Norwegian Subsea

Accurate Motion Measurements in Real Sea Conditions

Motion Reference Units

High performance, Affordable and Robust

MRU Compact

MRU Marine

MRU Subsea

MRU Ex

Norwegian Subsea

Table of Contents

Our advantages 4
Product overview 5
Applications 6
MRU Compact 8
MRU Marine 9
MRU Subsea 10
MRU Ex 11
MRU Specifications 12
ACC Ultra-Low-Noise accelerometer 13
Validated in real sea conditions 14
High accuracy, easy to use and no maintenance 16
About us 17
Selected customer references 18

Our advantages

High Accuracy

An MRU from Norwegian Subsea has robust and high-performance motion measurements even in irregular motions and during horizontal accelerations.

Other MRUs may perform well in regular motions, such as in single frequency sine wave motion in lab conditions, but a Norwegian Subsea MRU gives you the performance you need in real sea conditions.

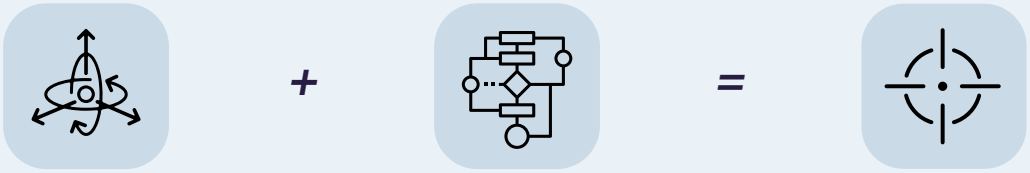
Affordable

High performance in all conditions at affordable prices set the Norwegian Subsea MRUs apart from the competition.

Easy to use

Our small and lightweight MRUs, with flexible cable options, are easy to install and come with free web browser configuration software for effortless integration into your system.

How do we achieve this?



MEMS sensors
Advances in MEMS technology gyroscopes and accelerometers enable new high accuracy sensors at low cost

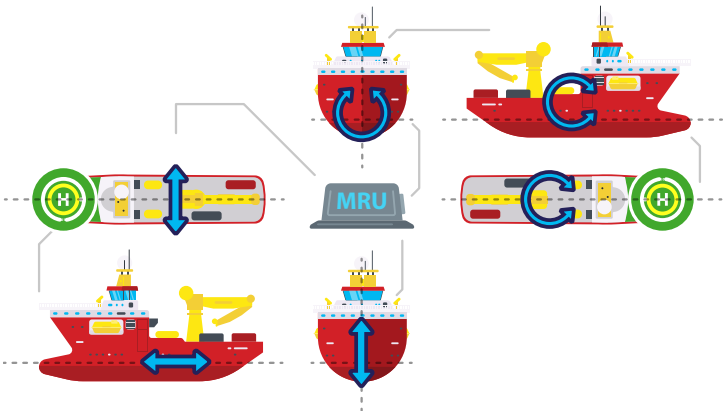
Sensor Fusion Algorithms
Our unique advanced sensor fusion algorithms get the most out of the best available sensors to provide great results under realistic circumstances

The Result: High Accuracy at low cost
High Accuracy in Real Sea Conditions

What is a Motion Reference Unit?

Motion Reference Units designed for your needs
A Motion Reference Unit (MRU) is a self-contained sensor that measures motion in all 6 degrees of freedom (DoF): Roll, Pitch, Yaw, Surge, Sway, and Heave. The 6 DoF positions, velocities and accelerations are measured by the MRU using high-end gyroscopes and accelerometers together with advanced sensor fusion algorithms.

An MRU has high accuracy Roll & Pitch measurements, and measures oscillatory Heave, Surge and Sway motions for wave periods at sea. Linear motions with very long periods, or steps, cannot be measured by an MRU as it assumes a 0 mean heave position.



Product overview

The Norwegian Subsea range of MRUs covers most marine and subsea applications.

The Compact, Marine, Subsea and Ex models have different mechanical and electrical interfaces suitable for your environment, whether installation is in a cabinet, on deck or at the bottom of the ocean.

Each model is available in the 3000, 6000 and 9000 series, to accommodate different accuracy requirements. All MRU models are available in the inclinometer/VRU version if you only need attitude measurements (Roll & Pitch).

All Norwegian Subsea sensors can be mounted in any position.

MRU Compact

Usage area
IP65

Heave accuracy
5.0 cm or 5.0 %

Roll & Pitch accuracy

3000 ± 0.05°
6000 ± 0.02°
9000 ± 0.01°

Connectors
RJ45 or RJ50

MRU Marine

Usage area
On deck, 50 m depth

Heave accuracy
5.0 cm or 5.0 %

Roll & Pitch accuracy

3000 ± 0.05°
6000 ± 0.02°
9000 ± 0.01°

Connectors
Lemo or Subconn

MRU Subsea

Usage area
6000 m depth

Heave accuracy
5.0 cm or 5.0 %

Roll & Pitch accuracy

3000 ± 0.05°
6000 ± 0.02°
9000 ± 0.01°

Connectors
Subconn

MRU Ex

Usage area
Hazardous areas

Heave accuracy
5.0 cm or 5.0 %

Roll & Pitch accuracy

3000 ± 0.05°
6000 ± 0.02°
9000 ± 0.01°

Connectors
Pigtail cable

Which series should I choose?

