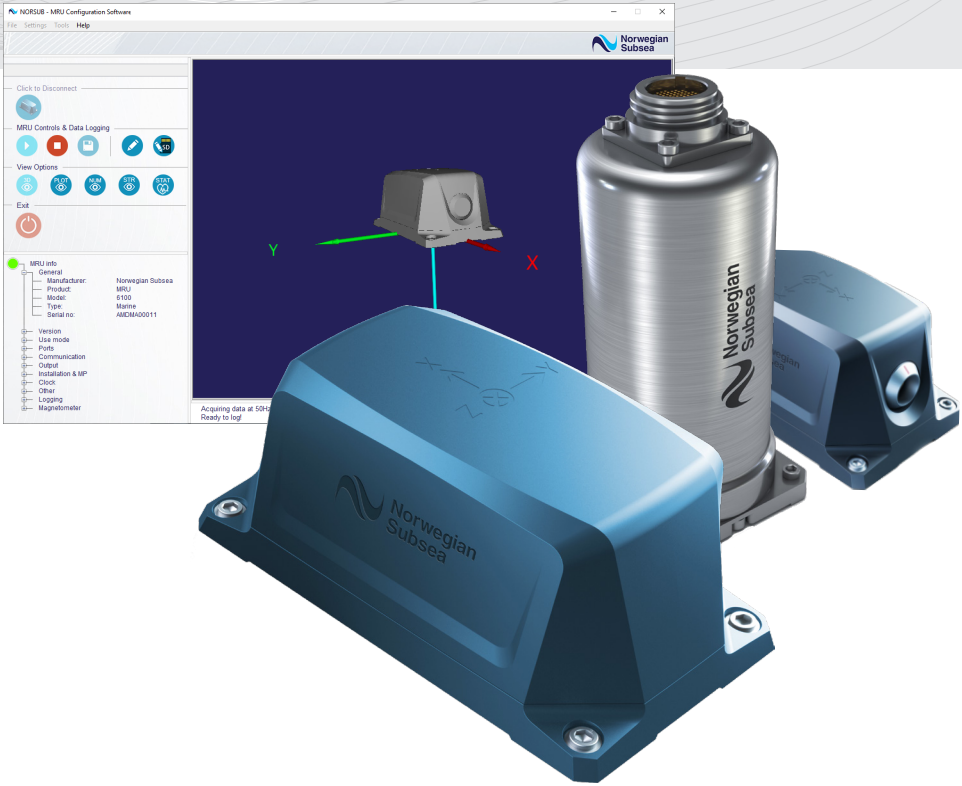
MOTION REFERENCE UNIT

SOFTWARE

Norwegian Subsea

CONFIGURATION SOFTWARE USER MANUAL



USER FRIENDLY & INTUITIVE

MRU CONFIGURATION SOFTWARE

MRU Configuration User Manual Version 1.6.0

Document number: NORSUB-CSUM-1.6.0

Intro

This user manual explains:

- how to connect and interface the MRU.
- how to install and use the MRU configuration software, versions 5.x.x.

In this manual the *italic style* is used to identify control and indicator fields in the software, while the `typewriter style` is used to identify terminal commands, paths or keyboard shortcuts. The quotation marks " " are used to refer to other section of this manual or controls in the Window Explorer windows.

The graphics of different versions of the software may sightly differ from the ones presented in this manual.

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.

NOTE

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

	MRU MARINE USER MANUAL (NORSUB-MMUM-x.x.x) REVISION HISTORY		
	VERSION	CODE	NOTES
LEGACY	1.4.0	NORSUB-MMUM-1.4.0	
LEGACY	1.5.0	NORSUB-MMUM-1.5.0	Updated to MRU Configuration Software ver. 5.7.7
CURRENT	1.6.0	NORSUB-MMUM-1.6.0	Updated to MRU Configuration Software ver. 5.8.6 - Updated figures to reflect new Configuration Software - Updated new configuration parameters (enable magnetometer) - Updated magnetometer calibration interface and instructions - Added new protocols NORSUB6g, SMCCg - Added new variables 191 to 193, 234 to 236, 334 to 336, 434 to 436, 506 to 510, 615 to 620, 1110 to 1115, 1201 to 1203, 1304 to 1312, 1401 to 1402 - Added magnetometer enabled parameter

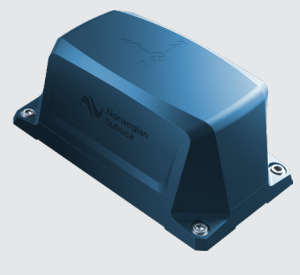
NOTE

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

ITEMS CHECK LIST

The shipment contains the following items (*):

1. 1 x Marine, Subsea, eMRU or OEM NORSUB MRU;
2. 1 x Standard marine or subsea cable (10 m);
3. 1 x Junction box;
4. 1 x Power supply;
5. 1 x USB flash drive containing the NORSUB MRU Configuration Software;
6. 1 x Configuration Software user manual and 1 x MRU user manual.



1. MRU

NORSUB Marine, Subsea, eMRU or OEM MRU

2. CABLE

Standard marine or subsea cable, 10m (**).

3. JUNCTION BOX

Junction box to connect the MRU to a system (***).

4. POWER SUPPLY

Standard 24V power supply (****).

5. USB FLASH DRIVE

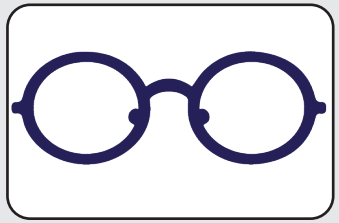
USB drive with the NORSUB MRU Configuration Software.

6. USER MANUALS

Configuration Software user manual and MRU user manual.

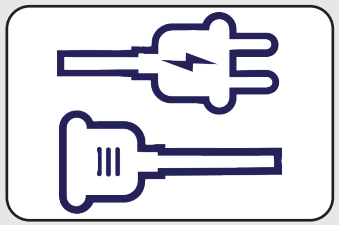
(*) The shipment content may vary based on the purchase agreement.
(**) Only included for Marine and Subsea MRUs.
(***) Only included for Marine MRUs.
(****) Only included with Marine MRUs and eMRUs.

QUICK START GUIDE



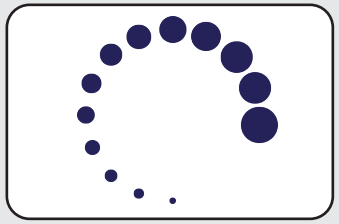
1. CHECK ITEMS

Verify that all the items listed under the “Items check list” are in the shipment (see previous page).



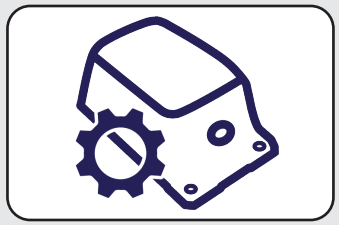
2. CONNECT THE MRU

Connect the MRU to a PC through an Ethernet port with an Ethernet cable, or through an RS-232 or RS-485 serial port with an RS-232 or RS-485 serial cable.



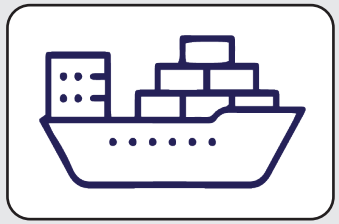
3. INSTALL THE SOFTWARE

Install the NORSUB MRU Configuration Software by double clicking on the installer file (`setup.exe`) contained in the USB memory stick.



4. CONFIGURE THE MRU

Run the NORSUB MRU Configuration Software to configure the MRU.



5. INSTALL THE MRU

Install the configured MRU at the desired location.

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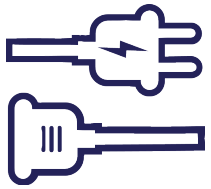
1. SYSTEM SET-UP



Connecting the Devices

The system set-up is summarized in the following steps (*):

- Connect the female connector of the MRU marine cable to the MRU socket, and its male connector to the junction box round socket.
- Connect the junction box through Ethernet or serial (RS-232/RS-485) to the host-PC by using the dedicated port.
- Connect the power supply to the power port on the junction box. It is suggested to plug the power supply to the power socket last, because this operation will start-up both the junction box and the MRU.

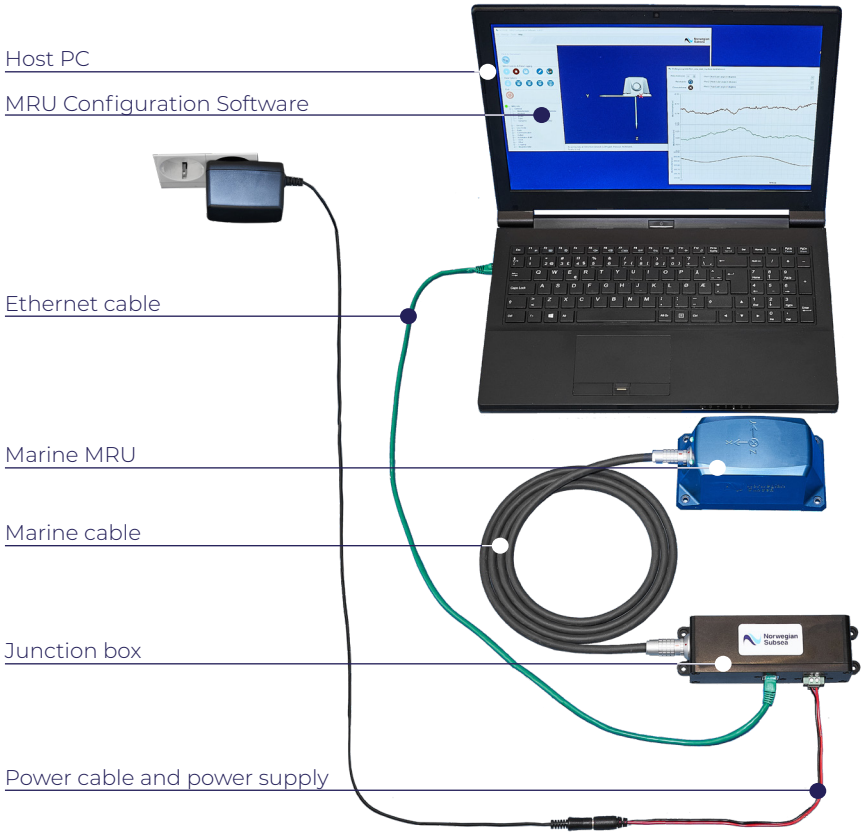


Figure 1 - System set-up (only Ethernet connection and Marine MRU are showed).

(*) This procedure refers to a Marine MRU connected through Ethernet, but it is similar for other MRU models and connection options.

2. SOFTWARE INSTALLATION

General Info and System Requirements

The software helps to perform the following operations:

- Connect to the MRU.
- Configure the MRU.
- Acquire MRU data in the desired format and at the desired rate.
- Log the acquired MRU data.

The software requires a PC with an Ethernet or RS-232 serial port (to connect to the MRU) and a USB port or an active internet connection (to retrieve the Configuration Software files).

The software is supported by Microsoft® Windows® 10 operating system or later versions. The PC should have a minimum of 500MB RAM and 500MB of free hard drive space, plus additional hard drive space for storage of logged data.

The software interface is optimized to be displayed with a resolution of 1280x800 pixels.

Installation Overview

Follow the following steps to install the software:

- Insert the USB memory stick into the PC or download the software folder using the link provided by Norwegian Subsea. Open the NORSUB MRU Configuration Software folder and execute the setup file (setup.exe). A window appears:

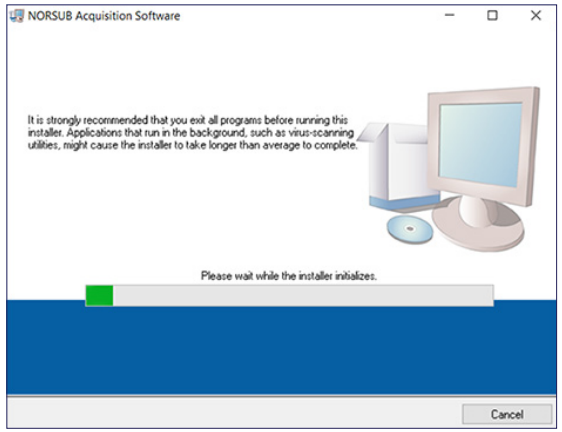


Figure 2 - Initialization of the installation software.

- Set the destination paths for the software and libraries when asked. The default paths are C:\Program Files (x86)\NORSUB Software for the software, and C:\Program Files (x86)\National Instruments for the libraries. Press “Next”.

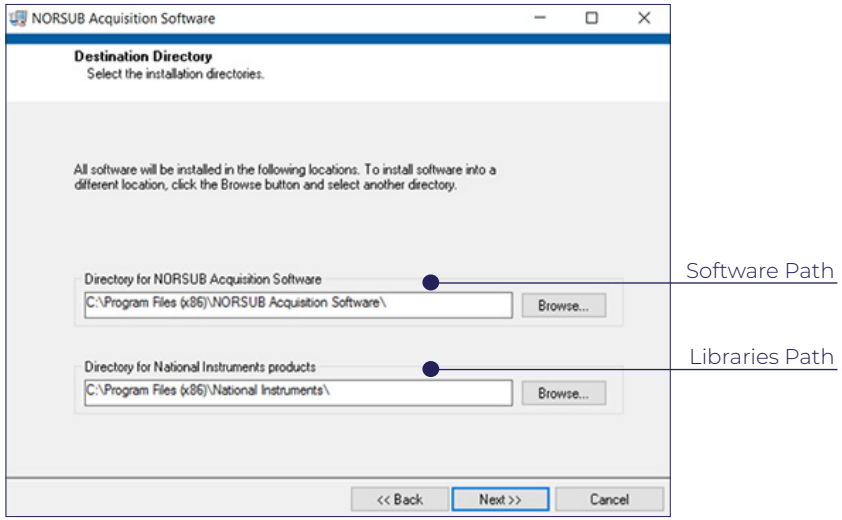


Figure 3 - Set the installation path.

Installation Overview

The software contains National Instruments™ libraries covered by a separate license. Please select “I accept the above 2 License Agreement(s)” and press “Next”.

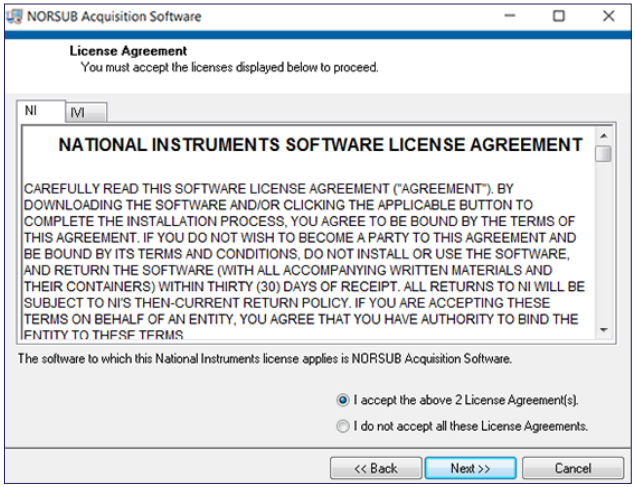


Figure 4 - Software license agreements.

The window shows a summary of software files to install. Click “Next” to start the installation.

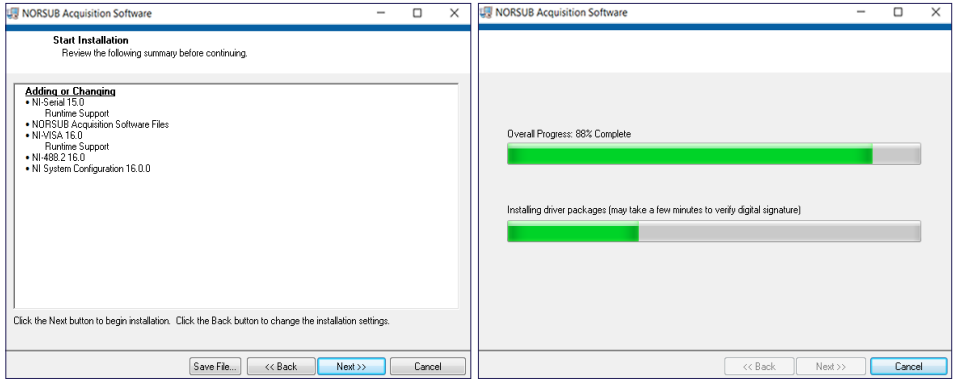


Figure 5 - Software installation process.

RESTART THE PC

Restart the PC after installation to ensure proper functioning of the software.

Set a Static IP Address on the PC

This procedure applies if the MRU is connected through an Ethernet port.

The MRU’s default IP is 10.0.0.50 and its default subnet mask is 255.255.0.0.
The PC IP and subnet mask should be set so that the MRU can be reachable. The PC should have an IP with the following structure: 10.0.xxx.xxx and the following subnet mask: 255.255.0.0 (an IP with the structure 10.0.0.xxx and subnet mask 255.255.255.0 are also admissible).

The PC can not have the same IP as the MRU or any other device connected to the network, since this generates an IP conflict. Please contact your network administrator to select an available IP address to be assigned to the PC.

Follow the following steps to set a new IP address on the PC:

1. Go to “Windows Network and Sharing Settings” and select “Change adapter settings”;
2. Select the Ethernet adapter in use (usually called “Ethernet”);
3. Select “Properties”;
4. From the list, double clock on “Internet Protocol Version 4 (TCP/IPv4)”;
5. Select “Use the following IP address” and insert the new IP address and subnet mask.

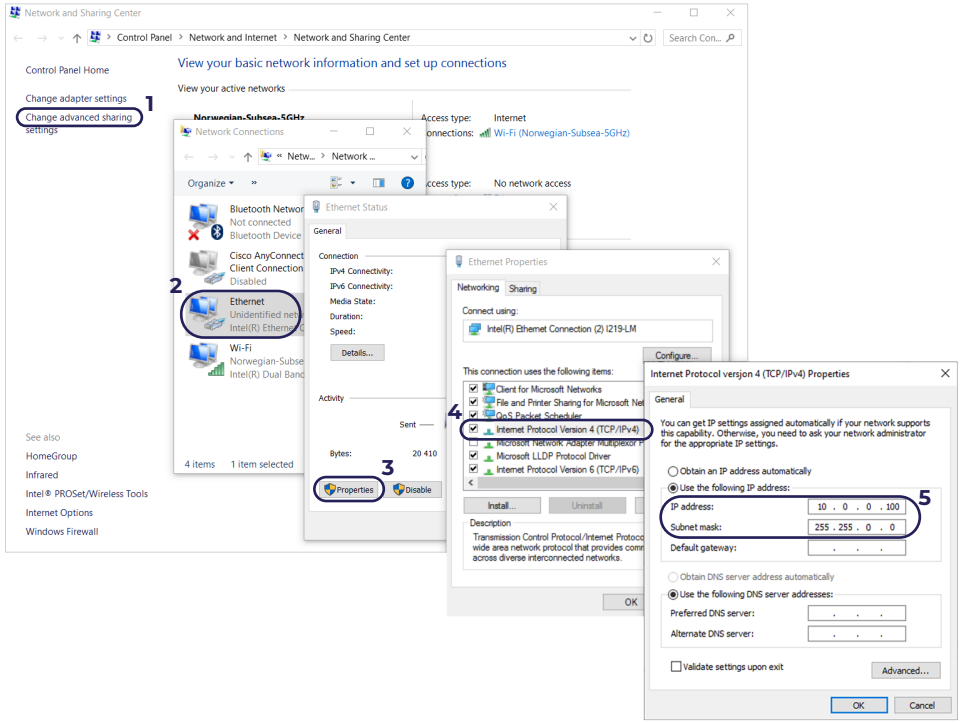


Figure 6 - Procedure to set a static IP address and subnet mask.

Adding a Windows Firewall Exception

To launch the software, double click on the `NORSUB MRU Configuration Software` shortcut on the Desktop or on the Windows Start Menu. Alternatively run the `NORSUB MRU Configuration Software.exe` file from the installation folder `C:\Program Files (x86)\NORSUB Software`.

Windows Firewall will ask to allow communication with the software. Select both the "Private networks" and "Public networks" check-boxes and click on "Allow access".

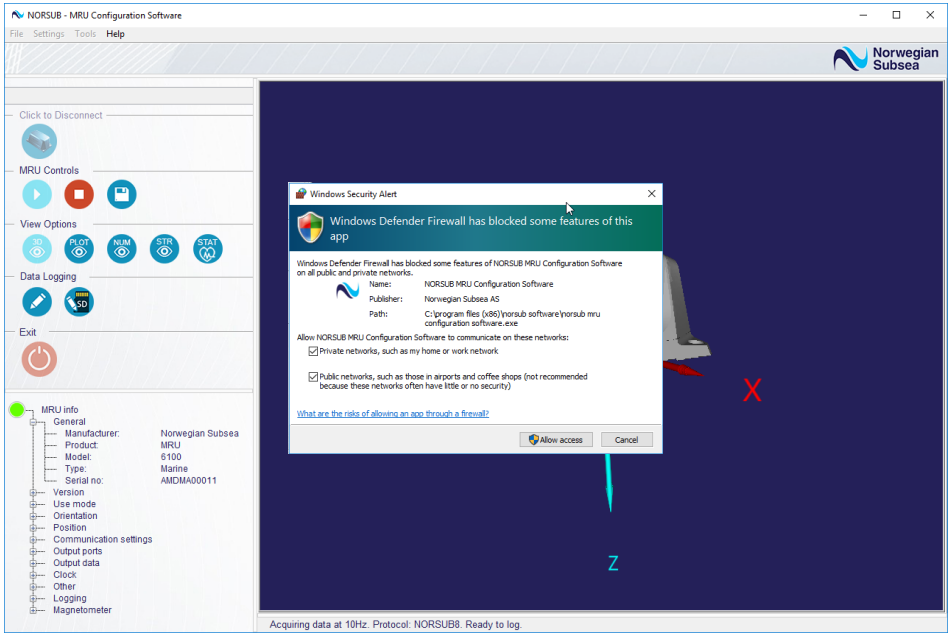


Figure 7 - Windows Firewall access settings.

AVOID IP CONFLICT

Ensure that no other device connected to the network has the same IP address as the MRU and/or the PC. Contact your network administrator if needed.

ANTIVIRUS

Antivirus software may override the Windows Firewall making ineffective the procedure explained in this page. In this case, it may be required to allow the access of the Configuration Software by adding an exception in the antivirus software settings.

SOFTWARE INSTALLATION

Adding a Windows Firewall Exception

The procedure applies when:

- The MRU is connected via Ethernet or wi-fi;
- Instructions in the "Starting the Application" section were followed, but there is still no communication with the MRU;
- The user has not allowed the software to access all the networks as shown in the previous page.

If it is not possible to establish a connection to the MRU, it may be necessary to manually create an exception for the Configuration Software in the Windows Firewall settings by following these steps:

1. Open the start menu and search for "Windows Defender Firewall". This window is also accessible under "System and Security" from the Control Panel.
2. Select "Allow an app or feature through Windows Defender Firewall".
3. Select "NORSUB MRU Configuration Software" and put a check mark for "Private" and "Public" (see Figure 8).
4. (Optional) If "NORSUB MRU Configuration Software" is not in the list, add it by clicking "Allow another app..." (this operation requires administrator rights) and select `NORSUB MRU Configuration Software.exe` from the installation folder (default location is `C:\Program Files (x86)\NORSUB Software`).

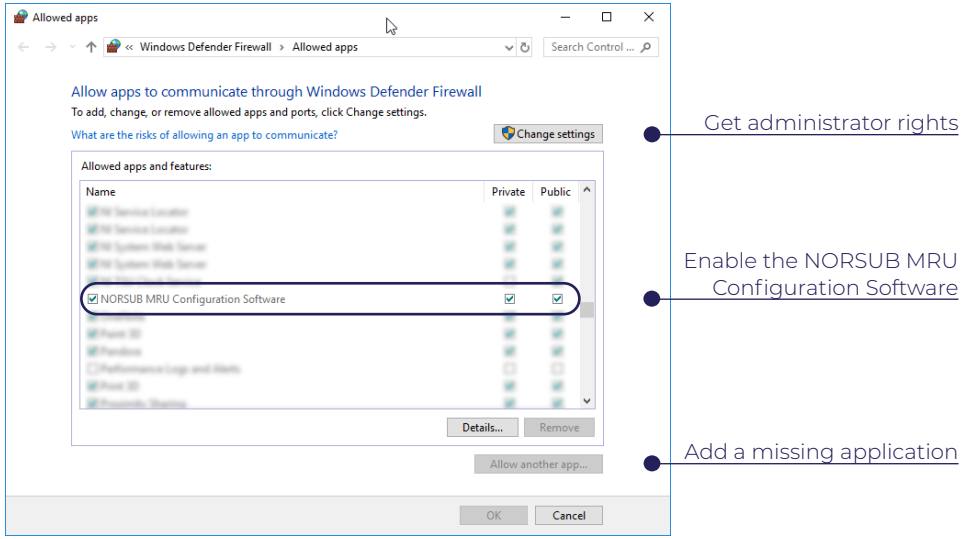


Figure 8 - Add exceptions to Windows Firewall.

3. USING THE SOFTWARE

Main Window

The main window gives access to the controls used to configure the MRU and to acquire, visualize, and log MRU data. Its main elements are:

- **Run-time menu:** contains all controls, organized by their main purpose.
- **Interface help:** displays help texts on controls mouse-over.
- **Data visualization panel:** shows one of the available real-time views of the MRU data.
- **Command panel:** contains the main software controls.
- **MRU information panel:** summarizes the MRU details and settings.
- **Status panel:** displays software and/or MRU status messages.

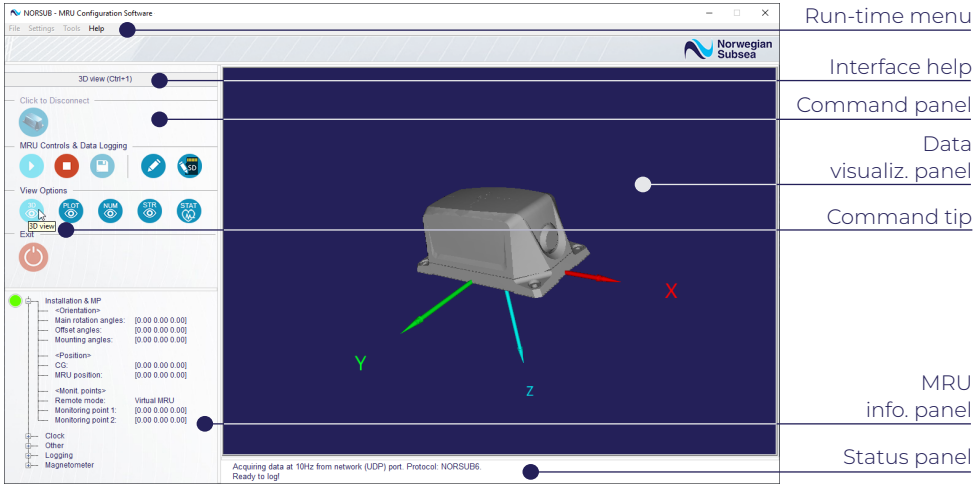
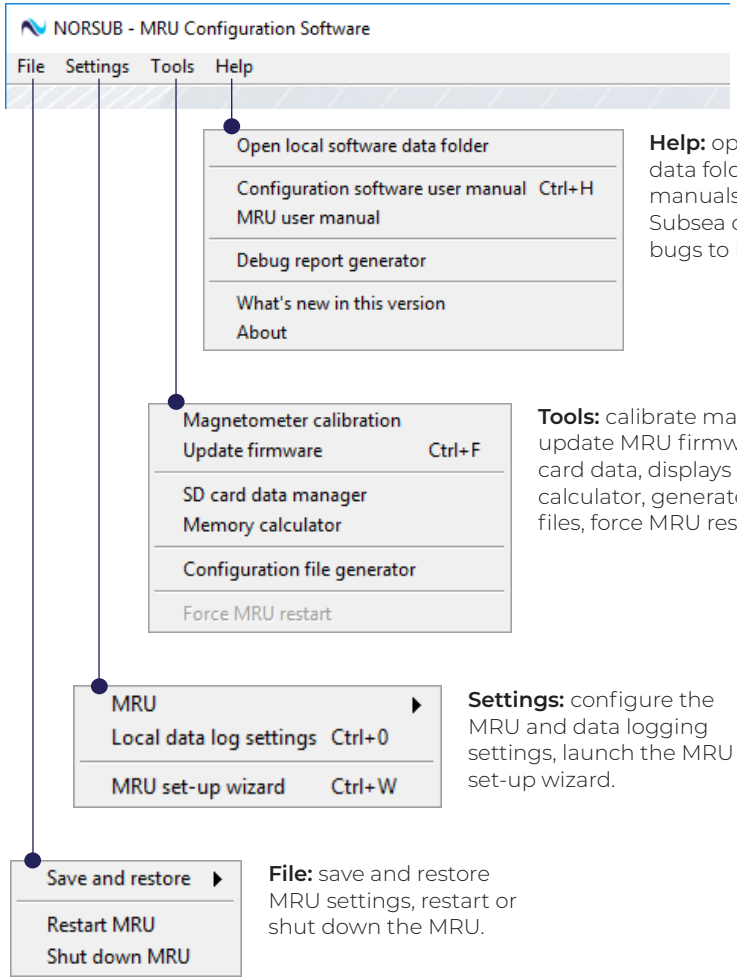


Figure 9 - Main window.

