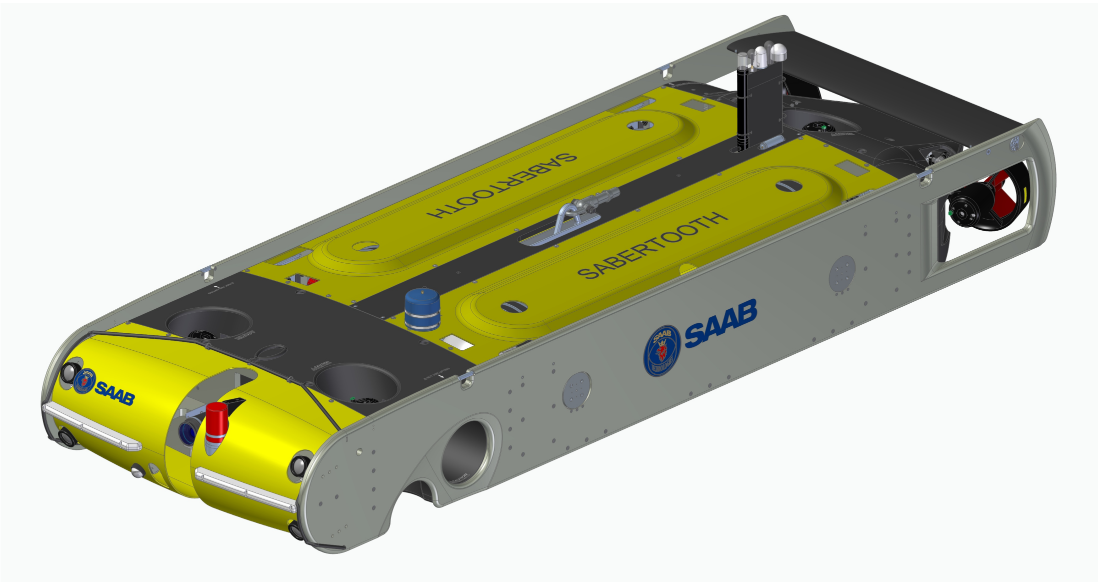
# Sabertooth

## Technical Manual 40-4162700

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# Preface

The purpose of this Technical Manual is to provide the Remotely Operated Vehicle maintainer/ operator with concise information and instructions on the operating, technical and maintenance aspects of the vehicle system. The book is written for a maintainer/operator with a reasonable understanding of electrical and mechanical principles and a sound understanding of safe working practices. It is recommended that on receipt of the Vehicle system that the handbook is read in their entirety prior to assembly, installation and first operational use. If a specialist understanding of the technical and maintenance aspects of the system is required a training course can be provided by Saab.

The Technical Manual consists of the following:

System Overview - This chapter provides a general description of the main units as an introduction to the system, the vehicle system technical specification and any related information.

Controls, Indicators and connections - This chapter provides a description of Sabertooth System controls, indicators and connections for easy reference.

Autonomous Missions - The vehicle is capable of autonomous missions. This chapter describes how missions are created and edited.

Assembly and Installation - This Chapter details the instructions for receipt and installation of the Sabertooth Vehicle system. On completion of installation a series of installation tests are carried out prior to the vehicles first operational dive. The installation tests ensure that the system is working correctly and allows the operator to become familiar with the units and controls.

Operational use - This chapter describes preparations and the main operations when using the system, like how to turn it on and off.

System functional description - This chapter describes the various functions of the Sabertooth system.

Maintenance Information - Provides maintenance instructions on how to remove, dismantle, assemble and refit the major units, procedures and diagnostics.

Diagnostic maintenance - Fault finding by ping, vehicle diagnose, node tester and changing node ID.

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# Issue Status and Amendments

| Issue Status | Pages Affected | Date of Change | Reason for Change |
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# Safety Notes for Readers

## Usage Instructions

Before using the equipment, you must ensure you have read the various Warning, Cautions, Notes and also relevant installation information.

Safety of the equipment may be impaired if it:

- Shows visible damage.
- Fails to perform the intended measurements.
- Has been incorrectly stored.
- Has been flooded with water (Surface Equipment) or stored in highly humid or dusty environment.
- Has been subjected to severe transport stresses.

## Lifting and Carrying Instructions

Please follow these recommendations when you move, lift or handle the ROV, Surface Equipment and its accessories:

- Lifting heavy equipment can cause spinal injury/sprains/injure your back/pull muscles or, if dropped, cause further injury (including crushing of feet) to you or others. The ROV weighs up to approximately 1500kg. Use suitable methods for handling and lifting and also protect yourself and others.
- Wear appropriate Personal Protective Equipment bearing in mind the weights mentioned above.
- To prevent damage to equipment, only use the lifting points where provided.
- Always adhere to regional health and safety guidelines and local safe systems of work.

## Warnings, Cautions and Notes

Throughout this publication warnings and notes are used to direct the readers attention to specific information.

A A **WARNING** is used to alert the reader to operational or maintenance activities that may, under certain circumstances, represent a threat to safety and health. A warning precedes the paragraph or procedure which gives rise to such a threat.

A **Caution** is used to alert the reader to operational or maintenance activities which, may under certain circumstances, cause damage to equipment and/or material. A caution precedes the paragraph or procedure to which it refers.

A Note contains information of a specific or general nature and is printed immediately after the paragraph to which it refers.

The following symbols are used through this document:

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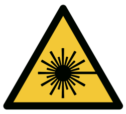
|  | **WARNING**<br>RISK OF PERSONAL INJURY. |
|  | **WARNING**<br>TAKE PRECAUTIONS AGAINST STATIC ELECTRICITY. |
|  | **WARNING**<br>RISK OF ELECTRIC SHOCK. |
|   | **WARNING**<br>RISK OF PERSONAL INJURY DUE TO HEAVY OBJECT. |
|  | **WARNING**<br>RISK OF PERSONAL INJURY DUE TO MOVING PARTS. |
|  | **WARNING**<br>RISK OF PERSONAL INJURY DUE TO LASER HAZARD. |
|  | **WARNING**<br>RISK OF PERSONAL INJURY DUE TO BRIGHT LED LIGHTS. WEAR PROTECTIVE GLASSES. |
|  | **WARNING**<br>WEAR PROTECTIVE CLOTHING AND EQUIPMENT. |
|  | **Caution**<br>Risk of damage to equipment. |

# List of Abbreviations & Acronyms

| | | | |
|---|---|---|---|
| **A** | Ampere | **LIM** | Line Isolation Monitor |
| **AC** | Alternating Current | **MCB** | Mains Circuit Breaker |
| **ADC** | Analogue to Digital Converter | **MSW** | Metres SeaWater |
| **AUV** | Autonomous Underwater Vehicle | **NAV** | Navigation Unit |
| **BMS** | Battery Management System | **OCB** | Operator Control Board |
| **CAN** | Controller Area Network | **PAC** | Payload Application Computer |
| **CCD** | Charge-coupled Device | **PCB** | Printed Circuit Board |
| **CFE** | Customer Furnished Equipment | **PCU** | Power Converter Unit |
| **CP** | Cathode Potential | **POE** | Power Over Ethernet |
| **CPU** | Central Processing Unit | **POCB** | Portable Operator Control Board |
| **CWDM** | Coarse Wavelength Division Multiplexing | **PSU** | Power Supply Unit |
| **DAC** | Digital to Analogue Converter | **PWM** | Pulse Width Modulated |
| **DC** | Direct Current | **RAC** | Vehicle Application Computer |
| **DEG.** | Degree(s) | **ROV** | Remotely Operated Vehicle |
| **DGPS** | Differential GPS; relative GPS | **RTK** | Real Time Kinematic |
| **DVL** | Doppler Velocity Log | **SAC** | Surface Application Computer |
| **EPOD** | Electronics Pod | **SBP** | Sub Bottom Profile |
| **FET** | Field Effect Transistor | **SCB** | Surface Communication Box |
| **Fig.** | Figure | **SCU** | Surface Control Unit |
| **FOR** | Fibre-Optic Receiver | **SLPB** | Superior Lithium Performance Bttaery |
| **GPS** | Global Positioning System | **SM9** | Thrusters |
| **GRP** | Glass-reinforced Plastic | **SOG** | Speed Over Ground |
| **HF** | High Frequency | **SVS** | Sound Velocity Sensor |
| **HMI** | Human Machine Interface | **TFT** | Thin Film Transistor |
| **Hz** | Hertz | **Toggle** | Change to one of two states. Hardware or Software |
| **IGFET** | Insulated Gate Field Effect Transistor | **USB** | Universal Serial Bus |
| **INS** | Inertial Navigation System | **UW** | Under Water |
| **I/O** | Input/output | **VAC** | Volts AC |
| **JB** | Junction Box | **VDC** | Volts DC |
| **Kbd** | Kilo Baud | **VHF** | Very High Frequency |
| **LCD** | Liquid Crystal Display | **W** | Watts |
| **LF** | Low Frequency | **Wi-Fi** | Wireless Fidelity |
| **LAN** | Local Area Network | | |

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# WARNINGS

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| | **DANGER OF FATAL ELECTRIC SHOCK.**<br><br>BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT, ISOLATE ALL THE UNITS POWER SUPPLIES. |
| | **DANGER OF FATAL ELECTRIC SHOCK.**<br><br>BEFORE CLEANING THE EQUIPMENT, DISCONNECT THE MAIN POWER SUPPLY. |
| | **DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL.**<br><br>DUE TO THE LONG LENGTHS AND HIGH VOLTAGES USED IN THIS EQUIPMENT, THE UMBILICAL CABLE AND WINCH CAN HOLD A LARGE CHARGE, WHICH COULD BE HAZARDOUS TO THE USER. THE CABLES/WINCH ASSEMBLIES SHOULD BE FULLY DISCHARGED BEFORE MAINTENANCE. |
| | **DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL.**<br><br>WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE ROV SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND HAVE TAKEN ADEQUATE PRECAUTIONS. |
| | **POSSIBILITY OF FATAL ELECTRIC SHOCK AND DAMAGE TO EQUIPMENT.**<br><br>BEFORE SWITCHING ON THE ROV SYSTEM, ENSURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION. |
| | **POSSIBILITY OF ELECTRIC SHOCK AND DAMAGE TO EQUIPMENT.**<br><br>ALWAYS USE ANTI-EXTRUSION RINGS ON THE VEHICLE EPODS. IF NOT USED, WATER CAN ENTER THE EPOD AND COULD CAUSE PERSONAL INJURY DUE TO ELECTRIC SHOCK. WATER WILL ALSO CAUSE DAMAGE TO THE EPOD COMPONENTS. |
| CAUTION<br>Heavy Object | **POSSIBLE DANGER TO PERSONNEL AND DAMAGE TO EQUIPMENT.**<br><br>THE ELECTRONICS PODS ARE VERY HEAVY AND CARE SHOULD THEREFORE BE TAKEN WHEN LIFTING THE POD FOR SLINGING PURPOSES. UNDER NO CIRCUMSTANCES SHOULD THE POD COMPOSITE ENDS BE USED FOR SLINGING. |
| CAUTION<br>Heavy Object | **POSSIBLE DANGER TO PERSONNEL AND DAMAGE TO EQUIPMENT.**<br><br>THE TRANSFORMER POD IS VERY HEAVY. TAKE EXTREME CARE AND USE THE NECESSARY EQUIPMENT (CRANE AND SLINGS) TO LIFT THE TRANSFORMER POD. THE TRANSFORMER POD COULD CAUSE SERIOUS PERSONAL INJURY AND/OR EQUIPMENT DAMAGE IF NOT LIFTED USING THE CORRECT EQUIPMENT. |
| | **DANGER TO PERSONNEL AND EQUIPMENT.**<br><br>A LIM (LINE INSULATION MONITOR) DOES NOT FUNCTION AS A PERSONAL SAFETY PROTECTION DEVICE. A LIM MONITORS THE STATUS OF THE SYSTEM AND WARNS OF A POTENTIAL FAULT. THE LIM CAN CUT SUPPLY FEED TO HELP PROTECT PERSONAL AND EQUIPMENT, BUT THE REACTION TIME OF THE LIM IS GENERALLY TOO SLOW TO PREVENT ELECTRICAL SHOCK. |

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| | **DANGER TO PERSONNEL AND EQUIPMENT.**<br><br>THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGISED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION AND PERSONNEL PRIOR TO ENERGISING THE DC SUPPLY. THE SYSTEM DC SUPPLY IS ENERGISED. |
| | **DANGER TO PERSONNEL AND EQUIPMENT.**<br><br>A CRUSHING/PINCHING HAZARD EXISTS FROM THE PIVOT ACTION OF THE CAMERAS AND LEDS (IF FITTED). A CRUSHING/PINCHING HAZARD ALSO EXISTS FROM THE TILT PLATFORM OR CHAIN DRIVE (WHERE APPLICABLE). MAKE SURE ADEQUATE PRECAUTIONS ARE TAKEN TO PROTECT PERSONNEL AND EQUIPMENT. |
| | **DANGER TO PERSONNEL.**<br><br>A CRUSHING/PINCHING HAZARD EXISTS FROM THE ACTION OF THE MANIPULATORS (IF FITTED). MAKE SURE ADEQUATE PRECAUTIONS ARE TAKEN TO PROTECT PERSONNEL. |
| | **DANGER TO PERSONNEL.**<br><br>A LACERATION HAZARD EXISTS FROM A CUTTER BLADE (IF FITTED). MAKE SURE ADEQUATE PRECAUTIONS ARE TAKEN TO PROTECT PERSONNEL. |
| | **DANGER TO PERSONNEL AND EQUIPMENT.**<br><br>ONLY USE THE ACCOMPANYING POWER SUPPLIES WITH THE EQUIPMENT. USING ANOTHER POWER SUPPLY MAY AFFECT THE SAFETY OF PERSONNEL OR CAUSE DAMAGE TO EQUIPMENT. |
| | **DANGER TO PERSONNEL AND EQUIPMENT.**<br><br>THE PROTECTION PROVIDED BY THE EQUIPMENT MAY BE IMPAIRED IF USED IN A MANNER NOT SPECIFIED BY SAAB SEAEYE. |
| | **DANGER TO PERSONNEL.**<br><br>A SLIP HAZARD EXISTS WHEN THE ROV IS REMOVED FROM THE WATER ONTO THE PLATFORM. TAKE ADEQUATE PRECAUTIONS. |
| | **DANGER TO PERSONNEL.**<br><br>IF A SONAR IS FITTED, TAKE ADEQUATE PROTECTION AGAINST POSSIBLE HEARING DAMAGE OR LOSS. |
| | **DANGER TO PERSONNEL FROM POSSIBLE EXPOSURE TO CHEMICAL IRRITANTS:**<br><br>DURING MAINTENANCE OR REPAIR, IT IS POSSIBLE TO COME IN CONTACT WITH SUBSTANCES THAT MAY CAUSE SKIN OR EYE IRRITATIONS. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS MAKE SURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL CHEMICAL SAFETY PROCEDURES HAVE BEEN READ AND UNDERSTOOD. |
| A | **DANGER TO PERSONNEL AND ENVIRONMENT.**<br><br>SOME ROV SYSTEMS REQUIRE MOBILECT 39 OIL. DISPOSE OF UNWANTED OIL ACCORDING TO THE MATERIAL SAFETY DATA SHEET (MSDS). |
| | **DANGER TO PERSONNEL FROM LASER EXPOSURE.**<br><br>INVISIBLE LASER RADIATION MAY BE EMITTED FROM DISCONNECTED FIBRES OR CONNECTORS. EXPOSURE TO LASER RADIATION CAN CAUSE DAMAGE TO EYES. WEAR PROTECTIVE GLASSES. |

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| | **WARNING - POSSIBILITY OF PERSONAL INJURY:**<br>TO AVOID PERSONAL INJURY, WEAR SAFETY EQUIPMENT. |
| | **DANGER TO PERSONNEL.**<br>LED LIGHTS PRODUCE AN INTENSE WHITE LIGHT WHICH CAN BE DAMAGING TO THE EYES IF LOOKED AT DIRECTLY WHILST SWITCHED ON. |

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# Cautions

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| | **Danger of damage to PCBs:**<br><br>Do not remove or replace PCBs unless the supply is switched off. PCBs must be handled in accordance with electrostatic discharge handling procedures. Damage to PCBs could affect the safe operation of the equipment. |
| | **Danger of damage to equipment:**<br><br>When checking connections, care is to be taken not to slacken them, otherwise their watertight integrity may be breached. |
| | **Danger of damage to equipment:**<br><br>When using an insulation meter, ensure that the cable under test is disconnected at both ends. |
| | **Danger of damage to the Thruster Motor:**<br><br>Do not operate the Thruster Motor in air for longer than one minute. |
| | **Possibility of damage to equipment:**<br><br>Ensure all vent plugs are securely fitted and shut prior to immersing the vehicle. |
| | **Possibility of damage to equipment:**<br><br>Ensure that the Surface Power Supply Unit (PSU) transformer tappings correspond to the external input power supply. |
| | **Possibility of poor vehicle handling:**<br><br>Addition of equipment or poor vehicle ballast or trim will affect vehicle performance. Ensure the vehicle trim and ballast is correct after adding or removing equipment. |

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# Important Advice Notice and Additional Recommendations

The following recommendations and instructions have resulted from observations and reports experienced by operators in the field:

- Do not subject the ROV or associated equipment to shock or impact; do not drop, or allow objects to impact the equipment.
- To prevent damage to or unnecessary stress on chassis components, always use the lifting point(s) factory fitted to ROV vehicles and TMS launch-systems.
- Operating an ROV in close proximity to pile drivers will subject the vehicle to high levels of shock and pressure. This may well result in destruction of lamp unit filaments due to severe vibration. Over-pressure created by underwater equipment such as pile drivers or explosive processes may exceed the ROV's proof-pressure test certificate, resulting in damage to seals and enclosures and subsequent flooding.
- Do not remove electrical components, equipment or PCB's while the system is electrically live.
- Permitting thrusters or ROV lamps to operate in air for periods in excess of that described in the Technical Manual may cause irreparable damage. Observe the cautions obtained in the relevant sections of the Technical Manual.
- Equipment should not be left exposed to direct sunlight as extreme temperatures can damage the electronic components.
- Equipment should not be left exposed to freezing conditions. Provide suitable covers or stow in a protected area.
- Do not disassemble equipment, particularly thrusters beyond the level described in the maintenance section.
- Do not attempt to increase the performance of the thrusters by subjecting them to voltages in excess of specified levels. Ensure that the PSU is set up and compensated correctly for the umbilical being used.
- System modifications carried out by customers or operators will not appear in either the Technical Manual or associated Wiring Diagrams Manual or in amendments issued by Seaeye.
- Adding or removing equipment from an ROV alters the vehicles payload and ballast, and therefore changes ROV performance. Always re-ballast and trim the ROV prior to operations when such payloads changes have been made.
- Ensure that all surface and subsea connectors are securely mated. Subsea neoprene connectors must be totally dry, clean and their end faces lightly coated with silicone grease before mating.
- It is usually necessary to carry out a complete Configuration procedure if PCB's and items of control equipment have been removed or replaced in the system.
- A Conducting pre and post-operational checks reduces operational downtime.
- Check for the security of fasteners, fixtures and fittings prior to and on completion of operational use.

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# CHAPTER 1

# SYSTEM OVERVIEW

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# 1. System Overview

This chapter provides a general description of the main units as an introduction to the Seaeye Sabertooth system, the vehicle system technical specification and any related information.

The Sabertooth is a battery and AC powered hybrid ROV/AUV vehicle. It can be configured and operated in both tethered and untethered modes. Tethered, it can be operated with a combined fibre and power cable. In tethered mode it performs in a similar manner to a conventional vehicle. It has advanced autopilots such as 6 DOF manoeuvrability and it can carry out station keeping and SOG control.

Untethered, it can operate in AUV mode executing missions with programmed waypoints, actions, behaviours and triggers. When used without the tether it can be manually controlled at the surface via Wi-Fi or radio for longer ranges.

The system is of modular and open design, enabling the use of new equipment and technology without the need to replace the main system elements. There are spare connectors and ports that can be used with new equipment. The design philosophy permits a step-by-step upgrade of both software and hardware.

## 1.1. Main Functions and Characteristics

The Sabertooth is a hovering vehicle with deep water capability, long excursion range and 360° manoeuvrability with 6 degrees of freedom. Sabertooth is ideal for autonomous inspection, maintenance of subsea installations and offshore survey work.

Main characteristics:

- Programmable, a complete mission can be built into the user interface.
- Mobile, the system is designed to be easily packed and moved between locations.
- Operational depth of 3000 msw.
- Advanced auto functions: heading, depth, pitch, roll, altitude and speed stabilisation.
- Full autonomous functionality with obstacle avoidance and behaviour based control.
- Communication to the vehicle via Wi-Fi, fibre-optics and other options (radio and acoustics).
- Battery power allowing long range operations, with either full operator control via a thin fibre optic tether or autonomous operation.
- Built-in redundancy.
- Non-invasive self-diagnostics.

The system software can be configured to suit individual pilot requirements, for more information see the HMI chapter.

## 1.2. System Contents

The system consists of the following major units (some are optional):

- Power Supply Unit (PSU) - optional
- Surface Control Unit (SCU)
- Surface Communication Box (SCB) - optional
- Operators Control Board (OCB)
- Portable Operators Control Board (POCB) - optional
- Monitors, keyboard, mouse
- Vehicle charger box housing the charger unit (if the optional PSU cabinet is not used). This is a standalone unit. Chargers are delivered in this box.
- Vehicle
- Launch and recovery hooks
- Weight set
- Dummy plug set
- Tool kit
- Cable set including start key
- Spares kit - optional
- Dunker 6 telemetry system - optional
- Mast and antenna system
- Winch - optional

The units and their sub-units are described briefly in the following sections.

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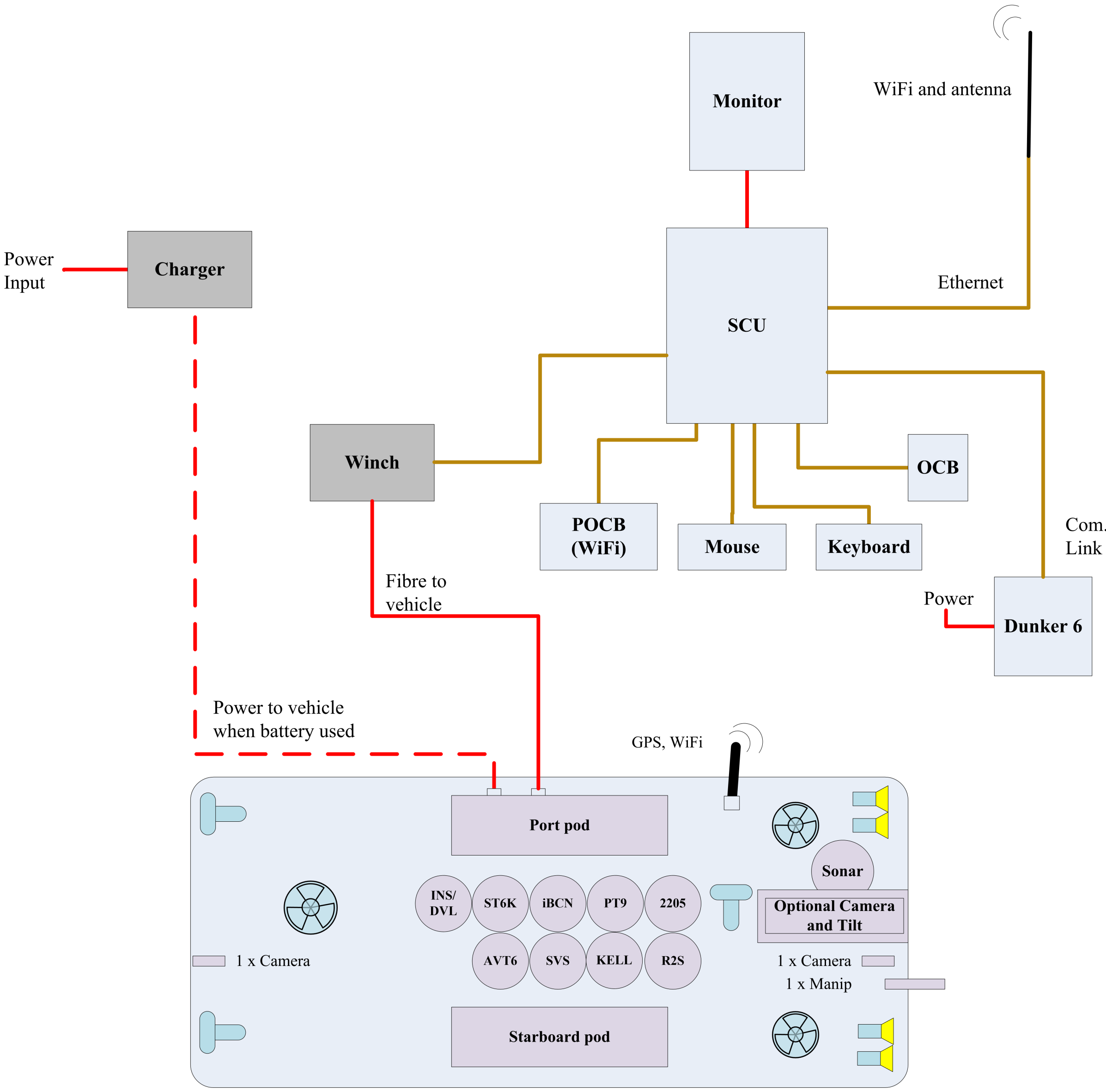


**Figure 1.1: Sabertooth Overview (some options shown)**

## 1.3. Vehicle

The Sabertooth is based on a double pressure hull design. The pressure hulls contain batteries, power and control electronics as well as sensors. Outside the pressure hulls, pressure compensated brushless motors are mounted. The pressure hulls are surrounded by a fairing, which protects the vehicle and its additional equipment (i.e. under water cameras, sonar etc.) against mechanical damage and reduces the influence of water drag on the vehicle.

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It can be powered from the surface or from three internal battery modules, which can be charged when the vehicle is out of the water. Communication and mission planning is carried out via the tether or Wi-Fi. The vehicle can operate autonomously or manually from the surface control units (HMI, OCB and POCB).

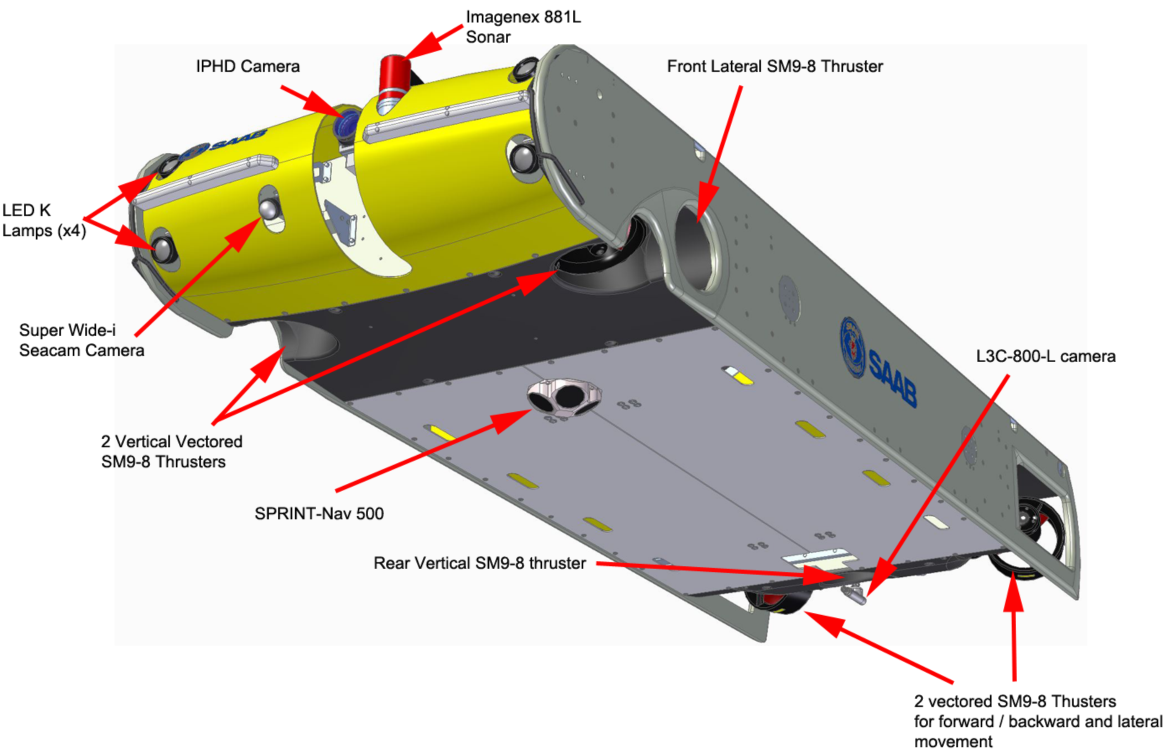


**Figure 1.2: Sabertooth bottom view, 3000m**

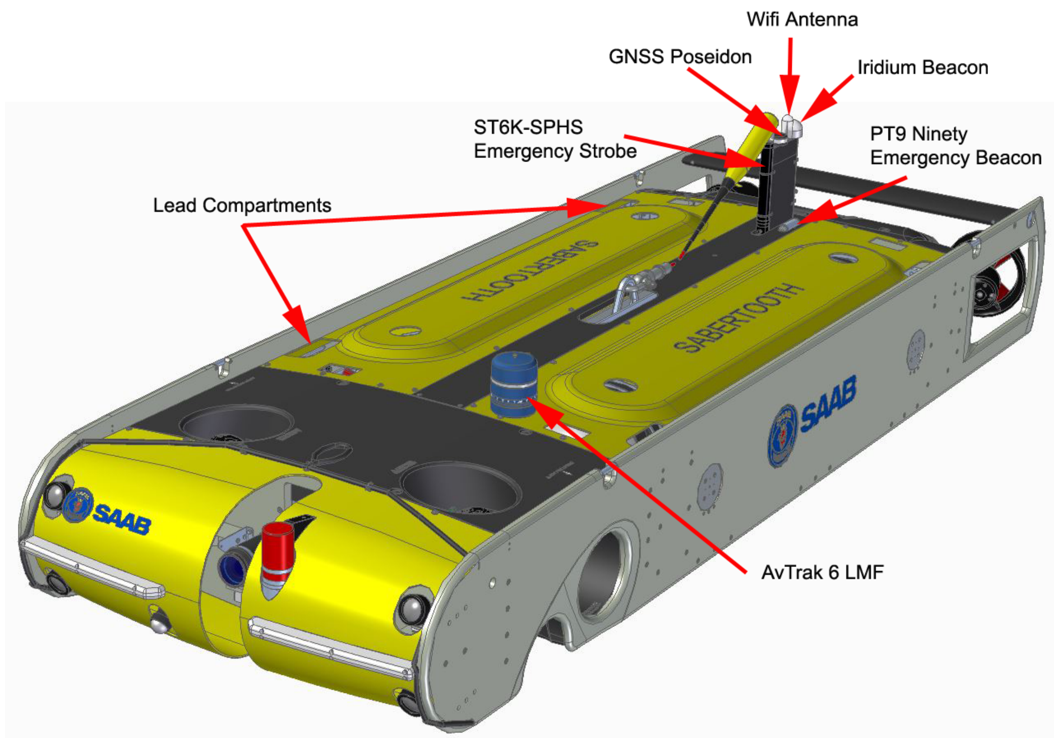


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**Figure 1.3: Sabertooth top view, 3000m**

This vehicle includes the following:

- Main propulsion: two vectored SM9 thrusters, for forward / backward and lateral movement and one thruster located on the bottom of the vehicle.
- 30 mm high strength side protection with integrated stabiliser.
- Vertical thrusters, 3 vectored SM9 thrusters.
- SM9 front lateral thruster.
- Wing, stabilises the vehicle and reduces power consumption.
- Two Electronics pods.
- Seaeye IPHD camera mounted on a tilt unit.
- Super Wide-i Seacam colour camera.
- Rear camera from Bowtech with built in lamp.
- Lamps (4 x Bowtech LED K series).
- SPRINT-Nav 500 (Sonardyne) all-in-one navigation system
- Imagenex 881L profiling sonar. Used for obstacle avoidance in autonomous mode.
- Lead compartments.
- GPS, Wi-Fi plus optional radio.
- Xenon strobe light (Bowtech ST6K).
- Emergency pinger (Novega, PT9 Ninety, 37.5 KHz).
- Iridium beacon (Novatech iBCN).
- Acoustic navigation and communication system (Sonardyne AvTrak LMF).
- Valeport miniSVS.
- Keller Depth sensor.
- External Payload/Tools Interface.