This depends on your application, here are some general guidelines.

3000

The 3000 series, with 0.05° accuracy in Roll & Pitch, is ideal for most ***monitoring applications*** where the main purpose is to collect motion data for analysis or decision making. This model is also suitable for some control applications, such as AHC for smaller vessels with short lever arms to the remote monitoring points.

6000

The 6000 series, with 0.02° accuracy in Roll & Pitch, is our most versatile MRU due to its high accuracy and is suitable for most applications. This is the recommended MRU for most ***control applications*** such as AHC and winch control.

9000

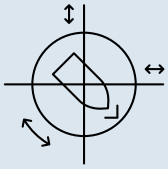
The 9000 series, with 0.01° accuracy in Roll & Pitch is our most accurate MRU. We recommend this MRU for ***sensor compensation applications*** such as hydrography, and for ***advanced control applications*** such as 3D motion compensated gangways.

Applications

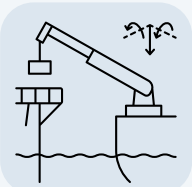
Norwegian Subsea Motion Reference Units (MRUs) can be used in a variety of Marine, Subsea and Wind Energy applications.

Marine Operations

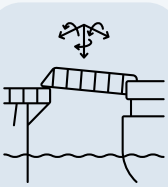
Ship Monitoring
Prevent Cargo damage and Container loss.
Add accurate ship motion measurements for safe and optimal vessel operations.



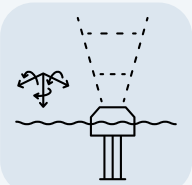
Dynamic Positioning
Motion compensation of GNSS antenna and other position reference systems.
Easy MRU retrofit and no recalibration.



Active Heave Compensation
Heave compensation of cranes, LARS and winches requires accurate heave measurements in Real sea conditions.

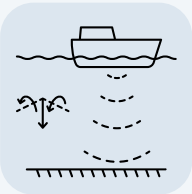


Gangway
3D motion compensated gangways require accurate 6DoF motion measurements at all times in Real sea conditions.

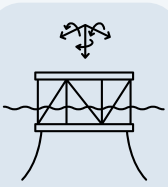


Wind Lidar Buoys
High quality wind data requires accurate heave, roll and pitch measurements in Real sea conditions.

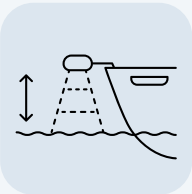
Helideck Monitoring
Accurate Heave velocity and roll and pitch measurements in Real sea conditions.
No recalibration and flawless operation in any temperature.



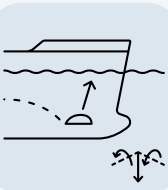
Hydrography
Accurate motion compensation of Sonars, ensuring high-quality seafloor maps.
Compact and cost-effective MRU.



Offshore Fish Farms
Condition monitoring of Offshore fish farms.
Reduce risk with Accurate motion measurements.

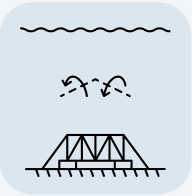


Wave Radar
Accurate heave measurements to compensate downward looking wave radars. Compact and no recalibration required.

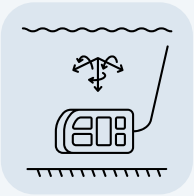


Stabilizing Fins
Roll damping systems and Stabilizing fins need accurate and affordable roll measurements in Real sea conditions.

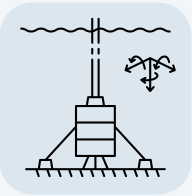
Subsea



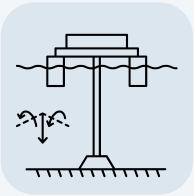
Subsea Surveys
Precise subsea tilt (roll & pitch) measurements at affordable prices.



ROV/AUV
Reliable and accurate motion measurements for navigation and payload sensor compensation.



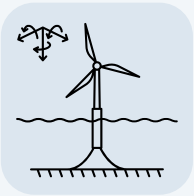
BOP Monitoring
Accurate 6DoF motion and vibration measurements to monitor BOP and other subsea structures.



Riser Monitoring
Topside motion sensors as input to the riser digital twin or subsea sensors attached to the riser.

Wind Energy

Bottom Fixed Offshore Wind
Turbine tower roll & pitch measurements as input to a wind tower digital twin model.
Ultra-low-noise accelerometer for structural monitoring.



Floating Wind Turbine Control
Accurate MRU measurements used in active pitch control to limit wave induced motions.

