MOTION REFERENCE UNIT
eMRU (MRU ETHERNET)

Norwegian Subsea

eMRU USER MANUAL

eMRU

HIGH PERFORMANCE, PLUG & PLAY
6DOF MOTION SENSOR

with Power Over Ethernet (PoE)!

5 CM / 5 % | **0.01 - 0.05 RMS°** | **IP65**

MRU eMRU User Manual Version 1.6.0

Document number: NORSUB-EMUM-1.6.0

Intro

The purpose of the user manual is to provide information about the Norwegian Subsea (NORSUB) Ethernet Motion Reference Unit (eMRU 3000, eMRU 6000, and eMRU 9000).

Restrictions in Warranty

The Seller's liability for defects is stated in the Norwegian Subsea general terms and conditions of sale. For the warranty to be valid the MRU:

- must not be subjected to extreme shock, rough handling or extensive vibrations.
- must only be opened by Norwegian Subsea.
- must not be stored or used in temperatures outside the range -40 to +85 deg. C.
- must be handled with care.
- must only be used with the correct power supply (10 – 36 V DC power).

Any breach of the points above will void the warranty.

Disposal

All electrical and electronic components have to be disposed of separately from the municipal waste stream via designated collection facilities appointed by the government or local authorities. The correct disposal and separate collection of your old appliance will help prevent potential negative consequences for the environment and human health. It is a precondition for reuse and recycling of used electrical and electronic equipment. For more detailed information about disposal of your old appliance, please contact your local authorities or waste disposal service.
In support of the global requirements to dispose of electrical waste within environmentally acceptable specifications, Norwegian Subsea offers customers the take-back and recycle process to properly dispose of surplus and end-of-life products.
Equipment that is returned to Norwegian Subsea through this program is disposed of in an environmentally safe manner using processes that comply with the WEEE (EU Directive on Waste Electrical and Electronic Equipment) regulations. All Norwegian Subsea-branded products are accepted under the program.

Support Information

Please contact Norwegian Subsea for technical support at support@norwegian-subsea.no.
Technical support is available Monday - Friday between 09.00 – 17.00 CET.

Product Returns

In case of product returns, the buyer shall arrange for return shipment to Norwegian Subsea. Please note that a return merchandise authorization (RMA) from Norwegian Subsea is required in advance.

The return address is:

Norwegian Subsea
Hovfaret 8
0275 Oslo
Norway

Export Restrictions

The MRU must not be exported or re-exported to countries listed on the Norwegian Ministry of Foreign Affairs' prohibition list. Please contact Norwegian Subsea for further details.

	eMRU USER MANUAL (NORSUB-EMUM-x.x.x) REVISION HISTORY		
	VERSION	CODE	NOTES
LEGACY	1.2.0	NORSUB-EMUM-1.2.0	First digital release.
	1.3.0	NORSUB-EMUM-1.3.0	First print release. The manual is completely redesigned to add all the important mechanical, electrical, and technical sensor information.
	1.3.1	NORSUB-EMUM-1.3.1	Minor correction of typos.
	1.3.5	NORSUB-EMUM-1.3.5	Modified section “Restrictions in warranty”. Added “Maintenance” section.
CURRENT	1.6.0	NORSUB-EMUM-1.6.0	Updated protocols.

NOTE

Please read this user manual to ensure proper use of the MRU and the configuration software.

NORSUB EMRU

High performance 6 DoF motion sensor

NORSUB Motion Reference Units (MRU) are high performance, compact and affordable. NORSUB MRUs use state-of-the-art MEMS technology and advanced sensor fusion algorithms. This results in accurate and reliable roll, pitch, yaw, surge, sway and heave position and velocity measurements. The performance is great also during horizontal accelerations and coupled motions.

Tailormade for marine use

NORSUB Ethernet eMRUs are ideal for use in marine applications such as motion compensation of sonars, active heave compensation of offshore cranes, helideck monitoring, vessel motion monitoring, DP systems and motion compensation of wave radars, gangways and offshore installations.

Tailormade for structural monitoring

The Ethernet eMRU is ideal for condition monitoring of e.g. wind turbine structures as the roll & pitch accuracy remains very high even in horizontal motions with large accelerations. The eMRU has a dedicated wind turbine mode which takes the surge & sway motions constraints into account.

Optimized for gangway control

The eMRU features a specialized mode to optimize surge and sway measurements during gangway control from a DP vessel. This feature is also available for remote monitoring points.

Plug & play ethernet interface

NORSUB Ethernet eMRUs are plug & play due to the standard RJ 45 ethernet connector with Power Over Ethernet (PoE). This makes cabling very fast & easy. A wide range of industry standard and custom protocols are included for compatibility with other systems.

NORSUB EMRU

Easy set-up and service

The eMRU is very easy to set-up and configure using the Norwegian Subsea MRU configuration software. The MRU does not require any maintenance and firmware upgrades are free. For optimal performance, re-calibration is recommended every third year.

