LAUV Operator Manual

Release 2.5-NTNU

OceanScan – Marine Systems and Technology Lda

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CHAPTER 1

Introduction

1.1 Preamble

Thank you for choosing the **Light Autonomous Underwater Vehicle** (LAUV) for your ocean application.

This user manual provides information regarding the set-up and operation of the LAUV system. In addition, it provides detailed description on how to use Neptus, the command and control software framework designed to create and upload mission plans to the vehicle and to download and display mission data.

The manual also contains information on basic maintenance designed to enhance operating safety and contribute to maintaining the value of your vehicle throughout an extended service life.

We advise you to read this user manual before operating your new vehicle.

1.2 Disclaimer

OceanScan – Marine Systems & Technology, Lda works in close cooperation with University of Porto's LSTS pursuing continuous and ongoing development to ensure that our systems embody the highest operational and quality standards combined with advanced, cutting edge technology. For this reason, it is possible that illustrations and features described in this user manual may differ from those on your vehicle.

When you ordered your vehicle, you chose several options and accessory equipment. Please bear in mind that the manual may contain information on accessories and equipment that you have not specified for your own system.

1.2.1 Glossary

AHRS Attitude Heading Reference System.

AUV Autonomous Underwater Vehicle.

C2 Command and Control.

C4I Command, Control, Communications, Computers and Intelligence.

CCU Command and Control Unit.

GPS Global Positioning System

GSM Global System for Mobile Communications.

HUD Heads-Up Display

IMC Inter-Module Communication protocol. LAUV message protocol.

IMU Inertial Measurement Unit.

INS Inertial Navigation System.

LAUV Light Autonomous Underwater Vehicle.

LBL Long Baseline.

M-JPEG Motion JPEG

MRA Mission Review and Analysis.

RI Reacquire-Identify.

SVG Scalable Vector Graphics.

TVG Time-Variable Gain

UAV Unmanned Aerial Vehicle.

USBL Ultra Short BaseLine.

USV Unmanned Surface Vehicle.

UTC Universal Time Coordinated.

UUV Unmanned Underwater Vehicle.

WGS-84 World Geodetic System, rev. 84

1.3 The LAUV System

The LAUV system was originally developed by the Underwater Systems and Technology Laboratory (LSTS) from the Porto University and has been further developed in cooperation with OceanScan – Marine Systems & Technology, Lda.

The complete LAUV system includes all the equipment required to communicate with the vehicle, the command and control software, external aids for navigation, and a set of optional devices to facilitate operation.

1.3.1 LAUV Vehicle

The *LAUV (Light Autonomous Underwater Vehicle)* (page 7) is a lightweight, modular platform prepared to integrate a set of different sensors and sonars. The vehicle is targeted at cost-effective oceanographic, environmental and inspection surveys to fulfil a wide range of scientific, civilian and military applications.

Fig. 1.1: LAUV - Light Autonomous Underwater Vehicle

When deployed, the LAUV executes a programmed mission plan. The vehicle executes the desired mission maintaining the programmed speed, depth, and course using its onboard sensors, motion algorithms, and navigation systems.

When at surface, the user can communicate with the vehicle via Wi-Fi, satellite communication, GSM (Global System for Mobile Communications) or acoustic modem. While submerged, communication is possible using the acoustic modem.

All data collected by is stored in the vehicle's hard drive or in a USB stick (optional). All data can be downloaded through Wi-Fi.

LAUV System

1.3.2 Manta Gateway

The Manta Gateway is a centralized communications hub, supporting several types of wireless networks. The system routes data among heterogeneous network links, balancing bandwidth and range. As a portable, self-powered device, the Manta gateway is a valuable asset aiding operations.

The Manta Gateway may integrate several capabilities and accessories:

- **Wi-Fi** — long-range, high-throughput communication.
- **Acoustic Modem** — long-range underwater communications, as well as LBL and/or USBL operations.
- **HSDPA/GSM modem** — can service as a hotspot, providing internet when network coverage is available.
- **Iridium Short Burst Data (SBD) Transceiver** — worldwide coverage satellite communications.
- **GPS** — real-time position. Useful to understand the operator's location against the mission map and also provides a reference frame for acoustic operations.

Fig. 1.2: Manta Gateway

1.3.3 Neptus - Command and Control Software

Neptus (page 29) is the command and control framework, used to interface and control the LAUV vehicle. This software targets the command and control of autonomous systems. Neptus evolved to support all the phases of mission life-cycle: planning, execution, and review and analysis of the collected data. For this purpose Neptus includes two distinct tools:

- The **Operator Console** supports the planning, execution, and (simplified) review phases.
- The **Mission Review and Analysis (MRA)** is the interface used to analyse data recorded by the LAUV vehicle.

1.3.4 Additional Devices

Besides the main system components introduced in this section, there's a set of optional devices/applications that may assist the operator in special operation scenarios or emergency recovery procedures. We strongly advise you to have the following devices near your operation site:

- **Cell Phone** — The LAUV vehicle is able to send SMS with status and location in emergency situations.
- **LAUV Remote (Android App)** – The LAUV Remote application enables direct control over the vehicle's propeller and fins. The application also contains a list of entities running and current state of the vehicle.
- **Pinger/Receiver Kit** — This kit is a reliable way to locate and retrieve the vehicle by listening to the emergency pinger signal with the pinger receiver kit.

1.4 Safety Recommendations

The following contains recommendations regarding the safe operation of the LAUV system. Everyone involved in its setup, operation, or maintenance should be thoroughly familiar with the information provided.

- Although designed as a lightweight vehicle, the LAUV will cause serious damage if dropped over someone's feet. For the sake of your health (and your vehicle's health as well) handle the vehicle with care and be sure to use protective footwear.
- Always keep your hands far from the propeller when the vehicle is powered on.
- Never power the vehicle on if it is suspected that water has leaked into the main hull.
- Always keep the vehicle powered off when executing maintenance procedures.
- Always launch and recover the vehicle as far away as possible from any obstructions, and be careful of persons and boats in the vicinity area.
- Always be familiar with the weather conditions, tides, currents and water depths, especially when launching the vehicle in an unknown area.

The LAUV Vehicle - Overview

2.1 The Vehicle at a Glance

The vehicle's structural design was developed to achieve a solution able to deal with the delicate balance of weight, buoyancy, space for payload, flexibility for installation of new equipment and robustness. Traditional materials such as aluminium and poly-acetal are used to implement most of the parts. Stainless steel is also used for the parts subject to wear and stress. Special urethanes are used to mould rubber parts like the antenna mast and fins. The location and orientation of each part within the vehicle cylinder was designed to achieve the lowest center of gravity as possible and to minimize electrical and magnetic interferences between components.

The LAUV is assembled in 3 main sections, as illustrated in the figure below.

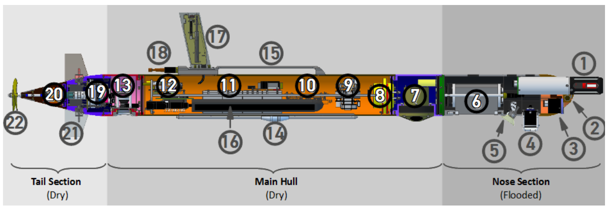


Fig. 2.1: LAUV Sections and Components

2.1.1 Nose Section

The nose section is an assembly of modules made in polyacetal and is free-flooding. It serves as a mounting platform for several sensors, sonars and transducers that have to be in direct contact with the water.

Devices that are installed in the nose section:

1. Environmental sensors (CTD, sound speed, fluorescence, turbidity...)
2. Emergency pinger
3. Forward looking sonar
4. Acoustic transducers (LBL and Acoustic modem)
5. Illumination module
6. Multi-beam echo-sounder

2.1.2 Main Hull

The main hull is a watertight compartment composed by the base cylinder, where the batteries, most of the electronic boards and specific (optional) modules like the DVL and/or the camera module are installed.

Components that are installed inside the main hull:

7. DVL (Doppler Velocity Log)
8. IMU (Inertial Measurement Unit)
9. Acoustic Modem (Electronics)
10. On-board CPU & solid-state hard disk
11. Batteries
12. Communication and Navigation boards (Wi-Fi, GPS, GSM, Iridium, Compass)
13. Camera

Components that are externally mounted in the main hull:

14. Ballast weights
15. Handle
16. Side Scan Sonar transducers
17. Flexible antennas mast (Wi-Fi, GPS, GSM, Iridium)
18. Batteries charging connector

2.1.3 Tail Section

The tail section contains the actuators that control the vehicle's propulsion and steering. The propulsion is provided by a three-phase brush-less motor controlled by a dedicated digital motor controller with full control of speed both in forward and reverse directions. Motion transmission between the motor output shaft and the propeller is accomplished through a permanent magnetic coupling, drastically reducing friction losses and ensuring absolute water tightness. Four fins are mounted externally to the tail section. The vertical fins control the vehicle's heading (yaw), and the horizontal fins control the vehicle's depth (pitch). All fins are controlled independently, providing active roll control for stabilized tilted operation. The fins are made of a flexible urethane to improve shock absorption, protecting the servomotors. If damaged, the fins may be easily replaced.

Components that are part of the tail section:

19. Thruster and controllers
20. Magnetic coupling
21. Flexible fins
22. Propeller

2.2 Power System

2.2.1 Turning the Vehicle On/Off

The vehicle's main power is controlled through a magnetic switch, so that no hull penetration is required. A strong permanent magnet is used to power the vehicle On and Off. The magnet is placed over the magnetic switch outside of the hull. When installed, the vehicle is Off. When removed, the vehicle powers On. The magnet should be installed any time the vehicle is not being used, to prevent unnecessary drain on the batteries or inadvertent activation of the propeller.

Warning:	Batteries that get completely discharged may be unrecoverable.

Fig. 2.2: Magnet

Warning:	Tape the magnet during shipping, to prevent it from coming loose.

2.2.2 Energy Management

The vehicle is powered by a configurable set of rechargeable lithium ion battery packs that connect directly to the power control board which distributes the power to all sensors, actuators and control electronics with the correct voltage level. Both the battery packs and the power control board contain internal electronic charging and safety circuitry. The power control board was specifically designed to support the LAUV energy management system, allowing individual power control over all the vehicle components. This board is connected to the vehicle's main CPU through a serial port connection, enabling continuous monitoring of all voltage levels and current consumptions. A specific process runs within the vehicle's onboard software to continuously update an estimate of the batteries status and capacity, providing that information to the operator via the Neptus operator console or the vehicle's web page.

Note: During operation, if the power level drops below a pre-determined threshold, the vehicle automatically stops the mission execution and pops to the surface, reserving a minimum amount of energy for operation during recovery. Reaching this point, the vehicle will only allow teleoperation mode. Any other command to execute a pre-programmed mission plan will not be executed. This threshold level can be configured and is factory set to 20% of the nominal battery level.

2.2.3 Charging the Batteries

The **LCharger** is a device that externally powers the LAUV to charge each battery pack installed in the vehicle.

Fig. 2.3: LCharger - LAUV Batteries Charger

1. Remove the dummy plug (5) that protects the batteries from the charge connector (4) by unscrewing the locking sleeve first.
2. Connect the power cord (3) to the LCharger (7). Connect the other end to the power source (standard 220Vac, optional 110Vac).
3. Connect the vehicle (4) to the LCharger (6) using the charge cable (2).
4. Turn on the LCharger's "Main Power" switch (red). The switch light will light up and the batteries will start to charge.
5. The charging process takes several hours. All batteries are charged as soon as all the LED's in the LCharger panel become green.
6. At the end, unplug all cables and plug the dummy connector.

The batteries are hermetically sealed, allowing them to be charged inside the vehicle's housing without any risk.

Note: The LEDs on the LCharger panel change colour during the charging process (discharged - orange, charged - green).

Warning: NEVER forget to plug the dummy connector and its locking sleeve.

Warning: To ensure convenient air circulation, LCharger lid MUST remain open during charging process.

2.3 Vehicle Status

As a first step, after turning on the vehicle, the operator should be aware of the status of the vehicle and all its internal systems. There are 3 ways to get this information:

1. Observing the LEDs blinking pattern in the antennas mast – This allows the operator to understand what is the current state of the vehicle, including initialization and shut-down progress;
2. Checking the vehicle's Control Center available through its embedded web server – a simple web page with detailed status indication of all tasks running in the vehicle's onboard software. It also provides information coming from the vehicle's sensors. It requires connection with a device that supports a web browser, like a laptop or a smart phone.
3. Checking the *Entity State Panel* (page 52) within Neptus – which allows visualization of the state of all entities reported by the vehicle. It requires connection with a computer running Neptus.

Note: These tools are extremely important when troubleshooting any problem that may come in your way. Be sure to get familiar with them and all the information they provide.

2.3.1 LED Patterns

The vehicle has installed in the antennas mast a set of 4 LEDs disposed in a configuration similar to the navigation lights used in waterborne vessels. These LEDs signal the vehicle's current status.

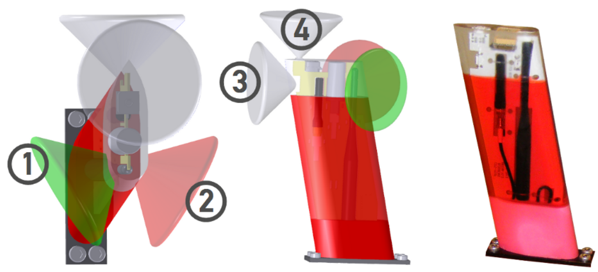


Fig. 2.4: Status LEDs

1. Green (starboard)
2. Red (port)

3. Rear White
4. Top White

Initialization sequence

When the magnet is removed the vehicle initializes lighting the LEDs in the following sequence:

1. All LEDs remain turned off for 2 seconds while the main power supply is turned on;
2. Top White LED: will stay lit for 2 seconds signaling that the radio has been turned on;
3. Rear White LED: will stay lit for 2 seconds signaling that the main computer has been turned on;
4. Red LED: will stay lit for 2 seconds signaling that the internal ethernet switch has been turned on;
5. Green LED: will stay lit signaling that the main power channels have been turned on and the system is waiting for the onboard software to take control. This stage lasts for approximately 4 seconds;
6. All LEDs are turned off for one second signaling that the onboard software has been started;
7. All LEDs are turned on signaling that the onboard software has taken control of the vehicle and is performing basic initializations. This stage lasts for approximately 4 seconds and is followed by a LED pattern from the System Status section.

System Status

Status	Pattern	Meaning
Normal / Service	Green LED flashes in a heartbeat pattern	All subsystems are active and the vehicle is ready to execute plans.
Calibration	Green, Rear White and Top White LEDs flash sequentially for 0.2 seconds	Seen after giving the order to execute a plan and before the vehicle starts maneuvering. During this stage the vehicle turns on and calibrates all configured subsystems.
Plan Executing	Green and Red LEDs flash alternately	Vehicle is executing a plan or in remote operation.
Error	Green LED flashes continuously	A non-critical error has occurred. The operator should verify the reason for the error and intervene, if needed, to restore the vehicle to its normal state.
Critical Error	Red, Rear White and Top White LEDs flash continuously	A critical error has been detected (e.g. leak) and the vehicle should be turned off immediately.

Shutdown sequence

Just before performing a full shutdown the system will flash all LEDs and then light them for half a second in the following sequence:

1. Green
2. Red
3. Rear White
4. Top White

2.3.2 Vehicle's Control Center

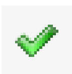
To access the vehicle's Control Center, the user has to:

- Be connected to the same wireless network as the vehicle;
- Open a regular web browser and use the following URL: "http://<vehicle_IP_Address>:8080" (e.g. http://10.0.10.10:8080)

Under the **Main** tab, in the **Overview** section the user can access:

- **System** — vehicle's name
- **Version** — version of the software installed the vehicle
- **Date** — current date and time
- **Uptime** — time since the vehicle's initialization
- **Position** — current position of the vehicle
- **CPU Usage** — current CPU workload
- **Available Storage** — amount of free space at the vehicle's storage drive
- **Available Energy** — amount of energy still available in the vehicle's batteries

The **Tasks** section provides individual information about each software process running in the vehicle. Each task has three possible states:

-  (Active) - The task is running as expected. This means the sub-systems related with this task are ready for operation;
-  (Warning) - The task is waiting for some input or event (e.g. the GPS is waiting for satellite information);
-  (Error) - The task is in error mode (e.g. a task wasn't able to communicate with a device).

Under the **Sensors** tab the user can access all the parameters being measured by the vehicle (sensors readings, voltage and current measurements, etc.).

The Vehicle's Control Center includes also a **Power** tab, where the user can selectively turn ON/OFF some of the devices installed in the vehicle.

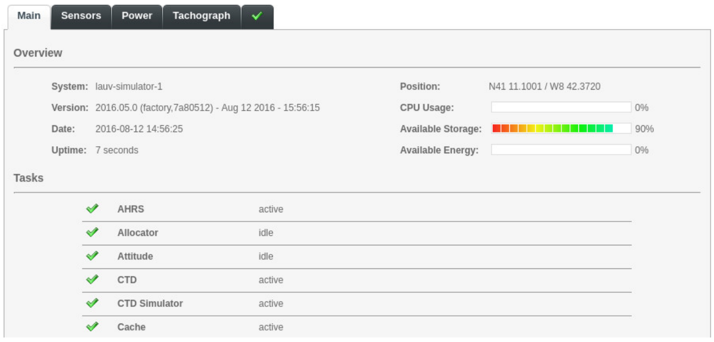


Fig. 2.5: Vehicle's Control Center - Main

Fig. 2.6: Vehicle's Control Center - Sensors

Warning: Do not use this feature unless you know exactly what you are doing or you have been instructed to do so by a technical adviser. Turning off some devices may cause unwanted behavior.

Under the **Tachograph** tab the user can access service related information including last service time, and time until next service. Other information such as maximum reached depth, maximum reached motor's RPMs, time in water, ground or underwater is also available.

2.4 Navigation

In its basic configuration the LAUV relies on the following sensors for navigation and position estimation:

- **Pressure sensor** — provides depth;
- **GPS** — position (at surface);
- **Propeller's RPMs** — estimate of the vehicle's velocity;
- **AHRS (Attitude and Heading Reference System)** — Pitch, roll and heading measurements (magnetically compensated);

The vehicle's onboard software continuously filters the data to update its position estimate. However, when the vehicle is below the surface, without GPS signals, this estimate degrades quickly resulting in poorer, low accuracy position information. To improve the position estimate accuracy, several optional navigation aids can be installed in the vehicle. The following sections provide a list of options. Please contact OceanScan detailed information.

2.4.1 LBL (Long BaseLine)

The use of an acoustic LBL navigation scheme implies the integration of an acoustic modem in the vehicle and the installation of a set of transponders in the operation area (minimum: 2 transponders). During operation, the LAUV interrogates each transponder, and uses their reply to calculate the range for each of them.

2.4.2 USBL (Ultra Short BaseLine)

A USBL implies the integration of a standard acoustic modem in the vehicle and the installation of the USBL modem in the operation area. A Manta Gateway can be used to connect/power the USBL modem while providing real-time positioning through the installed GPS. All data may be relayed to the Neptus console.

2.4.3 DVL (Doppler Velocity Log)

An acoustic DVL can be installed as an optional module that integrates the vehicle's main hull. The DVL usually has four down-looking transducers that measure the velocity of the vehicle relative to the bottom, as well as its altitude above the bottom. The DVL will only output valid velocity/altitude measurements when the water column height below the vehicle is within a given range which varies according with DVL provider.

2.4.4 IMU/INS (Inertial Navigation System)

The Inertial Navigation System provides an improved heading reference system compared to the standard AHRS installed in the LAUV. This means that it improves navigational capability and the vehicle can navigation for longer periods below the surface without introducing significant errors to the localization estimate. This navigation solution implies the integration of a tactical grade IMU (Inertial Measurement Unit) that measures the rotational and translation accelerations experienced by the vehicle more accurately. The navigation filter fusions data provided by the IMU to enhance with unique precision the position estimate. Equipped with this technology the vehicle can navigate for hours without GPS, introducing a few tens of meters of error in the estimated localization.

Warning: To save energy, IMU devices are usually powered off. For dead reckoning operations the operator must power on the device and **align the navigation** to eliminate initialization error. Since the IMU has bias errors that degrade navigation over time, it's recommended to repeat the alignment routines after long missions (2 hours or more), to reduce errors in the following missions.

2.5 Safety

The LAUV comes with a set of standard safety related monitors and supervisors to prevent risk of hazardous operations that may threaten system health.

2.5.1 Limits of Operation

- **Hardware Maximum Depth** — The vehicle has an allowed maximum depth. Plans with depth references beyond this limit will be scaled to maximum depth.
- **Hardware Minimum Altitude** — Minimum allowed altitude. Depending on vehicle sensor configuration (e.g: if it has an echo sounder for obstacle avoidance) this value may change. Plans with altitude references below this limit will be scaled to minimum allowed altitude.
- **Software Operational Limits** — please refer to *Operational Limits* (page 41)

2.5.2 Obstacle Avoidance

Given that the LAUV may be equipped with apparatus like Side Scan Sonars, Camera and Multibeams, we developed our own bottom tracking algorithm. Sometimes, especially due to Camera needs, the altitude tracking value will have to be very low (in the order of just a couple of meters from the sea floor). Since the bottom's shape is quite uncertain, it is possible that it suddenly becomes too steep for the vehicle's constrained dynamics. It may even occur that a bottom sitting obstacle presents itself in front of the AUV. For these reasons, the algorithm requires the following set of data:

- Depth measurements, or vertical distance to the water surface, usually obtained from the depth sensor.
- Altitude measurements, or vertical distance to the bottom, which are usually provided by the equipped DVL.
- Forward distance measurements, which are provided by a single beam echo sounder mounted pointing forward in the LAUV's nose.

What these three elements physically represent is depicted in the figure.

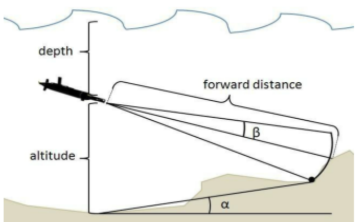


Fig. 2.7: Geometric depiction of the measurements required by the bottom tracking algorithm.

Even though the echo sounder is single beam, there is a non-zero beam apperture, represented by β in figure. The distance provided by the sensor may refer to any point along the arc formed by the apperture angle. When computing the sea floor's slope, we always assume the lowest point in the arc, as suggested in the figure. The expected slope α can be computed using trigonometry. In the next figure, we depict the "brake" procedure performed by the AUV when an obstacle is detected in front of it, or the sea bottom's slope becomes too steep. We define this behavior by stopping the propeller (t1), letting the buoyancy pull the vehicle upwards in the water column (t1, t2) and resume maneuvering when the path ahead is clear, hopefully navigating over the detected obstacle (t2, t3). The plot in the bottom of the picture presents the expected values for altitude and forward looking sonar measurements in a situation as the one we described. The forward distance value after avoiding the obstacle, should be the end of scale of the sensor. The same procedure is followed when altitude measurements become dangerously low. Indeed, this behavior will have an impact in the payload's data collected, due to sudden changes in kinematics (angles of attack and speed deeply affect Side Scan Sonar data for instance). However, we place the AUV's integrity as priority number one.

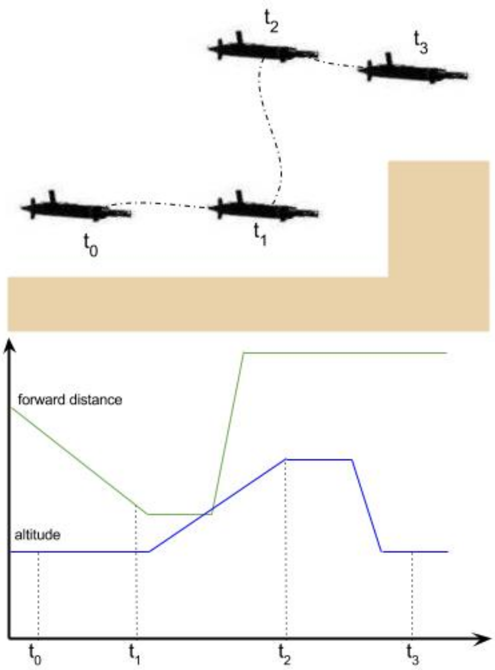


Fig. 2.8: Geometric depiction of the measurements required by the bottom tracking algorithm.

2.5.3 Diving

When an operator defines a plan to be executed by the LAUV, he will specify the cruise speed, among other things. The specified value, in meters per second or propeller revolutions per minute, may not be enough for submerging the vehicle, since it is a positively buoyant vessel. The diving mechanism works by inducing small increments in speed, every few seconds, until a minimum depth is attained (about a meter). We then switch the commanded speed back to the one originally specified by the operator, which will hopefully be enough to keep the vehicle at depth. The maximum speed commanded will take the AUV's motor limitations into account.

2.5.4 Dislodge

Although the bottom tracking algorithm has proven to work reliably, the AUV is not fully immune to become stuck by an undetected object or structure. We've learned from experience, that the echo returns from a fishing net on the forward looking echo sounder are not conclusive. Moreover, the scheme presented earlier for obstacle avoidance detects obstacles below and in front of the AUV, but not above it. We have developed a mechanism that detects a potential stuck situation by analyzing the following data:

1. No plan is being executed.
2. The last executed plan finished at depth and not at surface.
3. Current depth is larger than a certain amount (not very near to the surface).
4. The AUV is ascending in the water column too slowly (speed from positive buoyancy is shorter than expected).

If all the conditions are met, and there currently is no locking issue with the motor's shaft (which may happen if a cable of some sort gets tied around the propeller), the dislodge behavior is triggered.

Dislodge works by actuating the motor at maximum power, either forward or backwards, for short amounts of time, in an attempt to get the AUV unstuck. After each attempt, the conditions mentioned above (except for the first one) are retested and a new attempt takes place if necessary. When the maximum number of attempts is reached, an acoustic distress signal is issued to warn the operator that the AUV recovery procedures should be initiated. Also via the acoustic channel, the operator can issue the start of the dislodge behavior at any time, if he finds it appropriate.