Floating Wind Base Motion Monitoring
Structural monitoring of the floating wind base and mooring system using MRUs and Ultra-low-noise accelerometers.

MRU Compact

Compact
The MRU Compact is compact, dust and splash proof and is suitable for mounting indoors or inside a control box.

Plug & Play
The MRU Compact is plug & play due to the standard RJ 45 ether-net connector with passive power over ethernet (PoE). This makes cabling very fast & easy. The MRU comes with a wide range of standard and customized data protocols. Integration is never an issue.

Heave accuracy
5.0 cm or 5.0 %

Available models

3000	6000	9000
± 0.05°	± 0.02°	± 0.01°

Roll & Pitch accuracy

	RJ45	*RJ50*
Environment	IP65	
Connector	RJ45 with POE	10-pin RJ50 with POE
Ports	Ethernet	Ethernet & RS-232 / Ethernet & RS-485 / Ethernet & PPS
Communication	Ethernet: UDP, Modbus TCP, Ethernet/IP	
Weight	0.55 kg	
Footprint (L × B x H)	12.0 cm × 5.7 cm × 5.3 cm	
Enclosure material	Anodized aluminum 6061-T6	
Operating temperature range	-40 to +85 degrees Celsius	
Options	Magnetic Heading, Inclinometer / VRU version	

What is passive Power over Ethernet?
Passive Power over Ethernet means that the MRU Compact is powered through the Ethernet cable with 9 – 36 V DC. Please note that active PoE switches do not work with passive PoE devices like the MRU Compact.

We recommend using a PoE splitter / injector to power the MRU Compact.

Versions and Options
The MRU is also available in an inclinometer / VRU version without Heave/Surge/Sway output, which gives the same Roll & Pitch performance as the MRU, also in irregular coupled motions.

MRU Marine

Versatile placement
The MRU Marine can be used on deck or under water in up to 50 m water depth (MRU Marine SW). The MRU Marine comes with ethernet, RS232, RS485 and PPS time synchronization ports for easy communication with your system. Connection through custom length pig-tail cables with or without junction box.

Versatile connectivity
Industrial communication protocols (Modbus TCP, Ethernet/IP, Modbus RTU, etc.) can be used for PLC interfacing. The MRU comes with a wide range of standard and customized data protocols in ASCII or binary formats.

Heave accuracy
5.0 cm or 5.0 %

Available models

3000	6000	9000
± 0.05°	± 0.02°	± 0.01°

Roll & Pitch accuracy

	Marine	*Marine SW*	
Environment	IP68	50 m water depth	
Connector	Marine 16 pin male connector	8 pin SubConn MCBH8M	16 pin SubConn MCBH16M
Ports	Ethernet, RS-232, RS-485, PPS	Ethernet & RS-232 / Ethernet & 2-wire RS-485	Ethernet, RS-232, RS-485,PPS
Communication	Ethernet: UDP, Modbus TCP, Ethernet/IP. RS-485: Modbus RTU		
Weight	1.2 kg		
Footprint (L × B x H)	15.4 cm × 8.6 cm × 6.7 cm		
Enclosure material	Anodized aluminum 6061-T6		
Operating temperature range	-40 to +85 degrees Celsius		
Options	Magnetic Heading, Inclinometer / VRU version		

Analog outputs
Analog outputs are available using the analog output junction box. Configurable +/-10 V and 4-20 mA output signals are available.

Retrofit
Norwegian Subsea MRUs are often used as a drop-in replacement of older MRUs (retrofit) on Dynamic Positioning, Helideck Monitoring and Active Heave Compensation systems. For these applications, normally no recalibration is required.

Versions and Options
The MRU is also available in an inclinometer / VRU version without Heave/Surge/Sway output, which gives the same Roll & Pitch performance as the MRU, also in irregular coupled motions.

MRU Subsea

6000 m water depth rating
The MRU Subsea is ideal for use in subsea applications such as riser motion monitoring, ROV/ AUV or subsea surveys. The titanium casing is very compact and depth-rated to 6000 m! The small size and footprint make it easy to install almost anywhere. It is equipped with a Subconn wet-mate-able connector.

The Subsea Inclinometer version is popular due to its small size, high accuracy, and affordability.

All Norwegian Subsea sensors can be mounted in any position.

Heave accuracy
5.0 cm or 5.0 %

Available models

3000	6000	9000
± 0.05°	± 0.02°	± 0.01°

Roll & Pitch accuracy

	Subsea
Environment	6000 m water depth
Connector	8-pin SubConn FCR1508M
Ports	Ethernet & RS-232 Ethernet & 2-wire RS-485
Communication	Ethernet: UDP, Modbus TCP, Ethernet/IP
Weight	1.6 kg
Footprint (L × B x H)	7.6 cm × 7.6 cm × 16.5 cm
Enclosure material	Titanium housing
Operating temperature range	-40 to +70 degrees Celsius
Options	Magnetic Heading, Inclinometer / VRU version

Easy interfacing
The MRU Subsea comes in a 6000 m rated titanium housing with ethernet and serial ports for easy communication with your system. Industrial communication protocols can be used for PLC interfacing. The MRU comes with a wide range of standard and customized ASCII or binary data protocols. The MRU can be delivered with custom length cables with Subconn 8 pin connectors.

