. Proceed as follows to enter the MRU lever arm:

- In the Configuration Folder List, select **Sensor \ Geometry.**

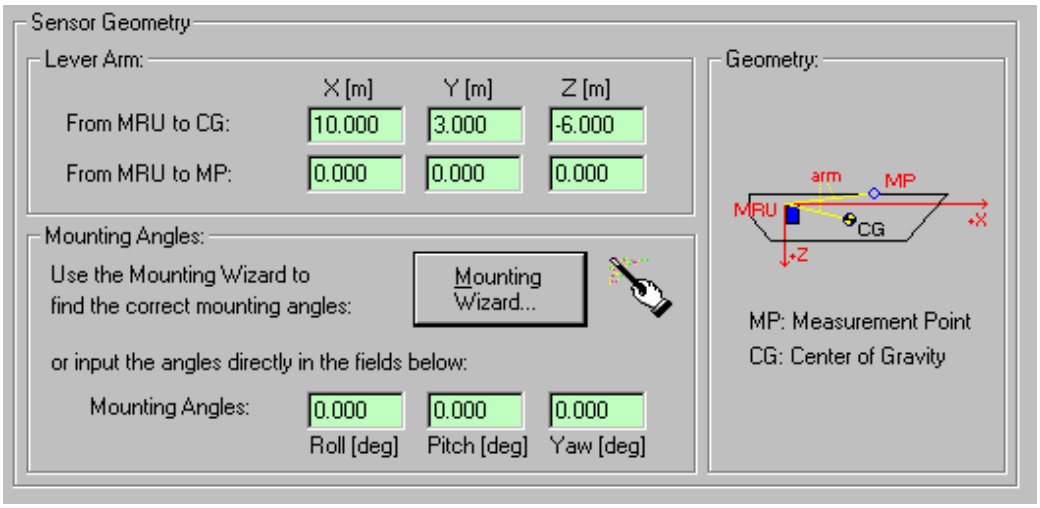

Figure 39 Sensor Geometry

- Enter the settings for Lever Arm. Look at the sketch of the 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 window". If not, check the signs and the co-ordinates input for the MRU, the vessel dimension and the entered location of CG.

The mounting angles can either be input manually or determined by use of the Mounting Wizard. To use the Mounting Wizard proceed as follows:

- Click the **Mounting Wizard** button to get to Step 1 of the MRU axis orientation. Choose to continue with Manual or Automatic setup of mounting angles.

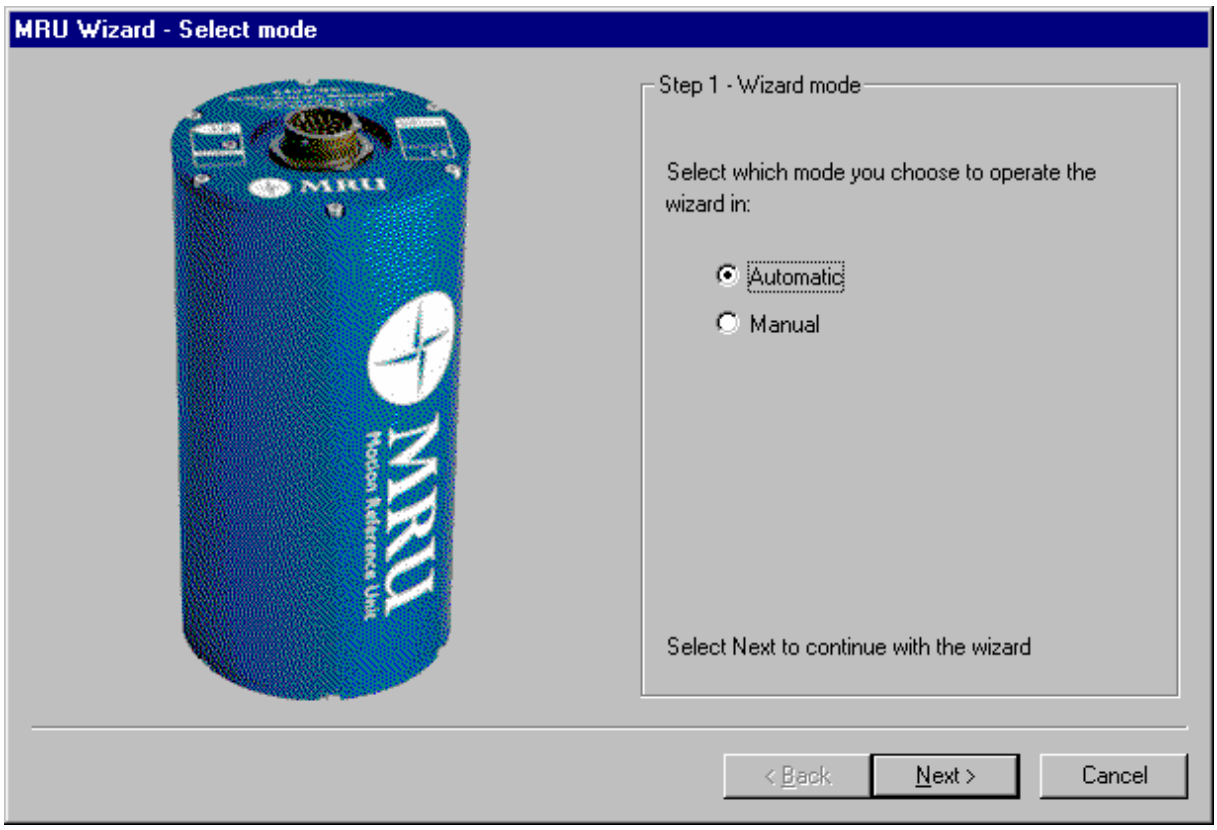

Figure 40 Step 1 of MRU Axis Orientation

Manual setup:

- Manual setup selected in Step 1. Click **Next** to go to the **Step 2 –Manual** window as shown in Figure 41. Click the **Previous** or **Next** buttons in the left part of the window to turn the MRU unit around in 90-degree steps, axis by axis. Click until the correct mounting orientation of the MRU has been found. The right part of the window is automatically updated with the actual main rotation of the MRU.

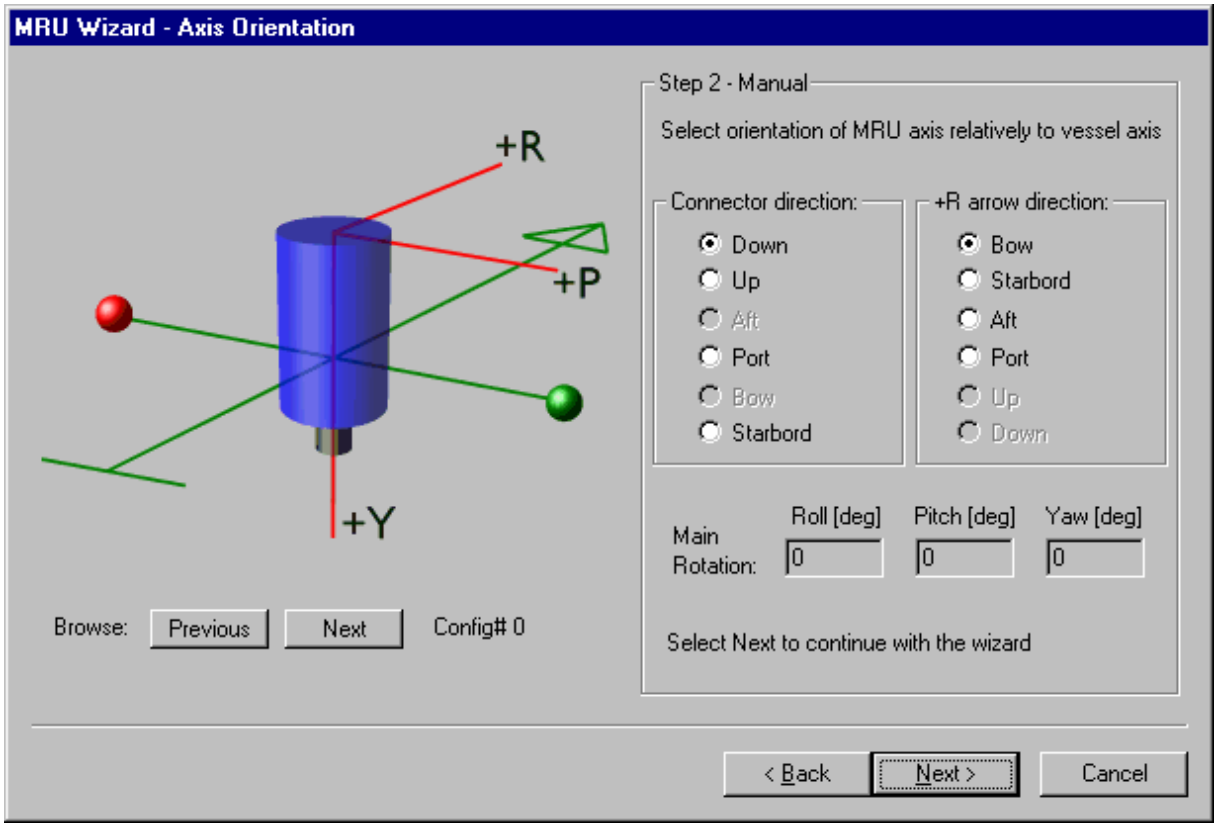

Figure 41 Step 2 of Manual MRU Axis Orientation

- Click the **Next** button in the lower right corner in order to proceed to **Step 3 - Manual**.

