NAVISUITE MOBULA – BLUE ROBOTICS

MANUAL

Last update: 03/05/2023
Version: 4.7.2

Contents

1 Start NaviSuite Mobula Blue Robotics BlueROV2

This section describes the necessary steps required for NaviSuite Mobula to start up.

1.1 Network setup

Before launching NaviSuite Mobula, we need to make sure that we can establish an Ethernet-based connection to the BlueROV2.

By default, the computer communicates with the BlueROV2 through Raspberry Pi with an IP address configured to *192.168.2.2*. To send commands to the BlueROV2 and to receive data from the BlueROV2, the Ethernet adapter in the computer used for communicating with the BlueROV2 must be set to the static IP *192.168.2.1.*

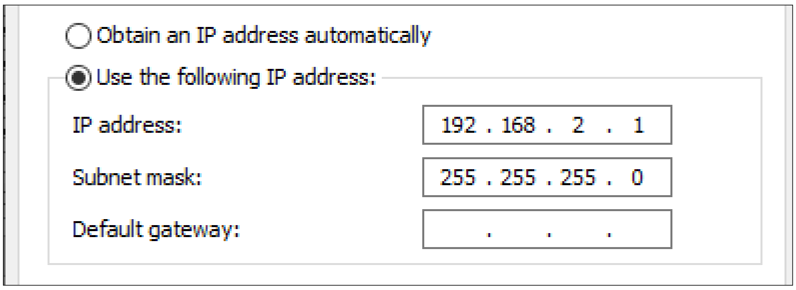


Figure 1 Setting IP address

To check the communication, ensure the BlueROV2 is powered and connected to the computer. Open the command prompt terminal and ping the vehicle with the *ping 192.168.2.2* command. You should receive a reply to the ping command. If you are unable to ping this address, then NaviSuite Mobula cannot control the vehicle. In this case, check the Ethernet configuration and make sure firewalls are not blocking NaviSuite Mobula.

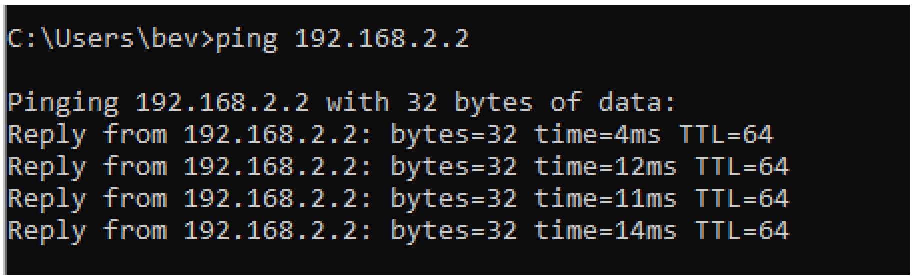


Figure 2 IP connection for NaviSuite Mobula

1.2 MAVLink version

NaviSuite Mobula uses MAVLink version 2 as communication protocol with the BlueROV2. This is what is used by default in newer versions of firmware running on the BlueROV2. If a problem with communication between the PC and BlueROV2 occurs, first the ethernet based connection should be checked, then the MAVLink version should be checked. In case MAVLink version 1 is installed, then it must be changed to version 2 prior to using NaviSuite Mobula.

There are two ways to see and change the currently installed MAVLink version.

1.2.1 Use MAVProxy web interface

0. Connect the BlueROV2 to the PC and connect the BlueROV battery
1. Open the website http://192.168.2.2:2770/mavproxy
2. On the web interface, click **System** on the top part of the page:

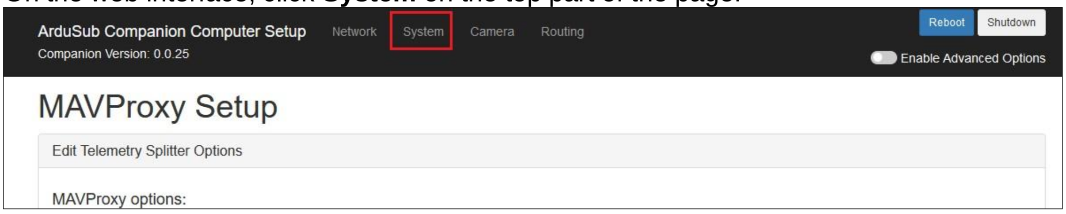


Figure 3 MAVProxy web interface

3. Look in the active services box. If the entry *mavlink2rest* exists, then MAVLink version 2 is installed

1.2.2 Use SSH connection with the Raspberry Pi of the Blue Robotics ROV2

The MAVLink version can also be changed in this way. You will need an SSH client for this, such as PuTTY.

1. Power up the Blue Robotics ROV2 and connect it to the PC
2. Start PuTTY (or your chosen SSH client)
3. Enter the **IP address** *192.168.2.2* and **Port** *22* and click **Open**

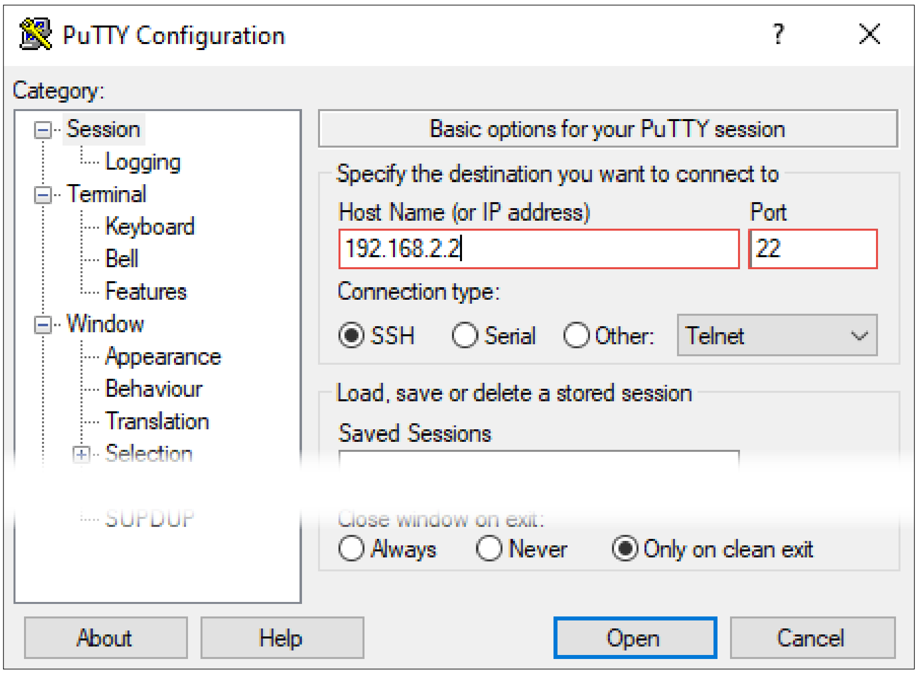


Figure 4 PuTTY connecting to the Raspberry Pi on Blue Robotics ROV

4. Login as *pi*
5. Password *companion* (hidden when entered)
6. Press **Enter** to open the command line window, as shown in the figure below:

Figure 5 Started SSH session with Raspberry Pi

7. Enter the command *cd companion/params/* and press **Enter**
8. Enter the command *nano serial0.param* and press **Enter**. Both commands are shown in the figure below:

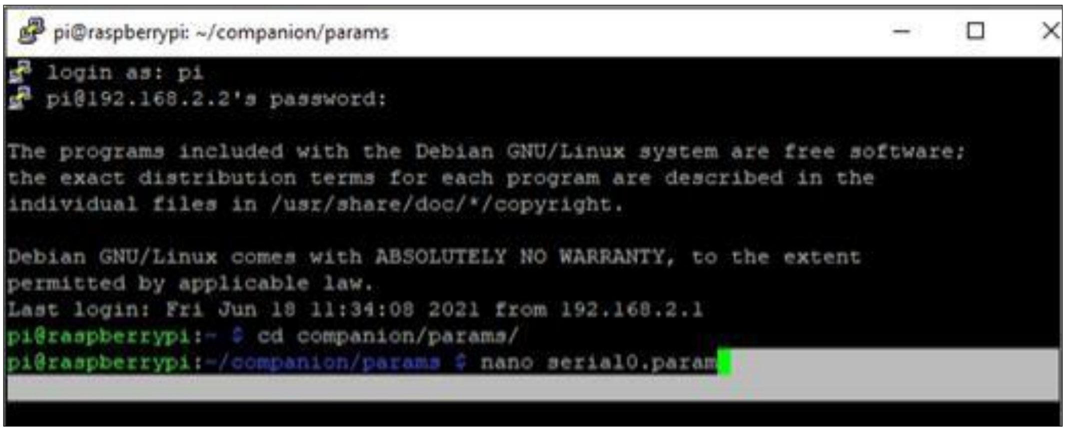


Figure 6 The file serial0.param opened using nano

9. When you execute the command, Nano will open the file *serial0.param*. Independently of the current MAVLink version, the user will see the following image.

Figure 7 SSH session with navigation commands to the correct directory

The number *2* indicates MAVLink version 2. If number *1* is shown, use the arrow keys to navigate to the end of the line, delete the number *1* and write *2*.
Note: The space between *SERIAL0_PROTOCOL* and *2* is important.

10. Press the keys **Ctrl+X** to save
11. Select **Yes** by pressing the key *Y*. Nano will ask for the name of the file. Since the file must be overwritten to be used, press the **Enter** key to save the file with the same name.

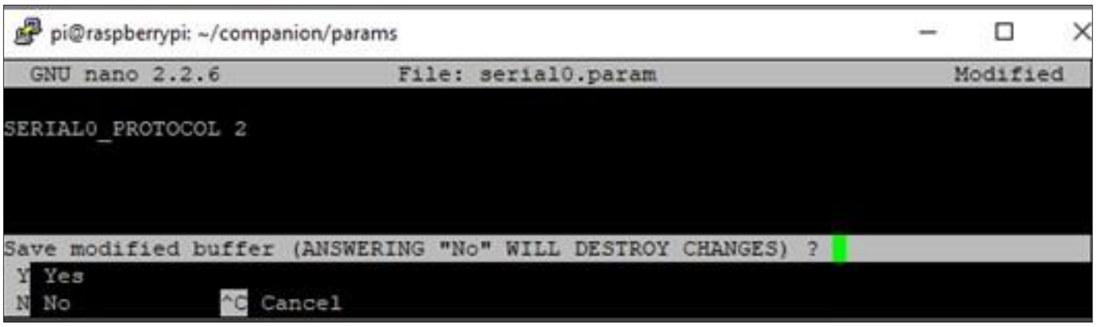


Figure 8 Nano save changes prompt

12. Close the SSH interface by pressing the red **x** on the window, or by entering the command: *sudo shutdown -h now*
13. Reboot the BlueROV2 by disconnecting and reconnecting the battery again, or by using the **Reboot** button on the MAVProxy web interface, as shown in the following figure:

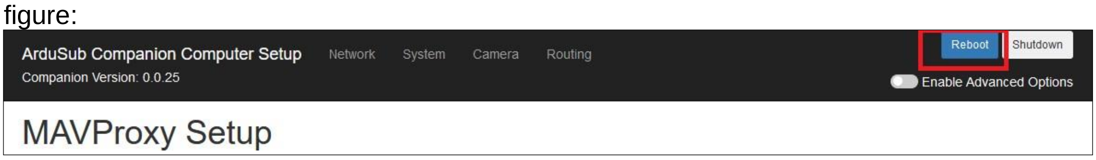


Figure 9 Using the MAVProxy web interface to reboot the Blue Robotics ROV2

The MAVProxy web interface can be reached with the vehicle connected to the PC and powered up by accessing the IP address [*http://192.168.2.2:2770/mavproxy*](http://192.168.2.2:2770/mavproxy) through any web browser

1.3 NaviSuite Mobula Toolbar

The NaviSuite Mobula **Toolbar** is by default displayed in the docked toolbar and it contains the following options:

Figure 10 NaviSuite Mobula Toolbar

1. **Start recording**. One click records, second click stops all camera feeds, tracks, and data in the config (.SBD file). Where the individual files are located is explained in chapter 4.6

2. Recording camera feed.
3. **Channel mapping**
4. **Start Sonar and DVL setup**
5. **Surface and Navigation setup** (available in NaviSuite Mobula Pro)
6. **Start sensor acquisition**
7. **Joystick setup**

NaviSuite Mobula Sonar and NaviSuite Mobula Core do not have the **Surface and Navigation setup** icon.

1.3.1 Starting Sonar and DVL setup

To start the config program, click on the icon second from left in the **ROV Control Toolbar**, as illustrated by the red rectangle of the following figure:

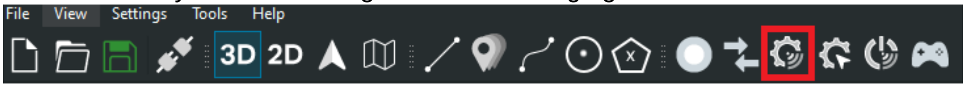


Figure 11 Sonar and DVL setup icon of the NaviSuite Mobula Toolbar

After setting up instruments, save it and exit from **Sonar and DVL setup**.

1.3.2 Starting Surface and Navigation

By default, **Surface and Navigation setup** is greyed out. The user must activate it by following the steps below:

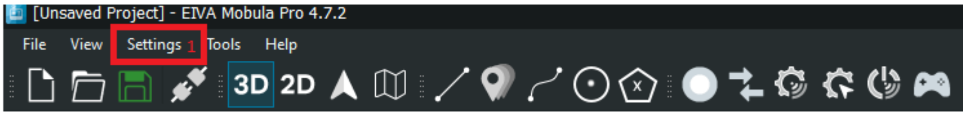


Figure 12 Starting Surface and Navigation in Mobula Pro step 1

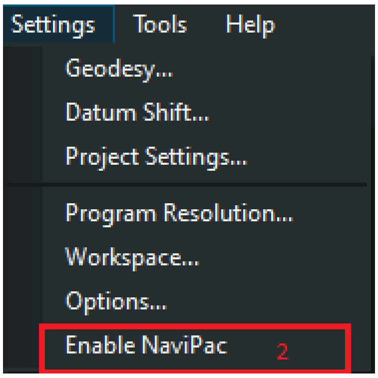


Figure 13 Starting Surface and Navigation in Mobula Pro step 2

To start **Surface and Navigation setup**, click on the gear icon of the **ROV Control Toolbar**, indicated by the red rectangle of the following figure.

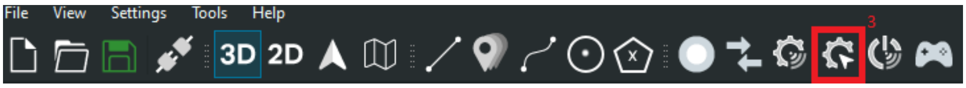


Figure 14 Enabling Surface and Navigation setup icon of the NaviSuite Mobula Toolbar

After setting up instruments, save it and exit from **Surface and Navigation setup**.

1.3.3 Going online

After successfully setting **Surface Navigation** and **Sonar and DVL**, go to data acquisition mode and click the **Start sensor acquisition**.

Figure 15 Start sensor acquisition is green, which means that you are online both in Start Sonar and DVL setup and in Surface and Navigation setup (NaviSuite Mobula Pro) or only Surface and Navigation (NaviSuite Mobula Core and NaviSuite Mobula Sonar)

NaviSuite Mobula automatically connects to the config program once it has been set up correctly. When the button is green, that is, online, the node should be populated in the project tree (sonar), and the NaviPac node should appear (navigation). If this is not the case, you can achieve this by manually clicking the **Connect** button.

Figure 16 Connect button as a part of the File Toolbar

2 Blue Robotics BlueROV2 device configuration

This chapter contains the most important functions that should be set by the operator to be able to freely operate the drone. Here we find: **Calibration, Joystick configuration**, **Thruster properties**, **Sonar and DVL setup**, **Channel Mapper**, **Lights** and **Camera control**.

2.1 IMU calibration: Accelerometer, Gyroscope and Compass

The IMU sensors on both the Navigator Board and Pixhawk can be calibrated in NaviSuite Mobula 4.7.2. **Accelerometer** and **Gyroscope** are calibrated together in a single procedure. **Compass** can be calibrated separately after a successful accelerometer and gyroscope calibration.

The accelerometer calibration procedure also estimates the board orientation, so it is not necessary to manually set it up before calibration. For this purpose, two samples are gathered in at least 2 out of 3 of the vehicle's principal axes.

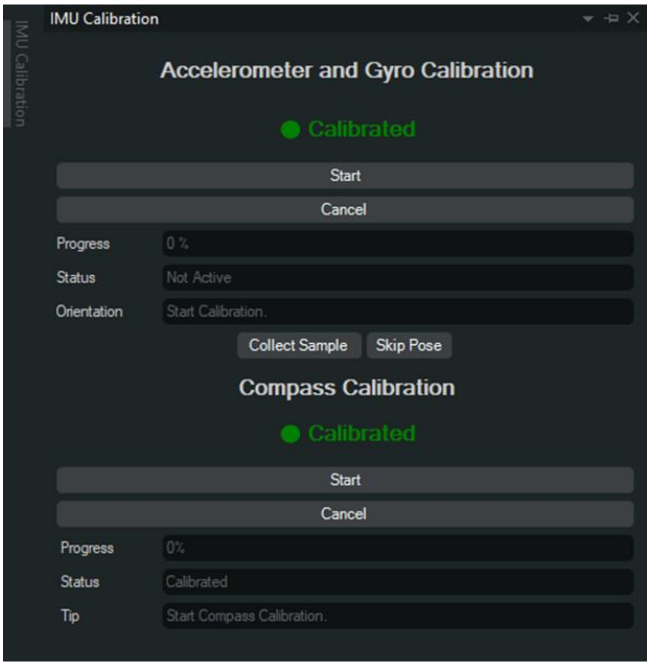


Figure 17 IMU Calibration window where the accelerometer, gyro, compass are calibrated

2.1.1 Introduction

In cases when the IMU sensors are not calibrated, the status will show *Calibration required*.

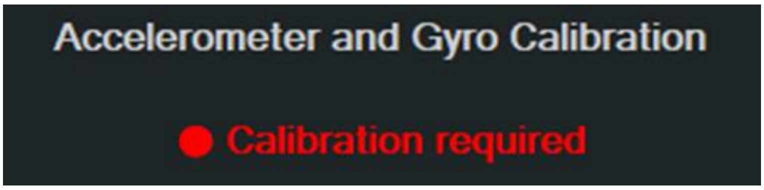


Figure 18 Calibration required

For the first time use, it is necessary to calibrate sensors in order to have optimal performance of the onboard AHRS algorithm.

Note: It is especially important to calibrate accelerometer in cases when user has not configured a board orientation in the original board software. It is not possible to independently change this setting without recalibrating the accelerometer through NaviSuite Mobula.

If the board IMU is already calibrated before it is used in NaviSuite Mobula, it is not required to recalibrate it.

In version 4.7.2 if the accelerometer is not calibrated, it is not possible to calibrate compasses.

2.1.2 Accelerometer and Gyroscope calibration

The accelerometer calibration consists of two phases: calibrating along the principal axis and calibrating in arbitrary orientations. To achieve the best possible calibration, the instructions on the screen should be followed. However, if any of the orientations are hard to reach there is an option to skip the current orientation. Skipping an orientation will add an additional arbitrary position to the calibration. Not all orientations are skippable. The first, second and third (Figures 20-26) are required orientations used for estimation of board orientation.

Note: Calibration is more prone to fail if the samples are done in almost the same orientation and a total of 9 samples is required to complete the calibration.

The gyroscope calibration requires no extra steps and will happen as part of the accelerometer calibration. The calibration is done during the same steps as the accelerometer and so it is important that the vehicle is moved as little as possible during sampling.

Figure 19 Accelerometer and Gyro Calibration window

The possible actions in the **Calibration** window are:

- **Start** – Starts the calibration
- **Cancel** – Cancels the current calibration
- **Collect Sample** – Starts collecting samples for calibration
- **Skip Pose** – Changes the current proposed orientation

The information texts will display the following:

- **Progress** – Shows the percentage of samples that have currently been sampled
- **Status** – Shows the current state the calibrator is in
    - *Not Active* – The calibrator has not been started.
    - *Cancelled* – The calibrator is currently not active due to being cancelled.
    - *Failed* – The calibrator is currently not active due to failing during calibration.
    - *Successfully calibrate* – The calibrator is currently not active due to being completed successfully.
    - *Sampling* – Hold the vehicle still, press sample and keep holding the vehicle still while the display says sampling. This is important as moving during sampling will cause the calibration to become worse or even fail.
    - *Waiting* – The calibration is waiting for the next sample and can be moved without the calibration being disturbed.
- **Orientation** – Shows the orientation the vehicle should be held in when pressing **Collect Sample**

2.1.3 Calibration orientations

The accelerometer is calibrated by collecting samples in the orientations described in the calibration window. For reference look at the images below in order to better understand the vehicles orientation in each step.

2.1.3.1 Required orientations

Step 1

Figure 20 Bottom downwards

Step 2

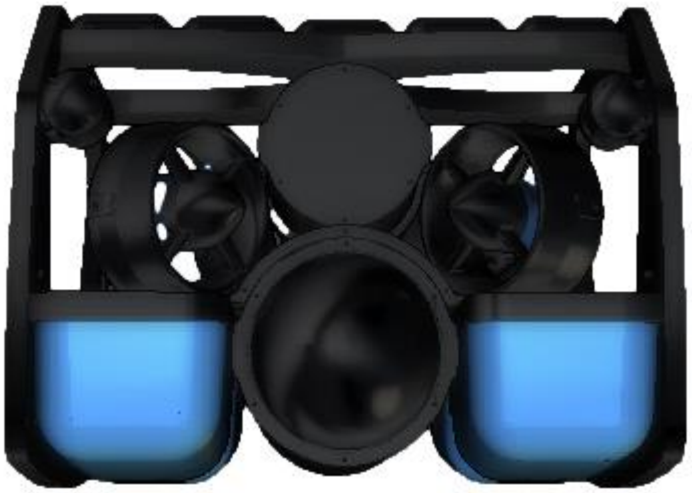


Figure 21 Top downwards

Step 3

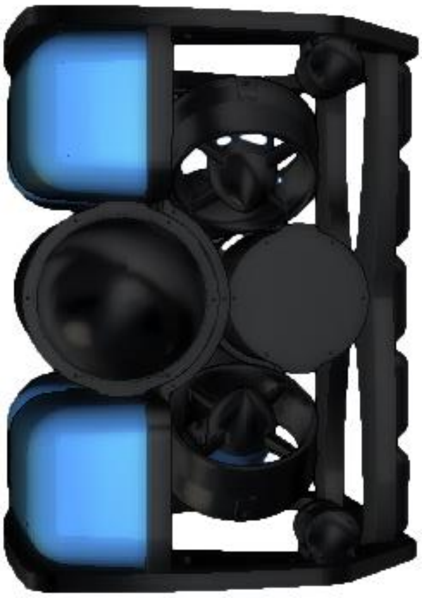


Figure 22 Starboard downwards

Step 4

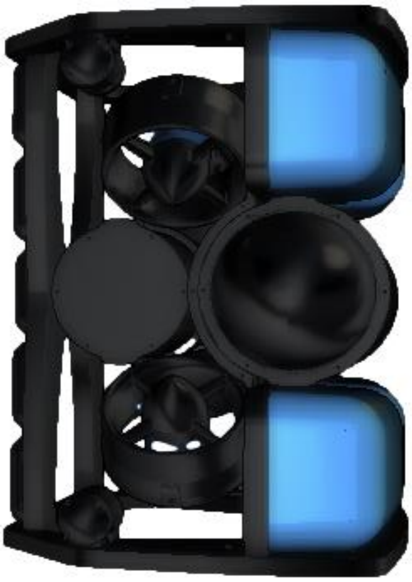


Figure 23 Portside downwards

Step 5

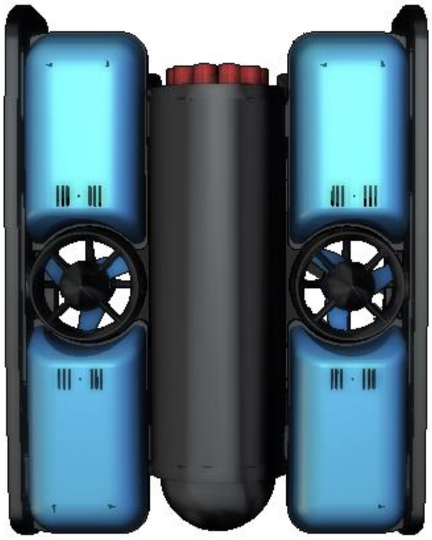


Figure 24 Front downwards

Step 6

Figure 25 Back downwards

2.1.3.2 Arbitrary proposals:

Step 7

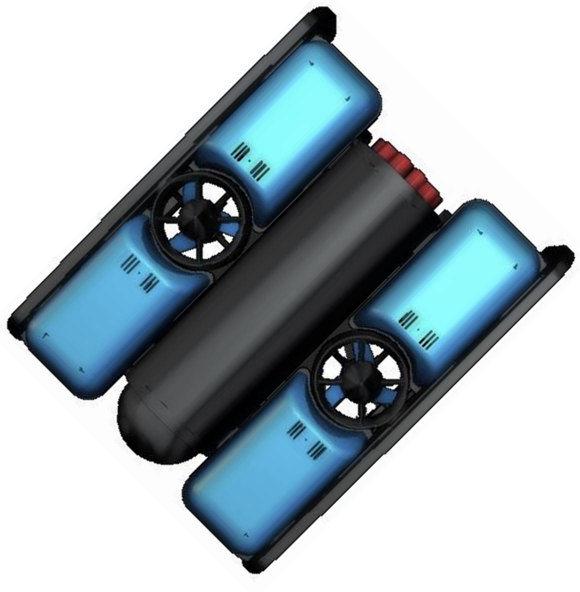


Figure 26 Arbitrary example 1

Step 8

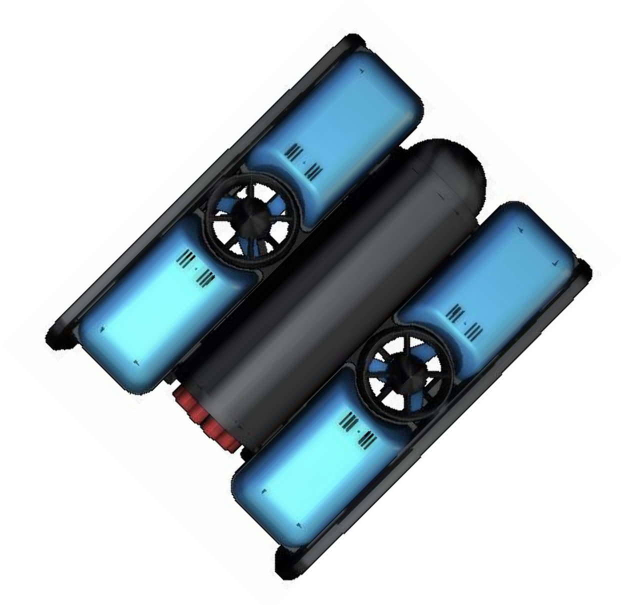


Figure 27 Arbitrary example 2

Step 9

Figure 28 Arbitrary example 3

2.1.4 Compass Calibration

Once the calibration is started, the calibration algorithm starts sampling the magnetic field. The **progress indicator** updates whenever new satisfactory samples are collected. On 33%, the algorithm is running the calibration procedure.