Versions and Options
The MRU is also available in an inclinometer / VRU version without Heave/Surge/Sway output, which gives the same Roll & Pitch performance as the MRU, also in irregular coupled motions.

MRU Ex

For Hazardous Areas
The Ex MRU is a cost-effective solution for hazardous areas. Easy to install with pigtail cable and including all certificates and documentation.

- Ex certificate II 2 G Ex d IIC Gb
- Compact and cost effective unit
- Stainless steel unit
- Ethernet & serial line

Versions and options
- Including pigtail cable in custom lengths

Heave accuracy
5.0 cm or 5.0 %

Available models

3000	6000	9000
± 0.05°	± 0.02°	± 0.01°

Roll & Pitch accuracy

	MRU Ex
Environment	II 2 G Ex d IIC Gb
Connector	Pigtail cable – 8 wires 10 m / 25 m / custom length
Ports	Ethernet & RS-232 Ethernet & 2-wire RS-485
Communication	Ethernet: UDP, Modbus TCP, Ethernet/IP. RS-485: Modbus RTU
Weight	15 kg (excluding cable)
Footprint (L × B x H)	19 cm ×19 cm × 20.5 cm
Enclosure material	AISI 316L
Operating temperature range	-20 to +40 degrees Celsius
Options	Magnetic Heading, Inclinometer / VRU version

Versions and Options
The MRU is also available in an inclinometer / VRU version without Heave/Surge/Sway output, which gives the same Roll & Pitch performance as the MRU, also in irregular coupled motions.

MRU Specifications

	3000	6000	9000	*Remarks*
		Performance		
Roll & Pitch	± 0.05°	± 0.02°	± 0.01°	RMS (dynamic)
Heave (real-time)	5.0 cm or 5.0 %	5.0 cm or 5.0 %	5.0 cm or 5.0 %	Whichever is greater for 0 to 25 s periods
Heading (optional)	± 0.5°	± 0.5°	± 0.5°	Magnetic heading
		Range		
Rotation speed	± 150°/s	± 450°/s	± 450°/s	-
Acceleration	± 3 g	± 4 g	± 10 g	-
Heave	± 50 m	± 50 m	± 50 m	-
Roll/Pitch/Yaw	± 180° / ± 90° / ± 360°			-
Output frequency	0–100 Hz	0–100 Hz	0–100 Hz	Adjustable output frequencies
		Gyro output		
Scale factor error	0.2% max/min	0.2% max/min	0.2% max/min	-
Angular rate noise	0.05°/s RMS	0.025°/s RMS	0.015°/s RMS	-
		Acceleration output		
Acceleration noise	0.0025 m/s^2 RMS	0.002 m/s^2 RMS	0.0015 m/s^2 RMS	-
Acceleration accuracy	0.01 m/s^2 RMS	0.01 m/s^2 RMS	0.01 m/s^2 RMS	-
		Power & Interface		
Power consumption	6 W			-
Supply voltage	9-36 V DC (24 V nominal)			-
Internal storage	32 GB			-
Data protocols	Custom NMEA, ASCII and Binary, Atlas, Gyrocompas 1, Ifremer Victor, MDL, NORSUB 1-8, Simrad EM 3000, SMCA, SMCC, Tokimek PTVG, RDI ADCP, TSS1 and many more. Please refer to user manual.			-
Configuration protocols	GET/SET through telnet or serial port and web server based configuration SW			-
Time synchronization	Sync to host PC, Sync to NTP server, Sync to PPS			-

	3000	6000	9000	*Remarks*
		Environmental specifications		
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			-

ACC Ultra-Low-Noise accelerometer

The ACC is high performance, ultra-low noise, and affordable. The ACC use state-of-the-art MEMS technology 3-axis accelerometers. The exceptional low noise density, velocity random walk (VRW) and bias instability make this accelerometer ideal for high demanding vibration monitoring applications.