- At the top of the **Step 3-Manual** window the found main rotation angles for the MRU are displayed. Enter the offset angles for Roll, Pitch and Yaw from the main rotation angles. A positive offset angle rotation is:

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

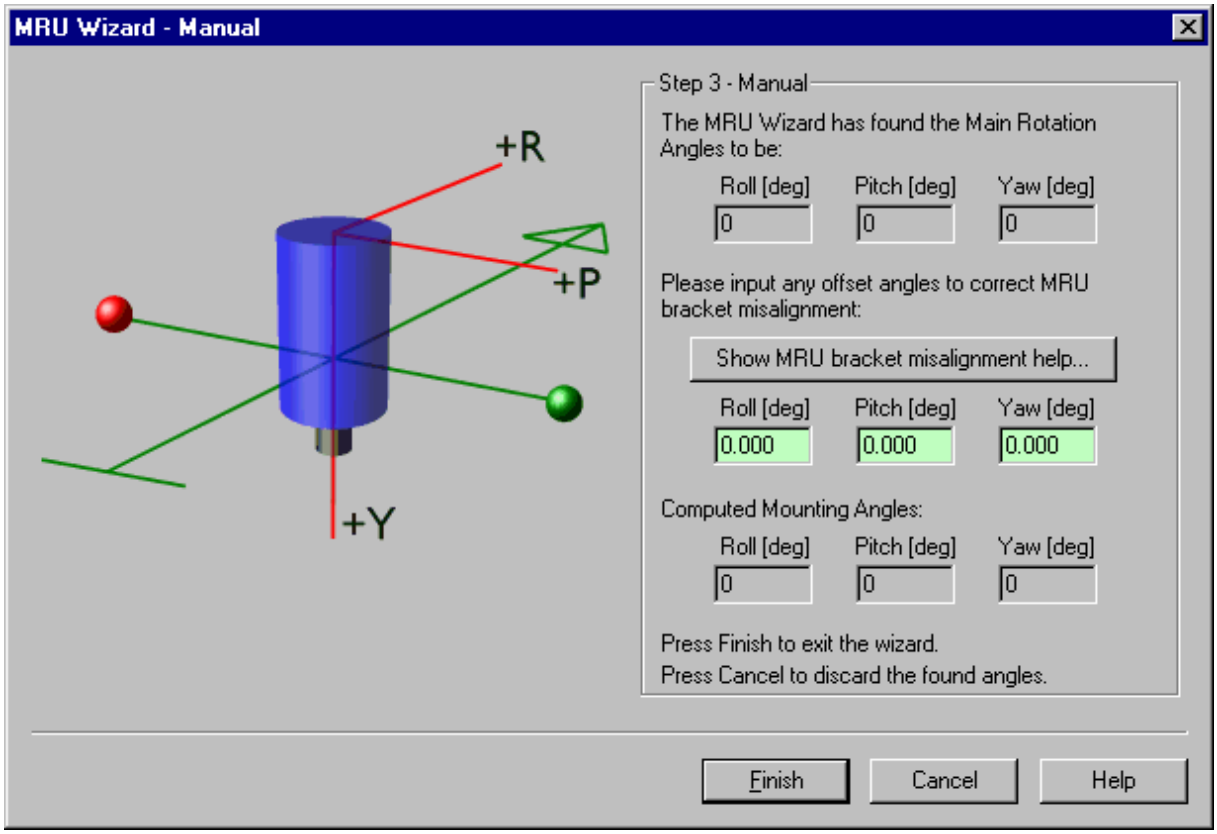

Figure 42 Step 3 of Manual MRU Axis Orientation

- To get more help on the sign of the offset angles, press the **Show MRU bracket misalignment help** button and the window in Figure 43 will appear.

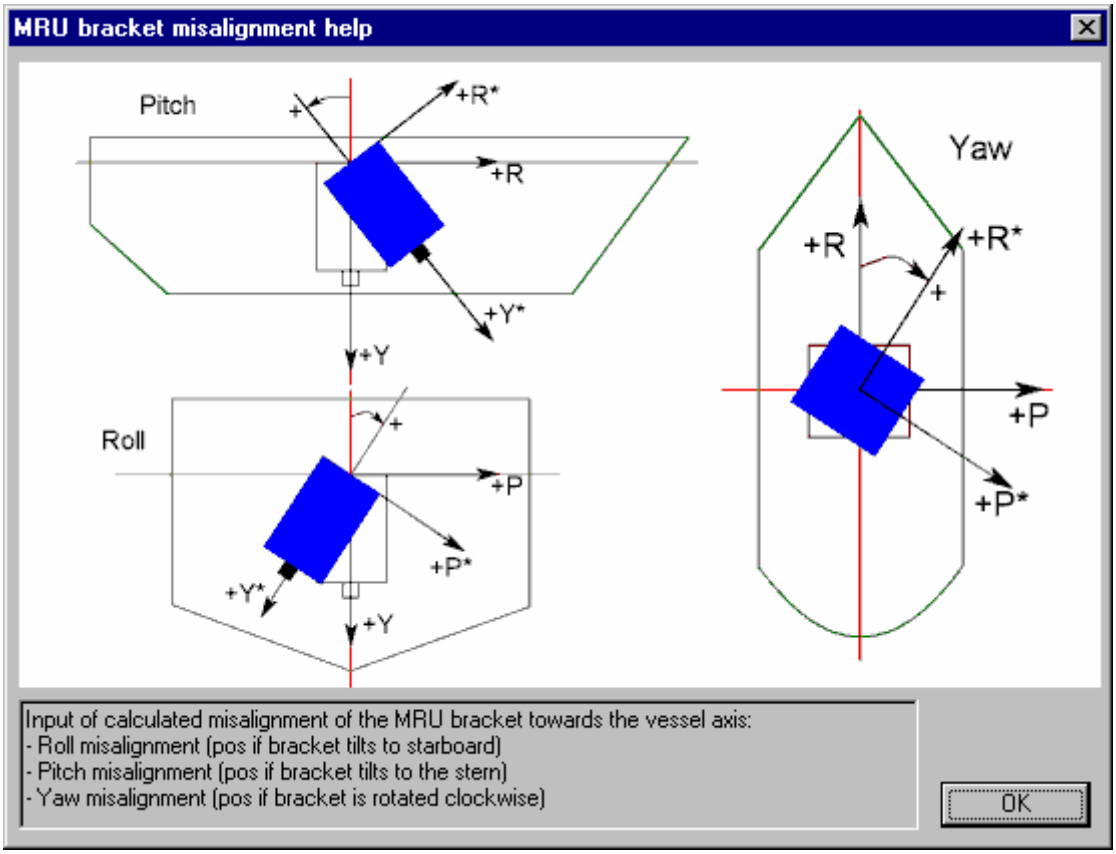

Figure 43 Positive offset angles rotations

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

Automatic setup:

- Automatic setup selected in Step 1. Click **Next** to go to the **Step 2 –Auto** window, as shown in Figure 44.

Note The automatic setup of mounting angles cannot be used if the MRU is mounted with the +R arrow pointing upward or downward. For these orientations manual setup has to be used.