Technical Note 1: If the progress is stuck below 33%, it is very likely that one of the magnetic sensor axes is aligned with the magnetic field vector. In that case, tilt the ROV by 45 degrees in roll and pitch and try brushing the sphere again.

Technical Note 2: Mounting the controlling board at a 45deg pitch offset improves the sensitivity of the magnetic sensor in respect to Note 1.

Technical Note 3: Compass calibration is influenced with surrounding magnetic fields and passive metals.

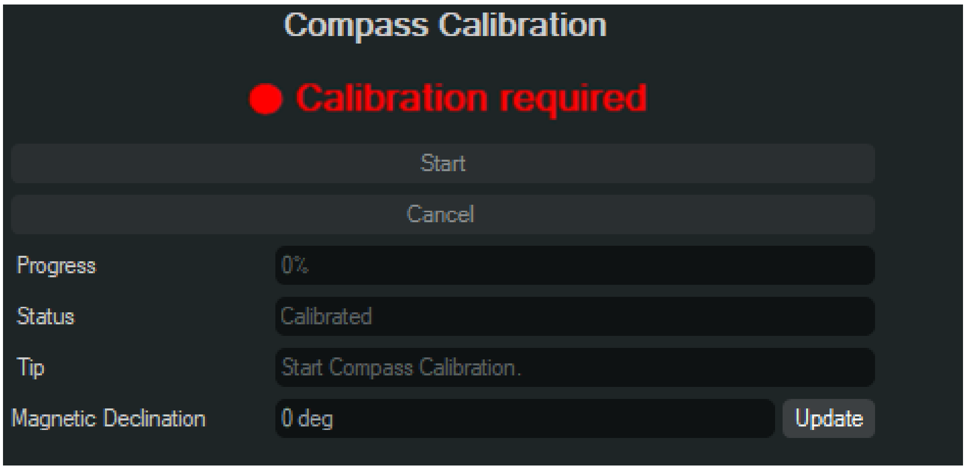


Figure 29 Compass Calibration window

The possible actions in the calibration window are:

- **Start** – Starts the calibration
- **Cancel** – Cancels the current calibration

The information texts will display the following:

- **Progress** – Shows the percentage of samples that have currently been sampled
- **Status** – Shows the current state that the calibrator is in
    - *Not Active* – The calibrator has not been started.
    - *Cancelled* – The calibrator is currently not active due to being cancelled
    - *Failed* – The calibrator is currently not active due to failing during calibration
    - *Successfully calibrated* – The calibrator is currently not active due to being completed successfully
- **Tip** – Shows *Brush the sphere with an ROV* once the calibration is started

Note: Failure in calibration can result from poor sampling, a very disturbed magnetic field or a malfunctioning compass.

For a detailed description of this feature, as well as a FAQ, follow the Calibration quick guide.

2.2 Joystick configuration

The main joystick functionality can be found in the **Joystick Setup** node which is part of the NaviSuite Mobula Toolbar:

Figure 30 Joystick not connected

Figure 31 Joystick connected

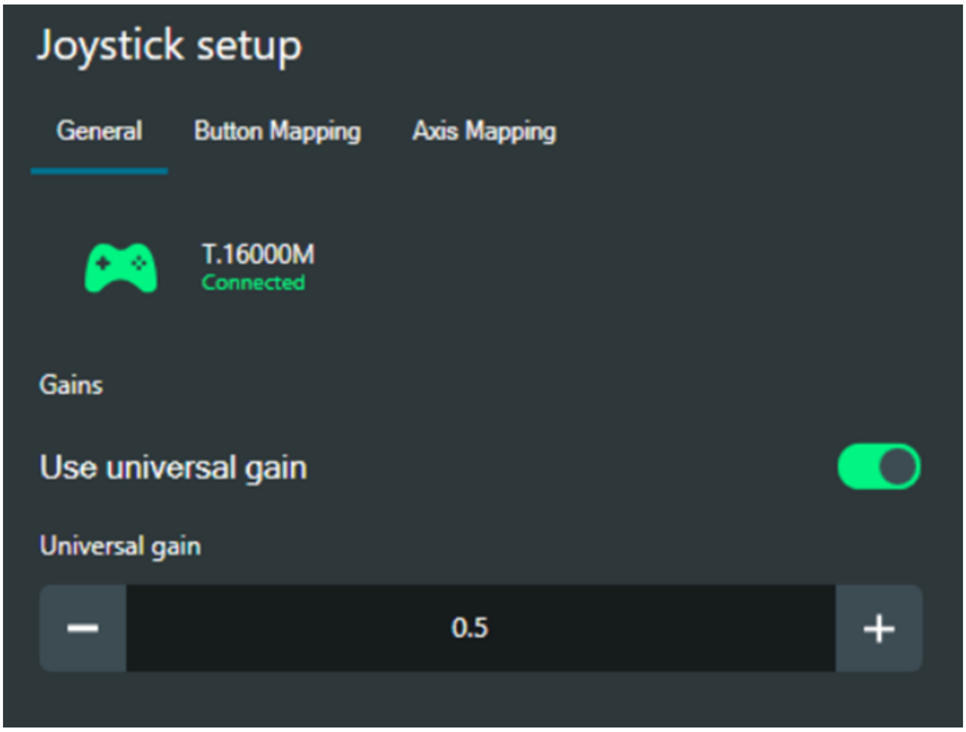


Figure 32 Joystick User Interface

NaviSuite Mobula supports any joystick. Depending on the joystick, the user may need to do some button / axis mapping before it can be used to a satisfactory degree.

Mobula will automatically detect any joystick plugged into the PC when started, however, should the joystick be plugged in after starting up or fall out during flight, clicking **Refresh Connection** from Joystick setup will setup the joystick.

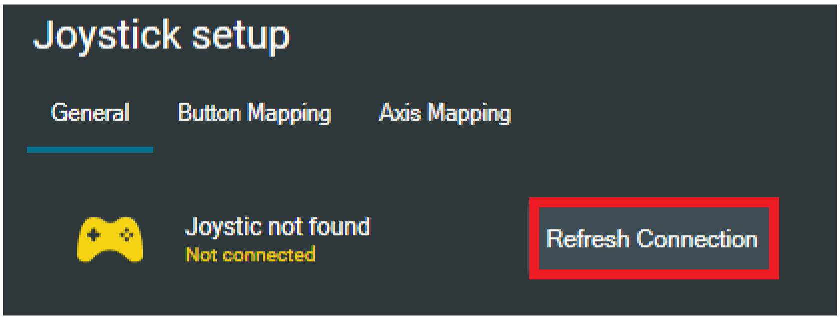


Figure 33 Refresh connection used to setup joystick

Note: ROV is automatically put in disarmed state if joystick disconnects.

2.2.1 Joystick Gains

Joystick Gains can be found in the **General** view for **Joystick** Setup.

There are two types of gains that can be selected: the **Universal gain** and **Individual gains** (surge, sway, heave, yaw, pitch, roll). When the **universal gain** is used, the same gain will be used for all the degrees of freedom (DoF). When the individual gains are used, a gain can be set for each DoF separately.

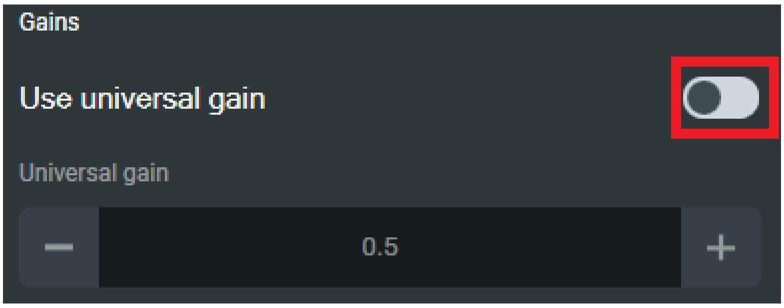


Figure 34 Universal gain is toggled off

The gains can be changed by toggling **Use universal gain**, and using the **+** and **-**, or by a button press on the joystick if any button has been bound to the *JS_GAIN_UP* or *JS_GAIN_DOWN* function. The minimum value is *0.1*, and the maximum is *1*.

Note: If **Individual gains** are *on*, and the gain is changed through a joystick button press, all gains will be increased/decreased by the same amount. So, if a gain for a specific DoF needs to be changed, this should be done through the UI.

The gains currently being used can be found in the **Joystick setup**, or they can be displayed as dashboards or overlays if desired.

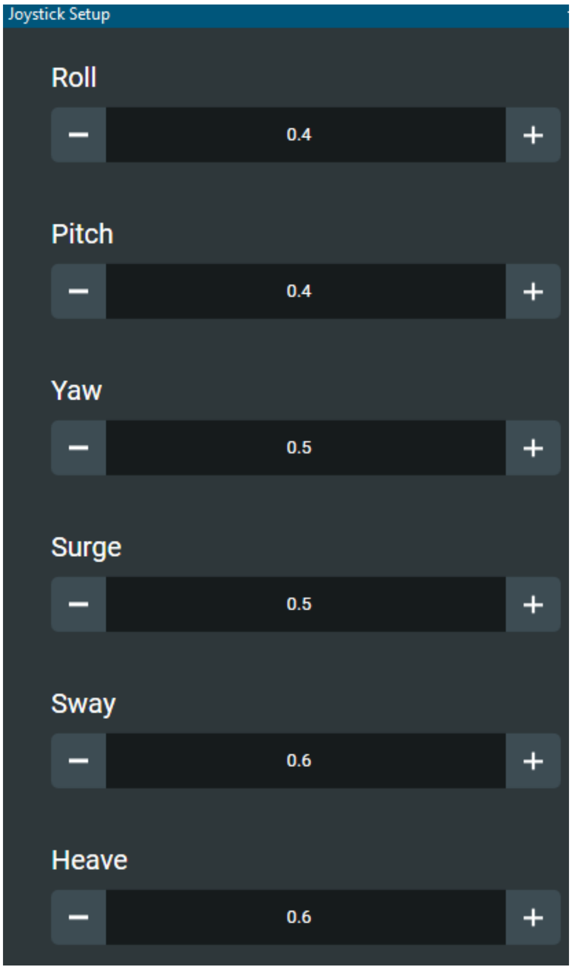


Figure 35 Individual joystick gains

2.2.2 Button mapping

The window for rebinding joystick keys can be found in the **Button Mapping** view in **Joystick Setup**.

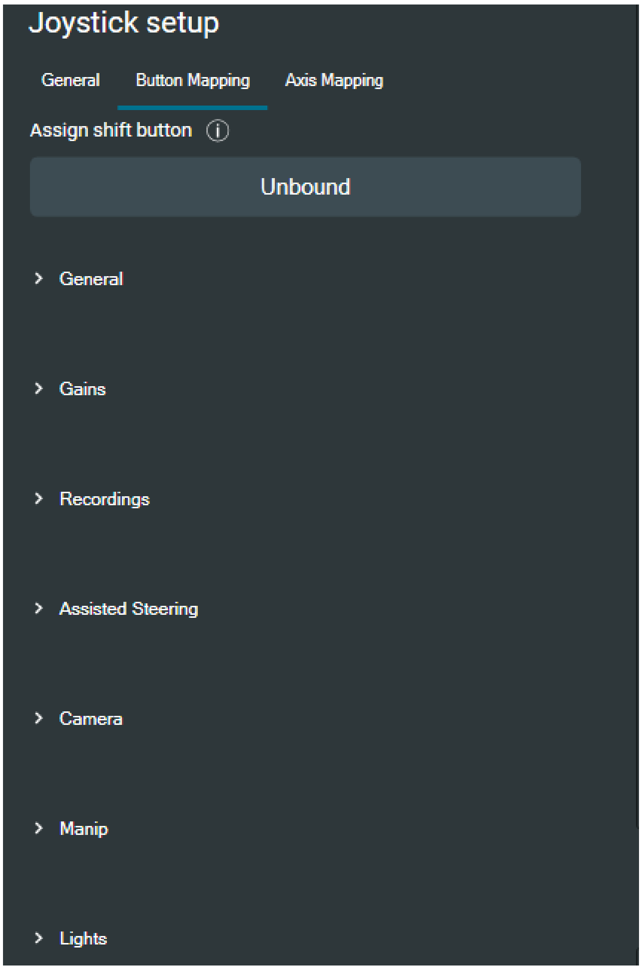


Figure 36 Button Mapping window with groups

In this window, any button on the joystick can be mapped to any action.

The **Assign shift button** binding option allows for a button to have an additional function when the associated key is pressed. This works by first binding the **Shift** toggling functionality to a button. Then, for each of other functionalities, a second button can be assigned separately from the primary one in the **Default** column. Whether **Shift** is toggled on can be seen as an overlay or via creating a **Dashboard** and searching for *Shift*.

2.2.3 Axis mapping

The joystick directions can be found in the **Axis Mapping** view for **Joystick Setup**.

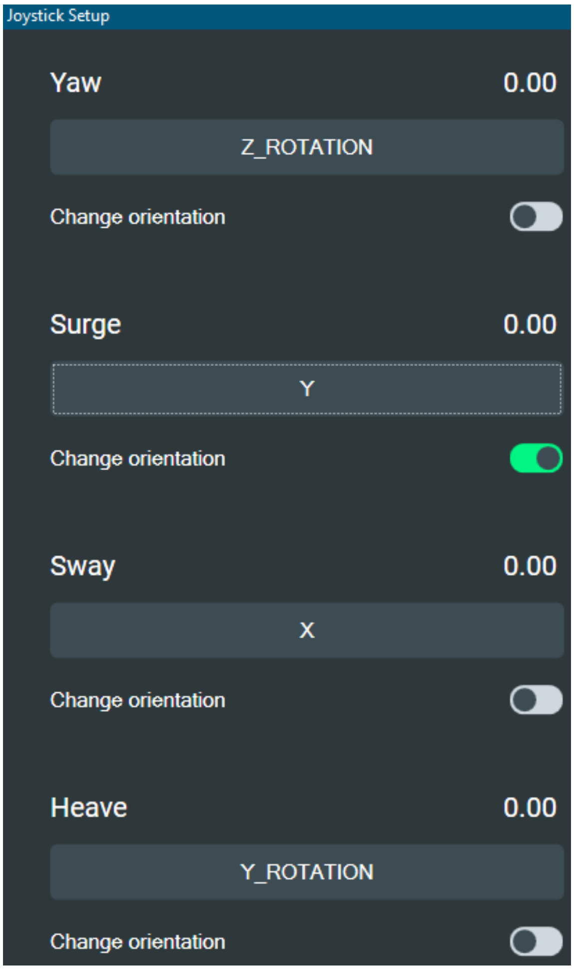


Figure 37 Joystick Axis Mapping

These define how the vehicle behaves when controlled through the joystick. Toggling the orientation for any DoF will swap the axis value direction, that is flip the values of the joystick output.

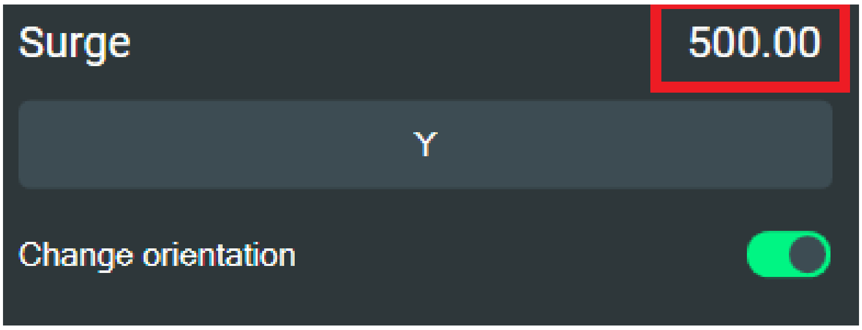


Figure 38 Example of the current output of the joystick for the surge axis

The value shows the current output of the joystick for the specific axis. The user can check if it works and if what is considered forward motion provides the right value. If the joystick is moved forward when mapped to surge, and it gives a negative value, the ROV will move backwards when the stick is moved forward. The orientation can be flipped to solve this.

The default directions have been set up to work for the Logitech Gamepad Joystick. If any other joystick is used, some of the directions might need to be flipped to have a natural feel when controlling the vehicle.

2.3 Thruster properties

In order to allow for customisation depending on the individual needs of the user, NaviSuite Mobula allows for setting the properties of the thrusters. Users can:

- Deactivate the thruster if it is broken and should not be used for control
- Change each individual thruster's direction of rotation
- Set up momentarily the PWM for each individual thruster for diagnostic and testing purposes
- Change the centre of mass for the ROV
- Change the centre of buoyancy for the ROV

The following will describe each of these functionalities and reasons why the user might want to set them.

2.3.1 Locating the Thruster properties window inside NaviSuite Mobula

The location of the **Thruster properties** window inside the NaviSuite Mobula workspace is shown in the following figure, highlighted by the red rectangle:

Figure 39 Location of the Thruster properties window

Hovering above it opens the **Thruster properties** window, which is shown in the following figure. Initially, the settings are not active, and the user cannot adjust the properties. This is a safety measure since setting individual thruster PWM outside of water can lead to thruster wear. To enable setting the thruster properties, toggle the **Show thruster configuration** switch, as highlighted by the red rectangle below.

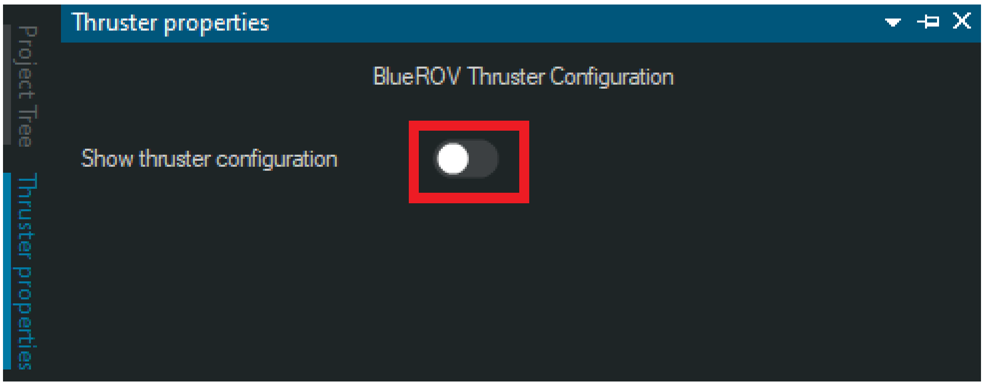


Figure 40 Initial Thruster properties window. Highlighted is the switch to enable the settings.

When enabled, the **Thruster properties** window appears as shown in the following figure, with the settings loosely separated into three areas: individual thruster settings, centre of mass and centre of buoyancy.

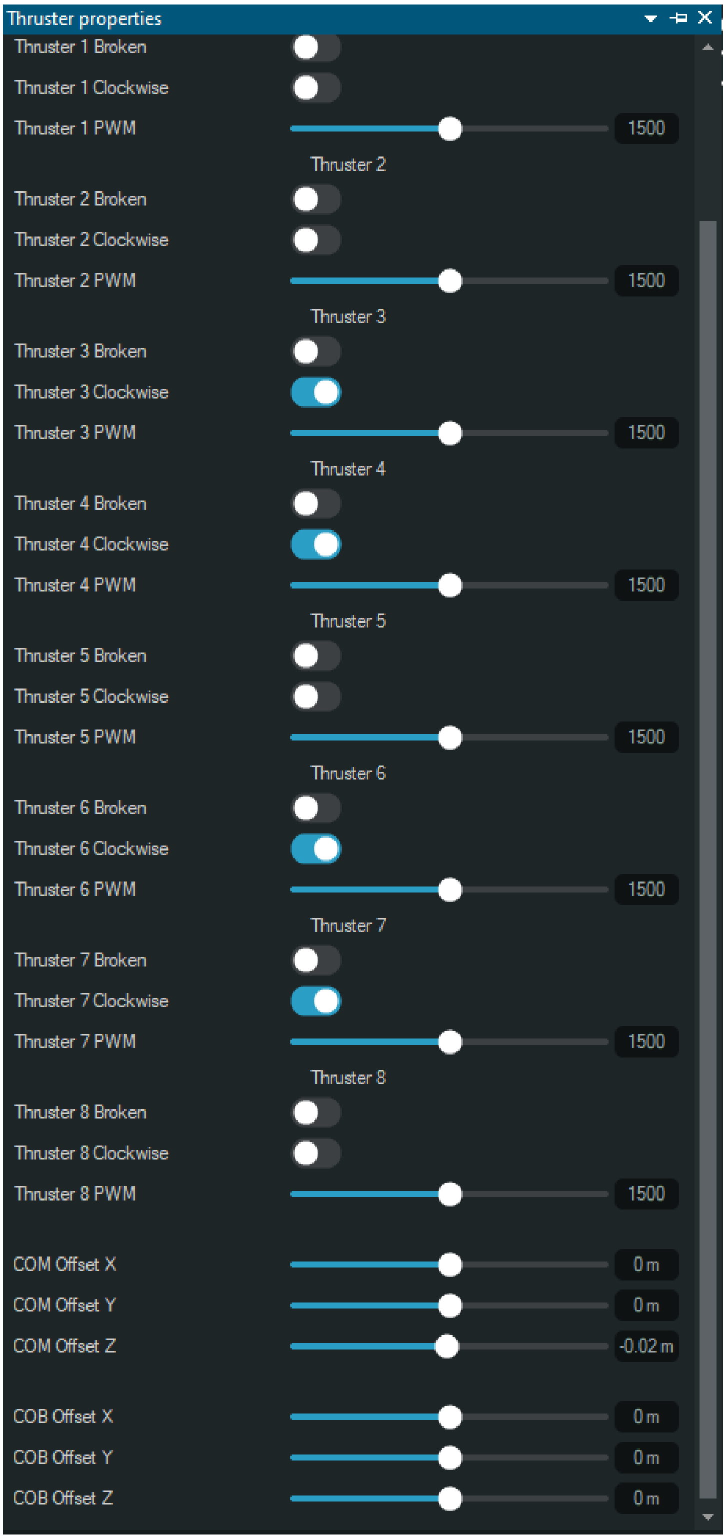


Figure 41 Thruster properties window enabled

2.3.2 Individual thruster PWM setting

The **Thruster properties** view will always show the number of thrusters available on their current frame: *6* for standard, *8* for heavy, *N* for custom. The following figure shows information for **Thruster 1**:

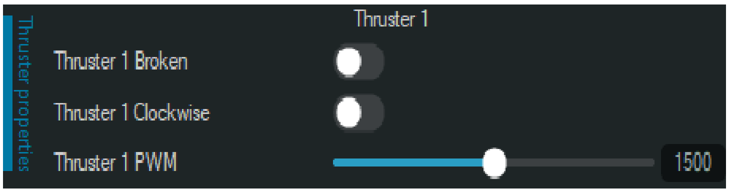


Figure 42 Thruster 1 settings

- **Thruster 1 Broken** – The user can mark a thruster as broken, so it will not be included when allocating thrust.
- **Thruster 1 Clockwise** The operator will need to change it to fit the blade type that is mounted on the thruster. For example, if the toggle **Thruster 1 Clockwise** is active, then for PWM values above 1500, thruster 1 will spin clockwise. If the thruster is spinning in the opposite direction when correctly configured, the operator might need to toggle the button, causing Thruster 1 to spin anti-clockwise. This situation could be caused by opposite thruster wiring, which changing thruster rotation direction can account for.
- **Thruster 1 PWM** – Setting the PWM for the thruster should be performed only when the vehicle is underwater or for short periods of time to avoid wear. The purpose of this setting is diagnostic. When the user has set the slider to a desired PWM value, the thrusters start spinning accordingly. The default PWM value is 1500, which corresponds to zero RPM.

2.3.3 Centre of mass correction

Depending on the equipment mounted on the ROV, the user may need to adjust the centre of mass to correct for deviations of weight when controlling the vehicle. This can be done using the **COM Offset X**, **Y** and **Z**. This area is shown in the following figure:

Figure 43 Adjustments of centre of mass correction

COM Offset X is positive in the fore direction, **COM Offset Y** in starboard direction and **COM Offset Z** is positive downwards in the heave direction.

0,0,0 corresponds to the Centre of Geometry of the ROV.

The units are in meters, so a correction of 6 cm corresponds to a slider value of 0.06 m as in the figure 26.

Confirmation of the value change is done by removing the focus from the field to have the value applied. Pressing **Tab** on the keyboard is a convenient way to do this.

2.3.4 Centre of buoyancy correction

Figure 44 Centre of mass correction

This correction may be necessary when an accurate total weight is to be determined. The user can move where the COB of the ROV is located. By default, NaviSuite Mobula assumes it is at 0,0,0 (centre of the ROV). However, for most configurations, this is very rarely the case, so ideally, the user should move the COB to the correct position for even better control.

Confirmation of the value change is done by pressing the **Tab** button or by changing focus from the field.

2.4 Sonar and DVL setup

2.4.1 How to open the config program

The **Sonar and DVL setup** is used to set up an ROV payload, such as FLS, DVL, Positioning sensors, etc.

The **Config** window can be opened from within NaviSuite Mobula by clicking on the icon shown below:


Figure 45 Sonar and DVL setup

2.4.2 Fitting default projects to a custom setup

The default **ROV** configuration window is opened at the beginning. It represents a possible full configuration that should be edited to fit the ROV. To add a desired instrument, either click on the **+** button to add a **New Instrument**(shown below) or right-click on empty space on the **ROV** window.