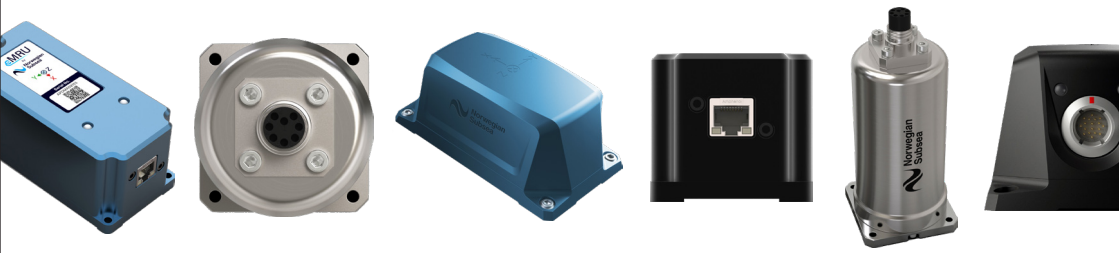
General information

The NORSUB eMRU outputs roll, pitch, yaw, heave, surge and sway measurements at configurable output rates up to 100 Hz. The eMRU consists of a high-end MEMS 6 DOF IMU (3 x gyroscopes and 3 x accelerometers) and a processing unit where the motions states are calculated using an advanced sensor fusion algorithm. The passive power over ethernet (PoE) interface makes it easy to install and set-up.

This manual describes the mechanical and electrical interfaces needed to integrate the eMRU in a system, and the technical specifications of all available models.

A solution for every application

Norwegian Subsea AS offers a portfolio of sensors, cables, connectors, and software tools which covers a variety of applications, environmental, and operational requirements. Visit the company website to choose the Norwegian Subsea MRU that fits your needs!



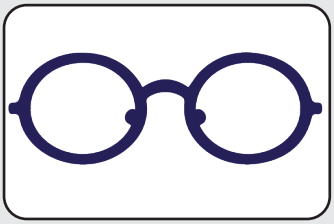
CONTENTS

FIGURES

TABLES

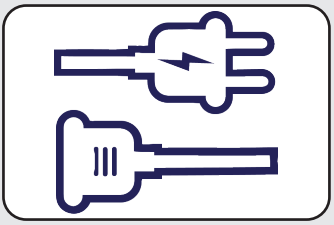
1. GENERAL INFORMATION

Quick Start Guide



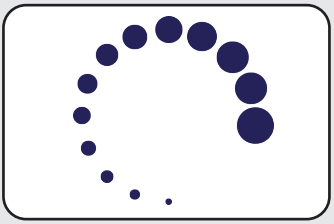
1. CHECK ITEMS

Verify that all the items are in the shipment (see eMRU User Manual for details).



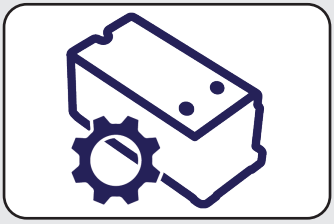
2. CONNECT THE MRU

Connect the eMRU to a PC through an Ethernet port with an Ethernet cable (see eMRU User Manual for details).



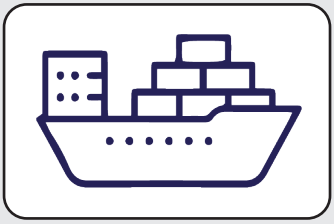
3. INSTALL THE SOFTWARE

Install the NORSUB MRU Configuration Software by double clicking on the installer file (`setup.exe`) on the USB memory stick (see MRU Configuration Software User Manual for details).



4. CONFIGURE THE MRU

Run the NORSUB MRU Configuration Software to configure the eMRU (see MRU Configuration Software User Manual for details).



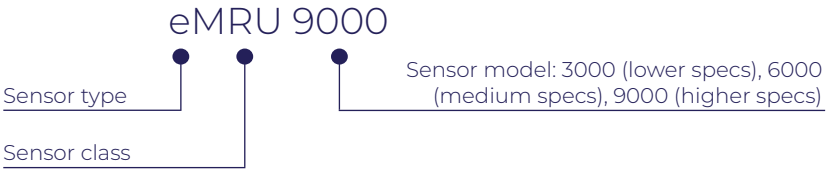
5. INSTALL THE MRU

Install the configured eMRU at the desired location.

eMRU Models

The eMRU comes in 3 different models which cover a variety of performance levels and features. The eMRU models are:

The model name is explained here:



Product List

The eMRU, eMRU industrial cables, and other accessories that are available for purchase at Norwegian Subsea are listed in the following:

NORWEGIAN SUBSEA eMRU-RELATED PRODUCT LIST		
PRODUCT NAME	PRODUCT CODE	
NORSUB MRU 9000 eMRU	10025	eMRU
NORSUB MRU 6000 eMRU	10026	
NORSUB MRU 3000 eMRU	10027	
eMRU Industrial Cat5e Cable 2 m	30033	eMRU CABLES
eMRU Industrial Cat5e Cable 5 m	30034	
eMRU Industrial Cat5e Cable 10 m	30035	
eMRU Industrial Cat5e Cable 20 m	30036	
eMRU Industrial Cat5e Cable xx m	30037	
Transport Case M	40001	ACCESSORIES
USB stick with MRU configuration software	40005	
PoE RJ45 splitter plug	40006	
PoE RJ45 splitter socket	40007	

Table 1: Norwegian Subsea eMRU-related product list.