Run-Time Menu

The software contains four run-time menus: *File*, *Settings*, *Tools* and *Help*.



Help: open the software data folder, access the user manuals and Norwegian Subsea contacts, report bugs to Norwegian Subsea.

Tools: calibrate magnetometer, update MRU firmware, retrieve SD card data, displays the memory calculator, generate configuration files, force MRU restart.

Settings: configure the MRU and data logging settings, launch the MRU set-up wizard.

File: save and restore MRU settings, restart or shut down the MRU.

Figure 10 - Run-time menus.

Command Panel

The buttons in the command panel are:

Connect / Disconnect to the MRU (CTRL+C): connect or disconnect the MRU.

Start data acquisition: start acquiring MRU data in the software.

Stop data acquisition: stop acquiring MRU data in the software.

Save MRU settings to memory (CTRL+S): save settings to MRU internal memory.

Start / Stop logging (CTRL+L): start/stop logging MRU data.

Start / Stop SD card logging: start/stop logging MRU data on the SD card (*).

3D view (CTRL+1): display MRU data in 3D view.

Plot view (CTRL+2): display MRU data in waveform plots.

Numerical view (CTRL+3): display MRU data in numerical values.

String view (CTRL+4): display MRU data in data string format.

MRU status view (CTRL+5): display MRU health status.

Exit the configuration software: exit the software.

(*) The logging on SD card is only available if an SD card is installed in the MRU.

MRU Information Panel

The MRU information panel is located in the bottom left corner of the main interface. It contains the overview of the current MRU type and model, MRU settings, communication, health and logging status, firmware and hardware versions.

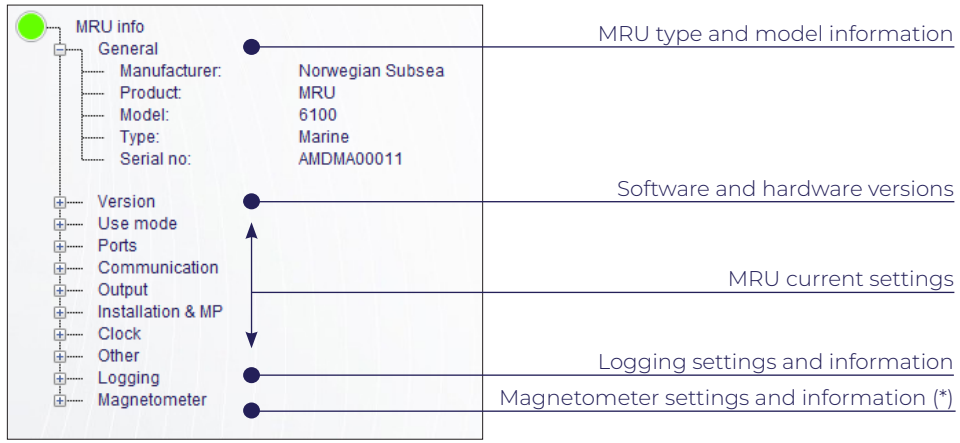


Figure 11 - MRU information panel.

(*) The magnetometer settings and information are only available is a magnetometer is installed in the MRU.

Software States

The software operates in five states (see Figure 12).
Functions and tools are enabled or disabled depending on the current software state:

- **Idle (not ready to acquire):** the software starts up in this state. Connect the MRU to use the software configuration or data visualization tools.
- **Idle (ready to acquire):** once connected to an MRU, it is possible to start data acquisition, configure the MRU, or update the MRU firmware.
- **Recovery mode:** an MRU is identified but some errors occurred during the connection phase. This may occur if the MRU has an old firmware (which is incompatible with the current configuration software) or the MRU is already connected to another device. It is possible to update the MRU firmware or force an MRU restart.
- **Acquiring:** while acquiring, it is possible to visualize the data flow on the data visualization panels and start data logging. It is not possible to configure the MRU while acquiring data.
- **Acquiring and logging:** the software is acquiring and logging the MRU data (either locally on PC, or on SD card).

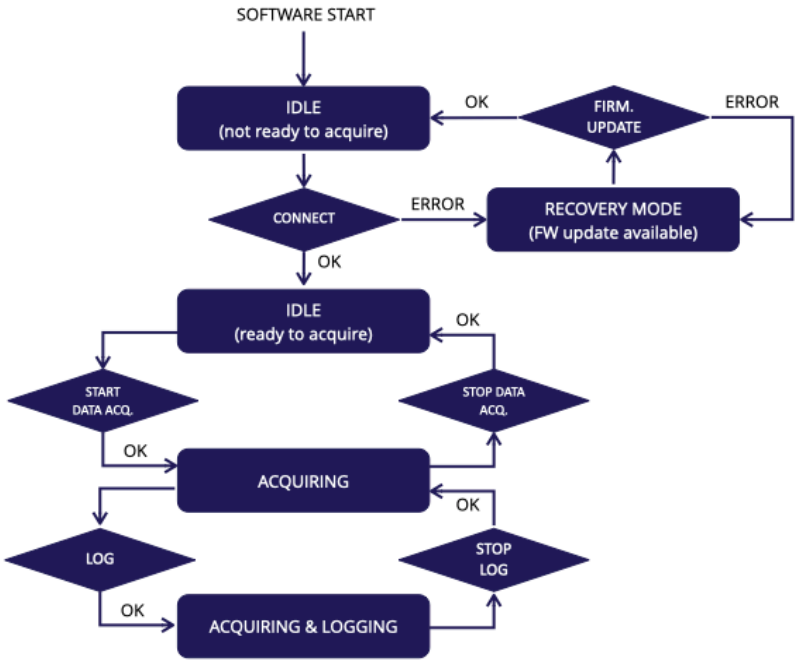


Figure 12 - Software states.

Connecting the MRU

Press the red *Connect* button to connect to the MRU. This button will become blue when the connection with the MRU is established.

There are three possibilities for connecting the MRU to the software:

- **Auto scan:** scans automatically for MRUs connected to the network or serial ports.
- **Ethernet/Wi-Fi:** connects directly to an MRU on the network by specifying the MRU IP address.
- **Serial Port:** connects directly to an MRU on serial port by specifying *Serial port*, *Baud rate*, *Data bits*, *Stop bits*, *Parity* and *Flow control*.

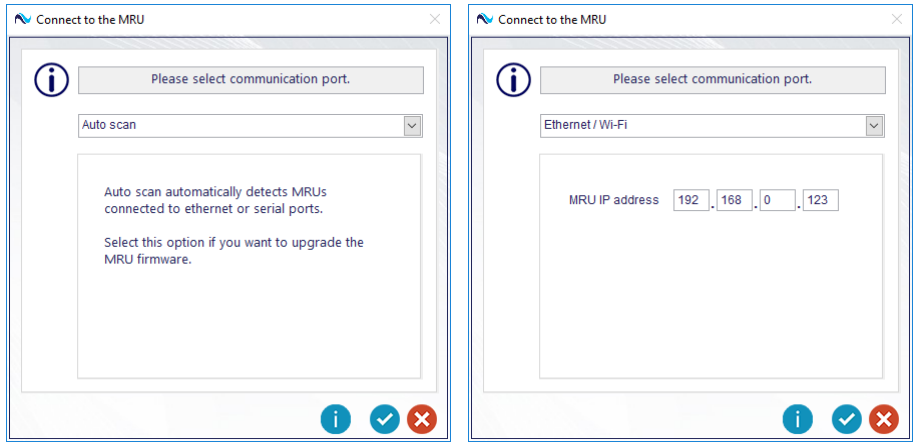


Figure 13 - Connect to the MRU with Auto scan (left) or Ethernet/Wi-fi (right).

This warning message might appear when the *Start data acquisition* button is pressed:

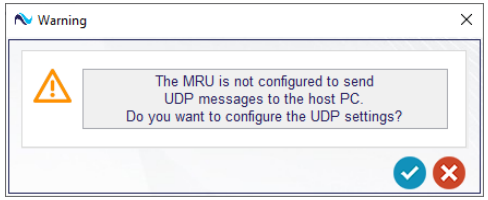


Figure 14 - UDP host IP.

This means that the MRU is currently sending UDP messages to an IP address which does not match the host PC. This does not allow the software to visualize the MRU data.
Click on the *Confirm* button to automatically fix the UDP settings on the MRU (allowing the data stream to the host PC), hence starting the acquisition.

Data Visualization Panels

The MRU data is displayed in four different formats:

- **3D view** : displays a real-time 3D model of the MRU matching the current attitude.
- **Plot view** : displays three customizable waveform plots.
- **Numerical view** : displays the numerical values of the most relevant MRU data.
- **String view** : displays the raw MRU data stream and the current protocol details.
- **MRU status view** : displays the MRU health status.

The data visualization panel is enabled when the software is in *Acquisition mode* (the *Start data acquisition* button is pressed).

3D View

The panel shows a 3D model of the MRU rotated to match the current attitude (roll, pitch, yaw). The body frame axes have a consistent color code throughout the software:

- **X (surge) axis:** red arrow, positive direction towards the MRU connector.
- **Y (sway) axis:** green arrow, positive direction towards the right MRU side.
- **Z (heave) axis:** blue arrow, positive towards the MRU bottom.

The rotations sign follows the right-hand convention: place the thumb along the desired axes, the positive rotation is indicated by the other fingers' direction.

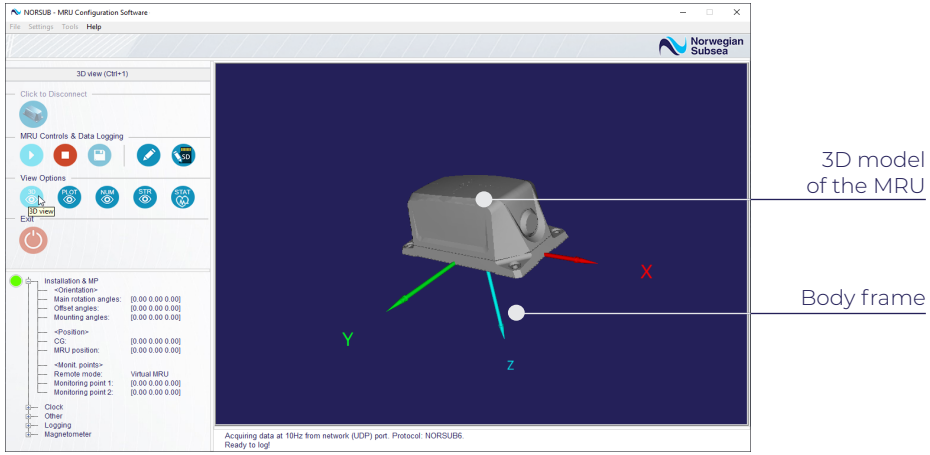


Figure 15 - 3D view.

Plot View

The plot view displays three waveform plots. Select the desired output variables from the corresponding drop-down list. Only the output variables that are included in the current output protocol are available. The list of output variables updates automatically when the output protocol is changed.

The plot length (time window/horizontal axis) is adjusted with the *Plots history [s]* field.

The *Reset plots* button refreshes the plots.

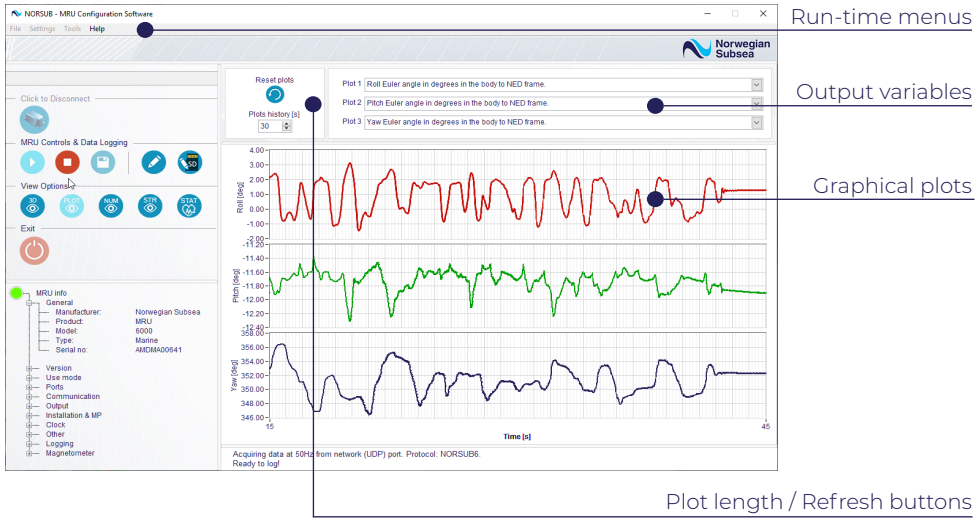


Figure 16 - Plot view.

Numerical View

The numerical view displays the MRU with reference frames and numerical values. The numerical values show the following (*):

- Roll and roll rate.
- Pitch and pitch rate.
- Yaw and yaw rate.
- Surge and surge velocity.
- Sway and sway velocity.
- Heave and heave velocity.

Select location and frame from the drop down list. The data is organized in one of the following location and frame combinations (*)(**):

- MRU location, MRU frame.
- MRU location, NED frame.
- MRU location, body frame.
- MRU location, heading frame.
- CG location, NED frame.
- CG location, body frame.
- CG location, heading frame.
- MP1 location, NED frame.
- MP1 location, body frame.
- MP1 location, heading frame.
- MP2 location, NED frame.
- MP2 location, body frame.
- MP2 location, heading frame.

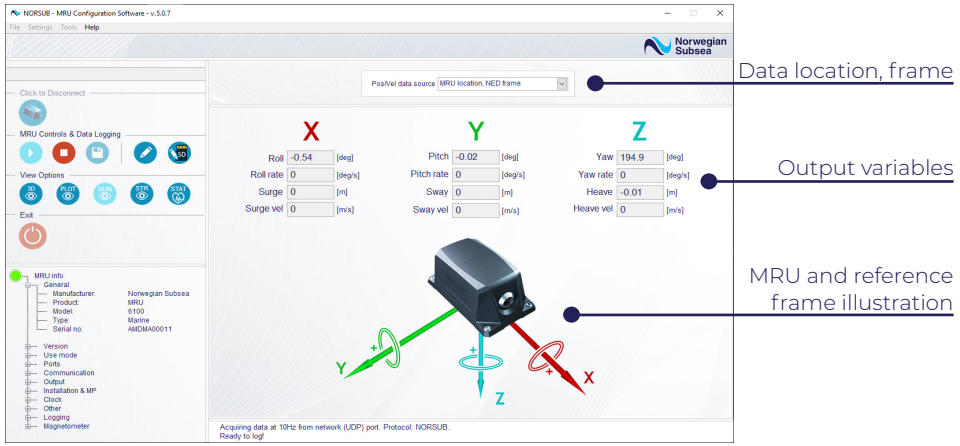


Figure 17 - Numerical view.

(*) The acronyms used in the list refer to: CG - Center Of Gravity, MP1 - Monitoring Point 1, MP2 - Monitoring Point 2.

(**) The availability of the listed data and location / frame combinations may vary depending by the selected protocol.

String View

The string view displays raw data from the MRU, the software output string and the details of the selected MRU protocol.

The *MRU output string* is the raw data streamed from the MRU, while the *Software output string* adds a timestamp at the beginning of every string. The timestamp is generated by using the host PC clock time. The *MRU output protocol details* lists the variables included in the protocol, their location, frame and measurement unit.

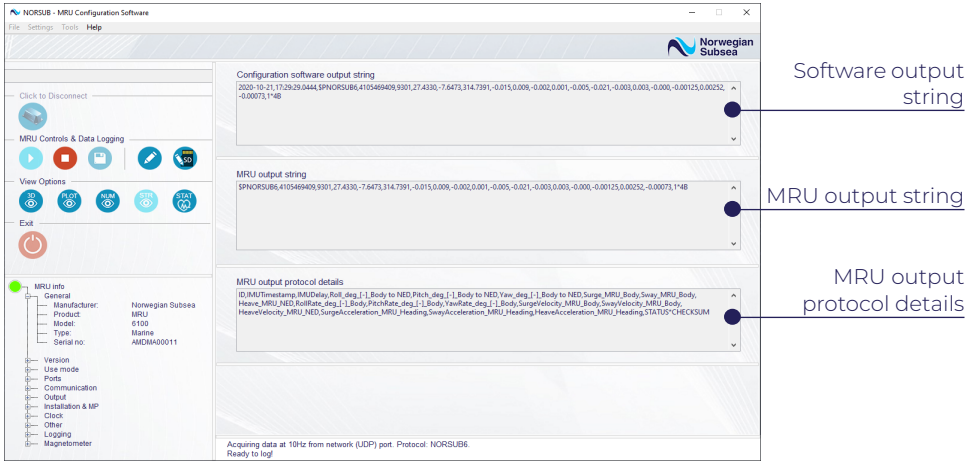


Figure 18 - String view.

MRU Status View

The MRU status view displays the MRU health monitoring (MRU status bits). Depending by the output protocol, one of the following three views are displayed:

- **Basic status view:** displays if the MRU is operating normally or not normally.
- **Standard status view:** displays if the components of the MRU (main system, sensor, environment & temperature, algorithms, aiding) are operating normally or not normally.
- **Advanced status view:** displays the whole status bits string (32 bits). This allows to see if all the hardware/software components of the MRU are operating normally or not normally.

The MRU status views may not be available for all the output protocols: some protocols do not carry status information, some protocols carry only one status bit, other protocols carry partial or the complete MRU status information. The basic status view and the detailed status view are showed in Figure 19 and Figure 20.

The MRU health status is given by the following icons:

Normal status: The MRU or component is operating normally.

Abnormal status: The MRU or component is not operating normally.

The standard status view is described by the following icons:

Main system: provides health status of the main system, time, clock and CPU.

Sensor: provides health status of the motion sensor.

Environment: shows if the operating temperature and vibration level is within the accepted range.

Algorithms: provides health status of the MRU internal algorithms.

Aiding: provides health status of the aiding sensors.

Refer to Chapter 9 on page 107 for further details on the MRU health monitoring and status bits.

USING THE SOFTWARE

MRU Status View

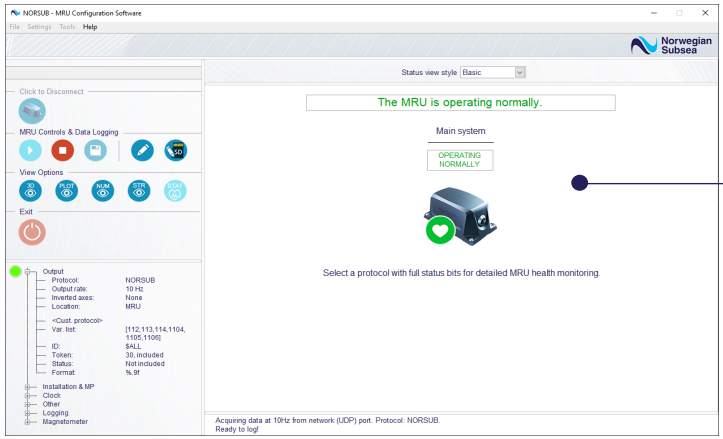


Figure 19 - Basic status view.

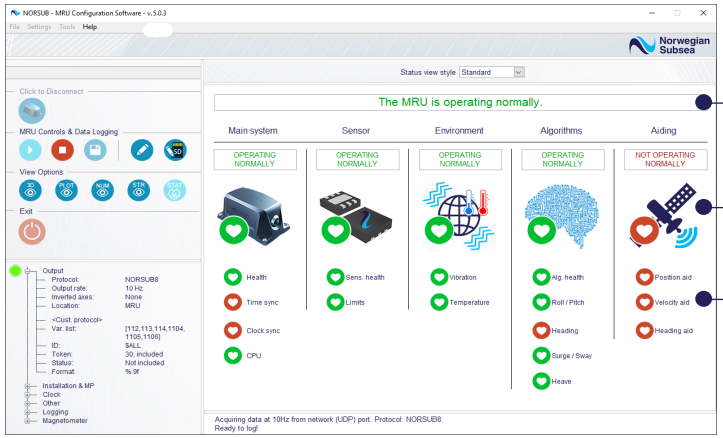
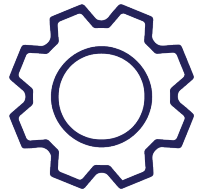


Figure 20 - Standard status view.

4. MRU CONFIGURATION



Save and Restore MRU Configurations

The save and restore settings functions are available from the *MRU set-up wizard* (see "MRU Set-Up Wizard Tool" on page 54) or by clicking the *Save and restore* element in the *Settings* run-time menu.

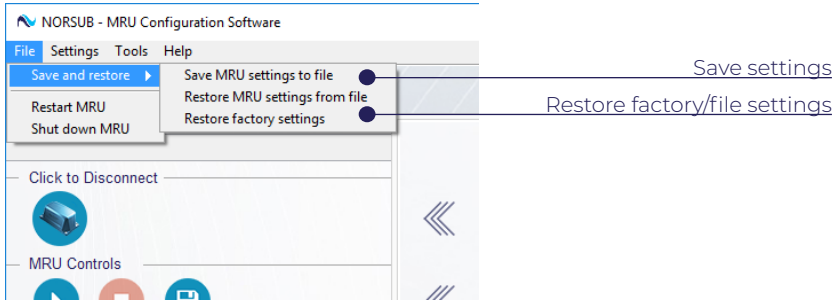


Figure 21 - Save and restore factory/file settings.

Save and restore settings are:

- **Save MRU Settings to file:** save a `*.MRUconfig` file to the PC. This file can be later uploaded to the MRU to restore the saved configuration (*).
- **Restore MRU Settings from file:** select a `*.MRUconfig` file to restore a previously saved configuration.
- **Restore factory settings:** reset the MRU configuration to factory settings.

The list of the MRU settings and the factory default values are given on the next page.

(*) The default folder in which the `*.MRUconfig` files are saved is:
`C:\Users\<user_name>\AppData\Local\NORSUB Software Files\MRUconfig Files`

Save and Restore MRU Configurations

MRU SETTINGS						FACTORY VALUE
LV.1	LV.2	LV.3	LV.4	LV.5		
Use mode					General purpose	
Ports & communication	Network	Ethernet port			Enabled	
		Ethernet port settings			100 Mbps/Full Duplex	
			Link speed		Static	
			IP address mode		192.168.0.110	
			IP address		255.255.0.0	
			Subnet mask		0.0.0.0	
			Gateway		0.0.0.0	
			DNS server			
		Network data output			UDP	
		Network data output settings			192.168.0.200	
			UDP	Host IP	2001	
				Port		
			Modbus TCP	Modbus register	Input	
			Ethernet/IP	Instance ID	100	
	RS-232	Port			Enabled	
		Port settings			115200	
			Baudrate		8	
			Data bits		No parity	
			Parity		1	
			Stop bits		None	
			Flow control			
		Data output			RS-232	
		Data output settings			Disabled	
	RS-485	Port			921600	
		Port settings			8	
			Baudrate		No parity	
			Data bits		1	
			Parity		None	
			Stop bits			
			Flow control			
		Data output			RS-485	
		Data output settings			1	
			Modbus RTU	Unit ID		
				Modbus register	Input	

Table 1 - MRU configuration parameters and factory (default) settings (part 1).

Save and Restore MRU Configurations

MRU SETTINGS			
LV.1	LV.2	LV.3	FACTORY VALUE
Output	Protocol (*)		NORSUB6
	Location (**)		MRU
	Output rate		50
	Custom protocol (***)	Code	[124, 125, 126, 133, 134, 147]
		Name	[Roll, Pitch, Yaw, Surge, Sway, Heave]
		Unit	[deg, deg, deg, m, m, m]
		Location	[-, -, -, MRU, MRU, MRU]
		Frame	[Body to NED, Body to NED, Body to NED, MRU, MRU, NED]
		ID (****)	$PSXN
		Enable status (****)	True
		Enable token (****)	True
		Token	19
		Format (****)	%8.3e
		Separator (****)	Comma [,]
	Invert axis	Roll / Pitch / Yaw / Surge / Sway / Heave	[0,0,0,0,0,0]
Installation & monitoring points	Orientation	Main rotation angles	[0,0,0]
		MRU offset angles	[0,0,0]
	Position	CG position	[0,0,0]
		MRU position	[0,0,0]
		MP1	[0,0,0]
		MP2	[0,0,0]
		Remote mode	Virtual MRU

Table 2 - MRU configuration parameters and factory (default) settings (part 2).

MRU CONFIGURATION

Save and Restore MRU Configurations

MRU SETTINGS			
LV.1	LV.2	LV.3	FACTORY VALUE
Clock	Sync to host PC time	Sync to host PC time	ON
	Sync to NTP server	Service status	OFF
		NTP servers list	0.pool.ntp.org 1.pool.ntp.org 2.pool.ntp.org 3.pool.ntp.org
Other	Geographical settings	Latitude	60 [degs]
		Declination (*****)	0 [degs]
	Tuning settings	Projected acceleration cut-off frequency	1 [Hz]
	Hardware settings	Activate magnetometer (*****)	ON
Log settings	Logs folder path		[user_path]\AppData\Local\NORSUB Software Files\MRU Data Logs
	N. samples / Time		0 [s]
	Maximum file(s) size		100 [MB]
	Add header		TRUE

Table 3 - MRU configuration parameters and factory (default) settings (part 3).

(*) The protocol list is limited to *Custom binary* if the Network data output port is set to *Modbus TCP*.
(**) Parameter not accessible if the selected protocol is *Custom NMEA* or *Custom binary*.
(***) Parameters accessible through the custom protocol generator tool.
(****) Parameters only accessible if *Protocol* is set to *Custom NMEA*.
(*****) Parameter only accessible for MRUs with magnetometer.

Configuration Settings Panels

The MRU can be configured through the following settings panels:

- **Use mode (CTRL+5).**
- **Ports & communication (CTRL+6).**
- **Output (CTRL+7).**
- **Installation & monitoring points (CTRL+8).**
- **Time synchronization (CTRL+9).**
- **Other settings (CTRL+0).**
- **Local data log settings.**

The following tools and wizards are contained in the listed settings panels:

- The *Installation & monitoring points* settings window gives access to the *Orientation wizard* and the *Position wizard* which allows to define the orientation and the position of the MRU on a vessel.
- The *Output* settings window gives access to the *Custom protocol generator*, which allows the user to define a custom protocol.

All the previous settings windows are also accessible from the *MRU set-up wizard*. Launch it by clicking on the *Settings* run-time submenu, or by the keyboard shortcut `CTRL+W`.

All the settings panels are explained in the following pages.

Use Mode

The use mode selects the optimal tuning of the internal algorithms for a given application.

- **General purpose:** the MRU is optimized for a general application.
- **DP mode:** the MRU is optimized for a vessel using a dynamic positioning (DP) system. If Use mode is set to *DP mode*, surge and sway measurements are found using the estimated peak heave period in the MRU's high pass filter. This is to attenuate the very low frequency DP motion from the surge and sway measurements.