2.5.5 Configurable Features

There are some extra tools that may be used by the operator to increase the level of safety when operating the system.

Emergency Monitor may be used to transmit distress messages through secondary communication links when Wi-Fi link is not available. More information is available on *Emergency Monitor* (page 21).

Safety Plans are contigency plans that may be launched at anytime to protect the vehicle from incoming threats (e.g: large ship entering the area. Please refer to *Safety Plans* (page 75) for details.

Safety Supervisor is a supervisor that checks the lack of communication to an operator console and the risk of drifting. Step-by-step details on how to setup this supervisor are available in *Safety Supervisor* (page 75).

2.6 Logging

Vehicle data is stored onboard the vehicle. As an additional feature, the user may opt to have an externally accessible USB pen drive with the data. This pen drive is usually mounted on the nose cone.

The USB pen drive's filesystem is **ext4** and the user must never format to a different filesystem than **ext4**.

> **Warning:** Do **not** format the USB pen drive filesystem to anything other than **ext4**

ext4 file system is not natively supported on Windows OS. For support, application **Ext2Fsd** is provided in OceanScan's OEM utility software.

In addition, when the vehicle is powered on it is always logging data to the pen drive. Removing the pen drive while vehicle is powered on will cause system failure, and data will be lost or corrupted.

> **Warning:** Power off the LAUV to exchange USB pen drive.

Finally, routine maintenance shall be executed annually. More information is contained in *Routine Maintenance* (page 24).

2.6.1 Using Ext2Fsd

On Windows OS, this application can be used to open the provided USB pen:

- **Install** — Click the file of ext2fsd_v*.exe. It will guide you for all.
- **Mount** — With "Ext2 Volume Manager". Just `Right-Click` on the dialog list, and select "Change Drive Letter". Then you'll see the mount point dialog, you can add, change or remove any driver letters.
- **Automatic start on boot** — Open "Ext2 Volume Manager" and click menu "Service Management" in submenu "Tools". Select "SERVICE_SYSTEM_START" and apply the changes. You could click the "Start" button to start ext2fsd service. But it's only start the service, not enabling auto-starting.

2.7 Communications System

The LAUV comes with a set of standard and optional devices that support the communications system. This allows interaction between the operator and the vehicle to program and manage mission data, real-time vehicle control and to assess the vehicle's position and status, which may be crucial for retrieval operations. Basic configuration comprises a Wi-Fi device and a GSM module. Additionally, satellite and acoustic interfaces may be added.

2.7.1 Wi-Fi

The Wi-Fi system is the main communication link between the operator and the vehicle. It allows wireless access at long distances. Range is affected by the height and relative position of the operator station antenna and the sea state conditions. In a favourable environment, the LAUV Wi-Fi range may exceed 1000m.

As the primary communication link the Wi-Fi system supports:

- Real-time link with vehicle for configuration and status monitoring;
- Uploading mission files to the vehicle;
- Downloading data from the vehicle;
- Locating the vehicle at the end of a mission;
- Remote operation teleoperation mode.

The vehicle's Wi-Fi device may be configured in two different ways:

- As a regular **wireless client** — In such case, a wireless router, typically a Manta Gateway, has to be used to interface the operator connection to the vehicle. This wireless router, or Manta Gateway, manages a wireless network where the operator console will be constantly connected, in spite of the vehicle's connection status.
- As an **access point** — In this case, it's the vehicle's Wi-Fi device that manages the wireless network where one or more operators will connect to establish communication with the vehicle. The wireless network broadcast signal will be lost every time the vehicle dives or moves out of range.

Warning: All Wi-Fi client devices must be configured to automatically search and connect to the access points' network SSID.

The vehicle is factory programmed with a static IP address within the range 10.0.10.X/16. The Manta Gateway has a DHCP service to provide IP addresses to systems connecting to the network (e.g. laptops).

2.7.2 GSM

The GSM system allows long range communications with the vehicle in coastal operations. This interface is mainly used in emergency situations when Wi-Fi range is limited. An emergency recipient must be configured and maintained to receive distress signals from the vehicle when unable to locate a software console. Although a reliable communication platform, please note that it's intrinsically conditioned by GSM network coverage.

Warning: check with the GSM service provider that manages the SIM card installed in the vehicle for area coverage near operation area. If this information is not available, GSM network coverage should be tested and evaluated prior to operations.

Emergency Monitor

The Emergency Monitor is a software process that monitors connectivity between the vehicle and the operator console. If connectivity is lost for a period that exceeds a preconfigured timeout parameter, an SMS message will be sent reporting the vehicle's position and relevant status information. The process will also trigger an SMS message if an **abort** is triggered during operation (e.g. water leak is detected, or execution aborted by operator).

There are 3 parameters that should be set to configure this process. Please refer to *Neptus systems configuration dialogue* (page 56) for details.

- **Emergency Monitor Enable** — Enable/disable this monitor. The distress SMS message will be sent if this argument is enabled **and** the vehicle is not underwater, or, if the vehicle is not executing a mission **and** is at water surface (this last condition ignores if monitor is disabled for safety purposes). Keep this monitor enabled, unless if you need to save SMS credits and vehicle is safe (e.g. powered on in a working desk)
- **SMS Recipient Number** — Cell phone number that receives the SMS messages.
- **Lost Communication SMS Timeout** — Timeout period the process waits before sending an SMS message whenever connectivity is lost. The process keeps sending SMS messages until connectivity is reestablished.

Tip: If Iridium is available on the system, the user may also opt to receive distress messages through GSM, Iridium, or both.

Tip: Please refer to *Enable Emergency Monitor* (page 71) on how to configure the emergency monitor.

SMS Messages

The GSM system installed in the LAUV allows bidirectional communication over SMS messages. As explained above the Emergency Monitor process manages messages sent by the vehicle when specific triggers are set. On the other hand, the operator can also send SMS messages requesting the vehicle status or with specific commands.

Vehicle Messages

Messages sent by the vehicle respect the following format:

```
(X) (Vehicle Name) Time / Latitude,Longitude / f:YY c:ZZ / p:WW
```

- **X** — Cause that triggered the message. This field can assume the value "T" if it was a connectivity Timeout or "A" if it was an Abort action.
- **Vehicle Name** — Name of the vehicle that sent the message.

- **Time** — Time when the message was sent.
- **Latitude,Longitude** — GPS coordinates of the vehicle's position.
- **YY** — Estimated fuel level (%).
- **ZZ** — Estimated fuel level confidence (%).
- **WW** — Plan progress (%). If no plan is being executed or the plan includes an endless maneuver (e.g. Teleoperation, Station Keeping or Loiter with timeout 0) this value will be "-1".

Example: (T) (lauv-xpto-1) 15:22:10 / 41 11.234567,-8 42.345678 / f:75 c:90 / p:-1

Operator Messages

These are messages available to the operator to send to the vehicle (case insensitive).

- **pos** — requests the vehicle position. The vehicle will send a message with the same format presented above.
- **gsm true** — Enable the emergency monitor.
- **gsm false** — Disable the emergency monitor.
- **plan <PLAN_NAME>** — execute plan <PLAN_NAME>. The <PLAN_NAME> has to be stored in the vehicle's plan database. Use **only** in an emergency scenario, when unable to establish connectivity with the system.

Good practices

The GSM communication module may be fundamental in emergency situations when the vehicle is out of sight and Wi-Fi. However, as typically it's used very seldom, operators tend to forget a few simple procedures. To assure the system works flawlessly, bare in mind the following good practices:

- Always configure the correct SMS Recipient Number. This should correspond to a cell phone present at the operation site. Test it before starting operations.
- Check with your GSM network providers for the best plan. If a prepaid plan is chosen, make sure there's minimum credit balance before each operation. A minimum of 100 messages is a good rule-of-thumb.
- Have a Neptus operator console running when you turn the vehicle on, or disable the monitor if in dry land to save SMS credits.
- When preparing operations in a particular site be sure to include a set of plans for emergency or recovery procedures and store them in the vehicle's plans database. A simple Station Keeping maneuver placed near the base station will do the job. This plans may latter be ignited, if needed, by SMS.

Warning: The "plan" command message should be used only when strictly necessary. In fact, latency on the delivery of SMS messages may not be as predictable as desirable. A delayed or apparently lost message may result in a plan execution starting in an unexpected or even undesirable moment. Moreover, no feedback is sent by the vehicle so behavior is not ascertained. Special characters like the underscore "_" are not well parsed and should be avoided when defining *Safety Plans* (page 75).

2.7.3 Acoustic Modem

The LAUV may be equipped with an acoustic modem that enables bidirectional communications with the operator, when at water.

To ensure communications connectivity between the operator and the vehicle, the operational setup requires a Manta Gateway fitted with a compatible acoustic modem. Several models provided by different manufacturers can be used for underwater communications capabilities. The specific model that is installed in your system and environmental conditions at the operations site will influence the range and data rates. Communication range can be as high as 3,5km and baud rates may reach 60kbit/s.

In the vehicle, the modem's transducer is usually mounted in the nose cone, facing downwards. Regarding the Manta gateway, the transducer is connected through a cable which allows access to water from a ship or a pier wall.

Warning: When using an acoustic modem from a support vessel, keep the transducer out of the water when the vessel's propeller is running. Irreversible damage will occur if the transducer/cable is caught by the propeller's blades.

The acoustic modem provides real time vehicle tracking and status information allowing operators to remotely monitor mission progress and vehicle location while the AUV is submerged. It's also used for sending mission control commands to the vehicle and measuring the distance between the vehicle and the acoustic modem transducer.

2.7.4 Iridium

For remote operations, LAUV can be fitted with an Iridium transceiver. The following lists some Iridium-related capabilities

- **Emergency Monitor** - send distress messages through Iridium (guaranteeing worldwide network coverage).
- **Publisher (Remote Monitoring)** - gather positions and time of last update from **all** *IMC* systems in the network and periodically publish to Iridium server.

> **Warning:** Unlike GSM services, peer-to-peer messaging is not supported. All messages are published to the server and need to be actively fetched. Since checking server's mailbox may consume Iridium credits (if there is nothing to receive), by default Iridium software driver **does not** check mailbox unless **enabled by operator**. Refer to *Iridium Mailbox* (page 78).

> **Tip:** Please refer to *Enable Emergency Monitor* (page 71) on how to configure the emergency monitor.

> **Tip:** Enable *e-mail forwarding* on Iridium server to receive all incoming messages on your e-mail inbox.

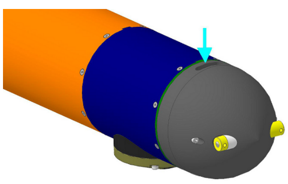
> **Warning:** For extra services, please contact support@oceanscan-mst.com.

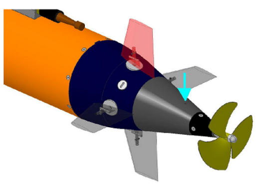
2.8 Routine Maintenance

2.8.1 Washing after operation

After operating the LAUV, it is strongly recommended to rinse the whole body with fresh water. Special care should be taken with closed structures like the nose cone and the extremity of the tail section, which is partially flooded. If possible, submerge the vehicle into a pool of fresh water for a few minutes.

1. Rinse the LAUV completely all around with fresh water.
2. Insert fresh water at the cut out, on top of the nose cone, to flush out salt water on the inside housing.
3. Insert fresh water at the tail section through the small hole to flush out the salt water. As water flow through the small hole is relatively limited take a few seconds to ensure enough water circulation.
4. Rinse all the optical sensors/lens, including camera lens, LED lights, fluorometers, etc.

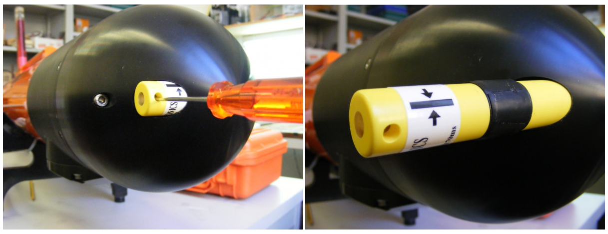




2.8.2 Replacing the Pinger

When the pinger's battery is dead, replace the pinger.

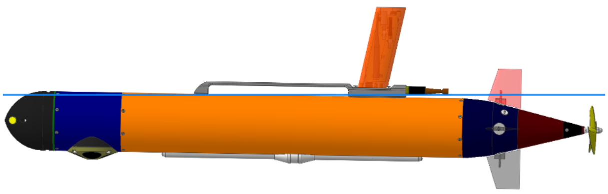
1. Unscrew the two M4x20 socket screws with a 2mm hex key.
2. Pull/push the pinger.
3. Put some tape around the middle of the new pinger before installing to eliminate the clearance.
4. Place the new unit inside the nose cavity and align the mounting holes.
5. Place the socket screws back to their original position.



2.8.3 Buoyancy and trimming

The LAUV is factory ballasted and trimmed for deployment in seawater with some extra buoyancy, for safety reasons. Before deploying the vehicle in a new area, the vehicle's buoyancy and trimming must be verified and, if necessary, ballasted for proper buoyancy. Correct buoyancy and trimming can be verified visually, checking the vehicle's relative position with respect to the water surface plane. When resting at surface, the vehicle should have its nose slightly elevated above the water level, but the tail section should be completely submerged. In these conditions, the vehicle's pitch is approximately 1º, as shown in the image below. The horizontal line represents the surface of the water.

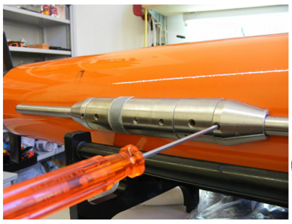
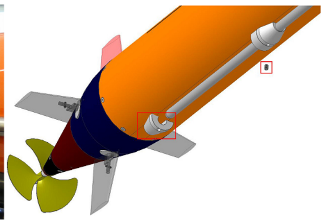
Tip: Proper ballast and trimming will have a positive effect on the vehicle's power consumption and controllability. Be sure to verify correct configuration whenever you move to a new operation site.



> **Warning:** Verify that the vehicle is properly ballasted before letting it free in the water. The vehicle will sink if ballast is too heavy.

1. Unscrew the M6x8 socket screws with a 3mm hex key.

2. Slide the weight off the ballast.
3. Slide on the necessary weights and position them according to buoyancy requirements Insert the M6x8 socket screws.
4. Make sure there is at least one zinc sacrificial anode weight.
5. Adjust the position of the ballast weights so that the nose is slightly elevated, approximately 1º.

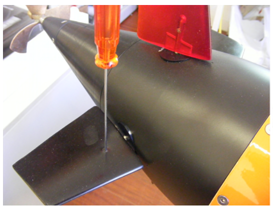
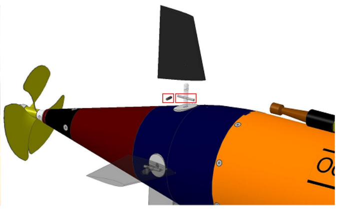



Note: The sacrificial anode is used for cathodic protection to mitigate corrosion on the aluminium structure. It must be replaced when presenting a high corrosion level.

2.8.4 Replacing a Fin

The LAUV fins are moulded with a flexible rubber urethane for better absorption of vibrations and impacts, thus protecting internal mechanisms. Routinely inspect the fins as they may suffer cuts and tears.

1. Unscrew the M3x10 socket screw with a 1,5 mm hex key.
2. Pull the fin out.
3. If required, replace the Ø3x24 pin.
4. Insert new fin and screw in the M3x10 socket screw back to place.

2.8.5 Spare parts

A package with a few selected spare parts is shipped along with vehicle, as they may be necessary in case of loss or damage during maintenance operations.

- 4x DIN913 A2-M3x10 flat point socket screw (Fins)
- 2x DIN913 A2-M4x20 flat point socket screw (Pinger)
- 2x DIN913 A2-M6x8 flat point socket screw (Ballast weights)
- 4x DIN7 A2-3x24 dowel pin (Fins)

- 4x Rubber fins
- Stainless steel ballast weights
- Zinc ballast weight

2.9 Deployment

This section introduces simple operational checklists. Symbol **(+)** marks optional entries or entries that may not apply.

2.9.1 Preparation Checklist

- Operational area:
  - Check expected ship traffic
  - GSM network coverage
  - Power supply
- Gather local emergency contacts: local authorities, divers etc.
- (+) Add extra identification labels on the equipament (english + native language)
- (+) LAUV Iridium credits
- LAUV GSM credits
- Equipment is charged:
  - LAUV
  - (+) Manta
  - Pinger console
  - Laptops/computers
  - Emergency cell phone
  - (+) Acoustic beacons / Radios / GPS etc.

2.9.2 Pre-Deployment Checklist

- Material Checklist
- Turn on and test LAUV emergency pinger
- Verify dummy plug (charging connector)
- Check vehicle status (LED patterns + entities status on Web/Neptus)
- Verify GSM emergency contact
- Start **LAUV Remote** app and test remote control
- (+) Set up acoustic beacons, get GPS position and update on Neptus

2.9.3 Deployment Checklist

- Add safety plans to LAUV
- Enable emergency contact
- Set proper safety supervisor strategy
- (+) Enable acoustic reports
- Deploy: Check trimming and buoyancy

2.9.4 End of Operations Checklist

- Wash all wet systems
- Turn off emergency pinger
- Download logs
- Check disk storage and delete if necessary

CHAPTER 3

Neptus - Operator Software

3.1 Introduction

Neptus is a C4I framework used to command autonomous vehicles.

Neptus has been developed at Porto University by LSTS – Underwater Systems and Technology Laboratory. Neptus aims at integrated planning, execution and analysis of unmanned systems.

Neptus provides support for different phases of a mission life-cycle: planning, execution and data analysis.

For a better user experience, Neptus is separated into a **LAUV Console** for planning and execution and **Mission Revision and Analysis (MRA)** for data analysis.

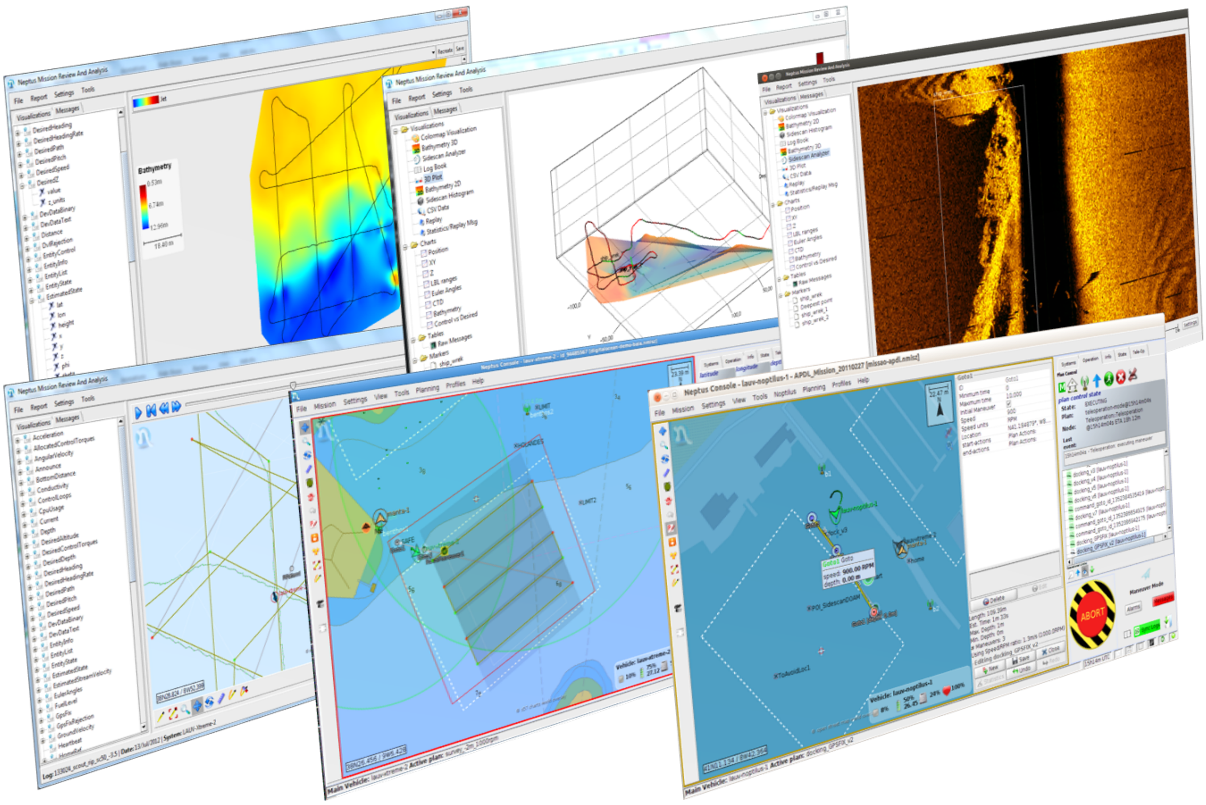


Fig. 3.1: Examples of Neptus interfaces

3.1.1 Installing Neptus

Minimum Requirements

To run Neptus, you should have at least 1 GB of available RAM memory, a 1 GHz CPU and 512 MB of hard drive space. For better performance, it is recommended that you have 2 GB of available RAM memory, an *Intel Core i3* or better CPU, an accelerated graphics card (for 3D visualizations) and extra disk space for storing incoming vehicle data.

Neptus supports both 32 and 64 bit architectures.

Windows

To install Neptus under Windows, download and execute the installer for your architecture (e.g. `Neptus*.exe`, the `'*'` part depends on the file name for the version to install). After reading and accepting the license (a copy of this license is available in the legal folder of Neptus installation directory), select the directory where to install Neptus (default: `C:\Neptus*`). Once installation is complete, you can launch Neptus from the Start Menu.

> **Warning:** Under **Windows**, do not install Neptus in `Program Files` folder. Choose to install it on your system's root folder.

Linux

To install Neptus under Linux, it is necessary to execute the installer for your architecture (e.g. `Neptus*.sh`). To run this installer, you can execute the command:

```
sh ./Neptus*.sh
```

As a result, a new folder, named `Neptus*` will be created with all required files to run Neptus. To execute Neptus, go to the installation directory and execute the command:

```
./neptus.sh
```

3.1.2 Interfaces

Neptus is divided in two main interfaces: the **operator console**, and the **review and analysis** (see figure *Operator Console (left) and Review and Analysis (right)* (page 31)).

Operator console supports planning, execution, and (simplified) review phases. The console interface is divided into two main parts: the mission map on the left and the planning elements and controls to the right.

The mission map (left) shows the virtual representation of the site with the world map, systems location, and data revision overlays. There are several options available for

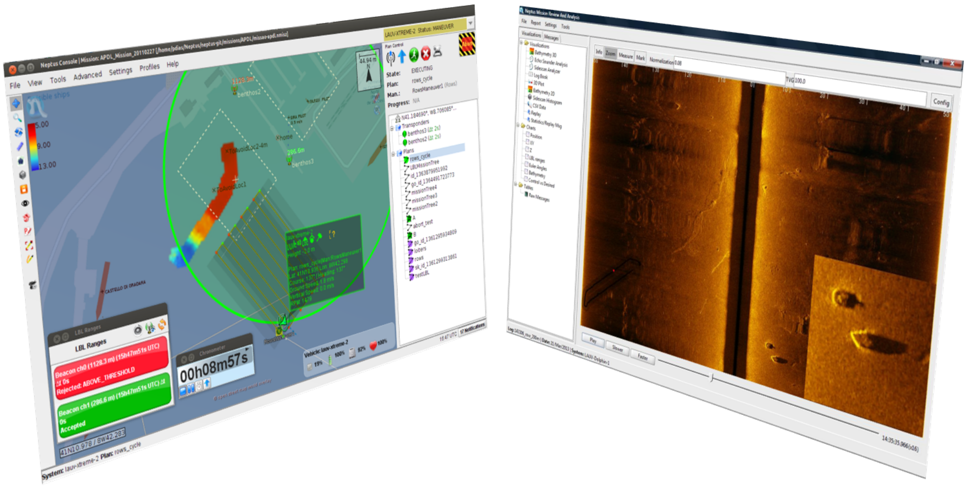


Fig. 3.2: Operator Console (left) and Review and Analysis (right)

the world map (e.g. Open Street Map, Google Maps, Virtual Earth, S57 etc.). Maps are downloaded automatically as needed from the Internet and cached on the computer for offline use. For the S57 nautical charts it is required to have compatible charts stored on disk.

On the right side of the console, the vehicle command widgets comprise plan execution controls and mission elements like transponders and plans. Other widgets are avalable through the menu bar.

Mission Review and Analysis (MRA) is the interface used to analyse produced data. There are several visualizations available in MRA and they vary according with data availability (sensor payloads are activated only on operator request). MRA allows inspection of all logged IMC messages in both a tabular format or by plotting data present on the messages in time-series plots.

3.1.3 Key Concepts

World Map

A **world map** is a map provided by a map server. It is cached for offline use and downloaded as needed.

Mission

A mission comprises location, plans and all mission map elements used. Mission data is stored in a file with *nmisz* extension.

Maneuver and Plan

A **plan** is a sequence of basic **maneuvers**. Plans are stored in the vehicle database and executed on command.

Each maneuver defines the desired speed, desired depth, and active payload (e.g. go to *X* at 1m/s with sidescan active; then go to *Y* at 1.5m/s with multibeam active)

Check *Supported Maneuvers* (page 79) section for more information.

Planning Phase

A mission starts before its actual execution. It usually needs to be prepared beforehand by studying the location characteristics. This is useful to decide where to deploy vehicles, navigation aids and base station.

If no Internet is available on site, cache world map tiles of the area by browsing the area in the Neptus console. Also, plans may be drafted and tested by simulation.

Execution Phase

On site, the plan(s) to be executed and the transponder's details **must** be synchronized with the vehicle.

In the execution phase, the operator prepares the vehicle for deployment, monitors the system's telemetry and executes/adapts the mission plans.

Data Analysis Phase

The review phase takes place on site or after the mission (or a plan) is concluded.

Start by downloading the data acquired by the vehicle. Then, use *MRA* to analyse it.

Data Log

A log contains all the messages for a specific plan. Each time a plan changes or a vehicle becomes idle, a new log is created. Typically a log structure is composed by the following file structure:

- Config.ini;
- Data.lsf.gz;
- IMC.xml;
- Output.txt.