Items List

A standard shipment of the eMRU 3000, eMRU 6000, and eMRU 9000 contains the following (*):

1. 1 x NORSUB eMRU;
2. 1 x Industrial Cat5e cable;
3. 1 x USB flash drive with the NORSUB MRU Configuration Software;
4. 1 x Configuration Software user manual and 1 x eMRU user manual.

1. MRU

NORSUB eMRU

2. CABLE

eMRU Industrial Cat5e cable

3. USB FLASH DRIVE

USB drive with the NORSUB MRU Configuration Software

4. USER MANUALS

Configuration Software user manual and MRU user manual

(*) The shipment content (such as cable length and cable connectors) may vary from the above item list depending on items in your order (see “Product List” on page 4).

System Set-Up

- Connect a RJ45 plug of the Cat5e cable to the eMRU.
- Connect the other RJ45 plug of the Cat5e cable to a passive PoE adapter (or a switch with passive PoE port).
- Connect the PoE adapter RJ45 plug to network or computer.
- Connect the power supply to 24V DC.

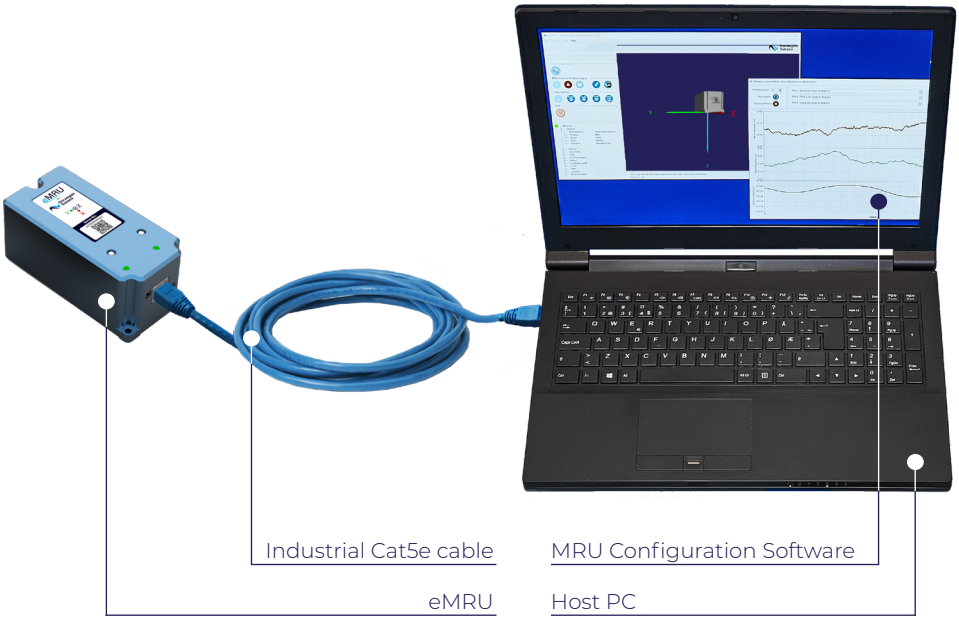


Figure 1: System set-up for the eMRU.

2. MECHANICAL INTERFACE

Design

The dimensions of the eMRU are:

- Length: 120 mm;
- Breadth: 57 mm;
- Height: 53 mm.

The footprint of the eMRU is seen in Figure 3 and Figure 7, dimensions are in millimeters. The figures shows the 3 mounting holes and the 2 alignment holes/slots on the center line. The eMRU is mounted to a solid surface using 3 x M4 screws. 4 mm diameter alignment dowels are recommended for best alignment during installation.

The eMRU 3000, eMRU 6000, and eMRU 9000 are identical when considering geometry, construction and materials.

Figure 2: eMRU: front and back views.

Design

Figure 3: eMRU: side, top, and bottom views.

LED Indicators

The eMRU models have two LED indicators that provide feedback on the MRU status and configuration.
The status LED 1 provides a general overview of the MRU status. Its color indicates if the MRU is working properly, requires a restart, or if a critical error must be investigated further (see Table 2).

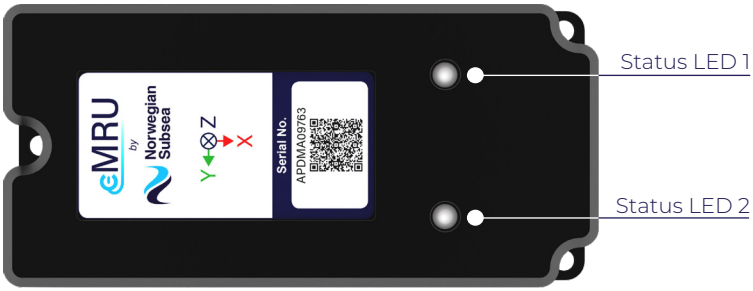


Figure 5: eMRU: status LED indicators.