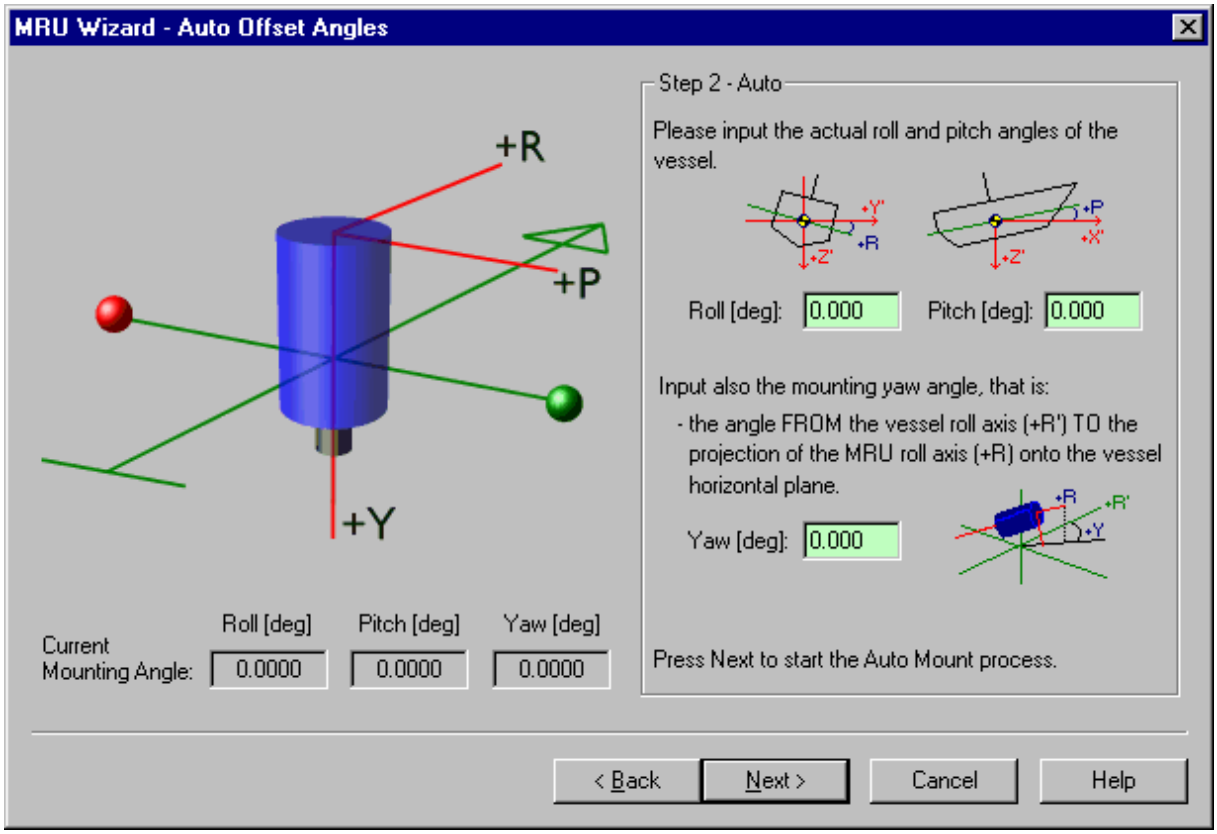

Figure 44 Step 2 of Auto MRU Axis Orientation

- First, input the actual roll and pitch angles of the vessel. A positive vessel angle is from the red to the green co-ordinate system or:

  - Positive pitch angle if the bow is up.
  - Positive roll angle if the starboard (right) side facing downward.

- Second, input the MRU mounting angle in yaw (positive clockwise). The yaw angle is found by projecting the MRU +R arrow to the horizontal plane. The yaw angle is then the angle between the longitudinal axis of the ship and the projected MRU +R arrow in the horizontal plane. It is important that this angle is measured accurately and input correctly to avoid degradation in the performance of the roll and pitch measurements from the MRU.

Note Before starting the Auto Mount process, be sure that the ship motion has stabilised and that the harbour conditions are calm.

- Click **Next** to start the Auto Mount process. The window in Figure 45 will appear and the MRU offset angles are computed. A time-out bar shows the progress. When finished and the found mounting angles look OK, press **Finish**.

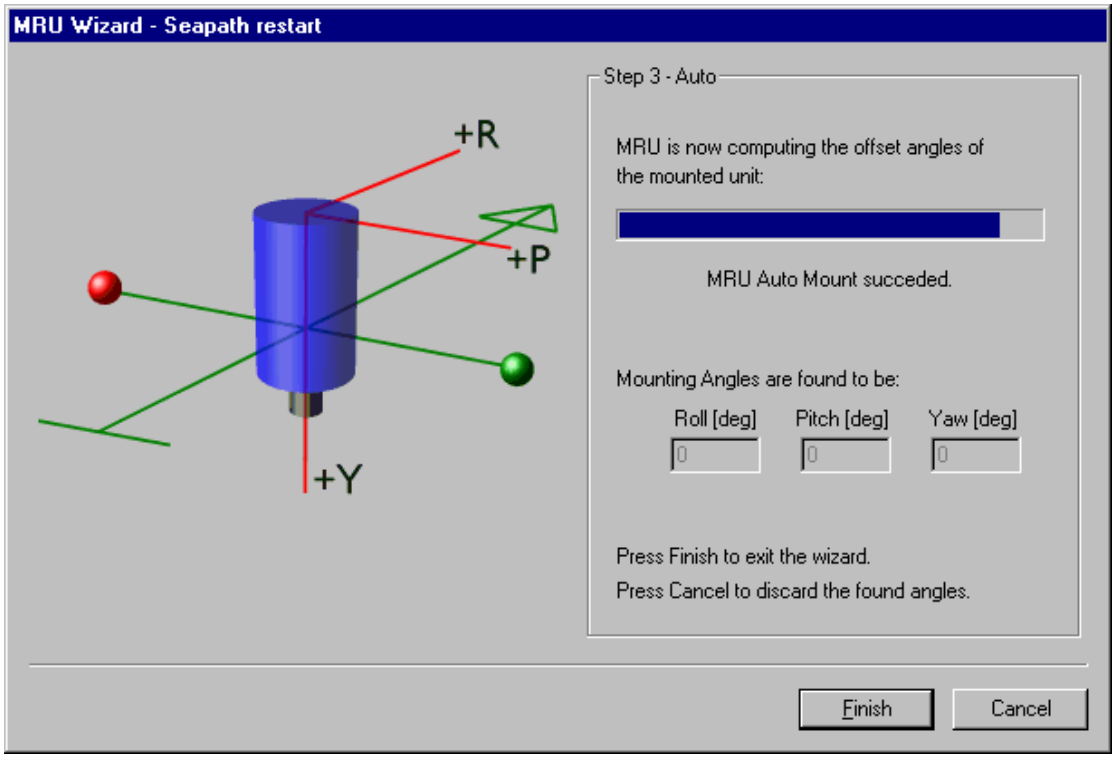

Figure 45 Step 3 of Auto MRU Axis Orientation

18.4.2.2 MRU heave configuration

When using MRU for heave measurements, it is important to tune the heave parameters (heave period and damping) to the vessel size and the motion characteristics for the actual weather conditions. The default settings in the MRC software for filter mode 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 of the MRU and tune the heave parameters until the best heave performance is achieved. An alternative is to select "Automatic" and let the MRU choose the best settings automatically. The following should be considered when selecting the different heave filter modes and parameters:

Filter mode:

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

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 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_o. 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. In operations with heave periods of more than 25 seconds, the damping factor should be reduced to 0.6 in order to achieve correct phase measurements. In operations with heave periods of less than 2 seconds, the damping factor should be increased to 0.8.

For more details on selection of heave filter mode and parameters, see the *User's Manual*. In order to select the heave configuration proceed as follows:

In the Configuration Folder List, select **Sensor \ Heave Config.**

- Enter the settings for Filter Mode and Filter Parameters. The pull-down **Filter Mode** 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 0.2 and 1.