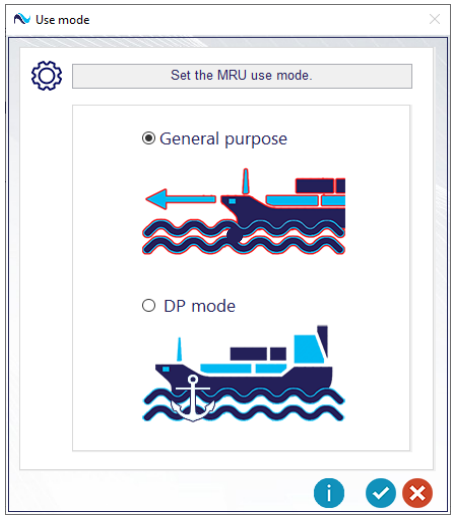


Figure 22 - MRU use mode settings.

Ports & Communication Settings

Enable or disable the communication ports and configure their settings. The MRU can be configured via Ethernet (TCP), RS-232 or RS-485 ports. The data output can be on network (Ethernet) and/or on one of the serial ports.

The network configuration port (TCP) cannot be disabled, to ensure that the MRU can always be reached for configuration.

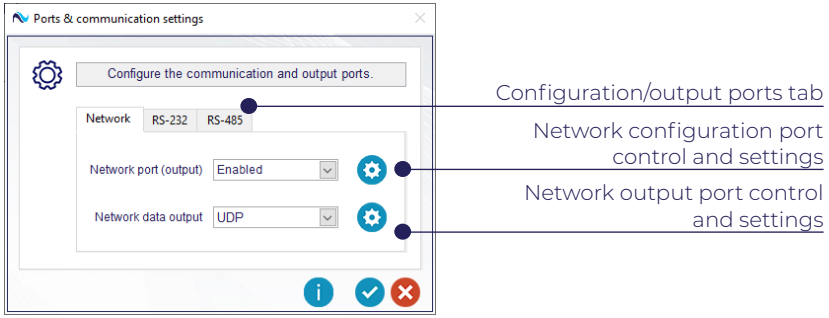


Figure 23 - MRU ports & communication settings.

- **Network:** disable or enable the *Network port (output)* and define the *Network data output* streamer as: *UDP, Modbus TCP, EtherNet/IP*:
  - **UDP:** a commonly used simple message-oriented transport layer protocol. It provides no guarantees to the upper layer protocol for message delivery. The data is sent to the selected UDP address and port.
  - **Modbus TCP:** Modbus is a de facto standard serial communication protocol commonly used by many industrial electronic devices. The Modbus port can be enabled or deactivated, and no settings can be modified. It does not require a checksum, since it provides lower lever checksum protection.
  - **EtherNet/IP:** one of the leading industrial network protocols. It adapts the Common Industrial Protocol (CIP) to standard Ethernet.
- **RS-232:** disable or enable the *RS-232 port* and define the *RS-232 data output* streamer. As of now, only the RS-232 option is available.
  - **RS-232:** standard data stream over the RS-232 port.
- **RS-485:** disable or enable the *RS-485 port* and define the *RS-485 data output* streamer among the following options: *RS-485, Modbus RTU*:
  - **RS-485:** standard data stream over the RS-485 port.
  - **Modbus RTU:** see the "Modbus TCP" brief description listed before.

MRU CONFIGURATION

Ports & Communication Settings

Communication and data output ports can be configured by clicking on the blue *Settings* button on the right side of the panel. The *Network settings* window is showed here:

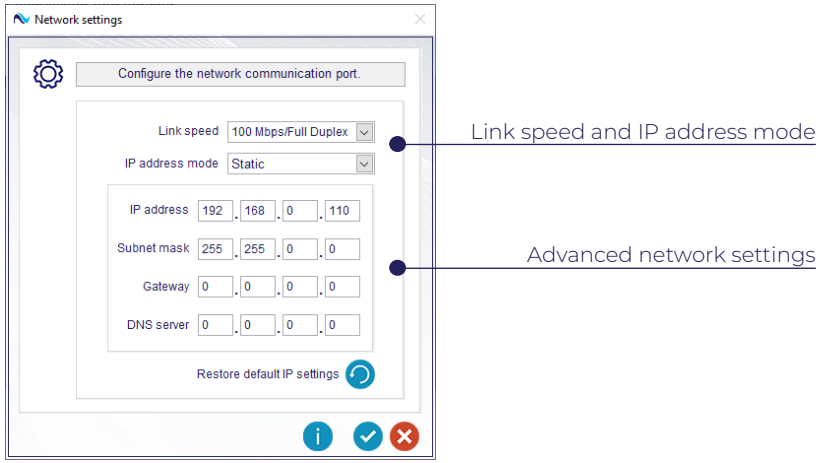


Figure 24 - Network settings.

- **Link speed:** can be set to *Autonegotiate*, *10 Mbps Half Duplex*, *10 Mbps Full Duplex*, *100 Mbps Half Duplex* or *100 Mbps Full Duplex*.
- **IP address mode:** can be set to *Static*, *DHCP or link local*, *Link local only* or *DHCP only*. If set to *Static*, the advanced network settings must be specified, otherwise the network settings will be assigned by the DHCP server in the local network.
- **IP address, Subnet mask, Gateway, DNS server:** network communication details. These settings are active if *IP address mode* is set to Static.

PORTS & PROTOCOLS

The *Modbus TCP*, *EtherNet/IP*, *Modbus RTU* options only support the *Custom binary* output protocol. Data sent with one of these output ports cannot include the token, and can only include *Single* and *U32* format variables (see Chapter 10 on page 113 for full variables list and formats).

NETWORK LINK SPEED

If you are unable to connect to the MRU via network, it may be because the MRU link speed is set to *Autonegotiate* and the MRU is unable to agree on a link speed with the device to which it is connected to. Try selecting a fixed link speed while connected to a switch or via serial port.

Ports & Communication Settings

The *Network data output settings* are:

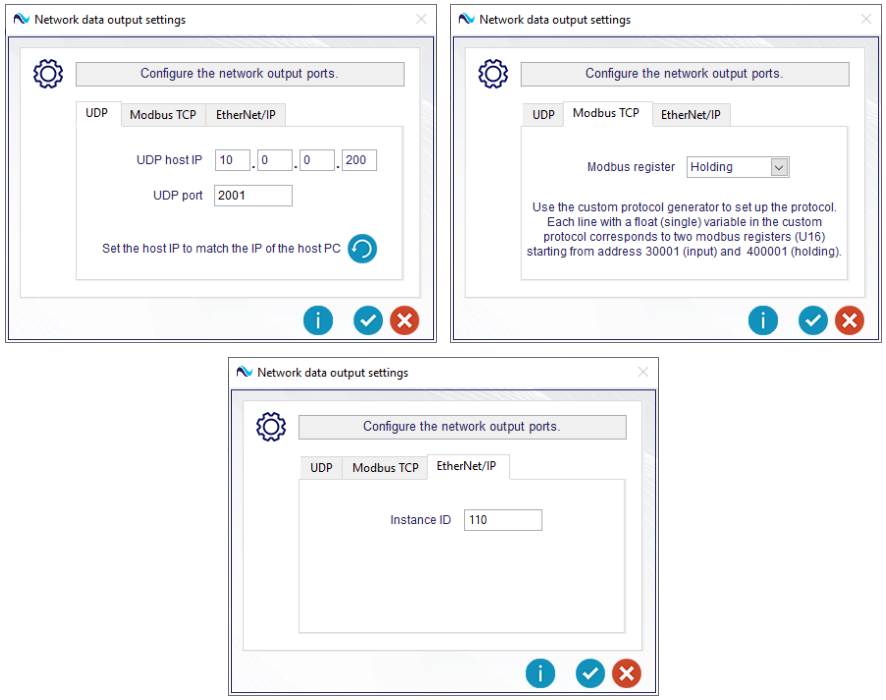


Figure 25 - Network output ports settings.

- **UDP:** configure the UDP network data output port:
  - **UDP host IP:** the IP address of the UDP receiver (e.g. host PC running the configuration software, or the DP system machine which requires the MRU data).
  - **UDP port:** the UDP port of the UDP receiver.
- **Modbus TCP:** configure the Modbus TCP network data output port:
  - **Modbus register:** defines the starting register for the temporary storage of the data stream: each line with a float (`single`) variable in the custom protocol corresponds to two Modbus registers (`U16`) starting from address 30001 (*Input*) and 40001 (*Holding*).
- **EtherNet/IP:** configure the EtherNet/IP network data output port:
  - **Instance ID:** defines the MRU ID used to establish the communication.

MRU CONFIGURATION

Ports & Communication Settings

The *RS-232/RS-486 settings* windows are showed here:

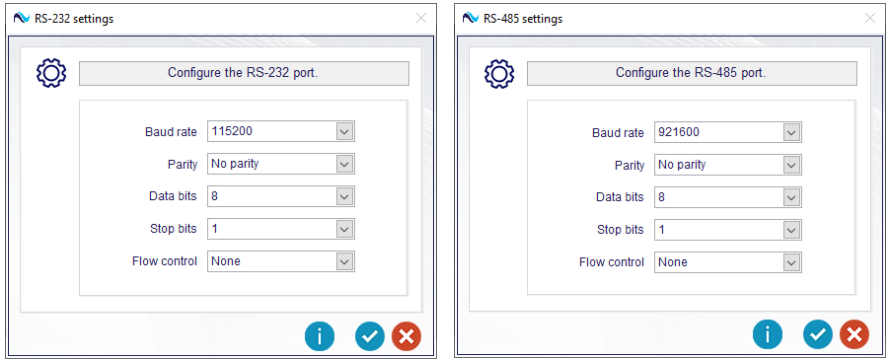


Figure 26 - RS-232 and RS-485 ports settings.

- **Baud rate, parity, data bits, stop bits, flow control:** serial communication settings.

The *RS-232 data output settings* are not available, since the only available option is *RS-232*.
The *RS-485 data output settings* allow to configure the Modbus RTU data output port:

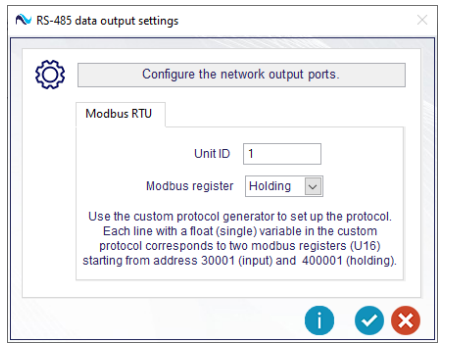


Figure 27 - RS-485 data output settings.

- **Unit ID:** defines the device ID used to establish the communication.
- **Modbus register:** defines the starting register for the temporary storage of the data stream: each line with a float (`single`) variable in the custom protocol corresponds to two Modbus registers (`U16`) starting from address 30001 (*Input*) and 40001 (*Holding*).

Ports & Communication Settings

The network, RS-232 and RS-485 data output settings may require the MRU to parse the data in a specific protocol. Consequently, certain configurations of ports and output protocols may not be compatible.

In the following table all the valid configuration ports, data output and output protocol are listed.

	ADMISSIBLE CONFIGURATIONS			
	CONFIG. 1	CONFIG. 2	CONFIG. 3	CONFIG. 4
Network port (config.)	Enabled (*)	Enabled (*)	Enabled (*)	Enabled (*)
Network port (output)	Enabled or Disabled	Enabled or Disabled	Enabled or Disabled	Enabled or Disabled
Network data output	If enabled: UDP or Modbus TCP or Ethernet/IP	If enabled: UDP	If enabled: UDP	If enabled: UDP or Modbus TCP or Ethernet/IP
RS-232 port	Disabled	Enabled	Disabled	Disabled
RS-232 data output	-	RS-232	-	-
RS-485 port	Disabled	Disabled	Enabled	Enabled
RS-485 data output	-	-	RS-485	Modbus RTU
Output protocol	Any	Any	Any	Custom binary

Table 4 - Ports/output protocols admissible configurations.

The MRU configuration software restores an admissible configuration if connected with an MRU with a not-admissible configuration, and will not allow to set up the MRU to a configuration different from the ones listed in the previous table.

(*) The network configuration port cannot be disabled.

Output

Configure the MRU output settings: *Protocol*, *Location*, and *Output rate*.

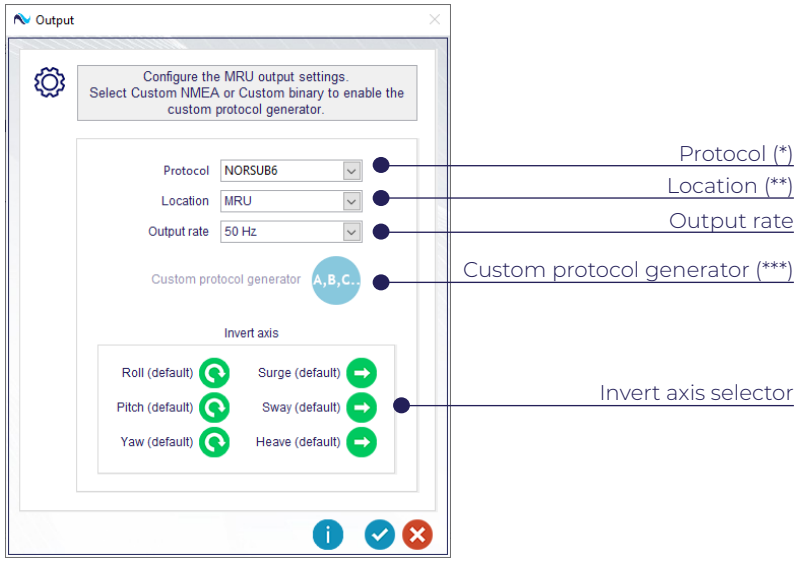


Figure 28 - Output settings.

The available ASCII protocols are:
Custom NMEA, Gyrocompas 1, MDL, NORSUB, NORSUB2, NORSUB6, NORSUB7, NORSUB7b, NORSUB8, NORSUB PRDID, Tokimek PTGV, RDI ADCP, SMCA, SMCC.

The available binary protocols are:
Custom binary, Atlas, Ifremer Victor, Simrad EM 3000, TSS1.

Data can be sent at one of the following output rates: *1, 2, 4, 5, 10, 20, 25, 50* or *100* Hz, and refers to the following locations: *MRU, CG* (Centre of Gravity), *MP1* (Monitoring Point 1) or *MP2* (Monitoring Point 2).

The data for one or more axes can be inverted in the *Invert axis* tab:

Default direction (linear/angular measurement).

Inverted direction (linear/angular measurement).

(*) The protocol list is reduced to *Custom binary* if one of the *Data output port* is set to
(**) *Modbus TCP, EtherNet/IP* or *Modbus RTU*.
(***) Deactivated if *Custom NMEA* or *Custom binary* protocols is selected.
Only active if *Custom NMEA* or *Custom binary* protocols is selected.

Custom Protocol Generator

Generate a custom protocol with the custom protocol generator. The *Custom protocol generator* is launched from the *Output settings* panel as shown below.

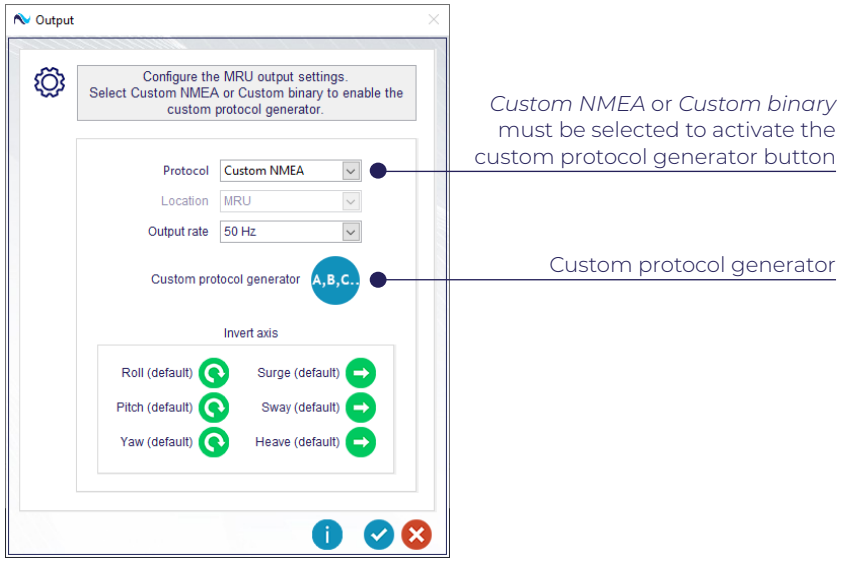


Figure 29 - Output settings panel.

The custom NMEA protocols have the following format:
`<ID>,<STATUS>,<TOKEN>,<var1>,<var2>, ...,<varN>,*<CHECKSUM>`
where `<CHECKSUM>` is NMEA checksum (`XOR` of characters between `$` and `*`).

The custom binary protocols have the following format:
`<ID><LENGTH><TOKEN><var1><var2>...<varN><CHECKSUM>`
where `<CHECKSUM>` is XOR of all bytes between `<TOKEN>` and `<CHECKSUM>`

`<LENGTH>` is the number of bytes after `<LENGTH>` including:
`<TOKEN>,<var1>, <var2>,...,<varN>,*<CHECKSUM>`

	TYPE
<ID>	U8
<STATUS>	U8
<LENGTH>	U8
<TOKEN>	U8
<CHECKSUM>	U8
<varN>	U8 / U32 / SINGLE (*)

Table 5 - Custom protocol elements type.

(*) For details about the MRU output variables, see the output variables list in Chapter 10 on page 113.

Custom Protocol Generator

The custom protocol generator (Figure 30) is used to build a protocol by adding or removing output variables. Select a new protocol variable by using the related *Code* (which determines the *Name*, *Unit*, *Location* and *Frame* of the variable), or by using the *Name*, *Unit*, *Location* and *Frame* fields (which will consequently update the variable *Code*) (*). The description field is updated with information about the selected variable.

Add the new variable to the custom protocol by using the *Add at the end*, *Add at the beginning* and *Add at the index* buttons (specify an index in the latter case). It is possible to add as many variable as desired.

It is also possible to customize the *ID*, *Token*, *Format* and *Separator*. A status bit can be included by selecting the *Status* checkbox, while the token can be enabled/disabled through the *Token* checkbox.

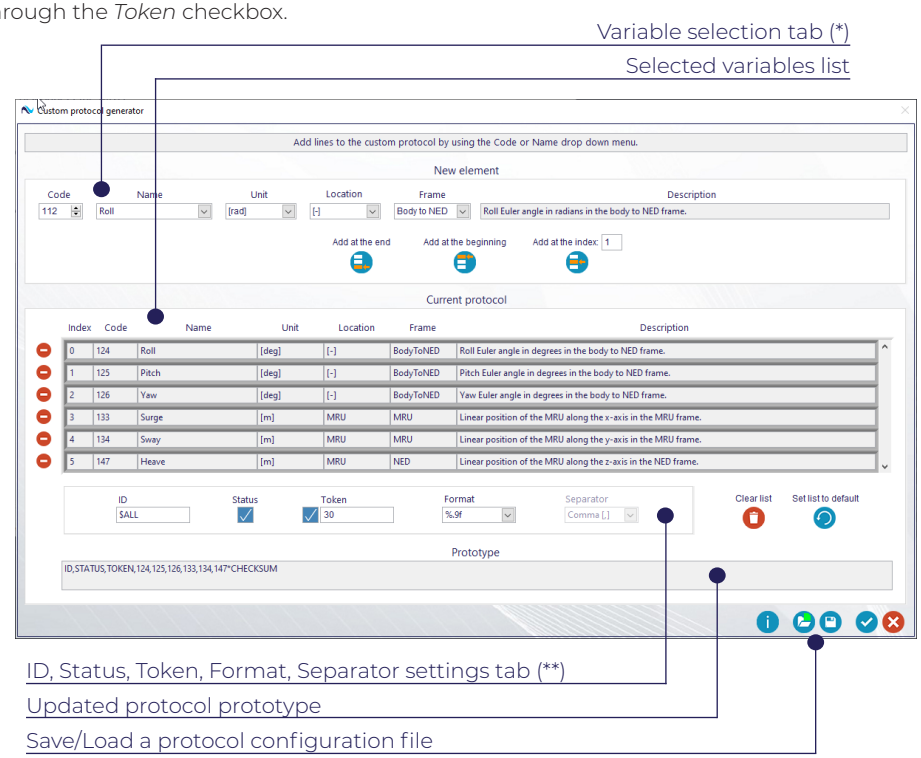


Figure 30 - Custom protocol generator.

(*) For details about the MRU output variables, see the output variables list in Chapter 10 on page 113.

(**) The *ID*, enable/disable *Status*, enable/disable *Token*, *Token*, *Format* and *Separator* fields are only visible when defining a *Custom NMEA protocol*. The Token field is accessible both for the *Custom NMEA* and for the *Custom binary protocols*.

Custom Protocol Generator

The buttons actions are listed in the following:

- Add variable at the beginning of the list. The other variables shift one position down.
- Add variable at the specified index. The following variables shift one position down.
- Add variable at the end of the list.
- Remove a variable from the list. The following variables shift one position up.
- Load the custom protocol configuration stored in the selected `*.MRUconfig` file.
- Save the custom protocol configuration into a `*.MRUconfig` file.
- Clear all the elements from the variables list.
- Reset the variables list to default: [124, 125, 126, 133, 134, 137].

Use the information icon in the *Custom protocol generator* to display a list of all available MRU output variables. The complete variables list is given in Chapter 10 on page 113.

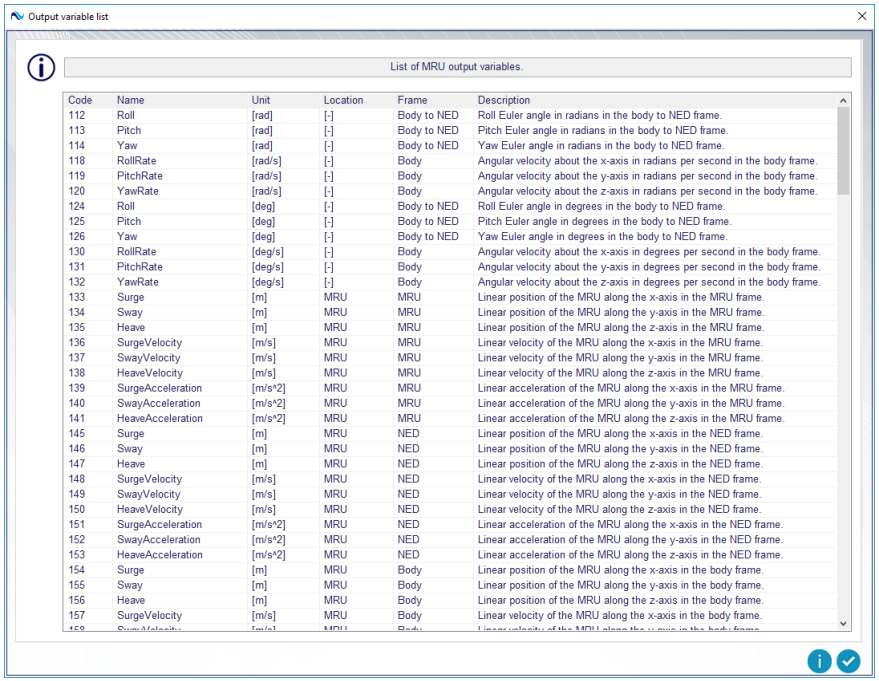


Figure 31 - List of MRU output variables.

Installation & Monitoring Points

The *Installation & monitoring points* settings window contains two panels:

- **MRU orientation:** use the *Orientation wizard* to set the mounting orientation of the MRU relative to the vessel (roll, pitch and yaw angles). Press the blue *Orientation wizard* button to launch the *Orientation wizard* (see "Orientation Wizard" on page 44 for more details).
- **MRU position:** use the *Position wizard* to set the mounting position of the MRU, the monitoring points relative to the *Survey Origin* (SO) and the *Remote mode*. Press the blue *Position wizard* button to launch the wizard (see "Position Wizard" on page 48 for more details).

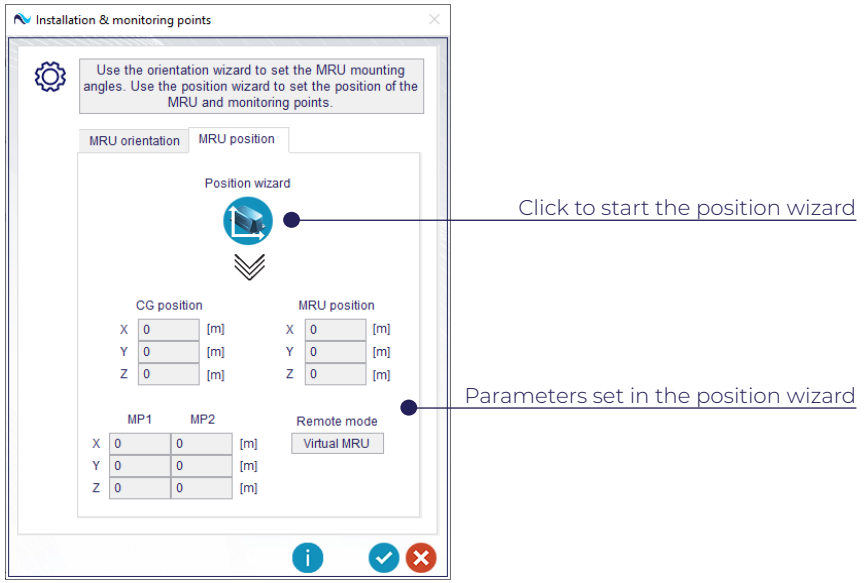


Figure 32 - Installation & monitoring points settings. In the figure, the MRU position page is selected.

Orientation Wizard

The *Orientation wizard* is used to set the mounting orientation (*Mounting angles*) of the MRU relative to the vessel. The *Mounting angles* are the result of two subsequent rotations:

- **Main rotation angles:** set the main rotation angles of the MRU relative to the vessel in steps of 90 degrees (coarse alignment). This is done in the STEP 1 of the orientation wizard.
- **MRU offset angles:** set the offset angles between the main rotation frame and the MRU (fine alignment). This is done in the STEP 2 of the orientation wizard.

The procedure is explained with an example. An MRU is mounted as seen in Figure 33. The x-axis is slightly tilted outwards to starboard.

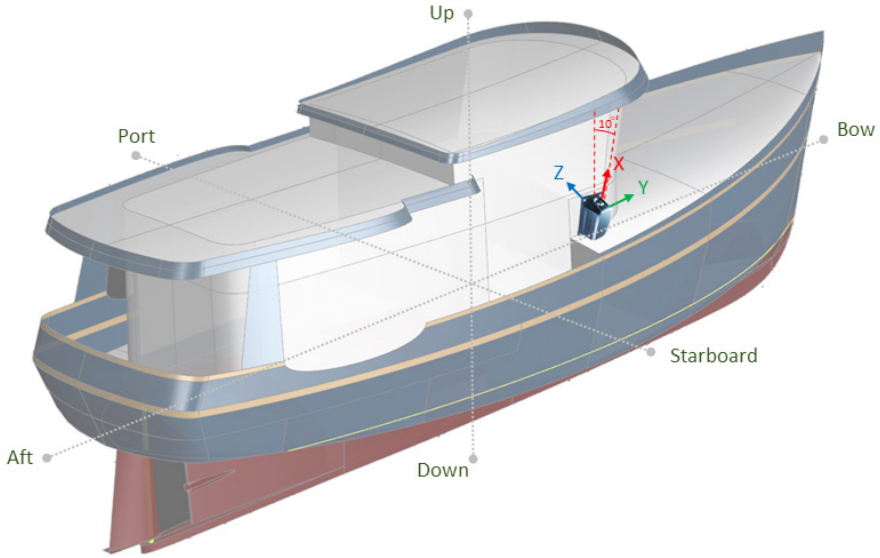


Figure 33 - Installation of the MRU on a vessel.

ROTATION FRAMES

- The *Main rotation angles* rotates the MRU about the ship frame indicated in the figure as *Aft-Bow* (x-axis; positive direction towards *Bow*), *Port-Starboard* (y-axis; positive direction towards *Starboard*) and *Up-Down* (z-axis; positive direction towards *Down*), see Figure 34.
- The *MRU offset angles* rotates the MRU about the new MRU frame set by the *Main rotation angles*. This is indicated in the software interface by the three thick lines without arrow-ending, see Figure 36.
- The total rotation is represented by the XYZ axis system attached to the MRU, see Figure 37.