STATUS LED 1		
COLOR	BLINKING PATTERN	DESCRIPTION
Green	Constant light	MRU powered up, everything is OK
Yellow	Constant light	MRU powered up, requires restart
Red	Constant light	MRU powered up, critical error. Check status bits

Table 2: Color and blinking pattern for status LED 1.

The status LED 2 provides detailed information about the MRU status and configuration. From its color and blinking pattern. The status LED 2 loops through 7 colors with fixed order (see Figure 4), and every color is associated to a status category.

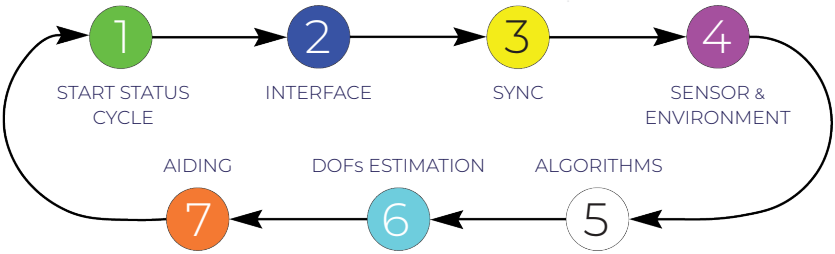


Figure 4: Status LED 2 colors cycle.

LED Indicators

To check the status of a category, simply monitor the blinking pattern of the category color. The blinking patterns are described in Table 4. For example, 3 pulses of status LED 2 in turquoise indicates that the heading measurement is faulty. The orange light following the turquoise blinking pattern tells the status of the aiding. If it blinks only once, then position, velocity and heading aiding are OK.

STATUS LED 2				
ORDER	COLOR	BLINKING PATTERN	DESCRIPTION	STATUS BIT
1	Green	1 long pulse	Sequence start	-
2	Blue	1 pulse	Only Ethernet configuration port available	-
		2 pulses	Ethernet and RS-232 port available	-
		3 pulses	Ethernet and RS-485 port available	-
3	Yellow	1 pulse	Time and clock synced	4, 5
		2 pulses	Time synced. Clock not synced	
		3 pulses	Time not synced. Clock synced	
		4 pulses	Time and clock not synced	
4	Magenta	1 pulse	Sensor and environment OK	9, 10, 11
		2 pulses	Sensor saturated, environment OK	
		3 pulses	Sensor OK, temp. or vibrations out of bounds	
5	White	1 pulse	Algorithms OK	13, 14, 15
		2 pulses	Unstable / initializing algorithms	
6	Turquoise	1 pulse	All DOFs OK	16, 18, 20, 22
		2 pulses	Roll/Pitch not OK	
		3 pulses	Heading not OK	
		4 pulses	Heave not OK	
		5 pulses	More than one DOF not OK	
7	Orange	1 pulse	Position, velocity and heading aiding	27, 28, 29
		2 pulses	Position and velocity aiding	
		3 pulses	Position and heading aiding	
		4 pulses	Heading and velocity aiding	
		5 pulses	No aiding	

Table 3: Color and blinking pattern for status LED 2.

Technical Drawings

eMRU top, side, and front technical drawings. All dimensions are in millimeters:

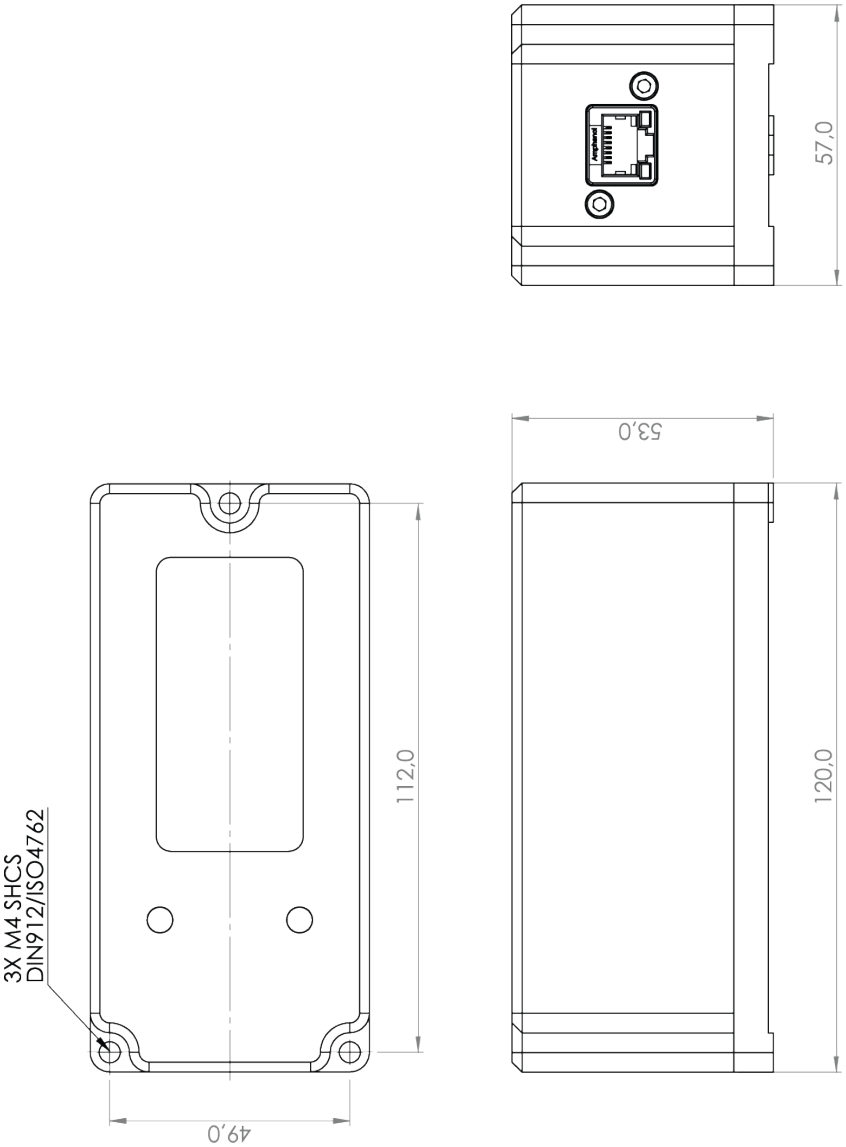


Figure 6: eMRU technical drawings: top, side, front views (dimensions in millimeters).

Technical Drawings

eMRU bottom technical drawing. All dimensions are in millimeters:

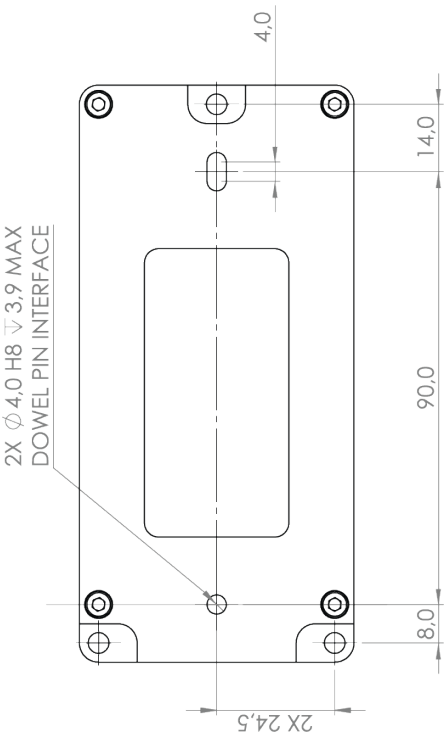


Figure 7: eMRU technical drawings: bottom view (dimensions in millimeters).

3. ELECTRICAL INTERFACE

Passive PoE

The eMRU uses a RJ45 connector with 24 V DC passive power over ethernet (PoE) for power and communication. A standard Cat5e ethernet cable with RJ45 plug can be used to interface the eMRU. The RJ45 connector on the eMRU and a Cat5e plug with T568A pins and coloring is seen in Figure 8. The pin out for the eMRU RJ45 connector is in Table 9.

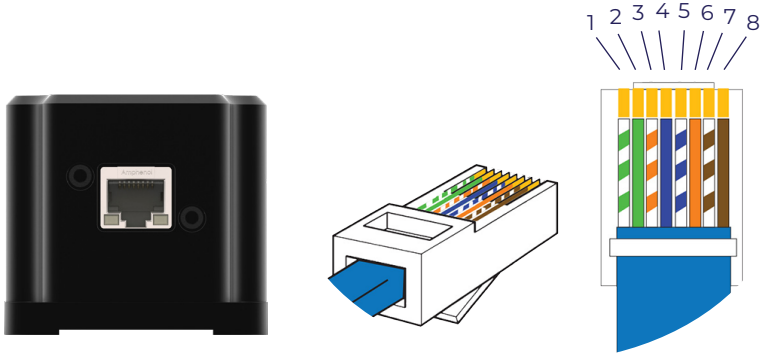


Figure 8: RJ45 connector with 24V DC passive PoE and Cat5e T568A plug with pin numbering.

RJ45 PINOUT		
WIRE COLOR	PIN N.	SIGNAL
TP 3 (White/Green)	1	Rx_D2+
TP 3 (Green)	2	Rx_D2-
TP 2 (White/Orange)	3	Tx_D1+
TP 1 (Blue)	4	24V
TP 1 (White/Blue)	5	24V
TP 2 (Orange)	6	Tx_D1-
TP 4 (White /Brown)	7	GND
TP 4 (Brown)	8	GND

Table 4: RJ45 pinout.

24 V DC PASSIVE POE

Must not be used with active PoE ports, e.g. IEEE 802.3af, 802.3at an 802.3bt. Connect eMRU only to ports with passive PoE with 24V DC.