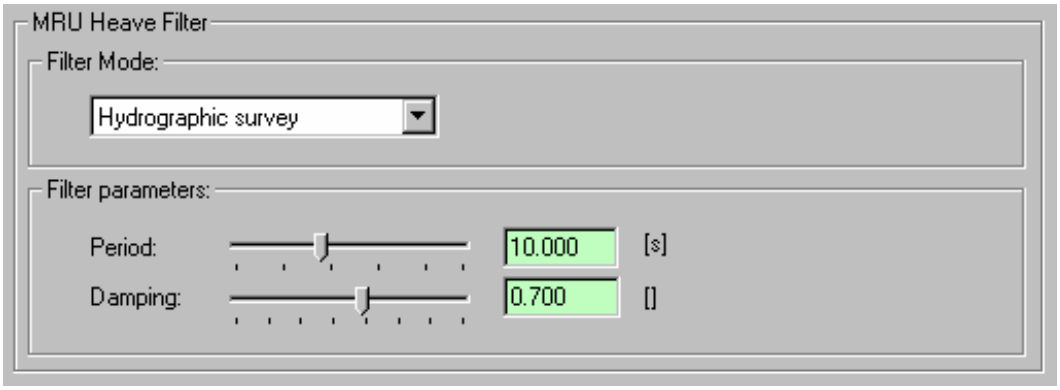

Figure 46 MRU Heave Filter

18.4.3 Data interface

18.4.3.1 Data interface - digital

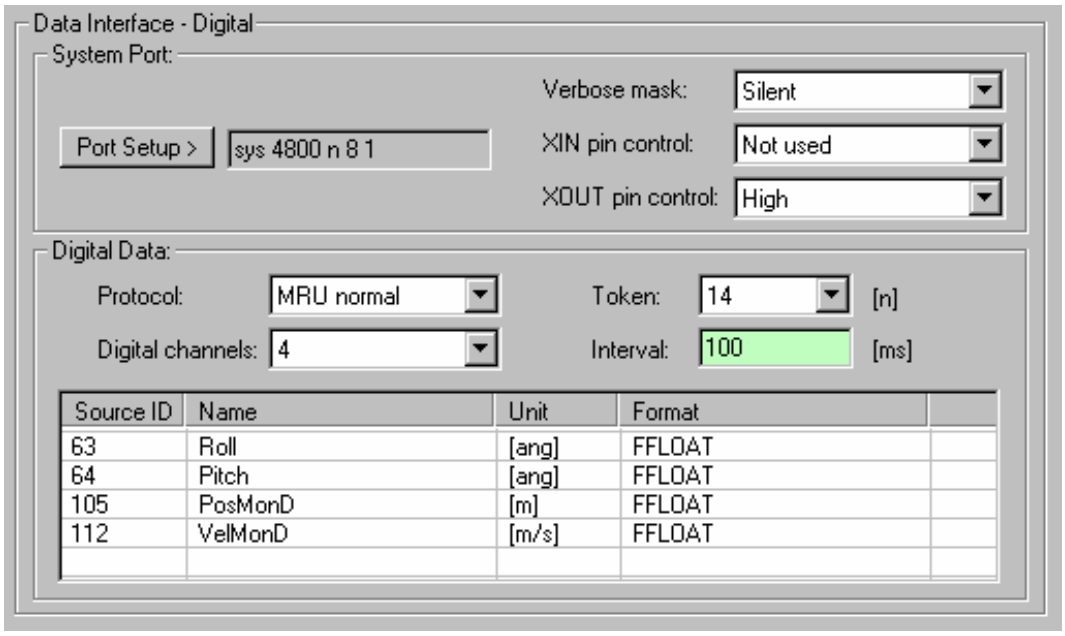

Figure 47 Data Interface - Digital

System Port

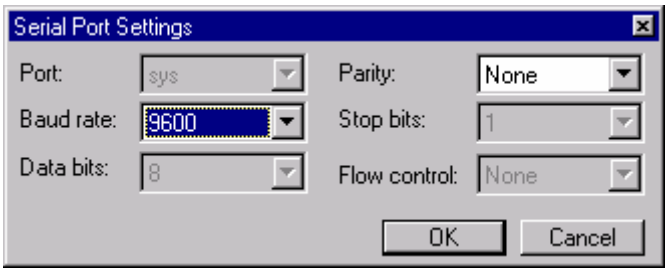

Figure 48 Serial Port Settings

The baud rate for the MRU system port can be set from 1200 to 57600. *Note that the baud rate setting of the MRC software is not contained in the user configuration*. When booted, the software does a self search for the baud rate setting of the MRU. If a fixed baud rate is always to be used, this baud rate can be specified on the command line of the configuration software.

The baud rate required depends on the required number of digital output channels and the sample rate. 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: 4 channels out at a sample rate of 20 Hz (50 ms):

$$(4ch \bullet 40 + 40) \bullet 20Hz = 4000 \text{ Baud (minimum)}$$

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.

Note The baud rate is changed approximately three seconds after downloading the configuration. This parameter may also be modified temporarily by a command sent to the MRU via the digital interface. The parameter will be reset to the configuration value after rebooting.

Verbose mask. This is the mask for status messages transmitted from the MRU. The following selections are available:

- **Silent**: No status messages transmitted.
- **Events**: Events messages transmitted.
- **Status**: Status messages transmitted.
- **Events+Status**: Event and status messages transmitted.

The default parameter is **Silent**. See Appendix B, C and D in the *MRU User's Manual* for a description of the different status messages.

XPIN pin control. This logical CMOS input line to the MRU can be used for several applications. For example, blocking of magnetic erection of orientation to the north, vertical acceleration erection, triggering of transmission of data etc. The following selections are available:

- Not used.
- Start message on neg. edge.
- Internal use.
- Disable magn erection.
- Disable magn & acc erection.
- Speed log pulse input.
- Time sync input, 1 sec

The default parameter is **Not used**. By selecting the **Speed log pulse input**, the MRU CMOS line will accept 200 pulses per nautical mile. See "Appendix C - External speed and heading input" for a detailed description of external input of speed log and heading to the MRU. See "Appendix D - Time Sync Input" for details on external input of time sync.

XOUT pin control. This is a logical CMOS output line with the following selections available:

- Low.
- Internal use.
- High.
- Low on analog data valid.

- High on analog data valid.

The default setting is **High**.

18.4.3.2 Digital data

Many output variables (Source IDs) are available from the MRU. By activating the drop-down menu a list of the available output sources is shown, see Figure 49 below. A complete list of available output variables is described in "Appendix F - Output variable list".

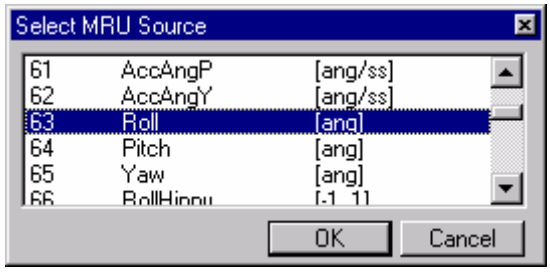

Figure 49 MRU source

The formats for the data output are:

- Char. 8 bit int (F18)
- Short. 16 bit int (F116)
- Long. 32 bit int (F132)
- Float. IEEE 32 bit float (FFLOAT)
- Byte. 8 bit unsigned int (FBYTE)

The default format is float. Please observe scaling when other than float is used.

Protocol. This parameter selects the MRU data output message protocol. The following selections are available:

- MRU normal
- NMEA propr.
- SOUNDER
- Simrad EM1000
- Simrad EM3000
- SUBMETRIX
- ADCP RDID
- Hippy 120
- ATLAS
- TSS1
- ADCP PRDID

The default parameter is **MRU normal**. Protocols other than **MRU normal** may limit the selection of the number of channels, source numbers and time interval. See "Appendix B - Other protocols for commands to MRU" for details on the other protocols.

Digital channels. The number of digital channels is limited to a maximum of 16 when using **MRU normal** and to normally six when using **NMEA propr**. The actual output variable for each digital channel can be selected freely between a number of sources. A description of available sources for each channel is given in the next chapter. The number of channels and the variables are defined in the protocol.

Be aware of the following when selecting the number of digital output channels:

- Too many channels at too low a baud rate may conflict with a short interval time. Ex: (4 bytes + 6 ch * 4 bytes) * 10 bit * 10 Hz = (min) 2800 Baud -> 4800.

- At maximum output data rate (10 ms) the maximum number of digital channels is mostly limited by the available baud rate. Set the **Verbose mask** to transmit status and event messages "Events+Status" from the MRU in order to check if the MRU computer is overloaded with the number of channels selected.

Use the pull down menu to set the number of digital channels (0 to 15).

Token. User selected numbers are associated with the set digital configuration. This is a unique message marking byte with a value in the range 10 to 254. It can be freely chosen. Use the pull down menu to set identification range.

Interval. Time interval for cyclic auto transmit of data. The interval must be selected in 10 milliseconds steps in the range {10...9,000,000}. If another number is entered, the MRU will use the nearest 10 ms number. Be aware of possible data overruns if the interval is too short.

The analog interface is always updated at 100 Hz and independent of the setting of the digital interface.

Note If the interval is set to 0, there will be no periodic output of data, but the information can be output from the MRU by using the **Data request** command.

0 == Auto Transmit OFF. Set interval in milliseconds.

18.4.3.3 Auxiliary

The MRU has a number of serial lines available for input of data. These are:

- The Aux1 port is used for external input of speed or heading information to the MRU, available on a serial line.
- The Aux2 port is used for the same purpose as the Aux1 port. The MRU can accommodate heading information on Aux1 and speed information on Aux2 port, or vice versa.
- The Aux3 port is used to input speed log information as a pulsed signal or time as a one second time pulse.

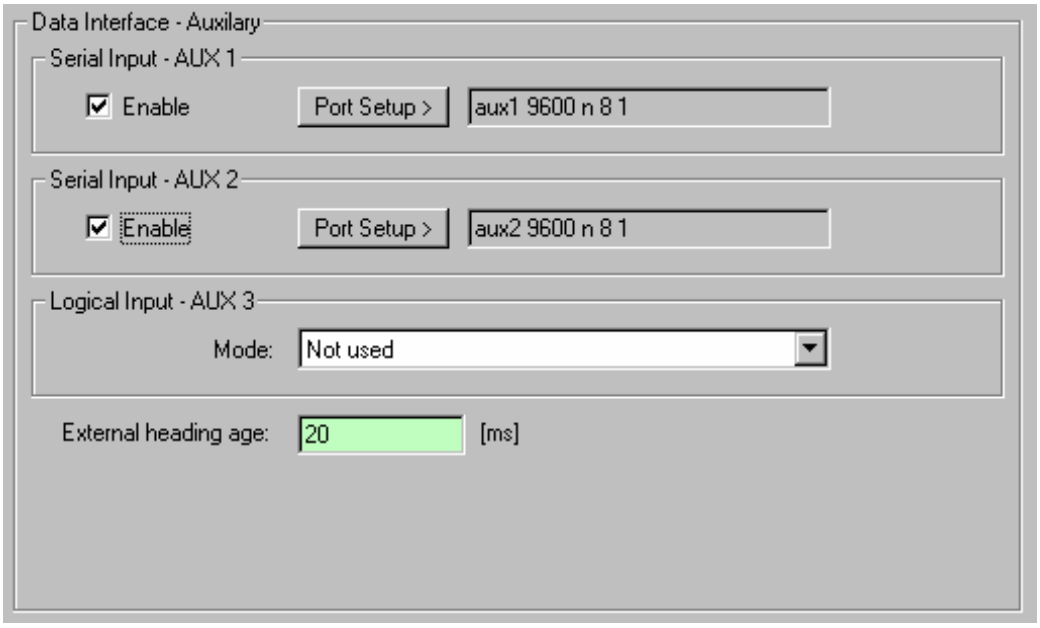

Figure 50 Data Interface - Auxiliary

Serial Input - AUX 1

This parameter is used to select an auxiliary serial data input line to the MRU. The auxiliary input data must be serial speed or heading information that is sent directly into the MRU H, 4, 5 or 6. The input data must be in the NMEA 0183 or the LR40 Lehmkuhl/ScanRepeater digital gyro repeater format. The NMEA messages HDT, HDM and VTG are accepted. The MRU will detect the format of the message received. For a detailed description of the accepted NMEA input formats, see"Appendix B - Other protocols for commands to MRU".