Orientation Wizard

- **STEP 1**

The main orientation is set by selecting the MRU x-axis towards up and the MRU y-axis towards bow in STEP 1 in the wizard.
The software automatically sets the *Main rotation angles [Roll, Pitch, Yaw] = [90, 90, 0] degrees* as showed in Figure 34.

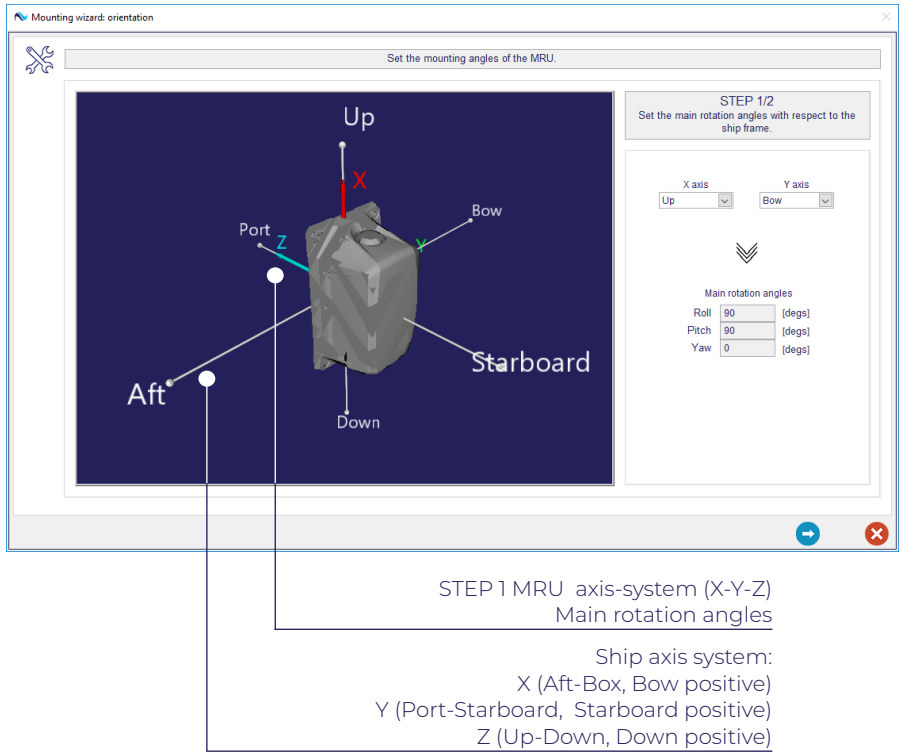


Figure 34 - Orientation wizard: STEP 1.

STEP 2

The small tilt angle of the x-axis towards starboard (Figure 35) can be corrected for in STEP 2 by setting the *MRU offset angles to [Roll, Pitch, Yaw] = [0, 10, 0] degrees* as showed in Figure 36. Note that the pitch angle is set to compensate for the tilt as the offset angle is relative to the main orientation set in STEP 1 (now represented with a thick axis system) and not the vessel frame (now grayed out).

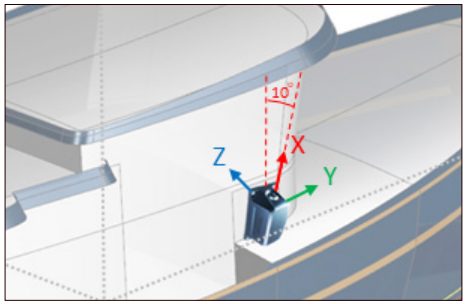


Figure 35 - MRU orientation offset.

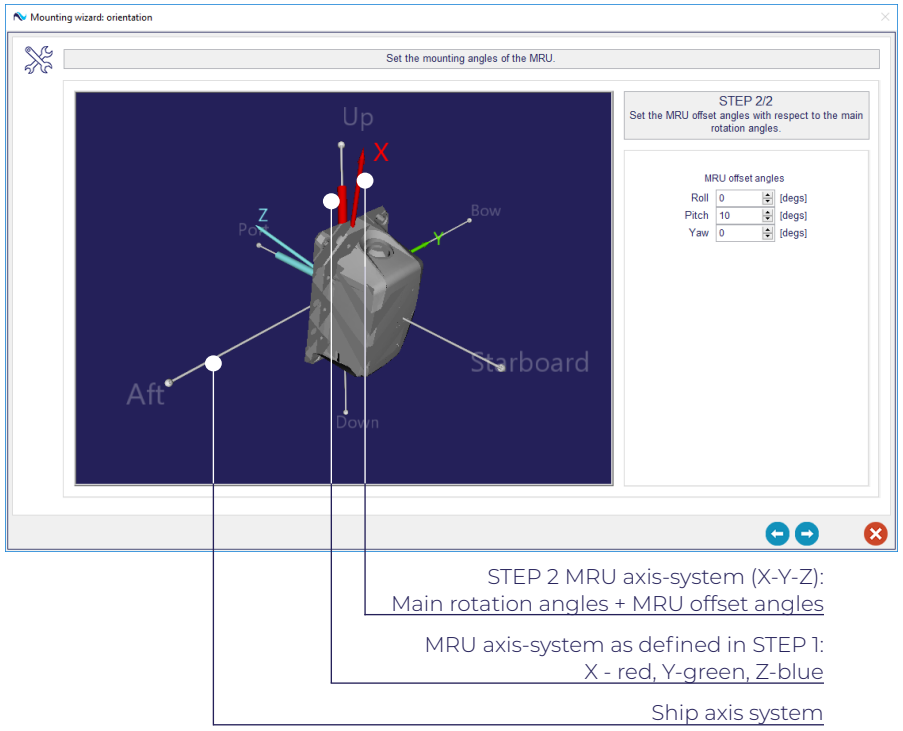


Figure 36 - Orientation wizard: STEP 2.

SUMMARY

The orientation wizard summary shows the selected *Main rotation angles* and *MRU offset angles*, and the resulting *Mounting angles* relative to the ship frame are *[Roll, Pitch, Yaw] = [180, 80, 90] degrees*.

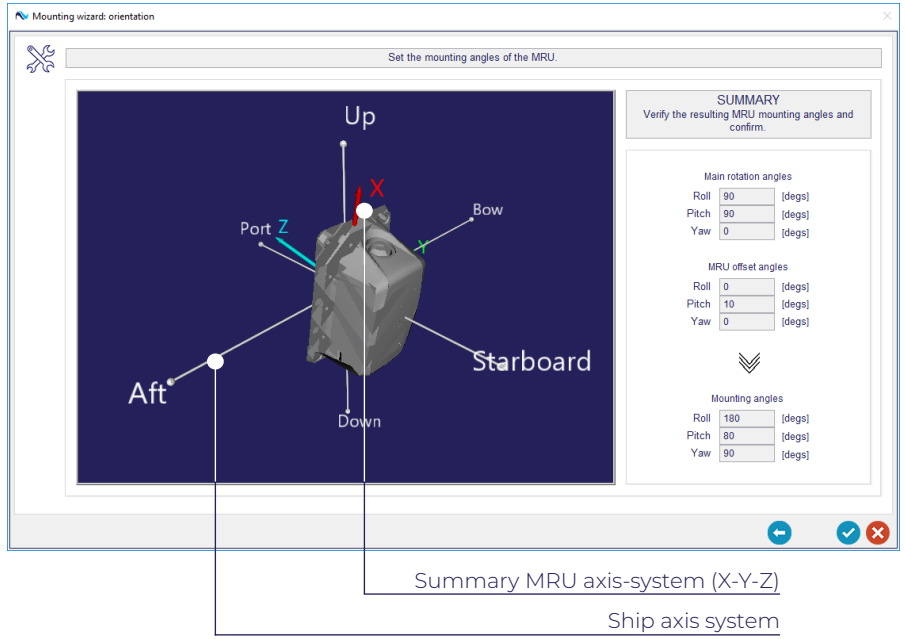


Figure 37 - Orientation wizard: summary.

MRU OFFSET ANGLES

Measuring the *MRU offset angles* with respect to the *Main rotation angles* can be difficult. In this case it is possible to automatically estimate them by using the *NORSUB MRU alignment tool*, which allows to estimate the installation offset between the MRU and the body frame. Notice that this tool requires the possibility to freely rotate the body (of known rotation) on which the MRU is installed. This tool is a separate software that can be downloaded from the Norwegian Subsea webpage.

Position Wizard

The position wizard is used to specify the characteristics of the vessel, the *Survey origin position* (SO), the *CG position* (center of gravity), *MRU position* and *Monitoring point 1* and *Monitoring point 2* positions (MP1, MP2).
Changing the position of the listed elements will update the dynamic elements in the top and side ship view in the *Position wizard*:

- Survey origin (SO) icon
- Center of gravity (COG) icon
- Monitoring point (MP1/MP2) icon

- MRU icon (front view)
- MRU icon (side view)
- MRU icon (top view)

STEP 1/2

You can set the *Ship type* and *Ship dimensions* in the STEP 1 of the position wizard. The *Survey origin position* can be placed relative to the vessel keel, stern and center line.

In Figure 38, the SO is placed at -3.5 m from the keel line and 4 m from the stern line. The CG is placed at *[x, y, z] = [4, 0, 1.75]m* from the SO (see Figure 38). This is defined in the interface as illustrated in Figure 39.

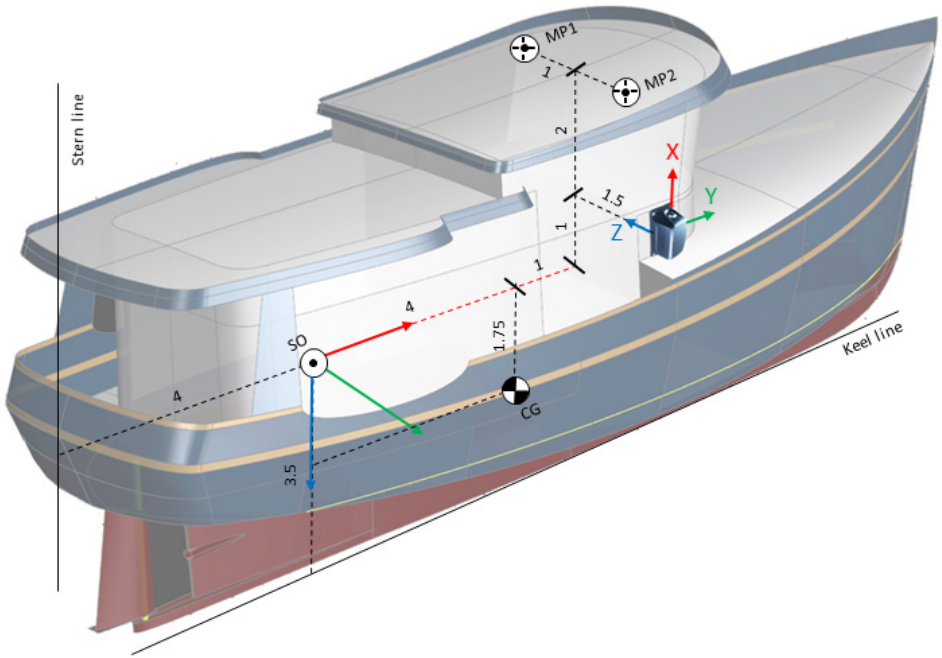


Figure 38 - Installation of the MRU on a vessel.

Position Wizard

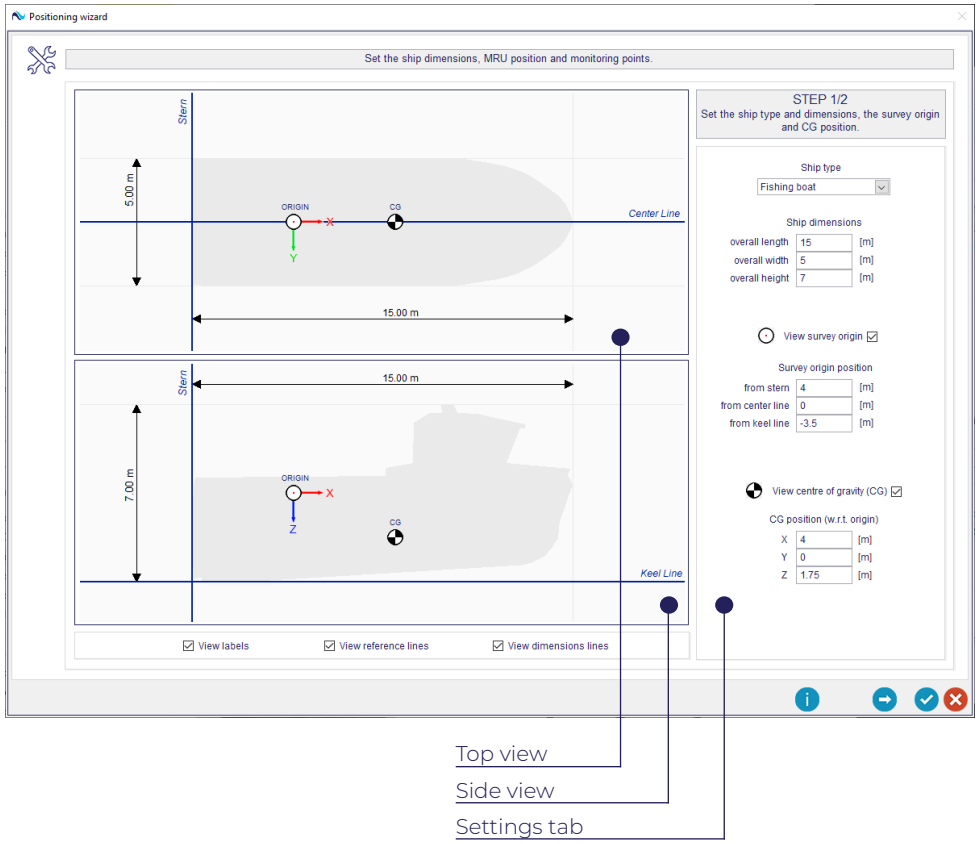


Figure 39 - Position wizard: STEP 1.

SURVEY ORIGIN (SO)

The *Survey Origin* (SO) correspond to the point in the vessel which is considered to be the reference point for the vessel frame: *[x, y, z] = [0, 0, 0]*. This is used to give a common reference to all the devices mounted on the vessel itself and should be already specified in the documentation for the equipment already installed on board. This point is usually defined w.r.t the physical elements of the ship (keel, stern and center lines).

Position Wizard

- **STEP 2/2**

In STEP 2 of the *Position wizard*, see Figure 40, set the *MRU position* and the *Monitoring point 1* and *Monitoring point 2* positions relative to the *Survey origin position* (SO).
For the example in Figure 38, the coordinates for the MRU and two monitoring points are:

MRU position = [5.0, 1.5, -1.0] m
Monitoring point 1 = [6.0, -1.0, -3.0] m
Monitoring point 2 = [6.0, 1.0, -3.0] m

Notice that the MRU icons in the top and side ship views of the *Position wizard* will reflect the *Main rotation angles* defined in the *Orientation wizard*.

If the remote mode is set to *Virtual MRU*, the output for the remote monitoring point is as if the MRU had been placed at that point (zero average surge, sway and heave position).
In *Projection mode*, the offset arm and displacement due to static roll/pitch are included in the output for the remote monitoring point.

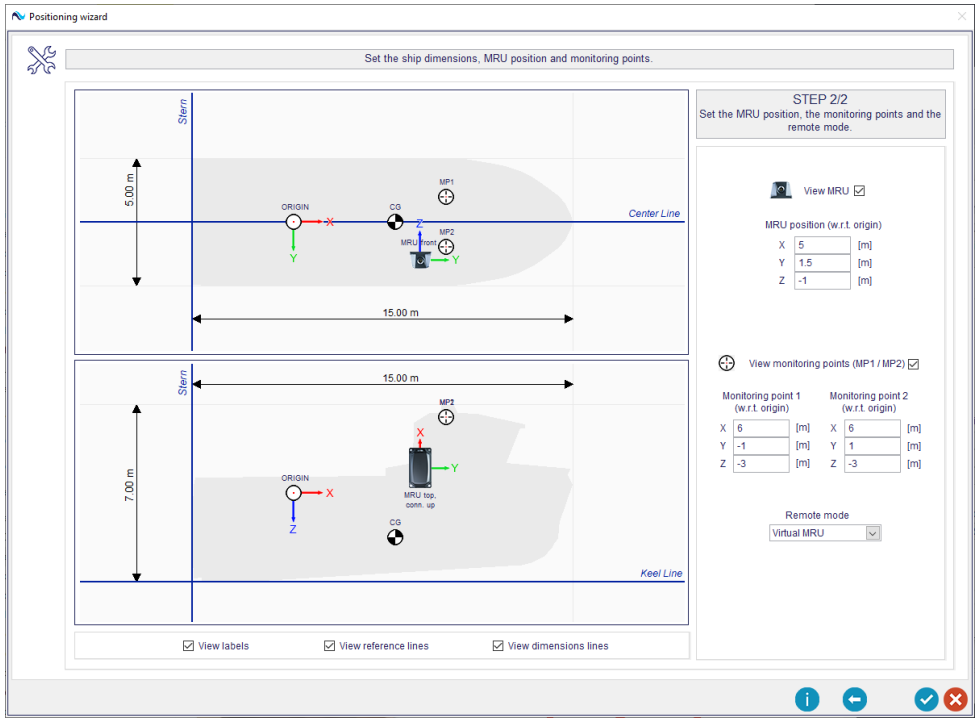


Figure 40 - Position wizard: STEP 2.

Time Synchronization

Configure the time and date settings of the MRU. Use the *Host PC time* panel to synchronize the MRU time with the host PC, or activate the NTP service to synchronize the MRU to the specified NTP server.

- **Sync to host PC time:** The MRU clock can be set to the host PC time by pressing the blue *PC sync* button (PC SYNC). This is allowed only if the *Synchronization method* is set to *Sync to host PC time*.

- **Sync to NTP server:** The NTP synchronization service can be activated/deactivated by pressing the blue *NTP ON/NTP OFF* button (NTP ON). The service status can be refreshed by pressing the blue *Refresh* button (it is automatically refreshed every 60 seconds). During the refresh process, the reachability of the servers is verified (*).
The *NTP server list* can be modified by adding new NTP servers or deleting the existing ones from the list. In the case of multiple servers, the NTP service selects the most accurate time source.

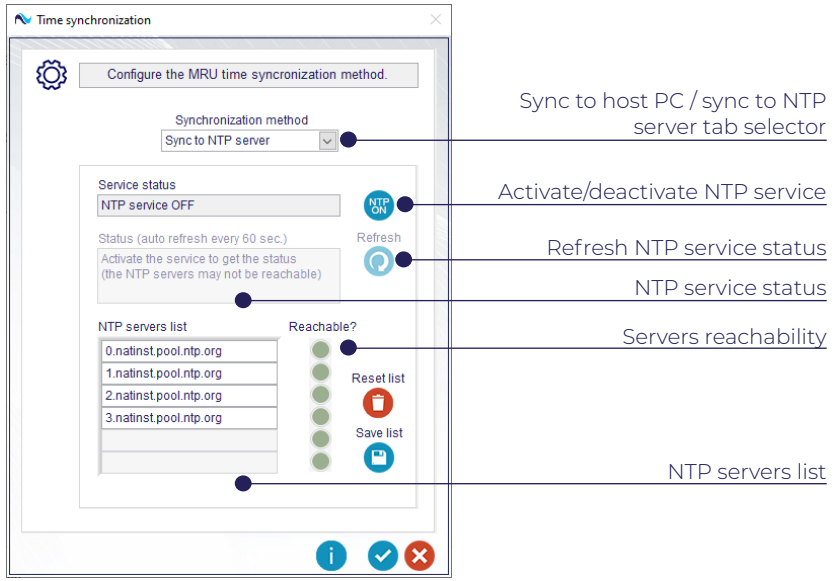


Figure 41 - MRU time synchronization settings: NTP service tab.

(*) The reachability of the servers can only be verified if the MRU is connected to the host PC through Ethernet and has a functioning Internet connection.

Other Settings

Set the geographical and tuning settings in the *Other settings* panel:

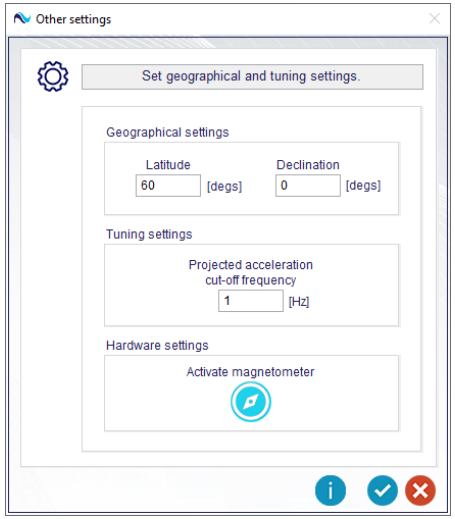


Figure 42 - MRU other setting.

- **Geographical settings:**
  - **Latitude:** set the latitude of the MRU location to provide an initial estimate of the acceleration of gravity.
  - **Declination:** set the declination to correct the magnetic heading output.
- **Tuning settings:**
  - **Projected acceleration cut-off frequency:** set the filter cut-off frequency depending by your application.
- **Hardware settings:**
  - **Activate magnetometer:** turn ON or OFF the magnetometer inside the MRU.

Local Data Log Settings

You can change the *Local data log settings* by customizing the log file path, header and time stamp settings. Time stamps are generated by the configuration software.

Select from the following log modes:

- **Log until "Stop log" button is pressed:** logging starts when the *Start logging* or the *Start SD-card logging* button is pressed, and lasts until the *Stop logging* or the *Stop SD-card logging* button is pressed;
- **Log for a specified period:** logs for the duration specified in the *Period (sec.)* field;
- **Log for a specified number of samples:** logging continues until the number of rows specified in the *Samples (number)* field is reached.

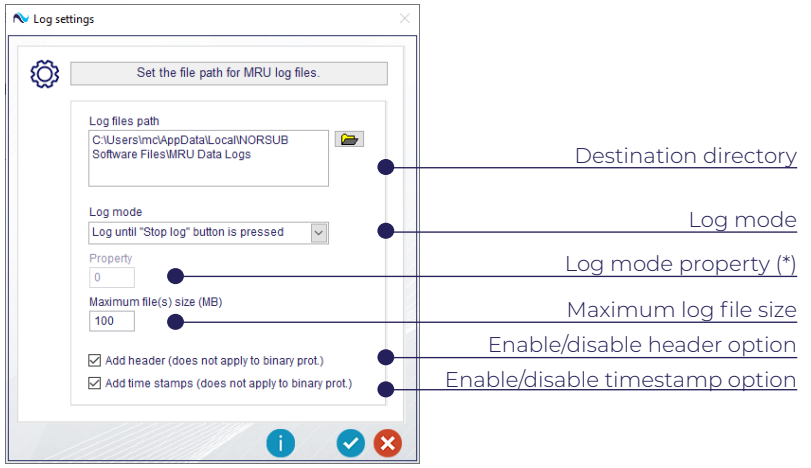


Figure 43 - Local data log settings.

(*) The property field is enabled if the selected *Log mode* is *Log for a specific period* or *Log for a specified number of samples*. The property field label becomes *Period (sec.)* if *Log for a specific period* is selected, while it becomes *Samples (number)* if *Log for a specified number of samples* is selected.

Local Data Log Settings

Use the checkboxes to add a header to the log file or insert a timestamp before an MRU protocol string. The name of the variables in the header contains the measurement unit (if applicable), location and frame:
`<variable_name>_<measurement_unit>_[<location>]_[<frame>]`

An example of MRU data ASCII log file is shown in Figure 44.

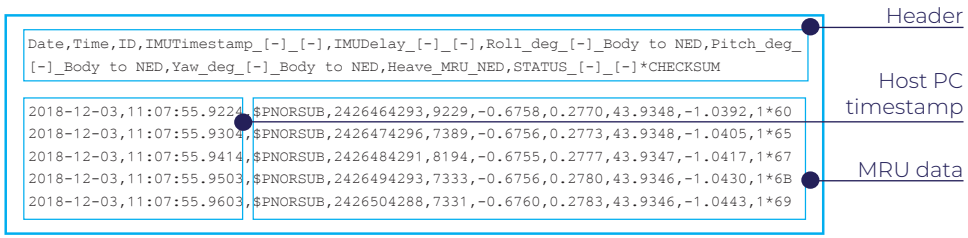


Figure 44 - Example of MRU data ASCII log file.

You can avoid very large log files by setting a preferred *Maximum log file size*. If the log file grows over this limit, another file will be created and tagged with a sequential index to keep the continuity of the data. The log file names are structured in the following way (see Figure 45):
`MRUlog_SET_<set_number>_PART_<sequential_index>_<protocol_name>_<rate>_<yyyy>_<mm>_<dd>_<hh>_<mm>.<extension>`

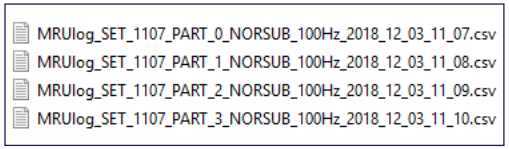


Figure 45 - Naming of MRU data log files.

MRU Set-Up Wizard Tool

Use the *MRU set-up wizard* to configure the MRU. The *MRU set-up wizard* automatically appears the first time the software is launched (it is possible to enable/disable the visualization of the wizard at every start up by checking/unchecking the *Open the wizard at start-up* checkbox). Press the *What's new in this version?* button ? to discover the last updates contained in the current software version.

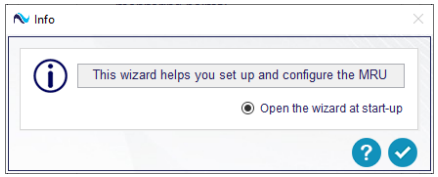


Figure 46 - Wizard start-up.

It is also possible to access the *MRU set-up wizard* from the *Settings* run-time menu, or use the keyboard shortcut `CTRL+W`. The set-up wizard can perform the following operations:

- Configure the MRU.
- Loading of a previous MRU configuration stored into a `*.MRUconfig` file.
- Revert to factory settings.

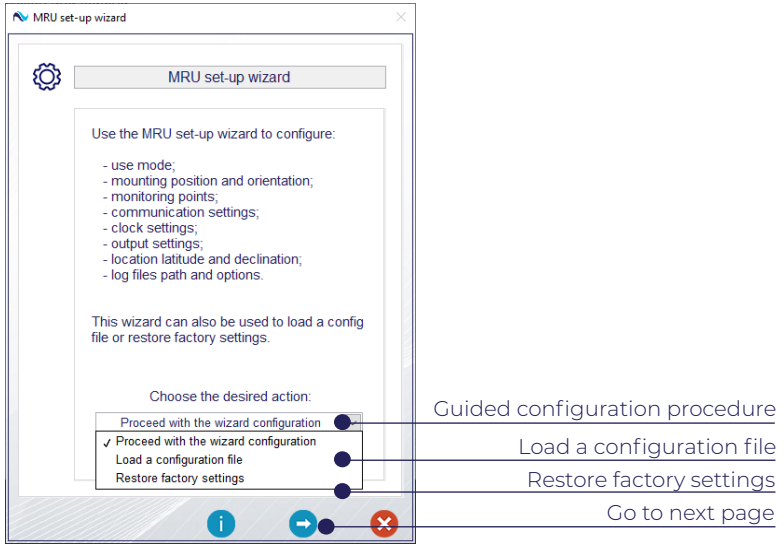


Figure 47 - MRU configuration wizard.

Select *Proceed with the wizard configuration* for a step-by-step configuration of the MRU. The wizard will navigate through the settings panels showed individually in the previous pages.

The selected MRU configuration is summarized on the last page of the wizard (summary).