4. TECHNICAL SPECIFICATIONS

Output Protocols

The MRU outputs industry standard or custom NMEA/ASCII and binary protocols are:

NAME	TYPE	DATA
Custom NMEA	NMEA	All data from parameter list, see chapter 6
Custom Binary	Binary	All data from parameter list, see chapter 6
ATLAS	Binary	Roll, pitch, heave
GYROCOMPAS1	NMEA	Roll, pitch, heading, status
IFREMER VICTOR	Binary	Roll, pitch, heading, roll rate, pitch rate, yaw rate, acc x, acc y, acc z
MDL	ASCII	Roll, pitch, heading
NORSUB	NMEA	Roll, pitch, yaw, heave
NORSUB2	NMEA	Roll, pitch, yaw, heave, heave vel
NORSUB6	NMEA	Roll, pitch, yaw, surge, sway, heave, roll rate,pitch rate, yaw rate, surge vel, sway vel, heave vel, acc x, acc y, acc z
NORSUB6g	NMEA	Roll, pitch, yaw, surge, sway, heave, roll rate,pitch rate, yaw rate, surge vel, sway vel, heave vel, acc x, acc y, acc z (including gravity)
NORSUB7	NMEA	Roll, pitch, yaw, surge (body frame), sway (body frame), heave, roll rate,pitch rate, yaw rate, surge vel (body frame), sway vel (body frame), heave vel, acc x (body frame), acc y (body frame) acc z, period x, period y, period z, amplitude x, amplitude y, amplitude z, STATUS
NORSUB7b	NMEA	Roll, pitch, yaw, surge (body frame), sway (body frame), heave, roll rate,pitch rate, yaw rate, surge vel (body frame), sway vel (body frame), heave vel, acc x (body frame), acc y (body frame) acc z, period x, period y, period z, amplitude x, amplitude y, amplitude z, STATUS_A, STATUS_B
NORSUB8	NMEA	Roll, pitch, yaw, surge (NED frame), sway (NED frame), heave, roll rate,pitch rate, yaw rate, surge vel (NED frame), sway vel (NED frame), heave vel, acc x (NED frame), acc y (NED frame), acc z, period x, period y, period z, amplitude x, amplitude y, amplitude z, STATUS
NORSUB PRDID	NMEA	Pitch, roll
Tokimek PTVG	NMEA	Roll, pitch, yaw
RDI ADCP	NMEA	Roll, pitch, yaw

Table 5: List of output protocols (part 1).

Output Protocols

NAME	TYPE	DATA
SMCA	NMEA	Roll, pitch, surge,sway, heave
SMCC	NMEA	Roll, pitch, yaw, surge, sway, heave, surge vel, sway vel, heave vel, acc x, acc y, acc z
SMCCg	NMEA	Roll, pitch, yaw, surge, sway, heave, surge vel, sway vel, heave vel, acc x, acc y, acc z (including gravity)
Simrad EM 3000	Binary	Roll, pitch, yaw, heave
TSS1	ASCII	Roll, pitch, heave, status

Table 6: List of output protocols (part 2).

Custom NMEA: custom output protocol in NMEA format. See the MRU Configuration Software User Manual for the full list of available output variables.

Custom Binary: custom output protocol in binary format. See the MRU Configuration Software User Manual for the full list of available output variables.

Output Variables

The following table shows the available variables for every protocol.