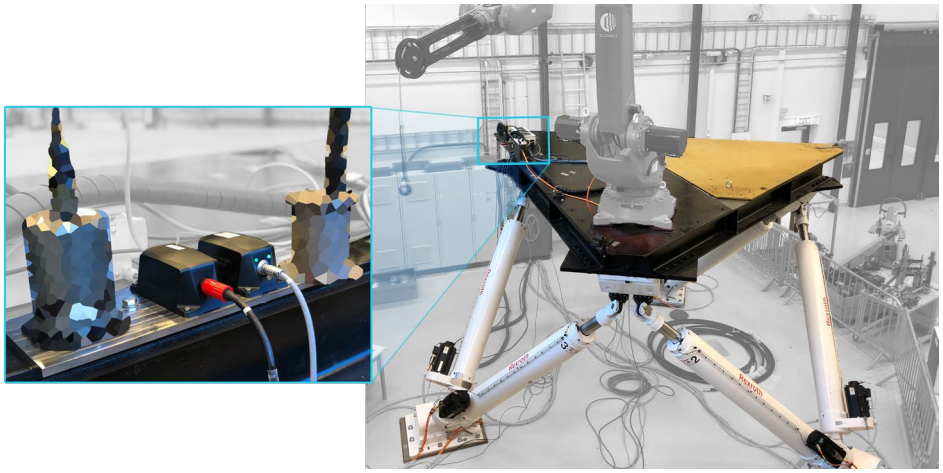
The ACC can be mounted in a dry area (ACC Compact & ACC Marine), on a floating substructure in up to 50 m water depth (ACC Marine SW) and subsea up to 6000m (ACC Subsea) and offers a very cost-effective solution for demanding vibration monitoring applications.

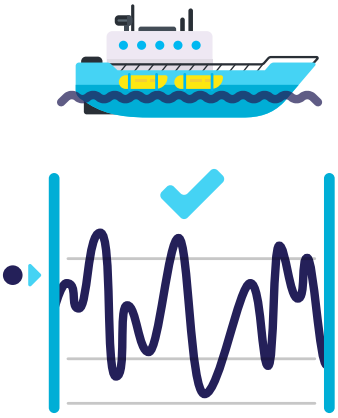
Developed for monitoring of floating offshore wind platforms, offshore structures and subsea templates or any other structure with demanding vibration monitoring requirements. The accelerometer can be used in real time applications to monitor the integrity of the installation, as an input to a digital twin model of the structure or as an input for fatigue life analysis.

	ACC *Ultra-Low-Noise Accelerometer*
Range	± 15 g
Scale factor	6.00E-05 mg/LSB
Misalignment axis to axis	0.1 degs
Nonlinearity	0.03 %FS
Initial error	2 mg
Bias repeatability	3 mg
In run bias instability	0.2 µg
Velocity random walk (VRW)	0.00012 m/s/sqrt(h)
Noise density	0.7 µg/sqrt(Hz) RMS
Frequency bandwidth 3dB	400 Hz

Validated in real sea conditions

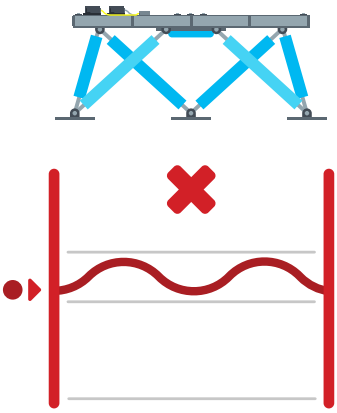
Tested in real sea conditions
Many suppliers tend to present test data solely for simple regular motions observed in laboratory conditions. Unfortunately, vessels experience irregular and coupled motions at sea. While most sensors perform well in sine wave motion, only a select few excel in irregular sea conditions. Our MRUs stand out as they consistently deliver exceptional performance across all conditions.





Real Sea condtions

3rd party test facility	Motion Lab, University of Agder Grimstad (Norway)
Motion reference platform	Bosch Rexroth eMotion-8000 hexapod with laser position measurements
Tested MRU	MRU Marine 6000
Tested scenarios	Regular and irregular sea-state conditions Based on real sea conditions Single and multi-axis coupled motions Motion periods from 3 to 25 seconds



Lab conditions

This test verifies that the Norwegian Subsea MRUs meet the specifications and demonstrates typical MRU performance in realistic sea conditions.

Two Norwegian Subsea MRUs were mounted on top of a hexapod and the MRU output was compared to the reference measurements from the hexapod (truth).

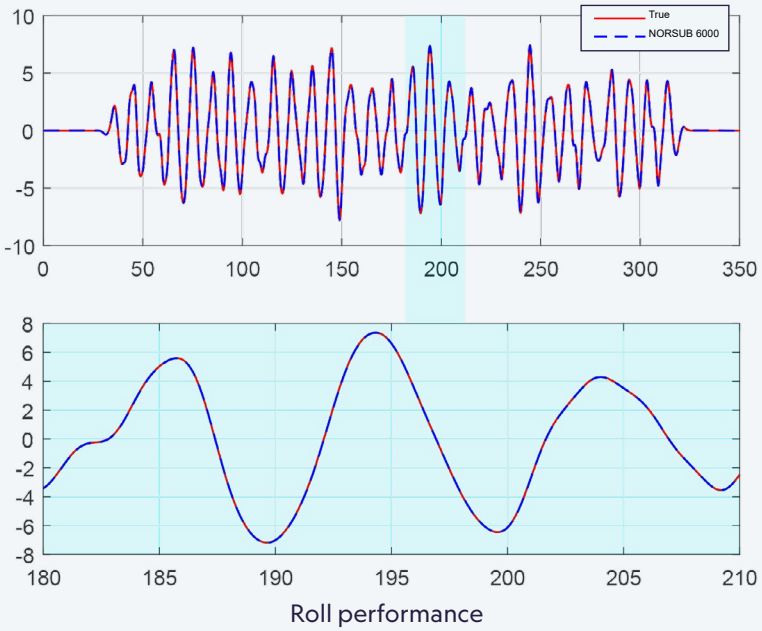
Both regular and irregular motion patterns were tested, with periods from 3 to 25 s and amplitudes from 0.1 to 0.8 m / 0 to 10 degrees. All degrees of freedom (DOFs) were tested individually and combined (coupled motions)