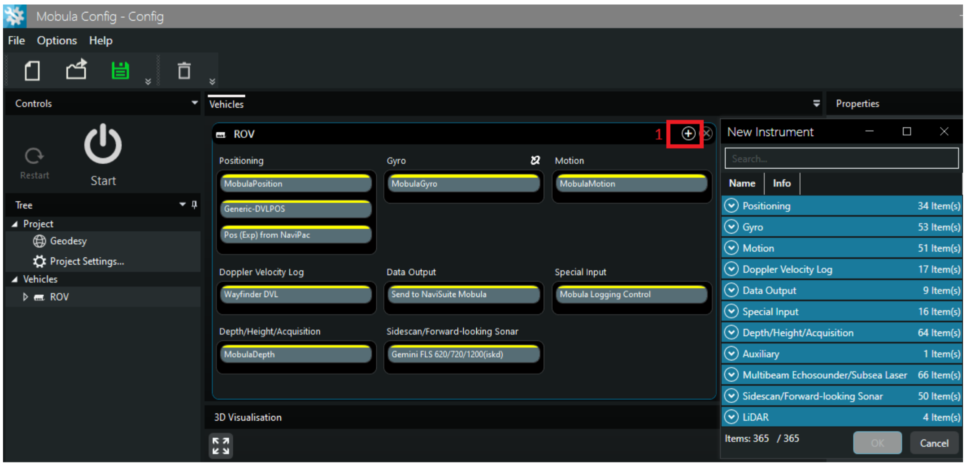


Figure 46 Add a new instrument using New Instrument button (+)

Removing an existing sensor should be performed by right-clicking and clicking **Remove Instrument**:

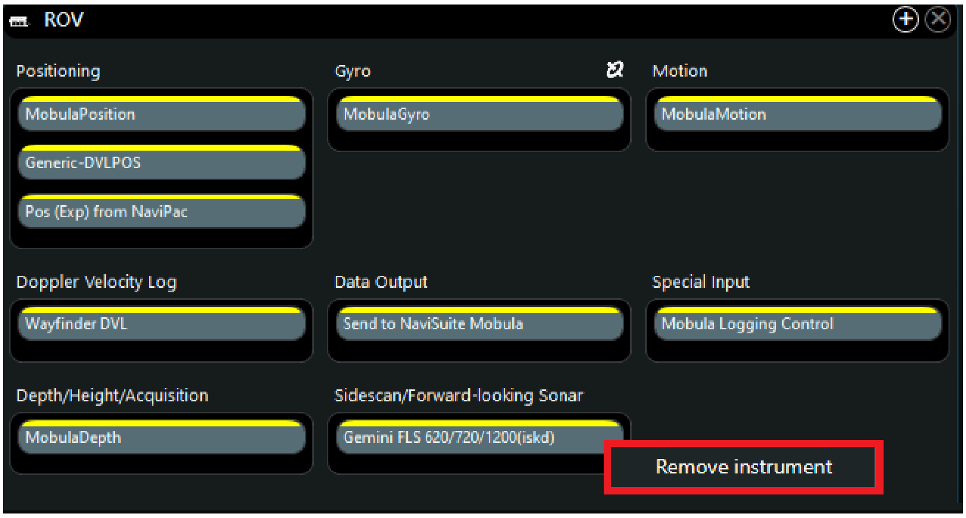


Figure 47 Remove an instrument using right mouse click

Then another one from the available list can be chosen from the list below:

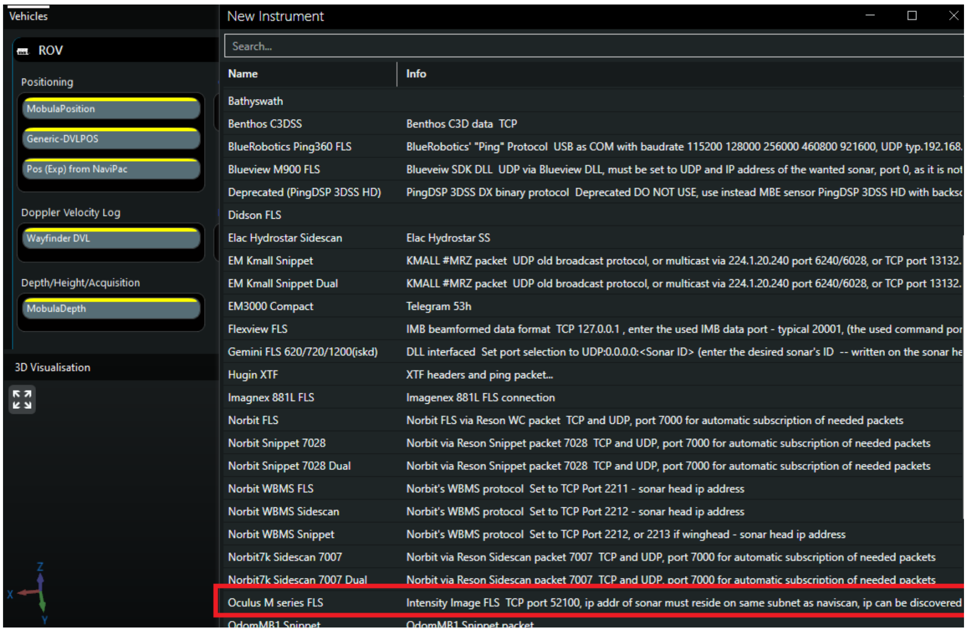


Figure 48 Selected FLS from the drop-down list

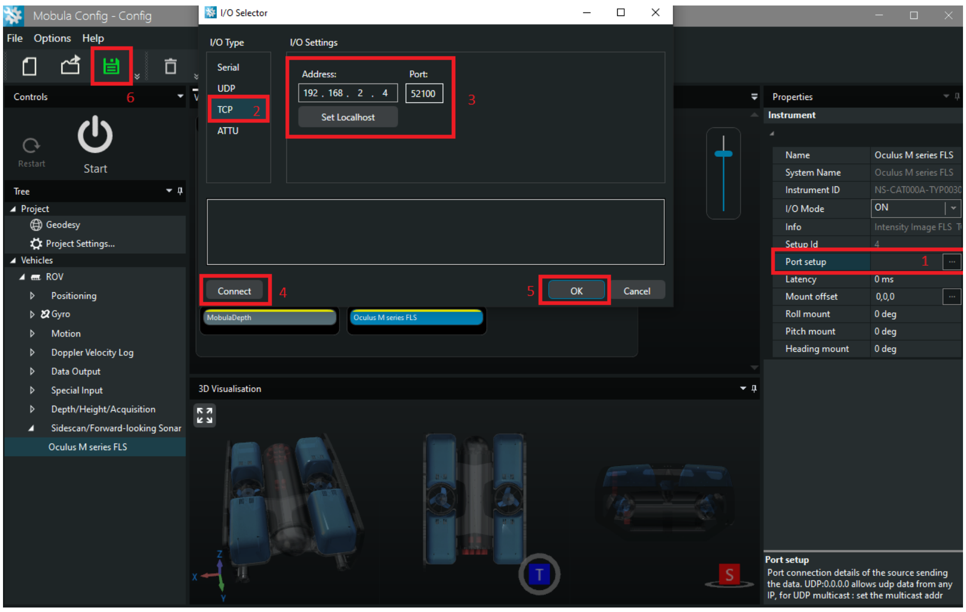


Figure 49 I/O settings for added FLS workflow

Set up the communication port of the FLS (the source of data):

1. Click **Port setup**
2. Click the **I/O Type**, here **TCP**

3. Enter *192.168.2.4* with **Port** *52100*

   Note: This is an example. Users' FLS may be on a different address/port.

4. Click **Connect**

   Note: Connect is just one way to make sure data is coming in. It is not required. Also, some sensors may not show any data coming in, even if they are working correctly.

5. Click **Ok**

6. Click the **Save** icon

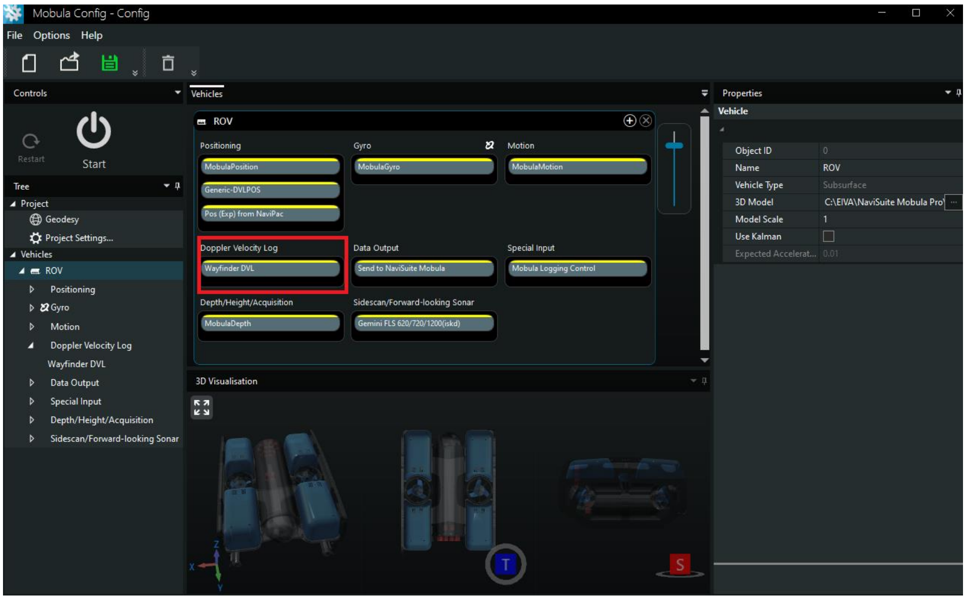


Figure 50 Wayfinder DVL by default is in the setup

The default project contains the **Wayfinder DVL**. It is a placeholder. The user should replace it with available device once configured and delete the unnecessary devices.

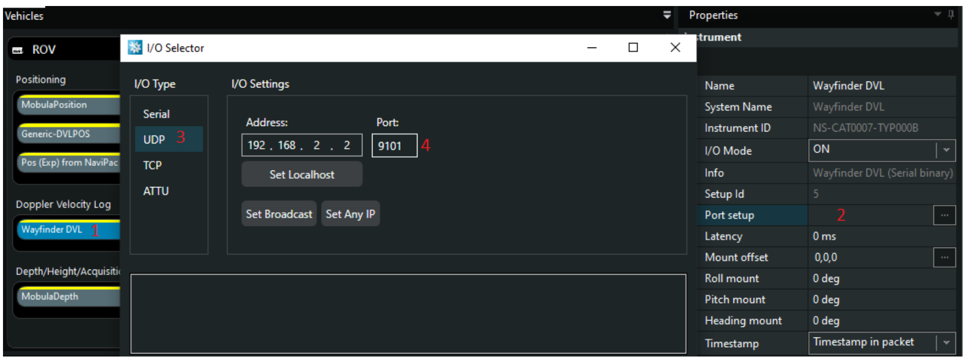


Figure 51 Example of I/O settings for Wayfinder DVL workflow

Clicking **Connect** allows the operator to see streaming data for some sensors. Some instruments will not show data here, even if data is coming in.

Clicking **Save** will save the project in the default location.

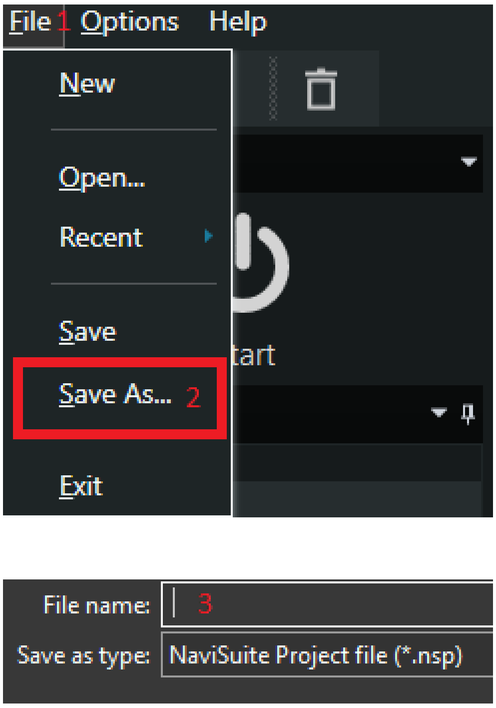


Figure 52 Save .NSP file with configuration

Note: When the Config program is started from within NaviSuite Mobula, it will load the configuration in the default location. If the project is saved elsewhere, it will have to be loaded manually.

After configuring instruments in the Mobula Config, the next step will be to refer to the instruments used in **Send to NaviSuite Mobula** instrument.

2.4.3 Send to NaviSuite Mobula instrument

The **Send to NaviSuite Mobula** instrument is used for sending data that will be used for control from **Config** into NaviSuite Mobula. Only the data specified in the **Send to NaviSuite Mobula** will be used for control. As the **Send to NaviSuite Mobula** is not a physical instrument, it is not receiving any data. Thus, when clicking **Connect**, no data will be shown, even when everything works correctly. The user should ensure that the selected instruments are receiving data, because the data they are receiving is what the repeater will send to NaviSuite Mobula, if selected.

The default setup in **NaviSuite Mobula Config** includes a **Send to NaviSuite Mobula** (**IP**: *127.0.0.1*, **UDP port**: *2340*). If it is not using the port *2340*, change it to do so. The **Send to NaviSuite Mobula** port must not change.

2.4.4 Examples of how to use Send to NaviSuite Mobula

Exclude a category selecting DVL.

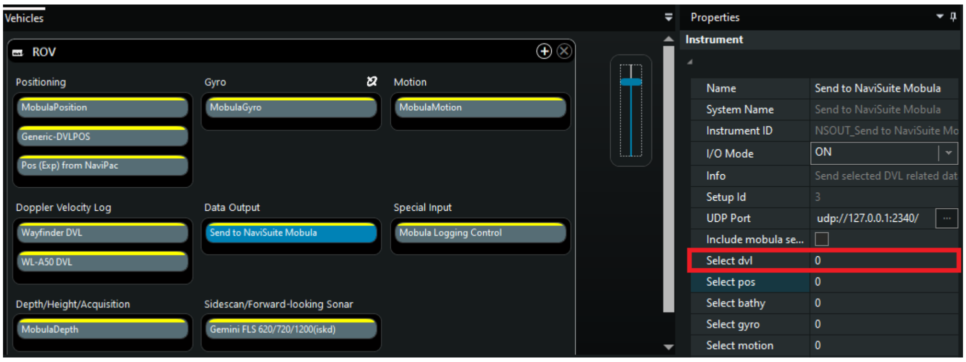


Figure 53 Send to NaviSuite Mobula points to the number in the display order of which DVL is selected. No DVL is selected

Include a category where the instrument is not the first one. The indicated *2* points to the *WL-A50 DVL* selected from the list.

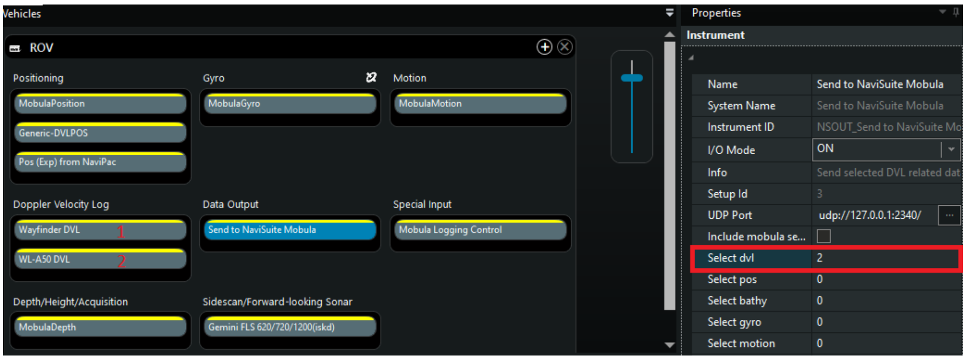


Figure 54 The Send to NaviSuite Mobula points to the number in the display order where the DVL is selected. Here the second instrument is selected (2).

Include a category with just one instrument. The indicated *1* points to *WL-A50 DVL* selected from the list.

Figure 55 Send to NaviSuite Mobula points to the number in the display order which DVL is selected. Only one instrument available.

After having configured the sonar and DVL setup, make sure NaviSuite Mobula is running and connected to the ROV before starting by clicking the **Start button** of config program.

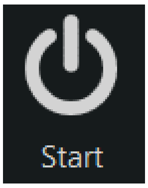


Figure 56 Start button of config program

Note: Selecting *0* means no external position source will be provided for NaviSuite Mobula. When both position and DVL are selected, the position will be used for control and DVL for assisting in control. If no position is selected, DVL will be used for control.

2.5 Channel Mapper

The **Channel Mapper** allows the user to remap the Navigator or Pixhawk physical channels in software without changing the physical connection.

Channel Mapper needs to reflect the control board in use. By default, the light, camera, and manipulator channels will follow the number of thrusters. So, if the user has 6 thrusters, the lights, camera, and manipulator will automatically be channel 7, 8 and 9 by default. If the user has 8 thrusters, they will be 9, 10, 11 by default. In NaviSuite Mobula with Navigator Control Board we can operate 2 sets of lights. By default, they are on channels 9 and 12.

If this is not how you have wired your control board, then you can use the **Channel Mapper** to change the channels of those instruments to reflect the wiring of your control board.

Figure 57 Channel Mapper as a part of the NaviSuite Mobula Toolbar

Figure 58 Example of Channel mapper configuration on heavy frame Blue Robotics ROV with a Navigator Control Board (16 available channels)

2.6 Lights

By default, the lights will be off. The **Lights** overlay indicates whether the lights are currently enabled or not.

Figure 59 Lights overlay indicating on/off state

In order to be able to operate the lights, they must first be turned on. We do this in the **Utilities** tab. It can be found pinned to the left side of the screen by default.

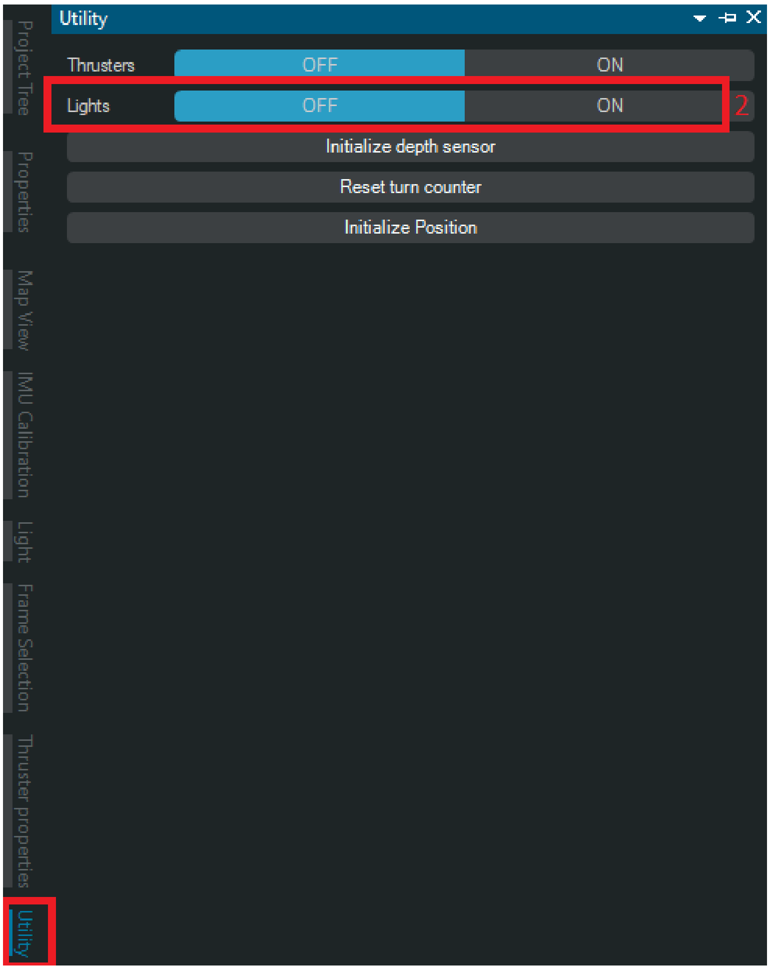


Figure 60 The button for toggling the lights on and off in Utility

In the **Lights** window, found pinned to the left by default, we have full control over 2 light sets. Here, you can find the settings to select the active set of lights or both at once when the user has 2 sets of lights. This is done by moving the **slider** of the light intensity value or entering the value in the frame. The increasing/decreasing light level can also be mapped to the joystick.

The intensity shown below is for reference.

Figure 61 Light Control with intensity sliders and on/off toggles

The lights being off is different from sending a light value of *0*, as when **In Use** is toggled off, no light commands are being sent. This can be useful for not accidentally turning on the lights when not needed. If the current light level is 100% (max) and the lights are off, no light command will be sent to the ROV, ensuring light commands are only being sent when desired.

2.7 Camera control

For now, camera tilting can only be controlled using the joystick, where the functions **Camera tilt down** and **Camera tilt up** must be bound to a button in Joystick setup.

Figure 62 Key binding window for tilting the camera up and down

3 Flight controls

Flight controls can be found in the **Assisted Steering** window pinned to the right side of the screen by default. When the cursor hovers over the pinned window, its content will be shown.

Figure 63 Assisted Steering controls

3.1 Joystick control

The joystick controls can be found pinned to the right side of the screen by default, it is part of the **Assisted Steering** window.

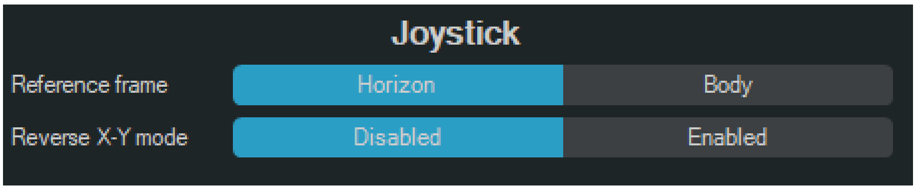


Figure 64 Joystick steering as part of Assisted Steering

The **Reference frame** determines how the BlueROV2 behaves when controlled manually using a joystick.

When in the **Body** frame, the BlueROV2 will always move in relation to the fore direction. This is illustrated in the following figure, where the ROV is shown pitching nose down. Moving the joystick controller forward will result in forward motion relative to the body frame directions on the BlueROV2. This resulting motion is shown with the red arrow. As a result, the ROV will also dive.

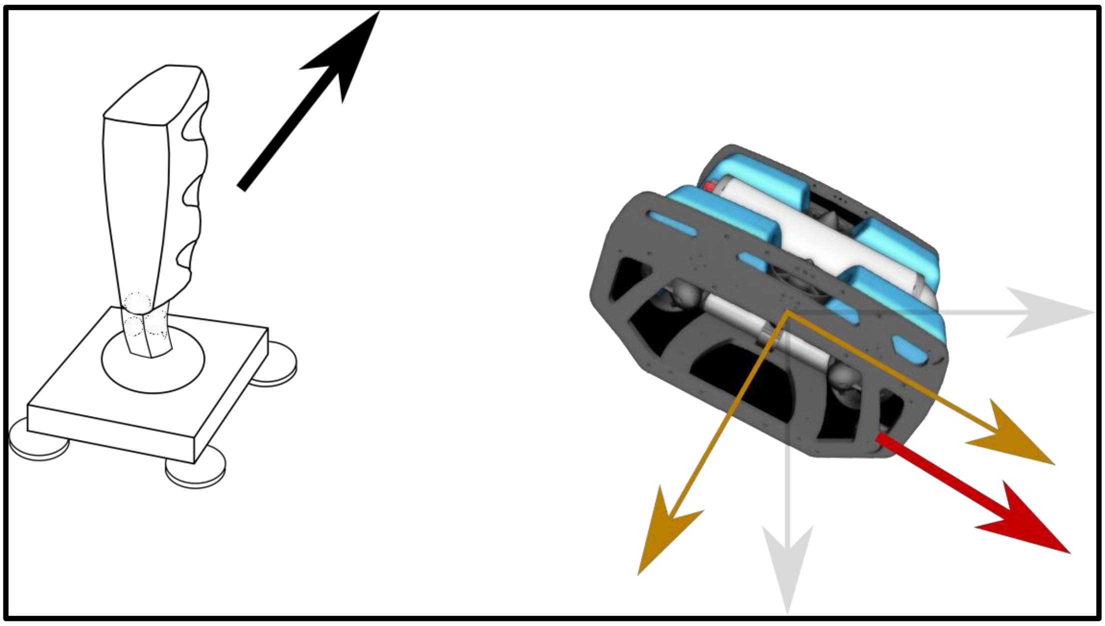


Figure 65 ROV moving in the body frame

When in the **Horizon** frame, the BlueROV2 will always move along the horizon regardless of orientation. This is shown in the following figure, where the ROV is keeping a pitch angle. Moving the joystick forward now will result in a forward motion relative to the horizon or world frame. As a result, the ROV will not dive but move forward while maintaining its pose.

This motion is shown with the red arrow. The horizon frame is shown in bold and does not rotate with the vehicle.

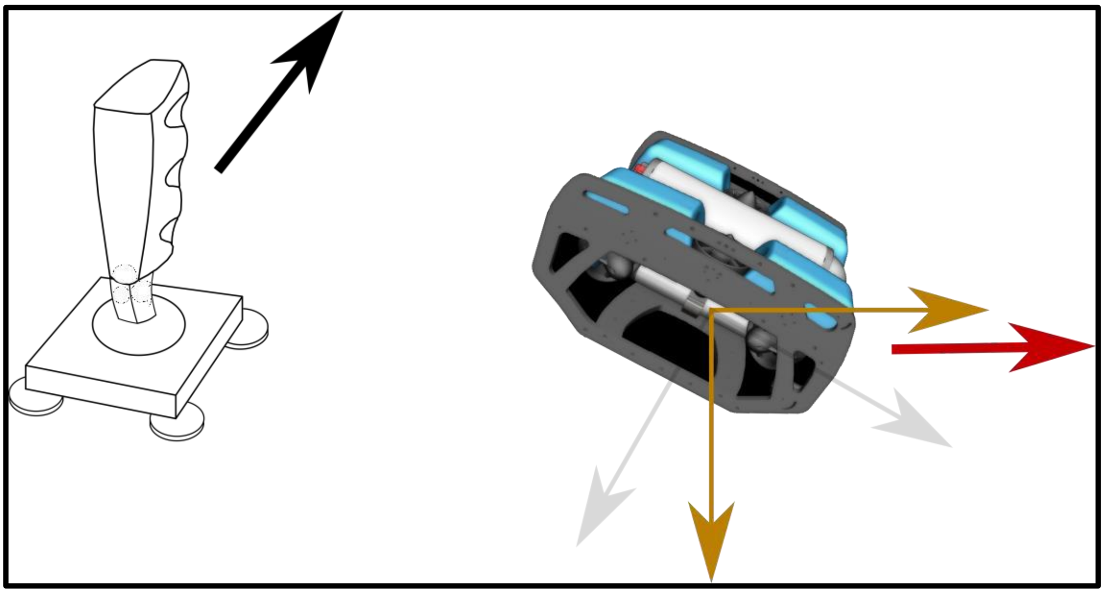


Figure 66 ROV moving in the horizon frame

The **Reverse X-Y mode** reverses surge and sway commands when given by the joystick, and as such does not affect trims or other control.

3.2 Trim control

The **Trims** control can be found in the **Assisted Steering** window, pinned to the right side of the screen by default.