Logs already opened may hold additional files and folders containing processed data. Some data logs may also hold dedicated data files depending on the active payload (eg: sidescan, current profile, camera etc.).

Vehicle Parameters

The vehicle contains a list of internal configuration parameters that may be modified by the user in Neptus (see *Systems Configuration* (page 56)).

Parameters' visibility may be *user* or *developer*. *User* parameters may be modified as needed. *Developer* parameters should not be modified without technical guidance.

Moreover, there are four levels of activation:

- **global** — parameters can be modified at any time.
- **idle** — parameters can be modified only when not executing a mission.
- **plan** — parameters may be enabled/disabled for the whole plan, or,
- **maneuver** — enabled/disabled for specific maneuvers.

3.2 LAUV Console

From the LAUV Console you can create missions, add map features, generate plan specifications, monitor the vehicle's execution and review data collected in previous missions.

The console should have a loaded mission, either pre-existing or a newly created one.

The console is divided into several sections as can be seen in the *figure* (page 33).

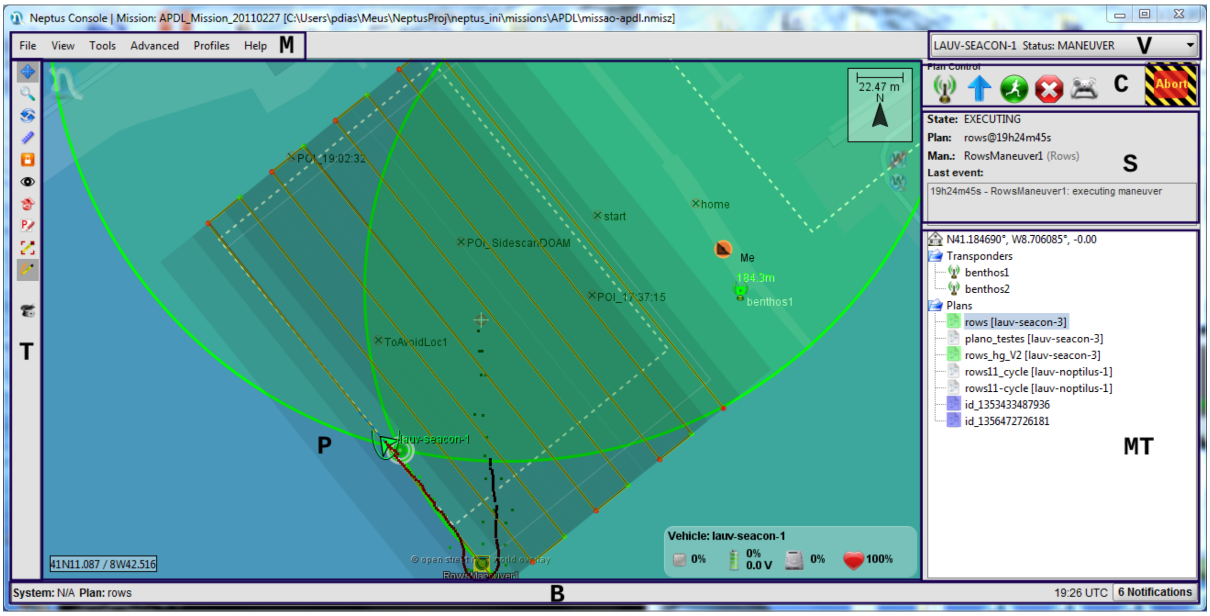


Fig. 3.3: The layout sections: M for menu bar, V for vehicle selection, T for tool bar, P for world panel, C for control, S for status, MT for mission tree and B for bottom bar.

The console handles multiple systems at the same time but most commands and telemetry come from the main vehicle. The main vehicle is selected in the *vehicle selection console* (page 33) section.

3.2.1 Main Vehicle

The Main Vehicle Selector provides two important functions :

1. **Lets the operator select a vehicle to control**
2. Informs the operator about the overall state of all connected vehicles

When the operator selects a main vehicle all components are updated to reflect selection. The vehicle state is also provided.

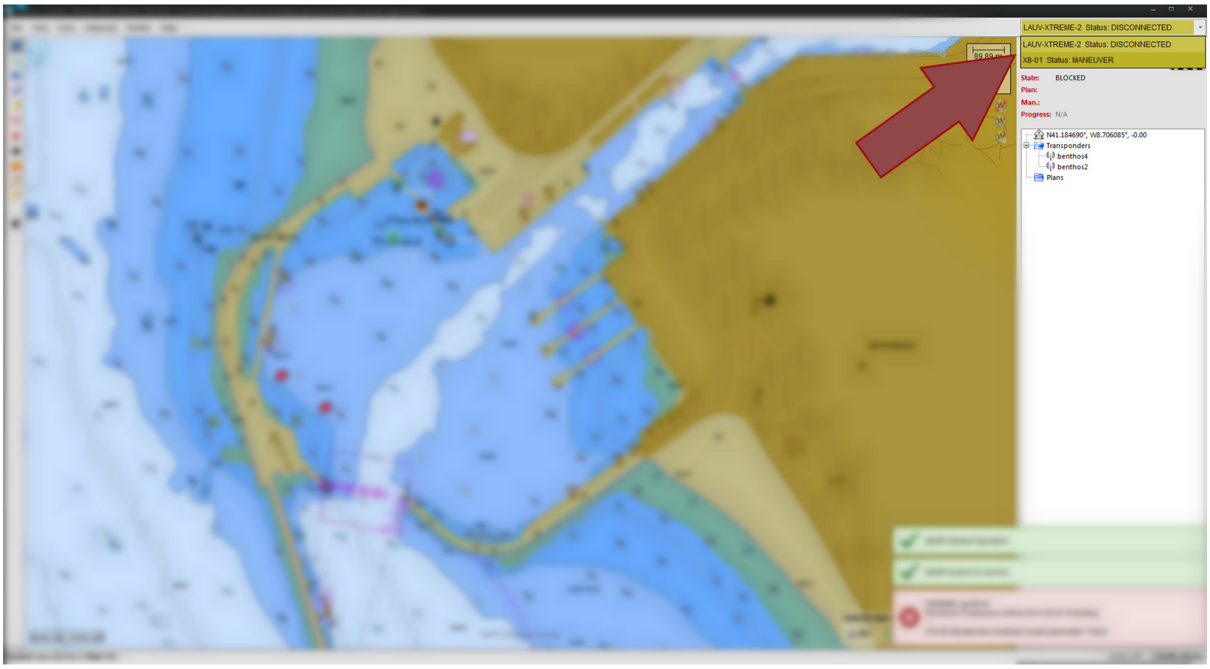


Fig. 3.4: Main System Selector

The different vehicle states are:

- **CONNECTED** — system is connected
- **BOOT** — onboard software is starting
- **SERVICE** — ready and waiting for commands.
- **CALIBRATION** — calibrating sensors for plan execution.
- **MANEUVER** — plan execution
- **ERROR** — vehicle is in error
- **TELEOPERATION** — remote operation
- **DISCONNECTED** — no Wi-Fi connection with the system

3.2.2 Plan Control

Plan Control (located below vehicle selector) sends mission execution related messages. The panel is shown in the *figure* (page 34).

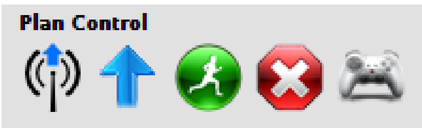


Fig. 3.5: Plan Control panel.

The following *table* (page 35) details all plan control actions.

Table 3.1: Plan Control actions

Icon	Description
	Send Acoustic Beacons
	Send Selected Plan to the main vehicle
	Start Selected Plan in the main vehicle
	Stop plan execution
	Start/Stop remote control

Note: When sending acoustic beacons to the vehicle, the list of acoustic transponders in the mission tree is synchronized to the vehicle. For LBL operations, a valid setup must be sent to the vehicle.

Plan Control State

The Plan Control state (*figure* (page 35)) informs the operator about the state of plan execution, which plan is loaded/being executed, and which maneuver.

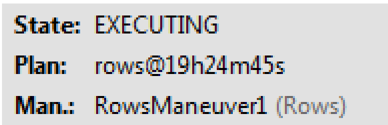


Fig. 3.6: Plan Control State panel.

Some plan progress information is available in the *Notification* (page 37) area.

Abort Button

This operational console component sends an abort request to the vehicle. All requests are made through Wi-Fi.

Fig. 3.7: Abort

Tip: If an external system with an acoustic modem is available (e.g. Manta Gateway) and connected via Wi-Fi, Neptus requests that system to forward the abort acoustically.

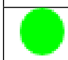
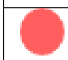
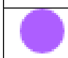
3.2.3 Mission Tree

The mission tree contains all the elements stored in the mission.

- the home reference
- list of transponders
- list of plans

The elements are identified by icons that contain information about it (see table *Element icons* (page 36)). Transponders and plans' icons may be modified to show extra information about them.

Table 3.2: Element icons

Icon	Name	Description
	Home Ref	Location reference to anchor the map.
	Transponder	A transponder element.
	Plan	A plan element.
A	Acoustic	A plan that can be started via acoustic modem
	Syncronized	Element synchronized between console and vehicle.
	Not Synched	Element is different between console and vehicle.
	Remote	The element exists only in the vehicle.
	Local	The element exists only in the console.

When in an underwater mission using transponders, next to the name of the transponder will appear the elapsed time since the last accepted range. This will turn from green to red if too much time has passed for safety.

Mission Tree Actions

All the available actions are listed by pressing the right mouse button. Some actions are always available while others are specific to element types or just need to have an element selected. To act upon an element select it with the left mouse button and then press the right mouse button.

List of mission tree actions:

- **Reload Panel** — refresh the list of elements in the mission tree.
- **View/Edit <element>** — update <element> location.
- **Remove <element>** — remove <element> from the mission tree. No plans or transponders are removed from vehicle.
- **Switch** — switch location of elements.
- **Add a new Transponder** — insert a new transponder into the mission.
- **Send <plan> to <vehicle>** — send selected plan to <vehicle>.
- **Remove <plan> from <vehicle>** — remove plan from vehicle.

- **Get <plan> from <vehicle>** — load selected plan into console from vehicle.

3.2.4 Notifications

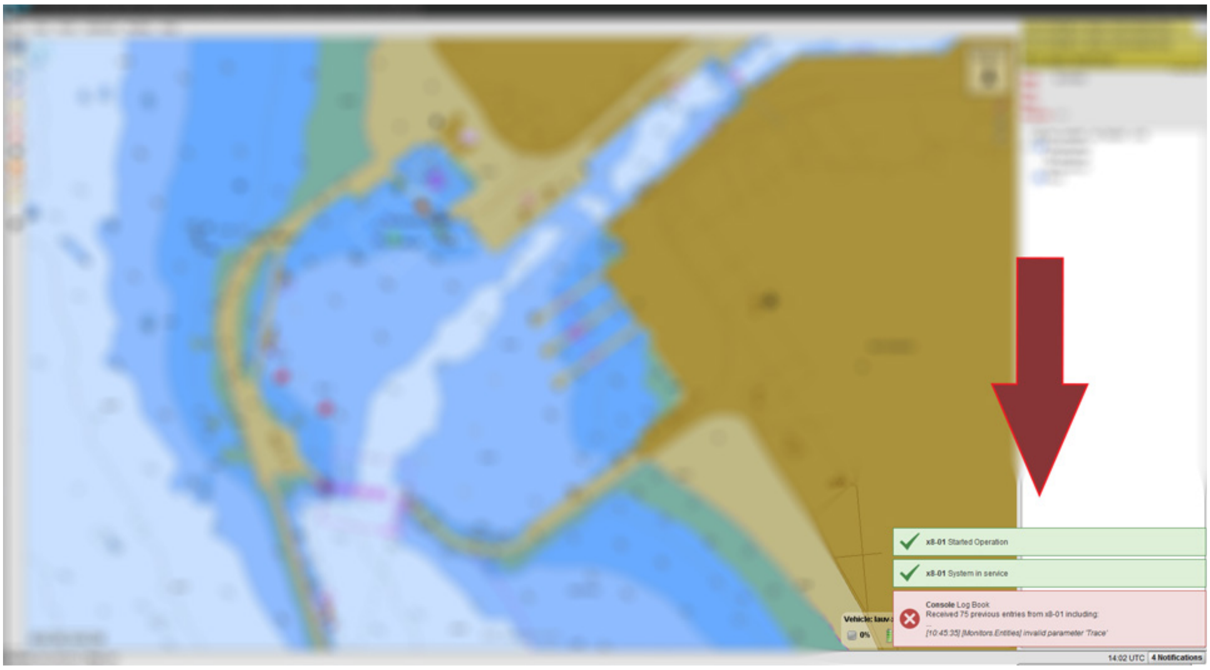


Fig. 3.8: Notifications Overview

Neptus has a *notification system* (page 37) to keep the operator informed about important events happening with the connected vehicles. The notification disappears after a few seconds. Error events must be acknowledged by clicking on the popup.

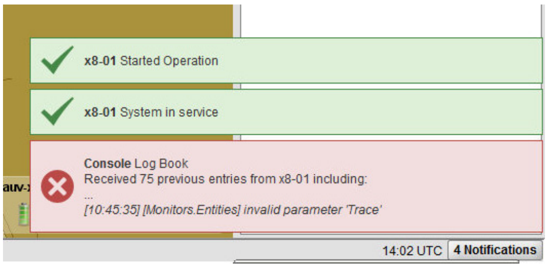


Fig. 3.9: Notifications Example

The operator can also open the notifications log by clicking the button at the right bottom corner which opens a *window* (page 38) with a list of the last notifications. It is possible to clear the list and disable popups.

3.2.5 Menu Bar

The *File* menu you can create, open and save a mission file.

In the *View* menu you tailored features that allow extra functionalities with the vehicle.

In the *Tools* and *Advanced* menus there are commands to configure the console, take a snapshot, clear vehicle's plan database etc.

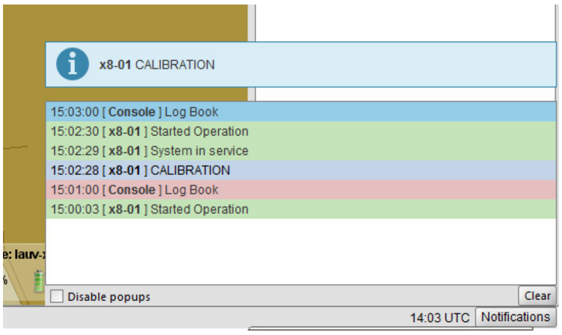


Fig. 3.10: Notifications Log

The *Profiles* menu allows the user to maximize the map.

3.2.6 Status Bar

In the bottom bar you can find information such as the main vehicle, the mission plan selected, the UTC clock, and the notifications area.

In the notifications area you can find the latest notifications of the console and vehicles. Check the *Notifications* (page 37) for details.

3.2.7 Locations

In Neptus, geo-referenced locations are edited with similar dialogs, optionally using the clipboard for copy/paste operations.

Location Parameters

The *Location Editor* (page 38) is used to edit locations in Neptus. Here, the user may insert the coordinates in different formats, as well as add North-East-Down offsets.

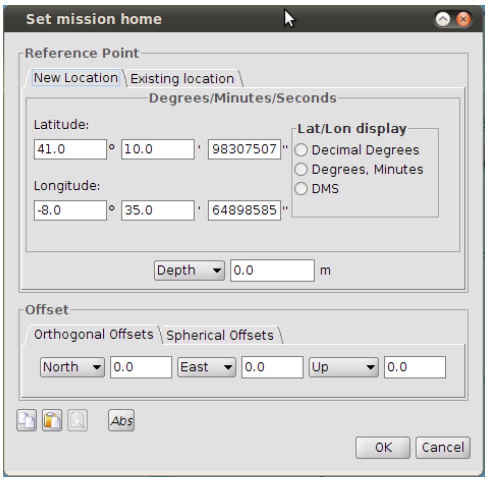


Fig. 3.11: Location Editor

Vertical references can be defined for Depth or Altitude from surface (drop-down selection)

On the bottom (*Copy/Paste panel* (page 39)), it is also possible to copy the current contents to clipboard or paste previously copied values. Locations may be copy/pasted without offsets by clicking on **Abs**.

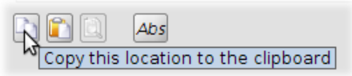


Fig. 3.12: Copy/Paste panel

3.2.8 Toolbar

The toolbar placed at the left of the map in the LAUV console. This toolbar allows the user to access extra features of the console.

Plan Editor

The plan editor creates and edits plans. Toggle *plan editor* (page 39) button in the map toolbar to enter this mode.

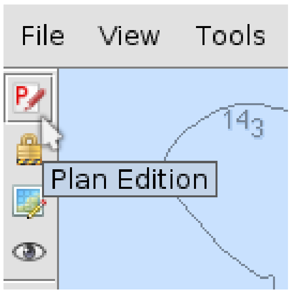


Fig. 3.13: Entering **Plan Editor** map interaction mode

When in plan editing, a side panel is added next to the map. Here, the user can view plan statistics, create and save plans, and also edit the parameters for each maneuver.

To add a *new plan*, click **New** on the side panel. If a plan was being edited, the user is prompted to save or discard any changes. Then, define the target vehicle for this plan. A new (empty) plan is created.

Note: Maneuvers' default parameters vary with the target vehicle

---

To **add** maneuvers, `Right-Click` on the desired location and select **Add <maneuver>**. The new maneuver copies parameters of previous maneuver or uses defaults.

Tip: Repeat last maneuver by pressing `Ctrl` and clicking on the map.

Tip: To copy any maneuver from the plan `Right-Click` on the handle then **Copy <maneuver> to clipboard**. Paste with `Right-Click` on the desired location and **Paste maneuver from clipboard**

To **edit** a maneuver, select the maneuver graphical handle (`Left-Click`) to view the parameters on the side panel. Maneuvers can be moved in the map using the handle.

To add a maneuver **before** another, `Right-Click` on the maneuver handle and select **add <maneuver> before <maneuver>**.

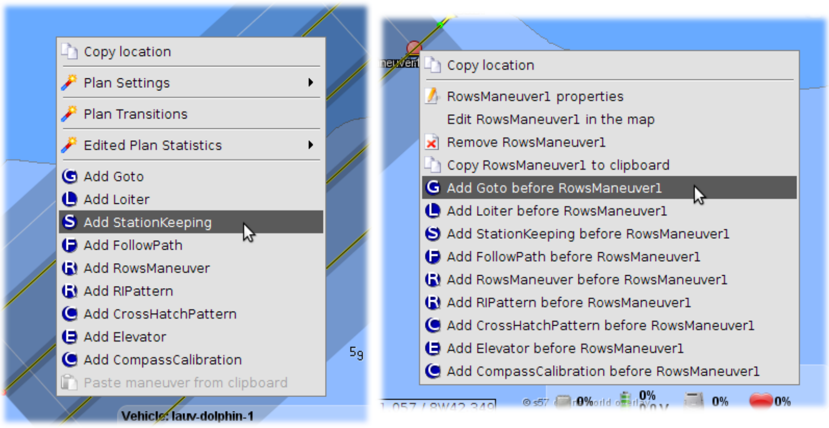


Fig. 3.14: Plan Editor: Right-click menu options (left) and maneuver options (right).

If multiple maneuvers' handles are overlapped, keep clicking to iterate through them.

Tip: Move the whole plan by moving any maneuver with `Ctrl` pressed.

Some maneuvers allow graphical edition using the mouse. These maneuvers are *FollowPath* (page 86), *Rows* (page 84) and *RIPattern* (page 86). For these, the user can double-click the handle maneuver, or, click **Edit** on the side panel - notice the color shift on the maneuver and also the text on the top of the map.

Remove maneuvers with `Right-Click` then **Remove <maneuver>** (*figure* (page 40)).

Plan Settings

Plan settings are common to **all** maneuvers in the plan. Edit them, by `Right-Click` in the map then open **Change Existing Maneuvers** menu option.

- **Plan depth / altitude** — set vertical reference for all maneuvers in the plan.
- **Plan speed** — set speed reference for the plan.
- **Payload settings** — edit payload for the plan.
- **Set plan vehicles** — (for advanced users) change the target vehicle for the plan.

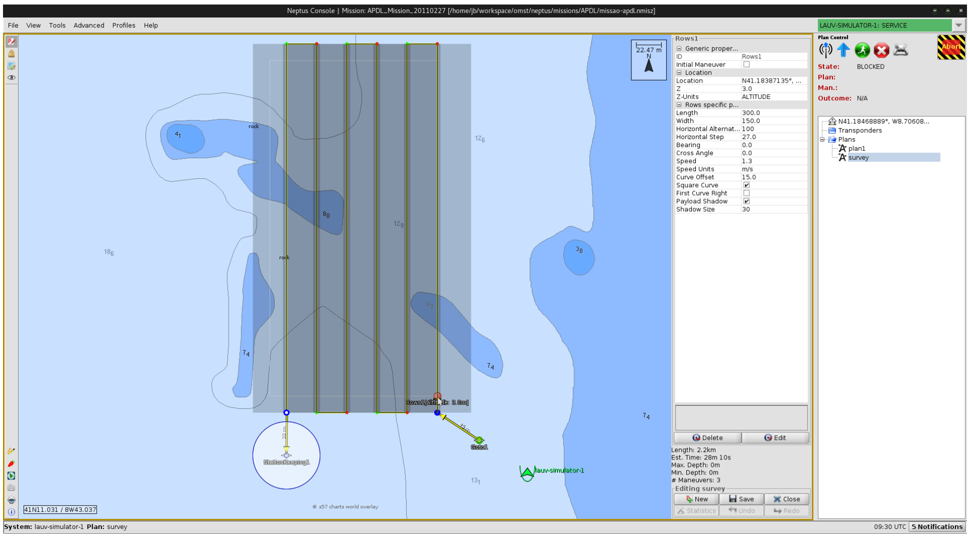


Fig. 3.15: Plan Edition mode

- **Revert plan transitions** — (for advanced users) *last* maneuver will be first, and transitions are reversing ending in the *initial* maneuver.

Note: These settings apply to **ALL** maneuvers.

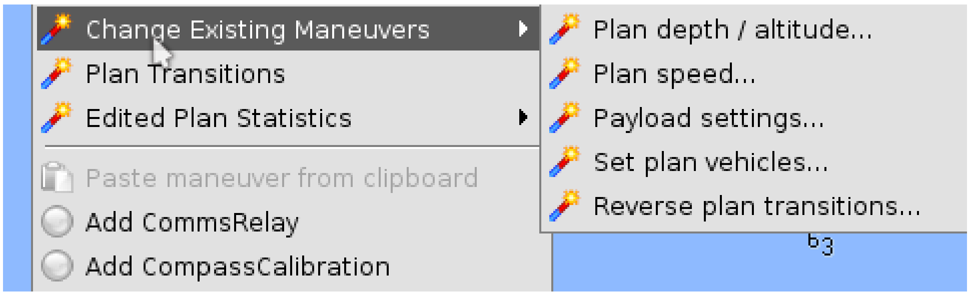


Fig. 3.16: Plan Settings menu actions are used for settings common to all maneuvers

Once plan is edited, verify all parameters (vertical reference, speed reference, active payload etc.) and click **Save** (side panel). Define plan's name and the new plan will be added to the mission tree.

Operational Limits

This modes enables the user to set the operational limits for the vehicle. Toggle *operational limits editor* (page 42) button in the map toolbar to enter this mode.

Once this mode is enabled, **Operational Limits** is visible on the top left corner of the map, and, upon `Right-Click` the map, the following *menu* (page 42) is shown to the user.

The menu options are:

- **Operational Limits** — opens a dialog to set limits.

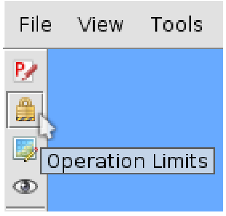


Fig. 3.17: Entering **Operational Limits** mode

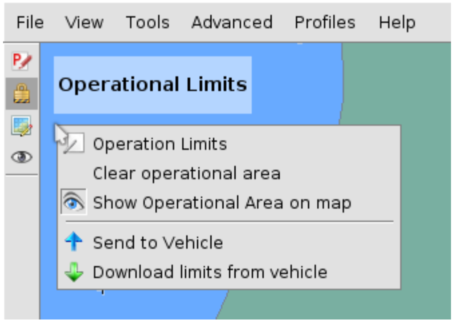


Fig. 3.18: Operational Limits menu

- **Clear operational area** — clears **Area Limits** ((1) see below).
- **Show operational area on map** — toggle area visibility.
- **Send to Vehicle** — synchronize limits in console to vehicle.
- **Download limits from vehicle** — synchronize limits in vehicle to console.

The user can set limits by selecting **Operational Limits** from the menu. The relevant LAUV options are:

- **Maximum Depth** - if the vehicle goes beyond this value, it enters in error mode.
- **Minimum Altitude** - if the vehicle approaches the seabed below this threshold, enters error mode.
- **(1) Area Limits** - horizontal area that define safe operation.

> **Warning:** When in error mode, depending on the entities in error, the vehicle does not start any plans. If the vehicle is breaching the operational area, then it is in error, and will reject plan start commands. To solve this, the user may 1) remove/update the limits, 2) command the vehicle in remote control, or, 3) press `Ctrl` while sending **Start Plan** to ignore errors during plan execution (advanced).

When **Area Limits** is selected, a popup window appears with a map. To select the area (rectangle), the user sets the width with two clicks to define one side's corners, and then the length (3rd click).

Figure (page 43) shows the limits dialog and also the area limit defined. Notice **Max Depth** visible on the top left corner.