This serial line is enabled or disabled by ticking the **Enable** box. Press the **Port Setup** button to configure AUX 1 serial port.

See "Appendix C - External speed and heading input" for a detailed description of the external input of speed log and heading to the MRU. The default parameters are **4800** and **8 data no parity**.

Serial Input - AUX 2

This serial line is enabled or disabled by ticking the **Enable** box. Press the **Port Setup** button to configure the AUX 2 serial port. This serial line is exactly of the same type as the AUX 1 line.

Logical Input - AUX 3

This parameter is used to select an auxiliary logic input line to the MRU. By selecting the **Speed log pulse input**, the Aux3 line will accept 200 pulses per nautical mile. See"Appendix C - External speed and heading input" for a detailed description of the external input of speed log and heading to the MRU. See "Appendix D - Time Sync Input" for details on external input of time sync.

The **Mode** pull down menu has the following options:

- Not used.
- Time sync input, 1 sec.
- Speed log pulse input.
- Disable Magn erection.
- Disable Magn & ACC erection.

The default parameter is **Not used**.

18.4.3.4 Analog

Four analog output channels are available from the MRU (standard version). 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, offset and limits.

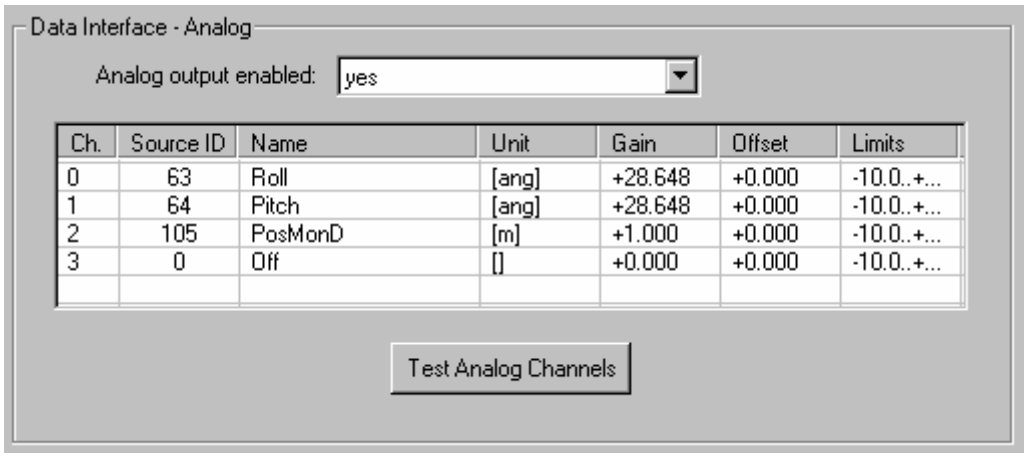

Figure 51 Data Interface - Analog

Figure 52 Source ID

Analog output enabled

The pull down menu **Analog output enabled** has the following options:

- No (no analog output).
- Yes (analog output, signals with full value immediately).
- Yes, 5 min fade-in (analog output, signals with full value after 5 minutes).
- Yes, 10 min fade-in (analog output, signals with full value after 10 minutes).

Gain

Gain is set according to the formula:

[Voltage out in Volts] = Gain • [Selected Variable + Offset]

The gain therefore has scaling volts per physical unit (for instance, volts/metre*). Note that the variables in the MRU are given in standard SI units*. Example: ±10 V shall give ±0.5236 radians (±30 degrees). The gain factor must be; Gain = volts/radians = 10/0.5236 = 19.0986 v/rad.

By clicking in the Gain, Offset or Limits field a help wizard for selecting correct parameters will appear. Fill in the fields in the help wizard shown in Figure 53.

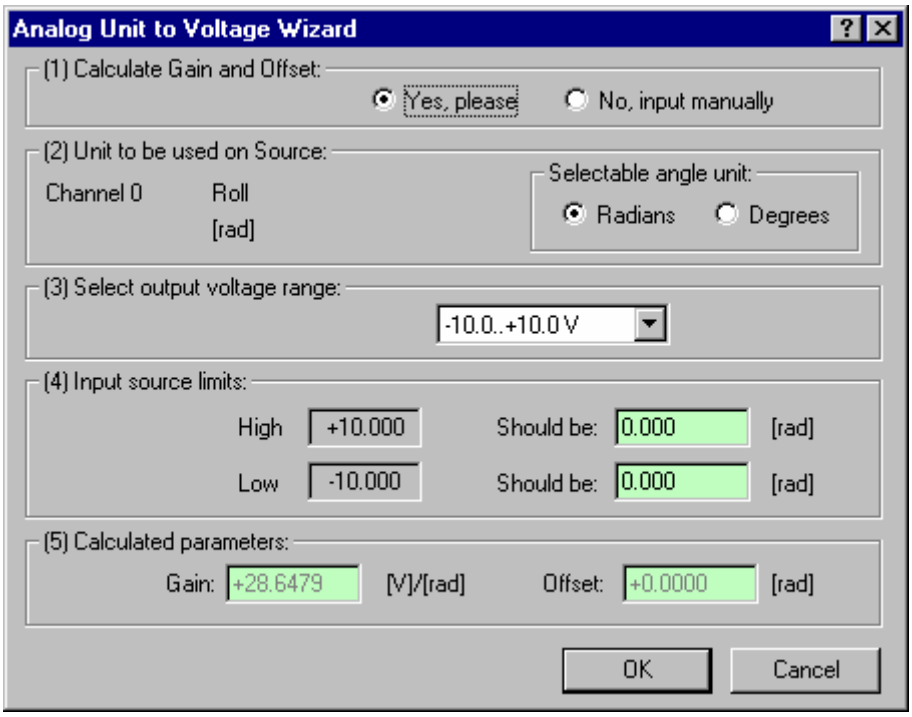

Figure 53 Analog setup wizard

Offset

The output offset is given in units of the physical variable. *Note that this variable should not be used to offset the physical variable, but to adjust for fixed offsets in the user's analog data acquisition system*. Example: -4 to +4 metre heave should be output in the range 0 to 10 V. Offset must then be set to +4 metres and the gain to 1.25 (Gain • [Selected Variable + Offset] = 1.25 • [+4 + 4] = +10 Volt max.).

By clicking in the Gain, Offset or Limits field a help wizard for selecting correct parameters will appear. Fill in the fields in the help wizard shown in Figure 53.

Limits

The hardware limits of the user's data acquisition system and can be ±10 V, ±5 V or 0 - 10 V.

By clicking in the Gain, Offset or Limits field a help wizard for selecting correct parameters will appear. Fill in the fields in the help wizard shown in Figure 53.

Datawell Hippy and Piro Compatible Analog Output Signals

In order for the MRU to output the Datawell Hippy or Piro compatible analog signals, the following variable numbers, gains and limits must be selected:

Var. No.	Name	Gain	Offset	Lim.
66	RollHippy	10	0.00	±10 Volt
67	PitchHippy	10	0.00	±10 Volt
102	PosMonD	-1	0.00	±10 Volt

Note Negative gain has to be used for *variables 102* in order to make the variables positive according to the Datawell co-ordinate system. From MRU version 2.53 and higher the variables RollHippy and PitchHippy must have a positive sign as shown above.

Analog Test

In order to trouble shoot the analog output channels it is possible to set out a specified voltage on selected channels. Select the channels to be checked and the voltage to be set out, and click the **Set Voltage** button to apply.

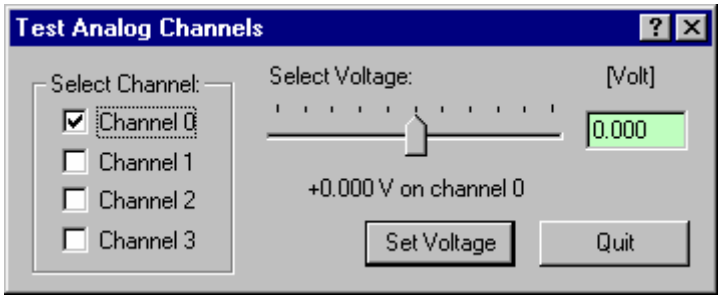

Figure 54 Test of analog channels

18.4.4 Special options

18.4.4.1 Filters

Figure 55 Filters

Surge Filter

The following selections are available in the MRU configuration in order to achieve the optimal surge measurements (forward direction):

- **Surge filter mode**. The filter mode is fixed to "General purpose".
- **Period**. The average surge period for the vessel, T_o.
- **Damping**. The surge damping factor ε to be used in the filter.

The user can set the average period T_o in the range 1 to 25 seconds. The recommended period for surge motion is in the range 2 to 4 seconds. The default value is 2.5 seconds.

The damping factor in surge can be selected in the 0.1 to 1.0 range by adjusting the parameter **damping**. This parameter influences the phase and amplitude response of the surge 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, but oscillations in position and velocity may occur. The damping factor should normally be set to 0.6.

Sway Filter

The following selections are available in the MRU configuration in order to achieve the optimal sway measurements (starboard direction):

- **Sway filter mode**. The filter mode is fixed to "General purpose".
- **Period**. The average sway period for the vessel, T_o.
- **Damping**. The sway damping factor ε to be used in the filter.