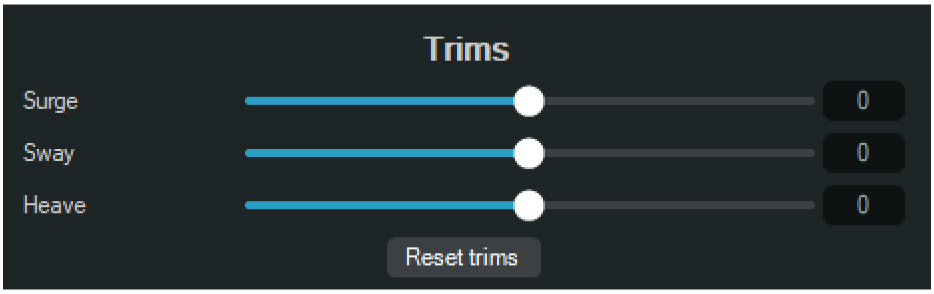


Figure 67 Trim control as part of Assisted Steering

The **Trims** control allow the user to set a constant thrust to the surge, sway, and heave direction. Trimming works together with manual joystick control. The trims always refer to the same frame as the selected reference frame, that is **Body** or **Horizon**.

Using the sliders, the trim for the DoF can be set. The trim takes effect immediately as the slider is moved.

The **Reset trims** button will set all the trims to *0*, disabling any trim that may have been active.

Reset trims can be bound to joystick button.

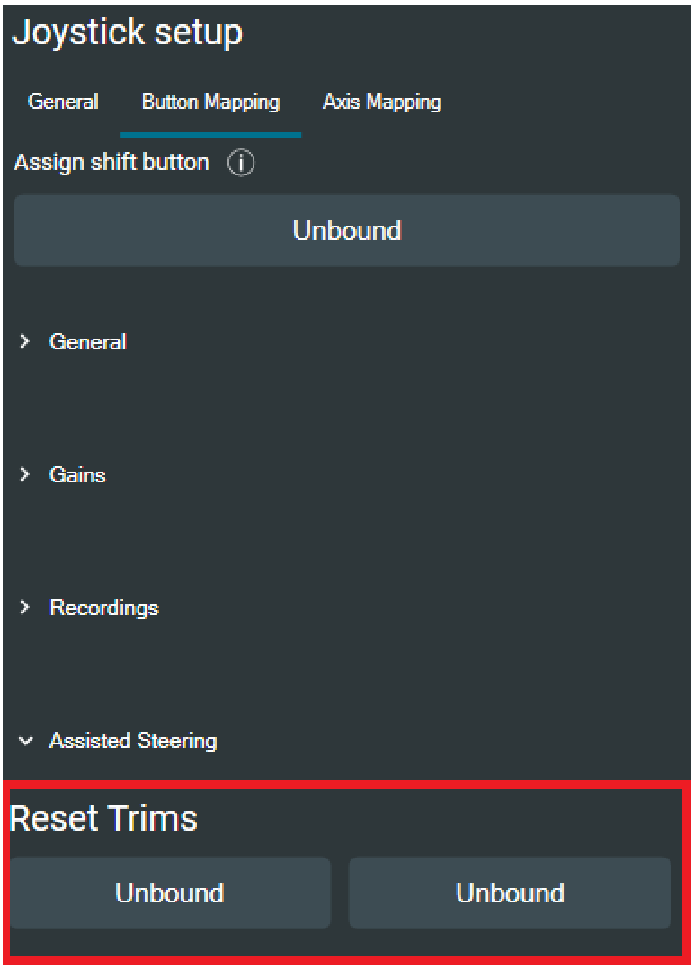


Figure 68 Reset Trims bound on joystick

3.2.1 Cruise control

Cruise control is a feature related to control of ROV. The operator can enter a cruise control state from a button click. It will set your current joystick values (surge, sway, heave) to trims.

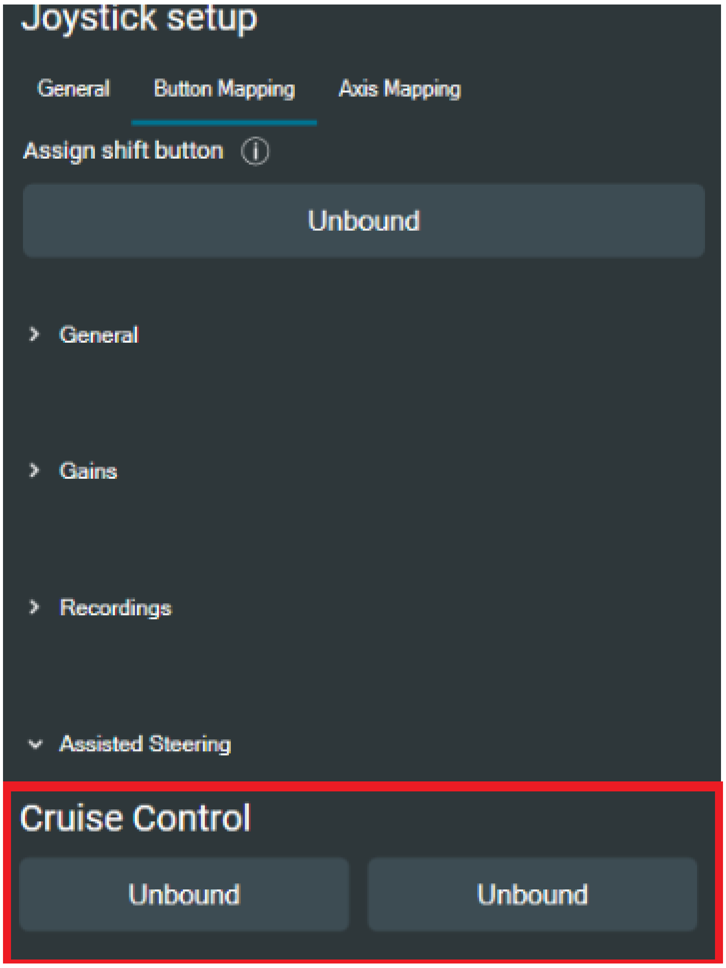


Figure 69 Cruise Control function bound on joystick

3.3 Auto hold

The **Auto hold** controls can be found pinned to the right side of the screen by default, it is part of the **Assisted Steering** window. The **Auto hold** controls allow the user to hold a given heading, pitch, roll, and/or depth, and toggle on/off **Station Keeping**.

- **Heading**, **Pitch**, and **Roll** requires attitude sensor data.
- **Depth** requires pressure/depth data.
- **Altitude** requires altitude data.
- **Keep distance** requires distance data.
- **Station keeping** requires position data.

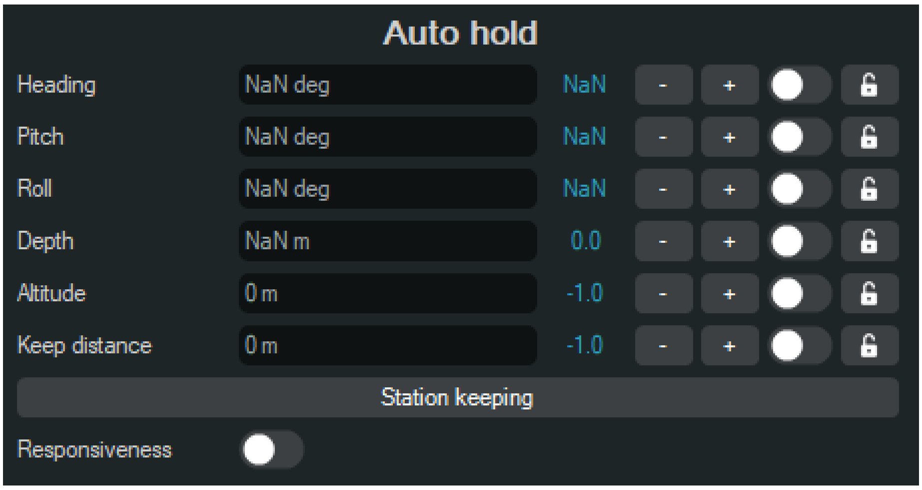


Figure 70 Auto hold as a part of Assisted Steering

In this window the user can see the current value and the target value for any given controller. The target value will be *NaN* if the controller is not active, as no target value exists at this point. The controller can be turned on by flipping the **Toggle** button or by joystick button press.

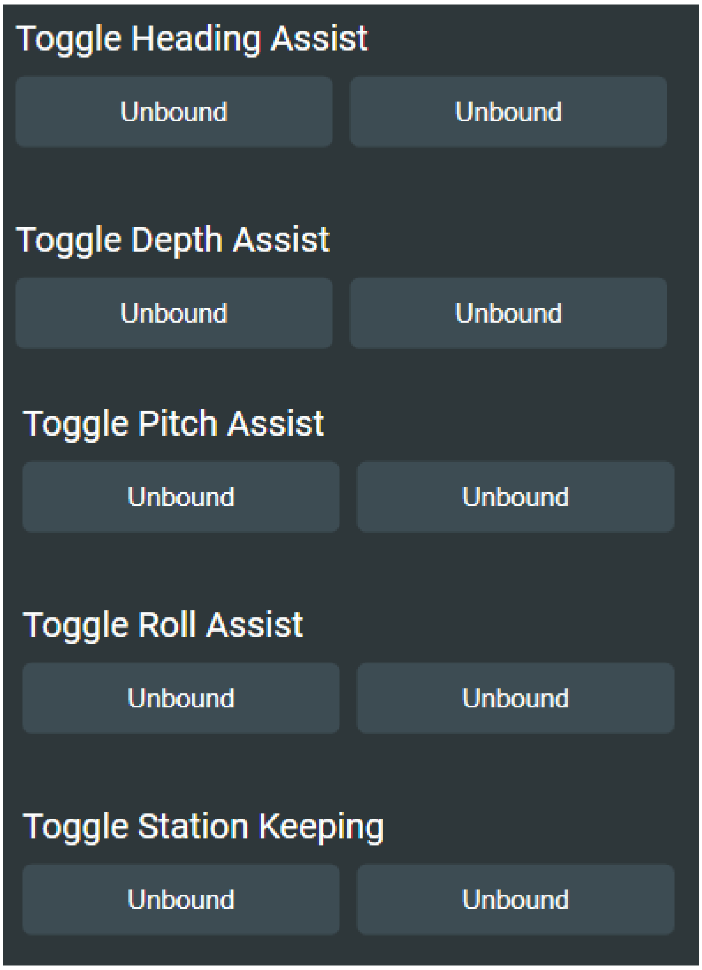


Figure 71 Auto hold controller can be bound on joystick

The **+** and **–** buttons can be used to increment/decrement the target value in small steps. The target value can also be changed using the joystick while the controller is active. If the row is locked, it will be greyed out, so it is no longer possible to accidentally change any of the current settings.

Locking can be achieved by clicking the **Lock** icon. The **Lock** icon can be clicked again to unlock the row.

Figure 72 Lock of row

The **Station keeping** button functions like a toggle and will toggle station keeping on/off. **Note**: **Station keeping** requires position data in order to function.

3.4 Responsiveness

The **Responsiveness** controls can be found in the Assisted **Steering** window pinned to the right side of the screen by default. With the selected functions in **Auto hold**, we can tune the responsiveness of depth, heading, roll, pitch in relation to the current behaviour. The user can make it more conservative or aggressive.

Note: This is an advanced feature.

Figure 73 Responsiveness controls as part of Assisted Steering

3.5 Go to waypoint

The **Waypoint** controls can be found pinned to the right side of the screen by default, underneath the **Assisted Steering** tab.

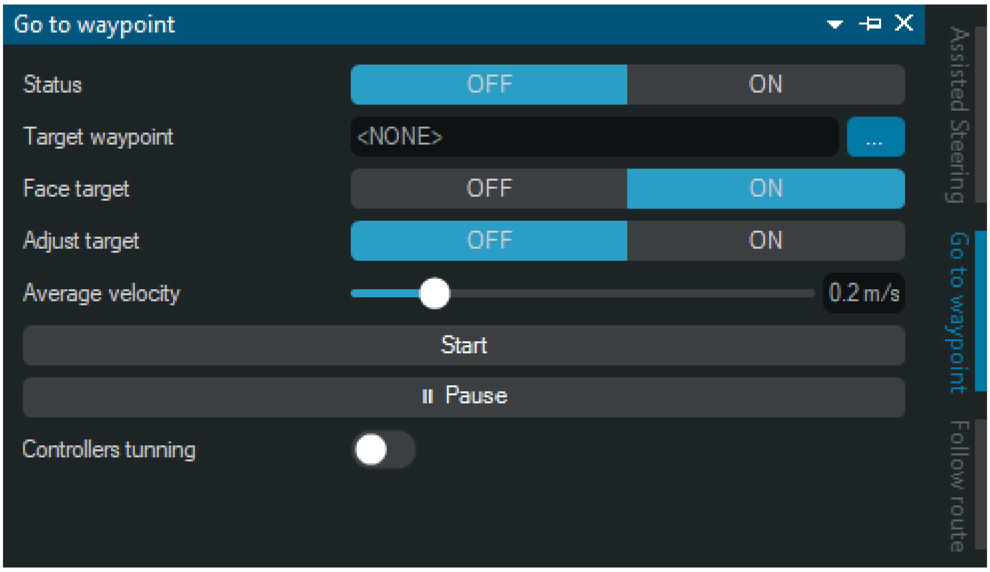


Figure 74 Go to waypoint control window

The user can also right-click on the selected waypoint on the 3D view to go there. This situation is shown below.

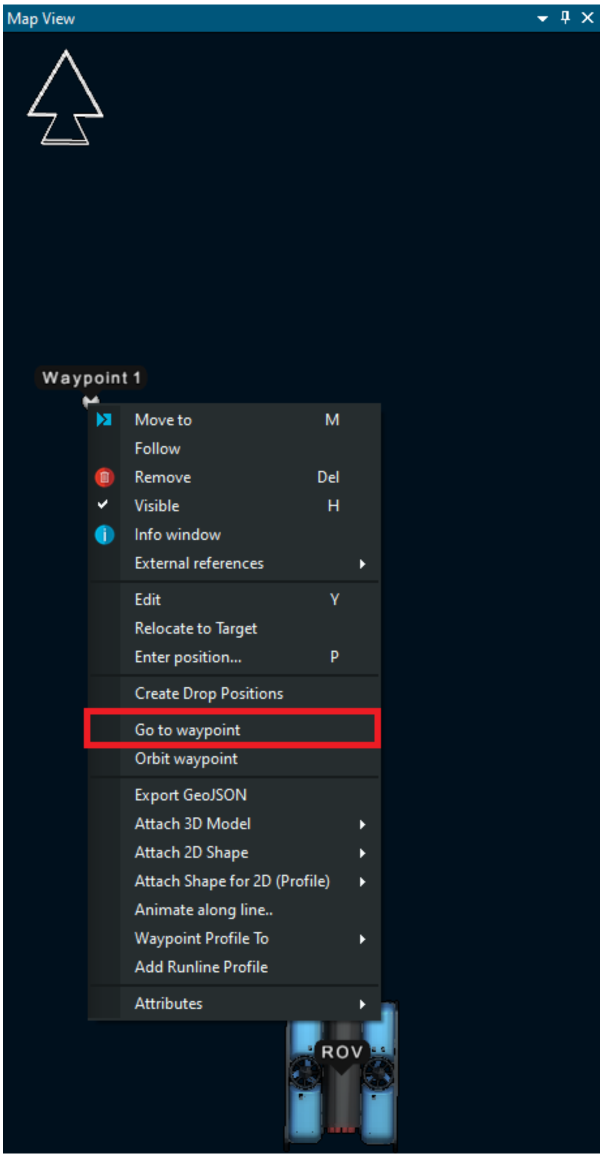


Figure 75 Go to waypoint by right-clicking the mouse on the indicated waypoint

Waypoint control mode always refers to the world or horizon frame. Since world coordinates are involved, the BlueROV2 could be initialised to its current global coordinates using GPS or another available global positioning method. This step allows for navigation using the global coordinates of the desired waypoints.

In the case that the ROV's position is not initialised when the **Go to waypoint** control is toggled *ON*, the initial position of the ROV coordinates will be (0 m,0 m). Consequently, the waypoints' locations should be described in relation to the (0 m, 0 m).

The option **Face target** makes the ROV look at the target waypoint while navigating towards it. If **Adjust target** is selected, the target can be adjusted using the joystick. This means the position of the target can be adjusted live while navigating towards it. The manual change of the ROV position with a joystick, for example, will be reflected in the reference waypoint change on the map. This means that the navigation course can be changed on the fly as well as the position of the waypoint.

Note: Adjust target should be thought of as a supervisory option. If a user notices a drift of the surveying target (like a pipe), this should be able to adjust for without needing to stop, which is very likely to happen, depending on the length of the survey and where the position source comes from.

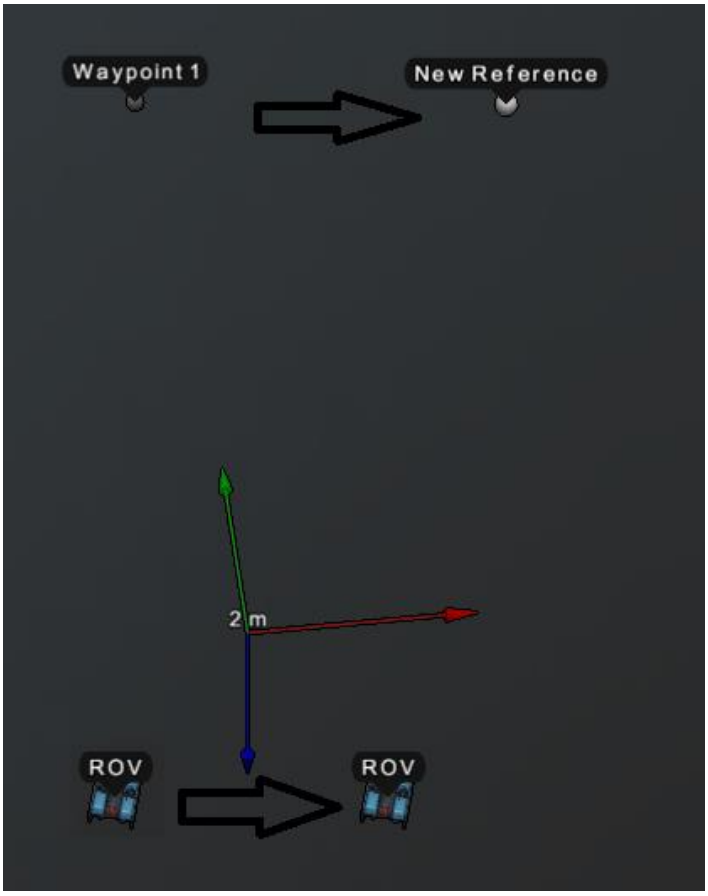


Figure 76 Adjust target in Go to waypoint

The option **Average velocity** uses a slider to set the speed with which the BlueROV2 will approach the target. The speed can be selected before clicking on **Start** and starting the trajectory and can be also adjusted live.

After clicking on the **Pause** button, the BlueROV2 will not move. This is a feature that allows the user to survey an area of interest manually before continuing their go to waypoint trajectory. The user must click Continue for the ROV to navigate to the chosen waypoint.

In **Controllers tuning**, navigation responsiveness can be adjusted between conservative and aggressive. This is an advanced feature.

Note: An example how to use **Go to waypoint** is shown in 7.2 Go to waypoint.

3.6 Follow route

Follow route controls can be found pinned to the right side of the screen by default, under the **Go to waypoint** tab. Using **Assisted Steering** with **Auto hold** allows you to change heading/pitch/roll and depth/altitude while automatically navigating to the specified destination.

In this automatic feature, the selections are like those previously discussed in **Go to waypoint**. We also have the option of **Face target**, if we want to approach it with heading straight ahead, and **Adjust target** when, for example, during the inspection of the pipe the position source may be unreliable and prone to drifting (this is the case if position source is only DVL). When the position drifts it can manually be adjusted live.

While sailing, the **Pause** function can be used. This is indicated on the **Map** view by showing **Station Keeping** under **Follow route** mode.

Figure 77 Follow route tab located on the right side of the screen by default

3.7 Orbit

The **Orbit** controls can be found pinned to the right side of the screen under **Follow route** by default. It is part of the **Auto Steering** window.

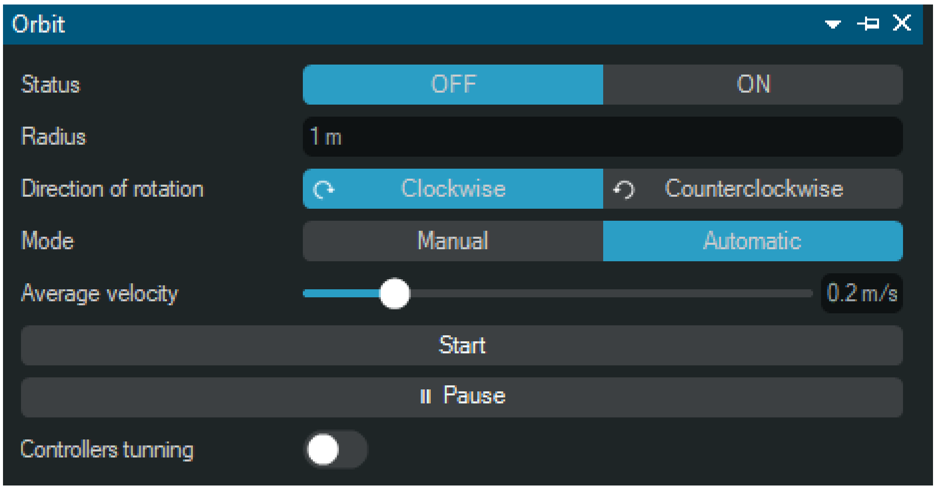


Figure 78 Orbit controls as seen in Automatic Steering

On the previously made waypoint on the 3D view, it is also possible to right-click and choose **Orbit waypoint**. In this case the orbit radius will be the distance the ROV currently has to the selected waypoint that we want to orbit.

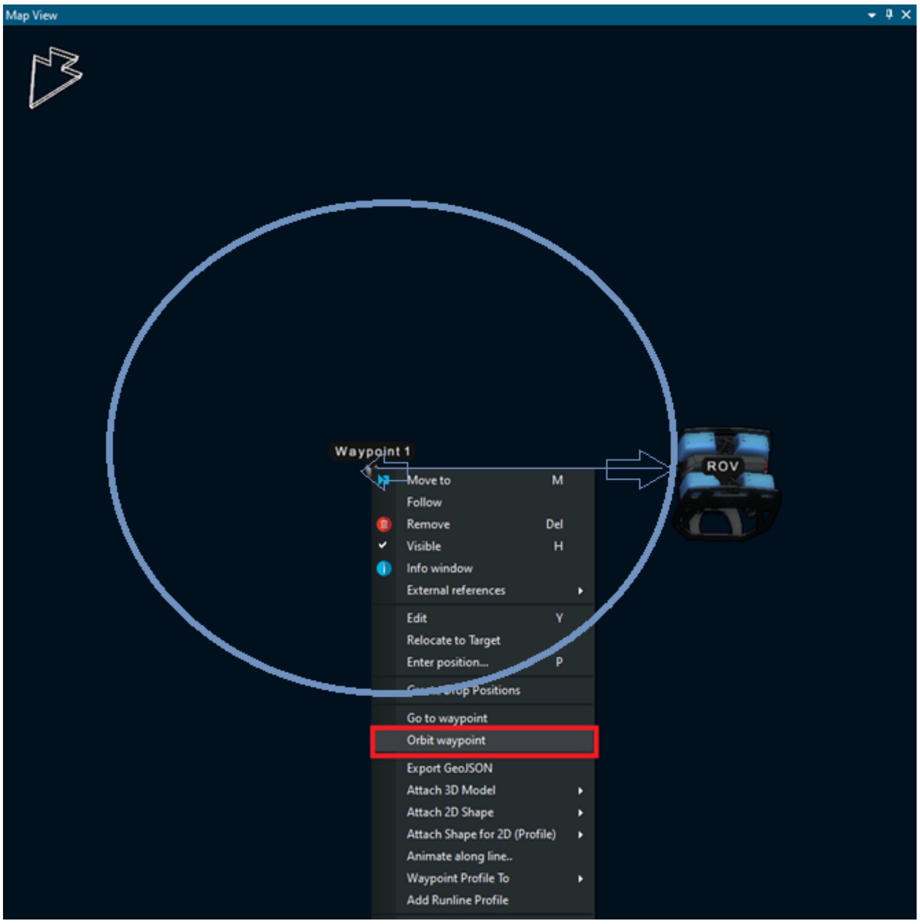


Figure 79 Orbit function can also be accessed by right-clicking on the selected waypoint

The **Orbit control** performs full circles, back and forth, in order to avoid entanglement. When the Orbit controller is toggled *ON*, the ROV is in station keeping mode to avoid entangling the tether.

Pausing the trajectory can be accomplished by pressing the **Pause** button. The ROV will station keep at its current position. When **Continue** is pressed, the orbit will continue from where it was paused. If the user manually inputs the radius, the minimum value is 0 and there is no maximum.

The buttons **Counter-Clockwise** and **Clockwise** refer to the initial rotation direction of the orbital trajectory.

The **Radius** field refers to the distance at which the ROV orbits the point.

There are limits for the extreme values of trajectory **Velocity** and **Radius**. The maximum velocity is also limited by the radius. A smaller radius value will result in lower maximum velocity. For the case of radius, the minimum orbit value is limited to *0.75* m and there is no maximum.

The following scenario exemplifies the use of the **Automatic Orbit** control mode.

3.8 Scan Wall

The **Scan Wall** controls can be found pinned to the right side of the screen under **Orbit** by default.

Figure 80 The scan wall window

The path has a predefined shape, adjustable sizes, and distance from the wall. The ROV follows the path using position source and maintains the distance to the wall using a distance source. Right now, distance source can only be obtained from FLS. The ROV starts scanning from its current position assuming it has the wall in front of it. The ROV station keeps once the scan wall is finished at the end of the path.

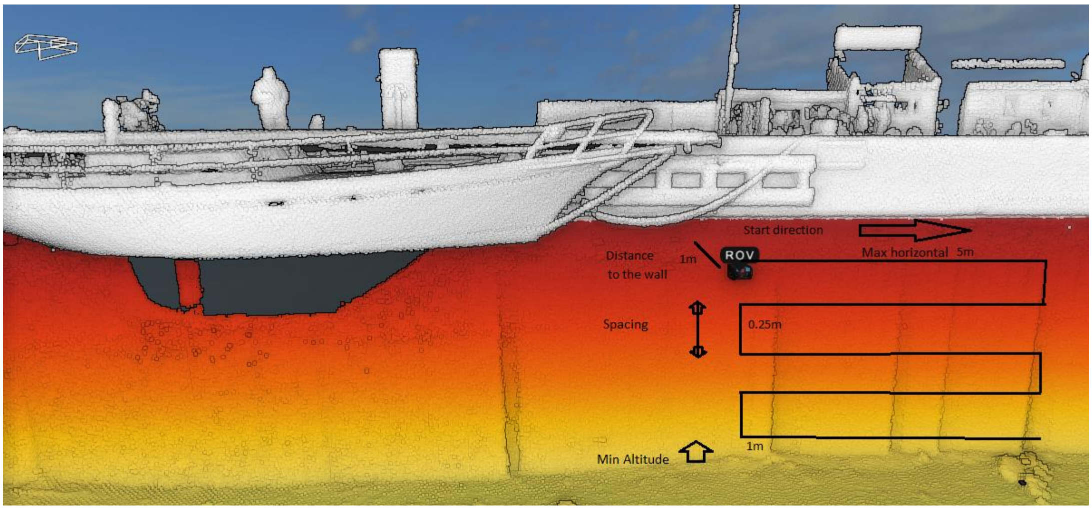


Figure 81 The scan wall visualization

- Set up the desired distance to maintain from the wall. Once the scan wall has started, FLS is used to keep this distance to the wall using FLS wedge.
- **Max horizontal** refers to the total horizontal length.
- **Min Altitude** describes the vertical length.
- **Spacing** refers to the distance between horizontal lines.
- **Start direction** basically describes the direction the horizontal lines will be created in. In other words, it describes on which side of the ROV the trajectory will be created.
- **Velocity** is the speed the ROV will move during Scan Wall.
- If **Heading correction** is on, the ROV will automatically try to point perpendicular to the wall, if not, user will have to do this manually in case of compass drift (which is likely if the compass is magnetic).