## 1.4. Power Supply Unit – 20kW (optional)

The PSU contains the battery charger for charging the batteries, and it can also supply the vehicle with power when connected to a tether.

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**Figure 1.4: 01-4172016 Power Supply Unit**

### 1.5. Surface Communication Box (optional)

The Surface Communication Box (SCB) contains a radio modem and associated electronics. Wi-Fi electronics can be connected to this. The SCB is a stainless box that can be mounted indoors or outdoors.


**Figure 1.5: Surface communication box (SCB)**

### 1.6. Surface Control Unit (SCU)

The Surface Control Unit (SCU) is a surface unit that is responsible for control and communication. The main parts of the SCU are:

- Surface Application Computer (SAC).
    - Ethernet switch with fibre optic SFP
    - POCB receiver box
    - Serial to Ethernet port server

The equipment is mounted in a 19” rack transport box with removable front and rear lids. The equipment can also be installed in a standard 19” rack. The SCU has the following interfaces:

- Fibre-optic link to the vehicle via winch and tether.
- USB interface to mouse and keyboard.
- USB interface to the Operators Control Board (OCB).
- Antenna connector for the POCB radio antenna.
- Monitor output for display of the graphical HMI.
- Ethernet interface to the Surface Communication Box (SCB) for communication with the vehicle in "untethered mode".


**Figure 1.6: SCU Front Side showing PC from the front**

### 1.6.1. Surface Application Computer (SAC)

The SAC is a single board PC. The software in the SAC carries out the following:

- It presents video and data from the vehicle on the HMI.
- It sends control data from the HMI, OCB and POCB to the vehicle.
- It logs data and records video when required. Video can be recorded as digital data streams in the format .asf. These video files can have simple overlay Date, Time and a small text. All vehicle data is recorded and can then be replayed in the playback HMI. The playback HMI can be used on the SAC but also on a separate PC so as not to be confused with the real system. There is a serial output available with vehicle data, which can be used for video overlay in 3rd party software packages.
- Missions are created in the Mission Planner and uploaded to the vehicle.

## 1.7. Control Boards

The Control boards are the interfaces between the Pilot and Sabertooth System.

### 1.7.1. Operators Control Board (OCB)

The Operators Control Board (OCB) is the device used to control and operate the Sabertooth vehicle. The OCB is a console with two joystick controls for manoeuvring the vehicle during operations. The unit is powered from the SAC via a universal serial bus (USB) cable.

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**Figure 1.7: Operators control board (OCB)**

### 1.7.2. Portable Operators Control Board (POCB)

The Portable OCB is to be used on deck during launch and recovery, as well as during PRE and POST dive checks. It has two joystick controls for manoeuvring the vehicle, and a display for viewing vehicle data. It is connected to the SCU via radio and is powered with a rechargeable battery.

NOTE: Depending on the system, the POCB may be optional.


**Figure 1.8: Portable operators control board (POCB)**

### 1.7.3. Monitor, Keyboard and Mouse

A 24 inch monitor with keyboard and mouse is used to display the HMI including video images from the fitted cameras and sonars. The keyboard and mouse allows the operator to interface with the system for configuration and connects to the SCU.

## 1.8. Wi-Fi Access Point with Antenna

Sabertooth can be used as an autonomous untethered vehicle. When used without the tether it can be manually controlled at the surface via Wi-Fi. It can then be programmed to perform autonomous operations.

## 1.9. Dummy Plug Set

The system is delivered with dummy plugs that can be used when cables are not connected to all connectors on the vehicle.

## 1.10. Cable Set including Vehicle Start Key

Cable set for the surface units, and the start key used when the vehicle batteries is to be used. The vehicle is started by connecting a shorting plug, called the start key, to the ON connector on the vehicle.

## 1.11. Vehicle and Fitted Components

The following units are fitted to the Sabertooth vehicle.

### 1.11.1. Framework vehicle

The Sabertooth is designed around a plastic and stainless steel framework. Inside the framework, all sensors, thrusters, buoyancy elements etc. are attached in a similar manner to a conventional open frame ROV. This framework is then covered with plastic outer fairings that give the Sabertooth a smooth, low drag exterior.

The vehicle has slightly positive buoyancy in fresh water. The buoyancy and balance for varying salinity conditions are trimmed with lead weights and/or buoyancy material.

### 1.11.2. Electronic Pods

The vehicle has two watertight electronics pods (EPOD) designed to provide the housing for the vehicle electronics, batteries as well as providing buoyancy. The pressure hulls are designed for a working water depth of 3000 m.

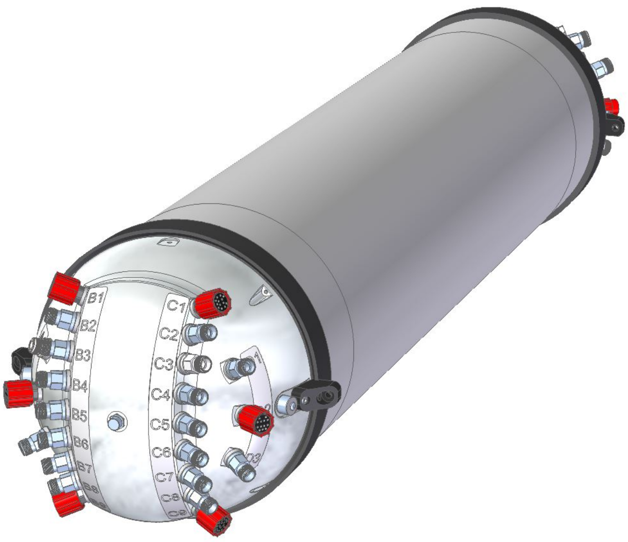

**Figure 1.9: Starboard Electronic Pod**

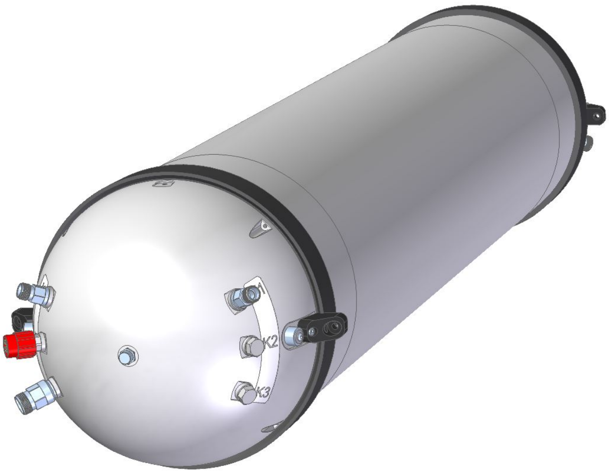


**Figure 1.10: Port Electronic Pod**

**The EPOD contains:**

The Sabertooth contains two main EPODs. The primary starboard e-pod contains the on-board computers, option and sensor interfaces, battery module, power interface and electronics for the thrusters.

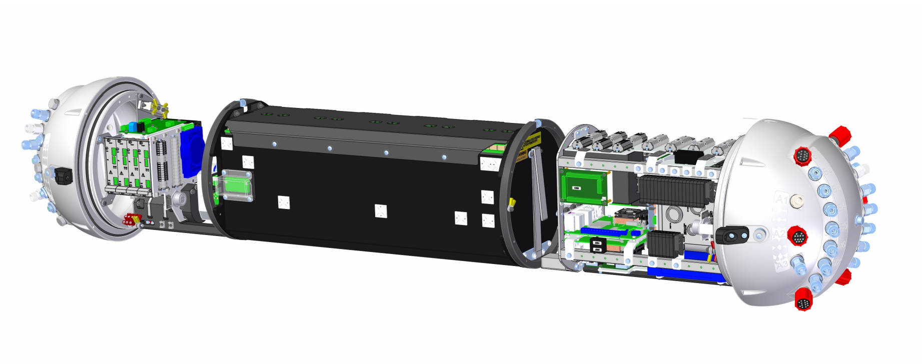

**Figure 1.11: Internal view of the Starboard EPOD**

The Secondary Port EPOD contains the second and third battery module.

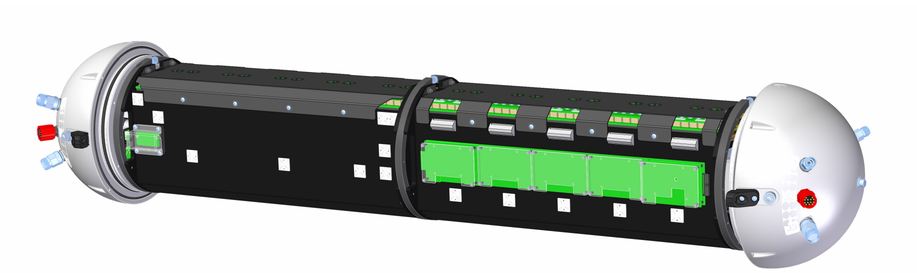

**Figure 1.12: Internal view of the Port EPOD**

The main pressure hulls are designed in such a way that the internal parts, except for the batteries are attached to the lids. The front lid is the low voltage side and the rear lid contains the supplies and connectors for higher voltage devices such as the thrusters.

The EPOD contains:

- Interfaces to Sprint NAV, sonars, mini-SVS, and Depth transducer
- Video servers
- DC/DC converters
- Leak detectors
- Temp sensor
- Earth fault supervisor
- Ethernet Switch with fibre optic SFP
- ROV Application Computer (RAC)
- Payload Application Computer (PAC)

Underwater Connections:

- Battery management and charging
- Lamps
- GPS, Wi-Fi and radio antenna
- Acoustic navigation system
- Sound velocity sensor
- Thrusters
- Cameras
- Sonars
- Tether
- Depth sensor
- Optional tools

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### 1.11.3. Thruster Motors

The vehicle is propelled by six SM9 thrusters. The thrusters are pressure-compensated brushless electrical motors with propellers. The thrusters are fitted to the vehicle to allow for galvanic isolation if required due to dissimilar metal surfaces.

The two main thrusters are vectored in such a way that they can provide efficient forward and heading control. In addition, they work with the front lateral thruster to propel the Sabertooth sideways.

The three remaining thrusters are vertical, two in the front and one in the rear. This gives the Sabertooth full '6 DOF' manoeuvrability as well as a large lift capacity.

The vehicle can be equipped with an optional SM9 thruster for extra thrust either in forward or in lateral configuration.

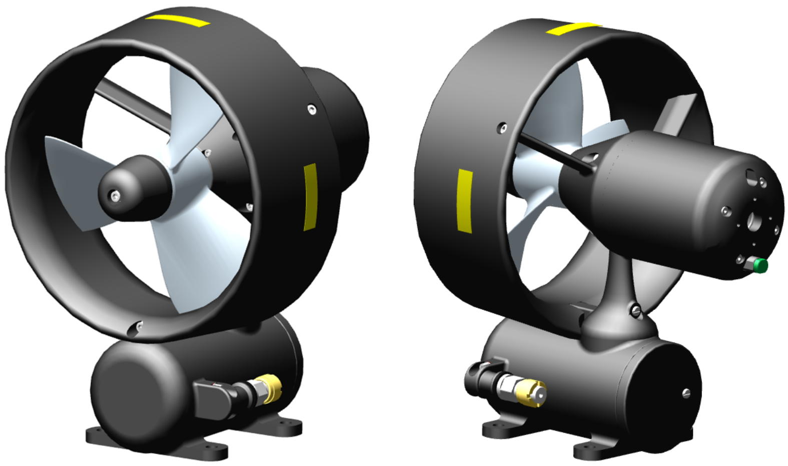

**Figure 1.13: SM9-8 thruster**

**Table 1.1: SM9 specification**

| SM9 thruster specification | |
|---|---|
| Nominal voltage | 300 VDC |
| Nominal current | 9 Amps nominal running |
| Nominal power | 2.5 kW |
| Forward Thrust @ 980 rpm | 60 kgF at 250 VDC |
| Forward Thrust @ 1200 rpm | 100 kgF at 500 VDC |
| Reverse Thrust @ 980 rpm | 60 kgF at 250 VDC |
| Reverse Thrust @ 1200 rpm | 100 kgF at 500 VDC |
| Weight in air | 15 kg (including propeller |
| Weight in Sea Water | 8.5 kg (including propeller and nozzle) |
| Depth Rating | 3000 msw |
| Control Signal | RS485 Interface |
| Connector | 5 Way Connector (2 x Power, 2 x Telemetry, 1 x Earth) |

### 1.11.4. Tilt Unit (Optional)

A A tilt unit is mounted at the front of the vehicle. An IPHD camera is mounted on the tilt unit. The tilt unit can be tilted +/- 90 degrees.


**Figure 1.14: Tilt Unit with IPHD Camera Pointing Forward**

### 1.11.5. Lamp Unit

Sabertooth has four LED lamp units of type Bowtech LED-K (5000 Lumen). The lamps are fitted on the vehicle frame at the front. The units are made from aluminium and features include low power consumption, light weight, high brightness and long life usage. It has telemetry control and a telemetry acquisition confirmation function that lights the units for five seconds and then turns them back off when the power is switched on.

For detailed specifications, refer to the relevant information in the Data Sheet chapter.


**Figure 1.15: Lamp Unit LED Lamp Bowtech LED-K**

### 1.11.6. Cameras

There are a number of camera options for the Sabertooth vehicle. These options will vary depending on the system requirements and configuration.

#### 1.11.6.1. Seaeye IPHD Colour Camera

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The Seaeye IHPD colour camera is fitted to the tilt unit at the front of the vehicle.

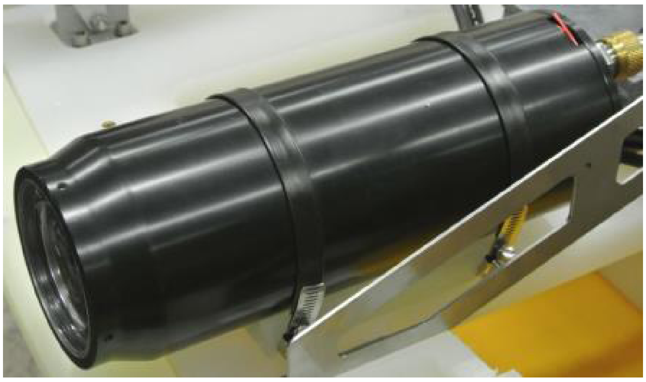

**Figure 1.16: Seaeye IPHD Colour Camera**

### 1.11.6.2. Teledyne Bowtech L3C-800-L Camera

The Bowtech L3C-800-L is a PAL camera, which can be either a colour or monochrome option. The camera features with integrated LEDs.

Features include:

- High Resolution – 800 TVL
- Integral LEDs
- Sapphire Window
- Titanium Housing
- 1000, 4000 and 6000 m rated options

**Table 1.2: L3C-800-L Camera Specifications**

| Specifications | | Values |
|---|---|---|
| Voltage (V) | | 12 - 24 |
| Current (mA) | | 150 |
| Video Output (V pk-pk) | | 1.0 |
| Resolution (TVL) | | 800 |
| Sensor | | 1/3.2” Sony CCD |
| Lens (mm) | 1000 m | 3.6 |
| | 4000 m | 3.6 |
| | 6000 m | 6.0 |
| Angle of View (°) | 3.6 mm lens | 57 |
| | 4.3 mm lens | 57 |
| | 6.0 mm lens | 40 |
| Sensitivity (lx) | Monochrome | 0.005 |
| | Colour | 0.05 |
| Signal to Noise Ratio (dB) | | >50 |
| Material | Housing | Titanium |
| | Window | Sapphire |
| Diameter (mm) | | 31 |

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| Specifications | | Values |
|---|---|---|
| Length without connector (mm) | 1000 m | 128.3 |
| | 4000 m | 129.8 |
| | 6000 m | 133.2 |
| Weight (kg) | In air | 0.280 |
| | In water | 0.190 |
| Water Depth (m) | | 1000 / 4000 / 6000 |
| Storage Temperature (°C) | | -20 to +60 (Humidity: 20% RH to 95% RH) |
| Operating Temperature (°C) | | -10 to +50 (Humidity: 20% RH to 95% RH) |
| Shock | | 3 axis (operating), 30 g peak, 6 ms half sine pulse |
| Vibration | | 10 g, 20 to 150 Hz |

#### 1.11.6.3. Super Wide-i-SeaCam Colour Camera

The vehicle is fitted with one Super Wide-i-SeaCam, which is a fish-eye colour camera.

The camera is located at the front of the vehicle on a fixed mounting that looks forward / downward.

For detailed specifications, refer to the relevant information in the Data Sheet chapter.

**Figure 1.17: Super-Wide-i-SeaCam Camera**

### 1.11.7. Sonars and sensors

There are a variety of sonars and sensors that can be fitted to the Sabertooth System.

#### 1.11.7.1. Imagenex 881L Sonar

An Imagenex 881L profiling sonar is mounted at the front of the vehicle and used for obstacle avoidance. It is a mechanically scanning sonar running on 24V and 10Mbit Ethernet. If the sonar detects an obstacle in automatic mode, the vehicle will slow down and try to steer around it. The vehicle will then return to its previous track. Due to the limited scanning speed, smaller obstacles may not be detected in time if the programmed speed is higher than 3 knots.

**Figure 1.18: Sonar Imagenex 881L**

**Table 1.3: Imagenex 881L Specification**

| Hardware Specifications | |
|---|---|
| Frequency | 675 kHz - Other frequencies can be selected through programmable software configurations. (Tunable from 600 kHz to 1 MHz in 5 kHz steps) |
| Transducer | Profiling type, fluid compensated |
| Transducer Beam Width | 600 kHz: 2.4°<br>675 kHz: 2.1°<br>1 MHz: 1.4° |
| Range Resolution | 1 m - 4 m: 2 mm (0.08")<br>5 m and up: 10 mm (0.4") |
| Min. Detectable Range | 150 mm (6") |
| Max. Operating Depth | 3000 m (Titanium version) |
| Max. Cable Length | Standard: 100 m CAT5e Cable length may be increased up to 9000 m using an Ethernet extender. |
| Interface | Standard: 10Mbps Ethernet (10 BASE-T) using TCP/IP Bit rate may vary if an Ethernet extender is in use. |
| Connector | Side mounted, eight conductor, wet mateable (Subconn MCNH8M-AS or MCBH8M-Ti), optional right angle or end mount connector. |
| Power Supply | 20 - 32 VDC at less 5 Watts |
| Dimensions (for both depth ratings) | 79.4mm (3.125") diameter x 234mm (9.2") length |
| Weight in Air for 3000 m version | 2.2 kg (4.8 lbs) |
| Weight in Water for 3000 m version | 1 kg (2.2 lbs) |
| Materials for 3000 m version | Titanium and Polyurethane |
| Finish | Hard Anodize |

### 1.11.7.2. Valeport MiniSVS Sound Velocity Sensor

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The Valeport Mini Sound Velocity Sensor (SVS) uses digital time-of-flight technology (25 mm path length) to measure the speed of sound in a body of water.

The Valeport Sound Velocity Sensor measures a single pulse of sound travelling over a known distance to provide the speed of sound within a specific body of water. The signal processing technique virtually eliminates signal noise, and gives almost instantaneous response.

Refer to the system configuration diagrams for information on connections.


**Figure 1.19: Valeport Sound Velocity Sensor**

**Table 1.4: MiniSVS Specifications**

| Specification | Value |
|---|---|
| Range | 1375-1900 m/s |
| Resolution | 0.001 m |
| Voltage | 9-28 VDC |
| Data Output | RS232 and RS485 output, selected by command code. |

For more information, refer to the relevant information in the data sheet chapter.

#### 1.11.7.3. Keller PA 33X, 300 bar, High Precision

The depth sensor measures the water pressure, which is used by the control system for depth control and to control the behaviour of the vehicle. The sensor is rated for 3000m working depth and has an RS485 interface.

**Figure 1.20: Keller PA 33X, 300 bar, High Precision**

#### 1.11.7.4. Sprint-NAV 500 Navigation System

The system is fitted with a Sonardyne Sprint-NAV 500 all-in-one navigation system. The system incorporates the following units within a single housing:

- Solid State Dual Attitude Heading Reference system (AHRS)
- Inertial Navigation System (INS)
- Syrinx Doppler Velocity Log (DVL)
- High pressure sensor

For information on the connections, refer to the system configuration diagrams at the end of this chapter.

Refer to the manufacturer's manuals for more information on set up and configuration.


**Figure 1.21: Sprint-NAV 500**

#### 1.11.7.5. AvTrak 6 LMF

The AvTrak 6 is an acoustic navigation and communications instrument designed to form part of an integrated vehicle navigation system. It combines the functions of transponder, transceiver and telemetry link in one low power unit that has been designed to meet the requirements of a wide variety of remote / autonomous vehicle mission scenarios and vehicle types. The unit operates in Sonardyne's Wideband® 2 or HPR 400 Series tone modes and is fully compatible with Sonardyne's family of survey quality LBL and USBL navigation systems.


**Figure 1.22: AvTrak 6 LMF**

#### 1.11.7.6. Antenna Brackets

The various communication devices are located at the rear of the vehicle mounted on Antenna Brackets.

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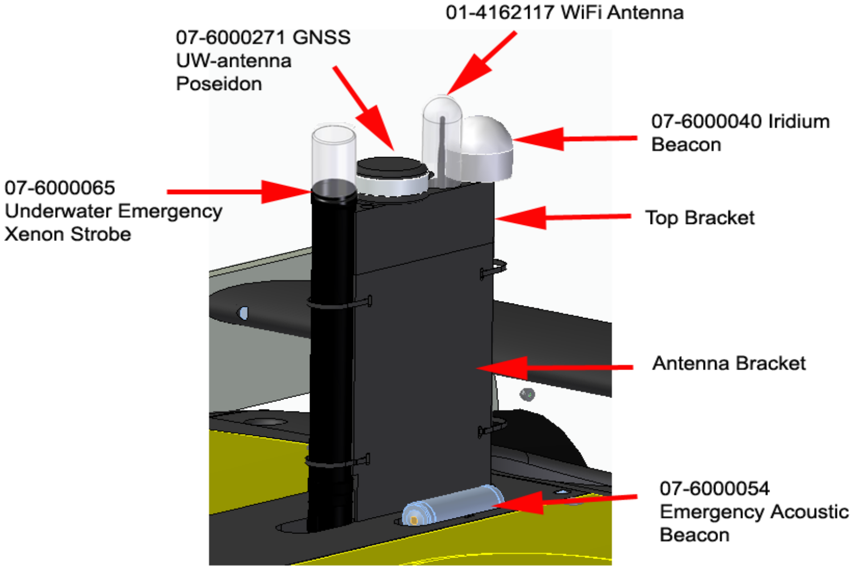


**Figure 1.23: Antenna Brackets with Various Communication Units Fitted**

### 1.11.7.7. Iridium Beacon 7500m

MetOceans iBCN is used to send the vehicles position via Iridium satelite. The iBCN is a standalone, battery powered, unit housed in a titanium tube. The position is obtained by a built in GPS in the top of the unit. To activate, remove the magnet on the Iridium head. Positions is sent when the vehicle reach the surface.

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**Figure 1.24: Top of the MetOcean Iridium beacon**

#### 1.11.7.8. Emergency Acoustic Beacon

Acoustic emergency beacon to track vehicle subsea similar to the black boxes in aeroplanes.

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**Figure 1.25: Emergency acoustic beacon**

### 1.11.7.9. 07-6000271 GNSS Poseidon

Poseidon is a multi-frequency subsea GNSS (Global Navigation Satellite System) antenna designed for underwater vehicles which require the ability to obtain a GNSS fix when surfaced.

For full specifications, refer to the data sheet.


**Figure 1.26: GNSS Poseidon Antenna**

### 1.11.7.10. ST6K-SPHS Xenon Emergency Strobe

The vehicle is equipped with a Xenon Emergency Strobe that is used to locate the ROV when it surfaces for recovery.

The high intensity xenon gas discharge lamp has a maximum power rating of 0.3 Watt seconds and can be seen up to 4 miles away depending upon environmental conditions, observers height and the frequency of the strobe setting.

For full specifications, refer to the data sheet.


**Figure 1.27: ST6K-SPHS Xenon Strobe**

## 1.12. Vehicle Charger

The vehicle charger is used for charging the vehicle batteries. The vehicle has three battery modules that are charged individually by the charger. The charging time is approximately 3.5 hours, if battery is fully discharged prior to the start of charging. For connectivity between the charger and the vehicle, three 20m cables are supplied for between the charger and the vehicle and a 10m cable is supplied between charger and main power.