The user can set the average period T_o in the range 1 to 25 seconds. The recommended period for sway motion is in the range 2 to 4 seconds. The default value is 2.5 seconds.

The damping factor in sway can be selected in the range 0.1 to 1.0 by adjusting the parameter **damping**. This parameter influences the phase and amplitude response of the sway 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 sway, but oscillations in position and velocity may occur. The damping factor should normally be set to 0.6.

Vibration Lowpass

This parameter is used for lowpass filtering of some of the signals in the MRU using a second order recursive filter. The internal filter limits may be clamped internally in the MRU to provide reasonable noise levels and function. The filters influence the following variables:

a) The angular velocity output (outputs no 1, 2 and 3).
b) The angular accelerations (outputs no 60, 61 and 62).
c) Angle outputs from an MRU 3. *Note that the output angles are not filtered in an MRU D, 2, Z, H, 4, 5 or MRU 6*.
d) The linear accelerations; all variables except variable no 92 (acceleration in Y-axis with g subtracted). *Note that velocities and positions are not filtered*.
e) Magnetic field.

The filter will also indirectly influence the linear velocity and the position if lever arms are used. A frequency of 0.01 to 25 Hz may be selected. The default value is 10 Hz, which gives the minimum filtering of the output signals.

Note These changes take effect after restart or rebooting.

18.4.4.2 Limitations

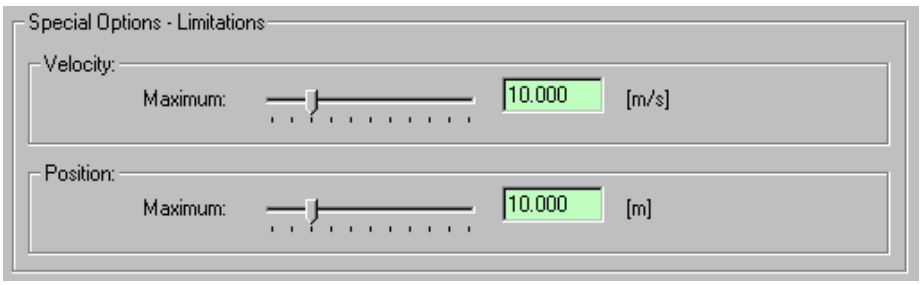

Figure 56 Limitations

Velocity [m/s]

This parameter may be set at 0.1 to 100.0 m/s (typically 10.0 m/s) and is the maximum velocity in the surge, sway and heave motion before clipping.

Position [m]

This parameter may be set at 0.1 to 100.0 metres (typically 10.0 m) and is the maximum position displacement in the surge, sway and heave motion before clipping.

18.4.4.3 Emulation

With this parameter it is possible to emulate a reduced MRU version.

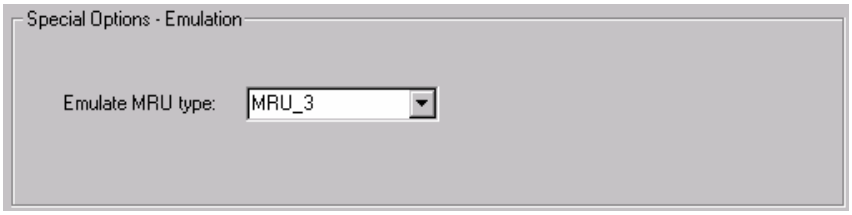

Figure 57 Emulation

The **Emulate MRU type** pull down menu have the following options:

- Off (default).
- MRU_1
- MRU_2
- MRU_3
- MRU_4
- MRU_5

This parameter is normally set to OFF.

Note These changes take effect after restarting of the MRU.

18.4.4.4 Magnetic conditions

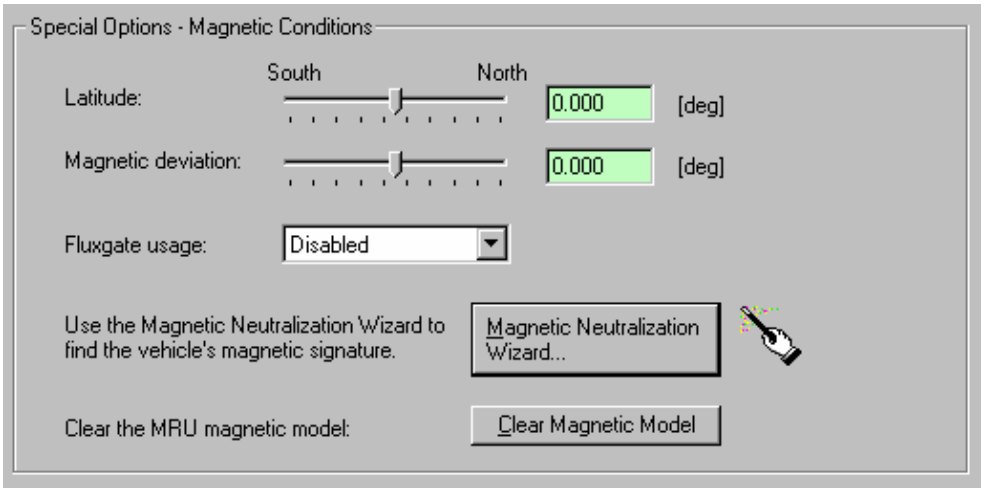

Figure 58 Magnetic Conditions

Latitude

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.

Magnetic deviation

The magnetic deviation angle at vehicle and ship locations is normally set to 0.0. The heading output (Yaw angle) after deviation correction is entered as:

(Output Heading) = (Measured Magnetic Heading) - (Entered Magnetic Deviation)

Fluxgate Usage

This parameter tells the MRU how the magnetic fluxgate compass is used and hence how strongly the heading erection should adhere to the magnetic north. This parameter is only valid for the MRU 5 & H models, which contain a magnetometer. The following selections are available:

- Disabled.
- Weak adhesion.
- Strong adhesion.

Note If the parameter **Disabled** is selected, the magnetic sensor in the unit will have no influence on the MRU heading erection. In this case, an MRU 6 will behave as an MRU 5 and an MRU 4 as an MRU H.

Magnetic Neutralization Wizard

For MRU models 4 and 6 which include a magnetic fluxgate compass a model of the vessel magnetic signature can be estimated by clicking the **Magnetic Neutralization Wizard** button. See chapter 18.4.6 on how to use the Magnetic Neutralization Wizard.

Clear Magnetic Model

Click this button to reset the estimated model to zero in order to start from the beginning.

18.4.5 Parameter management

18.4.5.1 Download

The edited parameters are applied by sending them to the MRU. In the Configuration Folder List, select **Parameter Management \ Download.** Click the **Download Parameters to MRU** button to download. The values of the edited parameters are transferred. Progress bar indicates downloading progress.

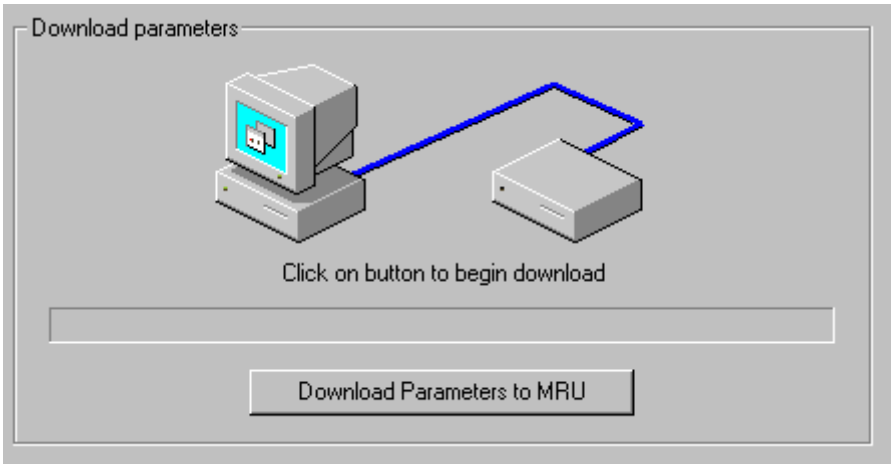

Figure 59 Download Parameters

18.4.5.2 Upload

In the Configuration Folder List, select **Parameter Management \ Upload.** Click the **Upload Parameters from MRU** button to upload parameters from the MRU to the MRC computer. Progress bar indicates uploading progress.

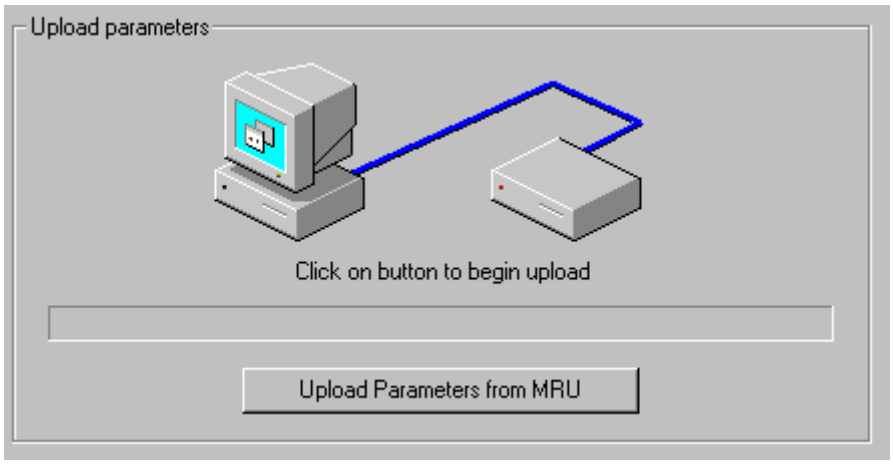

Figure 60 Upload Parameters

18.4.5.3 Save on file

Edited parameters can also be stored locally on disk in the MRC computer. In the Configuration Folder List, select **Parameter Management \ Save on file**, and the window below appears.