MRU Set-Up Wizard Tool

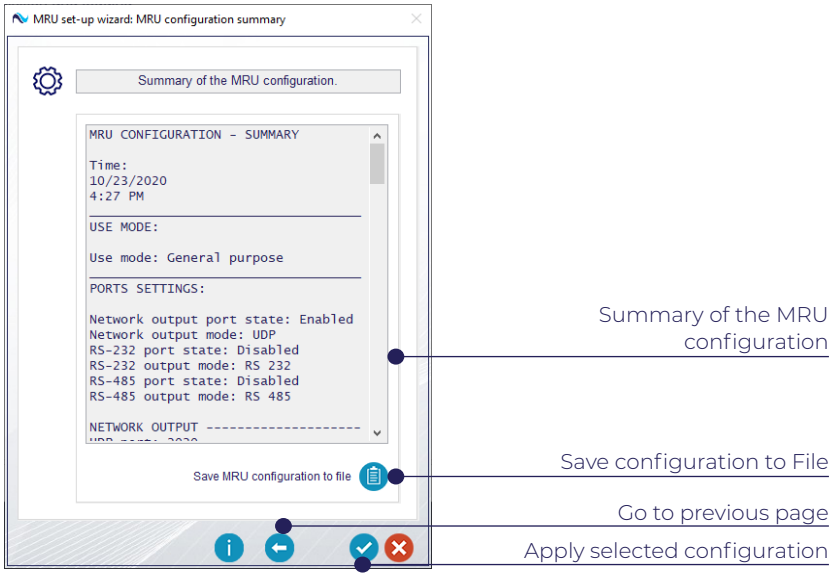


Figure 48 - Last page of the MRU set-up wizard tool: summary of the MRU configuration.

You can save the chosen settings into a file by selecting *Save MRU configuration to file*. The saved MRU configuration file (`*.MRUconfig`) can be reloaded later to the same or other MRUs.

Press the blue *Confirm* button to set the MRU configuration. Note that the configuration is lost if the MRU is powered off. To avoid this, press the *Save MRU settings to memory* button from the main interface to save the configuration to MRU memory.

In the first page of the MRU set-up wizard it is also possible to *Load a configuration file* or *Restore factory settings*:

- **Load a configuration file:** upload the MRU configuration contained in a `*.MRUconfig` file into the MRU set-up wizard.
- **Restore factory settings:** upload the MRU factory configuration into the MRU set-up wizard. The factory settings are summarized in Table 1.

After confirming the selection, it is possible to verify the loaded configuration in the MRU set-up wizard summary window. Press *Apply the selected configuration* button to upload it to the MRU.

SAVE CONFIGURATION TO MEMORY

Changes to the MRU configuration are applied but not saved when pressing the *Apply selected configuration button* Press the *Save MRU settings to memory* button in the main interface to save the configuration to MRU memory.

5. SOFTWARE TOOLS

Magnetometer Calibration Tool

To provide accurate heading measurements, the magnetometer in the MRU must be calibrated for soft and hard iron effects caused by nearby ferromagnetic materials.

- **Hard iron effects:** are caused by the magnetic field produced by nearby ferromagnetic materials. This produces an offset in the magnetometer measurements.
- **Soft iron effect:** are caused by changes in the magnetic field because certain materials set up a magnetic field in response to the Earth's magnetic field. This distortion depends on the orientation of the material in the Earth's magnetic field. The result is an elliptic distortion of a magnetometer triad that is rotated in the Earth's magnetic field.

Other error sources such as non-linearity and misalignment between magnetometer axes fit the same mathematical model as soft iron distortions and are lumped in the same calibration matrix.

The magnetometer calibration tool can be used to calculate the calibration matrix and offset vector to compensate for hard and soft iron effects. The calibration process requires the MRU, or vessel with the MRU, to be rotated about all, or just the vertical axis, depending on calibration mode (3D or 2D). The tool displays the current calibration method, and three panels corresponding to the calibration modes:

- **Factory calibration:** performed in-house by Norwegian Subsea, removes the distortion effects produced by the MRU casing and electronics. This calibration is applied by default.
- **User 3D calibration:** to be performed if it is possible to rotate the MRU about all axes after installation (e.g.: the MRU is installed in a small buoy).
- **User 2D calibration:** to be performed if it is possible to rotate the MRU only about the vertical axis after installation (e.g.: the MRU is installed on a ship).

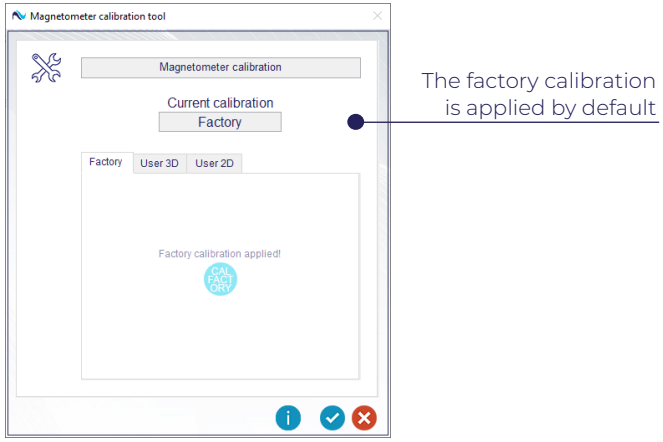


Figure 49 - Magnetometer factory calibration is applied by default.

Magnetometer Calibration Tool

User 3D calibration procedure:

1. Click on the *User 3D* tab, see Figure 50.
2. If the 3D calibration data (offset vector and scaling matrix) has not been calculated, only the option *Perform 3D calibration* is available (see Figure 50). Click on it to start the calibration procedure.

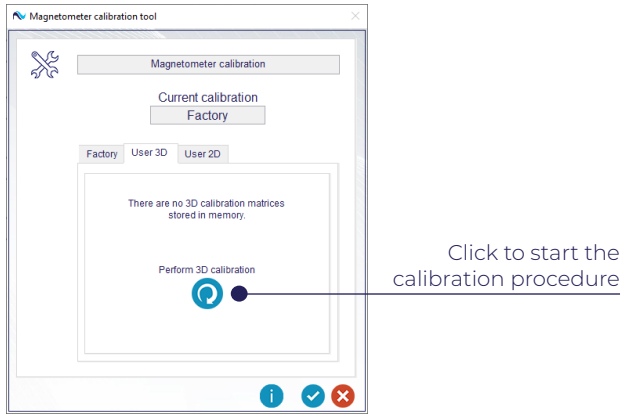


Figure 50 - Magnetometer calibration STEP 1,2.

3. A new window will appear as shown in Figure 51. Move the MRU about all the three axes while collecting data. The 3D plot should approximate a sphere, while the three plots showing the projections in the planes should approximate circles.

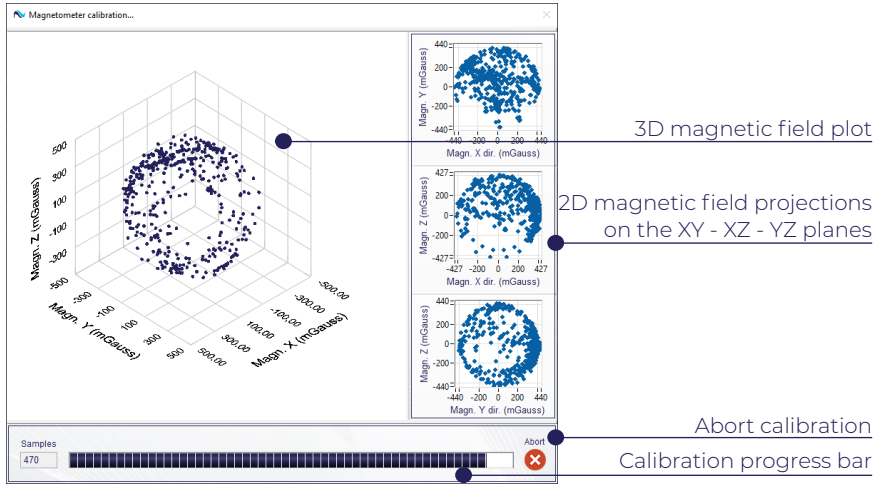


Figure 51 - User 3D magnetometer calibration.

Magnetometer Calibration Tool

The software stops to acquire calibration data if the MRU stops being rotated. In this case the window showed in Figure 52 appears until the motion restarts. From this window it is also possible to abort the calibration procedure.

Figure 52 - The MRU must be rotated for the software to keep collecting calibration data.

When the software has acquired 500 samples the window represented in Figure 53 pops-up. It is possible to proceed with calculating the calibration data based on the already collected samples, or acquire 200 extra data points. Select the latter option if the points cloud seems not to cover the whole 3D space (see Figure 51). A complete coverage ensures a better calibration.

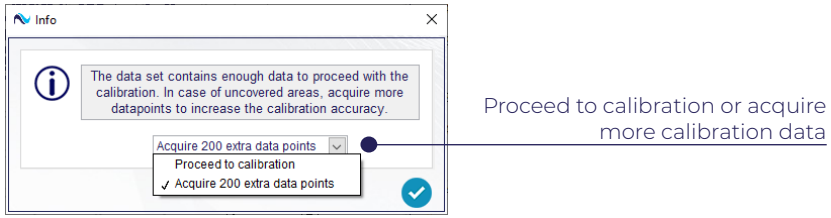


Figure 53 - Proceed to calibration / acquire more data.

At the end of the data collection phase the window showed in Figure 54 warns about possible gyroscope saturation: if the MRU has been rotated with excessively high speed during the calibration phase, the gyroscopes may have saturated. This can affect the quality of the MRU output data. In this case it is suggested to save the configuration and restart the MRU.

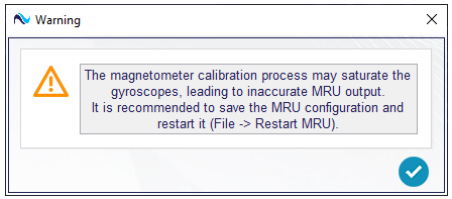


Figure 54 - Gyroscope saturation warning.

Magnetometer Calibration Tool

3. If *Proceed to calibration* is selected, the software calculates the calibration data and the magnetometer calibration panels opens again at the *User 3D* tab, which now it is filled with the calculated magnetometer *Scaling* and *Offset* calibration data as in Figure 55. From this tab it is possible to click on *Save 3D calibration data to memory* or *Clear 3D calibration data from memory* (if already present): saving the 3D calibration data to memory allows to switch between calibration modes keeping the possibility of recalling the calibration data without repeating the 3D calibration procedure.
4. Click on the *Apply user 3D calibration* button to switch from *Factory* to *User 3D* calibration. The MRU will start streaming calibrated data.
5. It is possible to perform a new calibration by clicking on the *Re-calibrate* button .

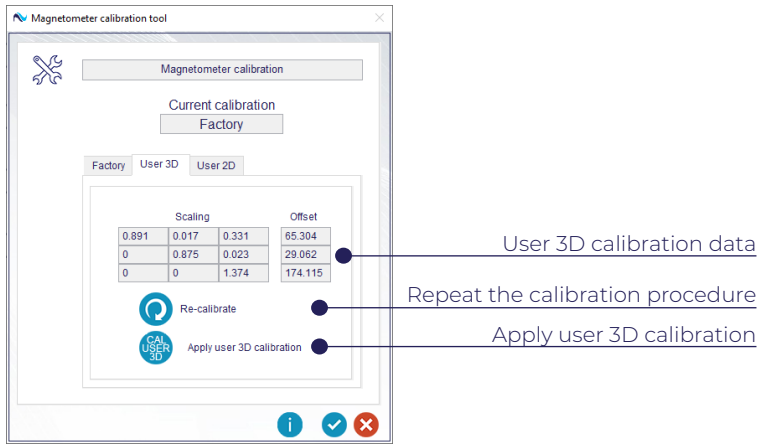


Figure 55 - User 3D calibration data panel.

SAVE VS APPLY USER 3D DATA

Click on the *Save 3D calibration data to memory* button to save the calibration data to MRU memory. This operation DOES NOT switch the calibration mode to *User 3D*. In order to set the *User 3D* calibration mode it is required to click on the *Apply user 3D calibration* button .

Magnetometer Calibration Tool

User 2D calibration procedure:

The User 2D calibration procedure is the same as the User 3D calibration procedure so it will not be extensively described. It is worth noticing that the calibration panel is different (see Figure 56) and that it is not possible to store the User 2D magnetometer calibration data in the MRU memory. This means that if the *Calibration mode* is not set to *User 2D* after the calibration procedure or it is switched to *User 3D* or *factory*, a new 2D calibration will be required.

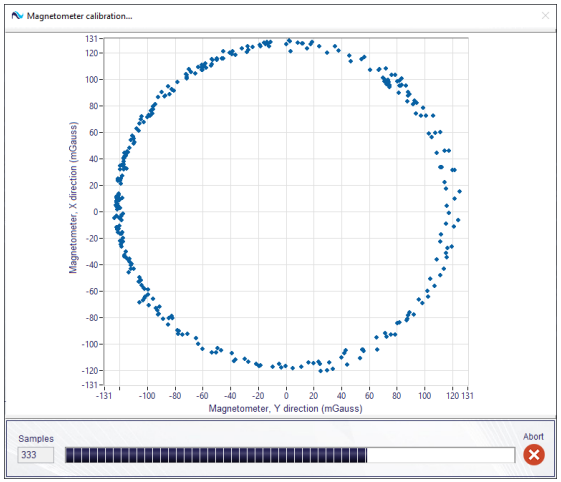


Figure 56 - User 2D magnetometer calibration.

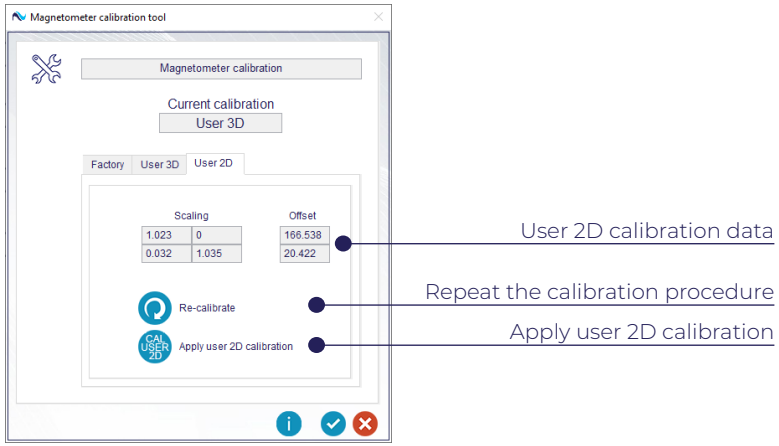


Figure 57 - User 2D calibration data panel.

MRU Firmware Update

Norwegian Subsea periodically releases firmware updates. Please use the Firmware update panel to update the firmware. Select *Tools* from the run-time menu, then *Update firmware*, or press `CTRL+F`. The following window appears:

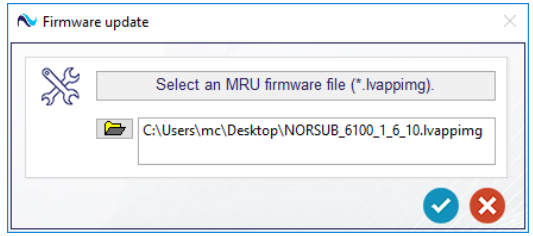


Figure 58 - Firmware update.

Update firmware by Ethernet with a `*.lvapping` firmware file or by serial connection with a `*.zip` firmware file.

Select the firmware file and press the blue *Update the firmware* button. This starts the firmware update, which can take up to 20 minutes. Do not power off the MRU during the firmware updates. At the end of the update, the MRU will restart.

Figure 59 - Firmware update status bar.

Reconnect by pressing the red *Connect* button from the main window.

WARNING: WAIT UNTIL COMPLETE

Firmware updates take up to 15 minutes with Ethernet connection and up to 20 minutes with serial connection and baud rate of 11500 bps. The update process causes a reboot of the MRU. Do not power off or disconnect the MRU during the firmware update process.

Retrieve SD Card Data

It is possible to view, download or delete the MRU data logs saved on the SD-card.
The SD card log files panel has functions to:

- Delete the selected log file from the SD-card.
- Delete all the log files from the SD-card.
- Copy the selected log file to the host PC.
- Copy all the log files to the host PC.

Notice that only the log files with size less than 100 MB will be previewed.

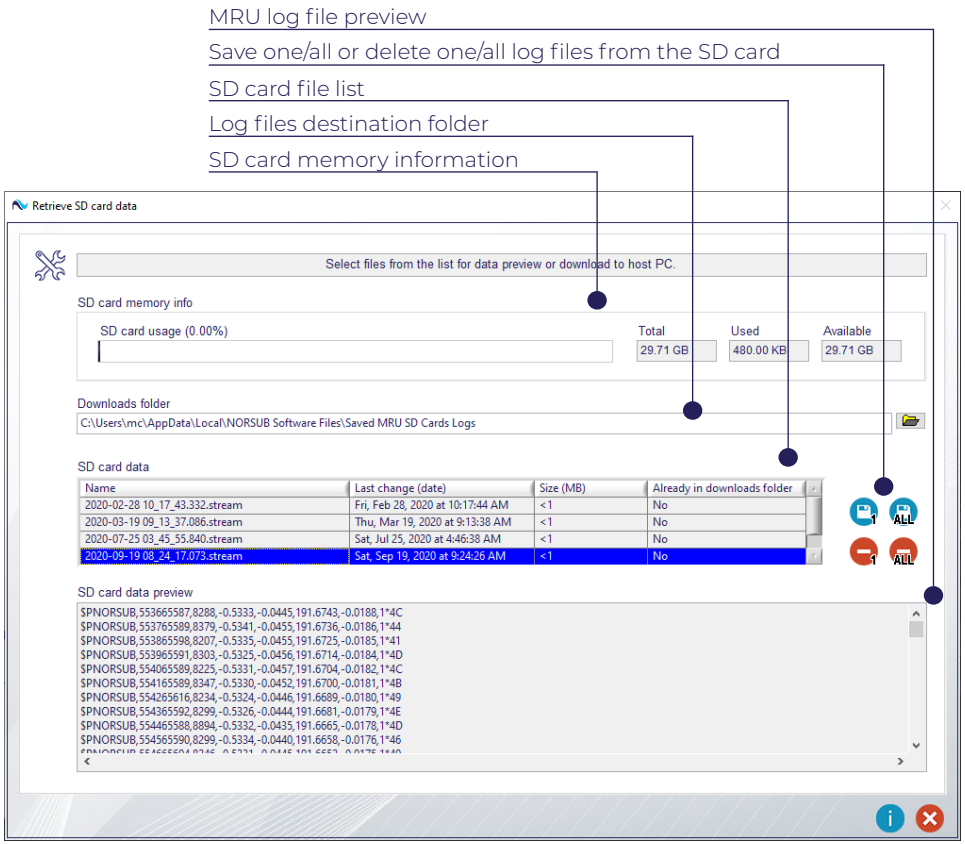


Figure 60 - SD-card data window.

Memory Calculator

The memory calculator finds the data rate (MB/h) and remaining log duration on the SD card and host PC for a given *Protocol* and *Output rate*.

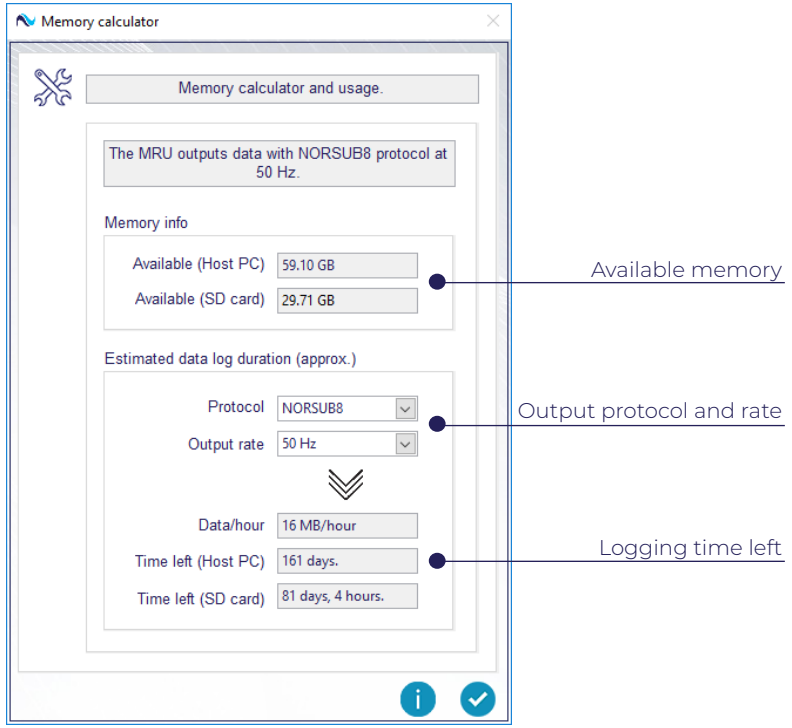


Figure 61 - Memory calculator window.

Configuration File Generator

The *Configuration file creator* generates a `*.MRUconfig` file. It has the same structure as the *MRU set-up wizard tool* and allows to edit all the MRU settings by successive steps.

Save the file by pressing the blue *Save MRU configuration to file* button on the last page. The default path is the following:

`C:\Users\<user_name>\AppData\Local\NORSUB Software Files\MRUconfig Files`

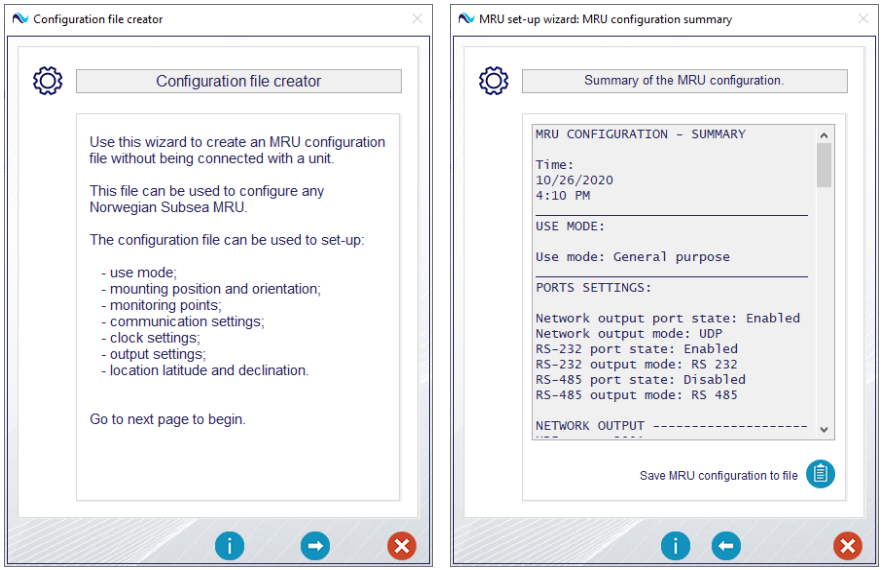


Figure 62 - Configuration file creator.

The configuration file can be successively loaded from the run-time menu (*File - Save and restore - Load MRU settings from file*) or from the *MRU set-up wizard tool* (see "MRU Set-Up Wizard Tool" on page 54).

6. HELP MENU

Local Software Data Folder

The MRU Configuration Software keeps the user files, data logs and debug reports in a directory structure created at the first software launch. The folder `NORSUB Software Files` is crated at: `C:\Users\<user_name>\AppData\Local\NORSUB Software Files\MRUconfig Files`

It is possible to open this directory in Windows Explorer by clicking on the Run-time menu *Help - Open local software data folder*.

The directory is organized as following:

```
MRUconfig Files
        |_ Debugging Reports
        |_ GUI Reports
        |_ MRU Data Logs
        |_ MRUconfig Files
        |_ PROTconfig Files
        |_ Saved MRU SD Card Logs
        |_ Temp
```

- **Debugging Reports:** default folder in which the *Debug report generator* saves the debug report folders.
- **GUI Reports:** collects all the GUI Manager Reports containing information about the Configuration Software errors, operations and processes. These files can be used by Norwegian Subsea to effectively resolve bugs and errors.
- **MRU Data Logs:** default folder in which the MRU data logs are saved.
- **MRUconfig Files:** default folder in which the *Configuration file generator* saves the `*.MRUconfig` files.
- **PROTconfig Files:** default folder in which the *Custom protocol generator* saves the `*.PROTconfig` files.
- **Saved MRU SD Card Logs:** default folder where the *Retrieve SD card data tool* copies the data logs retrieved from the MRU SD card.
- **Temp:** temporary files used by the configuration software for its functioning.

Debug report generator

The *Debug report generator* is a tool that gathers all the relevant MRU and MRU Configuration Software data in a bundle. It is strongly recommended to use it to communicate to Norwegian Subsea the presence of malfunctioning and bugs. The information collected in the bundle allows for a quicker bug-fixing.

To open the *Debug report generator* click on the Run-time menu *Help - Debug report generator*.

This tool automatically gathers the relevant data and sends it to *support@norwegian-subsea.no* by using the default Outlook mail account in the computer running the software.

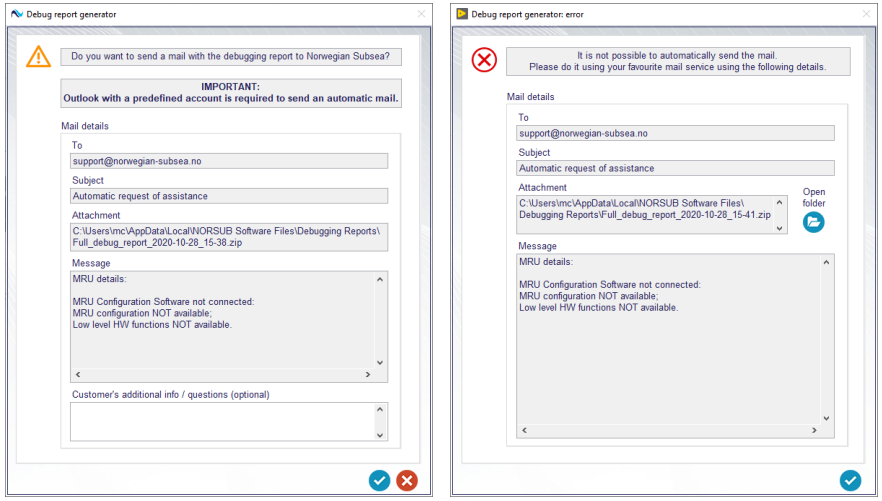


Figure 63 - Debug report generator and error window with debug information list.

MAIL ACCOUNT DATA

Norwegian Subsea software cannot know in any way the details of your mail account. The MRU Configuration Software uses an Outlook macro which allows to use the default mail account to send messages. No other information than the one specified in this document are included in the support mail.

Debug report generator

The *Debug report generator* creates a `*.zip` file with one of the following names:

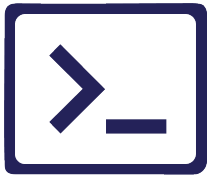
- `Full_debug_report_<date>_<time>.zip`
- `Off-line_debug_report_<date>_<time>.zip`
- `Off-line_HW_debug_report_<date>_<time>.zip`

The data contained in these bundles is described in the following:

- **Full debug report:** generated when the configuration software is connected to an MRU. It contains the full MRU configuration as mail message, while the attached archive contains the GUI Reports folder (with the GUI Manager Report files), the MRU Internal Reports folder (with all the internal MRU logs) and the MRUSystem Files folder (containing the calibration data and the MRU info data).
- **Off-line debug report:** generated when the configuration software is not connected to an MRU. The MRU configuration cannot be included, and the attached archives only contains the GU Reports folder.
- **Off-line HD debug report:** this is generated when the configuration software could connect to an MRU over Ethernet, but some errors occurred during the process of reading the MRU configuration. In this case the mail message cannot include the MRU configuration. The attached archives will contain both the GUI Reports folder, the MRU Internal Reports folder, and the MRU System Files folder.

If no mail accounts are set-up or if some errors are encountered, an error window will appear asking to manually send a support mail. Follow the instructions to include the required data to the mail.

7. CONFIGURATION COMMANDS



GET/SET

Configure the MRU via telnet or serial port. The main commands are listed in Table 7. All commands are case insensitive, thus will be reported with lowercasing to avoid confusion.

COMMAND	DESCRIPTION
get	get command parameters
set	set command parameters
exit	stop MRU
save	save parameters to flash (valid after reboot)
restart	restart the MRU

Table 6 - List of main commands.