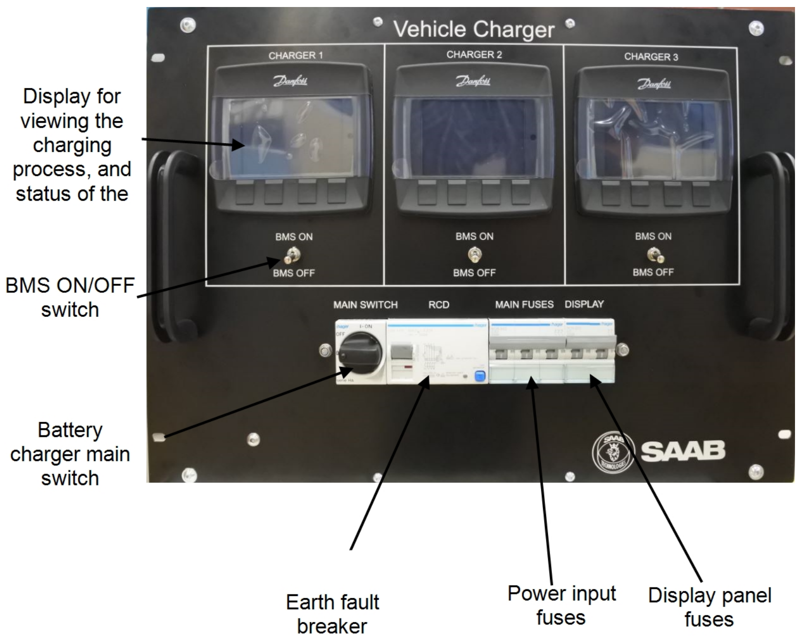


**Figure 1.28: Battery charger**

## 1.13. Sabertooth System Equipment Specifications

**Table 1.5: Surface Equipment Specification**

| Surface Control Unit | | |
|---|---|---|
| Dimensions | Depth (closed box) | 700 ± 50 mm (interior 19" rack 510 mm) |
| | Width | 750 ± 50 mm (Interior 19" rack) |
| | Height | 500 ± 50 mm (Interior 4U) |
| Weight (in closed Pelicase) | | 30 ± 2kg |
| Supply voltage | | Single 50/60 Hz, 230 VAC |

| | | |
|---|---|---|
| Power consumption | | Max 250 W |
| Power inlet | | IEC C13 socket (supplied with a detachable power cable with connector type CEE 7/4 "Shuko") |
| **Vehicle Charger for Charging Three Batteries** | | |
| Dimensions | Depth | 512 mm |
| | Width | 482 mm |
| | Height | 355 mm |
| Weight | | 33 ± 5kg + 10 kg box when used stand alone |
| Supply voltage | | Three phase 230VAC or 400VAC 32A |
| Frequency | | 50Hz |
| Power consumption | | 11kW |
| **Surface Communication Box** | | |
| Dimensions | Depth | 390 ± 50 mm |
| | Width | 300 ± 20 mm |
| | Height | 440 ± 50 mm (2U) |
| Weight | | 20±5 kg |
| Input voltage | | 230VAC @ 50/60Hz |
| Power consumption | | 200W, fuse 6A |
| Power inlet | | Amphenol 5P D38999/24MD5PN |

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**Table 1.6: Vehicle Specification**

| Vehicle | | |
|---|---|---|
| Length | | 4050 ± 50 mm (excluding sonar payload) |
| Width | | 1350 ± 10 mm |
| Height (excluding sonar payload). | | 670 ± 50 mm |
| Height (excluding sonar payload, raised antenna) | | 1090 ± 50 mm |
| Weight (excluding payload) | In air | 1360 ± 50 kg |
| | In water | Slightly positive buoyant |
| Lifting, SWL | | SWL 2000 kg |
| Payload Capacity | In air | 700 kg |
| | In water | 50 kg heavy |
| Operational depth | | 3000 m |
| Forward speed | | up to 4 knot (payload dependent) |
| Backward speed | | approx. 2.5 knot (payload dependent) |
| Lateral speed | | approx. 1.2 knot (payload dependent) |
| Vertical speed | | 1 knot |
| Bollard pull | Forward | approx. 1200N |
| | Vertical | approx. 1200N |
| | Lateral | 900N |
| Total battery capacity | | 30kWh |
| Operating temperature | Battery charging | 0 to +45°C |

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# CHAPTER 2

# CONTROLS, INDICATORS AND CONNECTIONS

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# 2. Controls, Indicators and Connections

This chapter provides a description of the Sabertooth System controls and connections for easy reference.

## 2.1. Introduction

The system includes the following controls, indicators and connections:

- Power Supply Unit
- Battery Charger
- SCB Surface Communication box.
- SCU Surface Control Unit.
- Operator Control Board (OCB).
- Portable Operator Control Board (POCB).
- HMI Control Software.
- HMI Player Software.
- Vehicle.

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## 2.2. Power Supply Unit Cabinet Controls (optional)

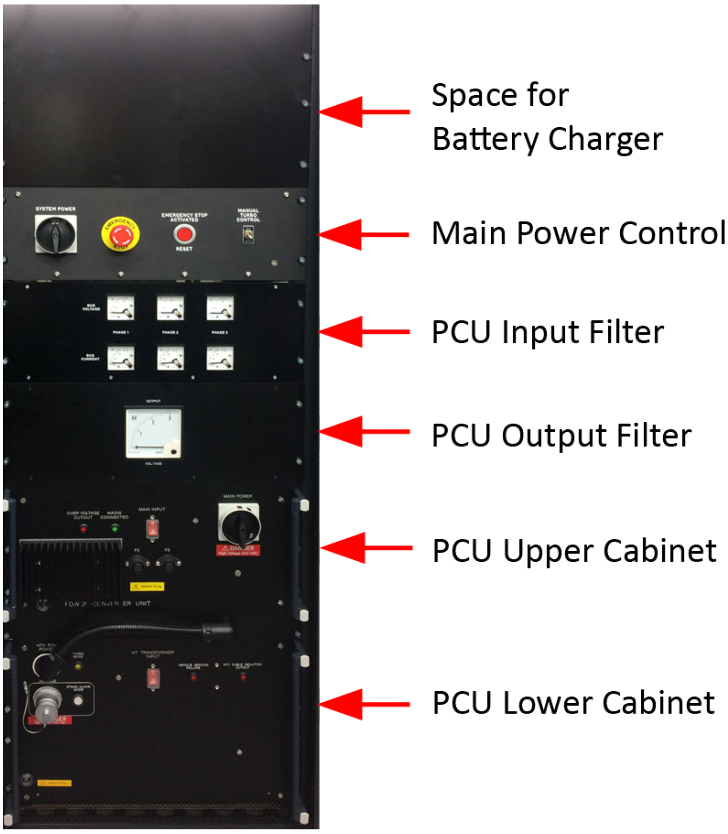


**Figure 2.1: PSU Cabinet**

**Table 2.1: PSU Controls and Indicators**

| Control Unit | Function |
|---|---|
| Battery charger | Used for charging the vehicle batteries. It can charge all three batteries at the same time. The charger can be removed and used as a stand alone unit. |
| Main power control unit | A 3-phase Main power switch turns ON / OFF the incoming main power to the PSU cabinet.<br>An emergency stop button switches OFF the incoming power when pressed.<br>A Manual Turbo Control switch turns the Turbo ON / OFF. |
| PCU input filter | Filters the 3-phase Main input to the Upper and Lower PCU.<br>Displays the 3-phase Main power voltage and current on the front panel when switched ON by the Main power switch. |
| PCU output filter | Filters the PCU HV output. Connect the power out to the deck cables. Display the HV power from the PCU on the front panel. |
| PCU upper cabinet | Rectifies and stabilize the main power and via a cable connect the DC voltage to the lower cabinet. |
| PCU lower cabinet | Convert the incoming DC voltage from the upper cabinet into a 800Hz square wave power that is transformed up to 2700V. The cabinet contains insulation and GND sense monitoring circuits. |

### 2.2.1. Main Power Control Unit

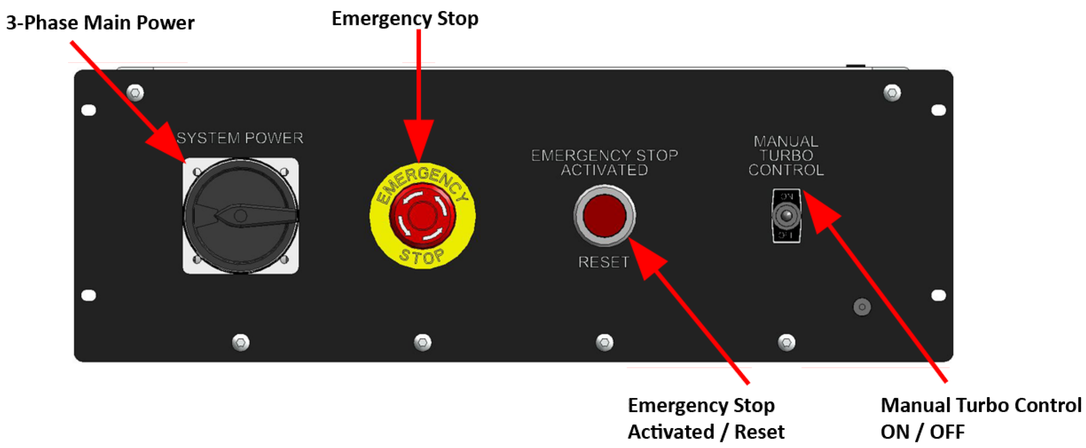


**Figure 2.2: Main power switch and emergency stop**

The 3-Phase 400 / 440V main power input is connected to the Main power switch, which, via a contactor and the PCU input filter, supplies the PCU.

If the emergency stop is pressed, the power to the PCU is switched off and the vehicle is switched off. A red push button (Emergency Stop Activated or Reset button) illuminates if the emergency stop is pressed. This button is also used to reset the emergency stop.

**WARNING - DANGER TO PERSONNEL:**

THE EMERGENCY STOP WILL NOT POWER OFF THE VEHICLE IF THE VEHICLE IS POWERED BY THE BATTERY.

The Manual Turbo Control button allows the operator to manually select the turbo control to ON / OFF. Turbo control should only be set to ON when the vehicle is in the water. Turbo control should be set to OFF when the vehicle is on deck.

**CAUTION - Possibility of damage to the vehicle:**

Do not set the turbo control to on when the vehicle is on deck. Using the turbo while on deck can cause damage to the transformer unit due to a heat dissipation issue.

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### 2.2.2. PCU Input Filter

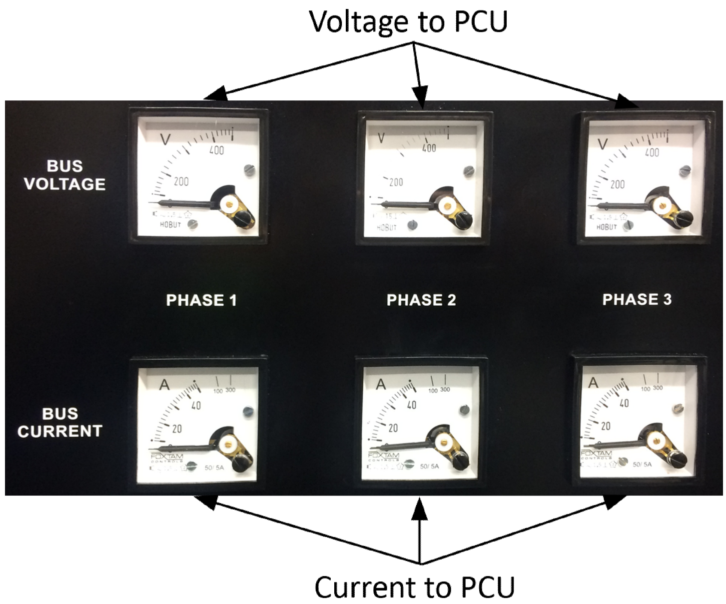


**Figure 2.3: PCU Input Filter**

The 3-phase Main power from the Main Power Control unit is connected the PCU input filter. Via ampere and voltmeters, the power is connected to a 3-phase input filter unit, which is connected to the PCU.

### 2.2.3. PCU Output Filter

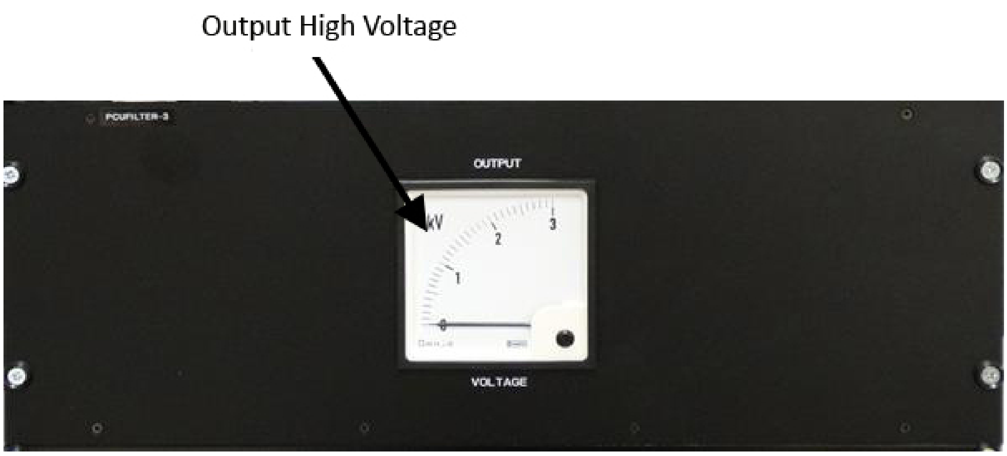


**Figure 2.4: PCU Output Filter**

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The HV output from the PCU is connected to a high voltage filter unit and then connected to the deck cable. A panel meter displays the high voltage level.

### 2.2.4. PCU

The PCU is divided in two units:

- Upper cabinet
- Lower cabinet

These two cabinets are connected together via cable connections on the rear panels.

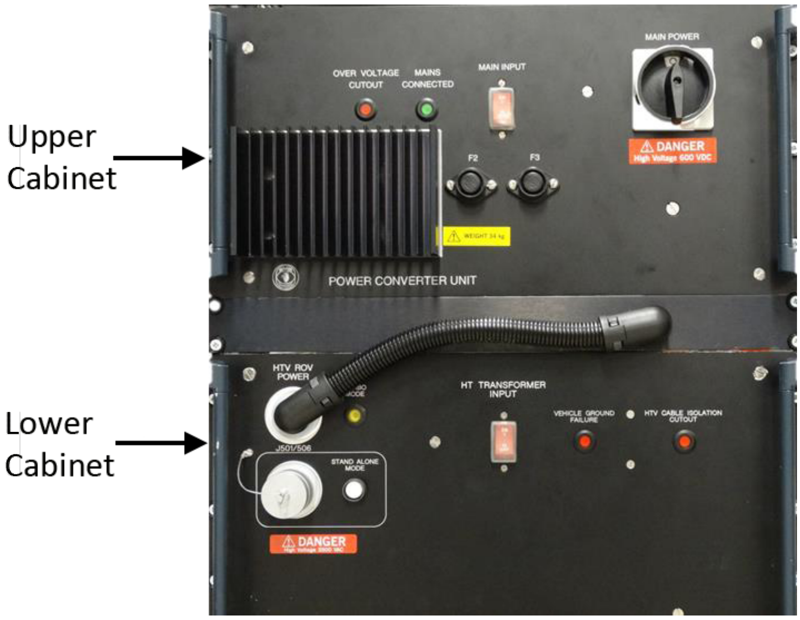


**Figure 2.5: PCU**

### 2.2.4.1. PCU Upper Cabinet

The PCU is powered from the PCU input filter. The Upper and Lower PCU act as one power supply unit; the upper unit providing power for the lower unit. The 400/440 VAC 3-Phase input to the Upper PCU is rectified within the unit to a high voltage stabilized DC supply, which is then routed to the Lower PCU. The DC voltage increases with increased current to compensate for voltage loss in the cable.

### 2.2.4.2. PCU Lower Cabinet

The Lower PCU takes the high voltage DC and creates a 800Hz square wave, and transforms it up to a 2.7 KV HV output to the vehicle. The voltage varies depending on the load.

Protection circuits provide protection against over voltage, over current, GND sense, insulation failure and temperature faults. A RS485 data link communicates with the SCU that is used for switching ON/OFF the vehicle and for sending information to the HMI regarding insulation, voltage, current and failures. The PCU HV cables, GND sense and GND are connected to a wiring terminal at the rear of the PSU cabinet.

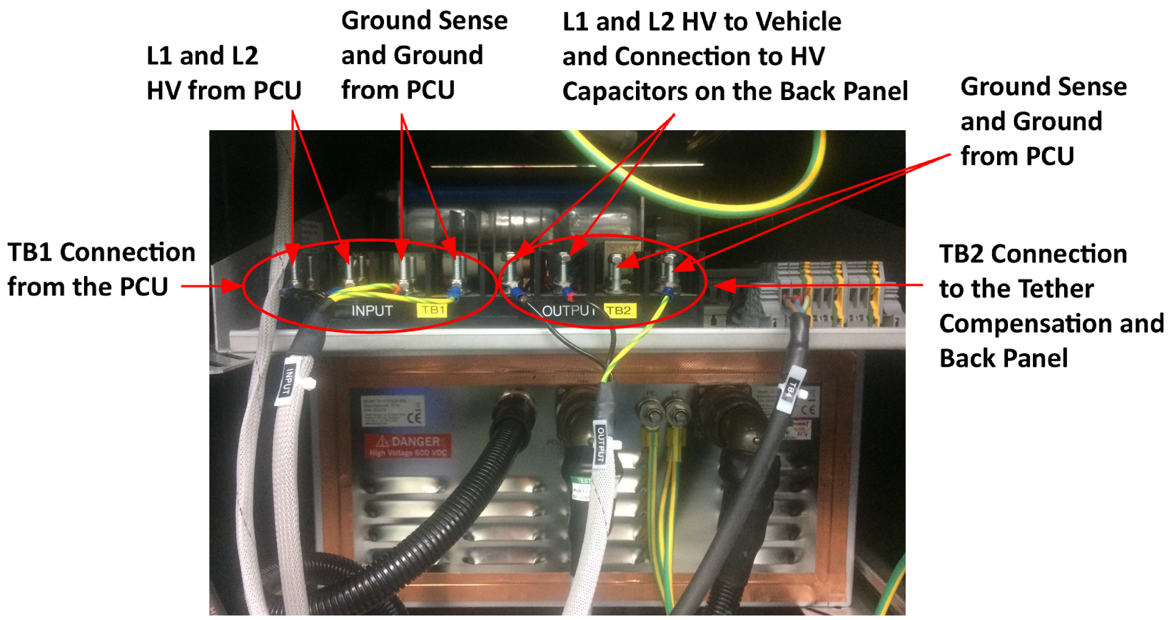


**Figure 2.6: Connection PCU power and deck cable**

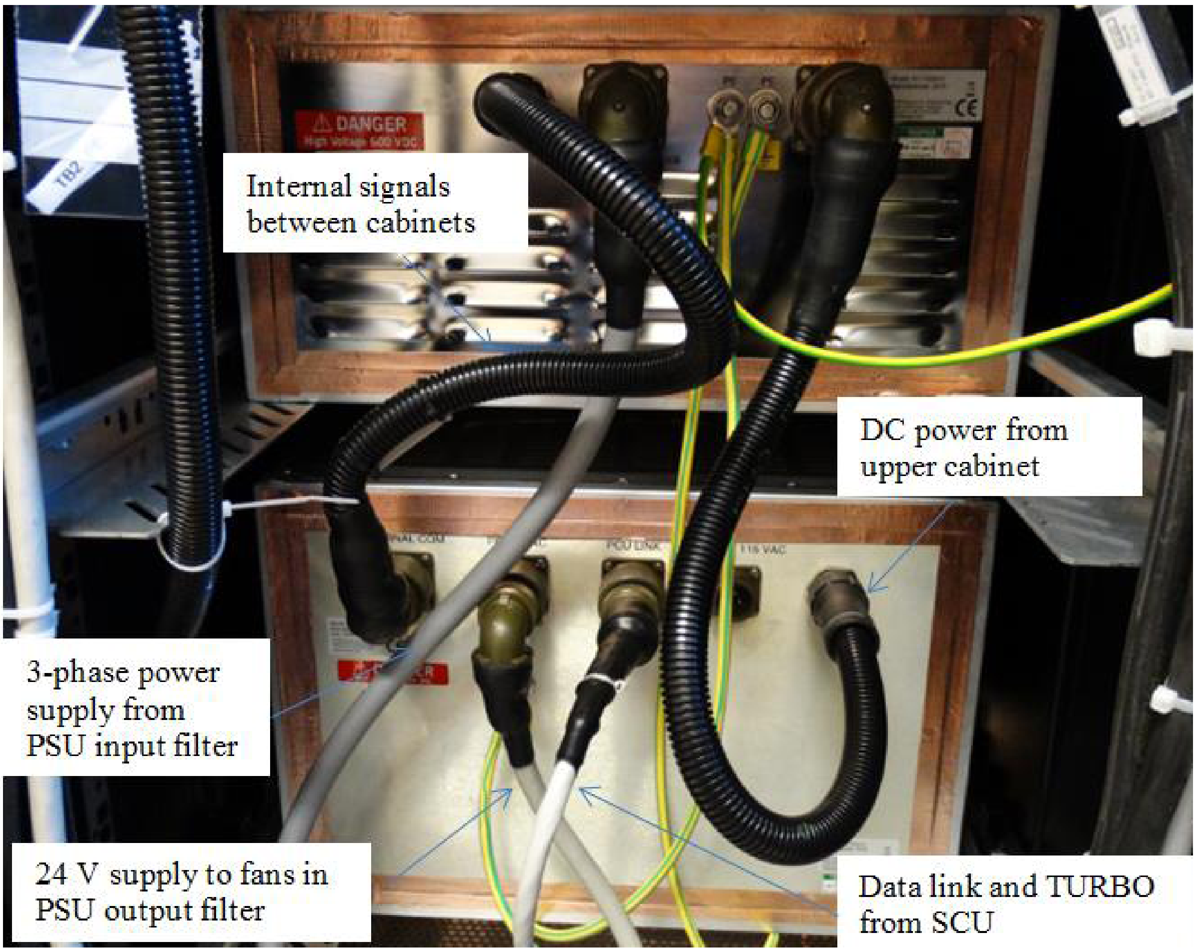


**Figure 2.7: PCU Rear connections**

## 2.3. Battery Charger

The charger unit consists of three chargers, one for each battery. It is supplied with either a 3-phase 230 VAC supply or a three-phase 400 VAC supply plus neutral. There are three power outputs for the three batteries. The charger can be used in the PSU rack or removed from the rack and used as a standalone unit. When used as a standalone, the charger unit is mounted in a separate enclosure.

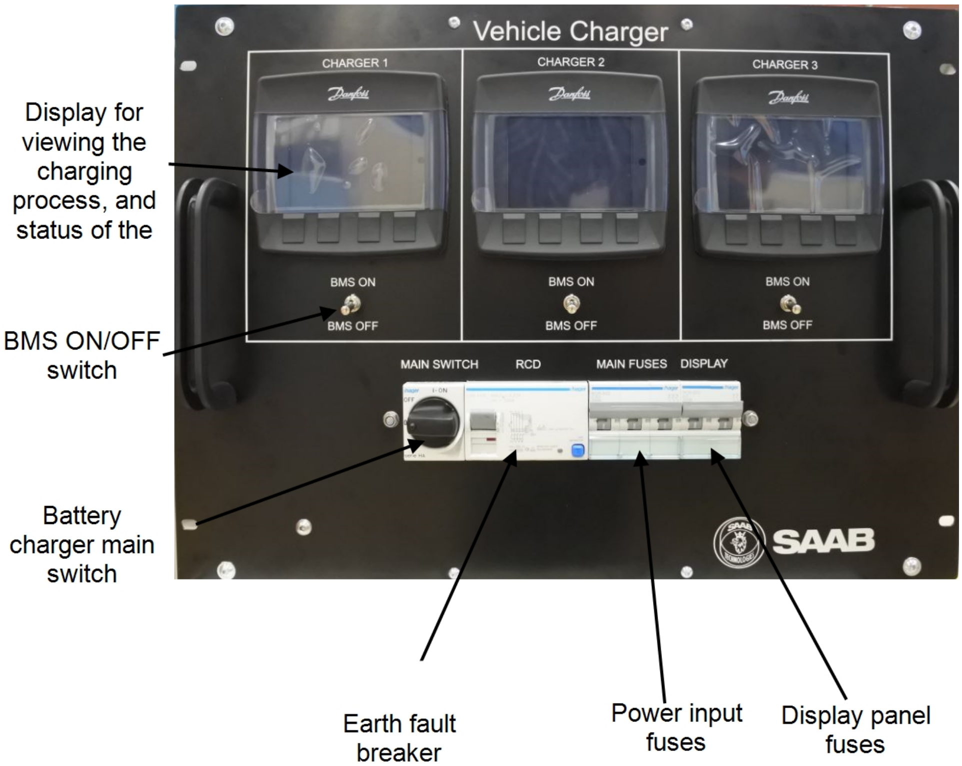


**Figure 2.8: Battery Charger Unit**

**Table 2.2: Battery Charger Controls and Indicators**

| Labels on Front Panel | Function |
|---|---|
| MAIN SWITCH | Switches on the 3-phase main input. |
| RCD | Earth fault breaker for the 3-phase main input. |
| MAIN FUSES | Fuse for the 3-phase main input. |
| DISPLAY | Fuse for the panel display. |
| BMS ON / BMS OFF | When switched ON, the BMS is started and starts searching after a charger. |
| CHARGER 1, 2 and 3 | Three digital displays showing the charging process and the status of the connected batteries. |


**Figure 2.9: Battery Charger Unit (rear view)**

**Table 2.3: Battery Charger Connections Rear Panel**

| Connectors on Rear Panel | Function |
|---|---|
| POWER IN | 3-Phase power supply unit connection. |
| CHARGER 1, 2 and 3 | Connection between the chargers and the vehicle batteries. The cables contain both power and CAN communication. |

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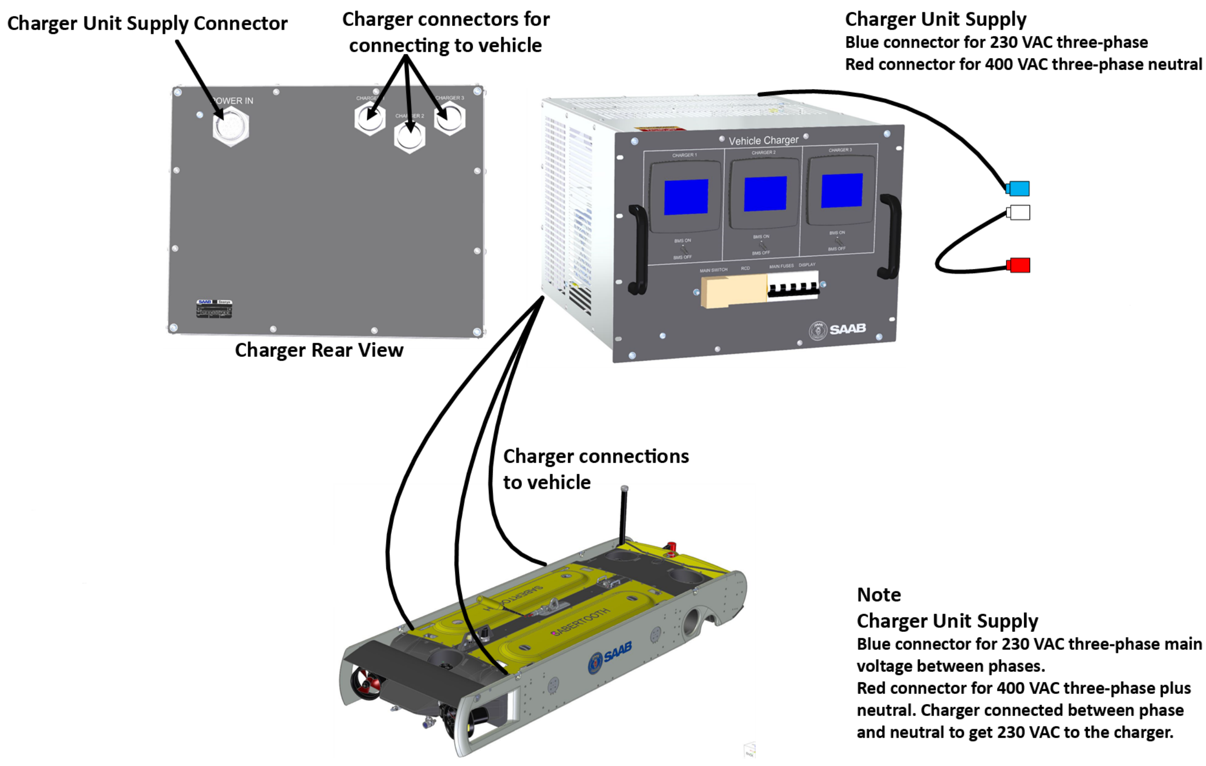


**Figure 2.10: Cable connections when charging battery on the vehicle**

## 2.3.1. Battery Panel Displays

The following table describes the information shown on the Battery Panels.

**Table 2.4: Battery Panel Displays**

| | |
|---|---|
| **Battery not connected** | The BMS is switched OFF.<br>When the main power switch is switched on and the start key has not been inserted, all three panel displays show “Battery not connected”. |
| BATTERY 2<br>Battery charge level: **77%**<br>Battery voltage: 274 V<br>Battery current: 9.9 A<br>Charger : Charging in progress<br>Battery: Output ON | Green LED illuminated – BMS active.<br>Also displays the % of battery charge, the battery voltage and the battery current.<br>Yellow LED illuminated – Charging in process.<br>Red LED lit – Battery Output ON. |
| **Charger can show the following messages:** | |
| Searching for connection | When the “BMS” switch is switched ON and the charger is not operational. |

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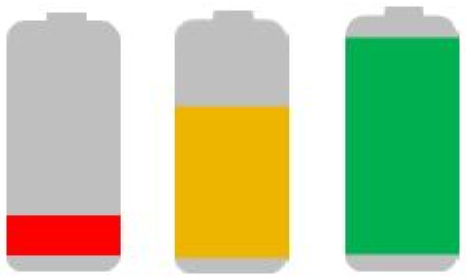
| | |
|---|---|
| Operational | The charger is powered up and ready to receive commands from BMS. |
| Charging in progress | The charger has started to charge the battery. |
| Charging ready | The charging is complete. |
| Charging pending | Charging will start momentarily. |
| ERROR, restart needed | Internal fault in the charger unit. |
| Disabled | Internal fault in the charger unit. |
| No Connection | The BMS has no connection with the charger inside the unit. |
| **Battery can show the following messages:** | |
| Output OFF | Battery power outlet relay is OFF. |
| Output ON | Battery power outlet relay is ON. |
| Output ON, Discharging | Battery power outlet relay is ON and current is drawn from the battery. |
| Equalizing in progress | Displays when the BMS is equalizing the battery cells to the same voltage level. |
| BMS shutdown pending | BMS will shut down momentarily. |
| BMS ERROR | Internal fault in the BMS. |
|  | The colour of the battery symbol on the display will change depending on the charge level of the battery. Red is the lowest charge level and Green is the highest. |

For more battery information, press the left button below the display to see the following information:

Press the left button under the display screen to view additional information

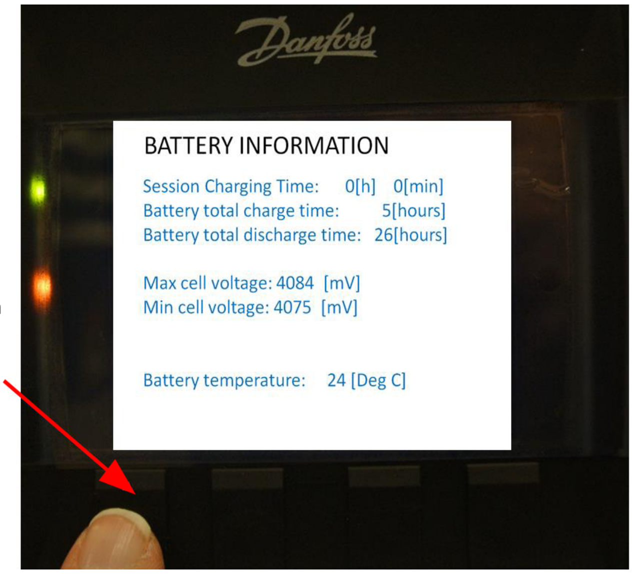



**Figure 2.11: Additional Battery Information**

## 2.4. Surface Communication Box (optional)

The Surface Communication Box (SCB) is a metal cased box containing the Wi-Fi and radio.