Note: If the altitude is available, the ROV will make sure not to hit the ground on the last pass which will alter the created trajectory.

4 Blue Robotics BlueROV2 Utilities

4.1 Utility window

The **Utility** window is pinned to the left side of the screen by default.

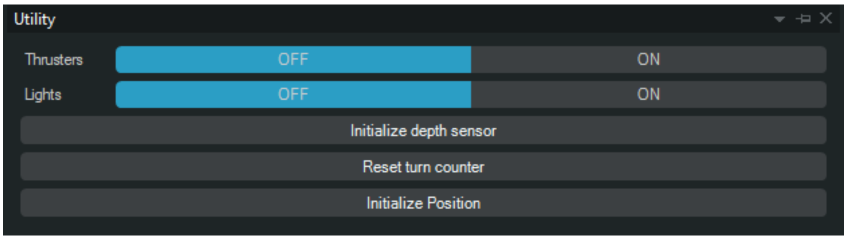


Figure 82 Utility window

The available options are:

- **Thrusters** – can be toggled to arm and disarm the thrusters
- **Lights –** can be toggled to enable and disable the lights
- **Initialize depth sensor**
    - If the depth sensor does not display *0* when on the surface, it should be initialised while at the surface before any controller using depth is engaged
- **Reset turn counter** – sets the new zero-point to the current heading

- **Initialize Position** – initialises the ROV position and gives two options
  - If a positioning device, such as GPS or USBL is present and has been set up using **Surface and Navigation Setup** in NaviSuite Mobula Pro, the initial position will match the values sent from the positioning device
  - If no positioning device is present, or a **Surface and Navigation Setup** project has not been set up, then a new window will pop up, as seen in the following figure. Here, in **Manual mode**, the coordinates can be set using the **Map** or another global positioning method. **Waypoint mode** gives the option to add the position and initialise it as a waypoint on the **Map** view.

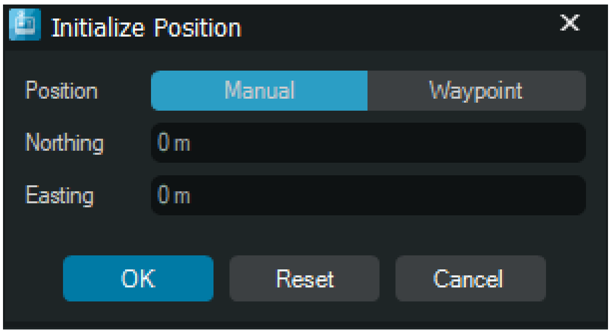


Figure 83 Initialize Position window pop-up

It is no longer possible to initialise a position while being in an automated navigation mode (**Go to waypoint**, **Follow route**, **Orbit, Scan Wall**). If it is attempted, a pop-up window will occur.

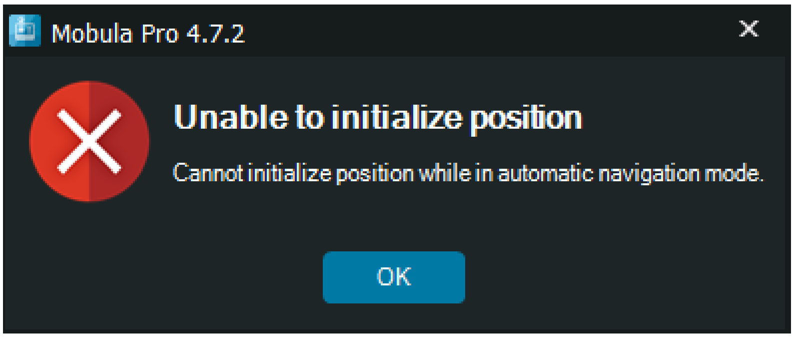


Figure 84 Warning window when trying to initiate position while in an automated navigation mode

4.2 Frame Selection window

The **Frame Selection** window is pinned to the left side of the screen by default. In the figure below, the default configuration is shown: a **Heavy** frame in Blue Robotics BlueROV2 with 8 thrusters. The remaining options are Blue Robotics BlueROV2 **Standard** with 6 thrusters and **Custom** frame.

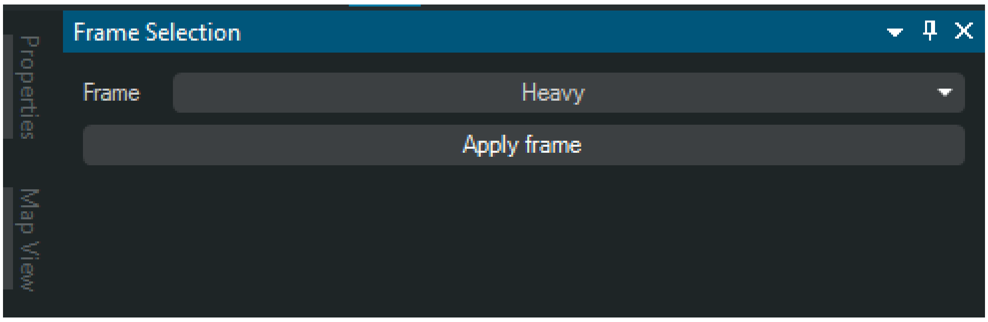


Figure 85 Frame selection window

Custom frames are supported, which can offer flexibility to operate any ROV using NaviSuite Mobula that has been built using the Blue Robotics platform. This is achieved by loading a frame that has been described in an .XML file with the correct format. It is only loaded automatically if it exists in the *C:Eiva/Mobula* folder. Ideally, the thrusters should be of the T200 type.

When the ROV is connected to the operator's computer and the **Custom Frame** option is selected in the **Frame Selection** window, and if the custom_frame.XML file is present in the installation directory *C:\\EIVA\\Mobula\\Mobula* and the frame is changed to **Custom**.

If the custom_frame.XML file is in another location, then a pop-up window is presented. Using the **Browse** button, the user can locate the custom_frame.XML file and load the frame.

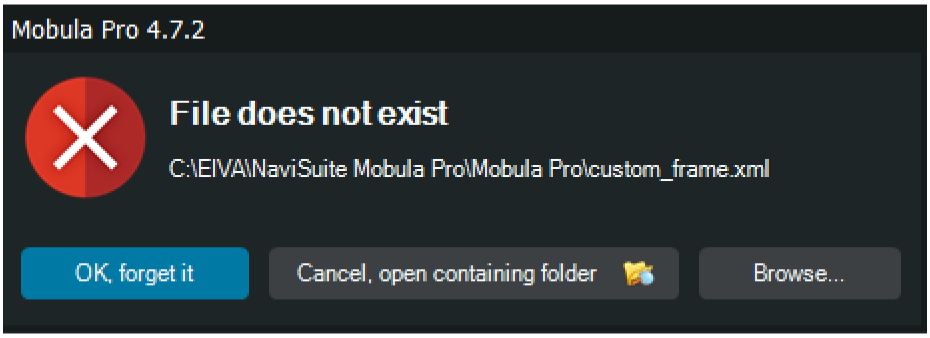


Figure 86 The pop-up window when the file custom_frame.XML is not present in the installation directory

4.2.1 Creating a custom frame XML file

A custom frame refers to the ROV's thruster layout, or their location on the vehicle relative to the centre of mass. For each T200 thruster, and attitude, in degrees, relative to the NED frame of the centre of mass is also needed. The attitude is represented in NaviSuite Mobula as successive rotations, relative always to the centre of mass of the NED frame. Each angle refers to a rotation based on the initial centre of mass of the NED frame.

Moreover, the choice of clockwise or counter-clockwise is required. The last can be changed on the fly inside NaviSuite Mobula and saved alongside the project.

An example of the custom_frame.XML file is shown in the following excerpt, where the template is shown and can be copied to include a different number of thrusters and their configurations.

```
<?xml version="1.0" encoding="UTF-8"?>
<frame>
        <frame_name>Some custom frame</frame_name>

        <motor>
                <unique_id>1</unique_id>            <!--Channel motor is connected to in
Pixhawk. First channel is 1-->
                <direction>cw</direction>           <!--Spin direction of the motor. cw or ccw-->

                <position>
                        <fore>0.156</fore>
                        <starboard>0.111</starboard>
                        <heave_NED>0</heave_NED>
                </position>

                <attitude_euler_angles>
                        <roll_deg>0</roll_deg>
                        <pitch_deg>0</pitch_deg>
                        <yaw_deg>135</yaw_deg>
                </attitude_euler_angles>
        </motor>

</frame>
```

Figure 87 Creating a custom frame XML file

In the proceeding example, the motor with id *1* is located 15.6 cm in the fore direction, 11.1 cm in the starboard direction and 0 cm in the heave direction. Similarly, it is rotated by 135 degrees around the heave axis, following the right-hand rule. If the thruster were vertical it would be rotated by 90 or -90 degrees around the starboard axis, so it would pitch. More motors can be added afterwards, identically to motor 1. The motor *<motor> </motor>* tags should be inside the *<frame> </frame>* tags. An example with two more motors, id *2* and *3*, is shown in the following figure:

```
<motor>
    <unique_id>2</unique_id>
    <direction>cw</direction>

    <position>
        <fore>0.156</fore>
        <starboard>-0.111</starboard>
        <heave_NED>0</heave_NED>
    </position>

    <attitude_euler_angles>
        <roll_deg>0</roll_deg>
        <pitch_deg>0</pitch_deg>
        <yaw_deg>225</yaw_deg>
    </attitude_euler_angles>
</motor>

<motor>
    <unique_id>3</unique_id>
    <direction>cw</direction>

    <position>
        <fore>-0.156</fore>
        <starboard>0.111</starboard>
        <heave_NED>0</heave_NED>
    </position>

    <attitude_euler_angles>
        <roll_deg>0</roll_deg>
        <pitch_deg>0</pitch_deg>
        <yaw_deg>45</yaw_deg>
    </attitude_euler_angles>
</motor>
```

Figure 88 Adding two new motors in the custom_frame.XML file

For detailed description of this feature follow a guide:

NaviSuite Mobula custom frame selection

4.3 Adding camera

The camera feed should be visible from the first launch of NaviSuite Mobula by default. However, if the camera disappears, or is accidentally closed, it can be re-added.

To add a camera, first the **IPCameras** node must be added to the **Project Tree**. This node is the container for all cameras that will be added to this project. To add the **IPCameras** node, right-click on the top node in the **Project Tree**, this will usually be called **Project** or the name of the current project, then select **Enable Camera Manager**.

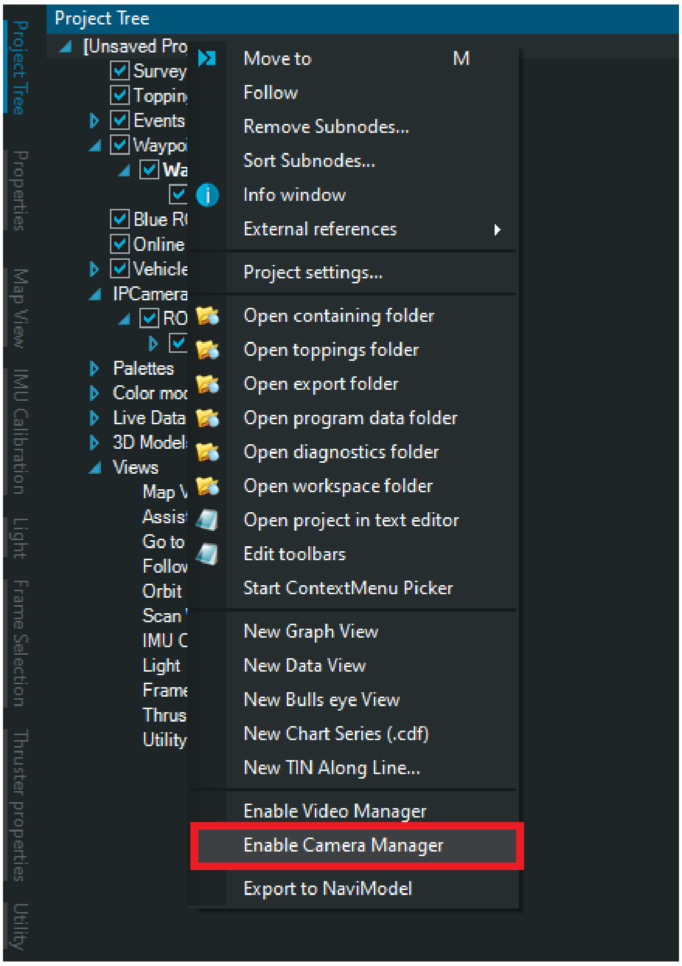


Figure 89 Enable Camera Manager used to add IPCameras node to the project

This will add the **IPCameras** node to the project.

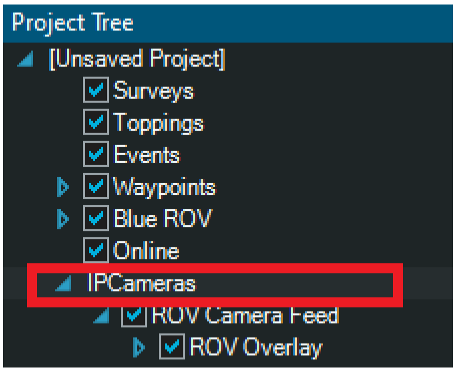


Figure 90 IPCameras node in the Project Tree

Next, add the camera that should display the feed by right-clicking on the **IPCameras** node and select **Add Camera**.

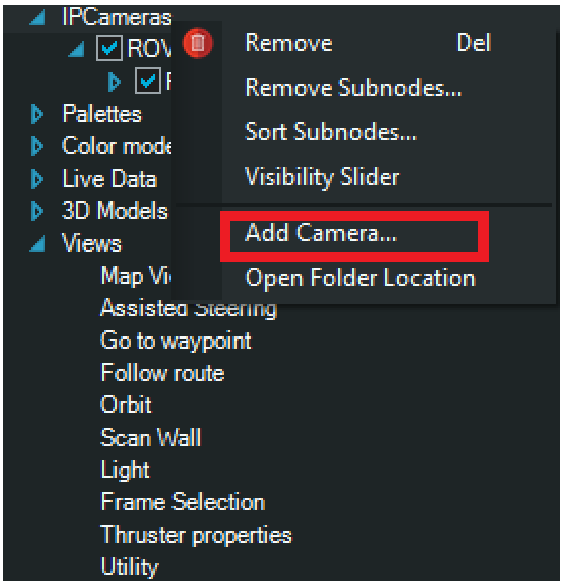


Figure 91 Add Camera under the IPCameras node

This will open a **New Camera** window where different information related to the camera can be entered.

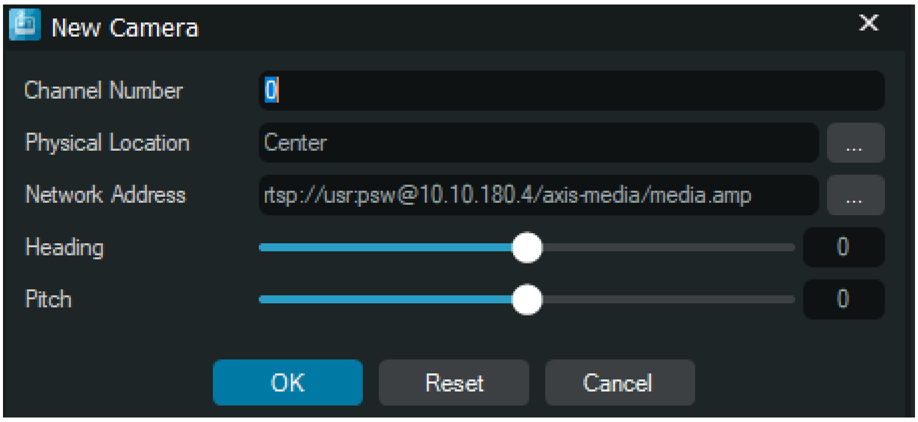


Figure 92 New Camera window

The most important field here is the **Network Address**. The address to the camera should be put here. The name of the camera view will default to what is in the physical location field, so here the user can name the camera view. When clicking **OK**, an attempt to connect to the entered network address will be made, and if successful, the feed will be displayed.

NaviSuite Mobula can also stream from an .SDP file which is used by VLC player. To do this, the user needs to provide the actual path to this file located on disk as a network address.

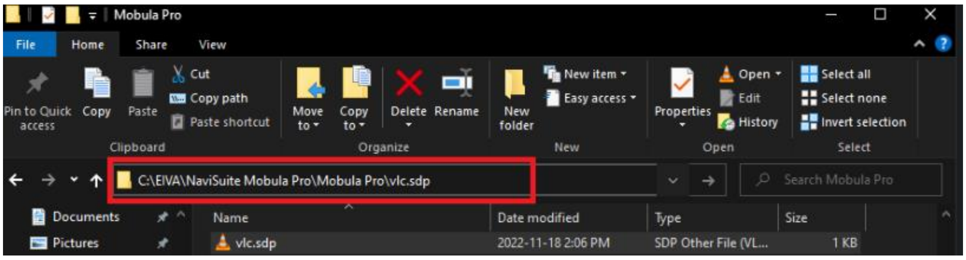


Figure 93 A path to the .SDP file located in the NaviSuite Mobula Pro folder on disk

4.4 Video overlay

There are different kinds of information that can be displayed in the video overlay. By default, on the overlay, the user can find the following:

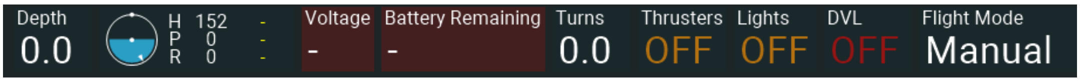


Figure 94 Default overlay diagnostics

- **Depth** shows the depth of the vehicle.
- The attitude of the vehicle is represented by **H** for heading, **P** for pitch, and **R** for roll. The - next to those numbers corresponds to references if any of those are on auto hold.
- **Voltage** is the battery voltage indicator. The Blue Robotics Lithium-ion battery has 14,8 V.
- **Battery Remaining** is the battery remaining indicator.
- **Turns** shows the turns indicator to count the turns.
    - The indicator shows the user how much tether is entangled.
- **Thrusters** refers to the arm state of the thrusters.
    - If it displays *OFF*, it means the thrusters are currently disarmed. When the thrusters are disarmed, no thrust commands will be sent to the ROV. This includes both joystick commands and flight mode commands. The thrusters must be armed before the vehicle can be controlled.
    - **Note**: When vehicle is disarmed, any flight mode that was previously active, will be disabled. So, when vehicle is armed, it will be in manual mode.
- **Lights** indicates whether the lights are enabled. This is like the arm state of the thrusters.
    - If it displays *OFF*, it means the lights are currently disabled. When the lights are disabled, no light commands will be sent to the ROV. The lights must be enabled before the lights can be turned on. Disabling the lights ensures that no power is being consumed by the lights by accident.
- **DVL** indicates whether DVL data is being received.
    - If it displays *OFF*, it means no DVL data is currently being received.
    - When it displays *ON*, it will either be displayed in a green colour, or an orange colour, like the **Thrusters** and **Lights** in the figure above.
    - When DVL *ON* is displayed in orange colours, it means data was received, but it was concluded as being invalid. If the data is invalid, the position flight modes might decide not to use it, and thereby halt their mission until valid data is received.
    - **Note**: If DVL data is being received, but it is invalid, and position flight modes continue to move in XY, it is advised to keep a close eye on the ROV.

4.4.1 Add overlay to video feed

When a camera has been added to the project, an overlay can be added to this camera. Right-click-on the **Camera** node in the **Project Tree** and click **Add screen overlay**.

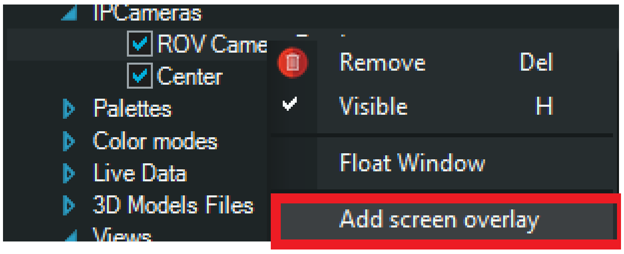


Figure 95 Add screen overlay to camera

This will add an **ROV Overlay** node to the **Project Tree**. This node is the container for all overlay widgets. A widget is a way to display/visualise data.

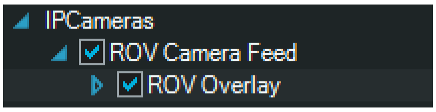


Figure 96 Overlay in the Project Tree

To add a widget, right-click on the **ROV Overlay** and click **Add Widget**. There are multiple widgets to choose from that visualise their chosen value in different ways.

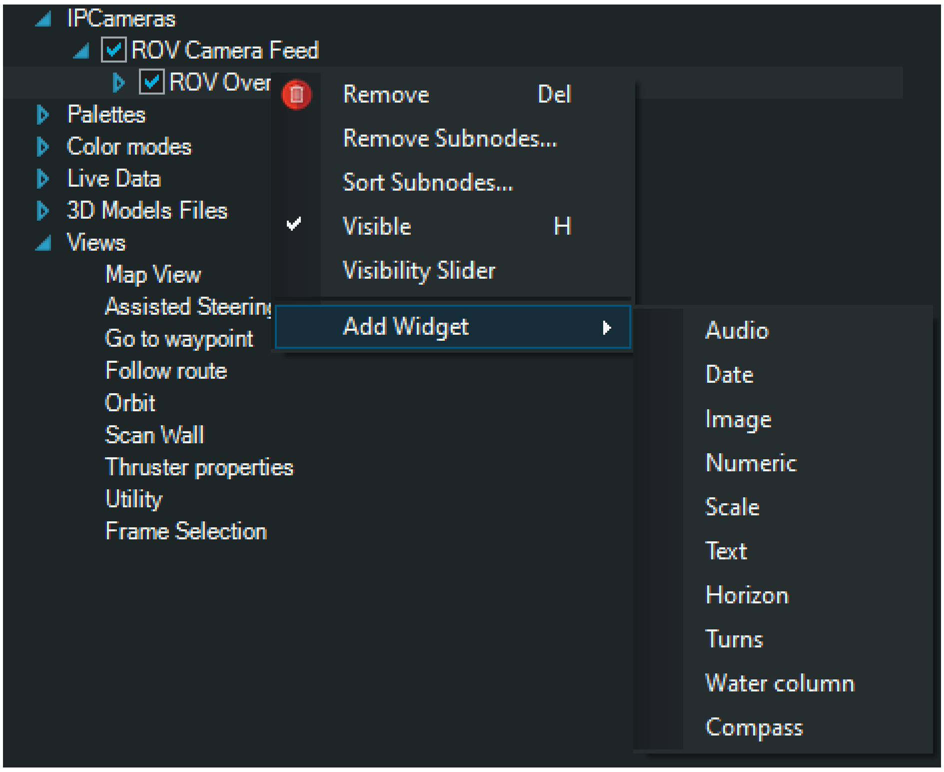


Figure 97 Widget options

When a widget is added, it will create a node in the **Project Tree**.

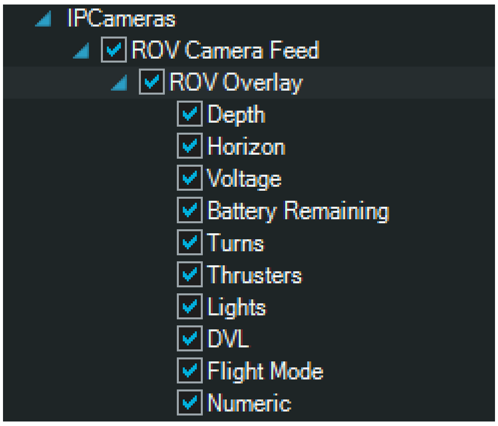


Figure 98 Chosen Numeric widget node in the Project Tree

When selected, the **Properties** view contains the different settings for that specific widget. This includes placement on the camera and more

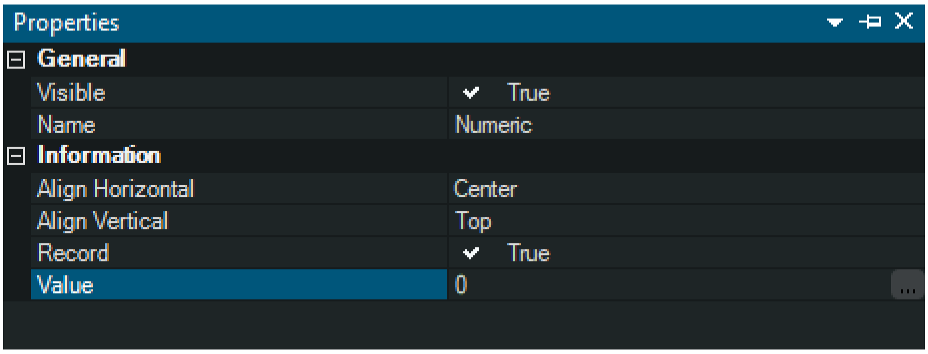


Figure 99 Properties view of Numeric widget

Below is a numeric widget, made to display numbers. In the **Value** field, the user can either enter a static value for the widget to show, or the user can choose from the available live data. Live data, as the name suggests, is data that describes the world as it is seen currently. This includes sensor data from the ROV, such as heading, pitch, roll, but also controller states and more.

Figure 100 Widget Value field, including the list of all available live data options for display

When clicking the **...** button, a list of all available live data will show up. Here the user can select the live data the user wants the widget to display.