The main functions GET and SET are used to get and set parameter values for the command groups listed in Table 8.

COMMAND GROUPS FOR GET/SET	
GROUP	ARGUMENTS
usemode	-
network	ipaddrmode, ip, subnetmask, gateway, dns, linkspeed
tcp	port
udp	hostip, port
modbustcp	registertype
ethernetip	instance id
serial	rs232, rs485, off
rs232	baudrate, databits, stopbits, parity, flowcontrol
rs485	baudrate, databits, stopbits, parity, flowcontrol
modbusrtu	unit id, registertype
output	protocol, location, rate, invertaxes, id, token, enabletoken, enablestatus, format start, stop, start232, start485, startSD, stopSD,
mounting	angles, anglesfine, mru, mp1, mp2, cg, remotemode
geo	latitude, declination
filter	gyroaccfc
timesync, ntp	state, serverlist, newserver
info	make, model, type, serialno, firmwarever, hardwarever

Table 7 - GET/SET command groups.

The definitions for command groups are given in the following sections.

Use Mode

Use mode configuration:

GET/SET USEMODE			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
usemode	use mode	generalpurpose	generalpurpose, DP

Table 8 - MRU modes settings.

Example:

```
get,usemode<CR><LF>
set,usemode,generalpurpose<CR><LF>
```

Network

Network configuration:

GET/SET NETWORK			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
ipaddrmode	IP address mode	static	static dhcplinklocal linklocal dhcp
ip	ip address of MRU	10.0.0.50	[0.0.0.0 - 255.255.255.255]
subnetmask	subnet mask	255.255.0.0	[0.0.0.0 - 255.255.255.255]
gateway	gateway	0.0.0.0	[0.0.0.0 - 255.255.255.255]
dns	DNS server	0.0.0.0	[0.0.0.0 - 255.255.255.255]
linkspeed	link speed	100full	autonegotiate 10half (10Mbps half duplex), 10full (10Mbps full duplex), 100half (100Mbps half duplex), 100full (100Mbps full duplex)

Table 9 - Network settings.

Example:

```
get,network,ipaddrmode<CR><LF>
get,network,ip<CR><LF>
get,network,subnetmask<CR><LF>
get,network,gateway<CR><LF>
get,network,dns<CR><LF>
get,network,linkspeed<CR><LF>

set,network,ipaddrmode,static<CR><LF>
set,network,ip,10.0.0.50<CR><LF>
set,network,subnetmask,255.255.0.0<CR><LF>
set,network,gateway,0.0.0.0<CR><LF>
set,network,dns,0.0.0.0<CR><LF>
set,network,linkspeed,100full<CR><LF>
```

Network

TCP configuration:

GET/SET TCP			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
port	TCP port	8090	[0 - 65535](*)

Table 10 - TCP settings.

Example:

```
get,tcp,port<CR><LF>                    set,tcp,port,8090<CR><LF>
```

UDP configuration:

GET/SET UDP			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
host ip	ip address of host computer	10.0.0.100	[0.0.0.0-255.255.255.255]
port	remote udp port	2001	[0 - 65535](*)

Table 11 - UDP settings.

Example:

```
get,udp,hostip<CR><LF>                  set,udp,hostip,10.0.0.100<CR><LF>
get,udp,port<CR><LF>                    set,udp,port,2001<CR><LF>
```

Modbus TCP configuration:

GET/SET MODBUSTCP			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
registertype	register type for Modbus TCP	input	input, holding

Table 12 - Modbus TCP settings.

Example:

```
get,modbustcp,registertype<CR><LF>  set,modbustcp,registertype,input<CR><LF>
```

Ethernet/IP configuration:

GET/SET ETHERNETIP			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
instanceid	device identifier	110	[102 - 199]

Table 13 - Ethernet/IP settings.

Example:

```
get,ethernetip,instanceid<CR><LF>       set,ethernetip,instanceid,110<CR><LF>
```

(*) Verify the availability of a port before set-up.

Serial

Serial ports configuration:

GET/SET SERIAL			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
serial	rs232	rs232	rs232, rs485, off

Table 14 - Serial ports settings.

Example:

```
get,serial<CR><LF>                      set,serial,rs232<CR><LF>
```

RS-232 configuration:

GET/SET RS232			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
baudrate	baudrate	115200	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200
databits	data bits	8	5, 6, 7, 8
parity	parity	0 (none)	0 (no parity), 1 (odd), 2 (even), 3 (mark), 4 (space)
stopbits	stop bits	1	10 (1), 20 (2)
flowcontrol	flow control	0 (none)	0 (none), 1 (XON/XOFF)

Table 15 - RS-232 settings.

Example:

```
get,rs-232,baudrate<CR><LF>             set,rs-232,baudrate,115200<CR><LF>
get,rs-232,databits<CR><LF>             set,rs-232,databits,8<CR><LF>
get,rs-232,parity<CR><LF>               set,rs-232,parity,0<CR><LF>
get,rs-232,stopbits<CR><LF>             set,rs-232,stopbits,10<CR><LF>
get,rs-232,flowcontrol<CR><LF>          set,rs-232,flowcontrol,0<CR><LF>
```

Serial

RS-485 configuration:

GET/SET RS485			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
baudrate	baudrate	115200	1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, 128000, 230400, 460800, 921600
databits	data bits	8	5, 6, 7, 8
parity	parity	0 (none)	0 (no parity), 1 (odd), 2 (even), 3 (mark), 4 (space)
stopbits	stop bits	1	10 (1), 20 (2)
flowcontrol	flow control	0 (none)	0 (none), 1 (XON/XOFF)

Table 16 - RS-485 settings.

Example:

```
get,rs-485,baudrate<CR><LF>          set,rs-485,baudrate,115200<CR><LF>
get,rs-485,databits<CR><LF>          set,rs-485,databits,8<CR><LF>
get,rs-485,parity<CR><LF>            set,rs-485,parity,0<CR><LF>
get,rs-485,stopbits<CR><LF>          set,rs-485,stopbits,10<CR><LF>
get,rs-485,flowcontrol<CR><LF>       set,rs-485,flowcontrol,0<CR><LF>
```

Modbus RTU configuration:

GET/SET MODBUSRTU			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
unitid	device identifier	1	[102 - 199]
registertype	register type for Modbus RTU	input	input, holding

Table 17 - Modbus TCP settings.

Example:

```
get,modbusrtu,unitid<CR><LF>          set,modbusrtu,unitid,1<CR><LF>
get,modbusrtu,registertype<CR><LF>    set,modbusrtu,registertype,input<CR><LF>
```


Output

Output configuration:

GET/SET OUTPUT			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
protocol	output protocol	norsub6	see protocol list
location	data reference point	mru	mru, cg, mp1, mp2, aid1, aid2
rate	output rate	50	1, 2, 4, 5, 10, 20, 25, 50, 100
invertaxes	inverted axes flags	[0 0 0 0 0 0]	-
id	custom protocol identifier	$PSXN	-
token	custom protocol token	19	-
enabletoken	enable token in cust. protocol	1	0 (false), 1 (true)
enablestatus	enable status in cust. protocol	1	0 (false), 1 (true)
format	cust. protocol variables format	%.3f	%8.3e, %9.4e %.2f, %.3f, %.4f %.5f, %.6f, %.7f %.8f, %.9f
start232	start streaming RS-232	-	-
start485	start streaming RS-485	-	-
startsd	start logging on SD card	-	-
stopsd	stop logging on SD card	-	-
stop	stop streaming serial data	-	-

Table 18 - Output settings.

Example:

```
get,output,protocol<CR><LF>          set,output,protocol,norsub6<CR><LF>
get,output,location<CR><LF>          set,output,location,mru<CR><LF>
get,output,rate<CR><LF>              set,output,rate,50<CR><LF>
get,output,invertaxes<CR><LF>        set,output,invertaxes,[0 0 0 0 0 0]<CR><LF>
get,output,id<CR><LF>                set,output,id,$PSXN<CR><LF>
get,output,token<CR><LF>             set,output,token,19<CR><LF>
get,output,enabletoken<CR><LF>       set,output,enabletoken,1<CR><LF>
get,output,enablestatus<CR><LF>      set,output,enablestatus,1<CR><LF>
get,output,format<CR><LF>            set,output,format,%.3f<CR><LF>
                                     set,output,start232<CR><LF>
                                     set,output,start485<CR><LF>
                                     set,output,startsd<CR><LF>
                                     set,output,stopsd<CR><LF>
                                     set,output,stop<CR><LF>
```

Mounting

Mounting configuration:

GET/SET MOUNTING			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
angles	orientation of MRU w.r.t. vessel in degrees	[0 0 0]	90 degrees steps
anglesfine	fine orientation of MRU w.r.t. coarse alignment axes in degrees	[0 0 0]	-
mru	arm from CO to MRU [m]	[0 0 0]	-
mp1	arm from CO to MP1 in meters	[0 0 0]	-
mp2	arm from CO to MP2 in meters	[0 0 0]	-
cg	arm from CO to CG [m]	[0 0 0]	-
remotemode	mode for remote monitoring	[0 0 0]	virtualmru, projection

Table 19 - Mounting settings.

Example:

```
get,mounting,angles<CR><LF>        set,mounting,angles,[90 0 0]<CR><LF>
get,mounting,anglesfine<CR><LF>    set,mounting,anglesfine,[1.2 0.1 0.3]<CR><LF>
get,mounting,mru<CR><LF>           set,mounting,mru,[6.78 1.65 2.43]<CR><LF>
get,mounting,mp1<CR><LF>           set,mounting,mp1,[0 0 23]<CR><LF>
get,mounting,mp2<CR><LF>           set,mounting,mp2,[20.5 0 0]<CR><LF>
get,mounting,cg<CR><LF>            set,mounting,cg,[14 0 1.4]<CR><LF>
get,mounting,remotemode<CR><LF>    set,mounting,remotemode,virtualmru<CR><LF>
```

Geo

Geographic settings:

GET/SET GEO			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
latitude	latitude in degrees	60	[-90 - 90]
declination	magnetic declination in degrees	0	[-180 - 180]

Table 20 - MRU geographic settings.

Example:

```
get,geo,latitude<CR><LF>           set,geo,latitude,58.49<CR><LF>
get,geo,declination<CR><LF>        set,geo,declination,-3.36<CR><LF>
```


Filter

Filter configuration:

GET/SET FILTER			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
gyroaccfc	latitude in degrees	1	[0 - inf]

Table 21 - MRU filter settings.

Example:

```
get,filter,gyroaccfc<CR><LF>        set,filter,gyroaccfc,1<CR><LF>
```

IMU,all

Hardware configuration:

GET/SET FILTER			
SETTING	DESCRIPTION	DEFAULT	VALID RANGE
mag_enable	magnetometer enabled	1	[0, 1]

Table 23 - MRU filter settings.

Example:

```
getpar,imu,all,mag_enable<CR><LF>      setpar,imu,all,mag_enable,1<CR><LF>
```

Timesync

Timesync configuration:

GET/SET TIMESYNC			
PARAMETER	DESCRIPTION	DEFAULT	VALID RANGE
state	state of NTP synchronization service	-	start, stop, restart
serverlist	NTP servers name		-

Table 22 - MRU timesync settings.

Example:

```
get,timesync,ntp,state<CR><LF>
get,timesync,ntp,serverlist<CR><LF>

set,timesync,ntp,state,start<CR><LF>
set,timesync,ntp,state,stop<CR><LF>
set,timesync,ntp,state,restart<CR><LF>
set,timesync,ntp,serverlist,0.no.pool.ntp.org;1.no.pool.ntp.org<CR><LF>
```

Info

MRU information:

GET INFO	
PARAMETER	DESCRIPTION
`make`	MRU make
`model`	MRU model number (3000, 6000)
`type`	MRU type (Marine, Subsea, OEM)
`serialno`	MRU serial number
`firmwarever`	firmware version number
`hardwarever`	hardware version number

Table 24 - Info parameters.

Example:

```
get,info,make<CR><LF>
get,info,model<CR><LF>
get,info,type<CR><LF>
get,info,serialno<CR><LF>
get,info,firmwarever<CR><LF>
get,info,hardwarever<CR><LF>
```


8. OUTPUT PROTOCOLS

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 25 - 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 26 - List of output protocols (part 2).

Custom NMEA: Creates a custom output protocol in NMEA format. See Chapter 10 on page 113 for a list of available output parameters.

Custom Binary: Creates a custom output protocol in binary format. See Chapter 10 on page 113 for a list of available output parameters.

Output Protocols

The following table shows available parameters in each protocol.

NAME	TYPE		DATA
Atlas	bin.	Heave	
Gyrocompasl	ASCII	Roll	
Ifremer Victor	bin.	Roll Pitch	
MDL	ASCII	Roll Pitch Heading	
NORSUB	ASCII	Roll Pitch Yaw Heave	
NORSUB2	ASCII	Roll Pitch Yaw Heave	
NORSUB6	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc.	
NORSUB6g	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc.	
NORSUB7	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc. Heave acc. (incl.g) Surge period Sway period Heave period Surge amplitude Sway amplitude Heave amplitde STATUS STATUS_A STATUS_B	
NORSUB7b	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc. Heave acc. (incl.g) Surge period Sway period Heave period Surge amplitude Sway amplitude Heave amplitde STATUS STATUS_A STATUS_B	

Table 27 - Output protocol data (part 1).

Output Protocols

NAME	TYPE	DATA
TSSI	bin.	Roll Pitch
Simrad EM 3000	bin.	Roll Pitch Yaw
SMCCg	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc. Heave acc. (incl.g)
SMCC	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc.
SMCA	ASCII	Roll Pitch Yaw Surge Sway Heave Surge velocity Sway velocity Heave velocity Surge acc. Sway acc. Heave acc. Heave acc. (incl.g) Surge period Sway period Heave period Surge amplitude Sway amplitude Heave amplitde STATUS STATUS_A STATUS_B
RDI ADCP	ASCII	Roll Pitch Yaw Heading Roll rate Pitch rate Yaw rate
Tokimek PTVG	ASCII	Roll Pitch Yaw
NORSUB PRDID	ASCII	Roll Pitch
NORSUB8	ASCII	Roll

Table 28 - Output protocol data (part 2).

ATLAS

(Atlas Fansweep 20)

Data:

- Roll, pitch
- Heave

Telegram:

BYTE N.	DESCRIPTION	NOTE
Byte 0	DLE	0x10
Byte 1	roll MSB	U16, LSB = 360/2^16 degs
Byte 2	roll LSB	
Byte 3	pitch MSB	U16, LSB = 360/2^16 degs
Byte 4	pitch LSB	
Byte 5	heave MSB	U16, LSB = 360/2^16 degs
Byte 6	heave LSB	
Byte 7	status	See table below for details
Byte 8	DLE	0x10

Table 29 - Atlas Fansweep 20 field description.

Status codes:

BYTE N.	DESCRIPTION
0	unaided, stable data.
1	unaided, unstable data.
2	speed aided, stable data.
3	speed aided, unstable data.
4	heading aided, stable data.
5	heading aided, unstable data.
6	full aided, stable data.
7	full aided, unstable data.

Table 30 - Atlas Fansweep status codes.

GYROCOMPAS 1

Data:

- Roll, pitch, heading

Telegram:

```
$HEHDT,x.xx,T*hh<CR><LF>
$PHTRO,x.xx,a,y.yy,b*hh<CR><LF>
$PHINF,ssssssss*hh<CR><LF>
```

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
HEHDT	x.xx	heading	[degs]	-	-
-	T	symbol	-	-	-
-	hh	checksum	-	-	-
PHTRO	x.xx	pitch	[degs]	-	-
-	a	pitch direction	-	-	M bow up, P bow down
-	y.yy	roll	[degs]	-	-
-	b	roll direction	-	-	B port down, T port up
-	hh	checksum	-	-	-
PHINF	ssssssss	status	-	-	-
-	hh	checksum	-	-	XOR of characters between $ and *

Table 31 - GYROCOMPAS1 field description.

Example:

```
$HEHDT,231.57,T*29<CR><LF>
$PHTRO,0.16,P,0.29,B*79<CR><LF>
$PHINF,00000000*117<CR><LF>
```

IFREMER VICTOR

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- x acceleration, y acceleration, z acceleration

Telegram:

<Q><n><id><F1><F2>.....<F9><F10><cs>

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
Byte 0	-	'Q'	-	-	sync
Byte 1	-	0x29	-	-	no bytes
Byte 2	-	0x0C	-	-	user ID
Byte 3-6	1	roll	[rads]	-	IEEE floating point, + port up
Byte 7-10	2	pitch	[rads]	-	IEEE floating point, + bow up
Byte 11-14	3	heading	[rads]	-	IEEE floating point
Byte 15-18	4	roll rate	[rads/s]	-	IEEE floating point
Byte 19-22	5	pitch rate	[rads/s]	-	IEEE floating point
Byte 23-26	6	heading rate	[rads/s]	-	IEEE floating point
Byte 27-30	7	x acceleration	[m/s2]	-	IEEE floating point
Byte 31-34	8	y acceleration	[m/s2]	-	IEEE floating point
Byte 35-38	9	z acceleration	[m/s2]	-	IEEE floating point
Bytes 39-42	10	spare	-	-	IEEE floating point
Byte 43	-	checksum	-	-	addition of bytes from 0 to 42

Table 32 - IFREMER VICTOR field description.

MDL

Data:

- Roll, pitch, heading

Telegram:

HhhhhP±xxxxR±yyyy<CR><LF>

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
-	hhhh	heading multiplied by 10	[degs]	-	-
-	xxxx	pitch multiplied by 100	[degs]	-	-
-	yyyy	roll multiplied by 100	[degs]	-	-

Table 33 - MDL field description.

Example:

H2650P- 16R- 36<CR><LF>

NORSUB

Data:

- Roll, pitch, heading
- Heave

Telegram:

`$PNORSUB,T1,T2,roll,pitch,heading,heave,status*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB	identifier	-	string	-
1	T1	time for valid measurement (internal clock)	[ms]	uint32	wraps from (2^32-1) to 0
2	T2	delay from T1 to diagram is sent	[ms]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	heave	heave	[m]	DBL	%.4f, z-down
7	status	status	-	uint32	%d, (1-OK, 0-error)
8	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 34 - NORSUB field description.

Example:

`$PNORSUB,203798,2,+0.117,-0.505,259.893,1.350,1*62<CR><LF>`

NORSUB2

Data:

- Roll, pitch, heading
- Heave
- Heave velocity

Telegram:

`$PNORSUB2,T1,T2,roll,pitch,heading,heave,heave_vel,status*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB2	identifier	-	string	-
1	T1	time for valid measurement (internal clock)	[ms]	uint32	wraps from (2^32-1) to 0
2	T2	delay from T1 to diagram is sent	[ms]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	heave	heave	[m]	DBL	%.4f, z-down
7	heave_vel	heave velocity	[m/s]	DBL	%.4f, z-down
8	status	status (1-OK, 0-error)	-	uint32	%d, (1-OK, 0-error)
9	CS	NMEA checksum (*)	-	hex	XOR of characters between $ and *

Table 35 - NORSUB2 field description.

Example:

`$PNORSUB2,203798,2,+0.117,-0.505,259.893,1.350,0.675,1*62<CR><LF>`

NORSUB6

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration

Telegram:

`$PNORSUB6,T1,T2,roll,pitch,heading,surge,sway,heave,roll_rate,pitch_rate,`
`yaw_rate,surge_vel,sway_vel, heave_vel,acc_x,acc_y,acc_z,status*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB6	identifier	-	string	-
1	T1	time for valid meas. (int. clock)	[us]	uint32	Wraps from (2^32-1) to 0
2	T2	delay from T1 to telegram is sent	[us]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	surge	surge	[m]	DBL	%.4f
7	sway	sway	[m]	DBL	%.4f
8	heave	heave	[m]	DBL	%.4f, z-down
9	roll rate	roll rate	[degs/s]	DBL	%.4f
10	pitch rate	pitch rate	[degs/s]	DBL	%.4f
11	yaw rate	yaw rate	[degs/s]	DBL	%.4f
12	surge vel	surge velocity	[m/s]	DBL	%.4f
13	sway vel	sway velocity	[m/s]	DBL	%.4f
14	heave vel	heave velocity	[m/s]	DBL	%.4f, z-down
15	acc x	acceleration x	[m/s2]	DBL	%.5f
16	acc y	acceleration y	[m/s2]	DBL	%.5f
17	acc z	acceleration z	[m/s2]	DBL	%.5f
18	status	status	-	uint32	%d, (1-OK, 0-error)
19	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 36 - NORSUB6 field description.

Example:

`$PNORSUB6,735924181,7566,0.188,0.447,357.132,0.012,-0.002,-0.001,-0.000,`
`-0.000,0.003,0.012,0.003,-0.002,0.07679,-0.04408,0.00007,1*71<CR><LF>`

NORSUB6g

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration (including gravity)

Telegram:

`$PNORSUB6,T1,T2,roll,pitch,heading,surge,sway,heave,roll_rate,pitch_rate,`
`yaw_rate,surge_vel,sway_vel, heave_vel,acc_x,acc_y,acc_z_G,status*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB6	identifier	-	string	-
1	T1	time for valid meas. (int. clock)	[us]	uint32	Wraps from (2^32-1) to 0
2	T2	delay from T1 to telegram is sent	[us]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	surge	surge	[m]	DBL	%.4f
7	sway	sway	[m]	DBL	%.4f
8	heave	heave	[m]	DBL	%.4f, z-down
9	roll rate	roll rate	[degs/s]	DBL	%.4f
10	pitch rate	pitch rate	[degs/s]	DBL	%.4f
11	yaw rate	yaw rate	[degs/s]	DBL	%.4f
12	surge vel	surge velocity	[m/s]	DBL	%.4f
13	sway vel	sway velocity	[m/s]	DBL	%.4f
14	heave vel	heave velocity	[m/s]	DBL	%.4f, z-down
15	acc x	acceleration x	[m/s2]	DBL	%.5f
16	acc y	acceleration y	[m/s2]	DBL	%.5f
17	acc z G	acceleration z incl. g	[m/s2]	DBL	%.5f
18	status	status	-	uint32	%d, (1-OK, 0-error)
19	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 37 - NORSUB6 field description.

Example:

`$PNORSUB6,735924181,7566,0.188,0.447,357.132,0.012,-0.002,-0.001,-0.000,`
`-0.000,0.003,0.012,0.003,-0.002,0.07679,-0.04408,-9.83225,1*71<CR><LF>`

NORSUB7

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration
- x period, y period, z period
- x amplitude, y amplitude, z amplitude
- full status word

Telegram:

```
$PNORSUB7,T1,T2,roll,pitch,heading,surge,sway,heave,roll_rate,pitch_rate,
yaw_rate,surge_vel,sway_vel, heave_vel,acc_x,acc_y,acc_z,T_x,T_y,T_z,
A_x,A_y,A_z,status_full*CS<CR><LF>
```

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB7	identifier	-	string	-
1	T1	time for valid meas. (int. clock)	[us]	uint32	Wraps from (2^32-1) to 0
2	T2	delay from T1 to the telegram is sent	[us]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	surge	surge	[m]	DBL	%.4f
7	sway	sway	[m]	DBL	%.4f
8	heave	heave	[m]	DBL	%.4f, z-down
9	roll rate	roll rate	[degs/s]	DBL	%.4f
10	pitch rate	pitch rate	[degs/s]	DBL	%.4f
11	yaw rate	yaw rate	[degs/s]	DBL	%.4f
12	surge vel	surge velocity	[m/s]	DBL	%.4f
13	sway vel	sway velocity	[m/s]	DBL	%.4f
14	heave vel	heave velocity	[m/s]	DBL	%.4f, z-down
15	acc x	acceleration x	[m/s2]	DBL	%.5f
16	acc y	acceleration y	[m/s2]	DBL	%.5f
17	acc z	acceleration z	[m/s2]	DBL	%.5f

Table 38 - NORSUB7 field description (part 1).

NORSUB7

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
18	T x	period x	[s]	DBL	%.2f
19	T y	period y	[s]	DBL	%.2f
20	T z	period z	[s]	DBL	%.2f
21	A x	amplitude x	[m]	DBL	%.2f
22	A y	amplitude y	[m]	DBL	%.2f
23	A z	amplitude z	[m]	DBL	%.2f
24	status full	status (full word)	-	uint32	%d
25	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 39 - NORSUB7 field description (part 2).

Example:

```
$PNORSUB7,1347578196,7939,-100.1028,0.8549,108.1722,0.029,0.021,-0.020,
-0.069,-0.017,0.035,0.009,0.003,-0.003,0.00154,-0.00190,0.00302, 24.97,
25.00,25.00,0.01,0.01,0.00,15957967*5
```

NORSUB7 / NORSUB7B / NORSUB8

NORSUB7, NORSUB7b and NORSUB8 are very similar in their structure. The important difference is that in the NORSUB7 and NORSUB7b protocol the surge, sway positions, velocities and accelerations are measured in the **body frame**, while in the NORSUB8 protocol they are measured in the **heading frame**. NORSUB7 and NORSUB8 contain the full STATUS word (n.24), while NORSUB7b contains the status split in to variables (n.24 and n.25): one containing the first two bytes, the other containing the last two.

NORSUB7b

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration
- x period, y period, z period
- x amplitude, y amplitude, z amplitude
- full status word

Telegram:

`$PNORSUB7B,T1,T2,roll,pitch,heading,surge,sway,heave,roll_rate,pitch_rate,yaw_rate,surge_vel,sway_vel, heave_vel,acc_x,acc_y,acc_z,T_x,T_y,T_z,A_x,A_y,A_z,status_A,status_B*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PNORSUB7B	identifier	-	string	-
1	T1	time for valid meas. (int. clock)	[us]	uint32	Wraps from (2^32-1) to 0
2	T2	delay from T1 to telegram is sent	[us]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	surge	surge	[m]	DBL	%.4f
7	sway	sway	[m]	DBL	%.4f
8	heave	heave (z-down)	[m]	DBL	%.4f, z-down
9	roll rate	roll rate	[degs/s]	DBL	%.4f
10	pitch rate	pitch rate	[degs/s]	DBL	%.4f
11	yaw rate	yaw rate	[degs/s]	DBL	%.4f
12	surge vel	surge velocity	[m/s]	DBL	%.4f
13	sway vel	sway velocity	[m/s]	DBL	%.4f
14	heave vel	heave velocity	[m/s]	DBL	%.4f, z-down
15	acc x	acceleration x	[m/s2]	DBL	%.5f
16	acc y	acceleration y	[m/s2]	DBL	%.5f
17	acc z	acceleration z	[m/s2]	DBL	%.5f

Table 40 - NORSUB7b field description (part 1).

NORSUB7b

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
18	T x	period x	[s]	DBL	%.2f
19	T y	period y	[s]	DBL	%.2f
20	T z	period z	[s]	DBL	%.2f
21	A x	amplitude x	[m]	DBL	%.2f
22	A y	amplitude y	[m]	DBL	%.2f
23	A z	amplitude z	[m]	DBL	%.2f
24	STATUS_A	status (first 2 bytes)	-	uint16	%d
25	STATUS_B	status (last 2 bytes)	-	uint16	%d
26	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 41 - NORSUB7b field description (part 2).

Example:

`$PNORSUB7B,2129668928,7985,-100.1022,0.8708,107.7754,-0.005,-0.023,-0.017,-0.035,0.019,-0.021,-0.003,-0.007,-0.002,0.00392,-0.00562,0.00544,25.00,25.00,25.00,0.01,0.00,0.00,15957967*55`

NORSUB7 / NORSUB7B / NORSUB8

NORSUB7, NORSUB7b and NORSUB8 are very similar in their structure. The important difference is that in the NORSUB7 and NORSUB7b protocol the surge, sway positions, velocities and accelerations are measured in the **body frame**, while in the NORSUB8 protocol they are measured in the **heading frame**. NORSUB7 and NORSUB8 contain the full STATUS word (n.24), while NORSUB7b contains the status split in to variables (n.24 and n.25): one containing the first two bytes, the other containing the last two.