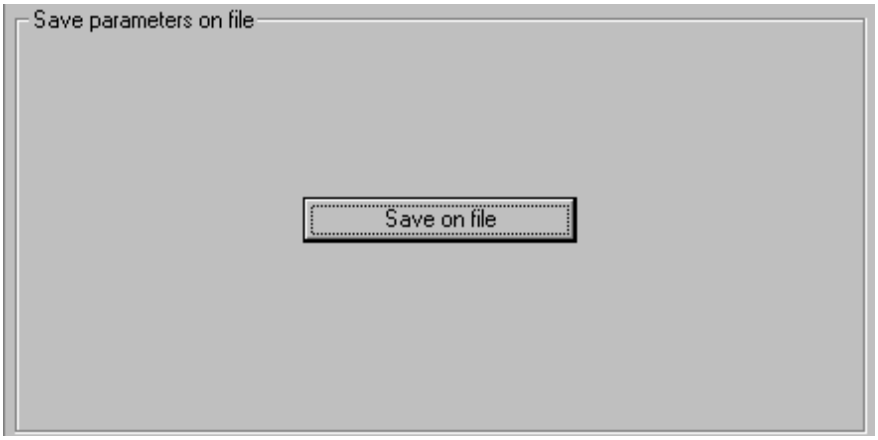

Figure 61 Save on file

Click the **Save on file** button, and the "standard save window" **Select file to save parameters on** appears. Choose wanted location and click **Save**.

18.4.5.4 Load from file

MRU parameters stored on file in the MRC computer can be loaded back into the workspace area for further editing or/and downloaded to the MRU. In the Configuration Folder List, select **Parameter Management \ Load from file,** and the window below appears.

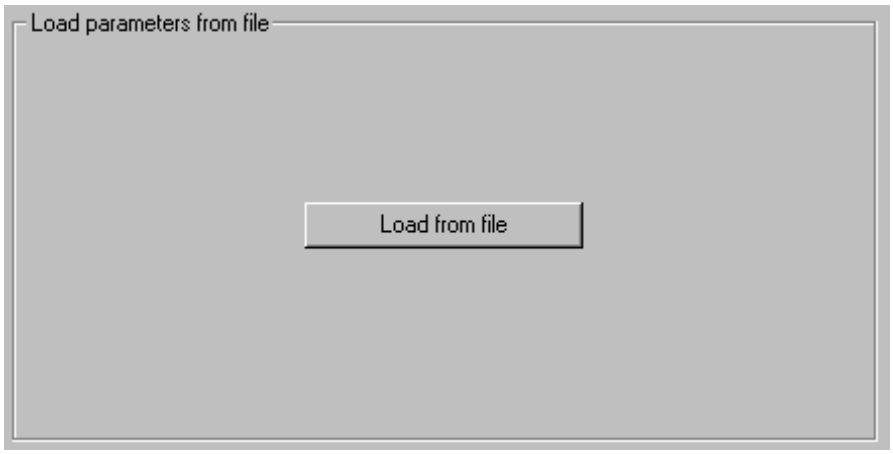

Figure 62 Load from file

Click the **Load from file** button, and the "standard open window" **Select file to open parameters from** appears. Choose wanted location and click **Open**.

18.4.5.5 Undo or set default

If the editing of MRU parameters for some reason fails, it is possible to overwrite the MRC workspace with the last saved parameters from the MRU at any time. In the Configuration Folder List, select **Parameter Management \ Undo** and the window below appears. Click **Undo** to retrieve the last saved parameters.

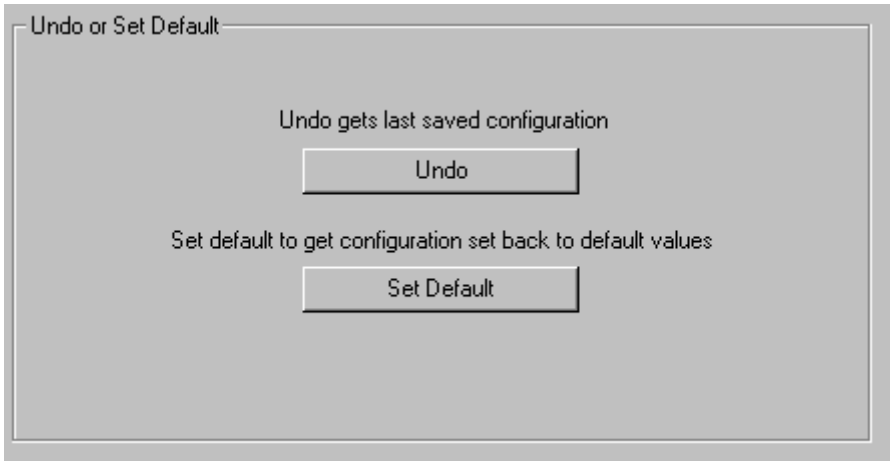

Figure 63 Undo

18.4.5.6 Generate report

A report with a list of all the configuration settings in the connected MRU or a configuration read from file is generated by clicking the **Generate configuration report** button as shown in Figure 64.

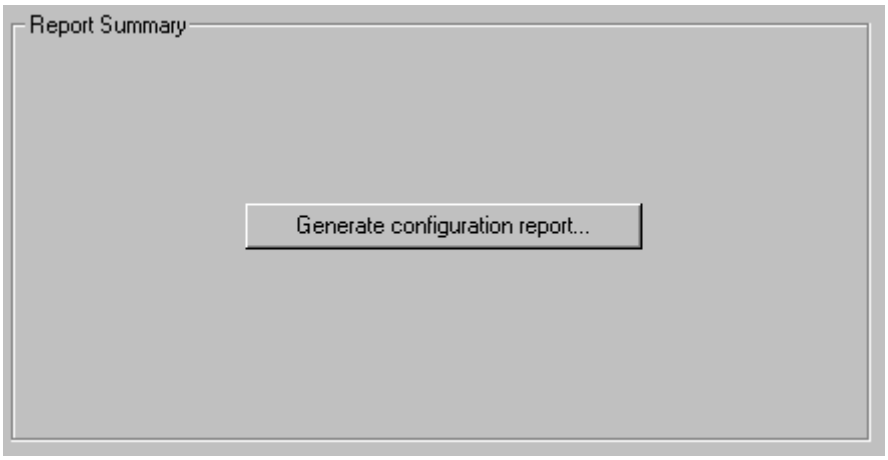

Figure 64 Generate configuration report

The MRU configuration report, Figure 65, can be saved to file or printed.

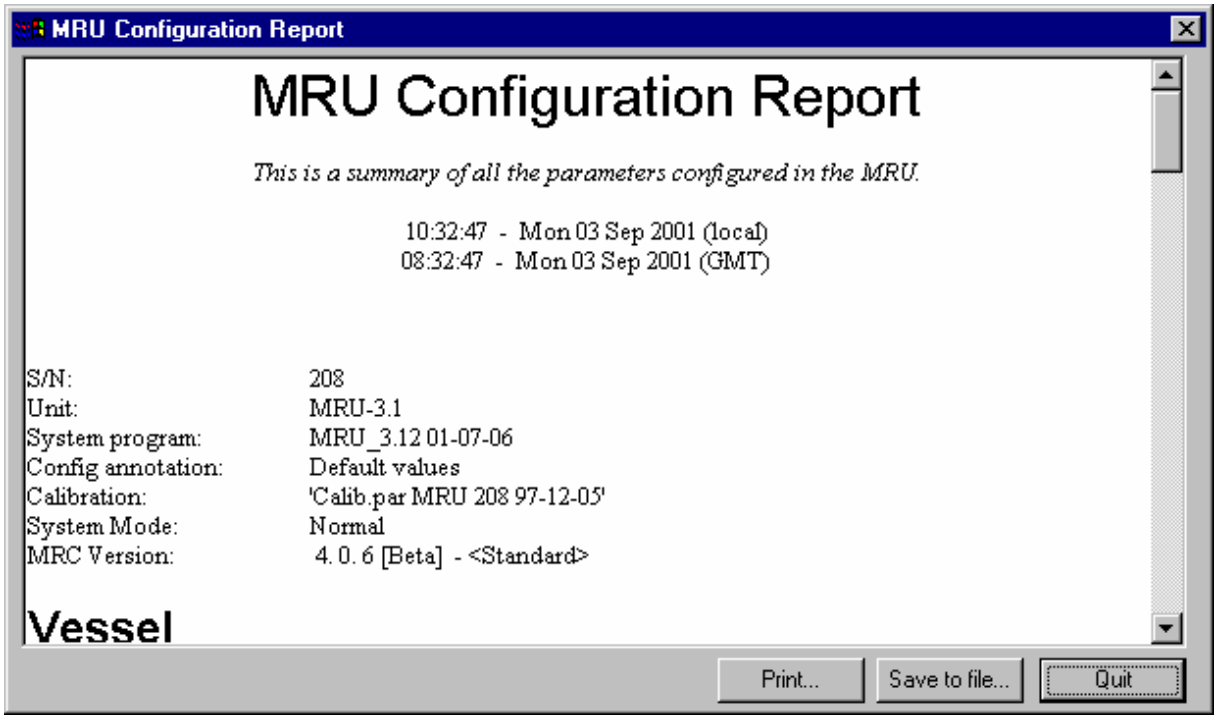

Figure 65 Configuration report

18.4.6 Magnetic neutralisation

The MRU 4 and 6 models contain a fluxgate magnetometer. This magnetometer measures the magnetic field at the MRU location, and can be used to find a true north reference when influenced by the earth magnetic field. The vessel itself normally has its own magnetic signature which can be estimated and compensated for in order to obtain the best possible heading reference accuracy.