Provider	Name	Category	Unit	Package Count
[Unsaved Project]	CPU Usage	System Diagnostics	%	29
[Unsaved Project]	RAM Available	System Diagnostics	MB	29
Joystick	Heave Gain	Joystick		1519
Joystick	Joystick Heave	Joystick		1519
Joystick	Joystick Pitch	Joystick		1519
Joystick	Joystick Roll	Joystick		1519
Joystick	Joystick Surge	Joystick		1519
Joystick	Joystick Sway	Joystick		1519
Joystick	Joystick Yaw	Joystick		1519
Joystick	Pitch Gain	Joystick		1519
Joystick	Roll Gain	Joystick		1519
Joystick	Surge Gain	Joystick		1519
Joystick	Sway Gain	Joystick		1519
Joystick	Universal Gain	Joystick		1519
Joystick	Yaw Gain	Joystick		1519
Simulator	Heave Force	Controller output		1519
Simulator	Pitch Moment	Controller output		1519
Simulator	Roll Moment	Controller output		1519
Simulator	Surge Force	Controller output		1519
Simulator	Sway Force	Controller output		1519
Simulator	Yaw Moment	Controller output		1519
Simulator	Altitude	DVL Data		1519
Simulator	DVL Altitude	DVL Data		1519
Simulator	Easting Dead Reckoning	DVL Data		1519
Simulator	Fore Dead Reckoning	DVL Data		1519
Simulator	Local Easting Dead Reckoning	DVL Data		1519
Simulator	Local Northing Dead Reckoning	DVL Data		1519
Simulator	Northing Dead Reckoning	DVL Data		1519
Simulator	Starboard Dead Reckoning	DVL Data		1519
Simulator	Heading	IMU Data	deg	1519
Simulator	Opposite Heading	IMU Data	deg	1519
Simulator	Pitch	IMU Data	deg	1519
Simulator	Pitch Radians	IMU Data	rad	1519
Simulator	Raw Acceleration X	IMU Data		1519
Simulator	Raw Acceleration Y	IMU Data		1519
Simulator	Raw Acceleration Z	IMU Data		1519
Simulator	Roll	IMU Data	deg	1519
Simulator	Roll Radians	IMU Data	rad	1519
Simulator	Heave input	Joystick Input		1158
Simulator	Pitch input	Joystick Input		1158
Simulator	Roll input	Joystick Input		1158
Simulator	Surge input	Joystick Input		1158
Simulator	Sway input	Joystick Input		1158
Simulator	Yaw input	Joystick Input		1158
Simulator	Altitude Reference	ROV State		1519
Simulator	Depth Reference	ROV State		1519
Simulator	Distance To Target	ROV State		1519
Simulator	Distance Travelled	ROV State		1519
Simulator	Heading Reference	ROV State		1519
Simulator	Pitch Reference	ROV State		1519
Simulator	Roll Reference	ROV State		1519
Simulator	Velocity Reference	ROV State		1519
Simulator	Angle Travelled	Sensor Data	°	1519
Simulator	Depth	Sensor Data	m	1519
Simulator	Distance Front	Sensor Data		1519

Figure 101 Live Data Overview for widget to display

The user can add multiple widgets to the same **ROV Overlay.** All widgets contained within the same **ROV Overlay** share the same overall settings, such as font, size, opacity etc. If different settings for different widgets are needed, a new **ROV Overlay** should be created, and widgets on that **ROV Overlay** should be added.

ROV Overlay and widgets can be removed by right-clicking on them and clicking **Remove**.

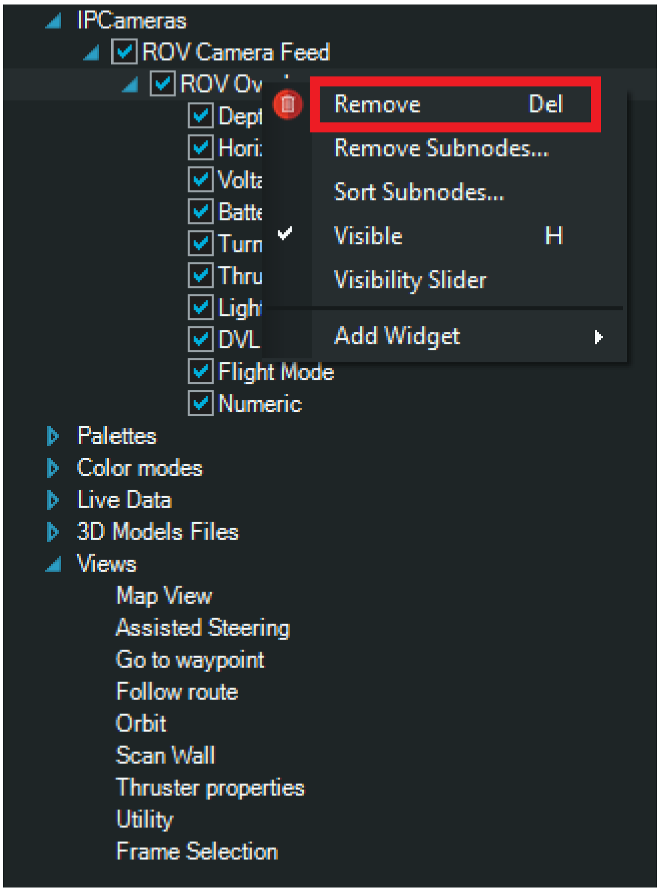


Figure 102 Removing a ROV Overlay

4.5 Dashboards

Dashboards share a lot of similarity with **ROV Overlay**, they are mostly the same thing. However, **Dashboards** cannot be overlayed on camera, instead, they will appear as a separate window.

To create such a **Dashboard**, navigate to the **View** menu and select **New Dashboard**. This will open the live data list, where the user can choose live data to display as numeric widgets.

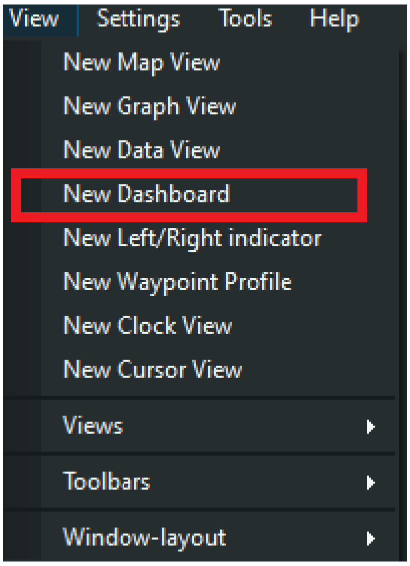


Figure 103 Addition of New Dashboard

Similarly, to the **ROV Overlay**, the user can choose different kinds of widgets to display/visualise the live data in different ways.

4.6 Recording camera feed

There are two ways to start recording the camera feed, all resulting in the same recording. When recording the camera feed, all overlayed data will also be recorded. The overlayed data will be recorded to a separate file, so it is possible to play back the recording with or without the overlayed data.

The user can start/stop recording using the toolbar by clicking the **Record** Button.

Figure 104 Record button – not recording

Figure 105 Record button - recording in progress

Figure 106 Start recording of the camera feed through the Record NaviSuite Mobula toolbar function

Start Recording records:

- **Video feed from ALL cameras** – with the default path *C:\Users\XXX\AppData\Local\Temp\Mobula Pro\ROV Camera Feed*
- **.SBD file** – to be found in *C:\EIVA\naviscan\data*
- **Track** – to be found in C:\ProgramData\EIVA\Mobula Pro
    - example of 3 track files:
        - *20221220T102519_geotrack.MGTR*
        - *20221220T102519_imu.RIMU*
        - *20221220T102519_ngeotrack.MNGTR*

The three track files are always replaced by the next most recent files. Therefore, we encourage copying them from here to have control.

Right-clicking on the camera feed will bring up a menu where it is also possible to start/stop recording.

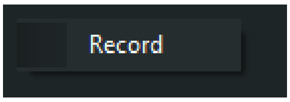


Figure 107 Recording started via camera feed right-click

4.7 Recording live data

All data available as live data can be recorded either to file or forwarded over UDP/TCP. It will be comma-separated.

To record live data, first the **LiveDataLogger** must be created. The **LiveDataLogger** can be created by navigating to the **Tools** menu and selecting **Log live data**. This will create the **LiveDataLogger** node in the **Project Tree**.

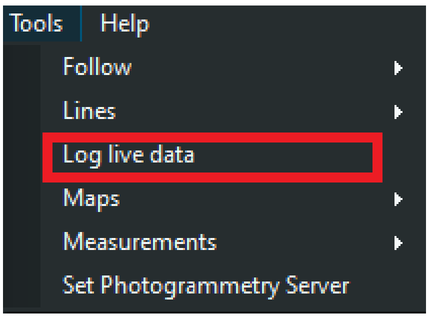


Figure 108 LiveDataLogger node created in Project Tree

To select the live data that should be logged, the user needs to right-click on the **LiveDataLogger** node and click **Select data to log**. This will open a window with all available live data. Select the live data the user wants to log and click **OK**.

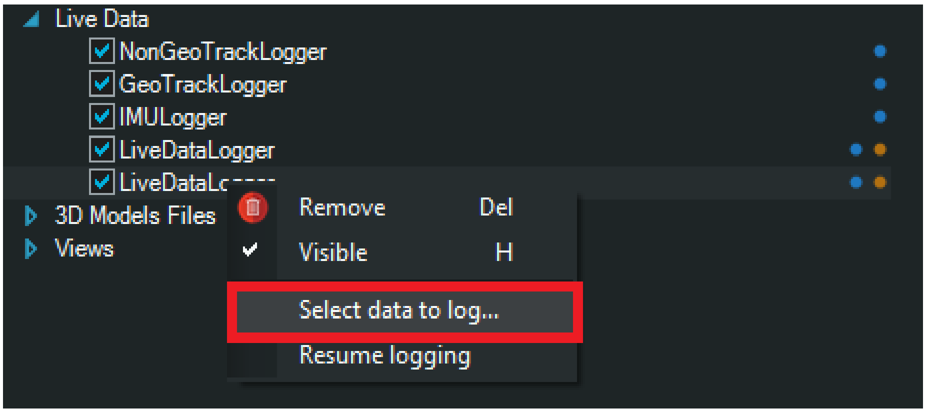


Figure 109 Select live data to be logged

Next, the location to log should be selected, and this will depend on whether the data should be logged to a file or over the network. Go to the **Properties** view while having the **LiveDataLogger** node selected and press the **…** button. This will open a view where the user can select whether to log to file or network and enter the path or IP and port.

Note: If choosing to log to a file, the user should include the file extension .TXT to the file name the user chooses.

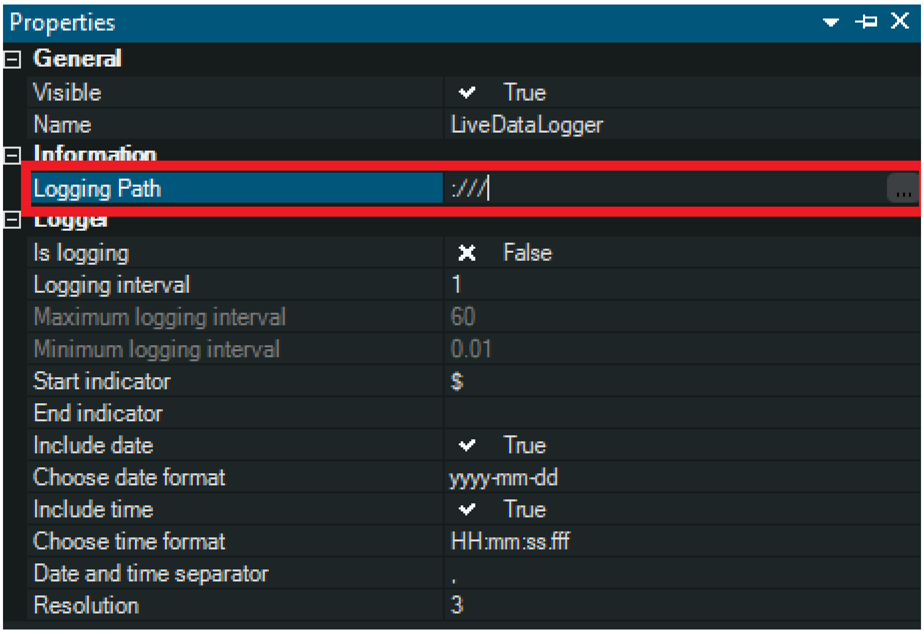


Figure 110 Logging Path selection

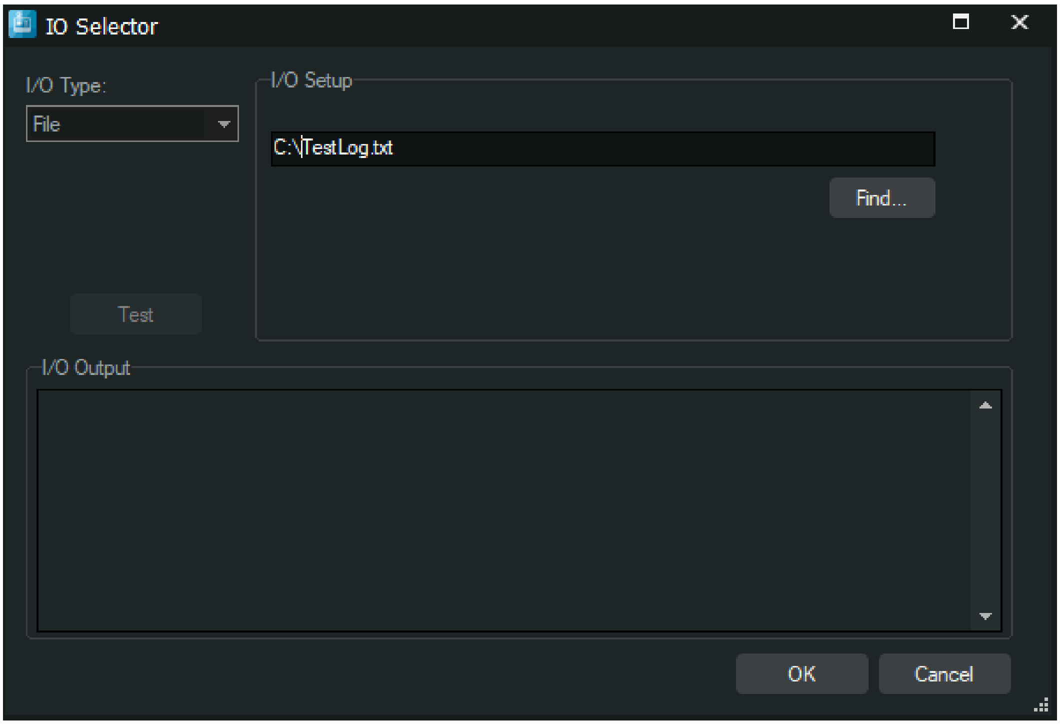


Figure 111 Log to file option

Next, the logging interval should be selected which is how often the data should logged. By default, data is logged once every second. If the interval is *0.1*, data would be logged 10 times a second, and if the interval is *10*, data would logged once every 10 seconds.

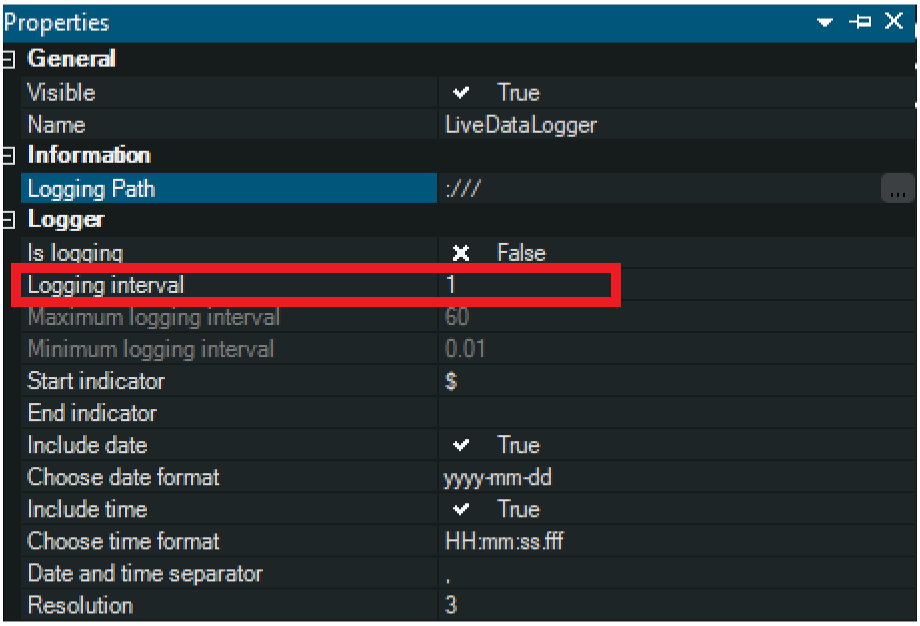


Figure 112 Logging interval setting

Lastly, the logger needs to be started by flipping the **Is Logging** field to *True*.

There are other settings that can be tweaked, such as the number of decimals and whether date and / or time should be included in the logged data. Here is an example of what the data might look like when logged to a file. Here we are logging date, time, and one live data. The file will include a header as well, which depends on the live data and the amount of live data chosen.

```
2021-03-05,16:18:05.671,5.463
2021-03-05,16:18:05.774,40.882
2021-03-05,16:18:05.875,5.913
2021-03-05,16:18:05.976,15.587
2021-03-05,16:18:06.077,5.413
2021-03-05,16:18:06.177,9.332
2021-03-05,16:18:06.278,9.922
2021-03-05,16:18:06.378,10.801
2021-03-05,16:18:06.479,6.661
2021-03-05,16:18:06.580,10.704
2021-03-05,16:18:06.680,7.140
2021-03-05,16:18:06.784,12.929
2021-03-05,16:18:06.884,6.443
2021-03-05,16:18:06.985,5.963
2021-03-05,16:18:07.090,8.543
2021-03-05,16:18:07.191,7.081
2021-03-05,16:18:07.292,12.850
2021-03-05,16:18:07.396,6.790
2021-03-05,16:18:07.496,7.706
```

Figure 113 Example of data logged to file

4.8 Leak detection

When NaviSuite Mobula detects a leak, an **Alarm Window** pops up.

Figure 114 Leak detected warning

5 Eventing feature

The eventing feature, consisting of the **Event Window** and **Eventing Tablet,** is located by default in the bottom left corner of the **Mobula** window.

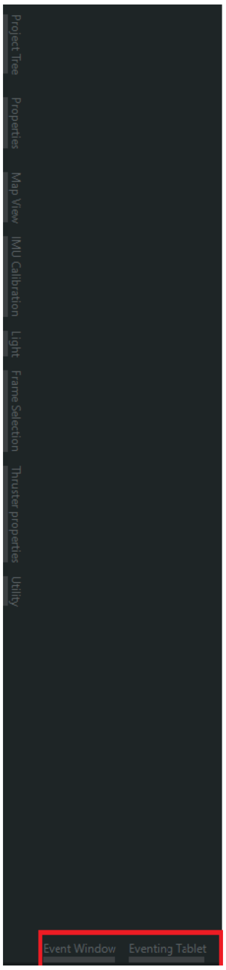


Figure 115 Location of Eventing feature in Mobula.

Event collection, by default, consists of 3 events: **Start Dive**, **End Dive** and **Observation**. In the **Eventing Table**, any of these can be clicked to create an event on the position of the ROV. An overview of all the events that has been created can be seen in the **Event Window**.

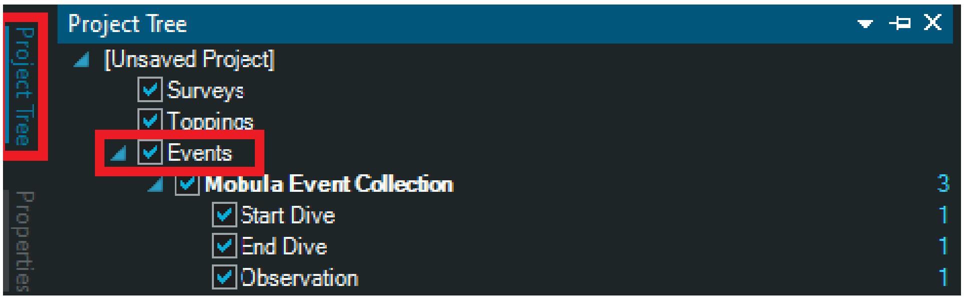


Figure 116 Mobula Event Collection is placed under Events in Project Tree

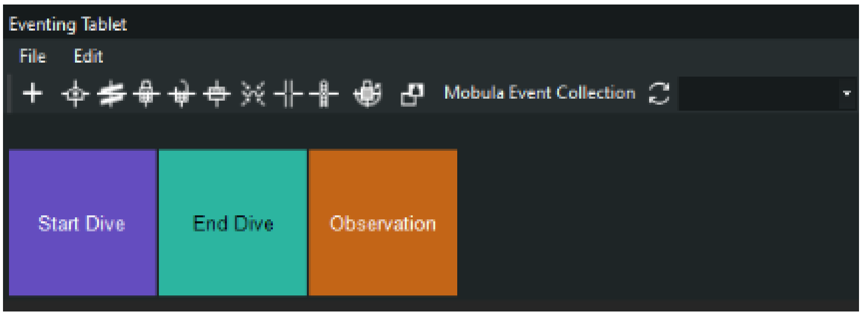


Figure 117 Default Mobula Event Collection with 3 available events.

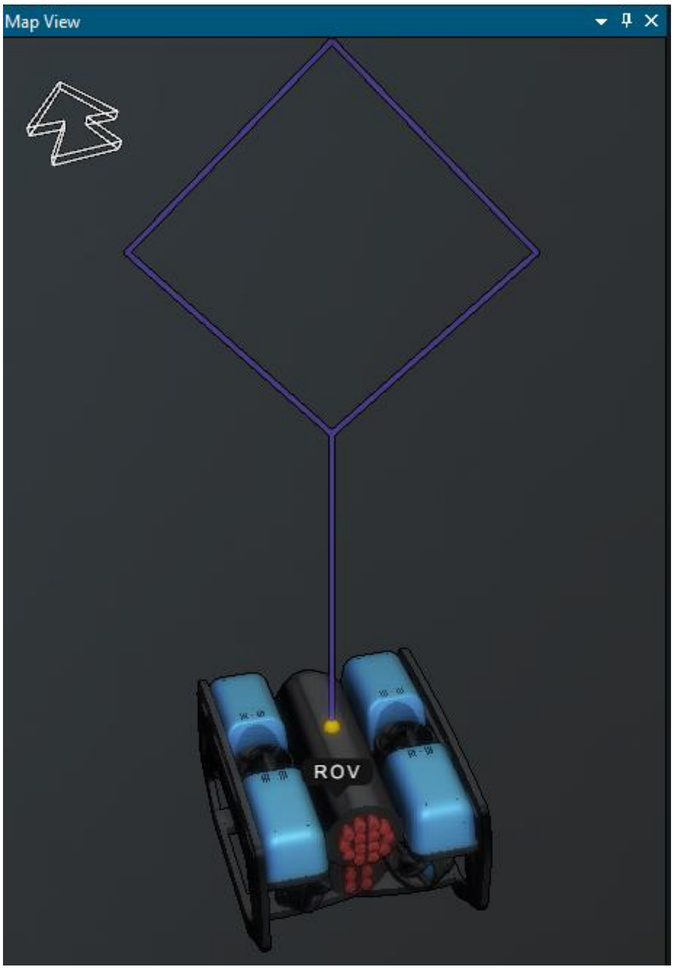


Figure 118 Chosen Start Dive event placed on the ROV position by default.

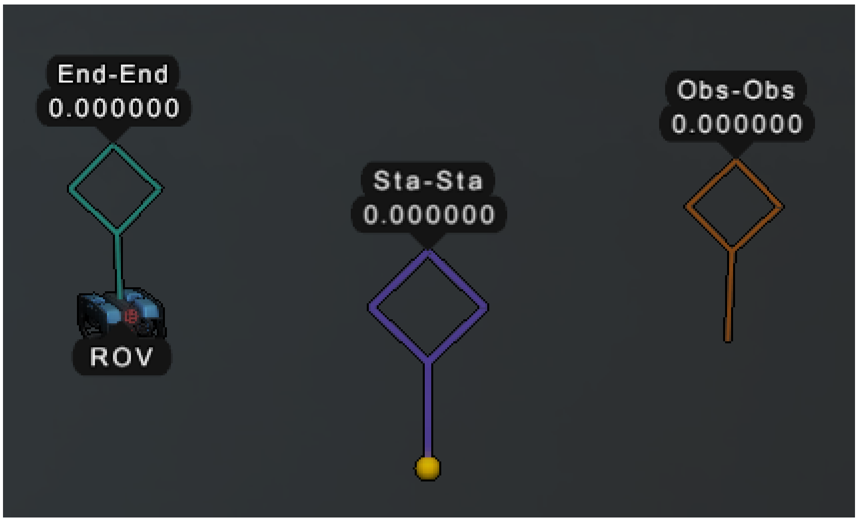
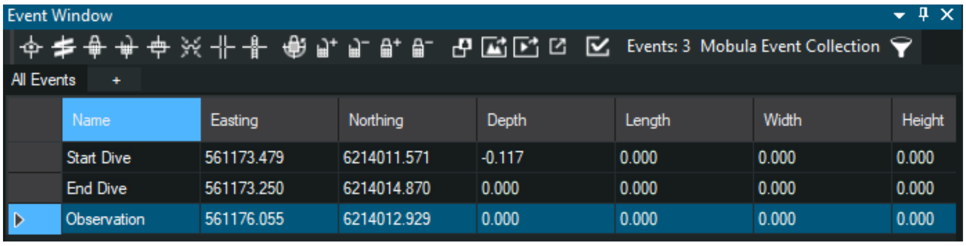


Figure 119 Start Dive, Observation and End Dive placed on the Map View.

The events are created with a position, depth, length, width, time stamp name/type with description.



Name	Easting	Northing	Depth	Length	Width	Height
Start Dive	561173.479	6214011.571	-0.117	0.000	0.000	0.000
End Dive	561173.250	6214014.870	0.000	0.000	0.000	0.000
Observation	561176.055	6214012.929	0.000	0.000	0.000	0.000

Figure 120 The event window is constantly updated with events that the operator enters using Map View and Eventing Tablet.

For a detailed description of eventing follow the guide on how eventing is handled in NaviModel which is part of Data processing software: NaviModel – Eventing

6 Compatibility

Projects made in NaviSuite Mobula 4.7.2 cannot be used in NaviSuite Mobula 4.7.1A or earlier.

7 Automated navigation - examples

7.1 Initialising position

It is possible to initialise position if no GPS or any position source is available in NaviSuite Mobula.

There are two ways to enter the ROV´s initial position and waypoint coordinates when this is required, designated by the options **Waypoint** and **Manual**.

- When the option **Waypoint** is selected, the position of the ROV will be initialised to the position of the waypoint.
- When the option **Manual** is selected, the position of the ROV will be initialised to the northing and easting entered otherwise the position is initialised to a waypoint already created on the **Map** that can be selected from the **Waypoint** option.