All connectors are on the small lower side of the box.

All connectors are keyed to avoid wrong connection.

The power switch for the unit is placed to the right on the front, see figure.

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Figure 2.12: Surface Communication Box

## 2.5. Indicators and Connector (SCU)

On the front side of the SCU there is a power switch and auxiliary Ethernet connectors.

On the rear side of the SCU there are connectors for serial communication, USB for OCB, keyboard and mouse, Ethernet connectors for SCB and Wi-Fi, monitor connections, connectors for optical fibre and POCB antenna and power inlet.

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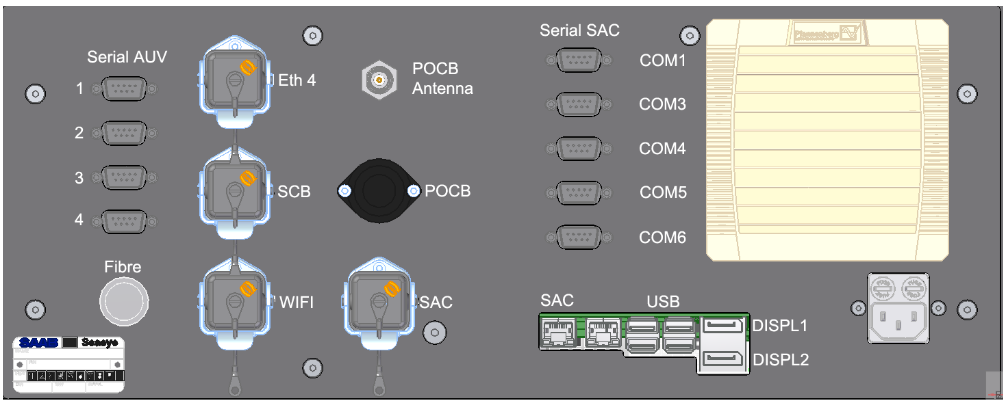


Figure 2.13: SCU rear side

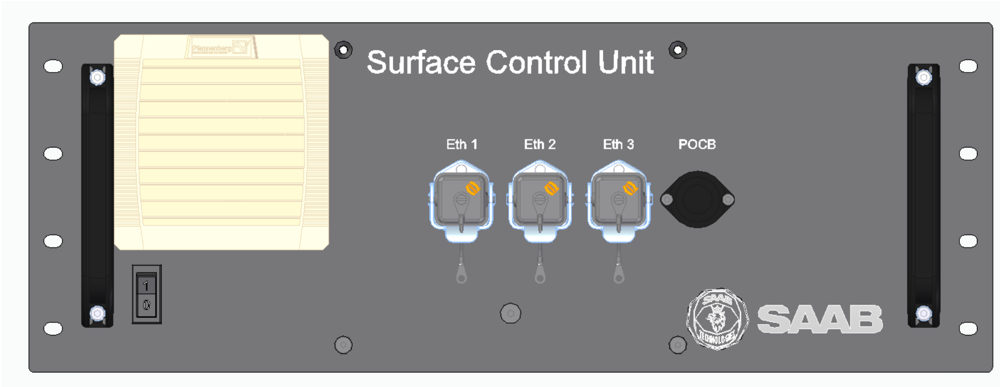


**Figure 2.14: SCU Front**

## 2.6. Operators Control Board (OCB)

The Operator Control Board (OCB) is used for operating the vehicle. It contains two joysticks and several switches. All switches are spring loaded back to the centre.

NOTE: The "take control" function works with both the OCB and POCB and either can take control at any time. Therefore the POCB and OCB operators must have a good communication to understand who is in control at any given time.


**Figure 2.15: SCU OCB Controls and Indicators**

| Item | Description |
|---|---|
| Left Joystick | This joystick proportionally controls depth, roll and pitch. Pitch is controlled by the thumb lever mounted at the front of the joystick. All joystick commands are proportional to the velocity of the corresponding function. This means that pushing the (left hand) depth joystick forward will make the vehicle dive vertically at a constant velocity, until the joystick is released to its neutral position. Since the vehicle features auto-depth capability, it will always maintain the current depth, whenever the depth joystick is left in the neutral position when in GLOBAL mode (See Control modes). It is important to realise that both pitch and roll behaves in a similar way. That is, pushing the thumb lever forward will |

| Item | Description |
|---|---|
| | pitch down the vehicle at a constant velocity, proportionally corresponding to how far the thumb lever has been pushed. Releasing the thumb lever back to its neutral position will automatically hold the current vehicle pitch angle. The roll function is equivalent to that of the pitch control. Never use the joysticks as “on/off switches”, use them cautiously. |
| Right joystick | This joystick proportionally controls all horizontal movements (forward/backward, sideways and yaw). |
| TILT – DOWN/UP | Switch that can be moved forwards and backwards. Holding the switch forwards tilts the tilt unit down. Holding the switch backwards tilts the tilt unit up. |
| PAN CAM – P/SB | Switch that can be moved left and right. Used with pan and tilt camera. Holding the switch left pans the camera to port. Holding the switch right pans the camera to starboard. |
| TILT CAM – DOWN/UP | Switch that can be moved forwards and backwards. Used with pan and tilt camera. Holding the switch forwards tilts the tilt camera down. Holding the switch backwards tilts the camera up. |
| DEPTH-INC/DEC | Switch that can be moved forwards and backwards. This step up/down button give thrust bursts that correspond to depth decrease/increase 1dm/click. This control only works in global mode. |
| JSTICK - 100%/50%/25%. | Switch that can be moved forwards and backwards. Selects the joystick sensitivity 25%, 50% or 100%. Moving the switch forwards increases the sensitivity with one step. Moving the switch backwards decreases the joystick sensitivity one step. The present selection is shown on the HMI. This means that clicking twice forwards always selects 100% while clicking backwards twice always selects 25%. |
| MODE | Switch that can be moved forwards and backwards. Selects the control mode of the vehicle. Moving the switch forwards will always change the mode to Deck mode. Moving the switch backwards changes to Thrust mode, Speed mode and Station mode. The present mode is shown on the HMI. |
| PITCH/ROLL – ZERO | Switch that can be moved forwards and backwards. Moving the switch forwards unsets Zero Pitch and Zero Roll making it possible to change Pitch and Roll from zero degrees. Moving the switch backwards sets Zero Pitch and Zero Roll. |
| TETHER – OUT/IN | Switch that can be moved forwards and backwards. Moving the switch forwards decreases tension set to the winch. Moving the switch backwards increases tension set to the winch. |
| YAW – P/SB | Switch that can be moved left and right. Each click will give one degree turn port or starboard. |
| SPEED – INC/DEC. | Switch that can be moved forwards and backwards. This step up/down button increase/decrease the Ref Adjust thrust in the forward/backward direction. |
| A REF ADJ | Switch that can be moved forwards and backwards. Moving in any direction will activate Ref Adj. This means that the present joystick thrust will be added as an offset. |
| LIGHTS – INC/DEC | Switch that can be moved forwards and backwards. Moving the switch forwards increases the light intensity. Moving the switch backwards decreases the light intensity. |
| STOP | Switch that can be moved forwards and backwards. Moving in any direction will make the vehicle stop and hold the current position. |

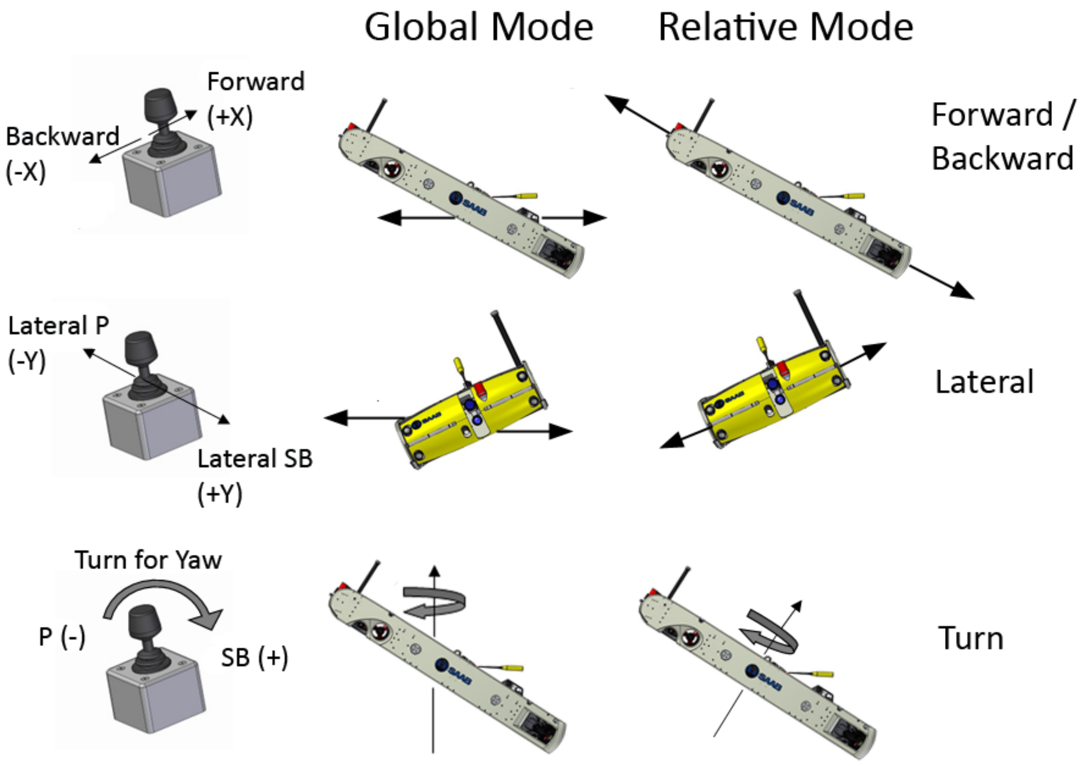


**Figure 2.16: OCB Control Modes (right joystick)**

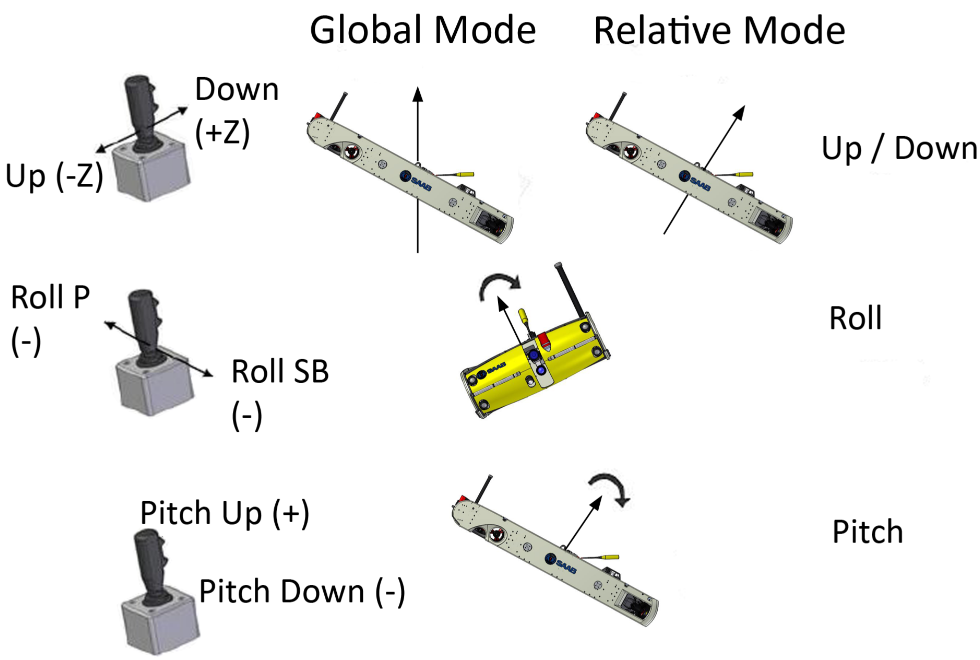


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**Figure 2.17: OCB Control Modes (Left Joystick)**

## 2.7. Portable Operators Control Board (POCB)

The Portable Operator Control Board (POCB) is used by the pilot for operating the vehicle whilst in close proximity. This is usually during launch and retrieval operations.

NOTE: It is important to know with POCB operation, that the POCB does not support all control modes of the OCB. If the pilot "takes control" with the POCB whilst the vehicle is in control mode "station"it will continue in the station mode but label it "speed". Saab recommends to always put the vehicle in to "speed" before the POCB takes control if the vehicle is in the water.

NOTE: The "take control" function works with both the OCB and POCB and either can take control at any time. Therefore the POCB and OCB operators must have a good communication to understand who is in control at any given time.

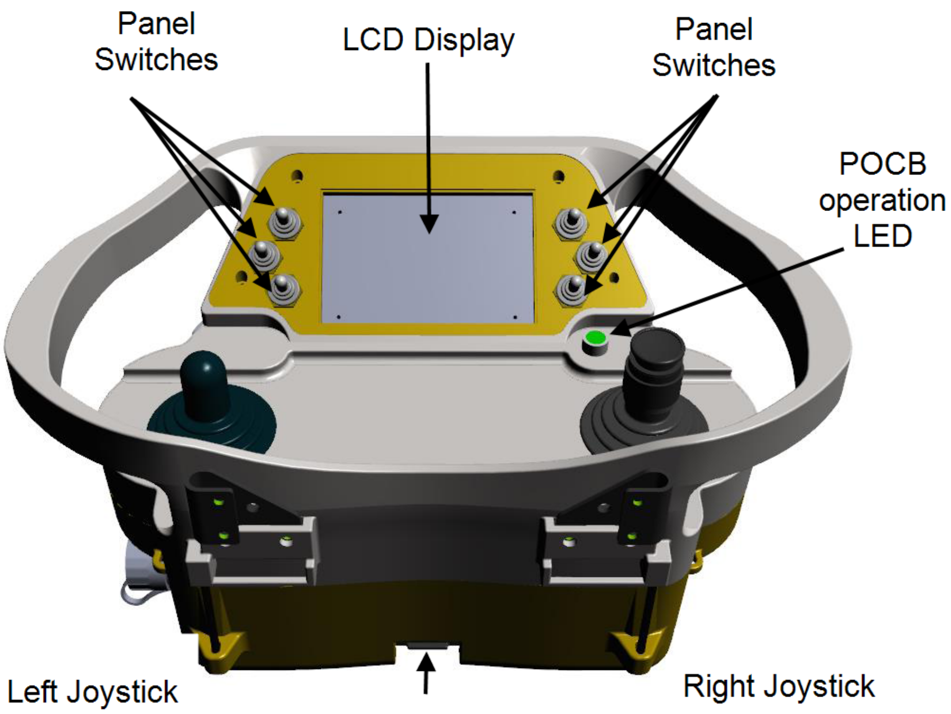


**Figure 2.18: POCB**

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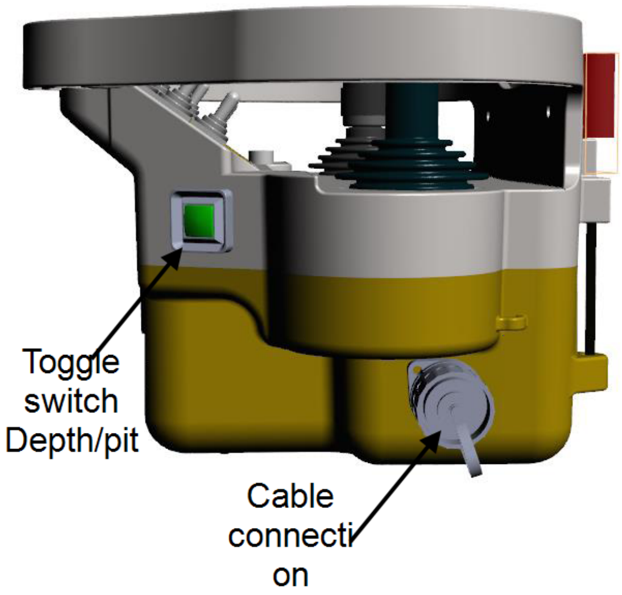


Figure 2.19: POCB Right Side

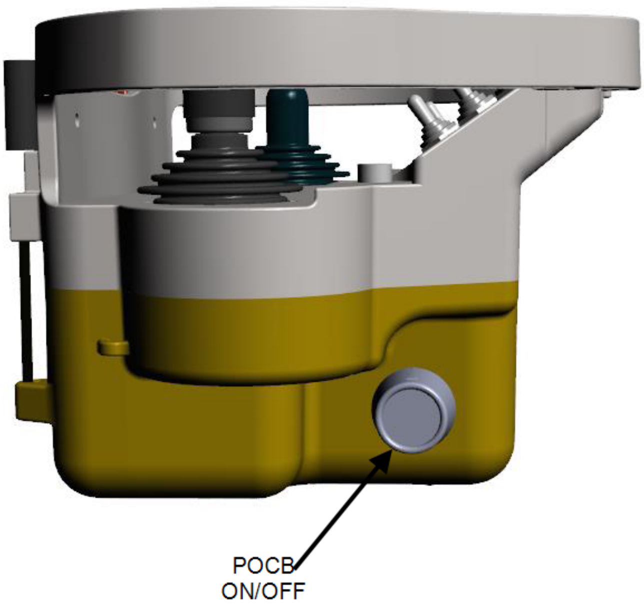


Figure 2.20: POCB Left Side

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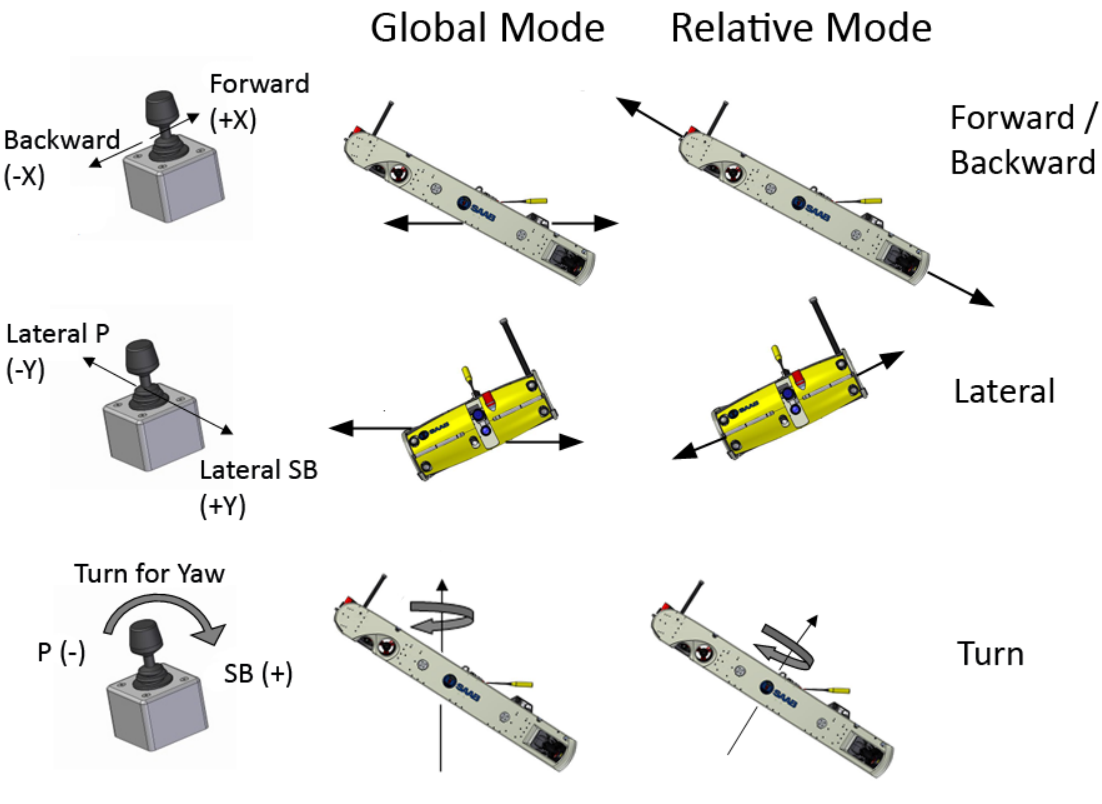


**Figure 2.21: OCB control modes right joystick**

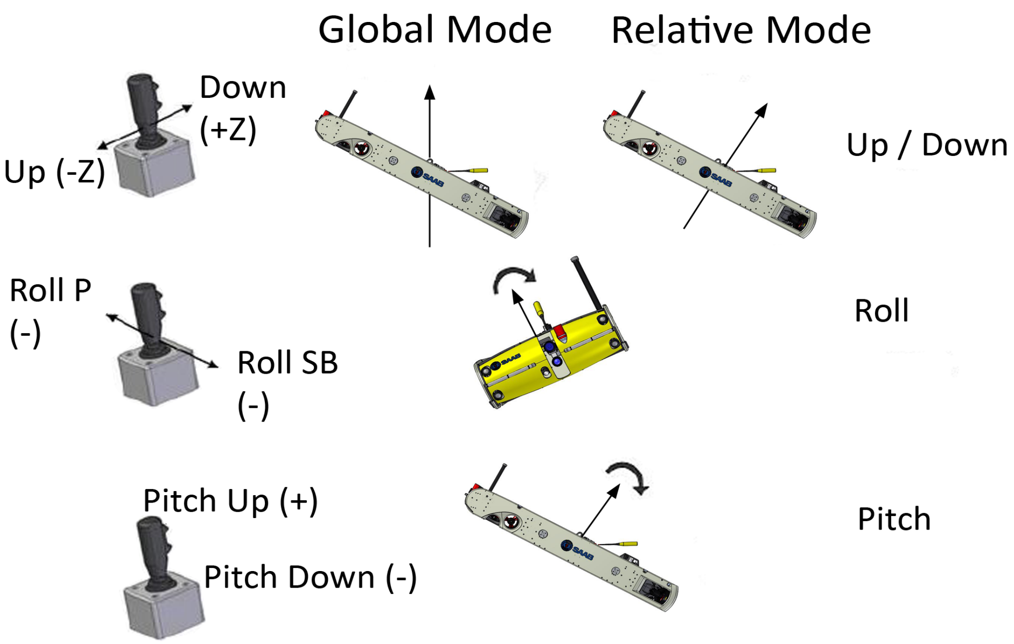


**Figure 2.22: OCB Control modes left stick**

### 2.7.1. POCB Panel


Function of the joysticks on the POCB.

**Figure 2.23: POCB joysticks**

### 2.7.2. Pitch Button


**Figure 2.24: POCB Pitch button**

When pitching the vehicle press the “PITCH” button on the left and use the depth stick to pitch up/down. It is a toggle switch; it does not need to be pressed all the time. “PITCH” is shown in the upper left corner of the display when selected. When finished with the pitch, press the button again to go back to use the stick for depth up/down.

### 2.7.3. POCB operation LED

When the POCB On/Off-switch is turned off, the operation LED is turned off.

When the POCB On/Off-switch is turned on, the operation LED is lit. The color and behavior is as follows:

Steady green = the battery is OK.

Slowly blinking red = the battery charge level is low. Replace the battery immediately.

Fast blinking red (and beeping) = the battery charge level is critically low and the POCB will shut off.

### 2.7.4. Replace the battery in the POCB

Place the POCB on a clean and dry surface. Remove the run down battery from the POCB by pushing towards the contact terminals and prizing outwards to then remove the run down battery and replace it with the new charged one.

Put the replaced run down battery immediately under charge.

### 2.7.5. Charge the battery for the POCB

Put the battery in the charger and connect the AC/DC adapter to power.

There are seven LEDs to indicate charge status on the charger. LED1, LED3, LED5 and LED7 are all red and turn on sequentially as the charge progresses. LED2, LED4 and LED6 are all green and turn on together when charge is complete and the red LEDs will also turn off. Below is a summary of the LEDs status relative to charge on the battery:

| Charge Status | LED 1 RED | LED2 GREEN | LED 3 RED | LED 4 GREEN | LED 5 RED | LED 6 GREEN | LED 7 RED |
|---|---|---|---|---|---|---|---|
| No Battery | off | off | off | off | off | off | off |
| 20% | on | off | off | off | off | off | off |
| 40% | on | off | on | off | off | off | off |
| 60% | on | off | on | off | on | off | off |
| 80% | on | off | on | off | on | off | on |
| 100% | off | on | off | on | off | on | off |

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### 2.7.6. Panel Switches


**Figure 2.25: POCB panel switches**

There are six three way momentary switches that are used for controlling the vehicle functions.

### 2.7.7. POCB display

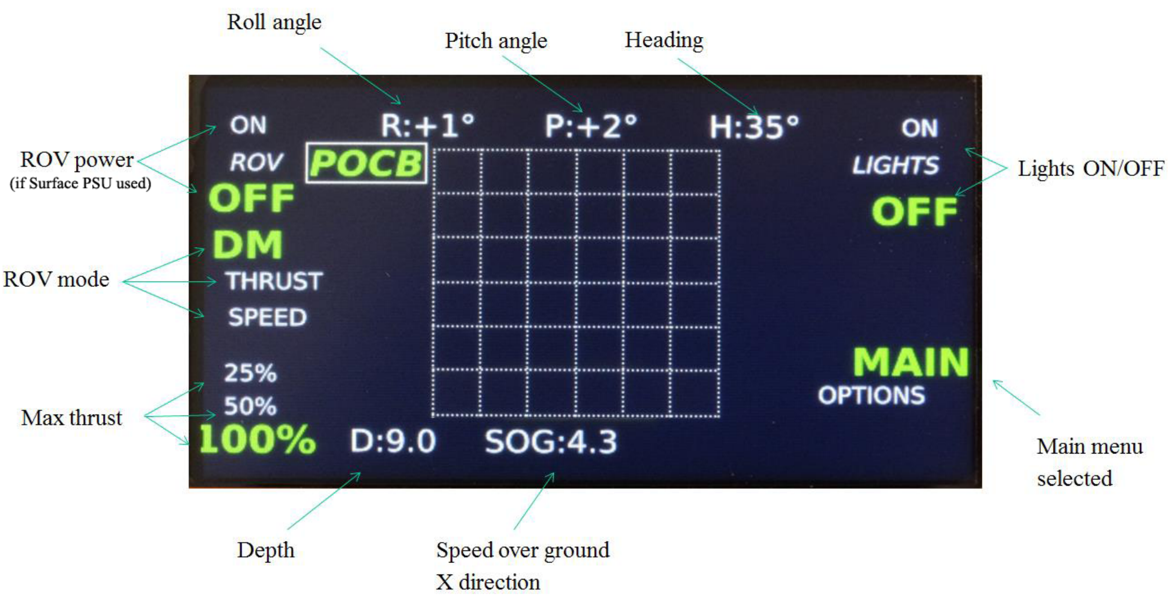
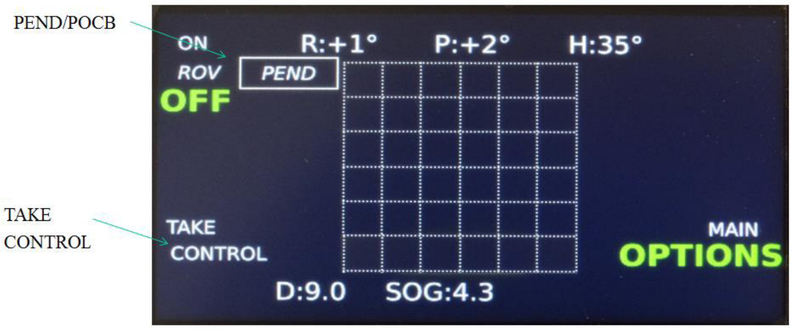
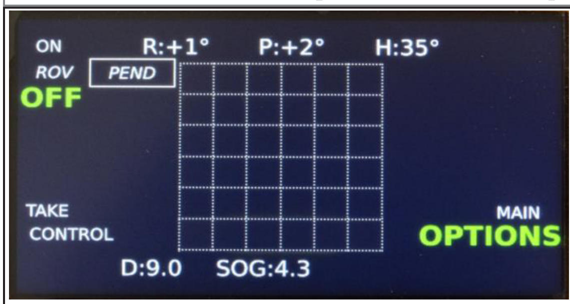
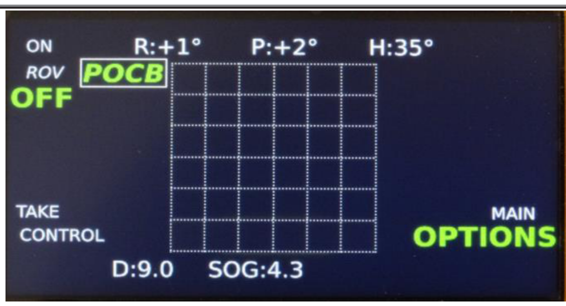


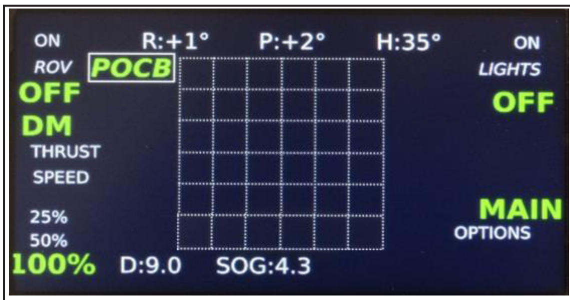

**Figure 2.26: POCB display**

(A) The POCB panel is used to give vehicle information to the POCB operator.