Running the MRU configuration program, MRC, while turning the vessel performs the training of the internal magnetic model. In the MRC magnetic neutralisation wizard a model quality figure is displayed that indicates when the model is properly trained. In order to inform the user about the collection process, the following information is shown in the **Magnetic Neutralization** window:

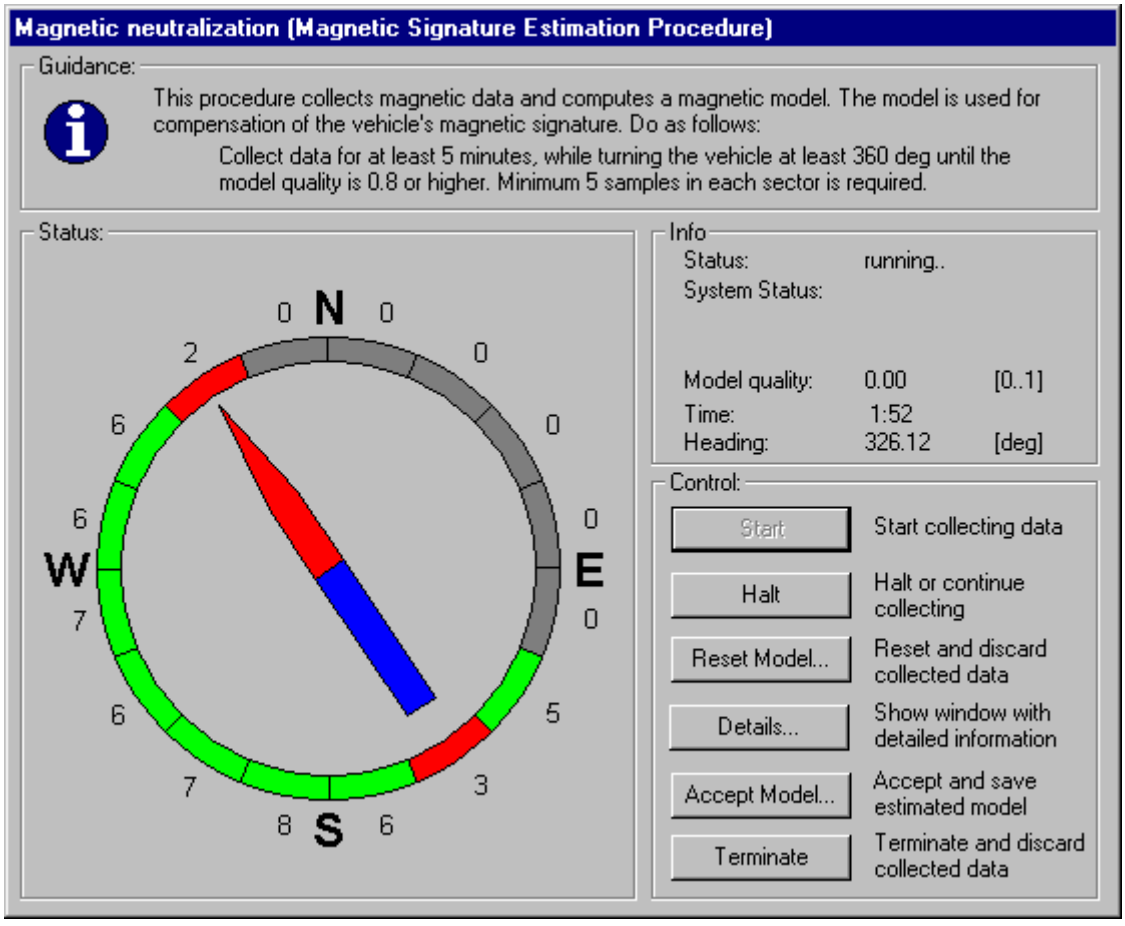

Figure 66 Magnetic Neutralization window

The window is divided into the following three parts:

Status:

This part shows a compass card as a circle divided into 16 sectors, each of 22.5 degrees. The compass needle points to the sector in which the MRC is collecting magnetic samples. The number on the outside of each sector shows the number of magnetic samples collected in this

sector. All sectors have grey colour until the collection of data is started. Sectors with more than four samples are coloured green and sectors with one to four samples are coloured red. Sectors with red sample numbers indicate that these sectors have too few samples in order to compute a good model. Minimum five samples in each sector are required to achieve a good model.

Info:

This part of the window includes the following information:

Status Shows the status of the estimation process such as initialising, running or stopped.

Model quality Is a number between 0 and 1 where 1 means an optimum magnetic model has been obtained. The model quality should be 0.8 or higher before a model is accepted.

Time Shows the time in minutes since the estimation process started. The estimation process will automatically terminate after 30 minutes.

Heading Shows the actual heading value for which the estimation process is collecting magnetic samples.

The vessel speed or turn rate are not important during the collection of magnetic measurements points. However, the user must ensure that enough magnetic samples (minimum five) are collected in each sector either by performing several circles or by turning slowly to ensure that enough samples are collected during one circle. The collection of magnetic samples should last for at least five minutes and the vessel has to complete at least one circle before a good magnetic model can be achieved. The data collection must continue until the model quality figure is 0.8 or higher.

Control:

This part of the window includes the following controls:

- **Start**. Click this button to start the collection process. Starts MRU internal data collection and model updating from initial zero data.

- **Halt/Continue**. Click this button to halt the process or to continue collecting data. Halts MRU internal data collection and model updating, but keeps the temporarily obtained data. This command is typically used when the neutralisation procedure is interrupted by an unexpected incident, which lasts for a short period, e.g. the close passing of a large vessel. Clicking **Continue** continues MRU internal data collection and model updating from the temporarily obtained data after neutralisation procedure suspension.

- **Reset Model**. Click this button to reset the estimated model to the original model figures.

- **Details**. Click this button to show details on the estimation process. This window shows details on the gain and offset values in the new estimated magnetic model and the last accepted model. Figures for the magnetic field, norm, mean and standard deviation values, yaw angle calculated from the raw data and the compensated magnetic field, are shown. At the bottom of the screen are shown; status, number of calls for data from the MRC to the MRU, total number of samples collected, number of samples in the sector with fewest hits together with model quality figure.

- **Accept Model**. Click this button to accept the estimated model and to save the model in the MRU configuration. The magnetic neutralisation model is not updated and downloaded to the MRU before selecting **Parameter Manager / Download** in the Configuration Folder List.

- **Terminate**. Click this button to stop the collection process and to exit the Magnetic Neutralization wizard.

18.4.6.1 Magnetic signature estimation procedure

The following procedure is used for generating a model of the vessel magnetic signature:

1. Connect the MRU to a PC using the standard serial interface cable if not already done, and start the MRC.

2. Choose the command wizard **Magnetic Neutralization** from the tool bar. Wait until the status in the Info box has changed to "initialized" before continuing.

3. Click the **Start** button and move the vessel in circle(s). Avoid vessel external constructions, which may have significant influence on the total magnetic field. Collect data for at least five minutes, while turning the vehicle at least 360 degrees, until the model quality is 0.8 or higher. The model quality figure, the different sectors and the number of magnetic samples collected in each sector are shown on the screen.

4. When finished, and the magnetic model quality has reached 0.8 or higher, the new vessel signature is updated in the MRU by clicking the **Accept** button.

If the model quality never reaches 0.8:

- Collect more magnetic samples in the sectors with less than five samples. All sectors must have at least four samples or more to reach 0.8 in model quality.

- Move the vessel to another location where the magnetic disturbances are less and continue the collection there.

- If the vessel is rolling and pitching a lot during collection of data, move to another area with less vessel motions and continue the collection there. This is important since the model estimation assumes that there are small roll and pitch values during the magnetic collection process and the motion should be as small as possible to achieve an optimal

model. Under no circumstances should the roll and pitch values exceed 10 degrees. Magnetic field samples for motions above 10 degrees will automatically be rejected.

Note If the vessel is operating in the vicinity of external constructions such as offshore structures, putting up an additional magnetic field, the true north reference can generally not be found, even though the vessel magnetic signature has been found.

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