Below are the steps we recommend for this:

- The **Map View** will be used in this example to showcase how to use an automated navigation

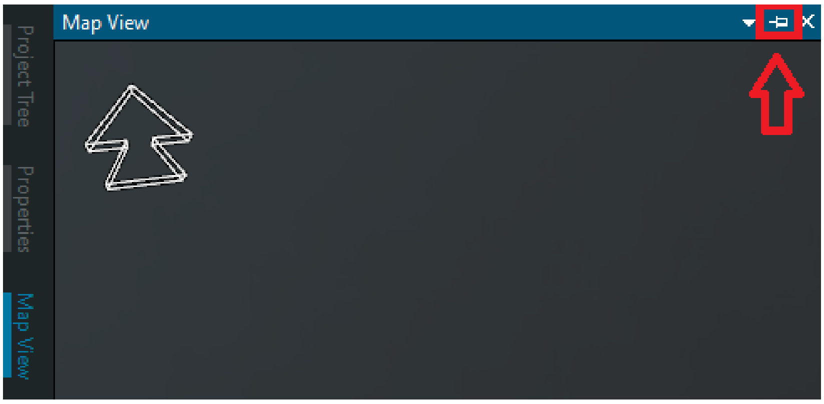


Figure 121 Unpinned Map view

This is achieved by clicking on **Map View** on the left side of the screen and then on the **Pin** icon illustrated in the preceding figure.

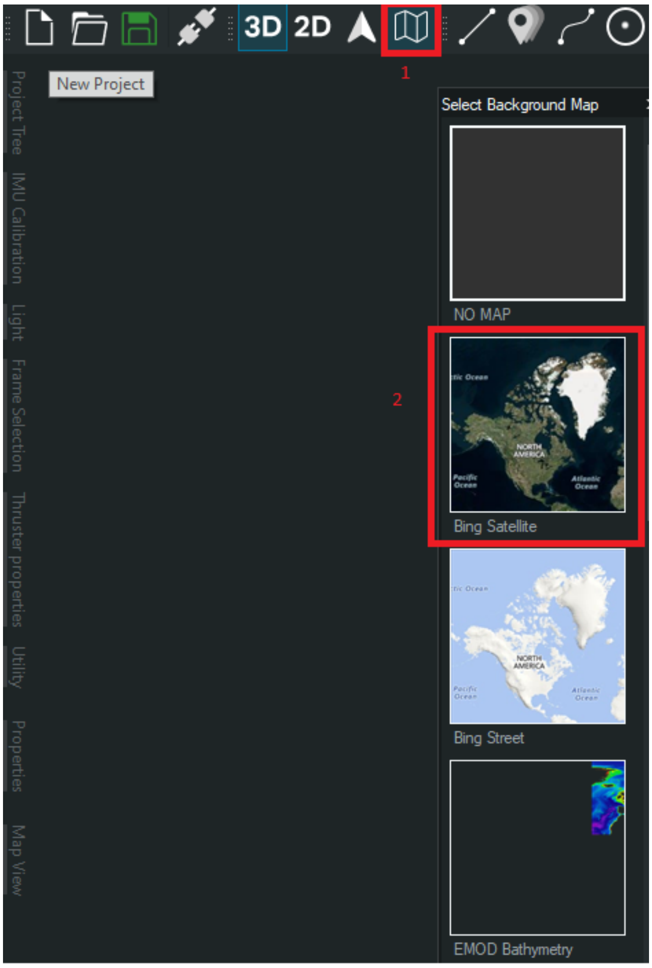


Figure 122 Accessing Background Maps and choosing the desired one

- Since there is no accurate positioning measurement available in this example, the user must localise the initial position of the ROV using global coordinates. This can be achieved by using smartphone GPS coordinates and then inferring the ROV position using intuition and relative accuracy. It can also be achieved by using the integrated maps.
    - This is especially useful if the user or the ROV can have their position pinpointed on the map using some landmark. Again, the accuracy is not comparable to a dedicated positioning sensor.
    - First, click on the **Select Background Maps** icon, highlighted by the red square marked *1* in the preceding figure. Select and double click on the desired map. An example here is shown with the red square marked *2*. The **Select Background Map** window can now be closed.

- Coordinates on the map. Used for **Manual** coordinates input.
  - After the map has been selected, the user can zoom using the mouse scroll wheel and navigate to the current position using the W, A, S, D keys of the keyboard or by double-clicking on the map. If the user decides that the coordinates of the initial point are accurate enough, the coordinates information is available in the bottom right of the **Map View**.

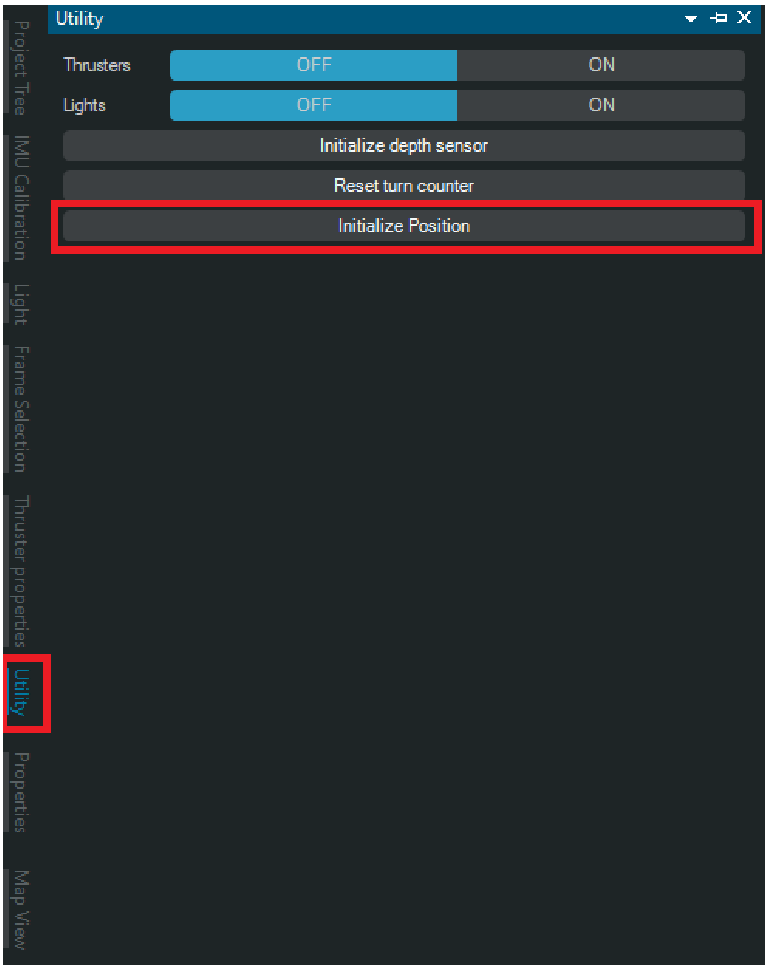


Figure 123 Initialize Position can be found in Utility on the left size

- The coordinates, in Easting-Northing format, are marked by the red square, as can be seen from the enhanced part of the figure:

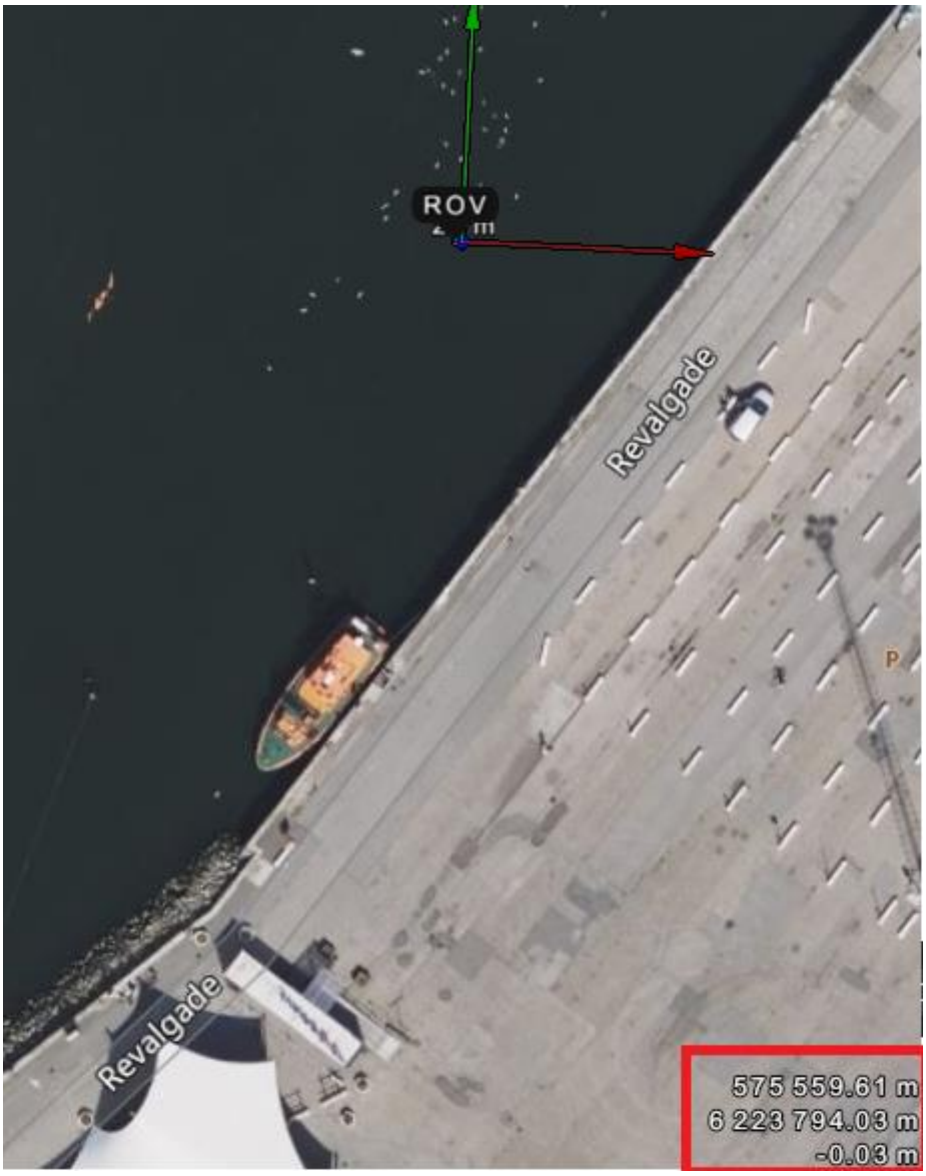


Figure 124 Location of coordinate data in Map View

In the **Waypoint control** field, in the **Utility** window we manually initialise position, as indicated in the Figure 97.

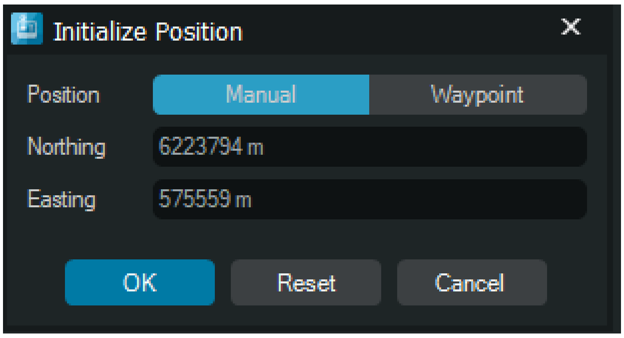


Figure 125 Manual waypoint initialisation

7.2 Go to waypoint

7.2.1 Waypoint coordinates.

It is much easier to initialise the ROV and give targets as waypoints. In this example, two waypoints will be created, one named **Home** used in the initialisation of the ROV mentioned in the beginning of the chapter 6 and one named **Target** that will be the target waypoint for the ROV to navigate to.

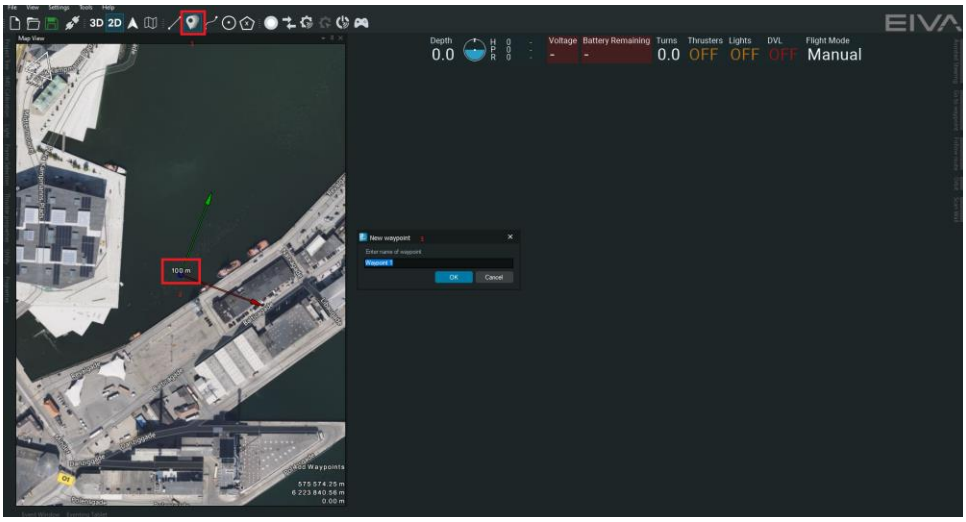


Figure 126 Waypoint creation overview

1. Click on the **New Waypoints** icon, indicated by red square marked *1*, highlighted in the enhanced figure.

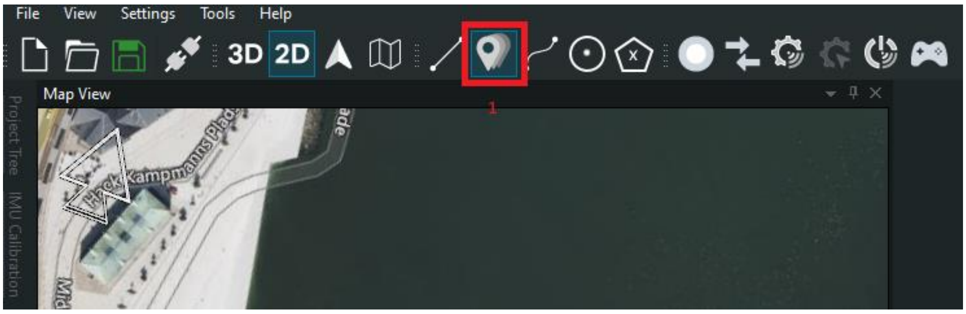


Figure 127 New waypoint creation – Waypoint icon on the toolbar

2. Click on the estimated initial ROV position, near the centre of the reference frame, highlighted by the red square 2 in the Map View of the overview figure.

Figure 128 New waypoint creation – left-click to put the waypoint in the red box area

3. Rename the waypoint *Home*, in order to make it easier to distinguish and use, in the window marked *3*, illustrated in the enhanced figure:

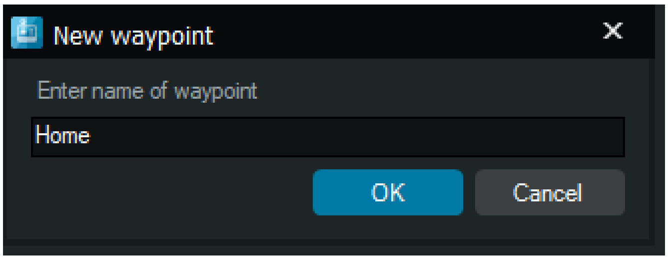


Figure 129 Rename waypoint for ease of use

This procedure will result in the following **Map View**:

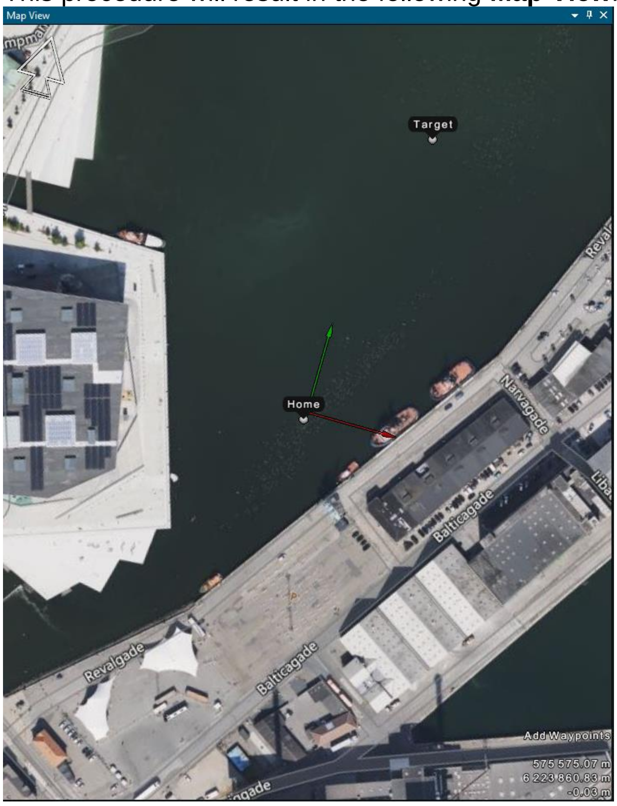


Figure 130 Map View as a result of origin and target waypoint creation

Note: More target waypoints can be added and given more descriptive names.

4. In the **Go to waypoint** control window, choose **Target waypoint** and select an object to which we are to go. In our case it will be object **Target**.

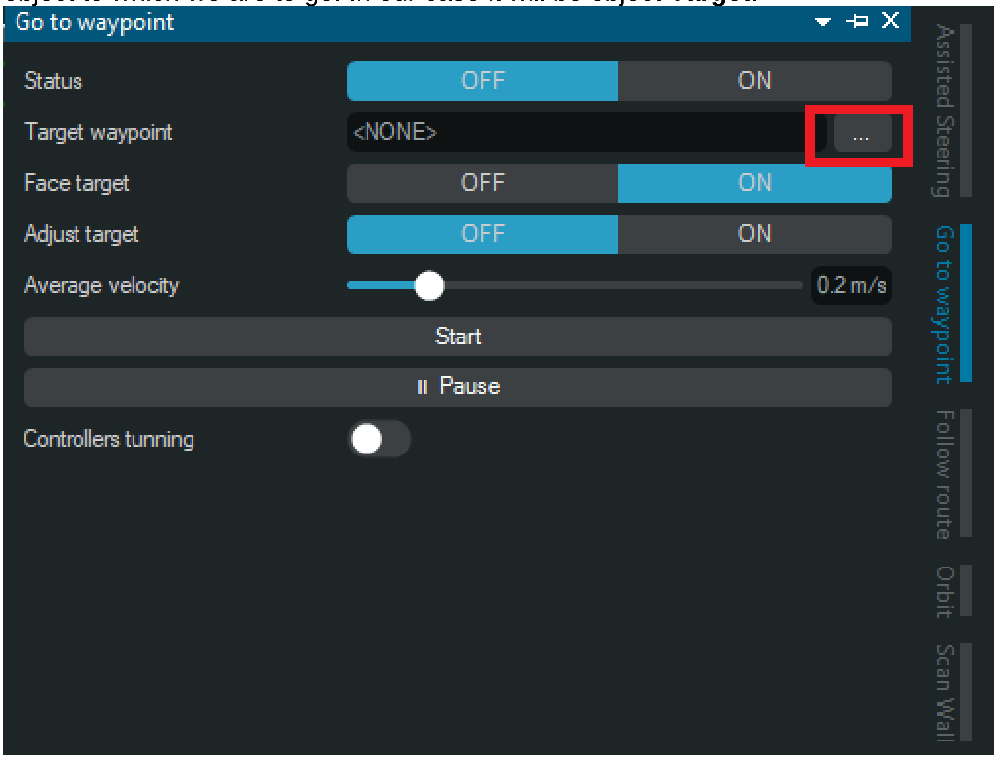


Figure 131 Choose a waypoint as a target

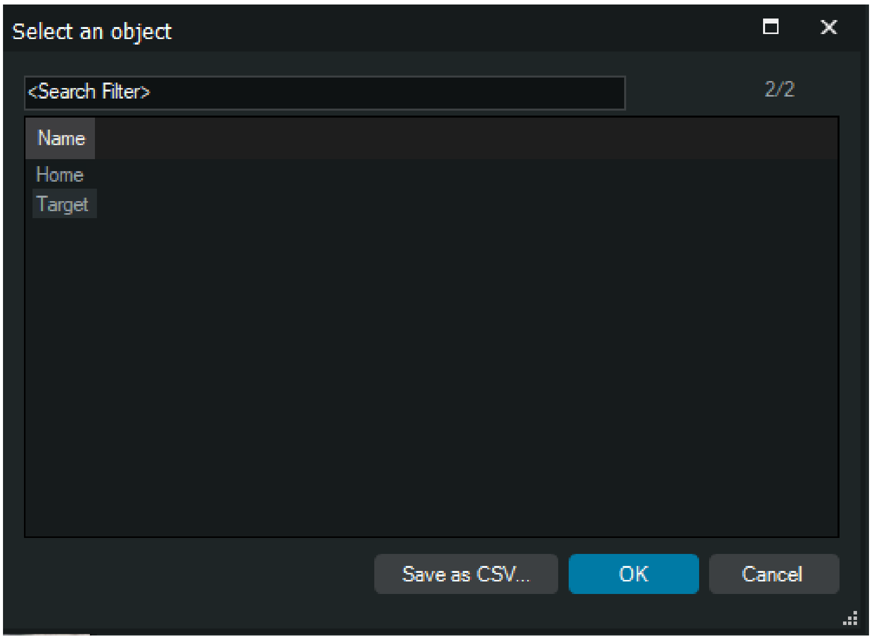


Figure 132 Select an object from to be our target

While navigating, the user can interact with assisted steering controllers freely – changing roll, pitch, heading (if face target is not selected), depth or altitude.

Figure 133 Blue Robotics BlueROV2 faced to Target waypoint

7.3 Follow Route example

7.3.1 Straight runline

1. After initialising the ROV position as a waypoint or from coordinates, create the runline the user wants to sail.

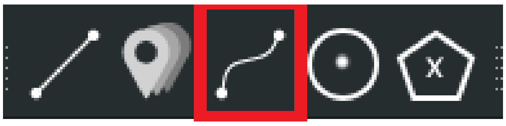


Figure 134 Create toolbar with marked Create Runline

Left-click where the user wants to start. If the user wants it to be a straight line change the radius to 0 then double-click where the user wants to end with the left mouse button. This procedure will result in the following **Map View**:

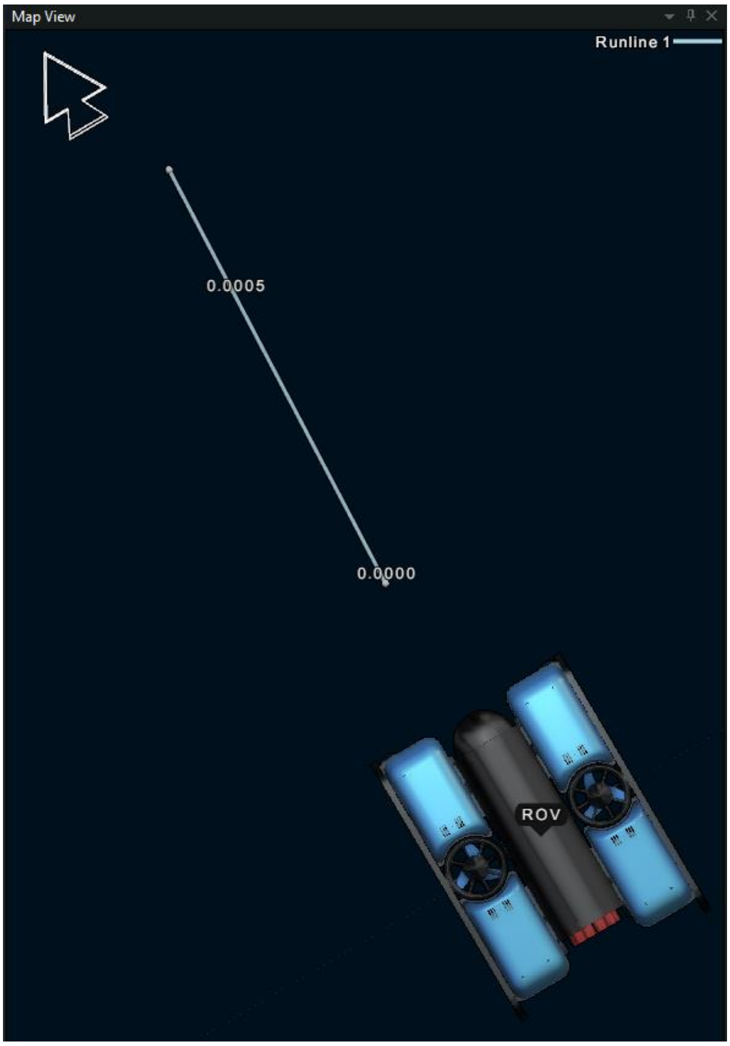


Figure 135 Created straight runline

2. Select the created straight Runline 1 in the **Select route** from the **Follow route** tab. Set the status to *ON* and click **Start** to begin the Follow route.

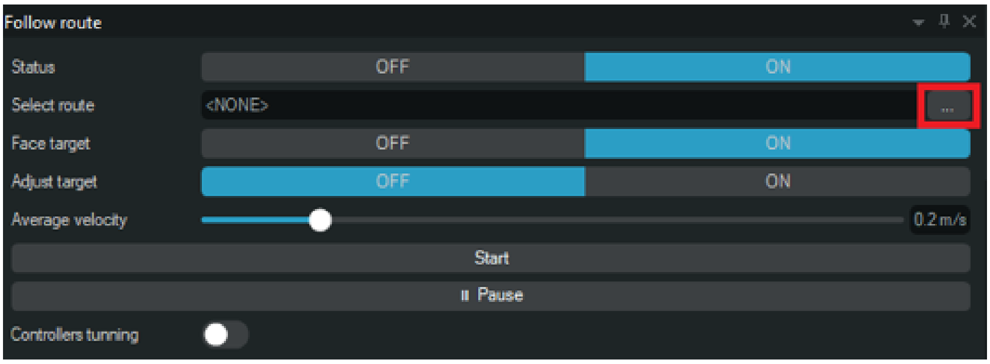


Figure 136 Select the created Runline 1

After completing the task, the ROV stops at the end of the line.