When "PEND" is shown the pilot has the control. The POCB operator can take control by pressing the "TAKE CONTROL" switch until "PEND" is changed to "POCB". PEND is momentarily shown in green until acknowledgement is received from the SCU. Prior to doing this, there must be good communication between the pilot and the POCB operator ensuring smooth transition of vehicle control. The pilot can take back the control and POCB is changed back to PEND, as with relinquishing control, this also requires good communication between the pilot and the POCB operator.

| | |
|---|---|
|   |   |
| The POCB is PENDING ready to take control. | The POCB has the control, PEND has changed to POCB. |

| | |
|---|---|
|   | Deck Mode is selected |
|   | THRUST mode is selected |

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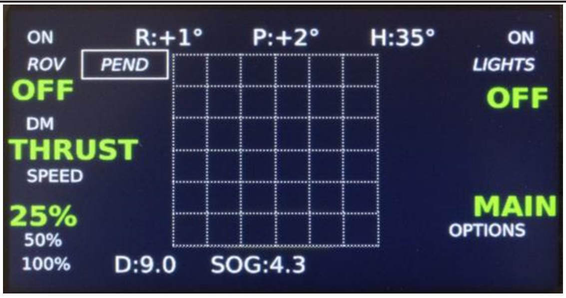
SPEED mode is selected




Max thrust is set to 25%


Max thrust is set to 50%


Max thrust is set to 100%

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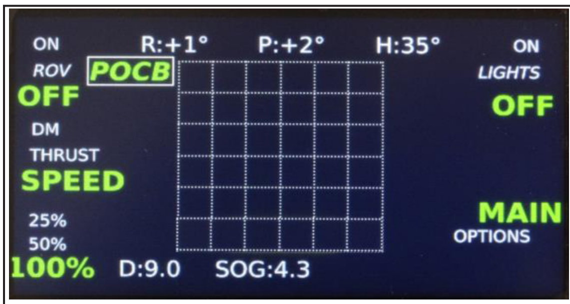
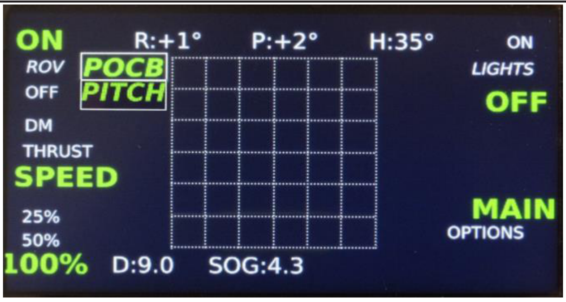
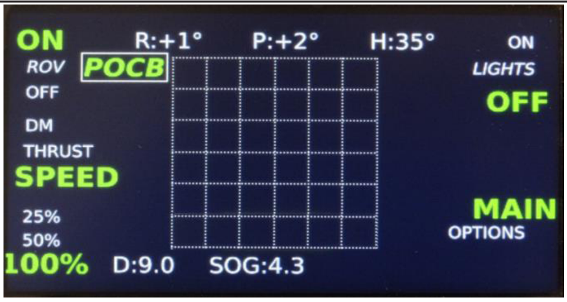



All LIGHTS are switched OFF

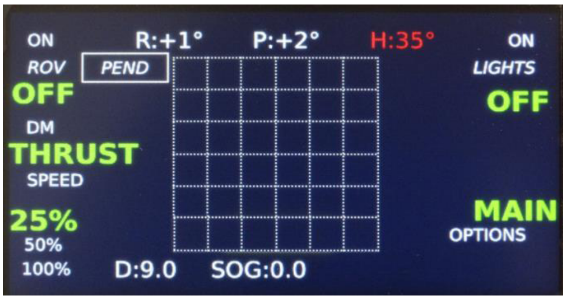

All LIGHTS are switched ON




The depth stick is used to PITCH the vehicle.



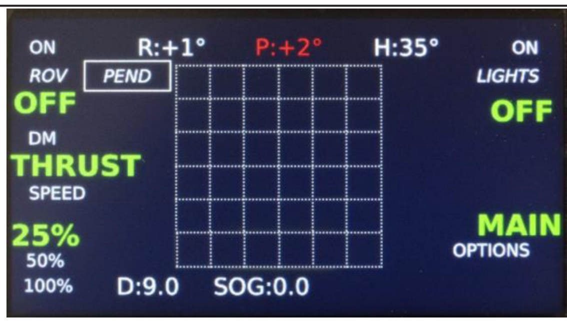

The depth stick is used to change the vehicle depth.




Heading data invalid

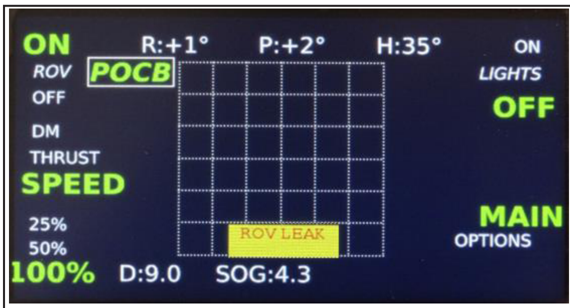

Depth data invalid


Roll data invalid



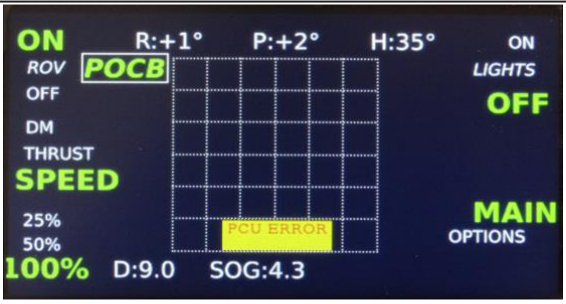

Pitch data invalid

A




ROV Leak

Leakage in the E-PODs or in the Transformer unit.

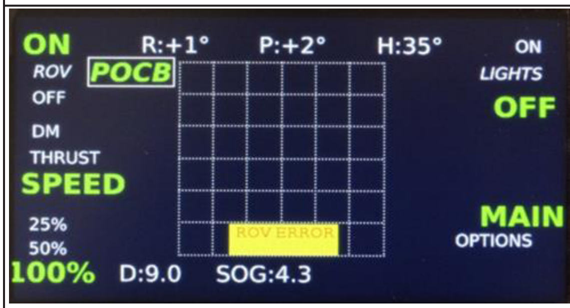



PCU ERROR

Internal fault in the PCU

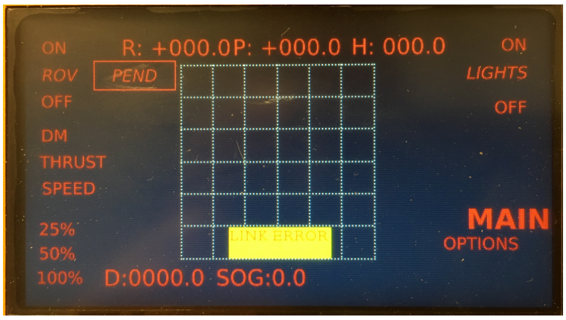

POSITION ERROR

Incorrect position




ROV ERROR

Data link not working




LINK ERROR

Data link between SCU and the POCB not working

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## 2.8. User Interface Screens

The user interface consists of a number of tabs for different aspects of the system. These tabs can be undocked into separate windows by double-clicking the tab title.

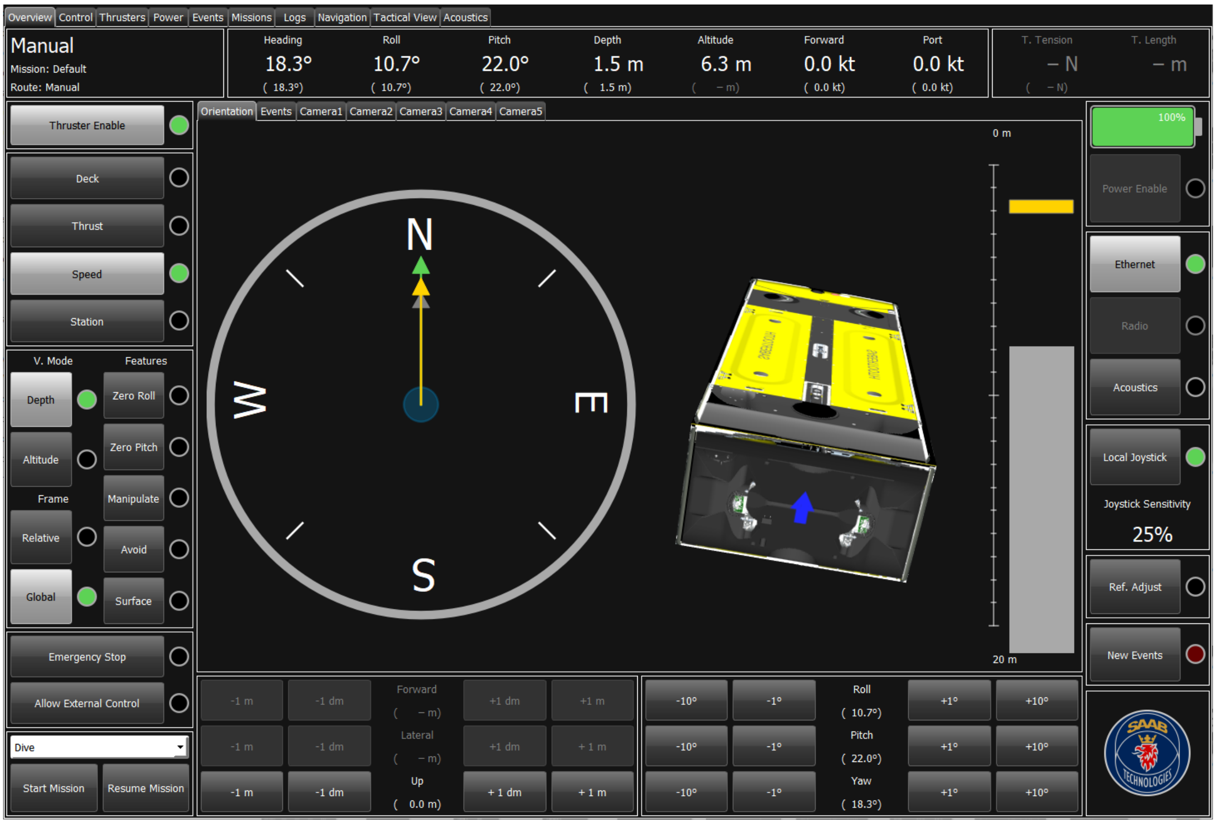


**Figure 2.27: Main Tabs**

List of tabs:

- Overview
- Control
- Thrusters
- Power
- Events
- Missions
- Logs
- Navigation
- Tactical View
- Acoustics

### 2.8.1. Overview

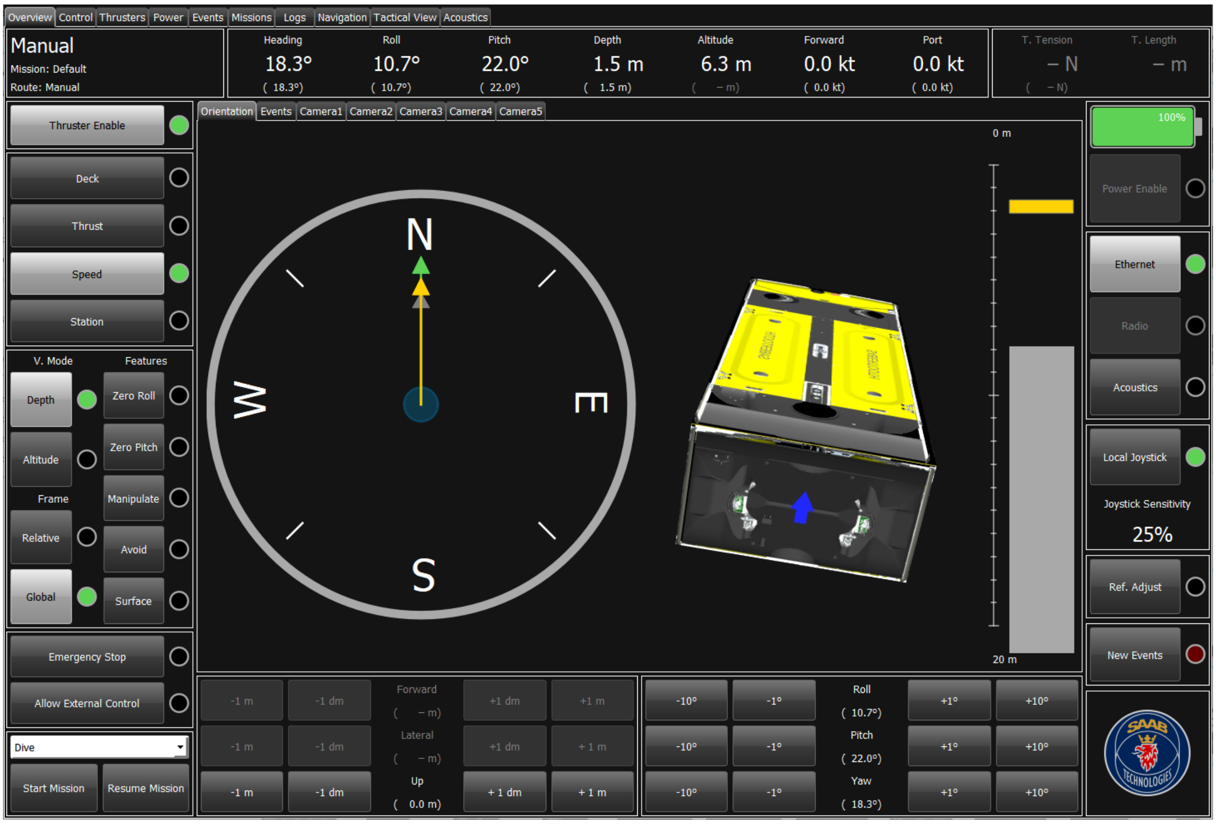


Figure 2.28: Overview

#### 2.8.1.1. Mission Information

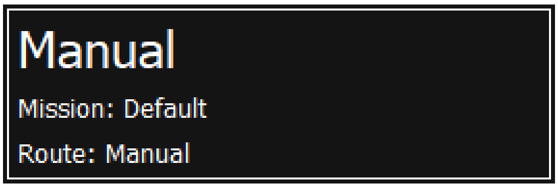


Figure 2.29: Mission Information

| Control / Indicator | Description |
|---|---|
| Mission | The mission that is executed by the vehicle. The "Default" mission is reserved by the system and used for manual operations. |
| Route | The route that the mission is on. |

### 2.8.1.2. Attitude

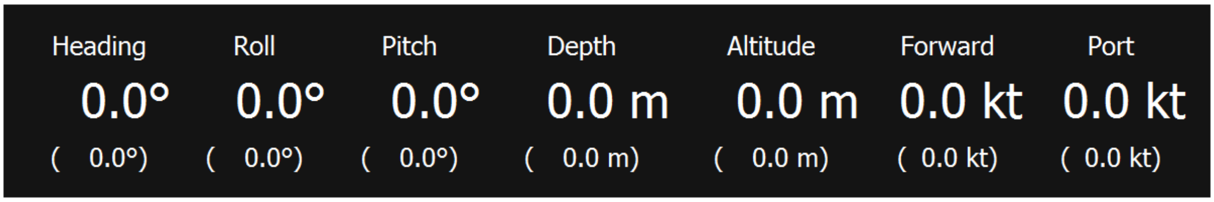


**Figure 2.30: Attitude**

| Control / Indicator | Description |
|---|---|
| Heading | Current vehicle heading (where the vehicle is pointing, not the direction of movement). |
| Heading set value (in brackets) | Commanded heading. |
| Roll | Current Vehicle roll angle |
| Roll set value (in brackets) | Commanded roll angle |
| Pitch | Current Vehicle pitch angle |
| Pitch set value (in brackets) | Commanded pitch angle |
| Depth | Current measured depth of the vehicle |
| Depth set value (in brackets) | Commanded depth |
| Altitude | The measured altitude of the vehicle |
| Altitude set value | Commanded altitude |
| Forward | Vehicle speed over ground in the forward direction, in global frame.<br><br>In global frame, direction forward is how the vehicle's centre moves forward in the horizontal plane, with a heading same as given by the Compass (global frame heading).<br><br>This is not necessarily the same as the direction in which the nose points, since the vehicle may move forwards over a flat seabed at constant altitude even if the nose is pointing downwards by some degrees. |
| Forward speed set value global (in brackets) | Commanded vehicle speed over ground |
| Port | Vehicle speed over ground in lateral direction, in global frame.<br><br>In global frame, direction port is how the vehicle's centre moves leftward relative Forward speed direction, in the horizontal plane.<br><br>This is not necessarily the same as leftward along the vehicle itself, since the vehicle may move to the left over a flat seabed at a constant altitude even if the vehicle is rolled over by some degrees. |
| Port speed set value global (in brackets) | Commanded vehicle lateral speed over ground |

#### 2.8.1.3. Tether

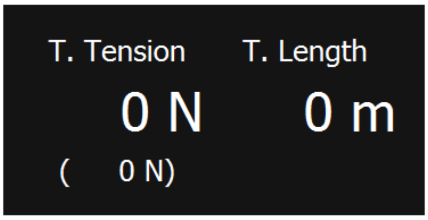


**Figure 2.31: Tether Information**

| Control / Indicator | Description |
|---|---|
| T. Tension | Current measured winch tension |
| Desired Tension (in brackets) | Shows the commanded tension from the GUI |
| T. Length | Length of tether rolled out |

#### 2.8.1.4. Thruster Enable Safety Control

Thruster enable is a button with a corresponding indicator that indicates if the thrusters are enabled. If this button is not enabled, the thrusters cannot rotate.

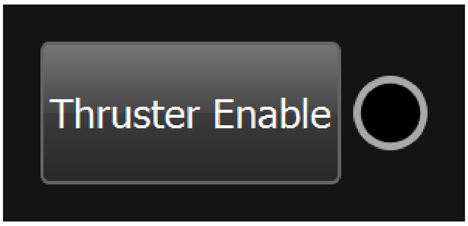


**Figure 2.32: Thruster Enable Safety Control**

#### 2.8.1.5. Control Modes

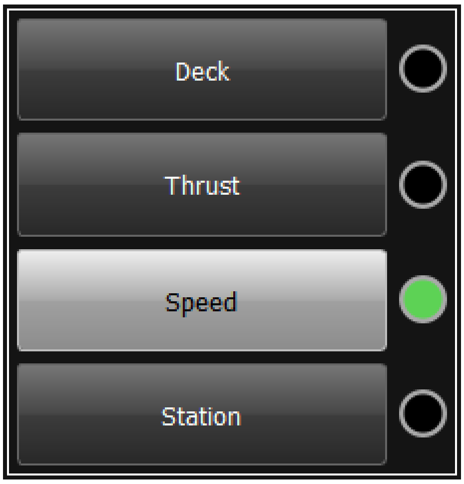


**Figure 2.33: Control Modes**

| Control / Indicator | Description |
|---|---|
| Deck | Thruster movement is proportional to joystick. Deck mode is used when testing the vehicle on deck. |
| Thrust | In thrust mode, the vehicle control system will try to keep the roll, pitch and heading of the vehicle.<br><br>NOTE: This will make the thrusters rotate after a while if thrust mode is enabled when the vehicle is on land or deck (not in water). When not in water deck mode shall be used. |
| Speed | In speed mode the control system will also control the speed over ground of the vehicle. If there is no joystick input the vehicle will be stationary. |
| Station | Station mode keeps the vehicle stationary on an position. The difference between speed and station is that if the vehicle is forced from the position in station mode the vehicle return to the original position while in speed mode the vehicle will stay at the new location. |

### 2.8.1.6. Manual Control


**Figure 2.34: Manual Control**

| Control / Indicator | Description |
|---|---|
| Depth | Makes the vehicle stay at constant depth. |
| Altitude | Makes the vehicle stay at constant distance to the seafloor or other object in range of the DVL ping.<br><br>Altitude mode can behave in two different ways, depending on the current reference frame (Relative or Global).<br><br>In global frame, the direction of the altitude keeping distance will always be earth down, i.e. straight down towards the seafloor, perpendicular to the horizontal plane defined by latitude and longitude. This means that the vertical control will not have affect on the current target latitude and longitude. If the vehicle is tilted too much, making the DVL not facing towards the seafloor any more, the system will automatically revert to depth mode instead.<br><br>In relative frame, the direction of the altitude keeping distance is instead vehicle up. This fact will have two major consequences. First, changing the ATTITUDE will change the direction of what is vehicle up, and hence probably also the current altitude value, making the vehicle controlling back to desired altitude. |

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| Control / Indicator | Description |
|---|---|
| | Larger manoeuvres in attitude is safer to perform in depth mode. Second, for the system to keep its desired altitude in the vehicle up frame, it will also change the current latitude and/or longitude. Meaning, it is not possible to be stationary in terms of horizontal position while at the same time keeping the relative altitude position.<br><br>Altitude mode will revert to depth mode if there is no DVL data available. |
| Relative | The vehicle moves relative the vehicles reference frame. |
| Global | The vehicle moves relative to the global reference frame. |
| Zero Roll | The Zero Roll button aborts any current attitude command and attempts to return the ROV to zero roll. The corresponding indicator is green when Zero Roll is active. |
| Zero Pitch | The Zero Pitch button aborts any current attitude command and attempts to return the ROV to zero pitch. The corresponding indicator is green when Zero Pitch is active. |
| Manipulate | In manipulate mode the vehicles control system will not counter act the fact that the vehicle is "stuck". The manipulate option can for example be used when using a manipulator. |
| Avoid | With the avoid option enabled the vehicle will avoid running into obstacles by stopping in front of them. |
| Surface | Surface mode is used when operating the vehicle on the surface. In this mode the vehicle will not try to counteract small wave movements but only try to keep it's heading and position. |

### 2.8.1.7. High Level Control

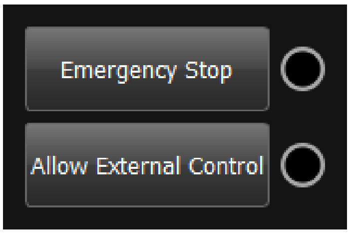


**Figure 2.35: High Level Control**

| Control / Indicator | Description |
|---|---|
| Emergency Stop | The indicator shows if the vehicle is in a semi-autonomous operating state. Pressing the button causes the vehicle to stop and hold position. The pilot needs to manually take control back before operations can resume. |
| Allow External Control | If enabled, external control of the vehicle can be taken via the API. Disabling the button while in external control returns the vehicle to manual mode. The lamp indicates if the vehicle is in External Mode. |

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### 2.8.1.8. Mission Control

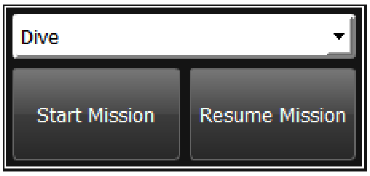


**Figure 2.36: Mission Control**

| Control / Indicator | Description |
|---|---|
| Mission Selection Drop Down Menu | Click the drop down arrow to see all the loaded missions. Select the one you want. If the selection list is empty, there are no loaded missions. |
| Start Mission | After selecting a mission in the selection list, press "Start Mission" to start the selected mission. |
| Resume Mission | Resume the previous mission. |

### 2.8.1.9. Central Tabs

The central part of the user interface contains a number of tabs displaying camera feeds, sonars, event details and others. These tabs can be undocked into separate windows by double-clicking the tab title.

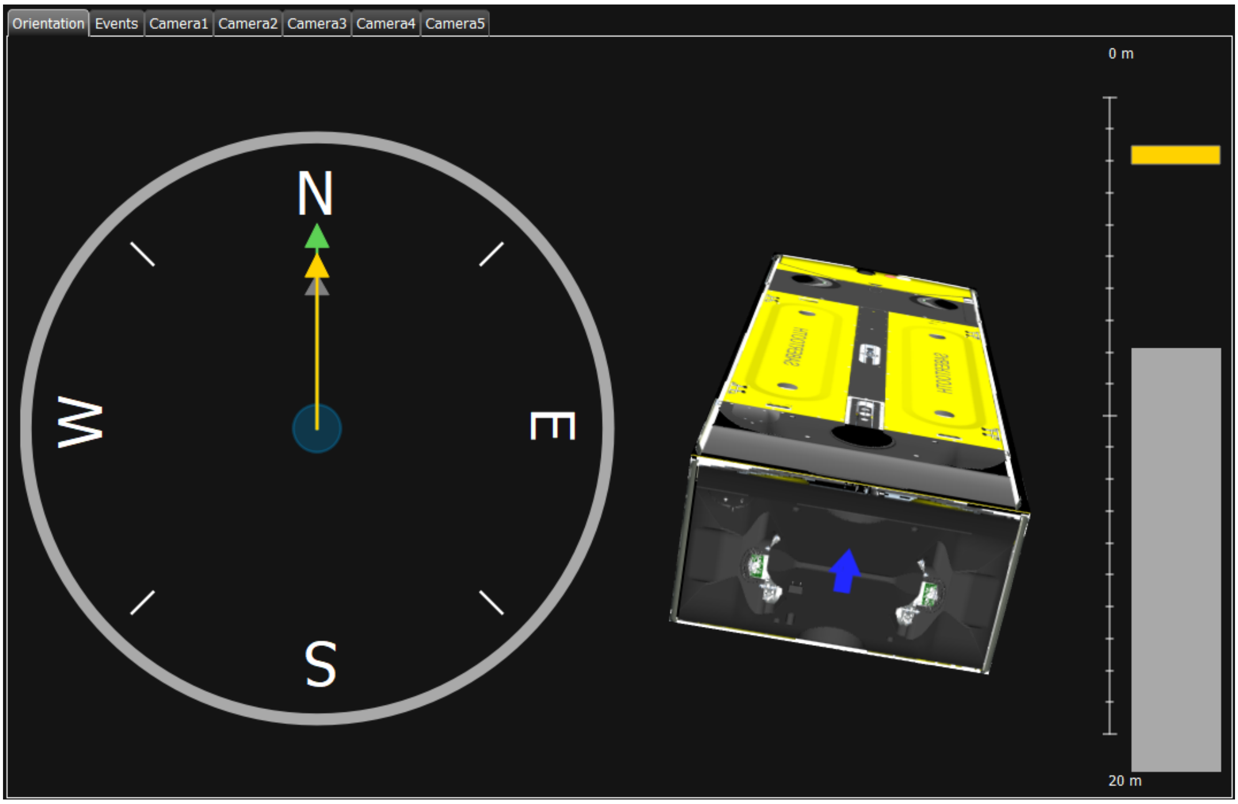


**Figure 2.37: Central Tabs**

List of tabs:

- Orientation
- Events
- Camera1
- Camera2
- Camera3
- Camera4
- Camera5

### 2.8.1.9.1. Orientation

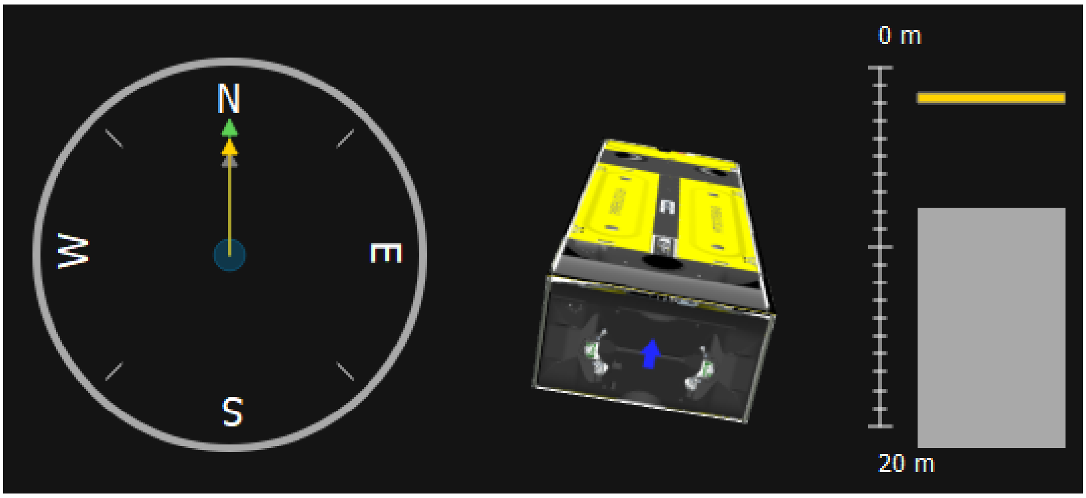


**Figure 2.38: Orientation**

| Control / Indicator | Description |
|---|---|
| Compass | The compass shows one or more arrows indicating the global frame heading or direction of the following:<br>• Vehicle heading (yellow)<br>• Vehicle commanded heading (grey)<br>• Vessel heading (green) |
| Attitude Display | The attitude display graphically shows the vehicle's current attitude and set attitude.<br>The vehicle's current attitude is shown by the vehicle image and the set attitude is shown as a grey box, if different from current value. |
| Depth Display | The depth display combines depth, altitude and set values into one display.<br>The yellow box represents the current vehicle placement. The grey rectangle shows the set value, if different from the current value. If altitude is available, a large grey box represents the sea floor. |