NORSUB8

Data:

- Roll, pitch, heading
- Roll rate, pitch rate, yaw rate
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration
- x period, y period, z period
- x amplitude, y amplitude, z amplitude
- full status word

Telegram:

`$PNORSUB8,T1,T2,roll,pitch,heading,surge,sway,heave,roll_rate,pitch_rate,yaw_rate,surge_vel,sway_vel, heave_vel,acc_x,acc_y,acc_z,T_x,T_y,T_z,A_x,A_y,A_z,status_full*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$NORSUB8	identifier	-	string	-
1	T1	time for valid meas. (int. clock)	[us]	uint32	Wraps from (2^32-1) to 0
2	T2	delay from T1 to telegram is sent	[us]	uint32	%d
3	roll	roll	[degs]	DBL	%.4f
4	pitch	pitch	[degs]	DBL	%.4f
5	heading	heading	[degs]	DBL	%.4f, [0 - 360]
6	surge	surge	[m]	DBL	%.4f
7	sway	sway	[m]	DBL	%.4f
8	heave	heave	[m]	DBL	%.4f, z-down
9	roll rate	roll rate	[degs/s]	DBL	%.4f
10	pitch rate	pitch rate	[degs/s]	DBL	%.4f
11	yaw rate	yaw rate	[degs/s]	DBL	%.4f
12	surge vel	surge velocity	[m/s]	DBL	%.4f
13	sway vel	sway velocity	[m/s]	DBL	%.4f
14	heave vel	heave velocity	[m/s]	DBL	%.4f, z-down
15	acc x	acceleration x	[m/s2]	DBL	%.5f
16	acc y	acceleration y	[m/s2]	DBL	%.5f
17	acc z	acceleration z	[m/s2]	DBL	%.5f

Table 42 - NORSUB8 field description (part 1).

NORSUB8

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
18	T x	period x	[s]	DBL	%.2f
19	T y	period y	[s]	DBL	%.2f
20	T z	period z	[s]	DBL	%.2f
21	A x	amplitude x	[m]	DBL	%.2f
22	A y	amplitude y	[m]	DBL	%.2f
23	A z	amplitude z	[m]	DBL	%.2f
24	status full	status (full word)	-	uint32	%d
25	CS	NMEA checksum	-	hex	XOR of characters between $ and *

Table 43 - NORSUB8 field description (part 2).

Example:

`$PNORSUB8,2129668928,7985,-100.1022,0.8708,107.7754,-0.005,-0.023,-0.017,-0.035,0.019,-0.021,-0.003,-0.007,-0.002,0.00392,-0.00562,0.00544,25.00,25.00,25.00,0.01,0.00,0.00,15957967*55`

NORSUB7 / NORSUB7B / NORSUB8

NORSUB7, NORSUB7b and NORSUB8 are very similar in their structure. The important difference is that in the NORSUB7 and NORSUB7b protocol the surge, sway positions, velocities and accelerations are measured in the **body frame**, while in the NORSUB8 protocol they are measured in the **heading frame**. NORSUB7 and NORSUB8 contain the full STATUS word (n.24), while NORSUB7b contains the status split in to variables (n.24 and n.25): one containing the first two bytes, the other containing the last two.

NORSUB PRDID

Data:

- Roll, pitch

Telegram:

`$PRDID,pitch,roll,*CS<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	`$PRDID`	identifier	-	`string`	-
1	`pitch`	pitch	`[degs]`	`DBL`	`%3.2f`
2	`roll`	roll	`[degs]`	`DBL`	`%3.2f`
3	`CS`	checksum	-	`HEX`	XOR of characters between $ and *

Table 44 - NORSUB PRDID description.

Example:

`$PRDID,-000.49,-000.14,*61<CR><LF>`

Tokimek PTVG

Data:

- Roll, pitch, heading

Telegram:

`$PTVG,abbbbP,accccR,ddd.dT*hh<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	`$PTVG`	identifier	-	`string`	-
1	`abbbbP`	pitch	`[degs]`	`INT`	Multiplied by 100, a `[-]` bow up / a `[space]` bow down
2	`accccR`	roll	`[degs]`	`INT`	Multiplied by 100, a `[-]` bow up / a `[space]` bow down
3	`ddd.dT`	heading	`[degs]`	`DBL`	-
4	`hh`	checksum	-	`HEX`	XOR of characters between $ and *

Table 45 - Tokimek PTVG description.

Example:

`$PTVG, 021P,- 036R,101.8T* 42<CR><LF>`

RDI ADCP

Data:

- Roll, pitch, heading

Telegram:

`$PRDID,sddd.dd, sddd.dd, sddd.dd <CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PRDID	identifier	-	string	-
1	sddd.dd	pitch	[degs]	DBL	s if [+] is bow up / s is [-] if bow down, leading zeros
2	sddd.dd	roll	[degs]	DBL	s if [+] is bow up / s is [-] if bow down, leading zeros
3	sddd.dd	heading	[degs]	DBL	-

Table 46 - RDI ADCP field description.

Example:

`$PRDID,-000.19,+000.04,158.32 <CR><LF>`

SMCA

Data:

- Roll, pitch
- Heave
- Surge, sway

Telegram:

`$PSMCA,±xx.xxx,±yy.yyy,±hh.hh,±ss.ss,±ww.ww<CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PSMCA	identifier	-	string	-
1	±xx.xxx	pitch	[degs]	DBL	±100 degs, resolution 0.001 degs
2	±yy.yyy	roll	[degs]	DBL	±100 degs, resolution 0.001 degs
3	±hh.hh	heading	m	DBL	±10 m, resolution 0.01 m
4	±ss.ss	surge	m	DBL	±10 m, resolution 0.01 m
5	±ww.ww	sway	m	DBL	±10 m, resolution 0.01 m

Table 47 - SMCA field description.

Example:

`$PSMCA,+00.060,-02.513,+00.01,+01.86,-00.79<CR><LF>`

SMCC

Data:

- Roll, pitch, heave
- Surge, sway, heave
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration

Telegram:

`$PSMCC,±xx.xx, ±yy.yy, ±zzz.z, ±ss.ss, ±ww.ww, ±hh.hh, ±sv.sv, ±sw.sw, ±hv.hv, ±ax.axa, ±ay.aya, ±az.aza*cs <CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PSMCC	identifier	-	string	-
1	±xx.xxx	pitch	[degs]	DBL	±100 degs, resolution 0.001 degs
2	±yy.yyy	roll	[degs]	DBL	±100 degs, resolution 0.001 degs
3	±zzz.z	yaw	[degs]	DBL	0-359.9 degs, resolution 0.1 degs
4	±ss.ss	surge	[m]	DBL	±10 m, resolution 0.01 m
5	±ww.ww	sway	[m]	DBL	±10 m, resolution 0.01 m
6	±hh.hh	heave	[m]	DBL	±10 m, resolution 0.01 m
7	±sv.sv	surge Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
8	±sw.sw	sway Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
9	±hv.hv	heave Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
10	±ax.axa	acc x	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
11	±ay.aya	acc y	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
12	±az.aza	acc z	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
13	CS	checksum	-	HEX	XOR of characters between $ and *

Table 48 - SMCC field description.

Example:

`$PSMCC,+00.28,-02.08,+106.0,-00.30,+00.08,-00.17,-00.06,+00.01,-00.02,-00.365,-00.046,-00.003*70<CR><LF>`

SMCCg

Data:

- Roll, pitch, heave
- Surge, sway, heave
- Surge velocity, sway velocity, heave velocity
- x acceleration, y acceleration, z acceleration (including gravity)

Telegram:

`$PSMCC,±xx.xx, ±yy.yy, ±zzz.z, ±ss.ss, ±ww.ww, ±hh.hh, ±sv.sv, ±sw.sw, ±hv.hv, ±ax.axa, ±ay.aya, ±az.aza *cs <CR><LF>`

FIELD N.	FIELD	DESCRIPTION	UNIT	TYPE	NOTE
0	$PSMCC	identifier	-	string	-
1	±xx.xxx	pitch	[degs]	DBL	±100 degs, resolution 0.001 degs
2	±yy.yyy	roll	[degs]	DBL	±100 degs, resolution 0.001 degs
3	±zzz.z	yaw	[degs]	DBL	0-359.9 degs, resolution 0.1 degs
4	±ss.ss	surge	[m]	DBL	±10 m, resolution 0.01 m
5	±ww.ww	sway	[m]	DBL	±10 m, resolution 0.01 m
6	±hh.hh	heave	[m]	DBL	±10 m, resolution 0.01 m
7	±sv.sv	surge Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
8	±sw.sw	sway Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
9	±hv.hv	heave Vel	[m/s]	DBL	±100 m/s, resolution 0.01 m/s
10	±ax.axa	acc x	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
11	±ay.aya	acc y	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
12	±az.aza	acc z (incl. g)	[m/s2]	DBL	±100 m/s2, resolution 0.001 m/s2
13	CS	checksum	-	HEX	XOR of characters between $ and *

Table 49 - SMCC field description.

Example:

`$PSMCC,+00.28,-02.08,+106.0,-00.30,+00.08,-00.17,-00.06,+00.01,-00.02,-00.365,-00.046,-09.813*70<CR><LF>`

Simrad EM 3000

Data:

- Roll, pitch
- Heading
- Heave

Telegram:

Byte n.	DESCRIPTION	NOTE
Byte 0	status byte	-
Byte 1	header	90 Hex
Byte 2	roll MSB	I16, LSB = 0.01 degs
Byte 3	roll LSB	
Byte 4	pitch MSB	I16, LSB = 0.01 degs
Byte 5	pitch LSB	
Byte 6	heave MSB	I16, LSB = 0.01 m
Byte 7	heave LSB	
Byte 8	heading LSB	U16, LSB = 0.01 degs
Byte 9	heading MSB	

Table 50 - Simrad EM 3000 byte description.

Note:
LSB first.

Status codes:

Byte n.	DESCRIPTION
90 Hex	normal
91 Hex	reduced performance
A0 Hex	invalid data

Table 51 - Simrad EM 3000 status codes.

TSS1

Data:

- Roll, pitch, heading

Telegram:

`:aabbbb shhhhxsrrrr spppp<CR><LF>`

FIELD	DESCRIPTION	TYPE	NOTE
:	identifier	-	-
aa	sway acceleration	HEX	2 char hex, unit = 0.0383 m/s2, range: 0 to 9.81 m/s2
bbbb	heave acceleration	HEX	4 char hex, unit = 0.000625 m/s2, range: -20.48 to 20.48 m/s2
s	sign	-	[space] positive, [-] negative
hhhh	heave position	INT	in 0.01 m
x	status	-	See table below
s	sign	-	[space] positive, [-] negative
rrrr	roll	INT	in 0.01 degs
s	sign	-	[space] positive, [-] negative
pppp	pitch	INT	in 0.01 degs

Table 52 - TSS1 field description.

Example:

`:0A2EE0 -0135U-0238 0367<CR><LF>`

FIELD	VALUE	DESCRIPTION	NUMERICAL
aa	0A	sway acceleration	0.4 m/s2
bbbb	2EE0	heave acceleration	-7.5 m/s2
shhhh	-0135	heave position	1.35 m
x	U	status	Unaided, stable data.
srrrr	-0238	roll	-2.38 degs
spppp	0367	pitch	3.67 degs

Table 53 - Example values TSS1.

Note: roll angle in the TSS1 message, Φ_{TSS1}, is not in Euler angles. The following relationship is used:

$$U_{TSS1} = \arcsin(\sin(U_{euler})\cos(H_{euler}))$$

where Φ_{euler} is the Euler roll angle and Θ_{euler} is the Euler pitch angle.

TSS1

Status codes:

Byte n.	DESCRIPTION
U	unaided, stable data.
u	unaided, unstable data.
G	speed aided, stable data.
g	speed aided, unstable data.
H	heading aided, stable data.
h	heading aided, unstable data.
F	full aided, stable data.
f	full aided, unstable data.

Table 54 - TSS1 status codes.

9. HEALTH MONITORING SYSTEM

NORSUB Status Bits

The MRU health is monitored with the NORSUB STATUS bits (output variable n.1007), which is a LSB word (4 bytes, U32). The status bits can also be reconstructed from other output variables such as 1091 STATUS_A (first and second STATUS bytes), 1092 STATUS_B (third and fourth STATUS bytes), 1093 STATUS_1 (first STATUS byte), 1094 STATUS_2 (second STATUS byte), 1095 STATUS_3 (third STATUS byte), 1096 STATUS_4 (fourth STATUS byte),

The default and initial value for all status bits is 0. The bits are set to 1 after the corresponding parameter checks have completed successfully. The status bits are divided in 5 categories; system, sensor, environment, algorithm and aiding in addition to the Main category which is an aggregate of all other status bits. If MAIN_OK is 1, there are no warnings, no errors and no detected degradation in the performance.

			BIT	PARAMETER	DESCRIPTION	
STATUS (1007)	STATUS_A (1091)	STATUS_1 (1093)	0	MAIN_OK	1 = no errors or warnings, initialization done. Everything OK.	MAIN
			1	MAIN_HEALTH	1 = no serious errors in sensor, algorithm or system.	
			2	SYSTEM_OK	1 = system operates normally.	SYSTEM
			3	SYSTEM_HEALTH	0 = system error. Restart required.	
			4	SYSTEM_TIME_SYNC	1 = time synchronized.	
			5	SYSTEM_CLOCK_SYNC	1 = clock synchronized.	
			6	SYSTEM_CPU_OK	1 = CPU load and memory are OK.	
			7	SENSOR_OK	1 = IMU is OK.	SENSOR
		STATUS_2 (1094)	8	SENSOR_HEALTH	0 = IMU is malfunctioning or broken. Repair or replace MRU.	
			9	SENSOR_LIMITS	0 = IMU sensors are saturated.	
			10	ENV_VIBRATION	1 = environmental vibration levels are OK.	
			11	ENV_TEMPERATRURE	1 = environmental temperature is OK.	
			12	ALG_OK	1 = MRU algorithms are OK.	ALGORITHMS
			13	ALG_HEALTH	0 = MRU algorithms are unstable. Restart recommended.	
			14	ALG_OBS_INIT	1 = initialization of observer.	
			15	ALG_HEADING_INIT	1 = Initialization of heading.	
	STATUS_B (1092)	STATUS_3 (1095)	16	ALG_ROLLP_OK	1 = roll/pitch are OK.	
			17	ALG_ROLLP_HEALTH	0 = roll/pitch are saturated/unstable. Restart recommended.	
			18	ALG_HEAD_OK	1 = heading is OK.	
			19	ALG_HEAD_HEALTH	0 = heading is saturated/unstable. Restart recommended.	
			20	ALG_SURGES_OK	1 = surge/sway are OK.	
			21	ALG_SURGES_HEALTH	0 = surge/sway saturated/unstable. Restart recommended.	
			22	ALG_HEAVE_OK	1 = heave is OK.	
			23	ALG_HEAVE_HEALTH	0 = heave is saturated or unstable. Restart recommended.	

Table 55 - NORSUB status bits (PART1).

			BIT	PARAMETER	DESCRIPTION	
STATUS (1007)	STATUS_B (1092)	STATUS_4 (1096)	24	AID_POS_RECEIVED	1 = external position aiding is received.	AIDING
			25	AID_VEL_RECEIVED	1 = external velocity aiding is received.	
			26	AID_HEAD_RECEIVED	1 = external heading aiding is received.	
			27	AID_POS_VALID	1 = position aiding is valid and used in the observer.	
			28	AID_VEL_VALID	1 = velocity aiding is valid and used in the observer.	
			29	AID_HEAD_VALID	1 = heading aiding is valid and used in the observer.	
			30	AID_VERTICAL_VALID	1 = vertical position is valid and used in the observer.	
			31	AID_HORIZONTAL_VALID	1 = horizontal position is valid and used in the observer.	

Table 56 - NORSUB status bits (PART2).

All status bits categories have two main status bits; OK and HEALTH. If OK is 1, then everything is working properly, and it is safe to use the output data. If OK is 0, the performance may be compromised, and the user should wait until performance has returned to normal. If HEALTH is 0, there may be sensor errors, bad environment or other errors which requires restart, repair or replacement of the MRU.

MAIN PARAMETERS	
NAME	INFORMATION
MAIN_OK	1 if SENSOR_OK, ALG_OK and SYSTEM_OK is 1. This is the main status bit. If set to 1, there are no warnings or performance issues. If aiding measurements are received but not accepted, MAIN_OK is also set to 0.
MAIN_HEALTH	1 if SENSOR_HEALTH, ALG_ HEALTH, and SYSTEM_HEALTH is 1.

Table 57 - NORSUB status bits: main parameters.

SYSTEM PARAMETERS	
NAME	INFORMATION
SYSTEM_OK	1 if no system errors or warnings are detected, and all system initialization processes are completed, and SYSTEM_CPU_OK is 1.
SYSTEM_HEALTH	0 if system errors are detected.
SYSTEM_TIME_SYNC	1 if synchronized with an NTP server.
SYSTEM_CLOCK_SYNC	1 if synchronized with an external clock.
SYSTEM_CPU_OK	1 if the total CPU and memory usage is less than 90 %.

Table 58 - NORSUB status bits: system parameters.

NORSUB Status Bits

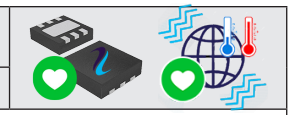
SENSOR PARAMETERS	
NAME	INFORMATION
SENSOR_OK	1 if SENSOR_LIMITS, ENV_VIBRATION, ENV_TEMPERATURE and SENSOR_HEALTH is 1.
SENSOR_HEALTH	0 if any of the follow occurs: ◊ valid data has not been received within 100 ms. ◊ accelerometer vector length is 1 g +/- 1.0 g within 500 ms and 1 g +/- 0.4 g within 60 s. This error usually means a malfunctioning sensor which needs repair or replacement if error does not disappear after reboot.
SENSOR_LIMITS	0 if any of the gyroscopes or accelerometers has been saturated. The SENSOR_LIMITS is returned to 1 after 60 s after all sensors are within range again.
ENV_VIBRATION	1 if the noise variance of the accelerometer length vector is less than 0.5 g with a window duration of 3 s. Move the MRU to a location with less vibration for increased performance if this status bit is 0.
ENV_TEMPERATURE	1 if the sensor temperature is in the range -40 to 85 degrees Celsius.

Table 59 - NORSUB status bits: sensor parameters.

ALGORITHMS PARAMETERS	
NAME	INFORMATION
ALG_NORMAL	1 if ALG_ROLLP_OK, ALG_HEAD_OK, ALG_SURGES_OK, ALG_HEAVE_OK and ALG_HEALTH is 1, and ALG_OBS_INIT is 0 (initialization is done).
ALG_HEALTH	1 if ALG_ROLLP_HEALTH, ALG_HEAD_HEALTH, ALG_SURGES_HEALTH and ALG_HEAVE_HEALTH is 1.
ALG_OBS_INIT	1 if initialization of sensor fusion algorithms completed successfully.
ALG_HEADING_INIT	1 if heading initialization has completed. i.e. the difference between heading reference and estimation is less than 5 degrees. This is only in use for MRUs with magnetometer or external heading aiding.
ALG_ROLLP_OK	1 if all gyroscopes biases are stable and ALG_ROLLP_HEALTH is 1.
ALG_ROLLP_HEALTH	0 if any gyroscope bias is saturated or SENSOR_HEALTH is 0.

Table 60 - NORSUB status bits: algorithms parameters (part 1).

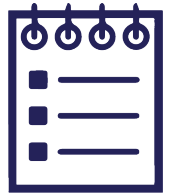
ALGORITHMS PARAMETERS	
NAME	INFORMATION
ALG_HEAD_OK	1 if the difference between heading reference and estimation is less than 1 degree. This is only in use for MRUs with magnetometer or external heading aiding.
ALG_HEAD_HEALTH	0 if the difference between heading reference and estimation is more than 10 degrees. This is only in use for MRUs with magnetometer or external heading aiding.
ALG_SURGES_OK	0 if transients in surge or sway are detected or ALG_SURGES_HEALTH is 0.
ALG_SURGES_HEALTH	0 if surge or sway are saturated.
ALG_HEAVE_OK	0 if transients in heave are detected or the acceleration bias is out of range or ALG_HEAVE_HEALTH is 0.
ALG_HEAVE_HEALTH	0 if heave is saturated.

Table 61 - NORSUB status bits: algorithms parameters (part 2).

AIDING PARAMETERS	
NAME	INFORMATION
AID_POS_RECEIVED	1 if an external position measurement has been received within 60 s. e.g. from GNSS or an acoustic positioning system.
AID_VEL_RECEIVED	1 if an external velocity measurement has been received within 60 s. e.g. from a Doppler velocity log or GNSS.
AID_HEAD_RECEIVED	1 if an external heading measurement has been received within 60 s. e.g. from a gyrocompass, GNSS compass or magnetometer.
AID_POS_VALID	1 if the received external position measurement is accepted for use as correction.
AID_VEL_VALID	1 if the received external velocity measurement is accepted for use as correction.
AID_HEAD_VALID	1 if the received external heading measurement is accepted for use as correction.
AID_VERTICAL_VALID	1 if the received position measurement contains a vertical component which is accepted for use as correction.
AID_HORIZONTAL_VALID	1 if the received position measurement contains horizontal components which are accepted for use as corrections.

Table 62 - NORSUB status bits: aiding parameters.

10. OUTPUT VARIABLES LIST



List of MRU output variables:

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
101	Quaternion1	[-]	[-]	MtoN	First element of the quaternion vector. MRU to NED frame.	Single
102	Quaternion2	[-]	[-]	MtoN	Second elem. of the quaternion vector. MRU to NED frame.	Single
103	Quaternion3	[-]	[-]	MtoN	Third element of the quaternion vector. MRU to NED frame.	Single
104	Quaternion4	[-]	[-]	MtoN	Fourth elem. of the quaternion vector. MRU to NED frame.	Single
105	Quaternion1	[-]	[-]	BtoN	First element of the quaternion vector. Body to NED frame.	Single
106	Quaternion2	[-]	[-]	BtoN	Second elem. of the quaternion vector. Body to NED frame.	Single
107	Quaternion3	[-]	[-]	BtoN	Third element of the quaternion vector. Body to NED frame.	Single
108	Quaternion4	[-]	[-]	BtoN	Fourth elem. of the quaternion vector. Body to NED frame.	Single
109	Roll	[rads]	[-]	MtoN	Roll euler angle in radians. MRU to NED frame.	Single
110	Pitch	[rads]	[-]	MtoN	Pitch euler angle in radians. MRU to NED frame.	Single
111	Yaw	[rads]	[-]	MtoN	Yaw euler angle in radians. MRU to NED frame.	Single
112	Roll	[rads]	[-]	BtoN	Roll euler angle in radians. Body to NED frame.	Single
113	Pitch	[rads]	[-]	BtoN	Pitch euler angle in radians. Body to NED frame.	Single
114	Yaw	[rads]	[-]	BtoN	Yaw euler angle in radians. Body to NED frame.	Single
115	RollRate	[rads/s]	[-]	MRU	Angular vel. about the x-axis of the MRU frame in radians/s.	Single
116	PitchRate	[rads/s]	[-]	MRU	Angular vel. about the y-axis of the MRU frame in radians/s.	Single
117	YawRate	[rads/s]	[-]	MRU	Angular vel. about the z-axis of the MRU frame in radians/s.	Single
118	RollRate	[rads/s]	[-]	Body	Angular vel. about the x-axis of the Body frame in radians/s.	Single
119	PitchRate	[rads/s]	[-]	Body	Angular vel. about the y-axis of the Body frame in radians/s.	Single
120	YawRate	[rads/s]	[-]	Body	Angular vel. about the z-axis of the Body frame in radians/s.	Single
121	Roll	[degs]	[-]	MtoN	Roll euler angle in degrees. MRU to NED frame.	Single
122	Pitch	[degs]	[-]	MtoN	Pitch euler angle in degrees. MRU to NED frame.	Single
123	Yaw	[degs]	[-]	MtoN	Yaw euler angle in degrees. MRU to NED frame.	Single
124	Roll	[degs]	[-]	BtoN	Roll euler angle in degrees. Body to NED frame.	Single
125	Pitch	[degs]	[-]	BtoN	Pitch euler angle in degrees. Body to NED frame.	Single
126	Yaw	[degs]	[-]	BtoN	Yaw euler angle in degrees. Body to NED frame.	Single
127	RollRate	[degs/s]	[-]	MRU	Angular vel. about the x-axis of the MRU frame in degrees/s.	Single
128	PitchRate	[degs/s]	[-]	MRU	Angular vel. about the y-axis of the MRU frame in degrees/s.	Single
129	YawRate	[degs/s]	[-]	MRU	Angular vel. about the z-axis of the MRU frame in degrees/s.	Single
130	RollRate	[degs/s]	[-]	Body	Angular vel. about the x-axis of the Body frame in degrees/s.	Single
131	PitchRate	[degs/s]	[-]	Body	Angular vel. about the y-axis of the Body frame in degrees/s.	Single
132	YawRate	[degs/s]	[-]	Body	Angular vel. about the z-axis of the Body frame in degrees/s.	Single
133	Surge	[m]	MRU	MRU	Linear pos. of the MRU along the x-axis in the MRU frame.	Single
134	Sway	[m]	MRU	MRU	Linear pos. of the MRU along the y-axis in the MRU frame.	Single
135	Heave	[m]	MRU	MRU	Linear pos. of the MRU along the z-axis in the MRU frame.	Single

Table 63 - List of output variables, part 1 (codes 101 to 135).

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
136	SurgeVelocity	[m/s]	MRU	MRU	Linear vel. of the MRU along the x-axis in the MRU frame.	Single
137	SwayVelocity	[m/s]	MRU	MRU	Linear vel. of the MRU along the y-axis in the MRU frame.	Single
138	HeaveVelocity	[m/s]	MRU	MRU	Linear vel. of the MRU along the z-axis in the MRU frame.	Single
139	SurgeAcceleration	[m/s2]	MRU	MRU	Linear accel. of the MRU along the x-axis in the MRU frame.	Single
140	SwayAcceleration	[m/s2]	MRU	MRU	Linear acc. of the MRU along the y-axis in the MRU frame.	Single
141	HeaveAcceleration	[m/s2]	MRU	MRU	Linear acc. of the MRU along the z-axis in the MRU frame.	Single
145	Surge	[m]	MRU	NED	Linear pos. of the MRU along the x-axis in the NED frame.	Single
146	Sway	[m]	MRU	NED	Linear pos. of the MRU along the y-axis in the NED frame.	Single
147	Heave	[m]	MRU	NED	Linear pos. of the MRU along the z-axis in the NED frame.	Single
148	SurgeVelocity	[m/s]	MRU	NED	Linear vel. of the MRU along the x-axis in the NED frame.	Single
149	SwayVelocity	[m/s]	MRU	NED	Linear vel. of the MRU along the y-axis in the NED frame.	Single
150	HeaveVelocity	[m/s]	MRU	NED	Linear velocity of the MRU along the z-axis in the NED frame.	Single
151	SurgeAcceleration	[m/s2]	MRU	NED	Linear acc. of the MRU along the x-axis in the NED frame.	Single
152	SwayAcceleration	[m/s2]	MRU	NED	Linear acc. of the MRU along the y-axis in the NED frame.	Single
153	HeaveAcceleration	[m/s2]	MRU	NED	Linear acc. of the MRU along the z-axis in the NED frame.	Single
154	Surge	[m]	MRU	Body	Linear pos. of the MRU along the x-axis in the Body frame.	Single
155	Sway	[m]	MRU	Body	Linear pos. of the MRU along the y-axis in the Body frame.	Single
156	Heave	[m]	MRU	Body	Linear pos. of the MRU along the z-axis in the Body frame.	Single
157	SurgeVelocity	[m/s]	MRU	Body	Linear vel. of the MRU along the x-axis in the Body frame.	Single
158	SwayVelocity	[m/s]	MRU	Body	Linear vel. of the MRU along the y-axis in the Body frame.	Single
159	HeaveVelocity	[m/s]	MRU	Body	Linear vel. of the MRU along the z-axis in the Body frame.	Single
160	SurgeAcceleration	[m/s2]	MRU	Body	Linear acc. of the MRU along the x-axis in the Body frame.	Single
161	SwayAcceleration	[m/s2]	MRU	Body	Linear acc. of the MRU along the y-axis in the Body frame.	Single
162	HeaveAcceleration	[m/s2]	MRU	Body	Linear acc. of the MRU along the z-axis in the Body frame.	Single
163	Surge	[m]	MRU	Head.	Lin. pos. of the MRU along the x-axis in the Heading frame.	Single
164	Sway	[m]	MRU	Head.	Lin. pos. of the MRU along the y-axis in the Heading frame.	Single
165	Heave	[m]	MRU	Head.	Lin. pos. of the MRU along the z-axis in the Heading frame.	Single
166	SurgeVelocity	[m/s]	MRU	Head.	Lin. vel.of the MRU along the x-axis in the Heading frame.	Single
167	SwayVelocity	[m/s]	MRU	Head.	Lin. vel. of the MRU along the y-axis in the Heading frame.	Single
168	HeaveVelocity	[m/s]	MRU	Head.	Lin. vel. of the MRU along the z-axis in the Heading frame.	Single
169	SurgeAcceleration	[m/s2]	MRU	Head.	Linear acc. of the MRU along the x-axis in the Head.frame.	Single
170	SwayAcceleration	[m/s2]	MRU	Head.	Linear acc. of the MRU along the y-axis in the Head.frame.	Single
171	HeaveAcceleration	[m/s2]	MRU	Head.	Linear acc. of the MRU along the z-axis in the Head.frame.	Single
172	Latitude	[degs]	MRU	[-]	Latitude of the MRU.	Single
173	Longitude	[degs]	MRU	[-]	Longitude of the MRU.	Single

Table 64 - List of output variables, part 2 (codes 136 to 173).