Combined roll and pitch test

Irregular motion profile with significant amplitude of 5 degrees and peak period of 10 s.

The test starts and stops with the MRU in the horizontal position (0 degrees).

The roll and pitch RMS error is calculated over the entire test duration of 350 s.



Roll performance

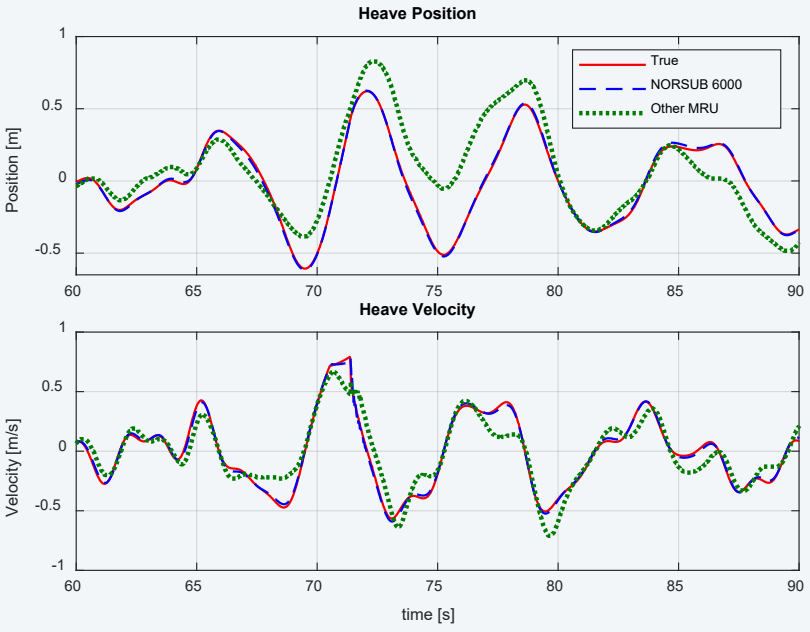
6000	*Datasheet Specs*	*Test Results*	*Approved*
Roll	0.02°	0.016°	✓
Pitch	0.02°	0.014°	✓

Heave Test

The heave test has an irregular motion profile with a significant amplitude of 0.5 m and peak period of 7 s. The heave filter uses automatic estimation of significant amplitude and peak period to optimize the performance.

The heave RMS error is calculated over the entire test duration of 250s. As you can see, the results are very accurate.

For reference, an MRU from another brand, having the same Heave accuracy specifications, was included in the tests. This MRU performed well in sine waves, but in real sea conditions, this MRU was not able to provide useful results.