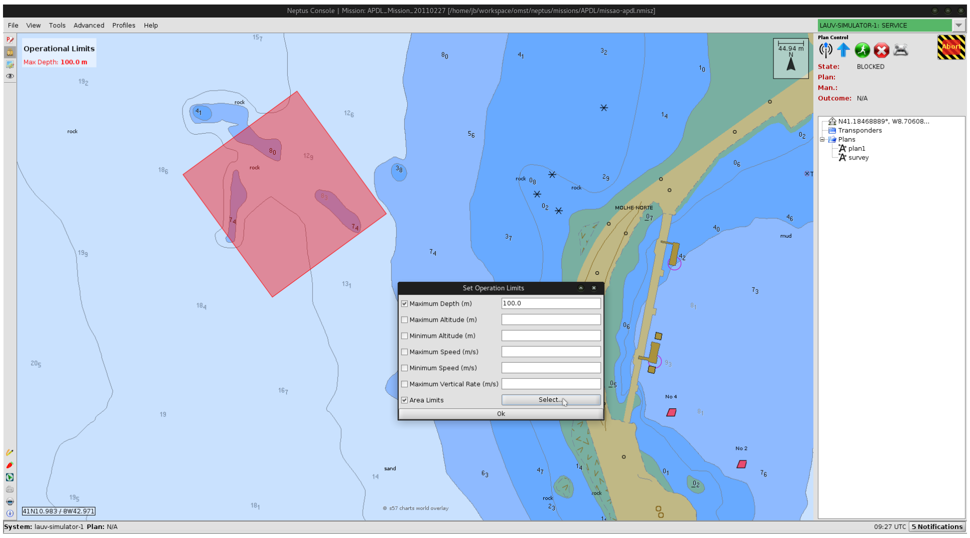


Fig. 3.19: Operional Limits mode - the red square is the current area limit.

Map Editor

Mission maps are a collection of features like geo-referenced marks, LBL beacon positions, images, polygons and other geometric elements which can be edited in Map Edition Mode. Enter map edition mode by toggling *Map Editor* (page 43).

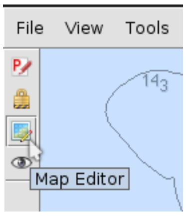


Fig. 3.20: Map Editor

Map Edition Tools

When in map edition mode, a new toolbar is added with edition tools. Here's a list:

Table 3.3: Map Edition Tools

Icon	Name	Description
	Box 2D	Add a box to the map
	Free-hand drawing	Open path (line) element
	Point-to-point drawing	Left-click to add line segments and right-click to finish the path
	Point-to-point polygon	Left-click to add line segments and right-click to finish the polygon
	Q-Route	Similar to the point-to-point but with a width property
	Mine danger area (MDA)	Click on the desired center of the MDA and move the mouse to define the circle
	Undo last operation	
	Redo last undone operation	

On top of these tools, the user can also right-click over the map to get a context-sensitive menu with options to add marks, cylinders, ellipsoids, aimges etc. A dialog with mark properties is then shown.

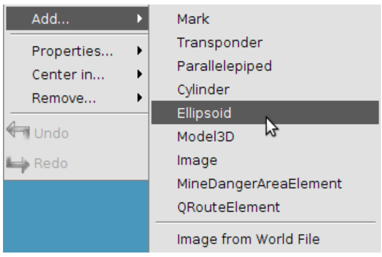


Fig. 3.21: Map pop-up menu

Object ID and *Object name* identify the object (no white spaces). By default, a valid ID is selected.

Objects' properties like geo-referenced location may be edited by right-clicking the object and selecting *Properties*. The location may also be edited through drag and drop. Some objects can be rotated while pressing the `Shift` key.

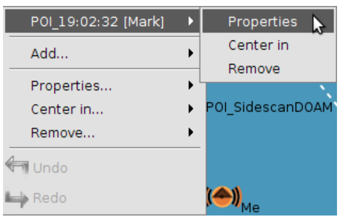


Fig. 3.22: Mark Properties

Figure *Map Features* (page 45) has a sample of possible object/feature options.

The map is saved to the mission file when leaving *Map Edition Mode*.

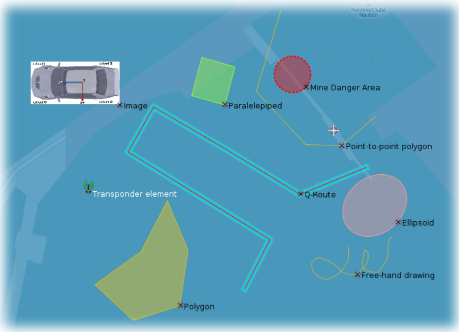


Fig. 3.23: Map Features

Log Preview

This mode allows the user to add layers with data from logs on top of the map.

To load the data, the user must enter the *log preview* (page 45) interaction mode.

Fig. 3.24: Entering **Log Preview** mode.

In this mode, a side control panel appears on the right of the map. Here, select a *log file* (page 45) (i.e. *Data.lsf.gz* file) and, from there, select which data overlays become visible. The user may also `Right-Click` the map and select **Open Lsf**.

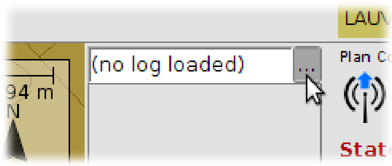


Fig. 3.25: Select log file using Log Preview toolbar.

Only the selected overlays are displayed on the map. Depending on the log, the list of available overlays may differ (e.g. Sidescan, Plan, GPS etc.)

Once the log is loaded, there are extra options available (`Right-Click` on the map):

- **Open LSF** — Open a different log file.
- **Open in MRA** — Open this log file using the Neptus MRA.
- **Import plan** — Import the plan in the log into this console.
- **3D Plot** — Show the vehicle's trajectory in 3 dimensions (popup window).

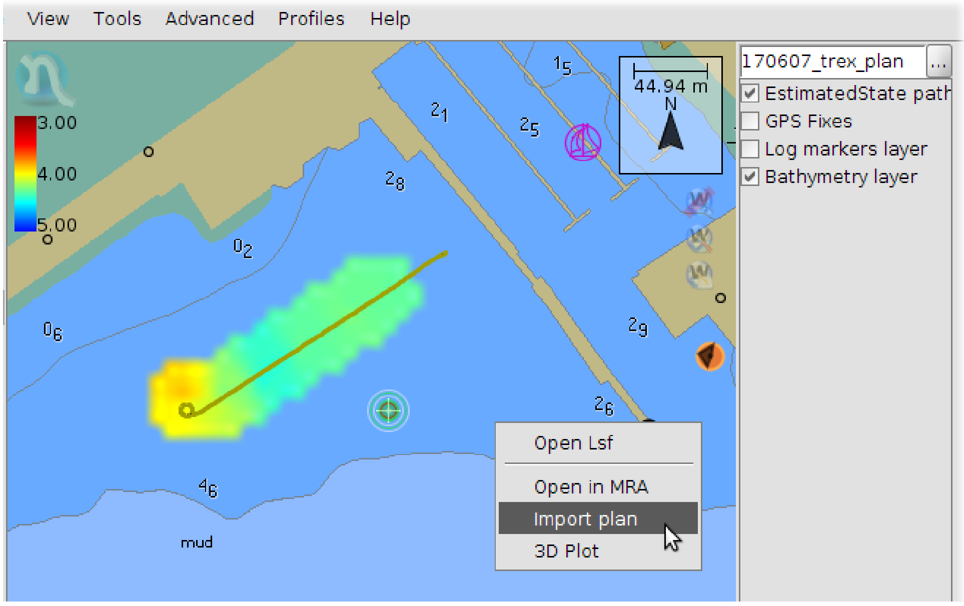


Fig. 3.26: Log Preview mode.

Tip: The data overlays remain visible if the user leaves the **Log Preview** mode.

Simulation Utilities

Neptus provides a series of simulation utilities that help the user predict and understand how a plan is being executed by the vehicle.

Plan execution preview

When a vehicle is executing a plan, the console's simulator executes the same plan in the background. Whenever the vehicle becomes disconnected, the simulated position of the vehicle becomes visible (gray arrow) to help keep track of execution.

Note: Be aware that the simulator computes position without external disturbances or knowledge of the environment. The actual state may differ.

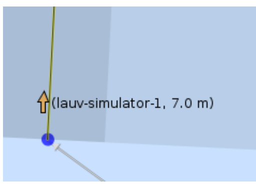


Fig. 3.27: Simulated vehicle position (the value *7.0m* is simulated depth)

Plan Simulation Mode

Neptus also provides a **Plan Simulation** mode where the user can preview the execution of any plan.

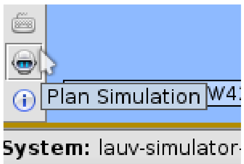


Fig. 3.28: Entering **Plan Simulation** mode

In **Plan Simulation** mode, a path with colored dots is added representing the expected travelled path of the vehicle.

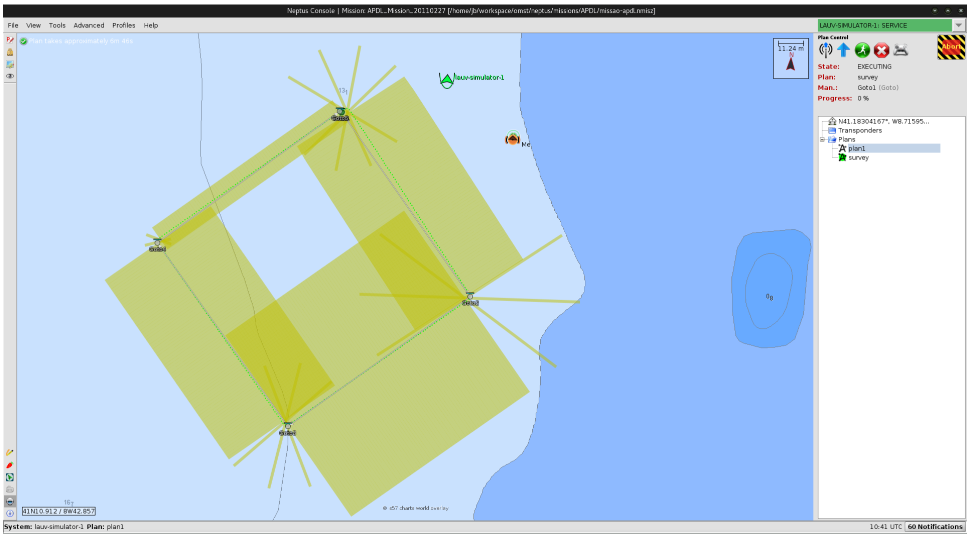


Fig. 3.29: Plan Simulation mode.

A useful feature is to display the areas covered by the sensor payloads, **as configured** in the plan. The covered area varies according with payload configuration, vehicle's trajectory and the depth of the ocean's floor.

Tip: Payload footprints have different colors. Yellow bars represent sidescan sonar coverage while blue bars represent multibeam coverage.

This mode assumes a default water channel height of *10m* which may be modified in the *console settings* (page 50) (advanced).

Extra Options

On the bottom of the toolbar, there are some extra tools.

- **Show tail** - allows to see the trail executed by the vehicle.

- **DesiredPath Layer** - draw on map the intended vehicle target.
- **Find Main System** - a layer is added to the map, on the right, signaling the distance and bearing between **My Location** and main system.
- **Keyboard Shortcuts** - shows the available shortcuts.
- **System Information On Map** - adds main system information on the bottom right corner of the map (CPU usage, fuel level, disk storage and communication link).

3.2.9 On-Map Features

World Map

World Map may be selected by `Right-Click` on the map and selecting **Choose Visible World Map**.

The configuration panel allows the map to be selected and downloaded, cache to be cleared, and visible area to be fetched. On the top of the dialog there's the zoom level indicator, used memory (whole application), and an indicator showing the number of tiles being loaded. *Stop Loading* clears all the memory tile cache and also stops all pending downloads tiles.

Tiles are loaded as needed. Some will take more time to load. Tiles are stored in disk in a `.cache/wmcache` folder. This folder can be copied to other consoles.

Note: Available map providers may vary. The map named *Mercator SVG (Local)* does not require internet access since it is generated from an internal SVG (Scalable Vector Graphics) file.

My Location

This component defines the operator's location. The icon drawn is the following . The arrow indicates the bearing. If bearing is unknown, the arrow points North.

`Right-Click` on the map to view **My location** menu. There are a few *options* (page 49):

- **Add My location to map as marker** - add current location as marker.
- **Copy/Paste** - copy/paste current my location.
- **Set this location as Mine** — update my location to the selected map position.
- **Set to use a system position and heading as mine** — useful if Manta Gateways are near.
- **Change the system to use heading from (using)** — use heading from <system>
- **Change the system to derive heading from (using)** — derive heading from <system>
- **Settings** — change settings.

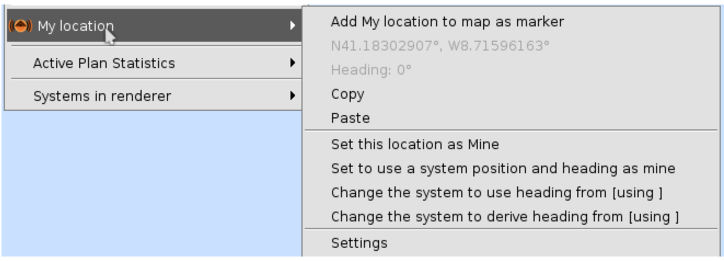


Fig. 3.30: My Location

Command Planner

The command planner allows the operator to send quick plans to the vehicle. The planner can be accessed via `Mouse Right-Click` (*figure* (page 49))

Fig. 3.31: Command Planner

Then, select **Command <vehicle>**. All maneuvers move the vehicle to the location clicked on the map.

Available commands:

- **Go here** – sends a *Goto* (page 80)
- **Surface here** – sends a *Station Keeping* (page 82)
- **Loiter here** – sends a *Loiter* (page 81)

Tip: Default parameters can be modified in the *Console Settings* (page 50)

Warning: Upon click on the selected command, it will be issue immediately to the vehicle.

Contact Marker

This feature adds/removes/copies marks to the map. This component is accessible as a menu on the renderer (*figure* (page 50)).

This component allows to add or remove marks, as well as to copy the location of those marks.

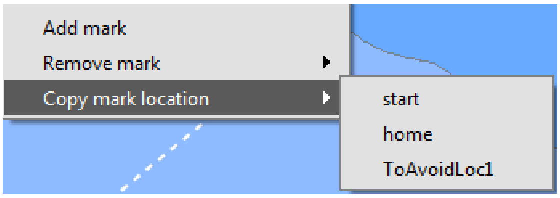


Fig. 3.32: Contact Marker

Note: You can add known systems locations as markers to the map.

3.3 Plugins

From the LAUV console, the user may access a list of plugins. These plugins interface with LAUV functionalities. This section identifies all the plugins available under "View" menu action.

3.3.1 Settings

Console components may have properties and configurations to be set. You can find them in the unified interface on the *View* → *Console Settings* (`Ctrl+F3`).

All properties with an asterisk (*) affect all windows of Neptus (both console and mission review) while the others only affect the console.

On the bottom of the dialog, "Advanced" check box show the advanced properties. These parameters can be saved or changes cancelled.

Warning: Do not change "advanced" properties unless you know exactly what you are doing or you have been instructed to do so by a technical adviser.

3.3.2 Acoustic Operations

This add-on handles acoustic operations requests from the user. This feature is available under "View" on the menu bar (or `Ctrl-M` shortcut).

This features opens a dialog with two tabs, **Acoustic Operations** and **Gateway State**. In the first the user may select the target system from a comprehensible list of systems (left) and the desired acoustic operation (right). There are a few options:

- **GW: <system>** — select default gateway, or, any.
- **Range system** — request gateway to ping another system (get the distance).
- **Send command** — send command (advanced only).

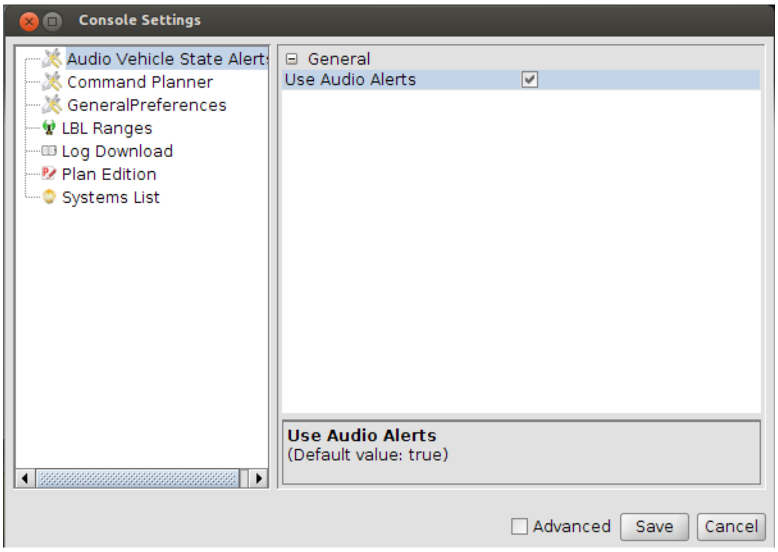


Fig. 3.33: Console Settings Dialog

- **Abort** — send an acoustic abort to the system.
- **Clear Ranges** — clear ranges drawn on the map.
- **Show Ranges** — checkbox to define if ranges are visible or not.

On the bottom of the first tab there's a text section with output.

The gateway state contains information about the selected gateway (if connected).

Tip:  The ranges are drawn as circles (with radius corresponding to the distance) and centered in the chosen gateway's location. Range from two systems to get a fix, or, range a system to keep track of plan progress.

3.3.3 Chronometer

This add-on allows the operator to keep track of time. The chronometer is accessible under "View" tab on the menu bar (or `Ctrl-K` shortcut).

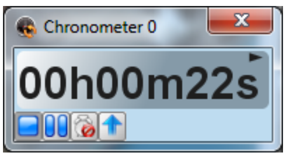


Fig. 3.34: Chronometer Panel

3.3.4 Controllers Panel

The controllers panel (`Ctrl-J`) allows the user to configure joysticks/gamepads for remote control of the LAUV. This feature should be tested before, by allocating functions to the gamepad and then testing the vehicle before deployment.

3.3.5 Entity State Panel

This component list all the entities' states (*figure* (page 52)) reported by main vehicle. Select **Entities** in menu bar's "View".

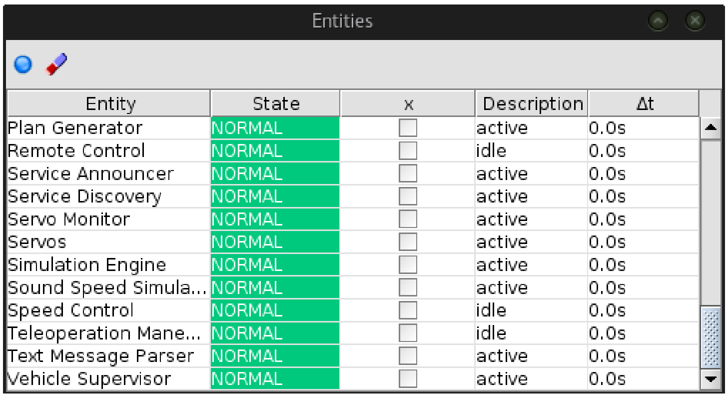


Fig. 3.35: Entities State Panel

This feature opens a panel in a tabular form. The first column shows the entity name. The second indicates the state (see below for the meaning). The third allows the user to ignore the state for the summary alarm. The fourth shows the entity state description. The last column indicates the elapsed time since last update.

On top, a LED indicator summarizes the overall state. Next to it, an eraser can reset the table. The next table indicates the states, color codes, and meanings.

Table 3.4: Entity State codes

Color	Meaning	Description
Green	Normal	Normal execution
Blue	Info	Entity booting/initializing
Yellow	Fault	Minor fault
Orange	Error	Entity in error
Red	Failure	Entity in critical failure

3.3.6 Navigation Alignment

This add-on helps the user aligning navigation for *dead-reckoning* operations after *tactical grade* IMU is enabled (i.e. powered on). This feature is available in *View→Navigation Alignment* (`Ctrl+I`)

Fig. 3.36: Navigation Alignment

This feature dialog has two buttons on top and a text box:

- **Enable IMU** — enables/disables the IMU device.
- **Do Alignment** — suggests an alignment template plan to be added to the plan list.

The current state of alignment is shown on the text box.

> **Warning:** The template generated by **Do Alignment** may not be safe. Edit plan to oversee generated path.

The user may also opt to create the plan. As soon as the IMU is enabled, the navigation filter fuses GPS, IMU and speed data to estimate initial heading

> **Tip:** **Any straight lines on the surface** align the navigation.

When alignment is done, the text box status is updated and there's also an audio alert to warn the operator.

3.3.7 LBL Ranges

This component oversees LBL execution (*figure* (page 53)). On top there's a toolbar with options. The bottom part shows the incoming ranges. The options on top are:

- **Play Sound** — toggle sounds (for range receptions)
- **Hide Tracker Data** — do not paint ranges
- **Reset Tracker** — resets tracker

Fig. 3.37: LBL Ranges

The ranges are *drawn on map* (page 54) centered around transponder/system.

3.3.8 LogBook History

This component shows the vehicle's low level *logbook output* (page 54).

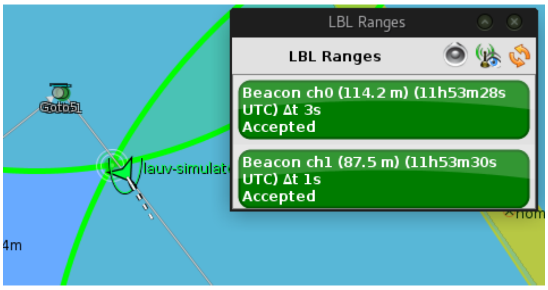


Fig. 3.38: LBL Ranges (green circles)

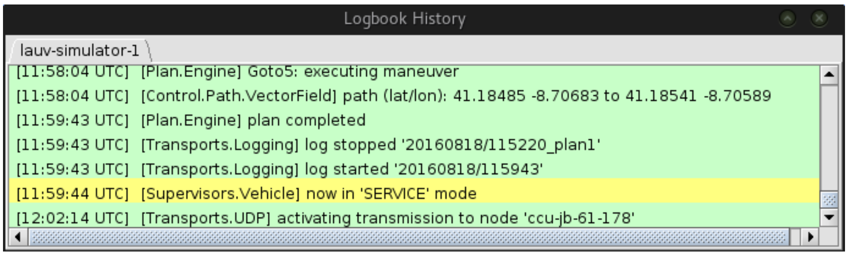


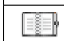
Fig. 3.39: LogBook History

Entries are colored according with importance. Red for highest importance (errors) yellow for medium importance (warnings) and green for low importance (information). Developer (debug) output is shown in grey.

3.3.9 Log Download

This component manages download of logs. The panel is composed of three buttons.

Table 3.5: Buttons explanation.

Symbols	Description
	*Deprecated*
Sync Logs	Synchronize current day's logs from system
	Open **Download Log Files**

Download Log Files

Log Download's third button opens this component. This controls and monitors download activities.

The component is comprised by three parts. The top left lists the log folders with download state icon indicators (see *table* (page 56)). The top right lists the files. On the bottom, the download state of each file is shown with options to retry or stop.

The *figure* (page 55) below shows the controls available. The first button synchronizes the log list from the system. The second and third buttons download selected folders and selected files, respectively. The fourth and fifth, delete folders and files from the remote system, respectively. The red button stops all downloads.

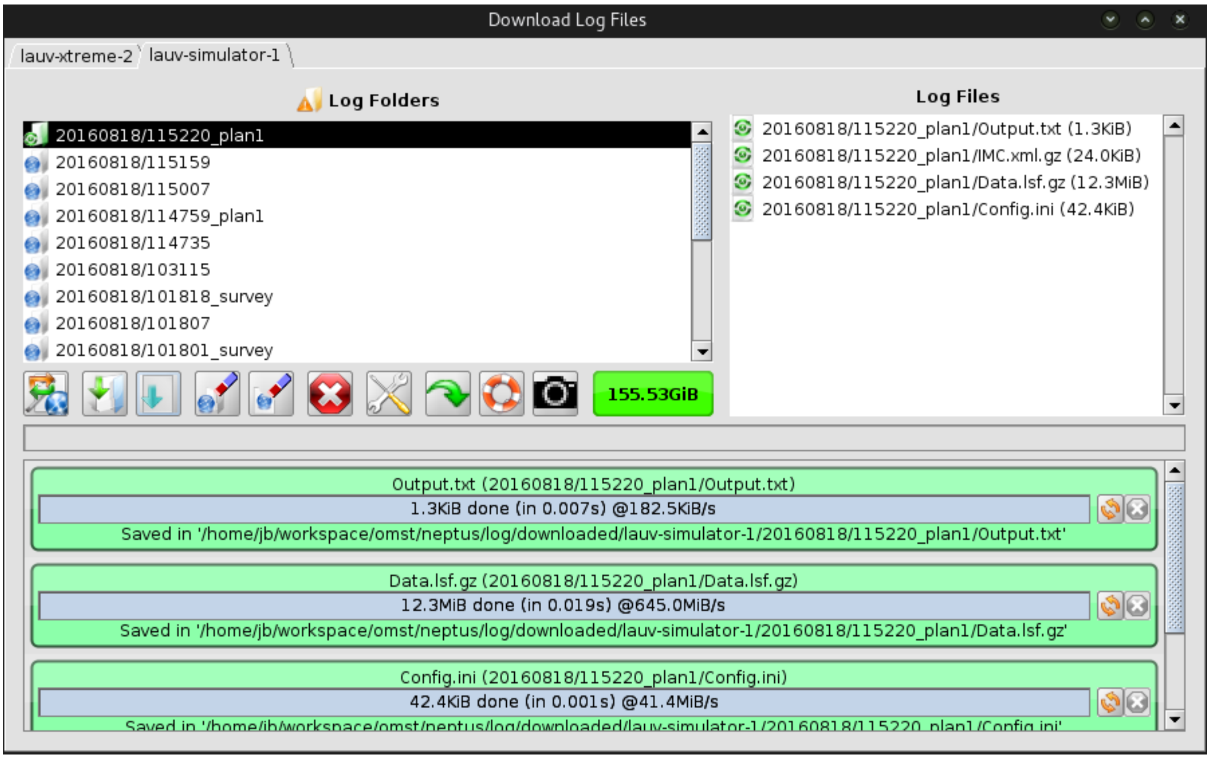


Fig. 3.40: Download Log Files

The *tools* button show the *network configurations* (page 55). These are automatically set.