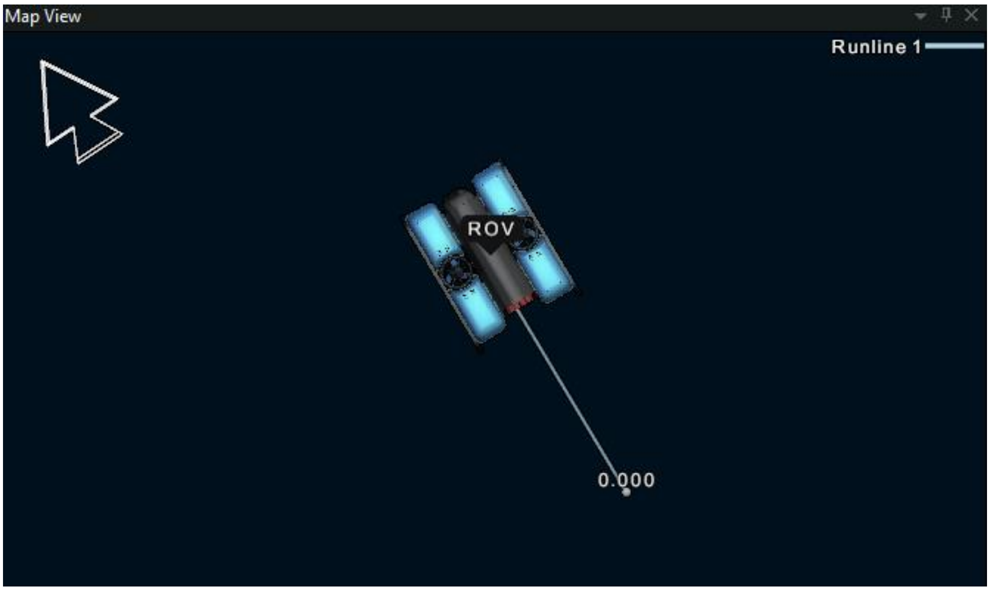


Figure 137 Follow route completed

7.3.2 S shaped runline with adjust target function

After initialising the ROV position as a waypoint or from coordinates, create the S shaped runline the user wants to sail.

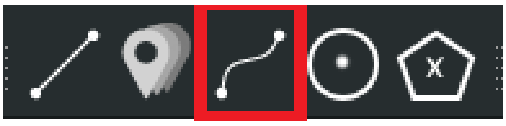


Figure 138 Create toolbar with marked Create Runline

Left-click where the user wants to start. If the user wants it to be a S shaped runline change the radius to, for example, -5, then make some segments and double click where the user wants to end with the left mouse button. This procedure will result in the following **Map View**.

Figure 139 Created S-shaped runline

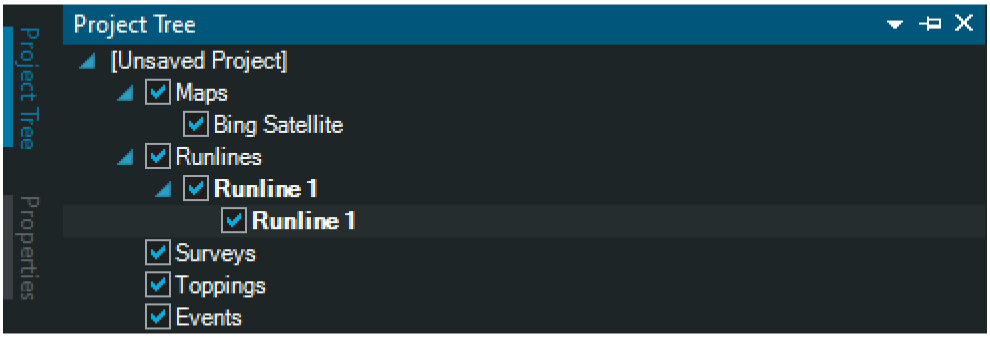


Figure 140 Visible S-shaped runline made in Project tree under Runline

There is a visible change in the depth at which the ROV is at 1.5m of depth during the Follow Route task. The ROV is currently in Station Keeping under Follow Route mode.

Figure 141 Mileage with visible survey S shaped runline, on the right side pinned the Assisted Steering and Follow Route tabs used together.

The Adjust target function can be very helpful when, for example, we inspect a pipe and when it turns out on site that it is shifted by a certain distance. We can adjust for this on the spot. When using a joystick, we moved the entire S-shaped runline by a certain distance as shown in figures 111 and 112.

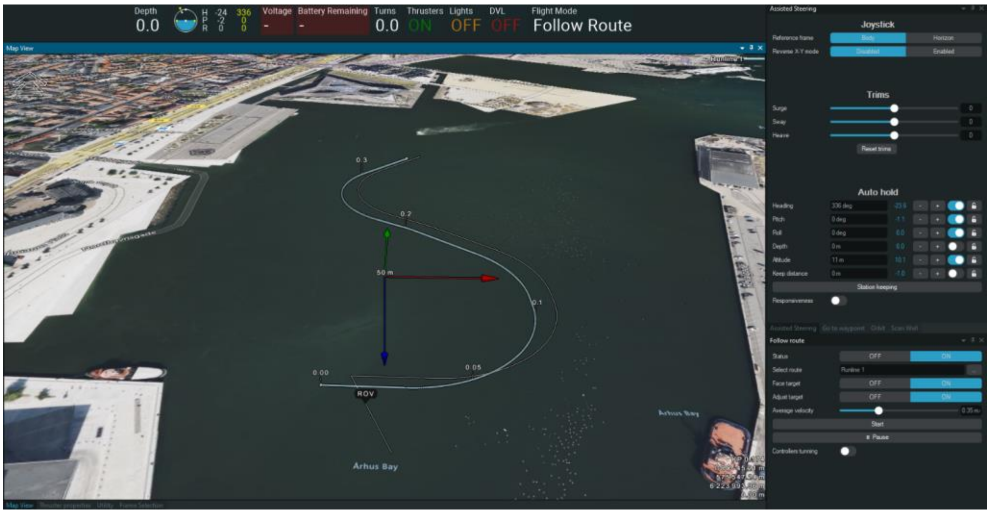


Figure 142 Adjust target function shown in practice.

Figure 143 Km remains the same, only the trajectory of the movement changes by the shift made by the joystick.

Adjust target creates a new line which is visible as a digitized line in the **Project tree**.

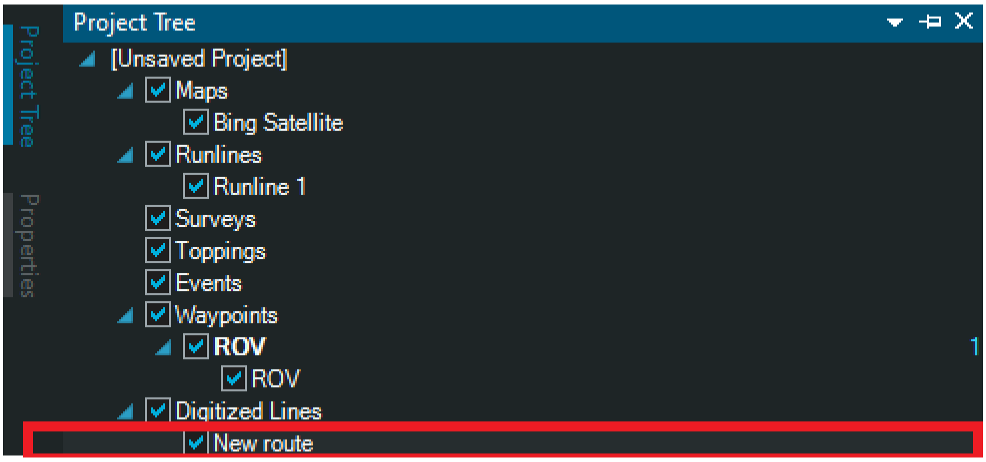


Figure 144 New route after Adjust target made in Follow route

7.3.3 Lawn Mower Pattern

The ROV route can be automatically created before a survey, based on a boundary. The operator can design the lawn mower type pattern depending on the desired spacing and orientation. It is also possible to create an exclusion zone within the boundary.

1. Create a boundary using **New Digitised Line**

Figure 145 New Digitised Line as part of the Create Toolbar

2. Right-click on the created boundary, go to **Line** and then to **Create Lawn Mower Pattern**.

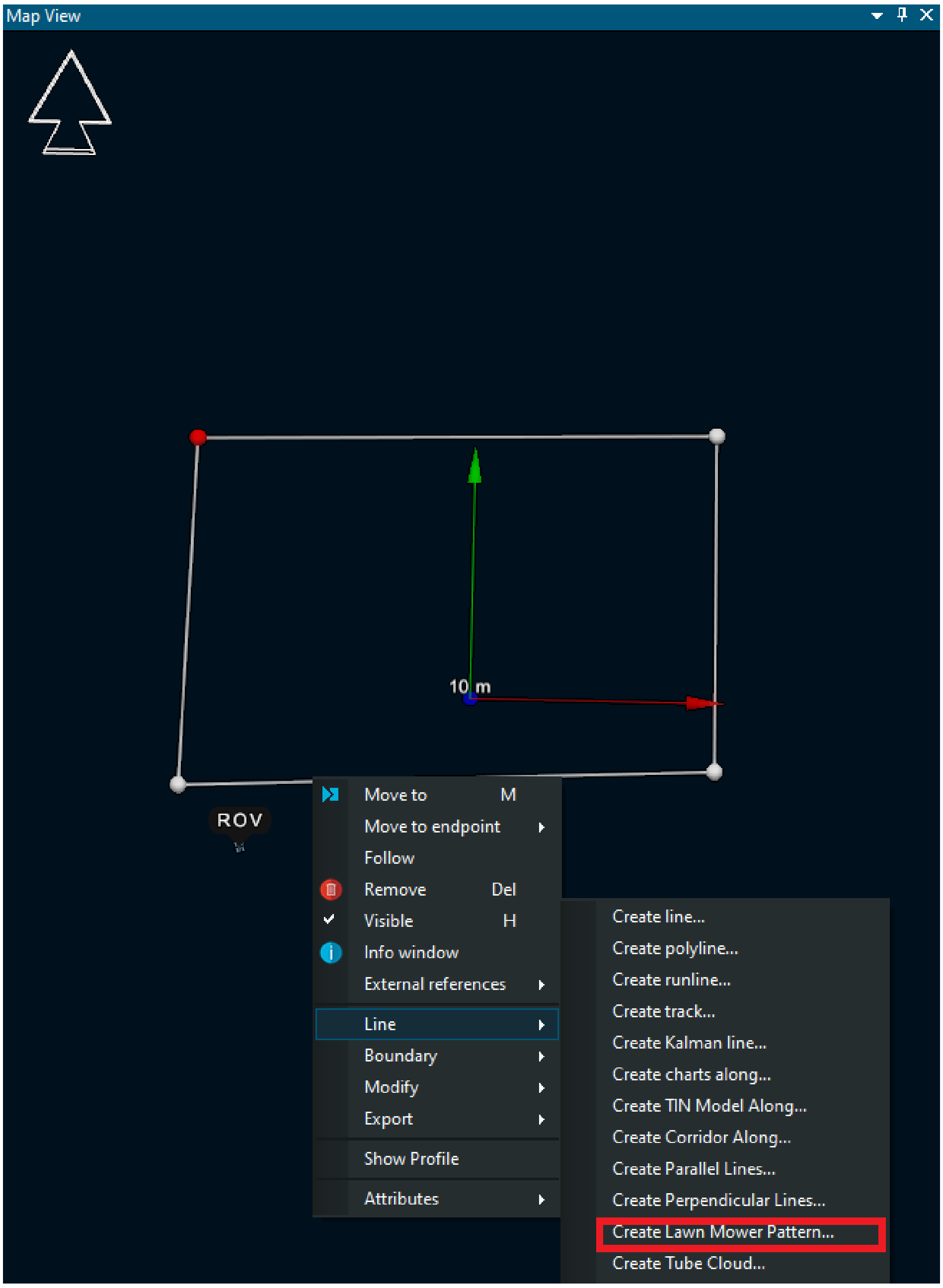


Figure 146 Create Lawn Mower Pattern option

3. Choose the boundary line, adjust **Distance Between Lines**, **Angle**, how the turns happen by setting **Turn radius** and toggling **Turn inside** to enable turns inside or outside boundary. The operator can also add exclusion zones.

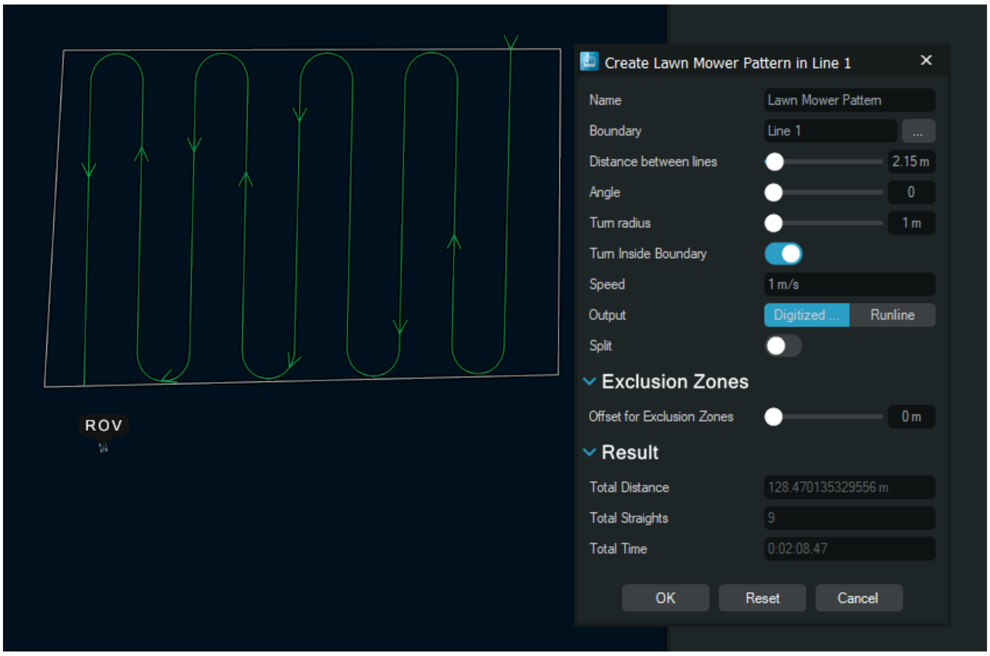


Figure 147 Lawn Mower Pattern is set up

As a result, we will get a summary with the total distance, total straights and total time based on a speed we indicated before.

4. Now we are ready to go to the **Follow route** tab on the right side of the window and select **Lawn Mower Pattern** route.

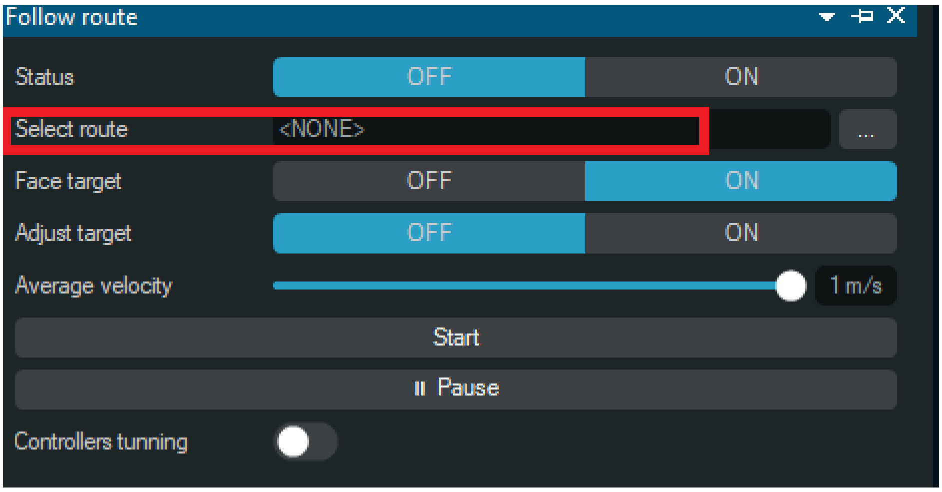


Figure 148 Follow route tab

In **Face target**, we can decide if we want to face the target by selecting *ON* and click **Start** when ready.

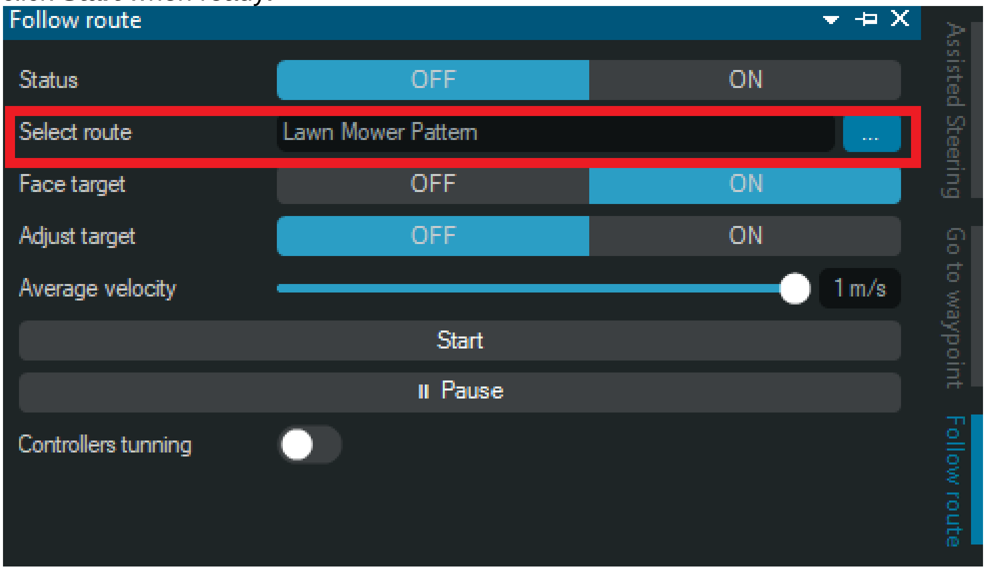


Figure 149 Follow route tab with chosen Lawn Mower Pattern

7.4 Orbit

7.4.1 Automatic orbit control

1. Create a waypoint
    - As shown in the section 7.2 Go to waypoint
2. Select the waypoint you wish to orbit around
3. Right-click on the waypoint on the **Map View**
4. Select **Orbit waypoint** from the list to begin orbiting

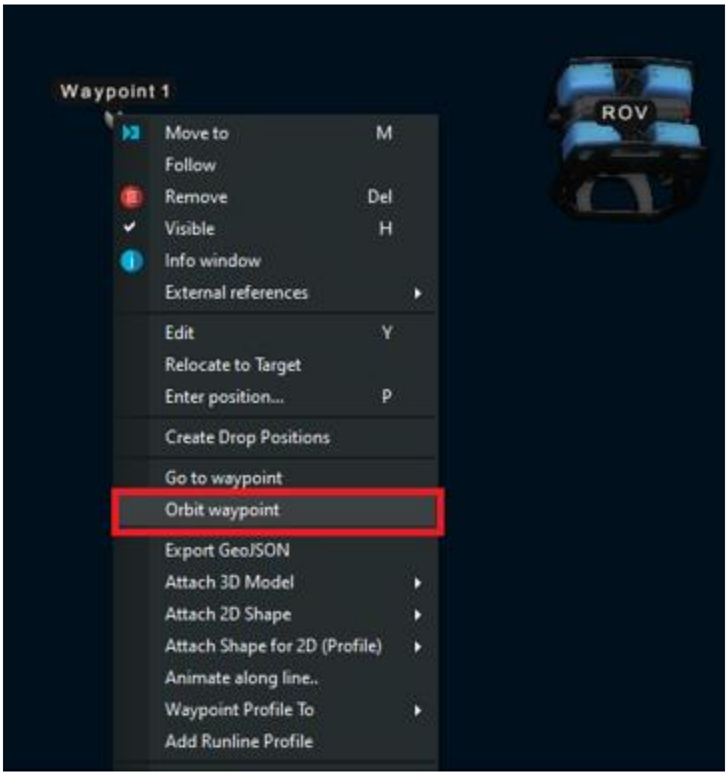


Figure 150 Orbit waypoint after right-clicking on the selected waypoint on the map view

Or by using the **Orbit** window tab:

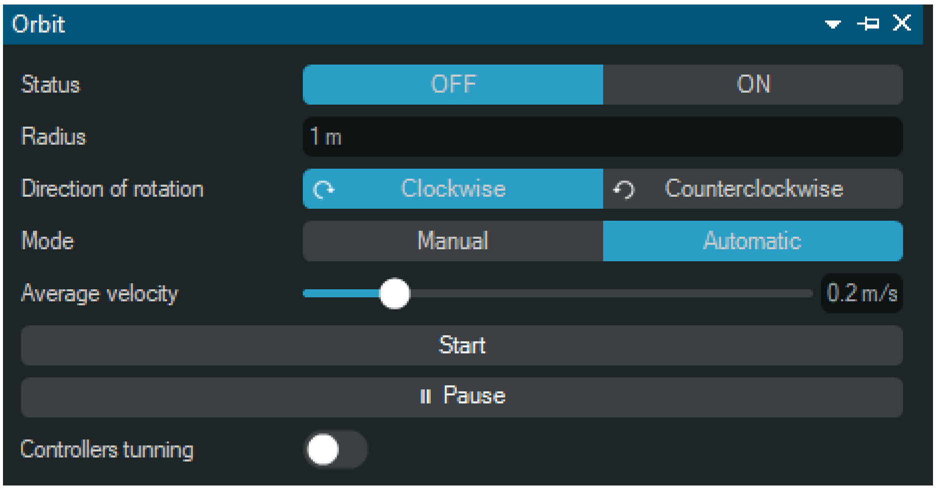


Figure 151 Orbit window tab

In **Automatic** mode, after setting the radius, direction of rotation and speed, NaviSuite Mobula will perform the **Orbit** command for the operator. In this mode, the user will only be able to move away from or approach the object while the ROV is moving automatically. This decreases or increases the radius.

Note: If the operator is changing trajectory, a new trajectory will start from the manually adjusted position. The result will be the changed radius of orbit.

7.4.2 Manual orbit

In **Manual** mode, moving the joystick forward (surging) will result in closing the distance between the ROV and the target. The velocity is not affected. Swaying moves the ROV along the orbit in either direction.

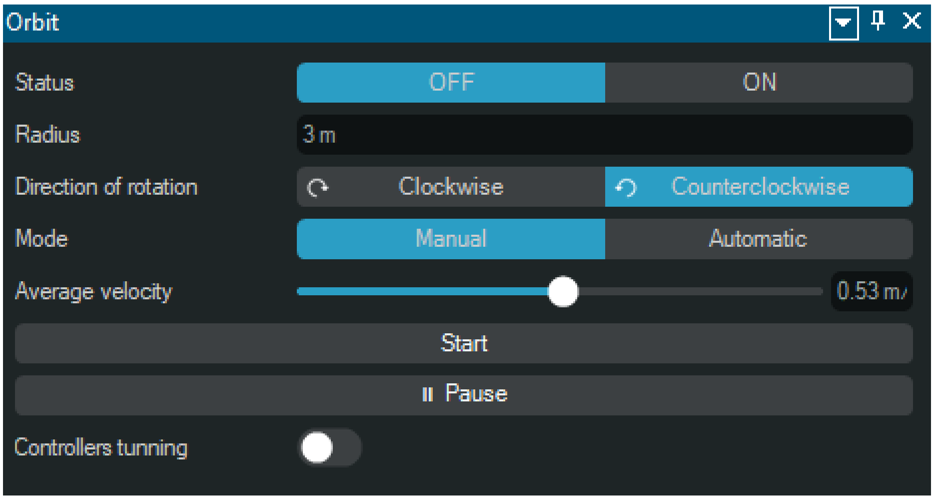


Figure 152 The Manual Orbit initial window

The manual orbit functionality is like the automatic orbit described above. The difference lies in that the user decides when and how the ROV will move on the circumference of a circle with the centre as the point of interest. The user sets the **Manual** orbit by selecting it from the **Mode**, clicks on **Start**, and then moves the joystick to the right or to the left. As a result, the ROV will move on the circle in the starboard or port direction respectively. It will also change its heading, so it always follows the orbit while pointing at the centre. Moreover, the user can move the joystick up or down and the radius of the circle will be reduced or increased respectively.

7.5 Scan Wall control

The operator can follow these steps to position the ROV before starting the **Scan Wall** mode.

1. Use **Manual** mode to place the ROV in the desired starting position.
2. Dive using manual controls and the engage **Auto Depth** to hold at the desired depth from the **Assisted Steering** window
3. Use **Auto hold Station keeping control** to maintain position in the presence of currents and use the joystick to find the angle where the ROV is perpendicular to the wall
   Or, alternatively,

4. If there are no currents, the operator can engage **Auto heading** in the **Assisted Steering** window to lock the heading angle where the x-axis of the ROV is perpendicular to the wall

7.5.1 Scan Wall control example

The operator can input distance to the wall using FLS wedge display and the max horizontal desired distance for the ROV to move. The distance required might come from a relatively accurate estimation of the operator, from known coordinates or from direct measurements. Assuming the ROV will inspect the pier with *1* m distance to the wall, *5* m horizontal length, keeping a minimum altitude of 1 m from the sea bottom, with *25* cm spacing between horizontal trajectory lines, moving to the right direction with velocity of 20 cm/s, the user will have the following **Scan Wall** configuration:

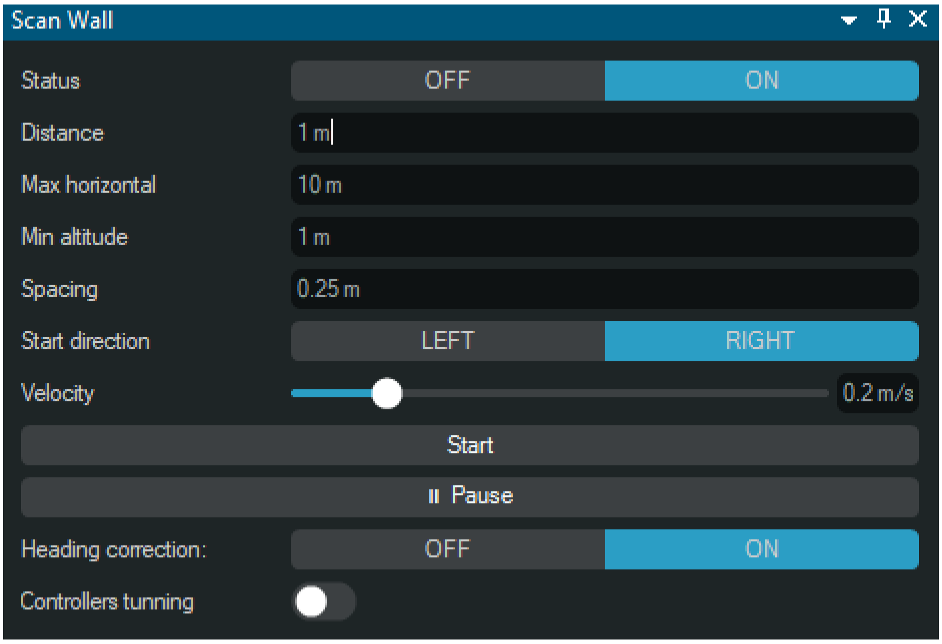


Figure 153 Example: Scan Wall configuration

When it is, ready toggle **Status** *ON* and click on the **Start** button; the manoeuvres will then start.

Note: It is required that the speed of motion is slow enough to allow for transients of smaller magnitude and time for the camera inspection feed.