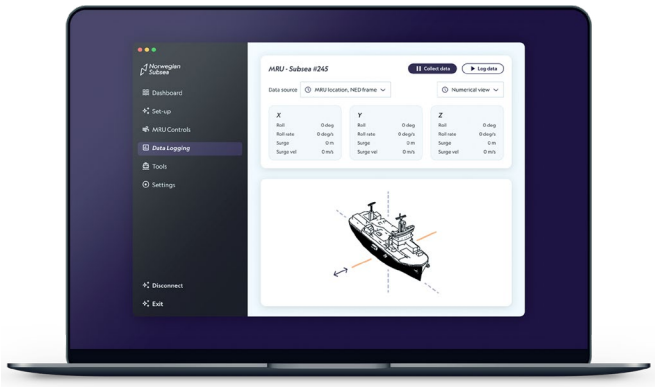


Heave position and velocity

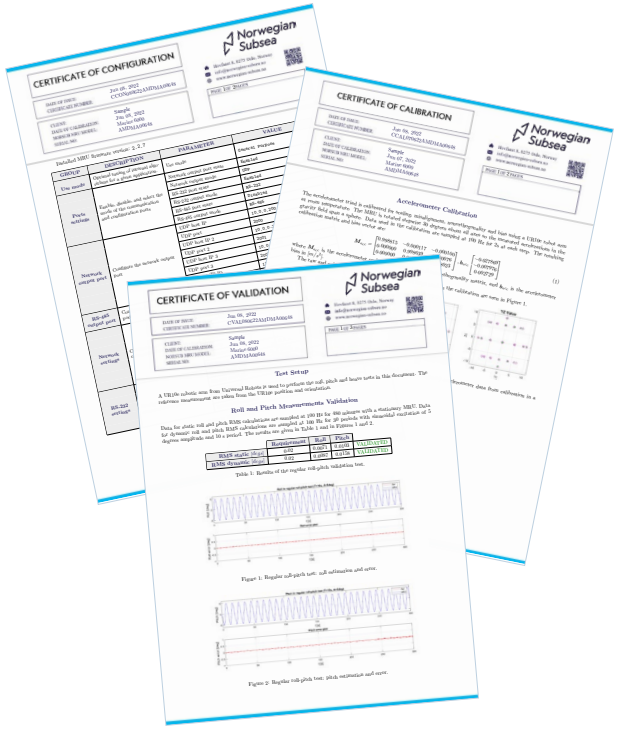
6000	*Datasheet Specs*	*Test Results*	*Approved*
Heave	0.05 m or 5.0%	0.017 m	✓
Heave Velocity	0.02 m/s or 3.0%	0.011 m/s	✓

High accuracy, easy to use and no maintenance

User friendly configuration
All MRUs and ACCs can be easily configured using the web based configurator. Here you can configure the communication ports, customize the output data protocol, configure the sensor installation parameters, or check the internal status. The software can also update the MRU firmware, log the sensor data to file, and plot output data. The configuration SW runs straight from the sensor, no downloads required.



Every sensor is calibrated, tested and validated
Every MRU is delivered with Configuration, Calibration, and Validation Certificates. All MEMS sensors are temperature calibrated so the sensor temperature does not influence the results. Every unit is calibrated and validated independently through a systematic sequence of rigorous tests in our labs.



No recalibration
The calibration certificate is valid for 4 years and full product specifications are maintained in this period under normal operating conditions. A slightly lower specification for Roll & Pitch is maintained during the lifetime of the sensor. For most applications, therefore no recalibration is required during the lifetime of the sensor.

Roll / pitch accuracy

	With recalibration	*Without recalibration*
3000	0.05°	0.1°
6000	0.02°	0.05°
9000	0.01°	0.035°

Retrofit of existing MRU
Many vessels have MRUs installed that need frequent recalibration and repair. Or are end-of-life since support and recalibration services are no longer available. For most applications, our MRUs do not require recalibration during its lifetime. This is because our MRUs use the latest generation high-end MEMS sensors that are extremely stable.

Typical applications for retrofit solution
Any application that uses a motion reference unit should consider our retrofit solution. But especially applications such as AHC, dynamic positioning and helideck motion monitoring can really benefit from the retrofit solution as you can switch to an affordable MRU that does not require recalibration.

Export license
Our MRUs do not require an export license as they are not on the list of dual use items as per EU regulations.

About us

Norwegian Subsea is a leading provider of high-performance Motion Reference Units (MRU) and motion sensors for marine, subsea and offshore wind applications. Accurate and reliable measurements for control and monitoring purposes.

Since its establishment in 2014, Norwegian Subsea has rapidly emerged as a trusted global supplier of motion sensors. Serving diverse industries such as ship motion monitoring, hydrography, green energy, and subsea oil production, our satisfied customers testify to the reliability and quality of our solutions.

Our mission is to develop exceptional and cost-effective motion sensors tailored for the marine, land, and subsea sectors. Through the fusion of advanced sensor algorithms, state-of-the-art MEMS sensors, and top-notch hardware, we create superior products. Rigorous testing in cutting-edge laboratories and real-world environments ensures the performance and dependability of our sensors.

With our headquarters situated in Oslo, Norway, Norwegian Subsea remains dedicated to providing innovative solutions that address the evolving needs of our customers in motion monitoring and beyond.

Norwegian Subsea is headquartered at Harbitzalléen 2A, 0275 Oslo, Norway.

Contact information

General Enquiries
info@norwegian-subsea.no
(+47) 406 35 500

Sales Enquiries
sales@norwegian-subsea.no
(+47) 406 35 200

Technical Support
support@norwegian-subsea.no

Selected customer references

Helideck Monitoring Systems

ShoreConnection · SWIRE · OBSERVATOR group · wise GROUP · nevis TECHNOLOGY

Floating wind lidar buoys

비갠 · Blue Aspirations · CLS COLLECTE LOCALISATION SATELLITES · FUGRO · GEPS TECHNO · SEATECH · WOODS HOLE GROUP

Motion Compensation of cranes, gangways, LARS & winches

Allseas · AXTech · Cranemaster · ENTEC · Hydrauvision Driven by technology · MOTUS · OCEANEERING · PALFINGER · SH GROUP · SMST · safeLINK · SEAONICS · SEAQUALIZE · SERVI GROUP · UPTIME · VHT VAN HALTEREN TECHNOLOGIES · Zbridge Offshore Access Solutions · ULMATEC