Fig. 3.41: Logs Downloader Controls

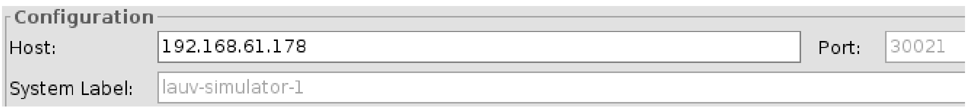


Fig. 3.42: Logs Downloader Config

The *green curly arrow* button resets the interface (in case of failure). The last button shows the icon's description help. The next *table* (page 56) summarizes this information.

Table 3.6: Download Log Files' icons description

Folder	File	Description
		New log in the server.
		Log being downloaded from the server.
		Log synchronized with the server.
		Log with errors.
		Log incomplete.
		Log only local.
		Log on local disk but state unknown.

Finally there's a label showing the available space on the remote system. This label changes color from green to red as free space diminishes.

3.3.10 Real-Time Plot

This component is a sort of developer add-on which may be helpful to monitor data in real-time. This component is a timeseries plot with two options:

- **Settings** — define instructions, periodicity, and number of trace points.
- **Clear** — clears current plot.

The basic instructions (*how to plot Euler Angles in degrees* (page 56)) are of type:

- <label>: ... ${*<IMC Message>*.*<field>*} ...

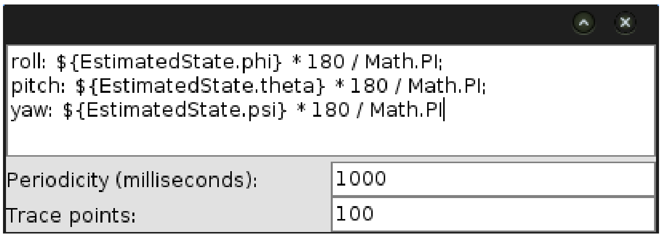


Fig. 3.43: Real-Time Plot: instructions example

This feature plots the data for **all** vehicles connected and not only main vehicle.

3.3.11 Systems Configuration

The system configuration handles the vehicle parameters (see *section* (page 32)). The figure *Systems Configuration* (page 57) depicts the interface for the *lauv-simulator-1* system. Each entry has a background color associated:

- **Red** — different from vehicle
- **Green** — synchronized with the vehicle.

Warning: Always hit **Refresh** before modifying new parameters.

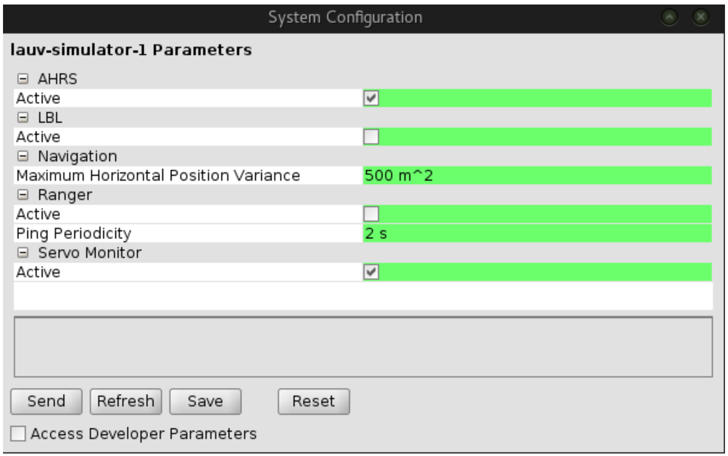


Fig. 3.44: Systems Configuration

On the bottom, the options are:

- **Send** — send to vehicle. Parameters **not saved** will be resetted during reboot.
- **Refresh** — get current parameters from vehicle.
- **Save** — saves parameters **in** vehicle (even if not synchronized with console).
- **Reset** — reset to default.
- **Access Developer Parameters** — (advanced) access full list of parameters.

Warning: Do **NOT** change developer parameters unless you know exactly what you are doing or you have been instructed to do so by a technical adviser. Sending the wrong parameters may result in an inoperable vehicle.

3.3.12 Systems List

The **Systems List** shows the known systems in the network and their summary state. *Figure* (page 58) shows the component with one system connected and without errors (*System List color codes* (page 58))

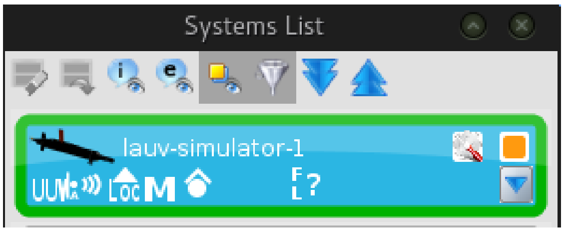


Fig. 3.45: Systems List Panel

Table 3.7: System List color codes

Color	Description
Cyan	Connected; no errors
Dark Blue	Not connected; no errors prior
Orange	Connected; with errors
Red	Not connected; with errors prior
Grey	System not being followed

The main vehicle is identified with the border color **green**.

On top of the component, the user may add information layers on map, filter other systems, expand/collapse information in component (*figure* (page 58)), etc..

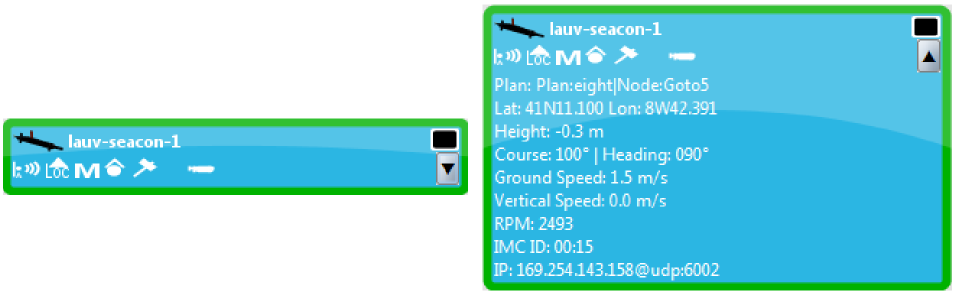


Fig. 3.46: Systems List Collapse and Extended

Each vehicle label inside Systems List has a series of icons (just below the vehicle name) that carry meaning:

Table 3.8: System List icons meaning

		Description
		Connectivity to the system.
		Location known/unknown (`Rigth-Click` to copy)
		Main Vehicle
		Authority (`Right-Click` to edit)
		Vehicle is executing a plan
		Require attention
		Two systems with same id in the network
		Fuel level indication

Authority actions:

- **OFF** — no message interaction with this system (system will be ignored).
- **NONE** — location is tracked but not main focus.
- **SYSTEM_FULL** – full system control (default)

3.3.13 USBL Configuration

This component manages USBL operations. The LAUV must be equipped with a USBL-compatible modem and an external USBL modem is required for this operation.

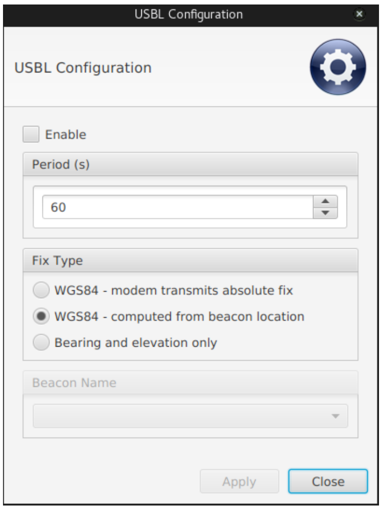


Fig. 3.47: USBL Configuration

LAUV supports three types of USBL interaction:

1. WGS84 - modem transmits absolute fix
2. WGS84 - computed from beacon location
3. Bearing and elevation only.

The *WGS84* interactions apply a 3-way acoustic transmission protocol between the LAUV and the USBL per measurement. The USBL **must be** connected to a Manta Gateway. The transmission protocol is:

1. When **Enable** is checked, vehicle sends an acoustic request with desired **Period** to the water channel. This request is sent repeatedly until a USBL modem replies back to confirm the setup.
2. A timer on the Manta Gateway triggers transmission (#1): USBL –> LAUV.
3. The acoustic modem on the LAUV replies automatically (#2): LAUV –> USBL.
4. USBL computes distance and angles, and transmits the data (#3): USBL –> LAUV.

The difference between both interactions is:

- **Modem transmits absolute fix** — Manta Gateway uses its position (from GPS) to convert distance and angles to WGS-84 coordinates. Some remarks:
  - If USBL position differs from Manta Gateway's, an error is introduced.
  - Errors on Manta Gateway's position estimation reduce fix quality.

  - The LAUV does not need to know location of the USBL.

- **Computed from beacon location** — in this mode, the raw data from USBL is transmitted immediately to the LAUV (distance and angles). The LAUV computes the WGS-84 location from a known (static) position:

  - To set USBL position on LAUV: add a *Transponder* to the mission tree. Transponder's configuration file must be the Manta Gateway. Select the Manta system on **Beacon Name**.
  - Any errors on the position given to the LAUV reduce fix quality.
  - If the beacon position is **not** given to the vehicle, the interaction still occurs, but no fix is computed (distance and angles are logged).

Both *WGS84* interactions require a USBL with an internal compass inside.

Finally, **Bearing and elevation only** do not provide a fix to the vehicle. This mode only provides the bearing and elevation from the LAUV to the USBL. This interaction establishes a 2-way acoustic transmission:

1. When **Enable** is checked, a LAUV timer with defined **Period** triggers an acoustic transmission (#1): LAUV –> USBL.
2. The acoustic modem computes bearing and elevation.
3. Manta Gateway transmits this information (#2): USBL –> LAUV.

This information is logged by the system.

3.3.14 Plugin Manager

Neptus is a framework that supports multiple systems. This means it has extra features usually hidden. Plugins may be added (or removed) to the console using the **Plugin Manager** under "View" menu action (`Ctrl-P`).

This manager is for advanced users. It shows two lists of plugins. The left list shows **all** available plugin options, while on the right, only the **active** plugins are shown (i.e. plugins added to the LAUV console). There are options to **add**, **remove**, and to edit **settings**.

> **Warning:** Do not use this feature unless you know exactly what you are doing or you have been instructed to do so by a technical adviser. Removing or adding plugins to the console may cause unwanted behavior.

3.4 Mission Revision and Analysis

The Neptus interface for analyzing data is the MRA (Mission Review and Analysis) shown in *figure* (page 61). This interface is used to view data logs.

MRA interface is divided in two panels. On the left side, the messages and available visualizations are listed, while on the right the active visualization is displayed. Any IMC

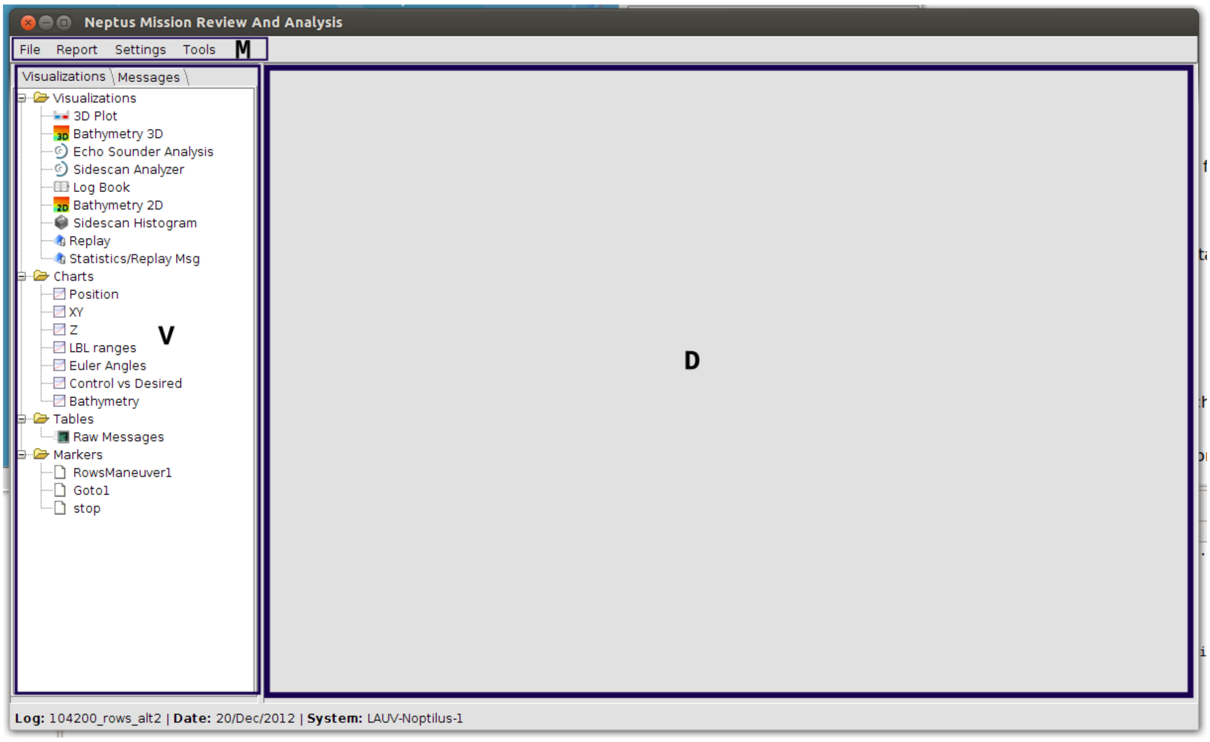


Fig. 3.48: MRA sections: **M** menu bar, **V** visualizations selection, **D** display panel.

message can be inspected in a tabular form or as a multi-variable/multi-message time-series plot. Some plots are predefined and others may be generated by selecting fields to plot.

Other specialized visualizations are also available, and similarly to the console widgets, can be added as Neptus plug-ins. Examples of these specialized visualizations are the sidescan analyzer, multi-variable plots, mission replays with map overlays and more.

3.4.1 Panels

Menu Bar

- **File** — open logs.
- **Report** — generate PDF log reports.
- **Settings** — edit Preferences; open a mission file to be applied in the replay; change tides.
- **Tools** — log downloader; concatenate or fuse logs; file exporter.

Visualizations/Messages Tabs

Select and create visualizations. Composed by two tabs: the **Visualizations** tree and **Messages** tab.

Visualizations Tree

The visualizations tree is the MRA component where you can find the available/opened visualizations.

In the tree you find four branches:

- **Visualizations** — available visualizations.
- **Charts** — available and created plots.
- **Tables** — available and created tables.
- **Markers** — list of markers.

Messages Tab

The message tab lists all logged IMC messages types. Each message can be expanded to view its fields.

Select a message type, `Right-Click` it and select *Show ... Data* to view all messages in a table.

You can also plot some of the message's fields. To do so, select one or more messages fields (hold `Ctrl` while selecting fields) and `Right-Click`. A pop up menu shows all options.

Display Panel

The display panel shows the active visualization.

3.4.2 Log Book

Log Book visualization (*figure* (page 63)) shows the output of a system. Entries are ordered by timestamp and background color denotes meaning:

- **Green** — Info
- **Yellow** — Warning
- **Red** — Error

3.4.3 Mission Replay

The *Mission Replay* (page 63) component is comprised of map component and a timeline. Replay can be in real-time or accelerated.

The timeline bar (LAUV logs data in UTC) contains the following buttons:

- **Play/Pause**
- **Replay Speed**

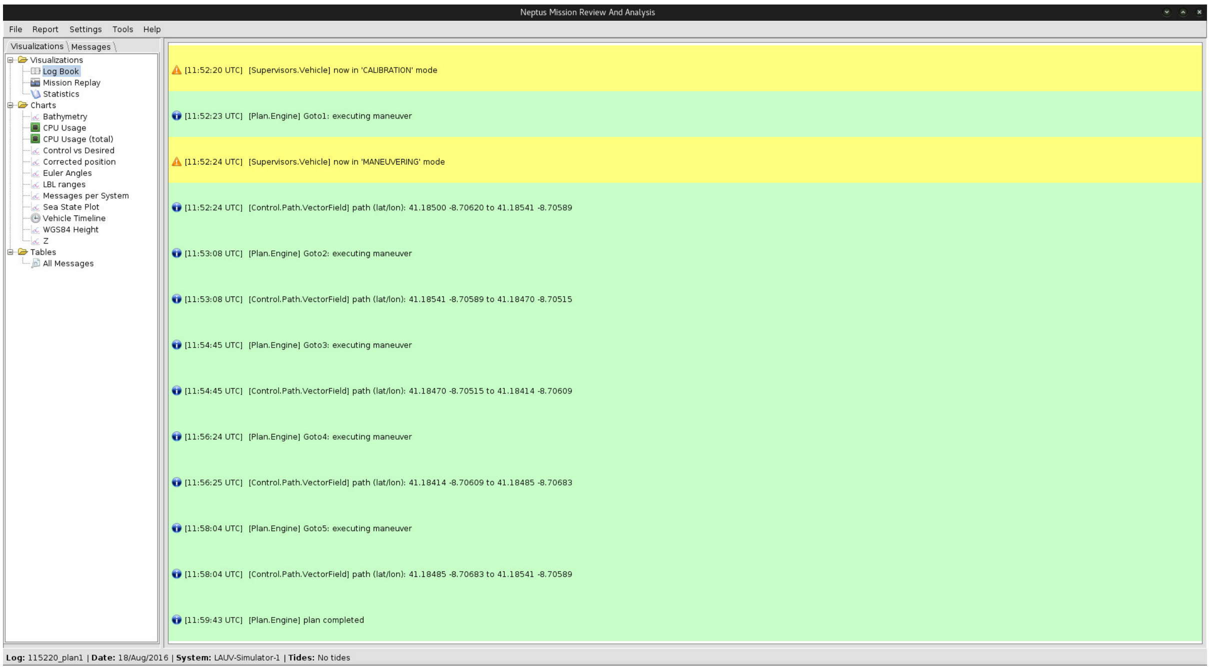


Fig. 3.49: Log Book Visualization

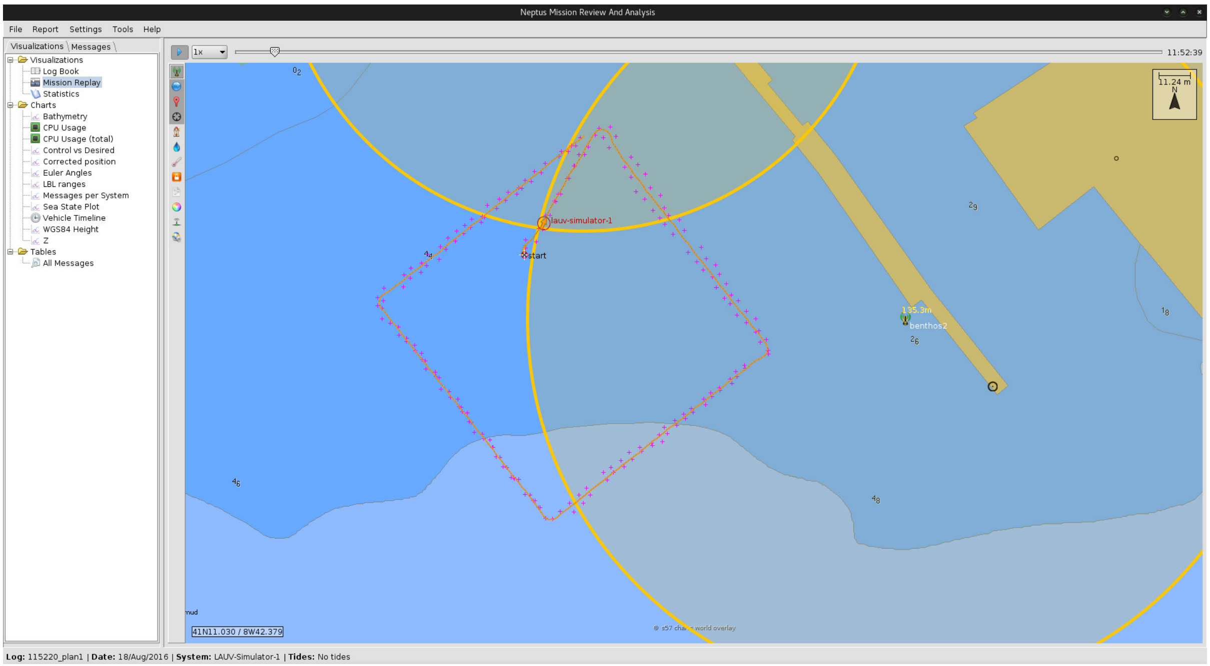


Fig. 3.50: Mission Replay

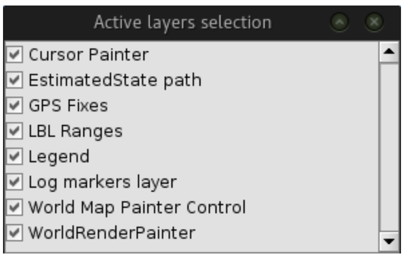


Fig. 3.51: Visible layers dialog

The layers added to the replay vary with payload. `Right-Click` on the map, then select **Choose Visible Layers** to list all options (see *example* (page 63)).

By default, more computational expensive layers like sidescan or bathymetry maps are not displayed.

3.4.4 Statistics

This is a *simple table* (page 64) with key statistics from log.

Vehicle	lauv-simulator-1
Mission start time	Thu Aug 18 12:52:20 WEST 2016
Mission end time	Thu Aug 18 12:59:43 WEST 2016
Mission duration	7m 23s
Maximum depth	2.14 m
Avg depth	1.85 m
Roll min/max/amp/avg	-2.31° / 2.05° / 4.36° / 0.08°
Pitch min/max/amp/avg	-14.43° / 0.13° / 14.55° / -2.19°
Distance travelled	523.85 m
Mean speed	1.18 m/s
Home Latitude	41N10'59.72405''
Home Longitude	8W42'58.776426''

Fig. 3.52: MRA Statistics

3.4.5 Sidescan Analyzer

Neptus MRA contains a **Sidescan Data Analyzer** that supports multiple file formats. It also supports the following features:

- Multiple simultaneous data channels
- Cascade annotation (available to all the other visualizations)
- Zooming and Measuring
- Per beam information
- Colormap customization
- TVG and normalization
- Vehicle position HUD
- MPEG record capability of the data replay.

Top Toolbar

The top toolbar contains the following options:

- **Info** — Displays information about the swath and beam being pointed to.
- **Length** — Select this mode to measure the length of objects (across beams).
- **Height** — Measure heights within beams - useful to measure shadows.
- **Mark** — Define a mark (shared with other visualizations) - useful for target tracking.
- **Zoom** — Zoomed layer.
- **Normalization** — Normalization index.

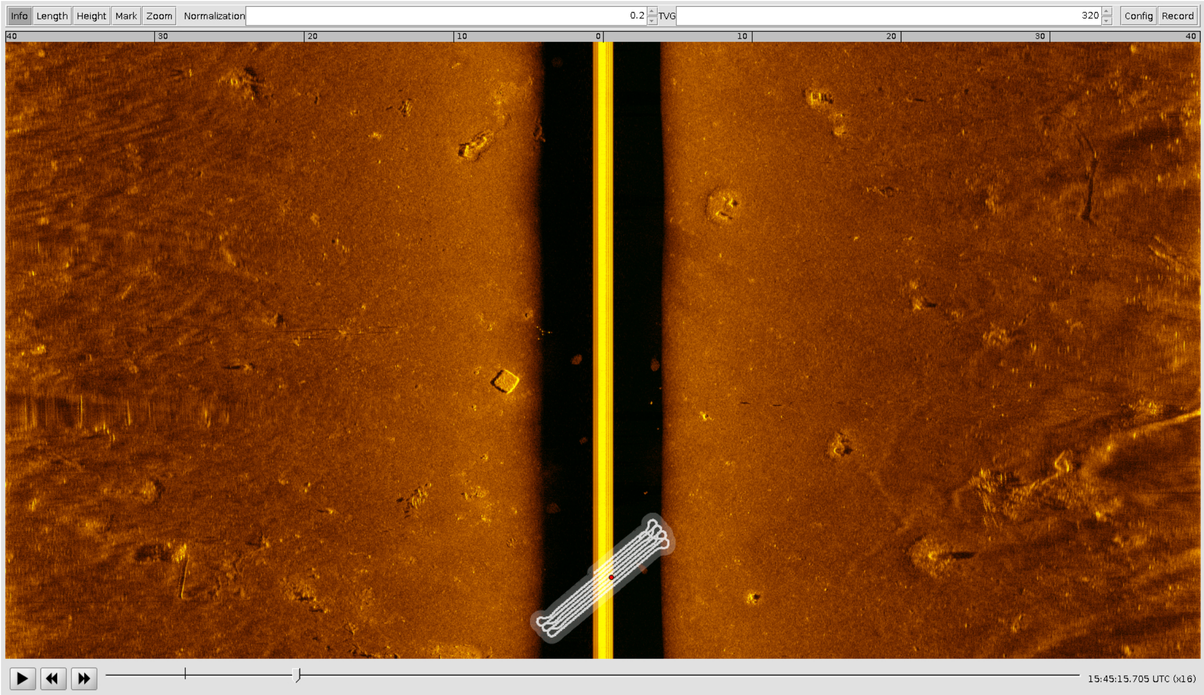


Fig. 3.53: Sidescan Analyzer

- **TVG** — Time-Variable Gain.
- **Config** — Analyzer settings.
- **Record** — Record video.

Normalization and Time-Variable Gain may vary according with sidescan model chosen. Here's a list of values normally used to properly view the data:

- **Klein UUV 3500 / Edgetech 2205** — Norm: (0.1, 0.2), TVG: (100, 280)
- **Imagenex 872** — Norm: 127.5, TVG: 0.5
- **DeepVision OSM2 / StarFish 450/900** — Norm: (30, 44), TVG: (-30, -38)

Timeline bar

The timeline bar contains the following buttons:

- **Play/Pause**
- **Replay Speed**

Markers are also drawn on the timeline.

Channel Configuration

Every channel can be configured through the **Config** button. The different options are:

- **Vehicle Path** — change path track color, toggle visualization, etc.
- **Apply slant range correction** — cross path correction with slant range.