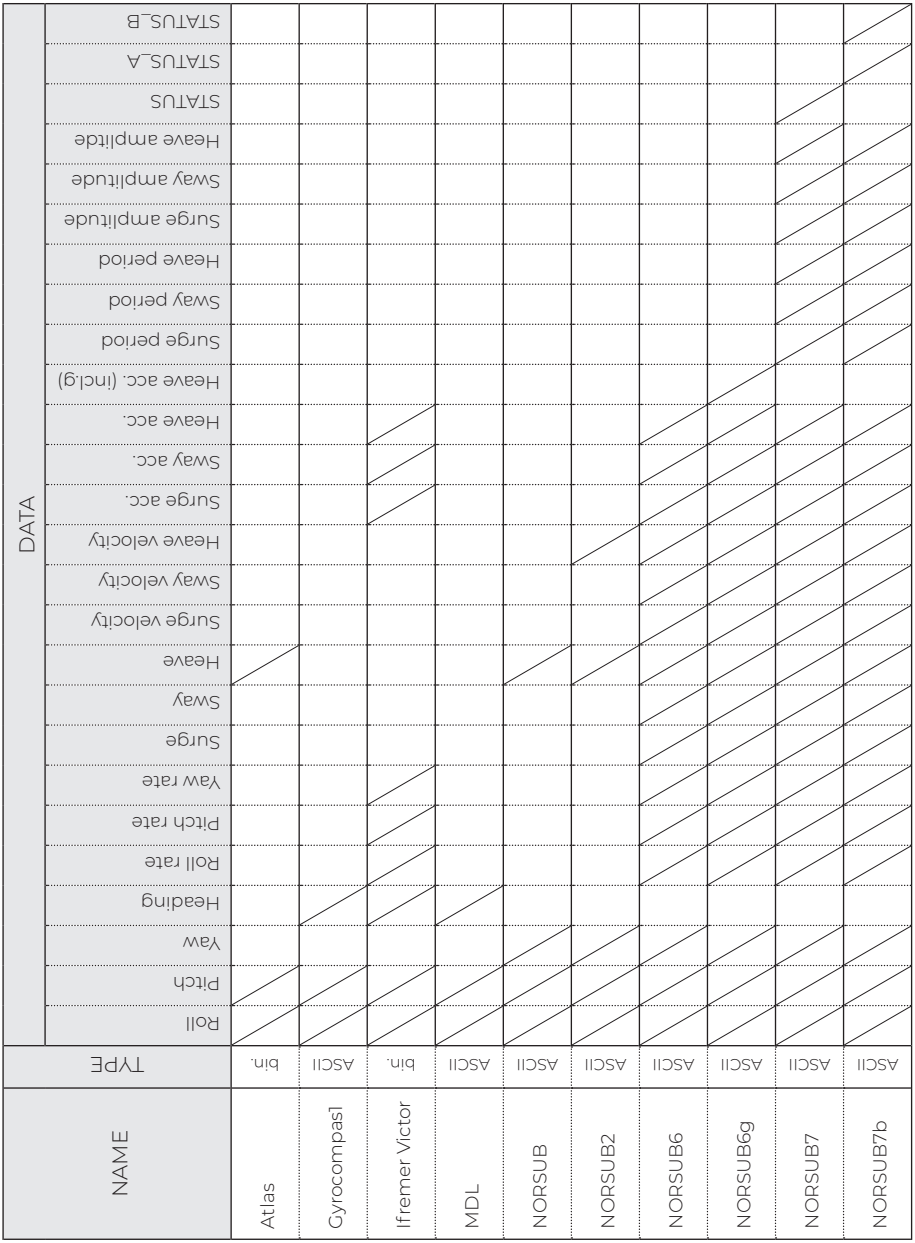


Table 7: Output protocol data (part 1).

Output Variables

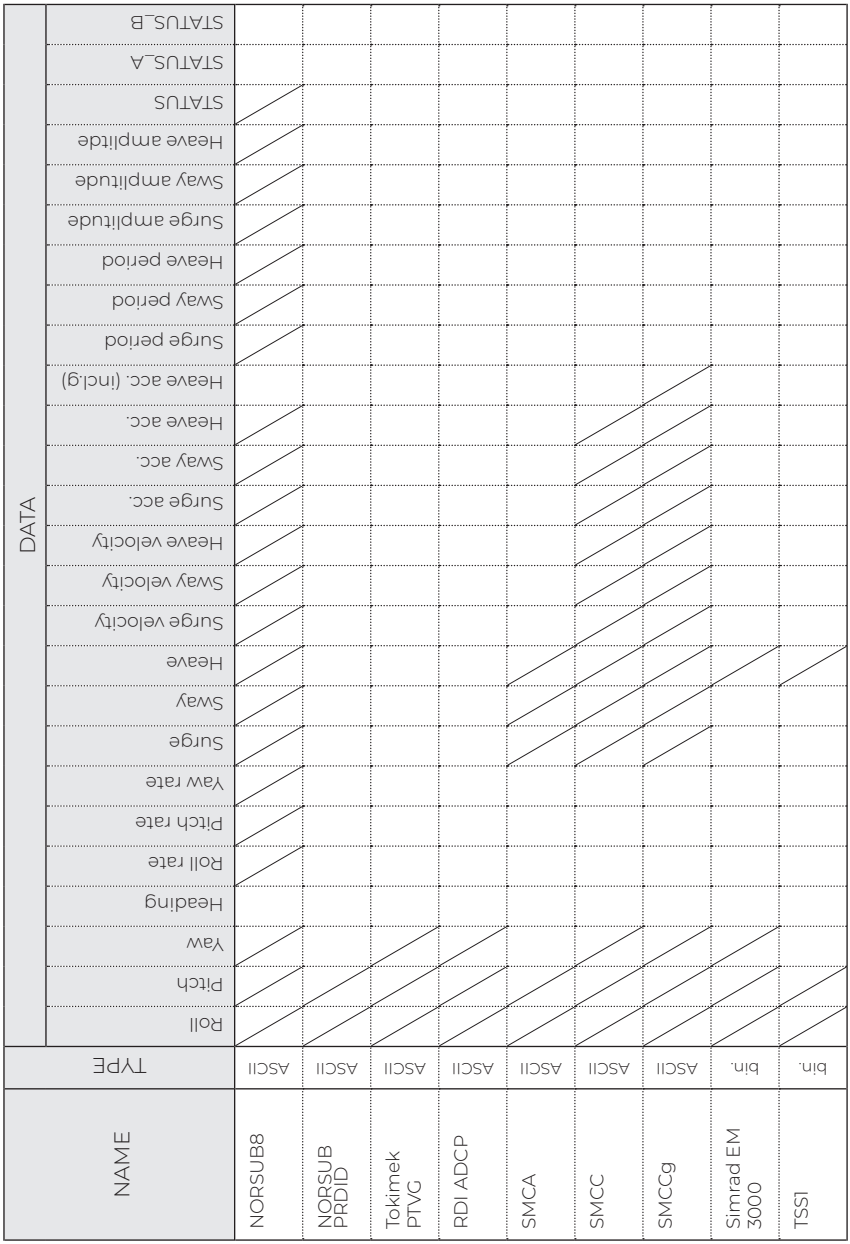


Table 8: Output protocol data (part 2).