A

#### 2.8.1.9.2. Events

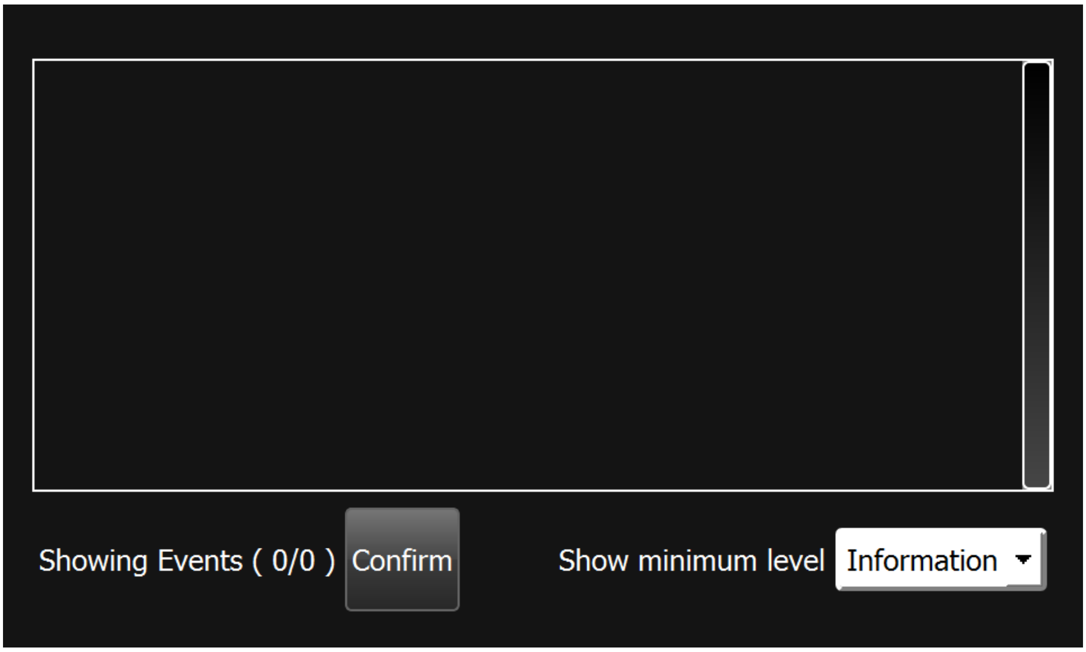


**Figure 2.39: Events**

| Control / Indicator | Description |
|---|---|
| Active Events | Lists the active events.<br><br>The event can be one of the following types, ordered by severity:<br>• Critical (purple)<br>• Error (red)<br>• Warning (yellow)<br>• Information (green) |
| Showing Events | Indicates the number of shown events and the total number of active and not suppressed events. |
| Confirm | Press to acknowledge the currently active events and stops the coloured frame from flashing. |
| Show minimum level | Select the event type from the drop down list to change which level of event should be displayed. |

A

#### 2.8.1.9.3. Camera Screens 1 to 5

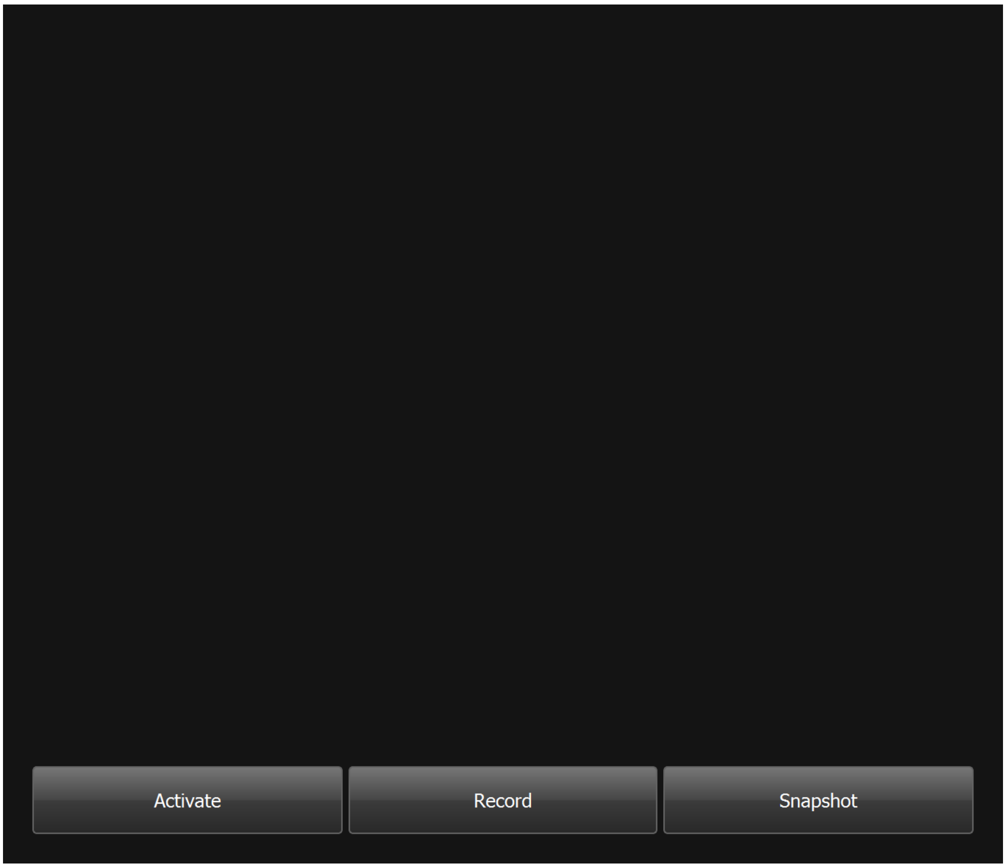


**Figure 2.40: Camera Screen**

| Control / Indicator | Description |
|---|---|
| Video display | Shows the video from the camera |
| Activate | Turns the video stream on and off |
| Record | Starts and stops recording video to the surface storage media. |
| Snapshot | Stores a snapshot of the video stream as an image to the surface media. |

#### 2.8.1.10. Manual Route Position

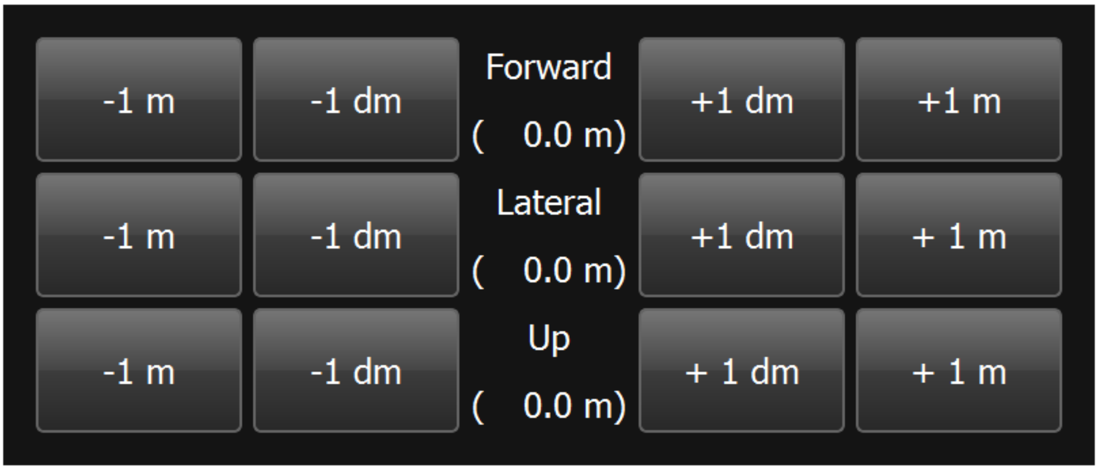


**Figure 2.41: Manual Route Position**

| Control / Indicator | Description |
|---|---|
| Forward | Distance to commanded position, forward positive.<br>Press +1m or +1dm buttons to move forward.<br>Press -1m or -1dm buttons to move backward. |
| Lateral | Distance to commanded position, starboard positive.<br>Press appropriate Lateral buttons to move in ±1m or ±1dm increments. |
| Up | Distance to commanded depth, up positive. Up commands<br>Press appropriate Up buttons to move in ±1m or ±1dm increments. |

#### 2.8.1.11. Manual Route Attitude

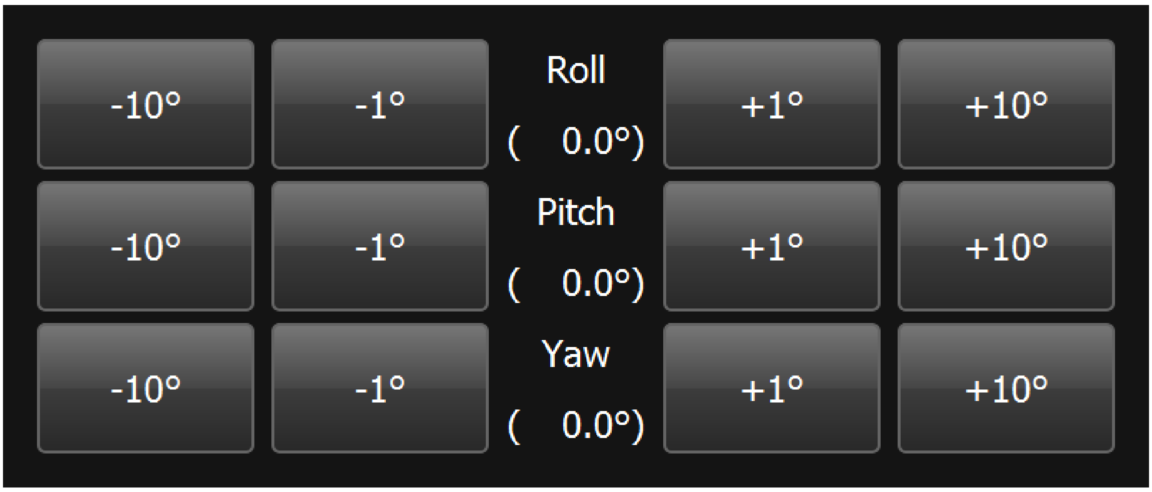


**Figure 2.42: Manual Route Attitude**

| Control / Indicator | Description |
|---|---|
| Roll | Commanded roll angle displayed in brackets. |

| Control / Indicator | Description |
|---|---|
| | Press appropriate Roll buttons to move in ±1° or ±10° increments. |
| Pitch | Commanded Pitch angle displayed in brackets.<br><br>Press appropriate Pitch buttons to move in ±1° or ±10° increments. |
| Yaw | Commanded heading displayed in brackets.<br><br>Press appropriate Yaw buttons to move in ±1° or ±10° increments. |

### 2.8.1.12. Power

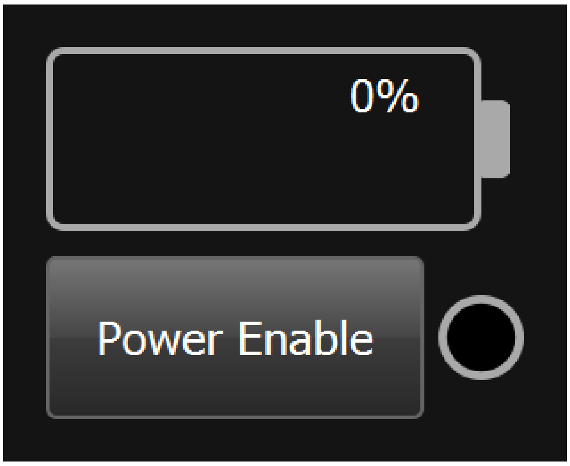


**Figure 2.43: Battery and PSU Indicators**

| Control / Indicator | Description |
|---|---|
| Battery Indicator | The battery indicator shows the estimated remaining battery capacity. A lightning symbol indicates that the battery is charging. |
| Power Enable | Press to Turn on and off the surface power. |
| | If the battery is activated (by the start key) and PSU is used, the battery will act as a UPS if PSU shuts down. When activated, the vehicle will run. |

### 2.8.1.13. Communication Link

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**Figure 2.44: Communication Link**

| Control / Indicator | Description |
|---|---|
| Ethernet | Use Ethernet for communicating with the vehicle. |
| Radio | Force the use of radio for communication with the vehicle, Ethernet will not be used. |
| Acoustics | Enable/Disable acoustic link. |
| Green Indicator | Green light indicates that the link has been established. |

### 2.8.1.14. Joystick

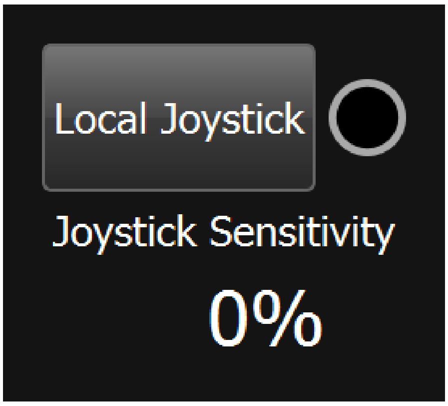


**Figure 2.45: Joystick**

| Control / Indicator | Description |
|---|---|
| Local Joystick | Press to make the local joystick (OCB) the active controller, taking control back from any remote (POCB) controller. The indicator shows if a remote (black) or local joystick (green) has control. |
| Joystick Sensitivity | Displays the current Joystick Sensitivity of the OCB. |

### 2.8.1.15. Ref Adjust

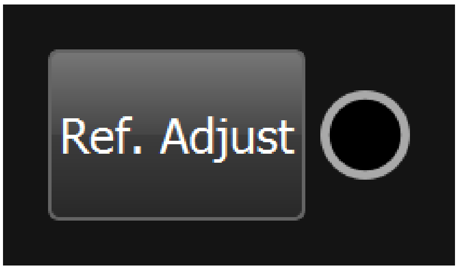


**Figure 2.46: Ref Adjust**

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| Control / Indicator | Description |
|---|---|
| Ref. Adjust | Set an offset to the joystick input. Pressing the button will set the offset to the current input of the joystick.<br><br>NOTE: Offset can be set to zero by pressing the button without any joystick input. |
| Status Indicator | Indicates if there is a offset applied. |

### 2.8.1.16. Events

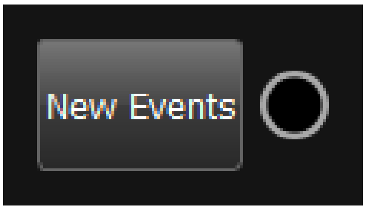


Figure 2.47: New Events

| Control / Indicator | Description |
|---|---|
| New Events | Press to check for new events. |
| Indicator | Indicates if there is a new event since last checked.. |

## 2.8.2. Control

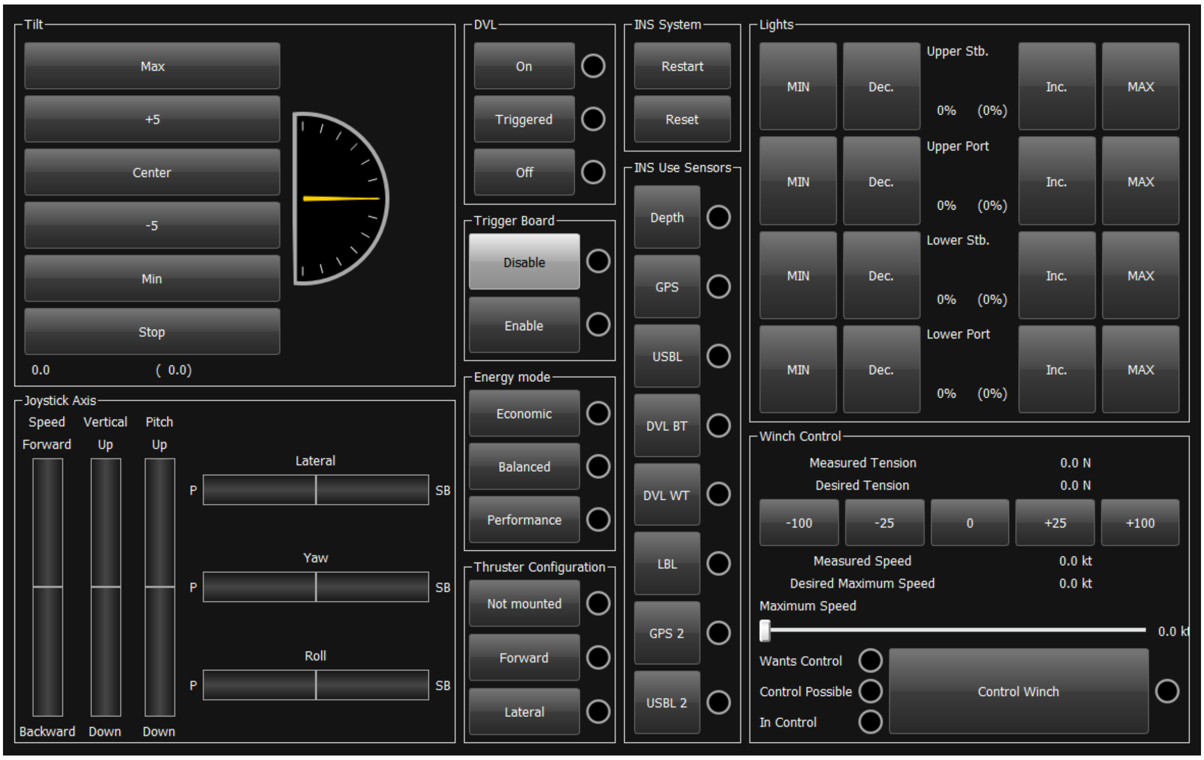


Figure 2.48: Control

### 2.8.2.1. Tilt

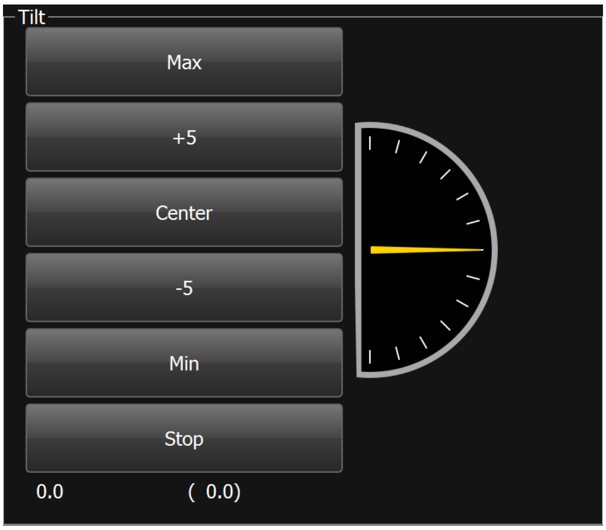


**Figure 2.49: Tilt**

| Control / Indicator | Description |
|---|---|
| Max | Increase the tilt as much as possible |
| +5 | Increase the tilt by 5 degrees |
| Center | Center the tilt |
| -5 | Reduce the tilt by 5 degrees |
| Min | Decrease the tilt as much as possible |
| Stop | Stops any tilt motion |
| Current Tilt | Numeric display of current tilt |
| Demanded Tilt | Numeric demanded tilt displayed in brackets |
| Current Tilt | Graphical display of the current tilt |

### 2.8.2.2. Joystick Axis

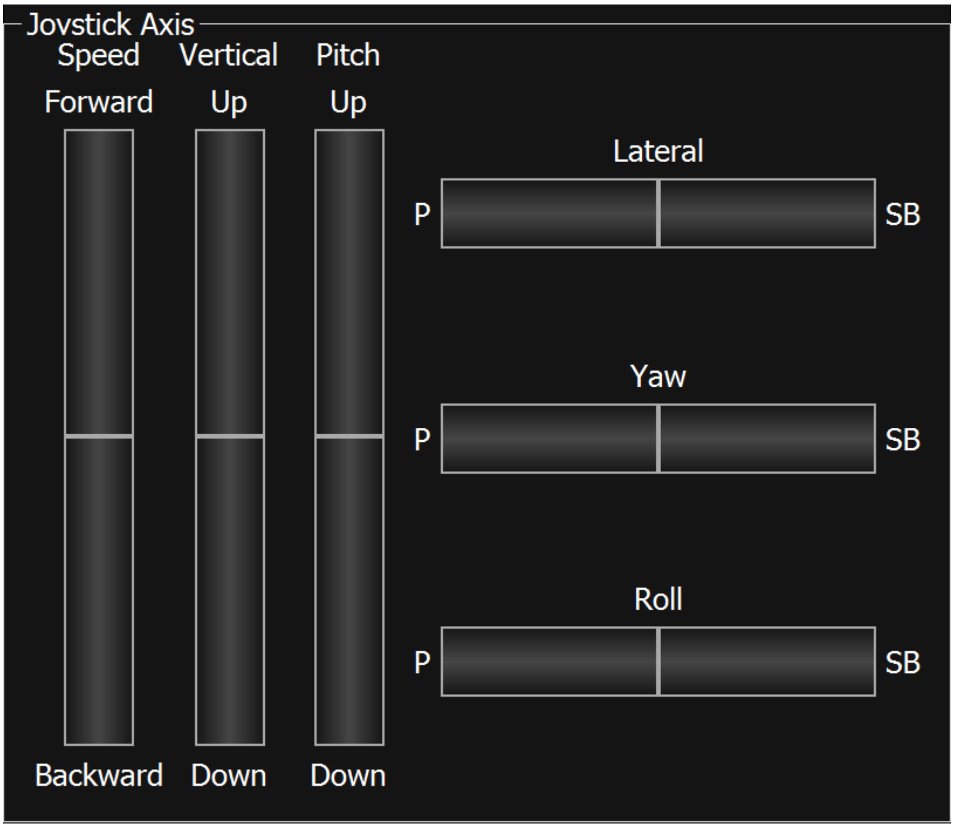


**Figure 2.50: Joystick Axis**

| Control / Indicator | Description |
|---|---|
| Speed output axis | Displays the present speed joystick demand from OCB/POCB |
| Vertical output axis | Displays the present vertical joystick demand from OCB/POCB |
| Pitch output axis | Displays the present pitch joystick demand from OCB/POCB |
| Lateral output axis | Displays the present lateral joystick demand from OCB/POCB |
| Yaw output axis | Displays the present yaw joystick demand from OCB/POCB |
| Roll output axis | Displays the present roll joystick demand from OCB/POCB |

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#### 2.8.2.3. DVL

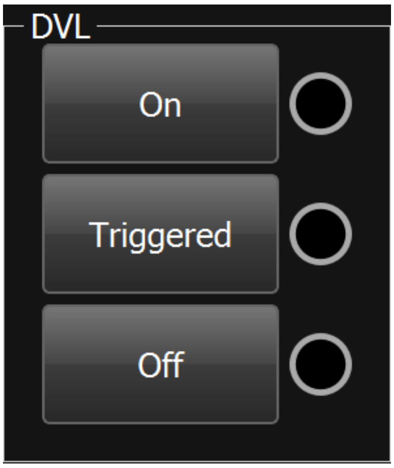


**Figure 2.51: DVL**

| Control / Indicator | Description |
|---|---|
| On | Turns DVL pinging on in free running mode. |
| Triggered | DVL on, triggered mode |
| Off | Turns DVL pinging off |

#### 2.8.2.4. Trigger Board

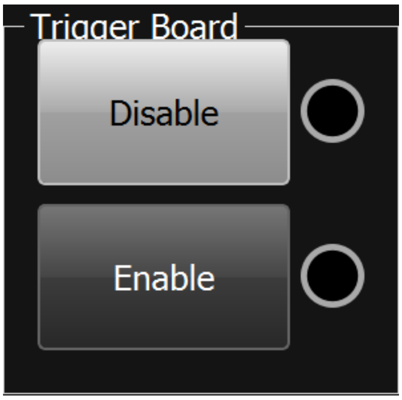


**Figure 2.52: Trigger Board**

| Control / Indicator | Description |
|---|---|
| Disable | Disable the trigger board |
| Enable | Enable the trigger board |

A

#### 2.8.2.5. Energy mode

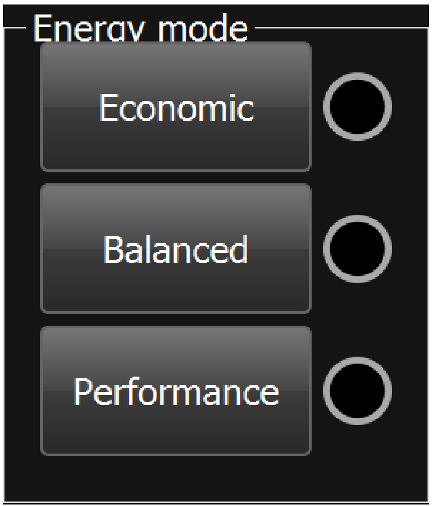


**Figure 2.53: Energy mode**

| Control / Indicator | Description |
|---|---|
| Economic | Sets a low prioritization of keeping the attitude of the vehicle |
| Balanced | Sets a balanced prioritization of keeping the attitude of the vehicle |
| Performance | Sets a high prioritization of keeping the attitude of the vehicle |

#### 2.8.2.6. Thruster Configuration (optional)


**Figure 2.54: Thruster Configuration**

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| Control / Indicator | Description |
|---|---|
| Not mounted | Press this button to indicate the Extra Thruster is not mounted |
| Forward | Press this button to indicate the Extra Thruster is mounted for forward thrust |
| Lateral | Press this button to indicate the Extra Thruster is mounted for sideways thrust |

### 2.8.2.7. INS System

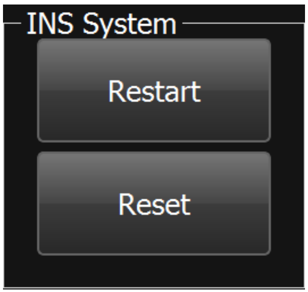


**Figure 2.55: INS System**

| Control / Indicator | Description |
|---|---|
| Restart | Full restart of INS navigation filter algorithm, making the INS realign. |
| Reset | Partial reset of INS filter, making INS reset its start position.<br><br>Can be used to force a GPS, manual or other position input to the INS. |

### 2.8.2.8. INS Use Sensors

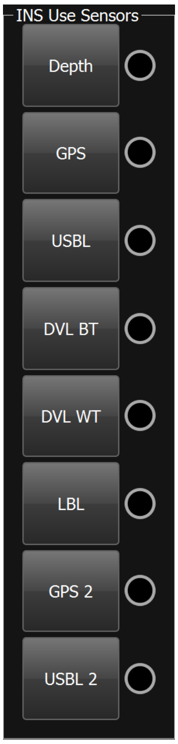


**Figure 2.56: INS Use Sensors**

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| Control / Indicator | Description |
|---|---|
| Depth | Turn on/off use of pressure sensor data in INS. |
| GPS | Turn on/off use of GPS sensor data in INS. |
| USBL | Turn on/off use of USBL sensor data in INS. |
| DVL BT | Turn on/off use of DVL bottom track sensor data in INS. |

| Control / Indicator | Description |
|---|---|
| DVL WT | Turn on/off use of DVL water track sensor data in INS. |
| LBL | Turn on/off use of LBL sensor data in INS. |
| GPS 2 | Turn on/off use of GPS 2 sensor data in INS. |
| USBL 2 | Turn on/off use of USBL 2 sensor data in INS. |

### 2.8.2.9. Lights

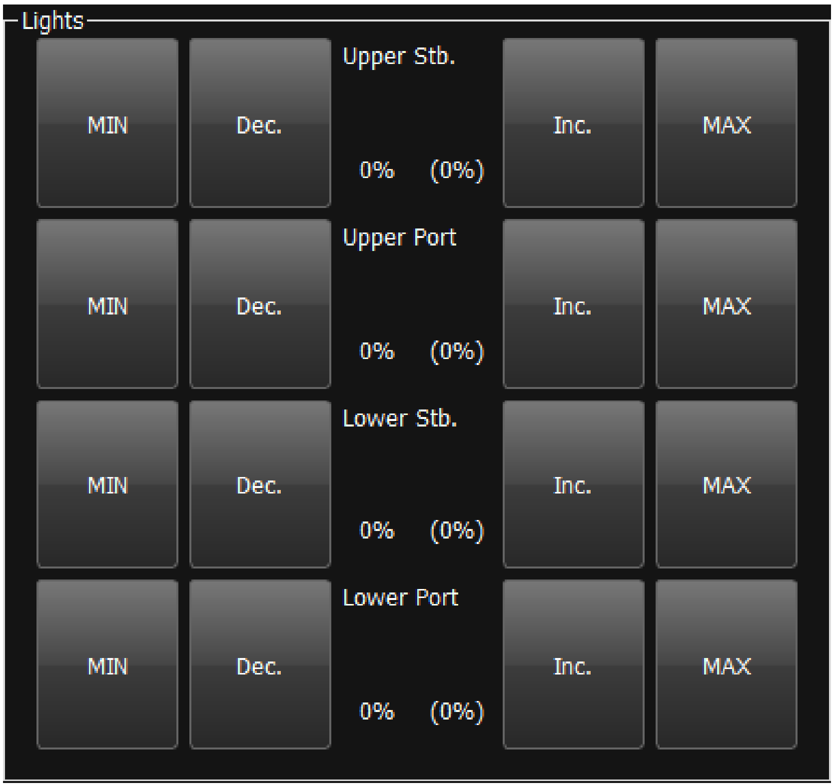


**Figure 2.57: Lights**

<table>
<tr><th>Control / Indicator</th><th>Description</th></tr>
<tr><td>Upper Stb (upper starboard lights)</td><td rowspan="4">Control the commanded light intensity for the relevant light using the MIN and MAX buttons or in increments using INC. and DEC. buttons.<br><br>The actual intensity (as reported by the hardware) is shown as a % and the selected intensity is shown in the brackets as a %.</td></tr>
<tr><td>Lower Stb (lower starboard lights)</td></tr>
<tr><td>Upper Port Lights</td></tr>
<tr><td>Lower Port Lights</td></tr>
</table>