Hydrography

- Our MRUs are used with the following sonar systems

GeoAcoustics · R2SONIC · TELEDYNE RESON · wassp MULTIBEAM SEE IT ALL

Dynamic positioning

- Our MRUs are used with the following DP systems

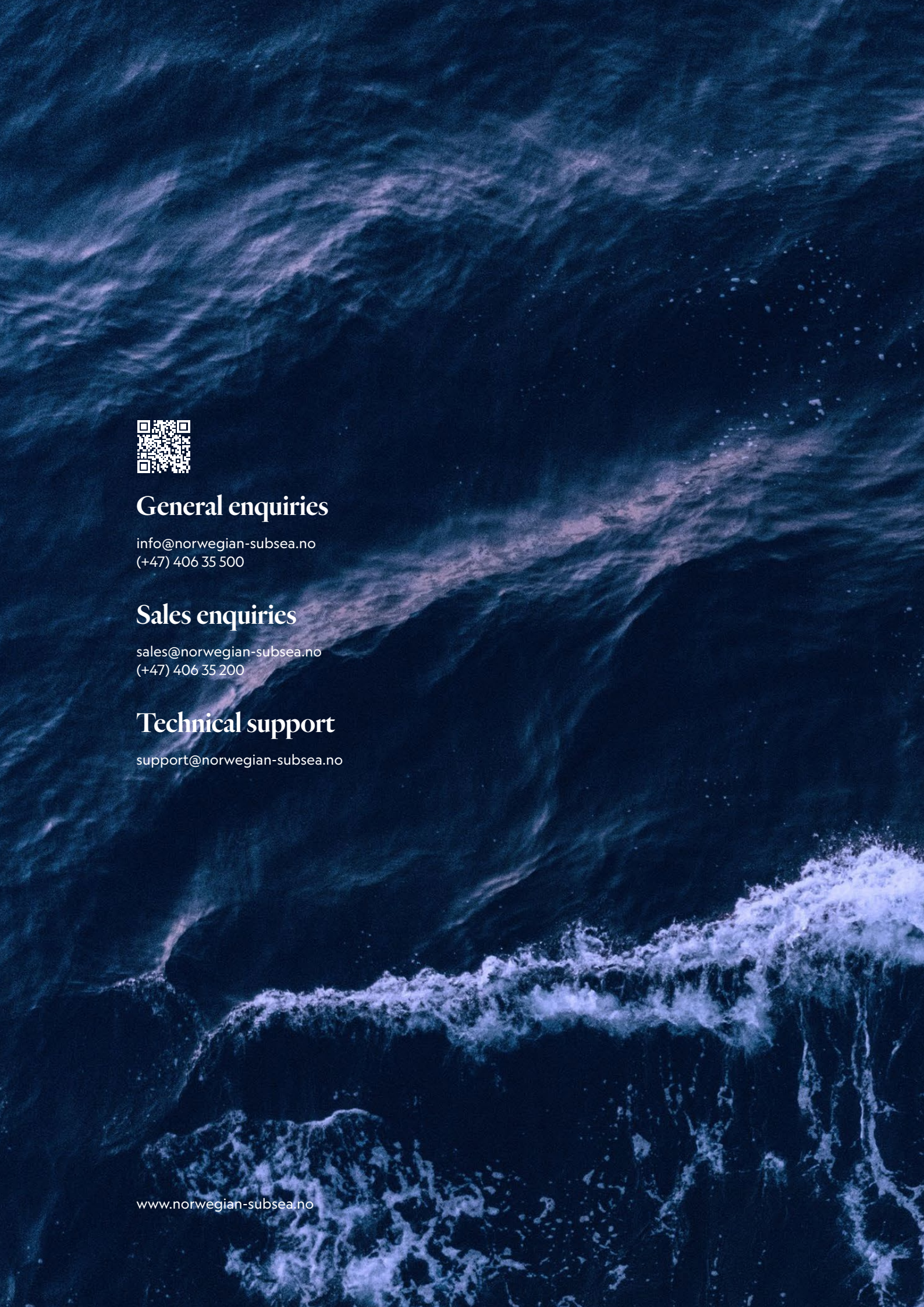
BRUNVOLL · MT · KONGSBERG

Wave radar

MIROS · RADAC

Other references

ARGUS · Baker Hughes · National Research Council of Italy · core marine · FORCE TECHNOLOGY · HITEC PRODUCTS · HÖEGH LNG · IHC · Jan De Nul GROUP · LIGHT STRUCTURES Passion for Monitoring · NIOT · pliant OFFSHORE · RN · SAIPEM · SINTEF · SUBSEA CONNECT · OSM Thome · YOKOGAWA



General enquiries

info@norwegian-subsea.no
(+47) 406 35 500

Sales enquiries

sales@norwegian-subsea.no
(+47) 406 35 200

Technical support

support@norwegian-subsea.no

www.norwegian-subsea.no