Technical Specifications

eMRU 3000/6000/9000 PHYSICAL CHARACTERISTICS	
PARAMETER	VALUE
Weight	550 g
L x B x H	120 x 57 x 53 mm
Depth rating	IP-65

Table 9: eMRU physical characteristics.

eMRU PERFORMANCE			
PARAMETER	3000	6000	9000
Roll & pitch	+/- 0.05 degs	+/- 0.02 degs	+/- 0.01 degs
Real-time heave	5.0 cm or 5.0 %	5.0 cm or 5.0 %	5.0 cm or 5.0 %

Table 10: eMRU performance.

eMRU RANGE			
PARAMETER	3000	6000	9000
Acceleration range	+/- 3 g	+/- 4 g	+/- 10 g
Gyroscopes	+/- 150 degs/s	+/- 450 degs/s	+/- 450 degs/s
Heave	+/- 50 m	+/- 50 m	+/- 50 m
Yaw	360 degs	360 degs	360 degs
Pitch	+/- 90 degs	+/- 90 degs	+/- 90 degs
Roll	+/- 180 degs	+/- 180 degs	+/- 180 degs
Output frequency	0 - 100 Hz	0 - 100 Hz	0 - 100 Hz

Table 11: eMRU range.

Technical Specifications

eMRU 3000/6000/9000 POWER AND INTERFACES	
PARAMETER	VALUE
Power consumption	6.0 W
Supply voltage	10-36 V DC (24 V nominal)
Internal storage	32 GB
Ports	Ethernet
Connector	RJ45, passive PoE at the connector
Protocols	See “Output Protocols” on page 22 for the complete list

Table 12: eMRU power and interfaces.

eMRU 3000/6000/9000 ENVIRONMENTAL SPECIFICATIONS	
PARAMETER	VALUE
Enclosure material	Aluminum
Operating temperature range	-40 to +85 degrees Celsius
Storage temperature range	-40 to +85 degrees Celsius
Electromagnetic compatibility (immunity/emission)	IEC 60945/EN 60945
Vibration	IEC 60945/EN 60945
Max shock non-operational (10 ms peak)	2000 m/s² (half-sine 0.5 msec)
MTBF (computed)	100000 h

Table 13: eMRU environmental specifications.

5. MAINTENANCE

Maintenance General Information

The Norwegian Subsea MRUs are designed to be maintenance free, and no field maintenance is expected.

Repair or modification to the MRU must be done by Norwegian Subsea personnel. Attempts of opening the MRU will void the warranty.

No periodic maintenance is expected except for firmware upgrades. Any other maintenance shall be carried out by Norwegian Subsea.

Firmware Upgrades

Norwegian Subsea releases free firmware upgrades for the MRUs. The latest version of the firmware can be downloaded from the download pages of the company home page after registration of an MRU. Please contact Norwegian Subsea support for legacy versions of the MRU firmware.

Please see the MRU Configuration Software manual for how to save and apply configuration settings of the MRU.

Re-calibration

The NORSUB MRU requires re-calibration every 3rd year to guarantee the specified performance in roll & pitch. The specified heave accuracy of 5 cm / 5% whichever is greater, is maintained without re-calibration.

The MRU will perform well after 3 years without re-calibration for most applications. Longer re-calibration intervals than 3 years may be used if the application does not require the specified accuracy in roll & pitch. Without re-calibration, a roll & pitch accuracy as given by Table 1 is assumed to be maintained for the lifetime of the MRU under normal use.

The computed MTBF (mean time between failure) for the NORSUB MRU Marine is 100000 hours, but actual lifetime depends on use, vibrations, and temperature. However, lifetime of 10 years or more in normal continuous operation can be expected.

See Table 13 for details.

Re-calibration

PARAMETER	MARINE 3000	MARINE 6000	MARINE 9000
Spec: Roll & pitch	0.05 degs	0.02 degs	0.01 degs
Spec: Heave	0.05 cm / 5%	0.05 cm / 5%	0.05 cm / 5%
Re-calibration interval	3 years	3 years	3 years
No recalibration: Roll & pitch	0.1 degs	0.05 degs	0.03 degs
No re-calibration: Heave	0.05 cm / 5%	0.05 cm / 5%	0.05 cm / 5%

Table 14: MRU performance and re-calibration.

Repairs

All repairs except for cable replacement must be performed by Norwegian Subsea.

Please contact Norwegian Subsea support if an MRU is assumed faulty. If troubleshooting with Norwegian Subsea support does not solve the issue, an RMA must be issued by Norwegian Subsea before the MRU can be sent for repair.

Troubleshooting

Please see the MRU Configuration Software manual for how to troubleshoot the MRU.

Norwegian Subsea was founded in 2014. Today, we are a fast-growing supplier of motion sensors to customers worldwide. We deliver motion sensors to satisfied customers in industries as diverse as ship motion monitoring, hydrography, green energy and subsea oil production.

Our mission is to create better and more affordable motion sensors for users in marine, land and subsea industries. We do this by combining advanced sensor fusion algorithms with high quality hardware and the latest MEMS sensors. Our sensors are thoroughly put to test in state-of-the-art labs as well as in the field.

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