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
174	Altitude	[m]	MRU	[-]	Altitude of the MRU.	Single
175	UTM_Surge	[m]	MRU	[-]	UTM Surge position of the MRU.	Single
176	UTM_Sway	[m]	MRU	[-]	UTM Sway position of the MRU.	Single
177	UTM_Zone	[-]	MRU	[-]	UTM zone number.	U32
185	AngularAccelX	[rad/s2]	[-]	MRU	Angular acceleration X in the MRU frame.	Single
186	AngularAccelY	[rad/s2]	[-]	MRU	Angular acceleration Y in the MRU frame.	Single
187	AngularAccelZ	[rad/s2]	[-]	MRU	Angular acceleration Z in the MRU frame.	Single
188	AngularAccelX	[rad/s2]	[-]	Body	Angular acceleration X in the body frame.	Single
189	AngularAccelY	[rad/s2]	[-]	Body	Angular acceleration Y in the body frame.	Single
190	AngularAccelZ	[rad/s2]	[-]	Body	Angular acceleration Z in the body frame.	Single
191	SurgeAccelerationG	[m/s2]	MRU	Body	Lin.acc. of the MRU along the x-axis in the body frame (incl.g)	Single
192	SwayAccelerationG	[m/s2]	MRU	Body	Lin.acc. of the MRU along the y-axis in the body frame (incl.g)	Single
193	HeaveAccelerationG	[m/s2]	MRU	Body	Lin.acc. of the MRU along the z-axis in the body frame (incl.g)	Single
201	Surge	[m]	CG	NED	Linear pos. of the CG along the x-axis in the NED frame.	Single
202	Sway	[m]	CG	NED	Linear pos. of the CG along the y-axis in the NED frame.	Single
203	Heave	[m]	CG	NED	Linear pos. of the CG along the z-axis in the NED frame.	Single
204	SurgeVelocity	[m/s]	CG	NED	Linear velocity of the CG along the x-axis in the NED frame.	Single
205	SwayVelocity	[m/s]	CG	NED	Linear velocity of the CG along the y-axis in the NED frame.	Single
206	HeaveVelocity	[m/s]	CG	NED	Linear velocity of the CG along the z-axis in the NED frame.	Single
207	SurgeAcceleration	[m/s2]	CG	NED	Linear acc. of the CG along the x-axis in the NED frame.	Single
208	SwayAcceleration	[m/s2]	CG	NED	Linear acc. of the CG along the y-axis in the NED frame.	Single
209	HeaveAcceleration	[m/s2]	CG	NED	Linear acc. of the CG along the z-axis in the NED frame.	Single
210	Surge	[m]	CG	Body	Linear pos. of the CG along the x-axis in the Body frame.	Single
211	Sway	[m]	CG	Body	Linear pos. of the CG along the y-axis in the Body frame.	Single
212	Heave	[m]	CG	Body	Linear pos. of the CG along the z-axis in the Body frame.	Single
213	SurgeVelocity	[m/s]	CG	Body	Linear vel. of the CG along the x-axis in the Body frame.	Single
214	SwayVelocity	[m/s]	CG	Body	Linear vel. of the CG along the y-axis in the Body frame.	Single
215	HeaveVelocity	[m/s]	CG	Body	Linear vel. of the CG along the z-axis in the Body frame.	Single
216	SurgeAcceleration	[m/s2]	CG	Body	Linear acc. of the CG along the x-axis in the Body frame.	Single
217	SwayAcceleration	[m/s2]	CG	Body	Linear acc. of the CG along the y-axis in the Body frame.	Single
218	HeaveAcceleration	[m/s2]	CG	Body	Linear acc. of the CG along the z-axis in the Body frame.	Single
219	Surge	[m]	CG	Head.	Linear pos. of the CG along the x-axis in the Heading frame.	Single
220	Sway	[m]	CG	Head.	Linear pos. of the CG along the y-axis in the Heading frame.	Single
221	Heave	[m]	CG	Head.	Linear pos. of the CG along the z-axis in the Heading frame.	Single

Table 65 - List of output variables, part 3 (codes 174 to 221).

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
222	SurgeVelocity	[m/s]	CG	Head.	Linear vel. of the CG along the y-axis in the Heading frame.	Single
223	SwayVelocity	[m/s]	CG	Head.	Linear vel. of the CG along the y-axis in the Heading frame.	Single
224	HeaveVelocity	[m/s]	CG	Head.	Linear vel. of the CG along the z-axis in the Heading frame.	Single
225	SurgeAcceleration	[m/s2]	CG	Head.	Linear acc. of the CG along the x-axis in the Head.frame.	Single
226	SwayAcceleration	[m/s2]	CG	Head.	Linear acc. of the CG along the y-axis in the Head.frame.	Single
227	HeaveAcceleration	[m/s2]	CG	Head.	Linear acc. of the CG along the z-axis in the Heading frame.	Single
228	Latitude	[degs]	CG	[-]	Latitude of the CG.	Single
229	Longitude	[degs]	CG	[-]	Longitude of the CG.	Single
230	Altitude	[m]	CG	[-]	Altitude of the CG.	Single
231	UTM_Surge	[m]	CG	[-]	UTM Surge position of the CG.	Single
232	UTM_Sway	[m]	CG	[-]	UTM Sway position of the CG.	Single
233	UTM_Zone	[-]	CG	[-]	UTM zone number of the CG.	U32
234	SurgeAccelerationG	[m/s2]	CG	Body	Lin.acc. of the CG along the x-axis in the body frame (incl.g)	Single
235	SwayAccelerationG	[m/s2]	CG	Body	Lin.acc. of the CG along the y-axis in the body frame (incl.g)	Single
236	HeaveAccelerationG	[m/s2]	CG	Body	Lin.acc. of the CG along the z-axis in the body frame (incl.g)	Single
301	Surge	[m]	MP1	NED	Linear pos. of the MP1 along the x-axis in the NED frame.	Single
302	Sway	[m]	MP1	NED	Linear pos. of the MP1 along the y-axis in the NED frame.	Single
303	Heave	[m]	MP1	NED	Linear pos. of the MP1 along the z-axis in the NED frame.	Single
304	SurgeVelocity	[m/s]	MP1	NED	Linear vel. of the MP1 along the x-axis in the NED frame.	Single
305	SwayVelocity	[m/s]	MP1	NED	Linear vel. of the MP1 along the y-axis in the NED frame.	Single
306	HeaveVelocity	[m/s]	MP1	NED	Linear vel. of the MP1 along the z-axis in the NED frame.	Single
307	SurgeAcceleration	[m/s2]	MP1	NED	Linear acc. of the MP1 along the x-axis in the NED frame.	Single
308	SwayAcceleration	[m/s2]	MP1	NED	Linear acc. of the MP1 along the y-axis in the NED frame.	Single
309	HeaveAcceleration	[m/s2]	MP1	NED	Linear acc. of the MP1 along the z-axis in the NED frame.	Single
310	Surge	[m]	MP1	Body	Linear pos. of the MP1 along the x-axis in the body frame.	Single
311	Sway	[m]	MP1	Body	Linear pos. of the MP1 along the y-axis in the body frame.	Single
312	Heave	[m]	MP1	Body	Linear pos. of the MP1 along the z-axis in the body frame.	Single
313	SurgeVelocity	[m/s]	MP1	Body	Linear vel. of the MP1 along the x-axis in the body frame.	Single
314	SwayVelocity	[m/s]	MP1	Body	Linear vel. of the MP1 along the y-axis in the body frame.	Single
315	HeaveVelocity	[m/s]	MP1	Body	Linear vel. of the MP1 along the z-axis in the body frame.	Single
316	SurgeAcceleration	[m/s2]	MP1	Body	Linear acc. of the MP1 along the x-axis in the body frame.	Single
317	SwayAcceleration	[m/s2]	MP1	Body	Linear acc. of the MP1 along the y-axis in the body frame.	Single
318	HeaveAcceleration	[m/s2]	MP1	Body	Linear acc. of the MP1 along the z-axis in the body frame.	Single

Table 66 - List of output variables, part 4 (codes 222 to 318).

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
319	Surge	[m]	MP1	Head.	Lin. pos. of the MP1 along the x-axis in the heading frame.	Single
320	Sway	[m]	MP1	Head.	Lin. pos. of the MP1 along the y-axis in the heading frame.	Single
321	Heave	[m]	MP1	Head.	Lin. pos. of the MP1 along the z-axis in the heading frame.	Single
322	SurgeVelocity	[m/s]	MP1	Head.	Linear vel. of the MP1 along the x-axis in the heading frame.	Single
323	SwayVelocity	[m/s]	MP1	Head.	Linear vel. of the MP1 along the y-axis in the heading frame.	Single
324	HeaveVelocity	[m/s]	MP1	Head.	Linear vel. of the MP1 along the z-axis in the heading frame.	Single
325	SurgeAcceleration	[m/s2]	MP1	Head.	Linear acc. of the MP1 along the x-axis in the Head.frame.	Single
326	SwayAcceleration	[m/s2]	MP1	Head.	Linear acc. of the MP1 along the y-axis in the Head.frame.	Single
327	HeaveAcceleration	[m/s2]	MP1	Head.	Linear acc. of the MP1 along the z-axis in the Head.frame.	Single
328	Latitude	[degs]	MP1	[-]	Latitude of the MP1.	Single
329	Longitude	[degs]	MP1	[-]	Longitude of the MP1.	Single
330	Altitude	[m]	MP1	[-]	Altitude of the MP1.	Single
331	UTM_Surge	[m]	MP1	[-]	UTM Surge position of the MP1.	Single
332	UTM_Sway	[m]	MP1	[-]	UTM Sway position of the MP1.	Single
333	UTM_Zone	[-]	MP1	[-]	UTM zone number of the MP1.	U32
334	SurgeAccelerationG	[m/s2]	MP1	Body	Lin.acc. of the MP1 along the x-axis in the body frame (incl.g)	Single
335	SwayAccelerationG	[m/s2]	MP1	Body	Lin.acc. of the MP1 along the y-axis in the body frame (incl.g)	Single
336	HeaveAccelerationG	[m/s2]	MP1	Body	Lin.acc. of the MP1 along the z-axis in the body frame (incl.g)	Single
401	Surge	[m]	MP2	NED	Linear pos. of the MP2 along the x-axis in the NED frame.	Single
402	Sway	[m]	MP2	NED	Linear pos. of the MP2 along the y-axis in the NED frame.	Single
403	Heave	[m]	MP2	NED	Linear pos. of the MP2 along the z-axis in the NED frame.	Single
404	SurgeVelocity	[m/s]	MP2	NED	Linear vel. of the MP2 along the x-axis in the NED frame.	Single
405	SwayVelocity	[m/s]	MP2	NED	Linear vel. of the MP2 along the y-axis in the NED frame.	Single
406	HeaveVelocity	[m/s]	MP2	NED	Linear vel. of the MP2 along the z-axis in the NED frame.	Single
407	SurgeAcceleration	[m/s2]	MP2	NED	Linear acc. of the MP2 along the x-axis in the NED frame.	Single
408	SwayAcceleration	[m/s2]	MP2	NED	Linear acc. of the MP2 along the y-axis in the NED frame.	Single
409	HeaveAcceleration	[m/s2]	MP2	NED	Linear acc. of the MP2 along the z-axis in the NED frame.	Single
410	Surge	[m]	MP2	Body	Linear pos. of the MP2 along the x-axis in the body frame.	Single
411	Sway	[m]	MP2	Body	Linear pos. of the MP2 along the y-axis in the body frame.	Single
412	Heave	[m]	MP2	Body	Linear pos. of the MP2 along the z-axis in the body frame.	Single
413	SurgeVelocity	[m/s]	MP2	Body	Linear vel. of the MP2 along the x-axis in the body frame.	Single
414	SwayVelocity	[m/s]	MP2	Body	Linear vel. of the MP2 along the y-axis in the body frame.	Single
415	HeaveVelocity	[m/s]	MP2	Body	Linear vel. of the MP2 along the z-axis in the body frame.	Single

Table 67 - List of output variables, part 5 (codes 319 to 415).

OUTPUT VARIABLES LIST

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
416	SurgeAcceleration	[m/s2]	MP2	Body	Linear acc. of the MP2 along the x-axis in the body frame.	Single
417	SwayAcceleration	[m/s2]	MP2	Body	Linear acc. of the MP2 along the y-axis in the body frame.	Single
418	HeaveAcceleration	[m/s2]	MP2	Body	Linear acc. of the MP2 along the z-axis in the body frame.	Single
419	Surge	[m]	MP2	Head.	Lin.pos. of the MP2 along the x-axis in the head. frame.	Single
420	Sway	[m]	MP2	Head.	Lin.pos. of the MP2 along the y-axis in the head. frame.	Single
421	Heave	[m]	MP2	Head.	Lin.pos. of the MP2 along the z-axis in the head. frame.	Single
422	SurgeVelocity	[m/s]	MP2	Head.	Lin.vel. of the MP2 along the x-axis in the heading frame.	Single
423	SwayVelocity	[m/s]	MP2	Head.	Lin. vel. of the MP2 along the y-axis in the head. frame.	Single
424	HeaveVelocity	[m/s]	MP2	Head.	Lin. vel. of the MP2 along the z-axis in the head. frame.	Single
425	SurgeAcceleration	[m/s2]	MP2	Head.	Lin. acc. of the MP2 along the x-axis in the Head.frame.	Single
426	SwayAcceleration	[m/s2]	MP2	Head.	Lin. acc. of the MP2 along the y-axis in the Head.frame.	Single
427	HeaveAcceleration	[m/s2]	MP2	Head.	Lin. acc. of the MP2 along the z-axis in the Head.frame.	Single
428	Latitude	[degs]	MP2	[-]	Latitude of the MP2.	Single
429	Longitude	[degs]	MP2	[-]	Longitude of the MP2.	Single
430	Altitude	[m]	MP2	[-]	Altitude of the MP2.	Single
431	UTM_Surge	[m]	MP2	[-]	UTM Surge position of the MP2.	Single
432	UTM_Sway	[m]	MP2	[-]	UTM Sway position of the MP2.	Single
433	UTM_Zone	[-]	MP2	[-]	UTM zone number of the MP2.	U32
434	SurgeAccelerationG	[m/s2]	MP2	Body	Lin.acc. of the MP2 along the x-axis in the body frame (incl.g)	Single
435	SwayAccelerationG	[m/s2]	MP2	Body	Lin.acc. of the MP2 along the y-axis in the body frame (incl.g)	Single
436	HeaveAccelerationG	[m/s2]	MP2	Body	Lin.acc. of the MP2 along the z-axis in the body frame (incl.g)	Single
501	MsgTimestamp	[us]	[-]	[-]	Parser data timestamp.	U32
502	IMUTimestamp	[us]	[-]	[-]	IMU timestamp in microseconds.	U32
503	IMUDelay	[us]	[-]	[-]	IMU delay in microseconds.	U32
504	IMUdt	[us]	[-]	[-]	IMU sampling time in microseconds.	U32
505	EpochTimeStamp	[s]	[-]	[-]	Parser data timestamp in sec. since 12:00AM, Jan.1,1904,UT	Single
506	PosixTimestamp	[s]	[-]	[-]	Parser data timestamp in sec. since 12:00AM, Jan.1,1904,UT	Single
507	SampleTime	[s]	[-]	[-]	Parser data timestamp in sec. since 12:00AM, Jan.1,1904,UT	I32
508	SampleTime	[ms]	[-]	[-]	Parser data timestamp in ms since 12:00AM, Jan.1,1904,UT	I32
509	SampleTime	[ns]	[-]	[-]	Parser data timestamp in ns since 12:00AM, Jan.1,1904,UT	I32
510	MsgTimestamp	[ms]	[-]	[-]	Parser data timestamp in milliseconds	U32
601	GyroX	[rads/s]	MRU	MRU	X-axis gyroscope output.	Single
602	GyroY	[rads/s]	MRU	MRU	Y-axis gyroscope output.	Single
603	GyroZ	[rads/s]	MRU	MRU	Z-axis gyroscope output.	Single

Table 68 - List of output variables, part 6 (codes 416 to 603).

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
604	AccX	[m/s2]	MRU	MRU	X-axis accelerometer output.	Single
605	AccY	[m/s2]	MRU	MRU	Y-axis accelerometer output.	Single
606	AccZ	[m/s2]	MRU	MRU	Z-axis accelerometer output.	Single
607	InclX	[m/s2]	MRU	MRU	X-axis inclinometer output.	Single
608	InclY	[m/s2]	MRU	MRU	Y-axis inclinometer output.	Single
609	InclZ	[m/s2]	MRU	MRU	Z-axis inclinometer output.	Single
610	IMU_CRC	[-]	[-]	[-]	IMU cycle redundancy check.	U8
611	IMUTimestamp	[us]	[-]	[-]	IMU timestamp in microseconds.	U32
612	IMU_CTS	[-]	[-]	[-]	IMU counter.	U32
613	IMUdt	[us]	[-]	[-]	IMU sampling time in microseconds.	U32
614	TempC	[degC]	[-]	[-]	IMU temperature	Single
615	DeltaRoll	[rads]	[-]	MRU to NED	Delta roll angle in rads in the MRU to NED frame.	Single
616	DeltaPitch	[rads]	[-]	MRU to NED	Delta pitch angle in rads in the MRU to NED frame	Single
617	DeltaYaw	[rads]	[-]	MRU to NED	Delta yaw angle in rads in the MRU to NED frame	Single
618	DeltaSurgeVelocity	[m/s2]	[-]	MRU	Delta velocity for surge in the MRU frame.	Single
619	DeltaSwayVelocity	[m/s2]	[-]	MRU	Delta velocity for sway in the MRU frame.	Single
620	DeltaHeaveVelocity	[m/s2]	[-]	MRU	Delta velocity for heave in the MRU frame.	Single
701	MagX	[mGauss]	MRU	MRU	X-axis magnetometer output.	Single
702	MagY	[mGauss]	MRU	MRU	Y-axis magnetometer output.	Single
703	MagZ	[mGauss]	MRU	MRU	Z-axis magnetometer output.	Single
704	Mag_CRC	[-]	[-]	[-]	Magnetometer cycle redundancy check.	u8
705	MagTimestamp	[us]	[-]	[-]	Magnetometer timestamp in microseconds.	u32
706	Mag_CTS	[-]	[-]	[-]	Magnetometer counter.	u32
801	Latitude	[degs]	AID1	[-]	Latitude at the AID1 location.	Single
802	Longitude	[degs]	AID1	[-]	Longitude at the AID1 location.	Single
803	Elevation	[m]	AID1	[-]	Elevation at the AID1 location.	Single
812	CounterPosition	[-]	[-]	[-]	Position aiding counter of the AID1.	U32
813	ReadyPosition	[-]	[-]	[-]	Status of the position aiding of the AID1.	U8
814	SOG	[m2/s2]	AID1	[-]	Speed over ground at the AID1 location.	Single
815	COG	[deg2]	AID1	[-]	Course over ground at AID1 location.	Single
824	CounterSpeed	[-]	[-]	[-]	Speed aiding counter of the AID1.	U32
825	ReadySpeed	[-]	[-]	[-]	Speed aiding status of the AID1.	U8
826	Heading	[degs]	AID1	[-]	Heading at the AID1 location.	Single
828	CounterHeading	[-]	[-]	[-]	Heading aiding counter of the AID1.	U32
829	ReadyHeading	[-]	[-]	[-]	Heading status of the AID1.	U8

Table 69 - List of output variables, part 7 (codes 604 to 829).

OUTPUT VARIABLES LIST

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
901	Latitude	[degs]	AID2	[-]	Latitude at the AID2 location.	Single
902	Longitude	[degs]	AID2	[-]	Longitude at the AID2 location.	Single
903	Elevation	[m]	AID2	[-]	Elevation at the AID2 location.	Single
912	CounterPosition	[-]	[-]	[-]	Position aiding counter of the AID2.	U32
913	ReadyPosition	[-]	[-]	[-]	Status of the position aiding of the AID2.	U8
914	SOG	[m2/s2]	AID2	[-]	Speed over ground at the AID2 location.	Single
915	COG	[deg2]	AID2	[-]	Course over ground at AID2 location.	Single
924	CounterSpeed	[-]	[-]	[-]	Speed aiding counter of the AID2.	U32
925	ReadySpeed	[-]	[-]	[-]	Speed aiding status of the AID2.	U8
926	Heading	[degs]	AID2	[-]	Heading at the AID2 location.	Single
928	CounterHeading	[-]	[-]	[-]	Heading aiding counter of the AID2.	U32
929	ReadyHeading	[-]	[-]	[-]	Heading status of the AID2.	U8
1001	PeriodX	[s]	[-]	[-]	Estimated motion period along the X-axis	Single
1002	PeriodY	[s]	[-]	[-]	Estimated motion period along the Y-axis	Single
1003	PeriodZ	[s]	[-]	[-]	Estimated motion period along the Z-axis	Single
1007	STATUS	[-]	[-]	[-]	Main MRU STATUS, 32 bit number indication status	U32
1008	ValidGeoPos	[-]	[-]	[-]	Status of the GeoPos.	U8
1009	ValidState	[-]	[-]	[-]	Status of the state estimation.	U8
1010	AmplitudeX	[m]	[-]	[-]	Peak motion amplitude in x direction.	Single
1011	AmplitudeY	[m]	[-]	[-]	Peak motion amplitude in y direction.	Single
1012	AmplitudeZ	[m]	[-]	[-]	Peak motion amplitude in z direction.	Single
1091	STATUS_A	[-]	[-]	[-]	First and second bytes of the status bits 1007.	U16
1092	STATUS_B	[-]	[-]	[-]	Third and fourth bytes of the status bits 1007.	U16
1093	STATUS_1	[-]	[-]	[-]	First byte of the status bits 1007.	U8
1094	STATUS_2	[-]	[-]	[-]	Second byte of the status bits 1007.	U8
1095	STATUS_3	[-]	[-]	[-]	Third byte of the status bits 1007.	U8
1096	STATUS_4	[-]	[-]	[-]	Fourth byte of the status bits 1007.	U8
1101	FiltGyroX	[rad/s]	MRU	MRU	X-axis gyroscope output in the MRU frame (filtered).	Single
1102	FiltGyroY	[rad/s]	MRU	MRU	Y-axis gyroscope output in the MRU frame (filtered).	Single
1103	FiltGyroZ	[rad/s]	MRU	MRU	Z-axis gyroscope output in the MRU frame (filtered).	Single
1104	FiltAccX	[m/s2]	MRU	MRU	X-axis accelerometers output in the MRU frame (filtered).	Single
1105	FiltAccY	[m/s2]	MRU	MRU	Y-axis accelerometers output in the MRU frame (filtered).	Single
1106	FiltAccZ	[m/s2]	MRU	MRU	Z-axis accelerometers output in the MRU frame (filtered).	Single

Table 70 - List of output variables, part 8 (codes 901 to 1106).

OUTPUT VARIABLES LIST

CODE	VARIABLE	M.U.	LOC.	FR.	DESCRIPTION	TYPE
1107	FiltGyroAccX	[rads/s]	MRU	MRU	X-axis gyro output in the MRU fr. (filtered with acc.cutoff freq.).	Single
1108	FiltGyroAccY	[rads/s]	MRU	MRU	Y-axis gyro output in the MRU fr. (filtered with acc.cutoff freq).	Single
1109	FiltGyroAccZ	[rads/s]	MRU	MRU	Z-axis gyro output in the MRU fr. (filtered with acc.cutoff freq).	Single
1110	GyroVarX	[rads/s]^2	MRU	MRU	X-axis gyro var. in the MRU fr. (filtered with 10 s moving window).	Single
1111	GyroVarY	[rads/s]^2	MRU	MRU	Y-axis gyro var. in the MRU fr. (filtered with 10 s moving window).	Single
1112	GyroVarZ	[rads/s]^2	MRU	MRU	Z-axis gyro var. in the MRU fr. (filtered with 10 s moving window).	Single
1113	AccVarX	[m/s2]^2	MRU	MRU	X-axis accel. var. in the MRU fr. (filtered with 10 s moving window).	Single
1114	AccVarY	[m/s2]^2	MRU	MRU	Y-axis accel. var. in the MRU fr. (filtered with 10 s moving window).	Single
1115	AccVarZ	[m/s2]^2	MRU	MRU	Z-axis accel. var. in the MRU fr. (filtered with 10 s moving window).	Single
1201	MagCalX	[mgauss]	MRU	MRU	X-axis calibrated magnetometer out. in the MRU frame (filtered).	Single
1202	MagCalY	[mgauss]	MRU	MRU	Y-axis calibrated magnetometer out. in the MRU frame (filtered).	Single
1203	MagCalZ	[mgauss]	MRU	MRU	Z-axis calibrated magnetometer out. in the MRU frame (filtered).	Single
1301	FiltAccBodyX	[m/s2]	MRU	Body	X-axis accelerometer output in the Body frame (filtered).	Single
1302	FiltAccBodyY	[m/s2]	MRU	Body	Y-axis accelerometer output in the Body frame (filtered).	Single
1303	FiltAccBodyZ	[m/s2]	MRU	Body	Z-axis accelerometer output in the Body frame (filtered).	Single
1304	MagneticHeading	[rads]	MRU	MRU to NED	Magnetic heading of MRU in the MRU to NED frame.	Single
1305	MagneticHeading	[degs]	MRU	MRU to NED	Magnetic heading of MRU in the MRU to NED frame.	Single
1306	DeltaRoll	[rads]	MRU	Body to NED	Delta roll angle in rads in the Body to NED frame.	Single
1307	DeltaPitch	[rads]	MRU	Body to NED	Delta pitch angle in rads in the Body to NED frame.	Single
1308	DeltaYaw	[rads]	MRU	Body to NED	Delta yaw angle in rads in the Body to NED frame.	Single
1309	DeltaSurgeVelocity	[m/s2]	MRU	Body	Delta velocity for surge in the Body frame.	Single
1310	DeltaSwayVelocity	[m/s2]	MRU	Body	Delta velocity for sway in the Body frame.	Single
1311	DeltaHeaveVelocity	[m/s2]	MRU	Body	Delta velocity for heave in the Body frame.	Single
1312	RateOfTurn	[rads/s]	MRU	Body	Rate of turn about yaw axis.	Single
1401	TemperatureHT	[degC]	[-]	[-]	Temperature in the MRU casing	Single
1402	HumidityHT	[%RH]	[-]	[-]	Humidity in the MRU casing	Single

Table 71 - List of output variables, part 9 (codes 1107 to 1402).

Norwegian Subsea delivers high performance Motion Reference Units (MRU) and motion sensors for marine, subsea and land use. Our products combine MEMS sensor technology and sensor fusion algorithms to give accurate and reliable motion, velocity and acceleration measurements for control and monitoring applications.

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.

Norwegian Subsea is headquartered in Oslo, Norway.

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