- **Color map to use** — multiple options to choose from.
- **Apply speed correction** — apply speed correction along path.

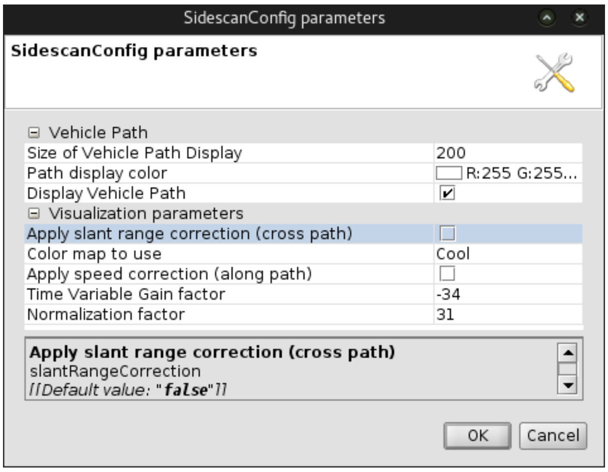


Fig. 3.54: Sidescan Analyer config.

3.4.6 Video

The **Video** visualization is used to analyze footage from on-board optical cameras. This visualization supports *.mjpeg* files.

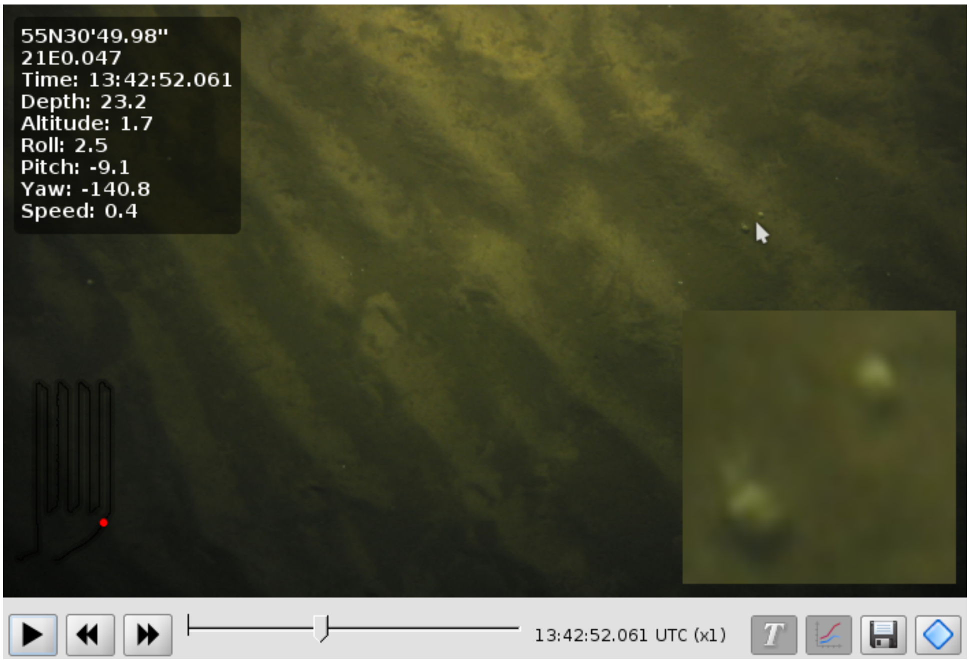


Fig. 3.55: Video visualization

This visualization has a timeline bar, HUD with vehicle information per frame and the vehicle track. Moreover, `Right-Click` the frame shows the zoomed location.

Timeline bar

The timeline bar contains the following buttons:

- **Play/Pause**
- **Replay Speed**
- **Show Caption** - toggle vehicle information.
- **Show Track** - toggle vehicle track.
- **Save Current Photo** - save a *.jpeg* file.
- **Add marker** - adds a marker in the current frame timestamp.

Markers drawn on the timeline.

3.4.7 Raw Data

Table Visualization

Table visualization shows all fields from a IMC message type (e.g: SoundSpeed).

To open a new table:

- In MRA, select **Messages** tab.
- `Right-Click` desired message.
- Select **Show <message> Data** option.

A new table visualization just like the following figure is added to the MRA.

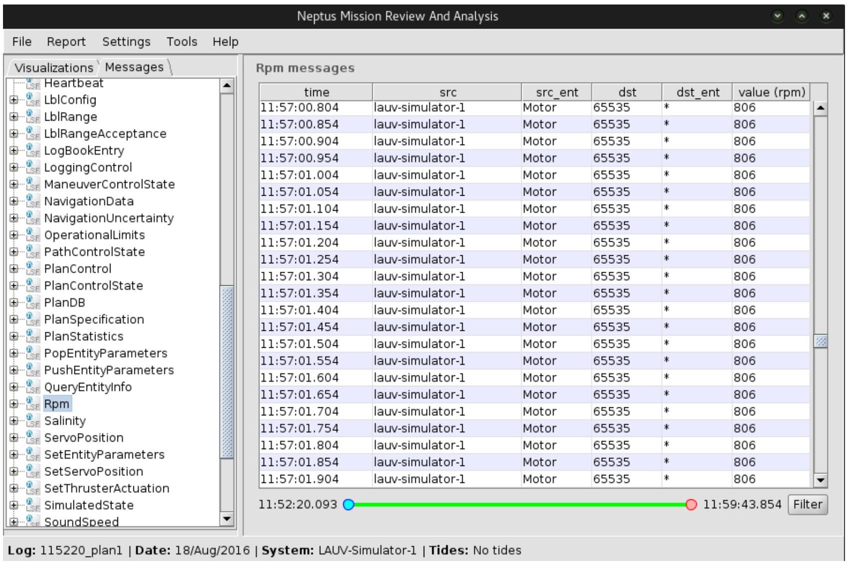


Fig. 3.56: Table example.

This table is added to the Tables list under Visualizations tab.

Time-series plots

Time-series plots allow to plot system variables over time. When opening a log in MRA there is a set of default plots available under 'Charts' in the Visualizations tab.

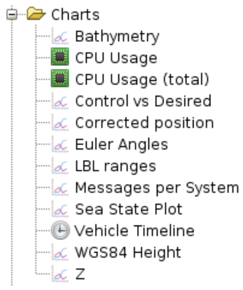


Fig. 3.57: List of generated plots.

Note: Generated plots vary according with data availability.

Custom time-series plots may be added with:

- In MRA, select **Messages** tab.
- Select messages' fields (multiple selection with `Ctrl`)
- `Right-Click` in any of selected messages to open context menu.

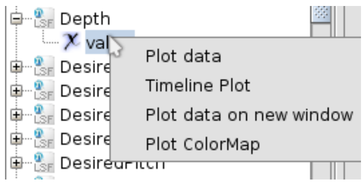


Fig. 3.58: Context menu to generate time-series plots.

Several options are available:

- **Plot Data** — plot data over time.
- **Timeline plot** — combines a timeseries plot with a timeline replay.
- **Plot Data on new window** — plot data on a new window.
- **Plot ColorMap*** — XY plot with a colormap.

The time-series plot has the following options:

- **Series** - filter entries by entity
- **Time Step** - change visualization time step (0 to plot everything)
- **Redraw** - redraw plot if time step has been modified.

`Right-Click` on the plot shows extra options:

- **Properties** - update plot properties.
- **Save as** - produce a *.png* figure of the plot

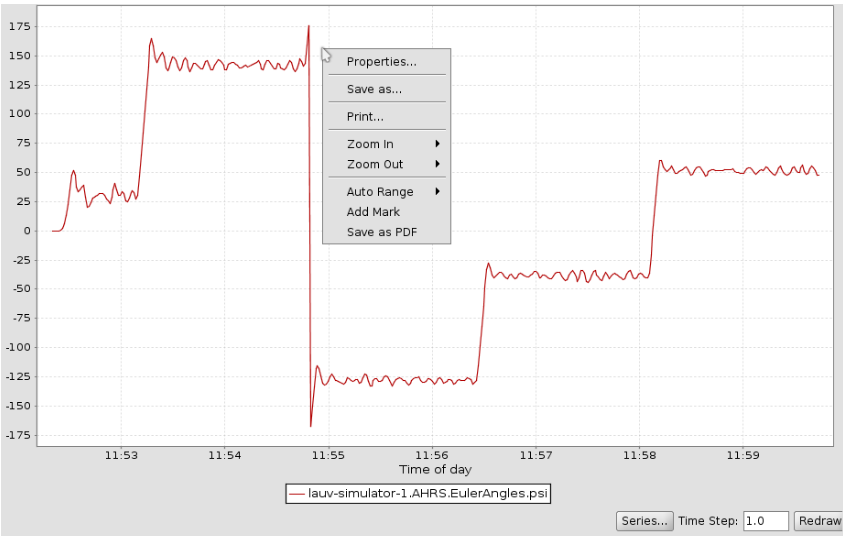


Fig. 3.59: Time-series plot.

- **Print**
- **Zoom In/Out** - select one of the axis or both.
- **Auto Range** - select one of the axis or both.
- **Add Mark** - adds a mark in the selected area.
- **Save as PDF** - produce a *.pdf* file with the plot.

CHAPTER 4

Operation Procedures

This chapter introduces key operation guidelines and a list of supported maneuvers.

4.1 Create Mission

1. Launch Neptus console
2. Select *File→Create Mission*
3. Insert coordinates for the mission location (vicinity of the area).
4. Select folder to save missions (mission files use *.nmisz* extension).
5. Insert mission name and Save.

Warning: The mission location should be focused near *My Location* (page 48) marker. To reduce computational costs, several elements on neptus are computed relative to map location.

After mission creation, there are no plans and no transponders in the *mission tree* (page 36).

4.2 Connect and Check Status

Before starting operations, it is paramount to check LAUV status before deploying the system into the water.

1. Power on the vehicle.
2. Verify LED sequence (*LED Patterns* (page 11)).
3. In the console, check if vehicle enters **SERVICE** mode.
4. Select *View→Entities* to open *Entity State Panel* (page 52).
5. Check if there are no entities in error or failure.

Warning: Do **not** deploy the vehicle if not in **SERVICE** mode.

4.3 Enable Acoustic Reports

Acoustic Reports are periodic acoustic messages sent through vehicle's modem that carry status information. This is useful to keep track of vehicle position during underwater mission execution, estimate plan progress or get current fuel level.

1. Select *View→System Configuration* (`Ctrl+Z`) to open the *Systems Configuration* (page 56) for the main vehicle.
2. Under **Report Supervisor** tab, enable **Acoustic Reports**.
3. Set periodicity in **Acoustic Reports Periodicity**
4. Press **Send**.

4.4 Enable Emergency Monitor

This feature functionality is described *here* (page 21). To enable this monitor:

1. Verify vehicle's credit.
2. Select *View→System Configuration* (`Ctrl+Z`) to open the *Systems Configuration* (page 56) for the main vehicle.
3. Under **Emergency Monitor** tab, update **SMS Recipient Number** with the number of an available cell phone - this cell phone must have GSM connectivity throughout the operation to guarantee emergency messages are received.
4. Define the timeout that the vehicles waits for a console before triggering emergency messages in **Lost Communications Timeout** check box.
5. Enable **Active**.
6. Press **Send**. Press **Save** for these parameters to be default.

Tip: Keep this feature enabled if you have credits to spare. To save credits, disable the monitor at the end.

Tip: Add to your *pre-deployment* checklist procedures to enable/disable this monitor and to keep SMS recipient number updated. After updating the SMS number, send an **ABORT** to test if vehicle replies with occurence.

Warning: If Iridium is available on the system, the user may also opt to receive distress messages through GSM, Iridium, or both. To do so, enable **Developer Parameters** in System Configuration and change **Transmission Interface** under the emergency monitor entity. Iridium messages are transmitted to the account server.

4.5 Create Plan

Plans are sequence of maneuvers that can be sent to the vehicle plan database and executed. Each maneuver has its own set of parameters (see *Supported Maneuvers* (page 79)). These parameters may include vehicle's desired speed, desired vertical reference (i.e. Z reference), duration, active payload etc.

For instance, the following steps show how to a create a plan composed of one *goto maneuver* (page 80) followed by a *rows maneuver* (page 84).

1. On the console, select *plan editor* (page 39) on the left toolbar.
2. Select the plan's main vehicle in the "Select vehicle" popup window.
3. Select a location in the map with the `Right-Click`. From the list of maneuvers, select **Add Goto**.

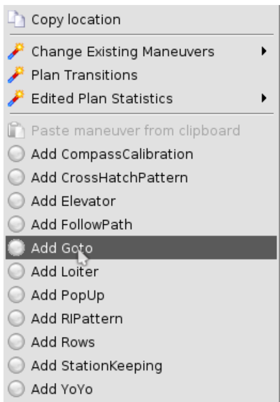


Fig. 4.1: Menu containing the list of maneuvers.

4. Once the maneuver is added, a small filled circle is added to the map. This circle is the maneuver's visual *handle* (page 80).
5. Selecting Goto's handle with `Left-Click` opens a side panel next to the map that shows maneuver's parameters. Extra options are available by `Right-Click` over the handle.
6. Now, `Right-Click` in a new location in map to add *Rows* (page 84). The plan now has a Goto and a Rows maneuver linked together, where Goto is the plan's initial maneuver. Again, the filled circle is the maneuver's visual handle. Select it to modify parameters.
7. Activate one of the available scientific paylods (e.g: sidescan)

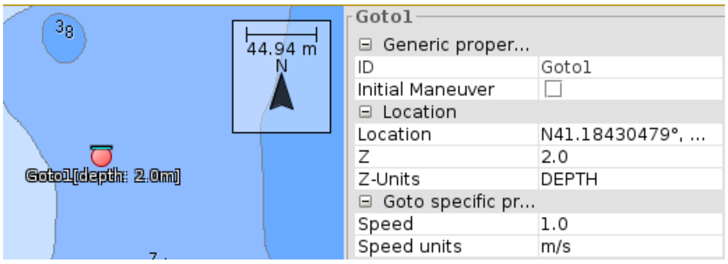


Fig. 4.2: The red filled circle indicates where the vehicle will go to, and, the side panel on the right show Goto maneuver parameters.

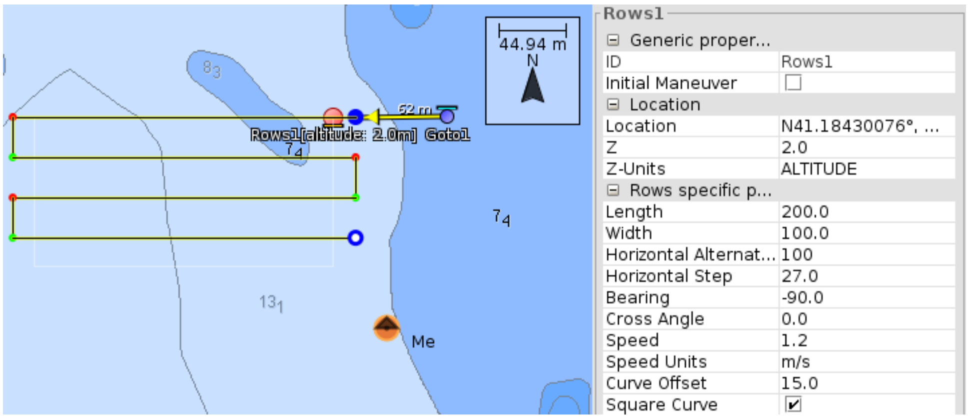


Fig. 4.3: The set of lines represent the path the vehicle will travel.

8. Edit plan parameters by `Right-Click` in the map and selecting **Change Existing Maneuvers**
9. Save, and write a unique plan name

The plan is now available on the *Mission Tree* (page 36) under the plans section.

Warning: Scientific payload depends on target vehicle and installed options.

4.6 Execute Plan

Plans in the mission tree may be synchronized to the vehicle's database and executed:

1. In the *Mission Tree* (page 36) select the plan to be executed.
2. Click in *Send Selected Plan* icon to synchronize the plan to the vehicle.
3. Click in *Start Plan* icon to start.

Table 4.1: Send Plan interface.

Symbols	Description
	Synchronize plan to the vehicle database.
	Start plan execution

Tip: Read table *Element icons* (page 36) to learn the meaning of the plans' icons in the mission tree.

Warning: Always verify all plan/maneuvers settings before sending and executing a new plan. Always synchronize plans (green icon) before verification.

4.7 Download Logs

The user can download data logs using the Wi-Fi link with the vehicle. If available, the user may also opt to access the LAUV's USB pen that contains vehicle data. The following steps describe how to download logs via Wi-Fi:

1. Select *View→Log Download* (`Ctrl+L`) to open the *Log Download* (page 54).
2. Press *Download Log Files* third button (described on *this table* (page 54)).
3. In "Download Log Files" window, click the left button to synchronize log list.
4. Select folders and download folders.

Tip: Logs files are located in the folder `<neptus folder>/log`.

Tip: Run *gather-day-logs.sh* from console to aggregate vehicle logs into a desired folder and clean neptus local contents (Linux only).

4.8 View Logs

1. On the console, select *Tools→MRA*;
2. From the MRA window, select *File→Open LSF Log*;
3. Browse to where the `*.lsf[.gz]` file is, select it and press Open.

4. If the index was already generated, a window will pop up asking if the user wants to regenerate it. You may select No.
5. Press *Mission Replay*, on the *visualizations* (page 61) tab. This component is described in *Mission Replay* (page 62)

The window now contains data that may be replayed in real-time.

4.9 Advanced

4.9.1 Safety Plans

When operating an LAUV, it is useful to have a group of backup plans that may be started on notice to assure vehicle is protected. A sudden change in the surrounding environment may pose an unexpected threat to the vehicle: for instance, a large ship entering the operational area.

Here are a couple of safety plan suggestions.

1. Have a timed (e.g: duration 600s) *Loiter* deep enough to avoid collision with an incoming ship, but not as deep as to collide with seabed. Do **not** use infinite duration as acoustic communications are subject to environmental conditions.
2. Have a *Goto* on the surface near base station.

Some remarks:

- These plans are generated like any other plan, through the *Plan Editor*.
- Design these plans **before** deployment, adjust when needed, and **always** synchronize with the vehicle - otherwise it won't be possible to execute them.
- Impose a naming convention known by everyone. Use letters and/or numbers only (*SMS Messages* (page 21)). For example:
  - *Loiter*: **"L"**
  - *Goto*: **"G"**
- Direct **RPM** speed reference is preferred (~1300 rpm).
- Use the acoustic modem to start the plan if vehicle is expected to be underwater, otherwise try GSM/Iridium when out of Wi-Fi reach.
- When using GSM/Iridium, messages are delivered when signal coverage is established - this may cause plans to start after recovery. A possible solution is to remove requested plan from vehicle plan database. Otherwise, plan accordingly and warn staff to avoid the propeller.

4.9.2 Safety Supervisor

Safety Supervisor is a supervisor that constantly checks vehicle status to detect possible loss of Wi-Fi link with an operator console. This supervisor checks the time elapsed since last successful transmission with operator software console, plus the time elapsed since the last plan finished and the vehicle is in IDLE mode waiting for new commands.

Thus, internally the supervisor manages two distinct timers. One for loss of communication link (Wi-Fi), the other for idle time.

- **Lost Comms Timeout** — loss of communications timeout time that triggers supervisor
- **Plan Idle Timeout** — plan idle timeout time that triggers supervisor

When both timers reach the timeout time, the supervisor applies one of the following strategies:

- **None** — no action
- **Keep Station** — station keeping in current position (avoid drifts)
- **Go To Launch** — station keeping to deployment position (position where system had first contact with water)
- **Go To Last Comms** — station keeping to last known position with valid Wi-Fi link with an operator console

In an operation scenario with intermittent Wi-Fi link, or for remote operations (e.g: commanded through the acoustic modem or through Iridium), we advise to enable **Keep Station** which actively prevents the vehicle from drifting.

If Wi-Fi link is always desired once vehicle finishes plans, then choose **Go To Launch** or **Go To Last Comms** depending on operation site. Keep in mind, vehicle goes in a straight line to the location, so please be cautious with the possibility of obstacles or ship traffic in the area.

Warning: Finally, the vehicle goes to the location at the **Traveling Depth** that is defined by the **Plan Generator** entity. To update this depth, check advanced parameters on *Systems Configuration* (page 56).

Warning: When executing tests in a controlled environment (e.g: in a lagoon, inside a water tank etc.) **ALWAYS** set the strategy to **None** to prevent unwanted actuations on the propeller.

4.9.3 LBL operation

LBL systems help to determine the position of a vehicle by acoustically measuring the distance from the vehicle to two or more deployed baseline transponders/modems.

For LBL operations, a valid setup must be defined in Neptus and synchronized with the LAUV, and the software service inside the vehicle that periodically **pings** the acoustic targets must be activated:

1. On mission tree, under *Transponders* list, edit an existing transponder, or, add a new one.

2. A transponder is defined by its position and configuration, so set latitude, longitude, depth and also **set** configuration file (bottom right of edit window).
3. Once position and configuration file is chosen, the user may move the transponder visually by dragging the transponder element in *Map Editor* (page 43).
4. Synchronize list with vehicle by pressing
5. Depending on acoustic modem, activate entity **LBL** or **Ranger** in *Systems Configuration* (page 56).

Tip: Edit modem/transponder configuration files by removing/adding entries in folder **<neptus path>/maps/** (choose an unique id for the file). For instance, to add a vehicle name *lauv-xx-1* as a LBL node, close neptus, add file named *lauv-xx-1.conf* (new id) and then re-open neptus.

Note: By default, LBL ranges are ignored when vehicle is at surface. Once pinger is enabled, ranges will be plotted on map if vehicle is within Wi-Fi reach. Constant errors in ranging usually imply beacon position needs to be corrected.

Warning: **DO NOT** combine operation with LBL and IMU. Use LBL **or** IMU. The LBL ranges *may* negatively affect yaw-rate bias estimation thus rendering IMU usage ineffective. This limitation shall be corrected in the future.

4.9.4 Dead Reckoning

Dead reckoning is the process of estimating current position by advancing from a previous position based upon known or estimated speeds over elapsed time and course. We assume the LAUV is performing dead reckoning operations whenever GPS and LBL/USBL are not available/installed.

Inside LAUV's navigation filter, there's one key difference:

- **without IMU** — here, the LAUV uses AHRS, DVL (or odometry) and pressure readings to estimate position. Errors grow unboundedly quicker. In this mode, the LAUV must surface whenever possible to correct estimate. Environment's magnetic disturbances affect navigation. No special measures are required to operate in this mode.
- **with IMU** — in addition to the standard navigation payload, a tactical grade IMU (or better) improves LAUV's capability to estimate current heading, thus reducing estimation error over time.

To execute dead reckoning operations with IMU there are a few steps:

1. Select *View→Navigation Alignment* (`Ctrl+I`).

2. Enable IMU — alignment state should now be **NOT ALIGNED**.
3. Execute straight lines at the surface with speed above 1m/s.
4. When the alignment state changes to **ALIGNED**, vehicle is ready.
5. When waiting at surface (i.e. with a couple of minutes of operation to spare), restart IMU to re-align navigation to reset yaw-rate bias estimate.

Warning: **DO NOT** combine operation with LBL and IMU. Use LBL **or** IMU. The LBL ranges *may* negatively affect yaw-rate bias estimation thus rendering IMU usage ineffective. This limitation shall be corrected in the future.

4.9.5 Iridium Mailbox

This feature is **only** for vehicles fitted with *Iridium* (page 23) transceivers.

1. Verify Iridium account's credit.
2. Select *View→System Configuration* (`Ctrl+Z`) to open the *Systems Configuration* (page 56) for the main vehicle.
3. Under **Iridium Modem** tab, enable **Active** and set periodicity in **Mailbox Check - Periodicity**.
4. Send to vehicle.

Note: **Iridium Modem** does not require to be **Active** to send Iridium messages. Message transmission requests are always accepted. When inactive, mailbox is **not** periodically polled (to save credits).

4.9.6 Persistent Power Channel Change

Some devices are usually powered off to save energy. These may incldue auxiliary computers, payload sensors etc. To change the default power state:

1. On the LAUV's web interface, select "Power".
2. Enable/disable the desired power channel.
3. Press **Save State**.

This saves the state on the power controller board memory. Once the onboard software takes control of the LAUV, it may override the state. To complete the modification, set the state on the onboard software side as well:

1. Select *View→System Configuration* (`Ctrl+Z`) to open the *Systems Configuration* (page 56) for the main vehicle.
2. Toggle **Developer Parameters**. Press **Refresh**.

3. Under *Power Supply*, each power channel has an unique name. Find the device name in one of the "Power Channel <*id*> - Name" parameters.
4. Change the corresponding state in "Power Channel <*id*> - State".
5. **Send** to synchronize with the LAUV.
6. Once synchronized, **Save** the state.

Warning: Do **NOT** change any power channel state without contacting OceanScan-MST. Sending the wrong parameters may result in an inoperable vehicle.

4.9.7 Use Manta as an Internet Hotspot

To use the internal 3G/4G modem you must install a SIM card in the SIM card slot. To do so, power off the Manta Gateway, insert the SIM card into the slot until it clicks, then power Manta Gateway on.

To configure and start the hotspot, do the following.

1. Access *Systems List* (page 57).
2. If only LAUV(s) are displayed, unselect the filter to view other systems.
3. In the Manta label, click "Settings" icon on the top-right corner. This will open Manta Gateway's *Systems Configuration* (page 56) window.
4. Update and Save parameters (User / Password / APN / Pin number).
5. Enable "Active".

4.10 Supported Maneuvers

The following introduces details of some maneuvers. The available maneuvers for a specific vehicle can be seen in plan edition mode. Unless noted otherwise, all units are SI units.

- *Goto* (page 80)
- *Launch* (page 81)
- *Loiter* (page 81)
- *Station Keeping* (page 82)
- *Elevator* (page 82)
- *Pop Up* (page 83)
- *Rows Maneuver* (page 84)
- *RI Pattern* (page 86)
- *Cross Hatch Pattern* (page 86)

- *Follow Path* (page 86)
- *YoYo* (page 88)
- *Compass Calibration* (page 89)

4.10.1 Goto

The Goto maneuver moves the vehicle to a waypoint. This maneuver is graphically represented by a single small circle The *figure* (page 80).