### 2.8.2.10. Winch Control

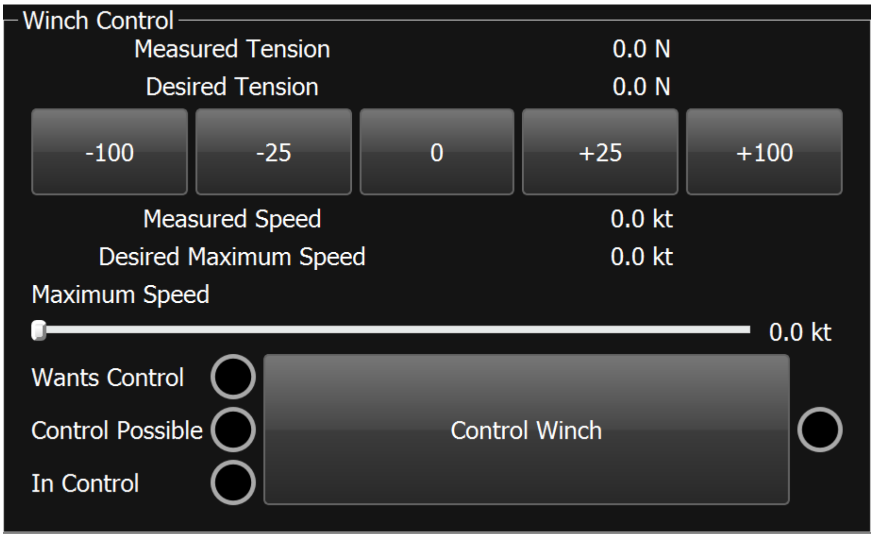


**Figure 2.58: Winch Control**

| Control / Indicator | Description |
|---|---|
| Measured Tension | Displays the current measured winch tension |
| Desired Tension | Displays the commanded tension from the GUI |
| Measured Speed | Displays the measured tether feeding speed |
| Desired Maximum Speed | Displays maximum desired tether feeding speed |
| Maximum Speed Input | User controlled limit on winch speed |
| Wants Control | Indicates user has requested control |
| Control Possible | Indicates if the winch allows remote control |
| In Control | Indicates request of control has been granted |
| Control Winch | Take remote control of the winch. The button will be disabled if the the winch does not allow remote control. |

### 2.8.3. Thrusters

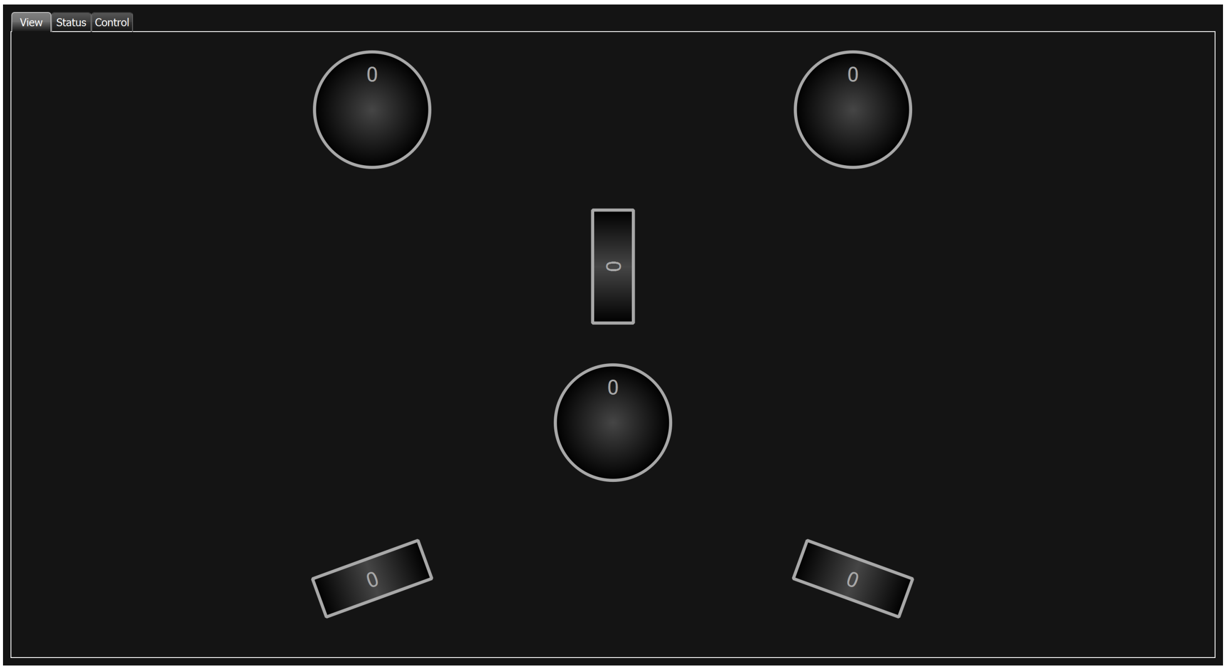


**Figure 2.59: Thrusters**

List of tabs:

- View
- Status
- Control

#### 2.8.3.1. View

Displays the thruster pull and the rotation of each thruster.

An orange (positive) circle/triangle indicates a vehicle movement in the forward or upward direction. A blue (negative) cross in the circle/triangle indicates a vehicle movement in the backward or downward direction.

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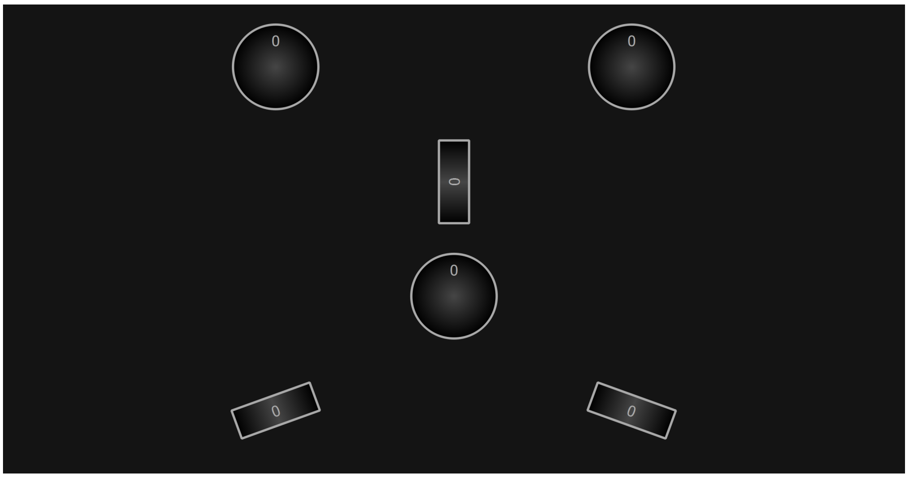


Figure 2.60: View

### 2.8.3.2. Status

The status screen provides information on each of the thrusters fitted to the system.

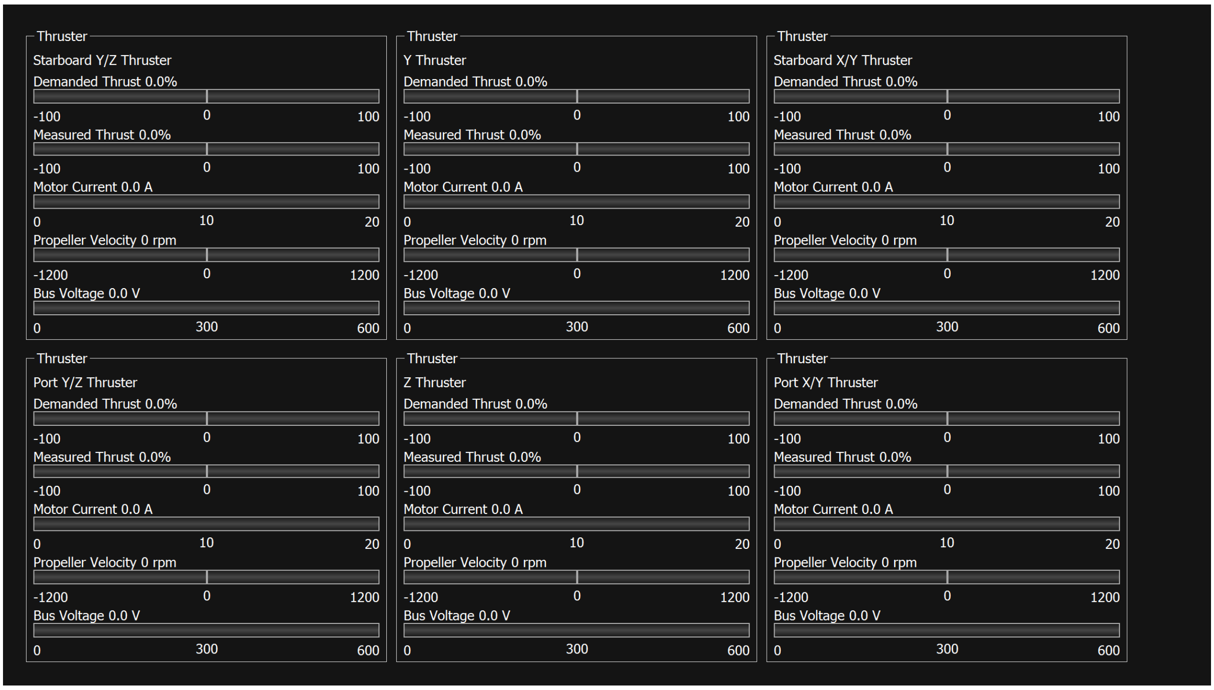


Figure 2.61: Status

The image and table below are applicable for all the thrusters fitted to the system.

A

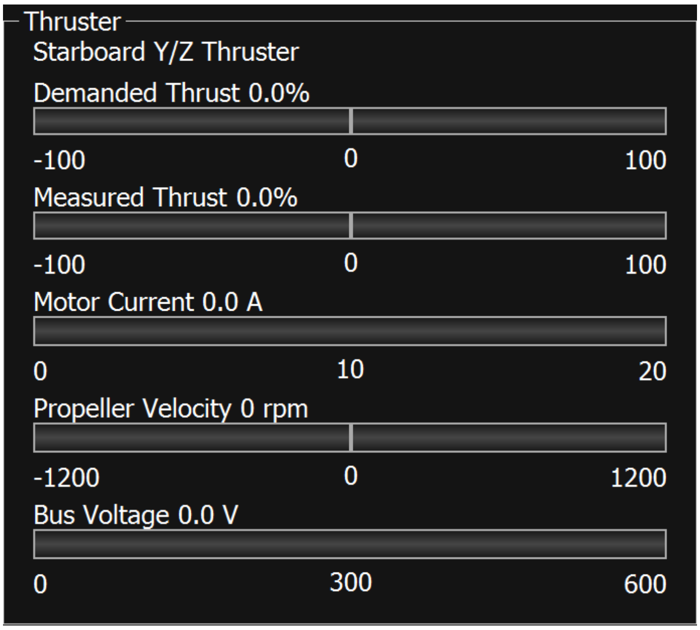


**Figure 2.62: Example of the Individual Thruster Status**

| Control / Indicator | Description |
|---|---|
| Thruster | Displays status for a specific thruster |
| Demanded Thrust | Demanded thrust in % of max |
| Measured Thrust | Measured thrust in % of max |
| Motor Current | Current to the motor |
| Propeller Velocity | Shows current RPM and direction of the motor |
| Bus Voltage | Supply voltage to the motor |

#### 2.8.3.3. Control

To test a specific thruster, click the Thruster to Test drop down arrow to select the relevant thruster.

There are the following test options (see more information in 2.8.3.3.1 and 2.8.3.3.2 below)

- Normal Test
- Pulse Wave Test

On this screen, set the vehicle into the Thruster Test Mode. The thrusters can only be controlled from the thruster test window.

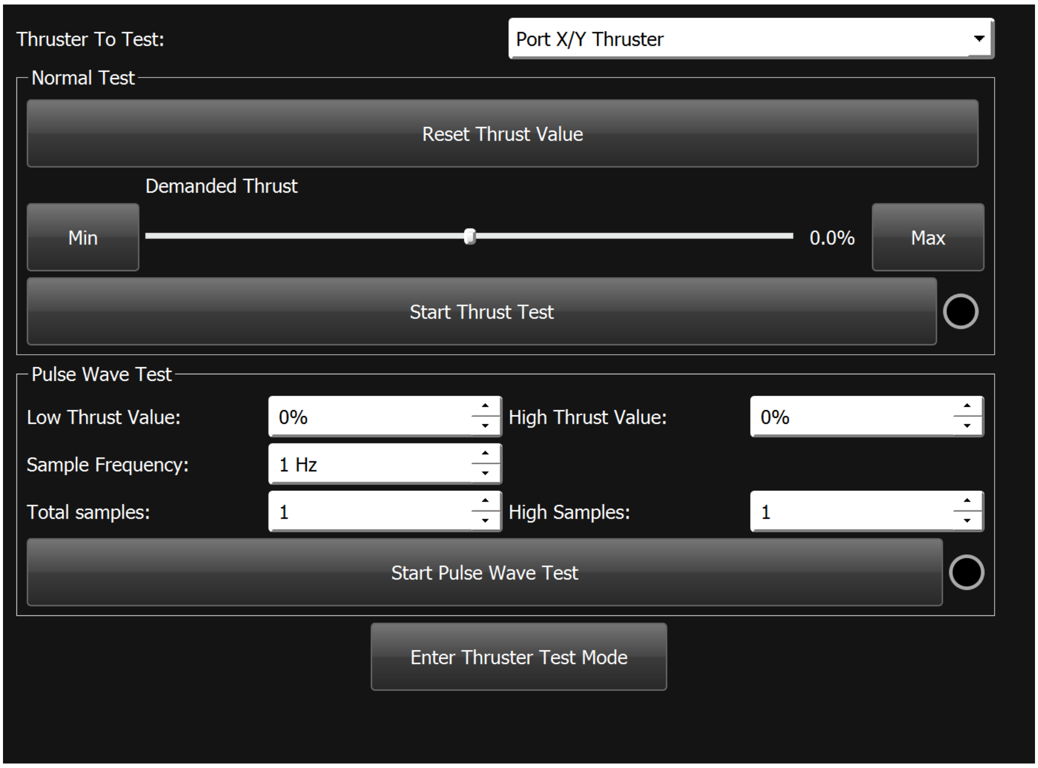


**Figure 2.63: Control**

### 2.8.3.3.1. Normal Test

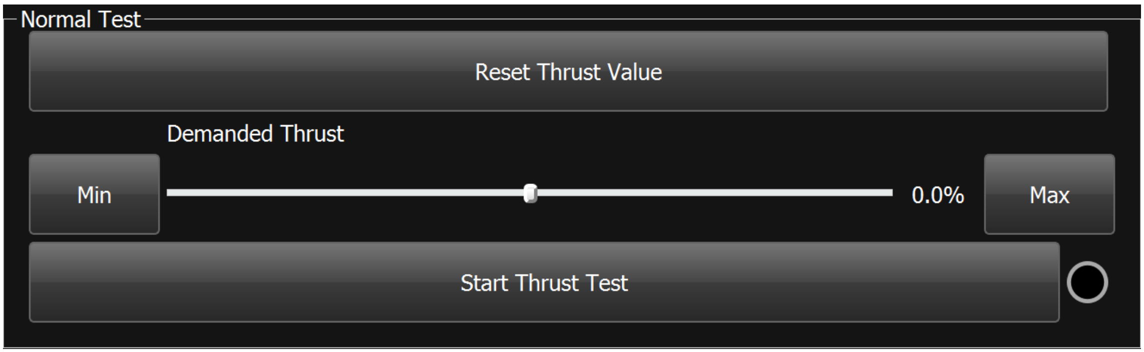


**Figure 2.64: Normal Test**

| Control / Indicator | Description |
|---|---|
| Reset Thrust Value | Click to set the demanded thrust to 0. |
| Demanded Thrust | Move the slider to the desired thrust value for the thruster. |
| Start Thrust Test | Click Start Thrust Test to test the thruster at the demanded thrust. |

A

### 2.8.3.3.2. Pulse Wave Test

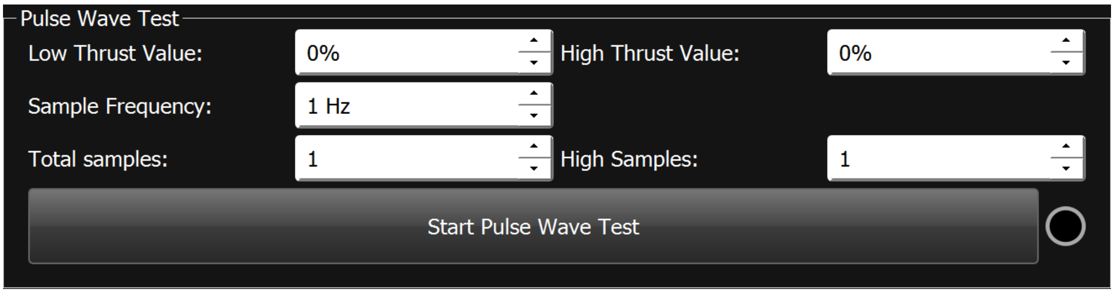


**Figure 2.65: Pulse Wave Test**

| Control / Indicator | Description |
|---|---|
| Low Thrust Value | The demanded value during the low thrust pulse. |
| Sample Frequency | The length of each sample. A sample frequency of 10 will cause each sample to be 100ms long. |
| Total samples | The total number of samples |
| High Thrust Value | The demanded value during the high thrust pulse. |
| High Samples | The number of high samples |
| Start Pulse Wave Test | Start the pule wave test. The pulse wave will start with the high pulse followed by the low before restarting after the total number of samples has been reached. |

### 2.8.4. Power

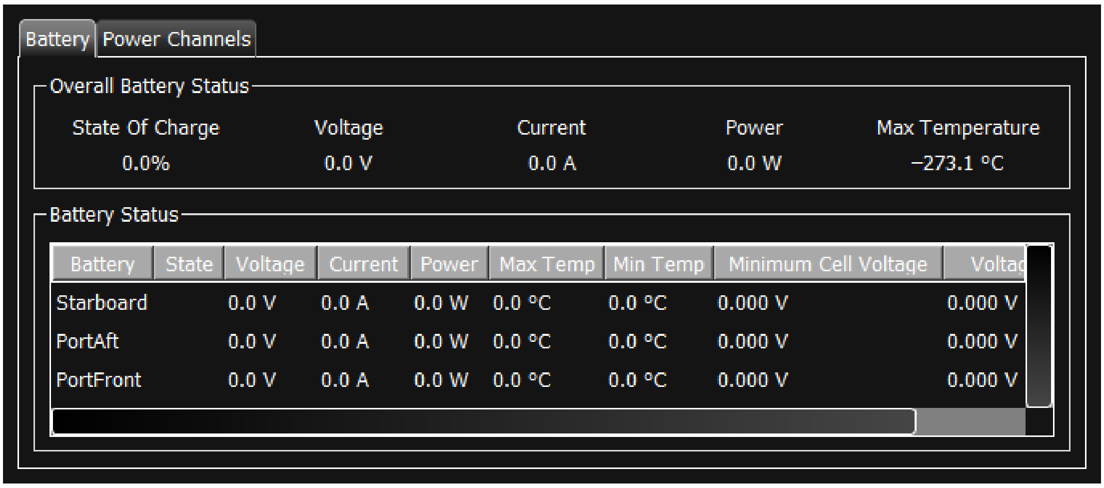


**Figure 2.66: Power**

List of tabs:

- Battery
- Power Channels

#### 2.8.4.1. Battery

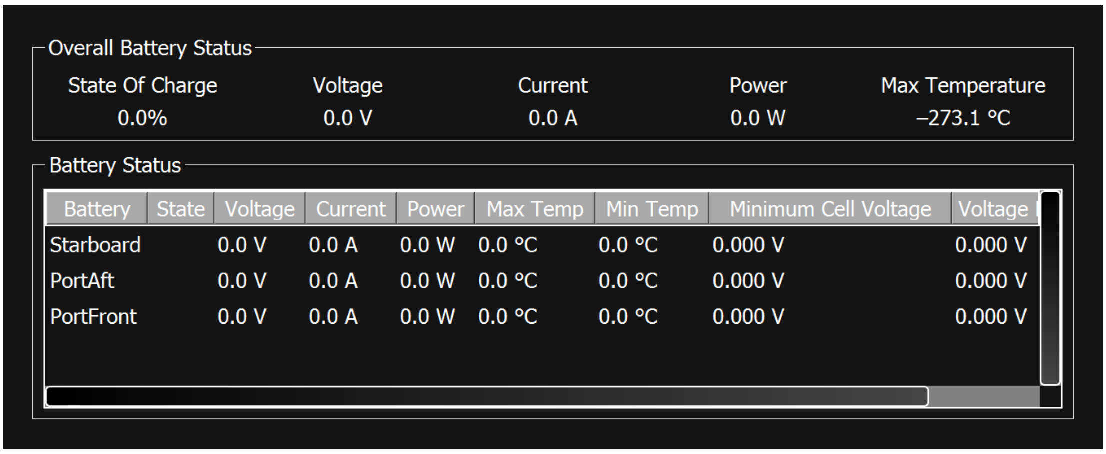


**Figure 2.67: Figure 51: Battery**

##### 2.8.4.1.1. Overall Battery Status

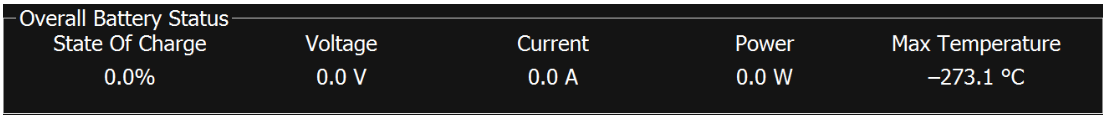


**Figure 2.68: Overall Battery Status**

| Control / Indicator | Description |
|---|---|
| State Of Charge | Indicates the % charge of the batteries. |
| Voltage | Indicates voltage (at present time) |
| Current | Indicates current (at present time) |
| Power | Indicates power consumption (at present time) |
| Max Temperature | The highest temperature measured during present session |

NOTE: The HMI State of Charge (SoC) is based on the current in / out. If the current sensor is not calibrated or not working properly, the key indicator is the cell voltage measurement as they are redundant and more static. If there are differences between the SoC and the cell voltage, always use the cell voltage measurement. See more information in the Battery Handling Safety Instructions in the Preventative Tasks chapter.

##### 2.8.4.1.2. Battery Status

Displays the status of the individual batteries in a table format.

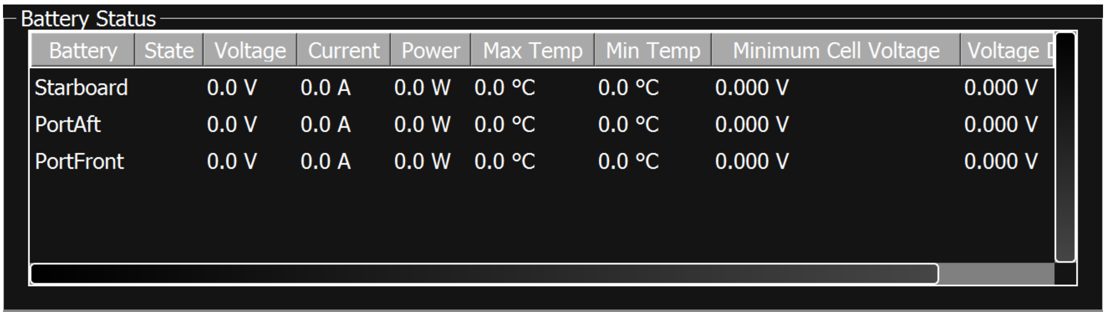


**Figure 2.69: Battery Status**

### 2.8.4.2. Power Channels

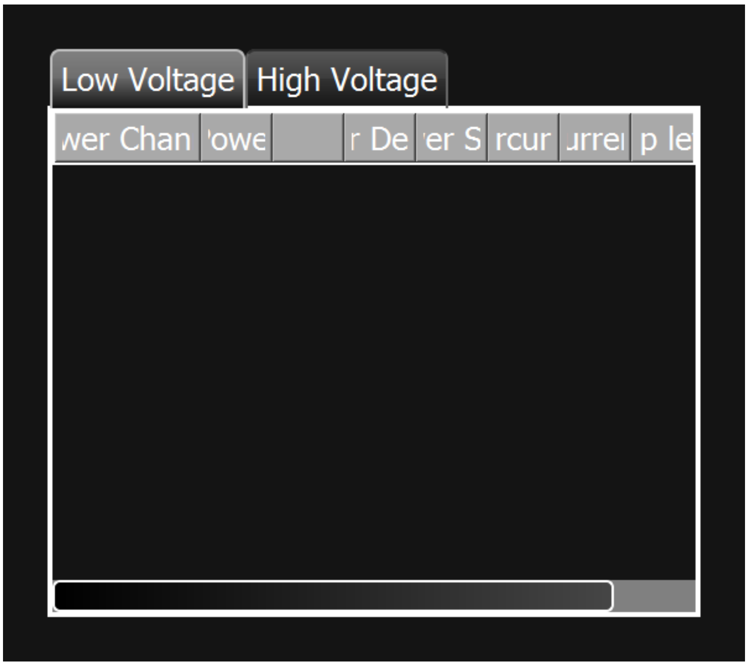


**Figure 2.70: Power Channels**

List of tabs:

- Low Voltage
- High Voltage

### 2.8.4.2.1. Low Voltage

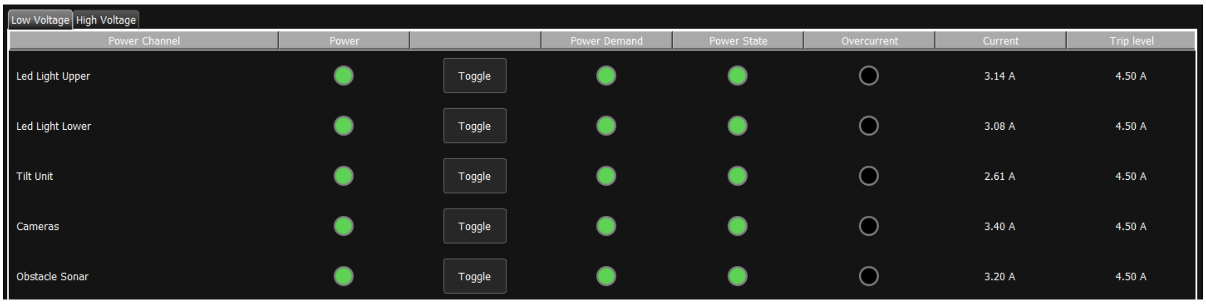


**Figure 2.71: Low Voltage Tabs**

| Control / Indicator | Description |
|---|---|
| Power Channel | Displays the power channel availability from the Low voltage hub. |
| Power Demand | Displays the last demand sent from the GUI:<br><br>green = power on<br><br>black = power off |
| Power state | Displays the actual power state reported from the hardware:<br><br>green = power on<br><br>black = power off |
| Toggle button | Toggles the power state demanded from the GUI and controls the power state lamp. |
| Overcurrent | Displays green if the hardware is sent to high current. |
| Current | Displays the current sent to the hardware. |
| Trip level | Displays the trip level of the hardware. |

### 2.8.4.2.2. High Voltage


**Figure 2.72: High Voltage Tabs**

| Control / Indicator | Description |
|---|---|
| Power Channel | Displays the power channel availability from the High voltage hub. |
| Power Demand | Displays the last demand sent from the GUI: |

| Control / Indicator | Description |
|---|---|
| | green = power on<br><br>black = power off |
| Toggle button | Toggles the power state demanded from the GUI and controls the power state lamp. |
| Power state | Displays the actual power state reported from the hardware:<br><br>green = power on<br><br>black = power off |
| Overcurrent | Displays green if the hardware is sent to high current. |
| Current | Displays the current sent to the hardware. |
| Trip level | Displays the trip level of the hardware. |

### 2.8.5. Events


**Figure 2.73: Events**

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#### 2.8.5.1. Active Events

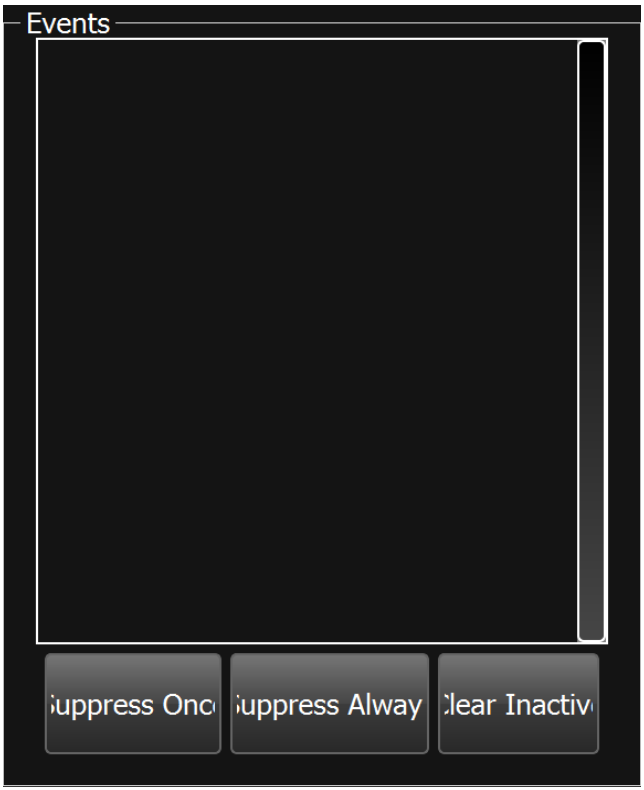


**Figure 2.74: Active Events**

| Control / Indicator | Description |
|---|---|
| Observed Events | Main events section displays a list of all received events. Inactive events are shown in grey. |
| Suppress Once | Click on an event and click Suppress Once to suppress the selected event(s) temporarily. If the event turns inactive, the suppression is removed. |
| Suppress Always | Click on an event and click Suppress Always to remove the selected event(s) until suppression is removed. |
| Clear Inactive | Remove all inactive events from the list |

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#### 2.8.5.2. Suppressed Events


**Figure 2.75: Suppressed Events**

| Control / Indicator | Description |
|---|---|
| Suppressed Events | Suppressed events section displays a list of all currently suppressed events. |
| Remove Suppression | Click on an event and click Remove Suppression. If the event is still active, it will be moved to the active events list. |

#### 2.8.5.3. Event Details

The Events Details displays information about a selected Event.