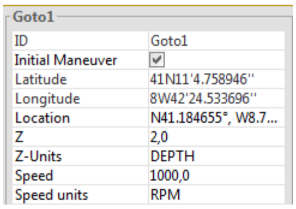
Maneuvers Common Graphical Representation

Fig. 4.4: Goto Maneuver

A *green* circles indicates the maneuver is the initial maneuver of the plan. *Blue* indicates a geo-referenced maneuver and *grey* if not. Please note that in most maneuvers this circle represents the initial or end points for the maneuver, but may also be a place holder/reference for the maneuver. In a plan the entry and exit arcs to/from the maneuver are the actuals passage points.

Maneuvers Common Parameters

All maneuver share a common set of parameters (depicted *here* (page 80)).



Goto1

ID	Goto1
Initial Maneuver	☑
Latitude	41N11'4.758946''
Longitude	8W42'24.533696''
Location	N41.184655°, W8.7...
Z	2,0
Z-Units	DEPTH
Speed	1000,0
Speed units	RPM

Fig. 4.5: Goto Maneuver Parameters

Parameters:

- **Initial Maneuver** — sets this maneuver as the plan start maneuver.
- **Latitude / Longitude / Location** — indicates the location (only editable on the map).
- **Z** — vertical reference value.
- **Z Units:**
  - *NONE*: Z has no reference.
  - *DEPTH*: water surface is the zero for Z (positive values means more depth).
  - *ALTITUDE*: seabed is the zero for Z (positive values means more altitude).
  - *HEIGHT*: WGS-84 height (not supported for AUV operations)

- **Speed** — speed reference value.
- **Speed units** — speed units (RPM, m/s, or %).

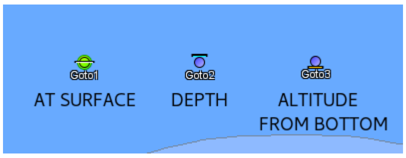


Fig. 4.6: Maneuver Z-Units visual representation

This *figure* (page 81) shows a Goto with dashes in different locations of the filled circle:

- **middle**: maneuver at water surface.
- **top**: maneuver in depth.
- **bottom**: maneuver in altitude.

4.10.2 Launch

Launch is a modified Goto maneuver. The difference is that the vehicle will only start motion when **water is detected**. For this, a medium sensor must be installed in the vehicle. The parameter list is exactly like the Goto. Useful when launching operations from a small boat.

Warning: **Guarantee vehicle is properly trimmed**

4.10.3 Loiter

This maneuver is used to loiter the vehicle. This can be done in a circular, or in a figure eight pattern (*Loiter Maneuver* (page 81)).

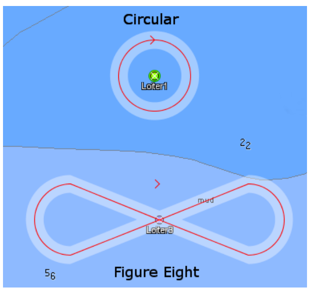
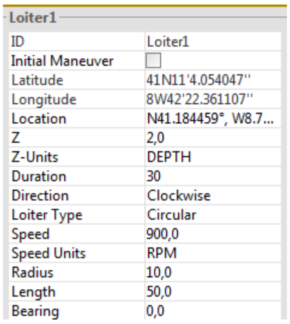


Fig. 4.7: Loiter Maneuver

The common parameters were already introduced *in the Goto maneuver* (page 80). The rest are described next (depicted in the *figure* (page 82)):

- **Duration** — maneuver duration (in seconds, 0 for unlimited).
- **Direction** — clockwise or counter-clockwise (other modes not supported).



Loiter1	
ID	Loiter1
Initial Maneuver	
Latitude	41N11'4.054047''
Longitude	8W42'22.361107''
Location	N41.184459°, W8.7...
Z	2,0
Z-Units	DEPTH
Duration	30
Direction	Clockwise
Loiter Type	Circular
Speed	900,0
Speed Units	RPM
Radius	10,0
Length	50,0
Bearing	0,0

Fig. 4.8: Loiter Maneuver Parameters

- **Loiter Type** — movement type: circular, figure-eight.
- **Radius** — radius for the loiter.
- **Length** — length for the loiter pattern.
- **Bearing** — loiter bearing (not applicable for circular type).

4.10.4 Station Keeping

Station keeping is similar to loitering but without constant motion. The vehicle moves to a given location, then waits there. If it drifts beyond a configurable radius, then it moves back in.

Fig. 4.9: Station Keeping Maneuver

Besides the common set of parameters (*goto* (page 80)) it also has:

- **Duration** — maneuver duration (in seconds, 0 for unlimited).
- **Radius** — station keeping area readius.

4.10.5 Elevator

The Elevator maneuver moves the vehicle up/down the water channel. *Figure* (page 83) is the graphical representation.

Here is the description of the *parameters* (page 83)):

- **Z / Z-Units** — final vertical reference.
- **Start Z / Start Z-Units** — initial vertical reference.
- **Radius** — the vehicle ascends/descends while loitering with this radius.
- **Start from current position** — if enabled, vehicle will start ascending/descending as soon as maneuver is started. Otherwise, the vehicle first moves to the location.

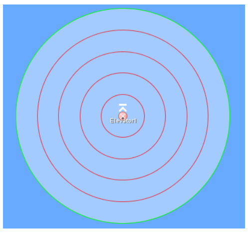


Fig. 4.10: Elevator Maneuver

Elevator1	
⊟ Generic proper...	
ID	Elevator1
Initial Maneuver	☐
⊟ Location	
Location	N41.18326374°, ...
Z	2.0
Z-Units	DEPTH
⊟ Elevator specifi...	
Radius (m)	10
Start Z (m)	2
Start Z Units	DEPTH
Speed	900
Speed units	m/s
Start from current...	☐

Fig. 4.11: Elevator Maneuver Parameters

Warning: Add a loiter or a station keeping if you want the vehicle to keep position once it reaches final vertical reference.

4.10.6 Pop Up

A PopUp maneuver makes the vehicle come to the surface and then stay in position for a certain amount of time, or, dive again to start next maneuver. When ascending/descending the vehicle executes an *Elevator maneuver* (page 82), and if it waits at surface, it does so with a *Station Keeping maneuver* (page 82).

Here's the complementary *maneuver parameters* (page 83):

PopUp1	
⊟ Generic proper...	
ID	PopUp1
Initial Maneuver	☐
⊟ Location	
Location	N41.18464246°, ...
Z	0.0
Z-Units	NONE
⊟ PopUp specific ...	
Speed	1.2
Speed units	m/s
Radius	10.0
Duration	300
CURR_POS	☐
WAIT_AT_SURFACE	☐
STATION_KEEP	☐

Fig. 4.12: PopUp Maneuver Parameters

- **Z** — vertical reference when changing **horizontal** position (before and after popping up at surface).
- **Radius** — popup's station keeping area readius.
- **Duration** — maneuver duration (in seconds, 0 for unlimited).

- **CURR_POS** — if enabled, vehicle will start ascending/descending as soon as maneuver is started. Otherwise, the vehicle first moves to the location. Vehicle dives again to correct position if it pops up in the wrong location.
- **WAIT_AT_SURFACE** — if enabled, vehicle waits at surface (station keeping) for the amount of time describes in *Duration*. Otherwise, it goes to *Z* vertical reference.
- **STATION_KEEP** — **DEPRECATED**.

4.10.7 Rows

Rows maneuver (also known as lawn mower pattern) is use to survey areas. The *figure* (page 84) depicts some configurations of this maneuver.

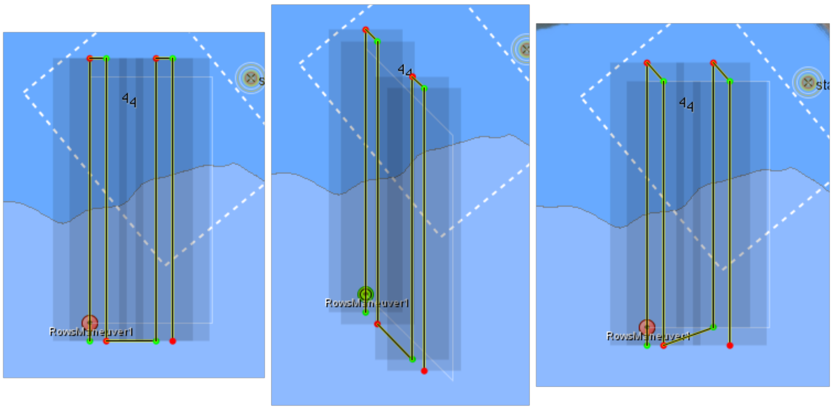


Fig. 4.13: Rows Maneuver

RowsManeuver1	
ID	RowsManeuver1
Initial Maneuver	☐
Latitude	41N11'4.395596''
Longitude	8W42'21.762438''
Location	N41.184554°, W8.7...
Z	0,0
Z-Units	NONE
Length	200,0
Width	100,0
Horizontal Alternat...	100
Horizontal Step	27,0
Bearing	0,0
Cross Angle	0,0
Speed	1000,0
Speed Units	RPM
Curve Offset	15,0
Square Curve	☑
First Curve Right	☑

Fig. 4.14: Rows Maneuver Parameters

Here's a list of maneuver parameters (depicted *here* (page 84)):

- **Length** — rows box length.
- **Width** — rows box width.
- **Horizontal Step** — distance between consecutive row legs.
- **Horizontal Alternation:**
  - Percentage of *Horizontal Step* distance between odd numbered **to** even numbered legs

  - **100%** — all spacing is equal.
  - **60%** — distance between leg 1 and 2, 3 and 4, ..., is 60% of *Horizontal Step* while the rest is 140%.

- **Curve Offset** — extra distance that the vehicle travels before turning to the next leg.
- **Square Curve** — do a square curve (two 90º rotations to turn) or turn to new leg directly (~180º). Square curve allows smoother entry.
- **Payload Shadow** — add a graphical shadow to represent expected survey coverage.
- **Shadow Size** — size of graphical shadow.

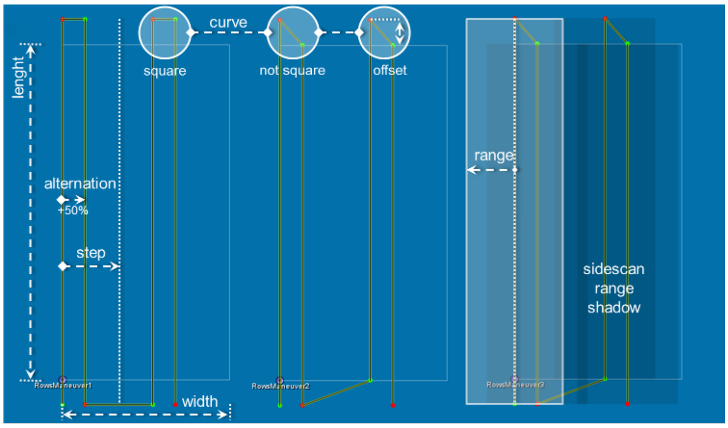


Fig. 4.15: Rows Maneuver Parameters Visual Aid 1

- **Bearing** — pattern bearing.
- **Cross Angle** — cross angle for the pattern, thus affecting geometry before bearing is applied.

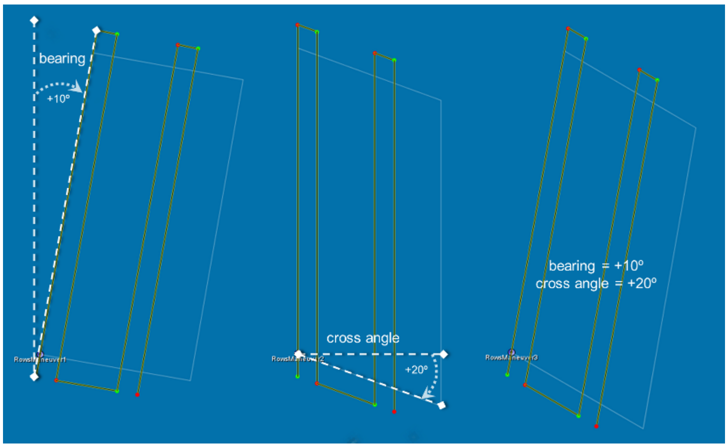


Fig. 4.16: Rows Maneuver Parameters Visual Aid 2

- **First Curve Right** is visual described in the following picture. This setting allows this pattern to be executed mirrored. Be aware of the positive rotation for the bearing angle and cross angle.

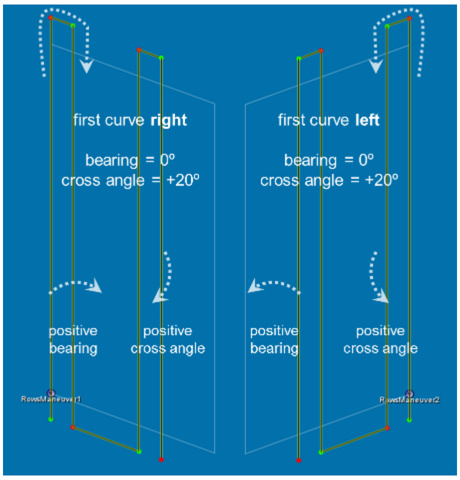


Fig. 4.17: Rows Maneuver Parameters Visual Aid 3

4.10.8 RI Pattern

Reacquire-Identify Pattern (page 86) maneuver can be use for intensive survey / target identification of a spot.

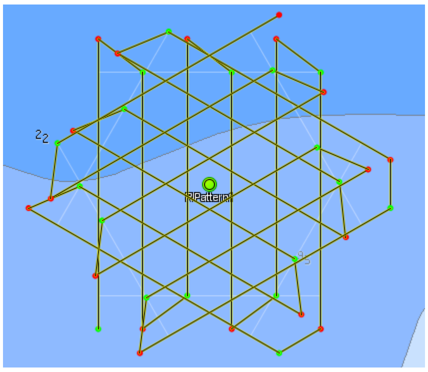


Fig. 4.18: RI (Reacquire-Identify) Pattern Maneuver

This pattern is a composition of three rows maneuvers (length equal to the width). There's a 60º rotation between rows patterns. The middle point is the handle and differs from the start and stop waypoints.

This maneuver has the same parameters as the *Rows Maneuver* (page 84).

4.10.9 Cross Hatch Pattern

Cross Hatch pattern maneuver is a combination of two *Rows* (page 84) rotated by 90º (depicted *here* (page 87)). Like the *RI Pattern* (page 86), the middle point is the handle and differs from the start and stop waypoints. It also has the same parameters as the *Rows Maneuver* (page 84).

4.10.10 Follow Path

Follow Path adds path points that the vehicle must travel (*figure* (page 88))

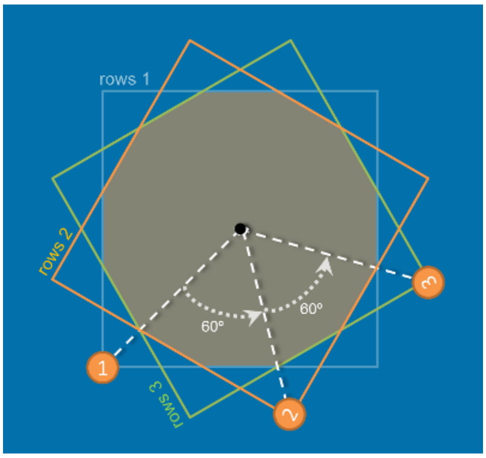
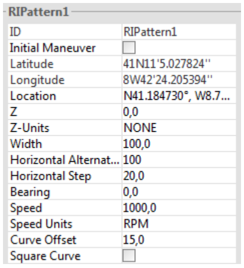


Fig. 4.19: RI (Reacquire-Identify) Pattern Maneuver explained



RIPattern1

ID	RIPattern1
Initial Maneuver	☐
Latitude	41N11'5.027824''
Longitude	8W42'24.205394''
Location	N41.184730°, W8.7...
Z	0,0
Z-Units	NONE
Width	100,0
Horizontal Alternat...	100
Horizontal Step	20,0
Bearing	0,0
Speed	1000,0
Speed Units	RPM
Curve Offset	15,0
Square Curve	☐

Fig. 4.20: RI (Reacquire-Identify) Pattern Maneuver Parameters

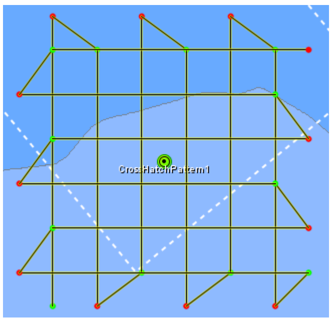


Fig. 4.21: Cross Hatch Pattern Maneuver

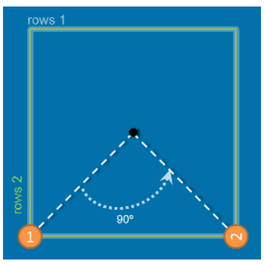
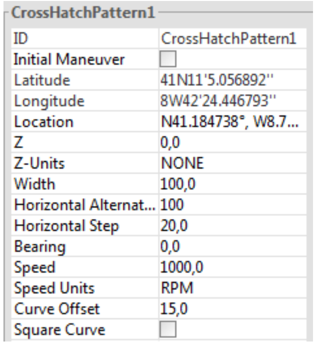


Fig. 4.22: Cross Hatch Pattern Maneuver explained



CrossHatchPattern1

ID	CrossHatchPattern1
Initial Maneuver	☐
Latitude	41N11'5.056892''
Longitude	8W42'24.446793''
Location	N41.184738°, W8.7...
Z	0,0
Z-Units	NONE
Width	100,0
Horizontal Alternat...	100
Horizontal Step	20,0
Bearing	0,0
Speed	1000,0
Speed Units	RPM
Curve Offset	15,0
Square Curve	☐

Fig. 4.23: Cross Hatch Pattern Maneuver Parameters

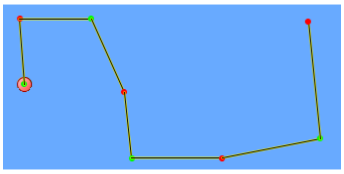
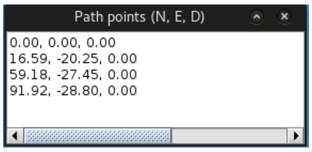


Fig. 4.24: Follow Path Maneuver

The path can be drawn graphically or edited in a text form (mouse click access) as shown *here* (page 88). Each line is a single path point with North-East-Down offsets. These refer to the maneuver handle location. Only the *common set* (page 80) parameters are required.



Path points (N, E, D)

0.00, 0.00, 0.00
16.59, -20.25, 0.00
59.18, -27.45, 0.00
91.92, -28.80, 0.00

Fig. 4.25: Follow Path Edition

4.10.11 YoYo

This maneuver moves the vehicle to a single waypoint, but, rather than travelling at a fixed Z reference, the vehicle changes pitch to move up and down the water column. This maneuver is useful for water column surveys to measure environmental features.

Here's the complementary *maneuver parameters* (page 89):

- **Z** — (center) vertical reference.
- **Amplitude** — center-to-peak vertical amplitude.
- **Pitch Angle** — desired maneuver pitch angle (text is in radians but there's a popup window that allows degrees to be inserted).

Note: For instance, if Z=50m (DEPTH), Amplitude=20m and Pitch Angle=10º, the vehicles goes from 30m to 70m while pitching down/up with 10º.

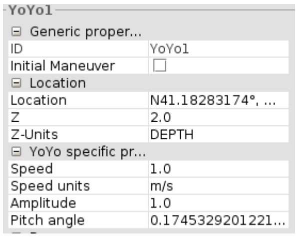


Fig. 4.26: YoYo Maneuver Parameters

4.10.12 Compass Calibration

All LAUV vehicles are equipped with a magnetic compass. Magnetic signature changes not only with hardware arrangement, but also with magnetic declination on area. To ensure magnetic readings are properly calibrated, this maneuver computes a new set of hard-iron calibration parameters and then reset's the parameters of the device.

This maneuver works by doing a few circular loiters around a fixed vertical reference, while pitching up/down. This *figure* (page 89) has the full list of arguments.

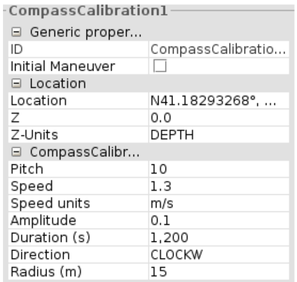


Fig. 4.27: Compass Calibration Maneuver Parameters

Here's the description:

- **Z** — (center) vertical reference.
- **Pitch** — desired maneuver pitch angle (in degrees).
- **Amplitude** — center-to-peak vertical amplitude.
- **Duration** — maneuver duration (in seconds, 0 for unlimited).
- **Direction** — clockwise or counter-clockwise (other modes not supported).
- **Radius** — radius for the loiter.

> **Warning:** Although the compass can be calibrated by exciting the vertical component of the magnetic field, our experiments show great results by just loitering at surface (small amplitude, Z=0.0 DEPTH). For a quick calibration execute at least 600s duration. Try 1200s or more for improved results.

Once the maneuver is finished the hard-iron calibration parameters are computed and immediately written to the device's non-volatile memory. These parameters are also saved in the vehicle's onboard software.

If the maneuver is stopped, or aborted by an error, data is either flushed or a new set of hard-iron parameters may be computed and shown to the operator but **not written to the device's memory**!

Note: When moving to a new location, execute a compass calibration before diving the vehicle. Also calibrate if angles are wrong, or if vehicle localization is degrading. Contact our technical advisors if conditions do not improve.

CHAPTER 5

Support

This section targets customer support, with details for data sharing, installed options, transport & handling procedures and more

Warning: For technical support please contact: support@oceanscan-mst.com

5.1 Uploading Logs to OceanScan-MST Servers

5.1.1 Log Selection

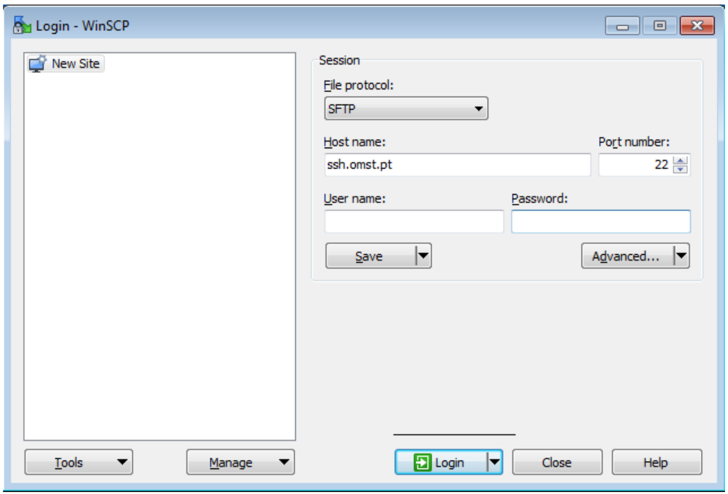
When facing an issue that requires support, it is imperative to report the occurrence to OceanScan and, if needed, to upload logs for internal analysis. Please choose the logs carefully, to avoid sending extra log files:

1. Do not send a full day's logs unless strictly required.
2. Remove **Data.lsf** and **mra** files from log folders.
3. Do **not** include payload files if not relevant
    - Sidescan files
    - Multibeam
    - Photos
    - (...)
4. Compress the folders (**7zip** is provided in utility software).
5. If possible, add a simple annotation describing each folder, and where and when the occurrence took place.

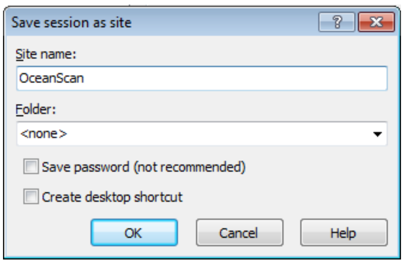
Tip: When internet access is slow, and immediate support is imperative, send relevant **Output.txt** files to us.

5.1.2 Upload Logs

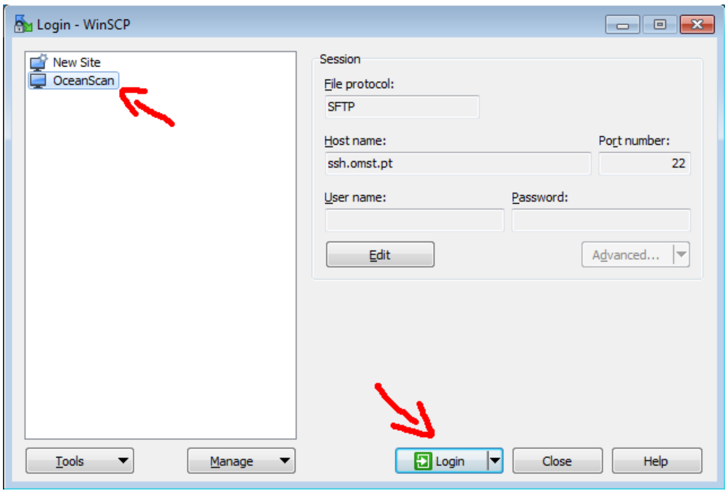
- Open the start menu folder and locate the program **WinSCP** (provided in OEM utility software)
- Execute the program **WinSCP**
- If this is the first time you execute **WinSCP** you will be presented with the following window

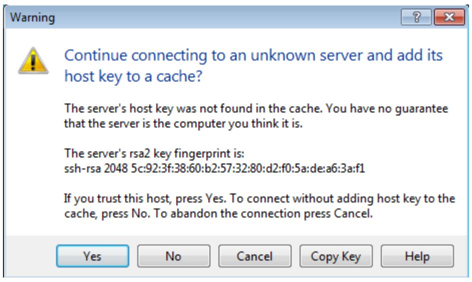


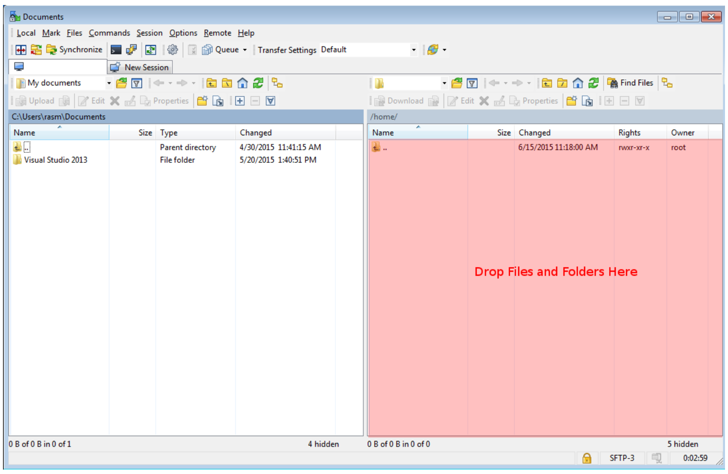
- Configure your session using the following settings and credentials:
  - **File protocol:** SFTP
  - **Host name:** ssh.omst.pt
  - **Port number:** 22
  - **User name:** available on customer documentation.
  - **Password:** available on customer documentation.
- Press the **Save** button and fill the form that opens like this:



- Press **OK**
- On the left side list select the entry **OceanScan** and click the **Login** button:
- If the following window opens, click **Yes**:
- If prompted for the password again, enter the same password
- You can now drag and drop files and folders to the list.


Login - WinSCP
New Site
OceanScan
Session
File protocol:
SFTP
Host name:
ssh.omst.pt
Port number:
22
User name:
Password:
Edit
Advanced...
Tools
Manage
Login
Close
Help


Warning
Continue connecting to an unknown server and add its host key to a cache?
The server's host key was not found in the cache. You have no guarantee that the server is the computer you think it is.
The server's rsa2 key fingerprint is:
ssh-rsa 2048 5c:92:3f:38:60:b2:57:32:80:d2:f0:5a:de:a6:3a:f1
If you trust this host, press Yes. To connect without adding host key to the cache, press No. To abandon the connection press Cancel.
Yes
No
Cancel
Copy Key
Help


Documents
Drop Files and Folders Here

5.2 Service Port access

When unable to establish Wi-Fi communication with the vehicle, or in the event of major software failure, the LAUV system provides a direct serial link with the vehicle main computer system.

Cabling instructions:

1. Connect a USB Type-B to the LCharger's service port and to your computer.
2. Connect the LCharger to the LAUV (*instructions* (page 10)).
3. Install FTDI drivers (provided in OEM utility software).
4. It's **not** required to turn on the LCharger.

Fig. 5.1: USB Type-B connector.

Software instructions:

1. Install **Tera Term** (provided in OEM utility software)
2. Select *Setup→Serial Port*
   - Baud Rate: 115200
   - Data: 8 bit
   - Parity: none
   - Stop: 1 bit
   - Flow Control: none
3. Establish a new serial conection

Tip: Please verify cables are properly connected and that the correct serial port device is chosen before reporting errors.

Warning: Service Port access shall be used only when strictly necessary.

5.3 Remote Desktop

OceanScan-MST can connect remotely to your desktop to provide over-the-wire customer support. To do so please follow these steps:

1. Install **TeamViewer** (provided in OEM utility software)
2. Start TeamViewer on the computer.
3. Provide OceanScan-MST with <ID> and <Password> (if using different version than provided, also provide software version).

Tip: If the issue is with the LAUV (or Manta Gateway), turn the system on, and connect the computer to the same Wi-Fi network. The systems shall be within reach, and a technician shall be nearby to follow instructions.

5.4 Shipping

The LAUV vehicle and Manta Gateway contain lithium-ion batteries that require special handling and documentation for shipping. Shipment by road should be your preferable method of shipment. Shipment over commercial passenger flights may not be possible, contact your courier service provider to check the lithium-ion shipping regulations. Failure to comply with the regulations may result in heavy penalties.

Information regarding the lithium-ion batteries installed in your LAUV vehicle and Manta Gateway, including the lithium-ion Material/Product Safety Data Sheet (MSDS/PSDS), is provided by OceanScan-MST with the system delivery. Please keep this documentation for future reference and possible future shipments.

The LAUV system is classified as dual-use item (civil and military) and an export license may be required. Make sure you comply with all the regulations that may apply. Contact your local export authorities for further information.

Customs authorities may need to open the LAUV transit case for inspection. We advise to use plastic straps to lock the LAUV transit case. Next to each handle there is a small hole were a plastic strap can be installed to lock the case. These should be enough to keep curious people away and if required customs authorities can access inside for inspection.

A courier service basic insurance typically does not cover the LAUV system value. Contact your courier service provider for further information or your insurance company.

The LAUV transit case is equipped with 4+2 handles. Loading and unloading of the LAUV transit case can be easily carried by 4 persons. The use of a forklift should be avoid. Nevertheless, if required, inform the forklift operator that the LAUV is a delicate instrument and should be handled with extreme care.

5.5 Storage

For long-term storage make sure the LAUV vehicle and accessories are clean (free of salt) and completely dry. It is recommend to apply a silicone spray (o-ring compatible) to prevent corrosion. Do not use lubricants that are not compatible with NBR o-rings. Oil based lubricants will reduce the o-rings lifetime and compromise the system seal.

All the equipment and accessories should be kept together in a dry and safe place at a temperature preferably not exceeding 30°C. High temperatures reduce the batteries lifetime. For long-term storage, keep the battery within a 30 ± 15 % state of charge. Avoid direct sun exposure, since it will reduce plastic, rubber and transducers lifetime.

Remove any alkaline batteries that your accessories may have, such as the LBL beacons. Turn-off the LAUV emergency acoustic marker to save battery. Install a label indicating that it was turned off, so everyone knows.

After a long-term storage run a full system visual inspection and a detailed pre-mission test to ensure the system is working properly. Do not forget to turn-on the LAUV emergency acoustic marker.

5.6 Troubleshooting

5.6.1 Preparation

1. Unable to connect to the LAUV.
    - Is Manta Gateway powered on ?
        - Check if it is discharged.
    - Is there a Wi-Fi signal ?
        - Try a Wi-Fi analyzer to check signal.
        - Check all cables and connections.
        - Check if there's power-over-ethernet on Manta Gateway's ports.
        - Replace Wi-Fi router or antenna.
    - Can you ping *any* of the systems ?
        - Computer must be connected to the LAUV Wi-Fi network.
        - Local IP address must be **10.0.X.X/16** to reach systems.
    - Are you able to access LAUV's web server ?
        - Check LAUV's LED patterns to look for a possible failure.
        - Is the LAUV possibly obstructed ?
    - Has the computer's Wi-Fi configuration changed during mission execution ?
        - Restart Neptus.
        - If vehicle is safe on ground reboot LAUV.
2. Sent SMS fails to reach destination.
    - Check LAUV GSM card credits.
    - Check RSSI signal (logged on data).
    - Double-check emergency recipient number.
    - Check if recipient has GSM connectivity.
    - Check area's GSM coverage with your GSM provider.

- For dry-tests, send SMS with "**pos**" to the LAUV.

5.6.2 Maneuvering

1. LAUV is having a hard time to dive.
    - The onboard software has an underlying control service that monitors diving operations. When unable to dive, the vehicle increases the speed with small increments to dive. If still unable to dive after an amount of time, the service ceases efforts and plan resumes at standard speed. A few possibilities:
        - Wrong trimming ? Vehicle may be too buoyant, thus requiring extra effort to dive. If so, please revise trimming.
        - Diving maneuver has continuous or sharp turns (e.g: downwards elevator). When turning, roll is less stable prompting the control to use fins to regain stability. This reduces pitch margin to dive - try a standard goto first.
        - Configured diving speed too low. The diving monitor works by adding small steps. If initial speed is too low, it may abandon attempts to dive before reaching optimal speed.
        - Strong currents in the area. Opt to dive the vehicle *against* the current for added drag.
2. Maneuver finishes successfully but vertical reference is not reached.
    - Maneuvers are attained when horizontal position/path is reached. Notable exception is the *Elevator* (page 82).

5.6.3 Navigation Alignment

1. Vehicle is taking longer to align than usual.
    - LAUV's dynamic alignment duration depends on external conditions including:
        - Quality of GPS signal.
        - Quality of DVL echo returns.
        - Harsh sea conditions.
    - If sea conditions are choppy:
        - Choose a line pattern that moves the vehicle **against** the current for added drag.
        - Avoid transversal currents which cause sway thus affecting roll and DVL returns.
        - Do not use slow speed nor maximum speed (which induce extra roll). Try speeds around ~1.3 - 1.5 m/s.
    - Although alignment *without* DVL is still possible, it will take way longer, and speed estimation will be very poor (from propeller odometry only).

2. Although vehicle is/was aligned, there was a position error larger than expected when it surfaced.
    - Do **not** continue operations.
    - Power cycle the IMU (which forces navigation to reset alignment).
    - Redo navigation alignment.

5.6.4 Emergency

1. Vehicle should've finished plan but position is unknown.
    - If your time reference is the neptus simulation, beware that the simulation shown is a rather simplistic one, which, for instance, is unable to take into account the time the vehicle takes to dive.
    - Check emergency cell phone and/or Iridium account for incoming messages.
        - Send "**pos**" to vehicle (GSM/Iridium) and keep an eye for feedback.
        - If a position is received, mark that position on Neptus and go for recovery.
    - Send an acoustic range to track the vehicle. Wait 30 seconds and range again. Repeat a couple of times:
        - Is vehicle progressing ? Plan takes longer than expected.
        - Vehicle is not progressing ? There's the risk it is stuck on a net. Using *Acoustic Operations* (page 50), choose the Gateway and check **Show Ranges**. Chage position to trilaterate the vehicle to know its whereabouts.
    - If enabled, wait for an acoustic report for full state feedback.
    - If there's no acoustic feedback, use the emergency pinger to triangulate the vehicle.
        - Use the Manta Gateway for immediate position feedback.
        - Try to get a signal using the emergency pinger's hydrophone.
        - Preferably, use a compass to get the heading of the pinger.
        - Report the heading to the operator.
        - Operator: with *Map Editor* (page 43) draw a line starting on Manta's position with given heading.
        - Change position and repeat tracking.

Contacts

[2]

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[2] http://www.oceanscan-mst.com

APPENDIX A

Systems

This chapter introduces details from purchased systems.

A.1 LAUV-HARALD

This section introduces details for LAUV HARALD vehicle.

- **Vehicle Details**
  - Name: LAUV Harald
  - Hostname: lauv-harald
  - IMC Identifier: 02:0d
- **Wi-Fi Configuration**
  - Role: Station
  - ESSID: LAUV-NTNU
  - Encryption Type: WPA2-AES
  - Password: eh4uffUG
  - Account Username: root
  - Account Password: B8d7DyQq
- **Emergency Pinger**
  - Brand: Sonotronics
  - Model: EMT-01-1
  - Frequency: 70 kHz
  - Code: 3-4-4
  - Interval: 860 ms
- **IPv4 Addresses**
  - Main Computer: 10.0.10.60
  - Wi-Fi Radio: 10.0.10.61
  - User Computer: 10.0.10.66

- **Software Versions**
  - GLUED: glued-2016.10-omst
  - DUNE: dune-2016.10.1-omst
  - Neptus: neptus-2016.10.1-omst
- **Installed Hardware Options**
  - DVL: Nortek DVL 1MHz
  - Acoustic Modem: Evologics S2CR 18/34
  - CTD: SeaBird SBE 49 FastCAT
  - Dissolved Oxygen: Aanderaa Optode 4831F
  - Fluorometer: WetLabs EcoPuck Triplet
  - Satellite: Iridium SBD Module
  - User Computer: NVIDIA Jetson TX1
- **OceanScan FTP Server**
  - File protocol: SFTP
  - Host name: ssh.omst.pt
  - Port number: 22
  - User name: ntnu
  - Password: 7jsGDhNw
- **Iridium Module**
  - Serial Number: RockBlock 10190
  - IMEI: 300234064427600
- **User Computer**
  - User name: ubuntu
  - Password: ubuntu

Vehicle Parameters:

A.1.1 CTD

SeaBird's pumped CTD device driver. This device can measure conductivity, temperature and pressure. It contains the following list of parameters:

- **Active** — manual device activation (only if **Automatic Activation** is disabled).
- **Automatic Activation** — toggle automatic activation
  - *Not Checked* — device activation is manual.
  - *Checked* — device activation is automatic depending on vehicle medium.

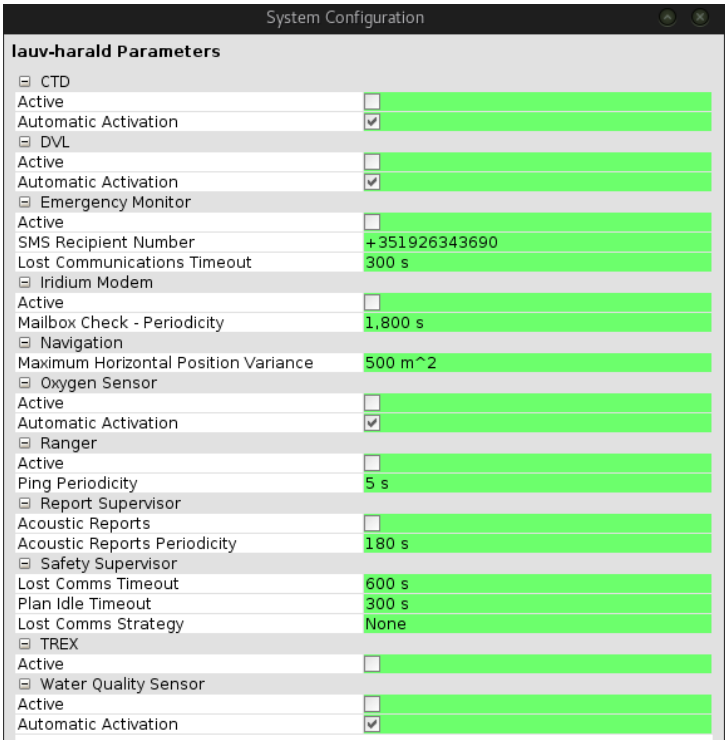

Fig. A.1: Parameters List for LAUV HARALD

A.1.2 DVL

Nortek's DVL device driver. This device can measure velocity relative to the ground when bottom-lock is acquired or velocity relative to the water. It also provides four beams to measure distance to the seabed. Furthermore, this equipment is also a current profiler.

Here's the list of arguments:

- **Active** — manual device activation (only if **Automatic Activation** is disabled).
- **Automatic Activation** — toggle automatic activation
  - *Not Checked* — device activation is manual.
  - *Checked* — device activation is automatic depending on vehicle medium.
- **Current Profiler – Enabled** *(advanced)* — enable current profiler mode.
- **Current Profiler – Record File** *(advanced)* — current profile data file name.
- **Current Profiler – Get At Nth Ping** *(advanced)* — get a current profile measurement at the N-th ping.
- **Current Profiler – Number of Cells** *(advanced)* — number of cells for the current profiler.
- **Current Profiler – Cell Size** *(advanced)* — cell size.
- **Current Profiler – Blanking Distance** *(advanced)* — blanking distance.

> **Warning:** Do **NOT** change any other parameters unless you know exactly what you are doing or you have been instructed to do so by a technical adviser. Sending the wrong parameters may result in an inoperable vehicle.

A.1.3 Emergency Monitor

Emergency Monitor service. Please refer to *Enable Emergency Monitor* (page 71) on how to use this service.

A.1.4 Iridium Modem

Iridum Mailbox service. Please refer to *Iridium Mailbox* (page 78) on how to use this service.

A.1.5 Navigation

Navigation is the software service responsible for fusing data from sensors and estimating current vehicle position.

Filter may be configured to abort if position uncertainty goes beyond a configurable value:

- **Maximum Horizontal Position Variance**: maximum allowed position error.

A.1.6 Oxygen Sensor

Aanderaa's Optode 4831F oxygen sensor. This device measures dissolved oxygen concentrations.

- **Active** — manual device activation (only if **Automatic Activation** is disabled).
- **Automatic Activation** — toggle automatic activation
  - *Not Checked* — device activation is manual.
  - *Checked* — device activation is automatic depending on vehicle medium.

A.1.7 Ranger

This service is a communication protocol that uses acoustic transmissions to other acoustic modems to implement a LBL setup. **Ranger** sends empty messages with acknowledgement so that other modem in the network reply back allowing ranging to be computed. This data is used by the navigation filter.

For this service **only** acoustic modems can be added (**no** basic transponders) to the LBL setup. Only one modem is pinged at a time.

For a step-by-step guideline on how to setup LBL on Neptus refer to *LBL operation* (page 76).

Here's the list of arguments:

- **Active** — enable service.
- **Ping Periodicity** — time interval between pings.

A.1.8 Report Supervisor

Report Supervisor handles report requests through multiple communication interfaces. This feature is still in ongoing development but the goal is to use it as an HUB to request reports from any communication interface to any of the communication interfaces (e.g: send an SMS to start acoustic reports each 20min).

For backward compatibility with previous software versions, this service has default parameters to setup acoustic reports:

- **Acoustic Reports** - activate service.
- **Acoustic Reports Periodicity** - change time interval between reports.

(see step-by-step in *Enable Acoustic Reports* (page 71))

A.1.9 Safety Supervisor

Safety Supervisor service. Please refer to *Safety Supervisor* (page 75) for complete instructions regarding this service.

A.1.10 T-REX

T-REX client service. For deliberative planning procedures, this entity must be activated to allow commands from T-REX to be executed.

A.1.11 Water Quality Sensor

WetLabs Triple-Measurement Meter EcoPuck. This device measures dissolved organic matter, chlorophyll and has an optical backscatter.

- **Active** — manual device activation (only if **Automatic Activation** is disabled).
- **Automatic Activation** — toggle automatic activation
  - *Not Checked* — device activation is manual.
  - *Checked* — device activation is automatic depending on vehicle medium.

A.2 LAUV FRIDTJOF

This section introduces details for LAUV FRIDTJOF vehicle.

- **Vehicle Details**
  - Name: LAUV Fridtjof
  - Hostname: lauv-fridtjof

  - IMC Identifier: 02:0e
- **Wi-Fi Configuration**
  - Role: Station
  - ESSID: LAUV-NTNU
  - Encryption Type: WPA2-AES
  - Password: eh4uffUG
  - Account Username: root
  - Account Password: B8d7DyQq
- **Emergency Pinger**
  - Brand: Sonotronics
  - Model: EMT-01-1
  - Frequency: 75 kHz
  - Code: 3-4-4
  - Interval: 870 ms
- **IPv4 Addresses**
  - Main Computer: 10.0.10.70
  - Wi-Fi Radio: 10.0.10.71
  - Auxiliary Computer: 10.0.10.73
  - User Computer: 10.0.10.76
- **Software Versions**
  - GLUED: glued-2016.10-omst
  - DUNE: dune-2016.10.0-omst
  - Neptus: neptus-2016.10.0-omst
- **Installed Hardware Options**
  - External USB pen drive
  - Forward Looking Sonar: Imagenex 852
  - DVL: Nortek DVL 1MHz
  - Acoustic Modem: Evologics S2CR 18/34
  - Satellite: Iridium SBD Module
  - Sidescan Sonar: Deepvision OSM2
  - Camera: Lumenera Le165 and LED lighting
  - User Computer: NVIDIA Jetson TX1
- **OceanScan FTP Server**
  - File protocol: SFTP

  - Host name: ssh.omst.pt
  - Port number: 22
  - User name: ntnu
  - Password: 7jsGDhNw

- **Iridium Module**
  - Serial Number: RockBlock 10054
  - IMEI: 300234063369100
- **User Computer**
  - User name: ubuntu
  - Password: ubuntu

Vehicle Parameters:

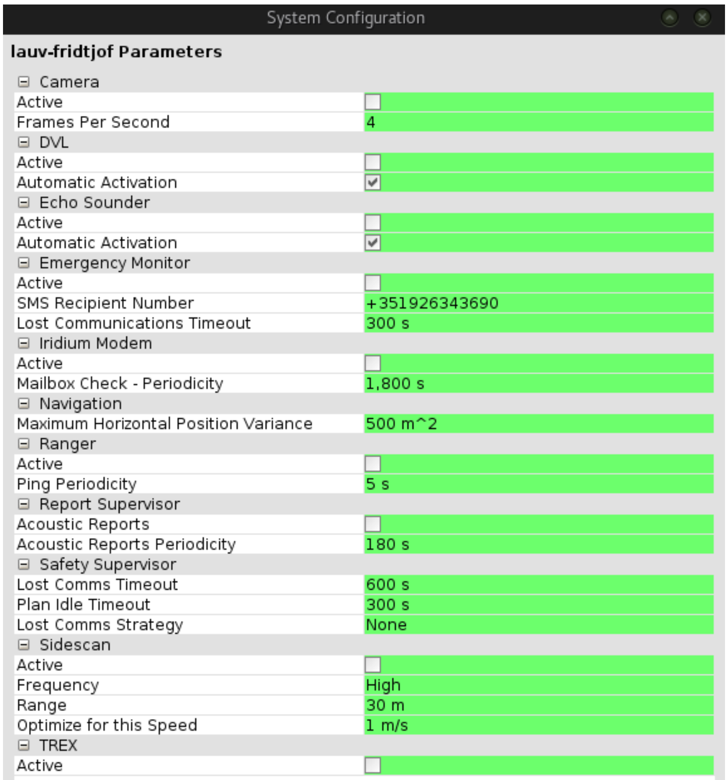

Fig. A.2: Parameters List for LAUV FRIDTJOF

A.2.1 Camera

Your LAUV is equipped with an industrial video camera. This camera is usually powered off to save energy. This payload activation scope is **maneuver** (see *Vehicle Parameters* (page 32)) which means the user can activate the camera **only** when needed, and on maneuver:

- **Active** — enable device.
- **Frames Per Second** — number of frames per second supported.

A.2.2 Echo Sounder

Forward Looking Sonar device driver. This device is used for obstacle avoidance:

Here's the list of arguments:

- **Active** — manual device activation (only if **Automatic Control** is disabled).
- **Automatic Control** — toggle automatic activation
  - *Not Checked* — device activation is manual.
  - *Checked* — device activation is automatic depending on vehicle medium.

Warning: Due to reflections at surface, vehicle can only detect obstacles when navigation beyond 0.5 meters of depth.

A.2.3 Sidescan

Your LAUV is equipped with a Deepvision sidescan sonar system. This sidescan is usually powered off to save energy. This payload activation scope is **maneuver** (see *Vehicle Parameters* (page 32)) which means the user may activate the device **only** when it is actually needed, and on maneuver:

- **Active** — enable device.
- **Frequency** — choose frequency type.
- **Range** — choose sidescan range.
- **Optimize for this Speed** — set this speed reference to desired survey speed. This value indicates sample resolution along-track which is then used to select a decimation that matches sample resolution in the shots (cross-track).
- **Output Data Format** *(advanced)* — change default output data formats.

Warning: MRA does not support **DVS** format (Deepvision's file format).

Warning: Do **NOT** change any other parameters unless you know exactly what you are doing or you have been instructed to do so by a technical adviser. Sending the wrong parameters may result in an inoperable vehicle.

A.3 MANTA-NTNU-1

A.3.1 System Details

This section introduces details for Manta NTNU-1 vehicle.

- **Vehicle Details**
  - Name: Manta NTNU-1
  - Hostname: manta-ntnu-1
  - IMC Identifier: 80:70
- **Wi-Fi Configuration**
  - Role: Access Point
  - ESSID: LAUV-NTNU
  - Encryption Type: WPA2-AES
  - Password: eh4uffUG
  - Account Username: root
  - Account Password: B8d7DyQq
- **IPv4 Addresses**
  - Main Computer: 10.0.30.25
  - Wi-Fi Radio: 10.0.60.27
- **Software Versions**
  - GLUED: glued-2016.10-omst
  - DUNE: dune-2016.10.0-omst
- **Installed Hardware Options**
  - GSM: Huawei E1550
  - GPS: U-Blox EVK-6H
  - Acoustic Modem: Evologics S2CR 18/34 USBL
  - Satellite: Iridium SBD Module
- **Iridium Module**
  - Serial Number: RockBlock 10188
  - IMEI: 300234064229230

A.3.2 Parameters

To view Manta Gateway parameters:

1. Select *View→Systems List* (`Ctrl+S`).
2. Toggle **Enable Filter** button on top to view all systems.

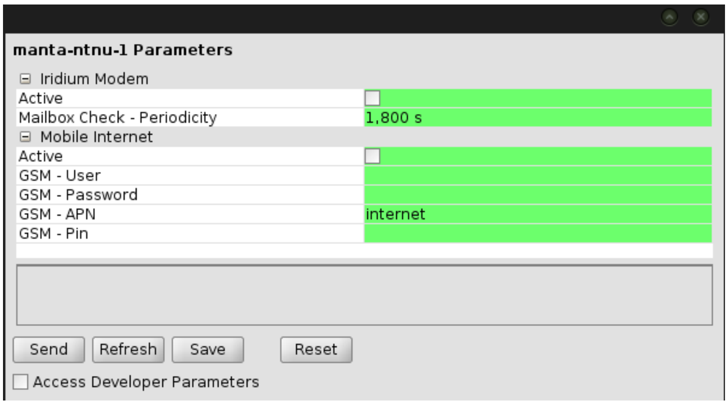

Fig. A.3: Parameters List for Manta NTNU-1

3. `Right-Click` on settings button.

Fig. A.4: Open Manta Gateway Parameters

Iridium Modem

Iridium Modem device driver for Manta Gateways. Refer to *Iridium Mailbox* (page 78) for details.

Mobile Internet

Manta Gateways can be used as a internet hotspots. **Mobile Internet** is the software service that configures this functionality.

To start hotspot service:

1. Set username, password, APN and pin
2. Save parameters if they will be re-used.
3. Toggle **Active** and send to gateway.
4. Check activation progress in Manta's web server service description (URL: "http://<Manta_IP_Address>:8080")

Tip: If activation succeeds, manta's external IP address is given in web server service description.