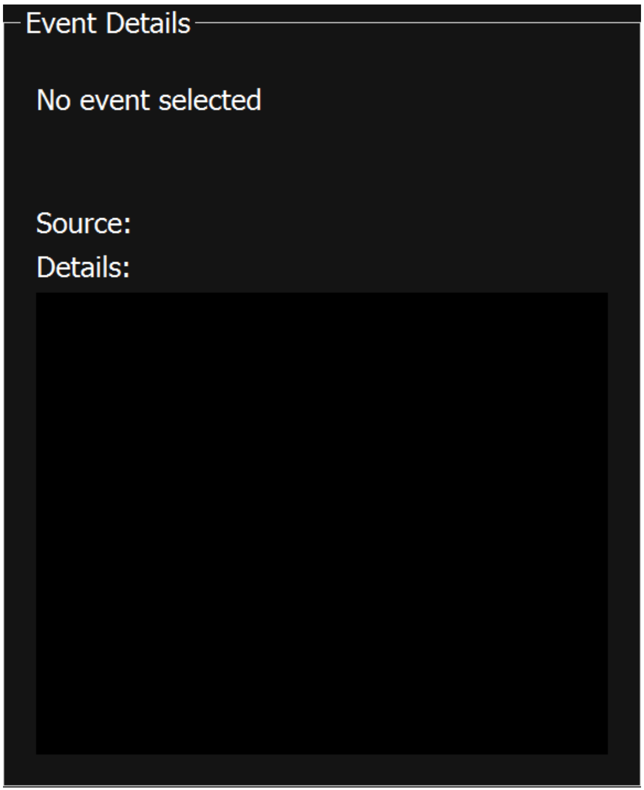


**Figure 2.76: Event Details**

| Control / Indicator | Description |
|---|---|
| Event Severity | The events severity is indicated by the colour of the text. The possible severities are: Critical (purple)<br><br>Error (red)<br><br>Warning (yellow)<br><br>Information (green) |
| Event Type | Shows the events type and event classification. |
| Event State | Displays the current event state. |
| Details | Detailed information of the event. |
| Event Timestamp | Displays a Timestamp showing when the event became active or inactive. |
| Source | Displays the source of the event. |

### 2.8.6. Missions

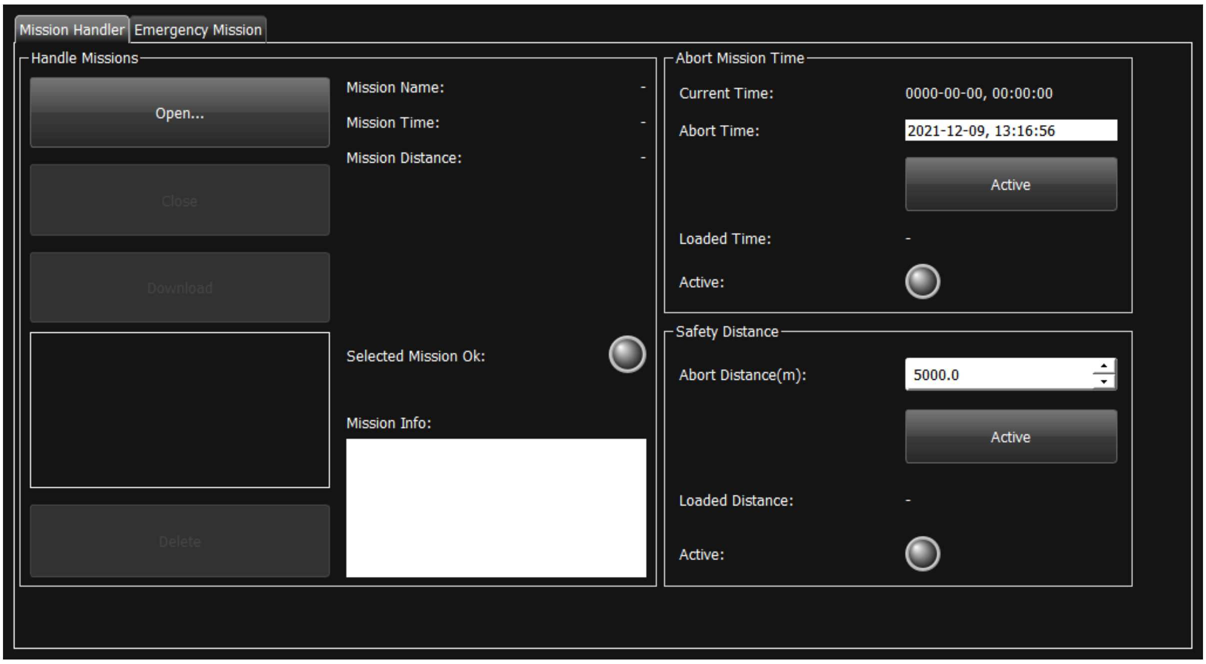


**Figure 2.77: Missions**

List of tabs:

- Mission Handler
- Emergency Mission

#### 2.8.6.1. Mission Handler

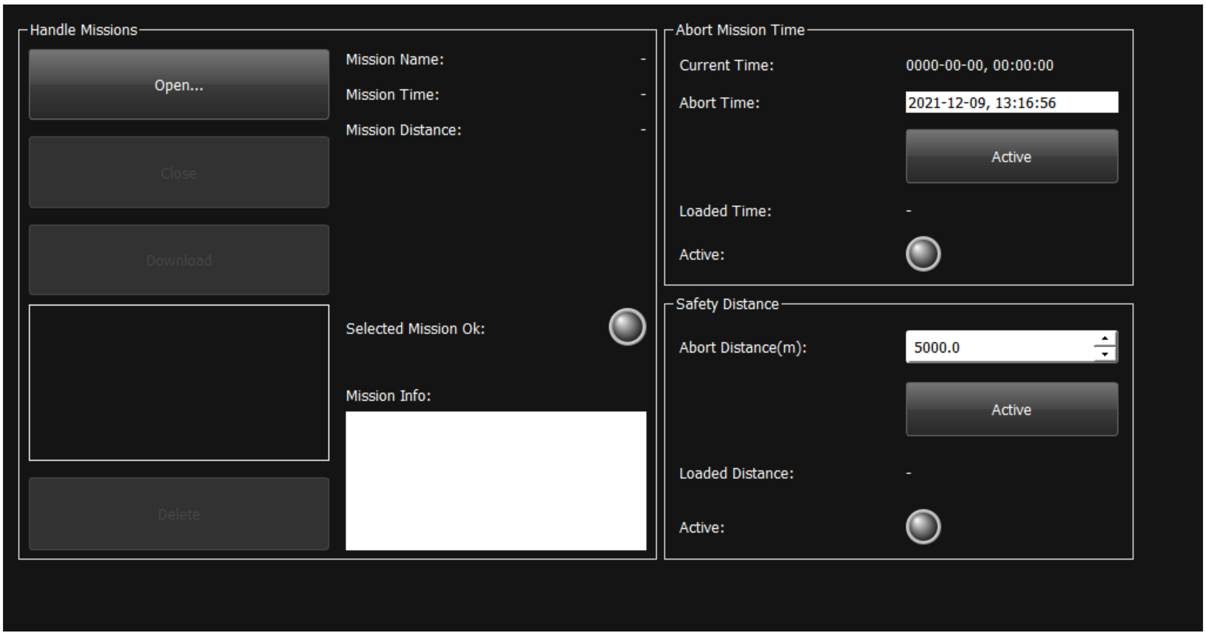


**Figure 2.78: Mission Handler**

### 2.8.6.2. Emergency Mission - Manual Emergency Control

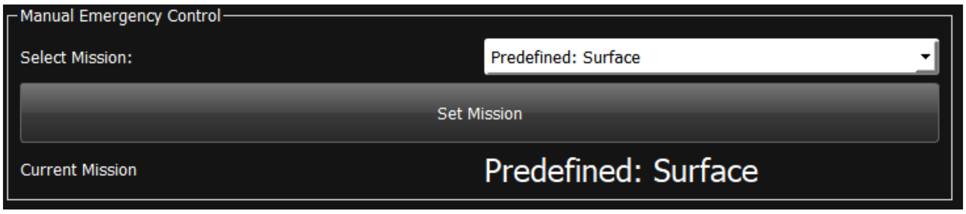


**Figure 2.79: Emergency Mission**

| Control / Indicator | Description |
|---|---|
| Select Mission | Dropdown menu displays a list of missions that can be used as Emergency missions. |
| Set Mission | Sets the selected mission as the emergency mission. |
| Current Mission | Displays the name of the currently loaded emergency mission. |

### 2.8.7. Logs

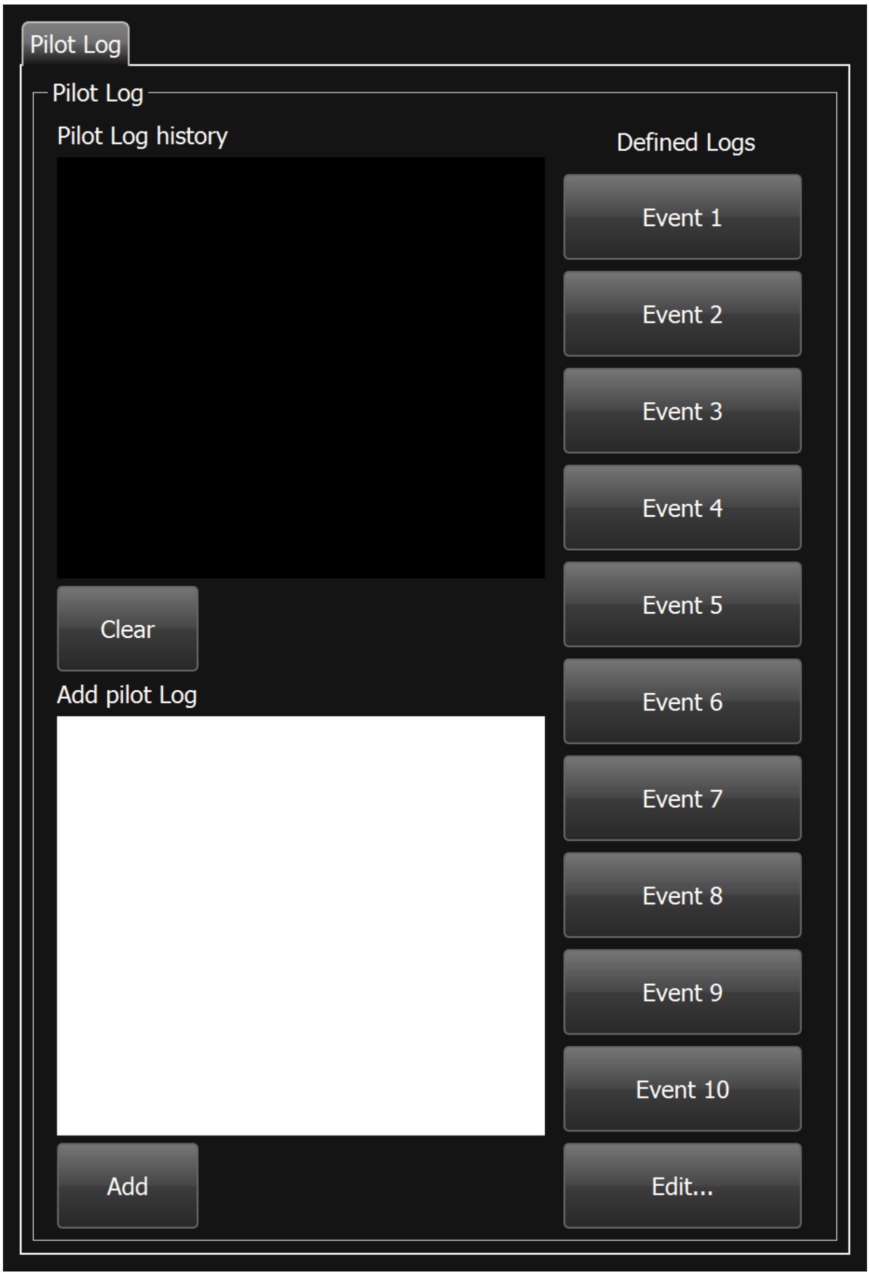


**Figure 2.80: Pilot Logs**

| Control / Indicator | Description |
|---|---|
| Pilot Log history | Displays a list of the logs saved to the log file. |
| Add pilot Log | To manually add a new Pilot Log, type the information in the Add to log window and press the Add button below. Log events are timestamped automatically when entered to the log. |
| Event 1 | Sends the predefined text associated with Event 1 |
| Event 2 | Sends the predefined text associated with Event 2 |
| Event 3 | Sends the predefined text associated with Event 3 |
| Event 4 | Sends the predefined text associated with Event 4 |

| Control / Indicator | Description |
|---|---|
| Event 5 | Sends the predefined text associated with Event 5 |
| Event 6 | Sends the predefined text associated with Event 6 |
| Event 7 | Sends the predefined text associated with Event 7 |
| Event 8 | Sends the predefined text associated with Event 8 |
| Event 9 | Sends the predefined text associated with Event 9 |
| Event 10 | Sends the predefined text associated with Event 10 |
| Edit... | Opens a dialogue where the pilot can create predefined log texts. Log texts are time stamped automatically when entered to the log. |

### 2.8.8. Navigation

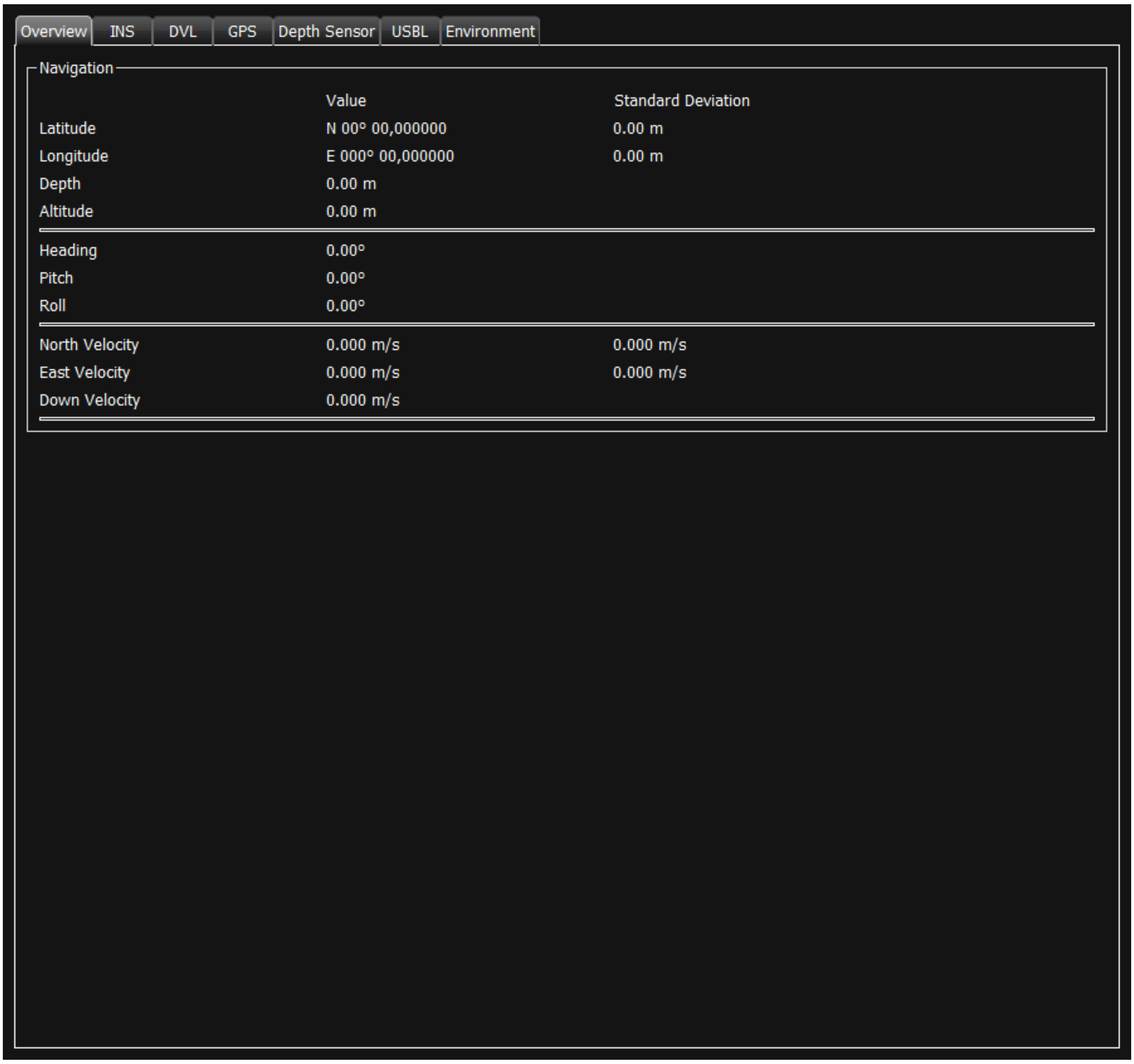


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**Figure 2.81: Navigation**

List of tabs:

- Overview
- INS

- DVL
- GPS
- Depth Sensor
- USBL
- Environment

### 2.8.8.1. Navigation Tab

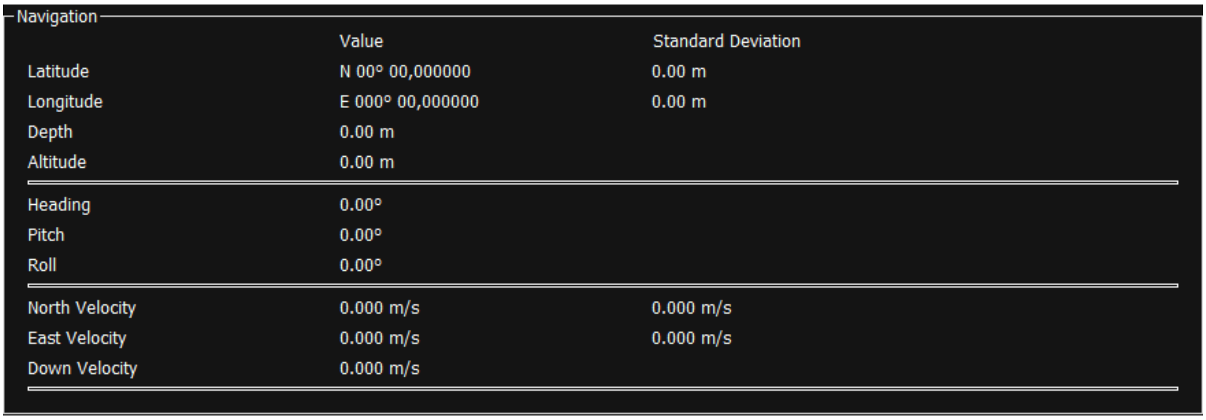


**Figure 2.82: Navigation Tab**

| Control / Indicator | Description |
|---|---|
| Latitude | Displays current vehicle latitude |
| Longitude | Displays current vehicle longitude |
| Depth | Displays the measured depth of the vehicle |
| Altitude | Displays the measured altitude of the vehicle |
| Heading | Displays the vehicle heading (where the vehicle is pointing, not the direction of movement) |
| Pitch | Displays the vehicle pitch angle |
| Roll | Displays the vehicle roll angle |
| North Velocity | Displays the vehicle velocity in direction north |
| East Velocity | Displays the vehicle velocity in direction east |
| Down Velocity | Displays the vehicle velocity in direction down |
| Latitude Std | Displays the Latitude standard deviation (i.e. uncertainty value, lower is better) |
| Longitude Std | Displays the Longitude standard deviation (i.e. uncertainty value, lower is better) |
| North Std | Displays the North velocity standard deviation (i.e. uncertainty value, lower is better) |
| East Std | Displays East velocity standard deviation (i.e. uncertainty value, lower is better) |

### 2.8.8.2. INS

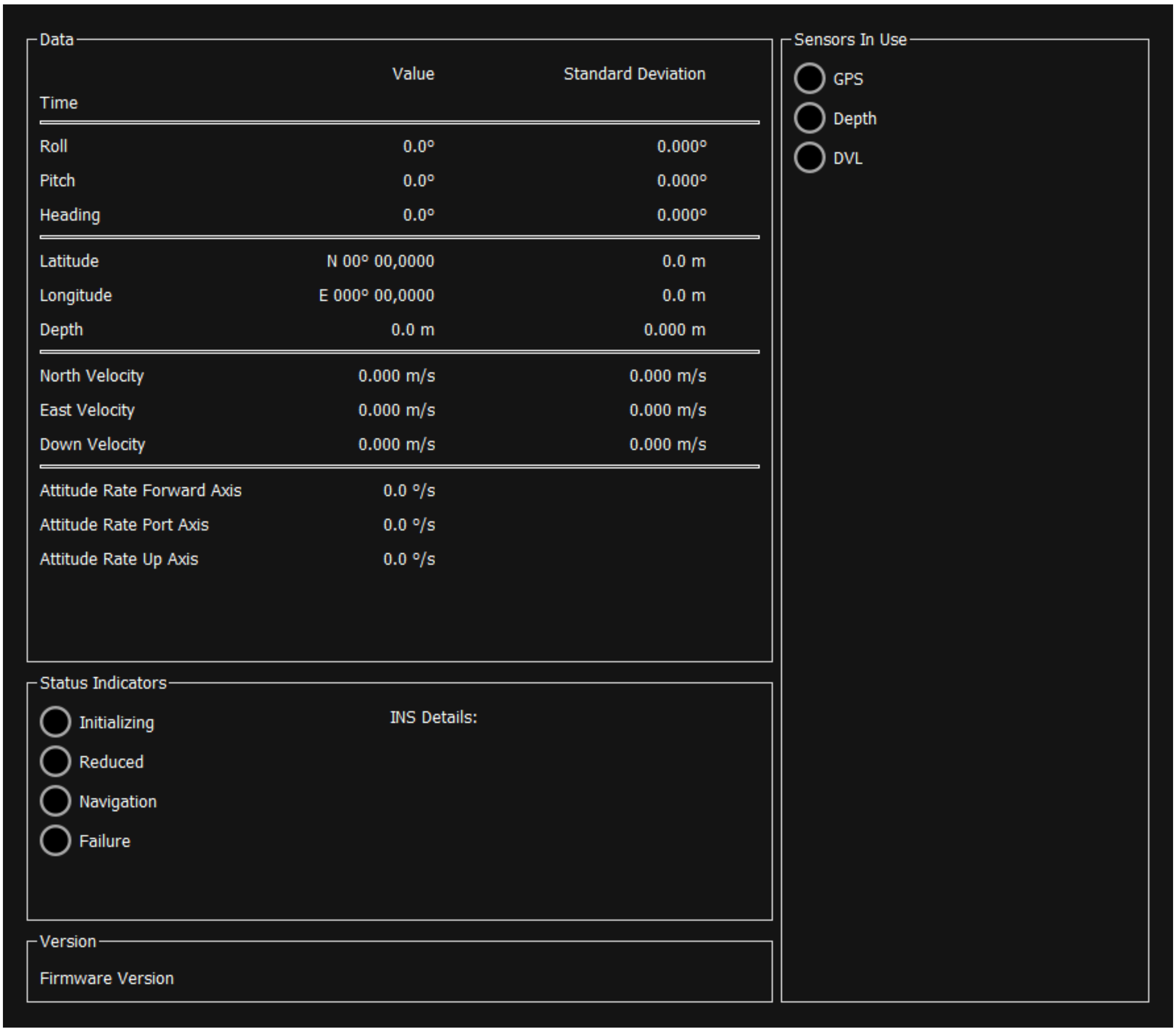


**Figure 2.83: INS**

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#### 2.8.8.2.1. Data

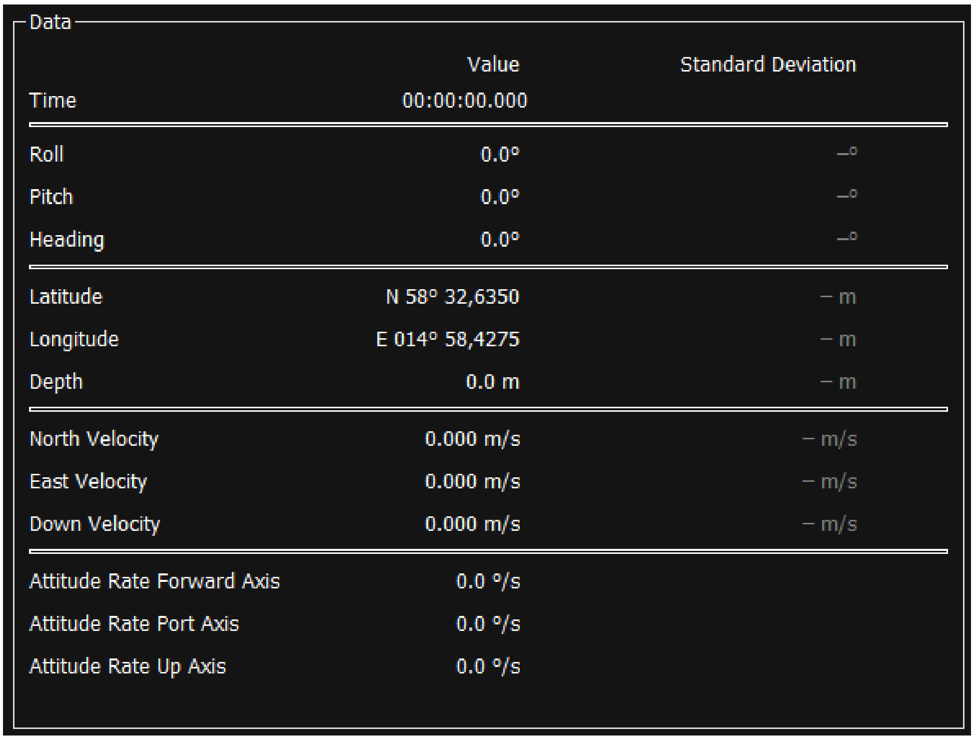


**Figure 2.84: INS Data**

| Control / Indicator | Description |
|---|---|
| Time | Displays the current time |
| Roll | Displays the Vehicle roll angle |
| Pitch | Displays the Vehicle pitch angle |
| Heading | Displays the Vehicle yaw angle |
| Latitude | Displays the Vehicle latitude |
| Longitude | Displays the Vehicle longitude |
| Depth | Displays the Vehicle depth |
| North Velocity | Displays the Vehicle speed northwards |
| East Velocity | Displays the Vehicle speed eastwards |
| Down Velocity | Displays the Vehicle speed downwards |
| Attitude Rate Forward Axis | Displays the Angular velocity roll-wise |
| Attitude Rate Port Axis | Displays the Angular velocity pitch-wise |
| Attitude Rate Up Axis | Displays the Angular velocity yaw-wise |
| Latitude Std | Displays the Vehicle latitude standard deviation (i.e. uncertainty) |
| Longitude Std | Displays the Vehicle longitude standard deviation (i.e. uncertainty) |
| Depth Std | Displays the Depth standard deviation (i.e. uncertainty) |
| North Speed Std | Displays the North speed standard deviation (i.e. uncertainty) |
| East Speed Std | Displays the East speed standard deviation (i.e. uncertainty) |
| Down Speed Std | Displays the Downward speed standard deviation (i.e. uncertainty) |
| Roll Std | Displays the Roll standard deviation (i.e. uncertainty) |
| Pitch Std | Displays the Pitch standard deviation (i.e. uncertainty) |
| Heading Std | Displays the Heading standard deviation (i.e. uncertainty) |

#### 2.8.8.2.2. Status Indicators

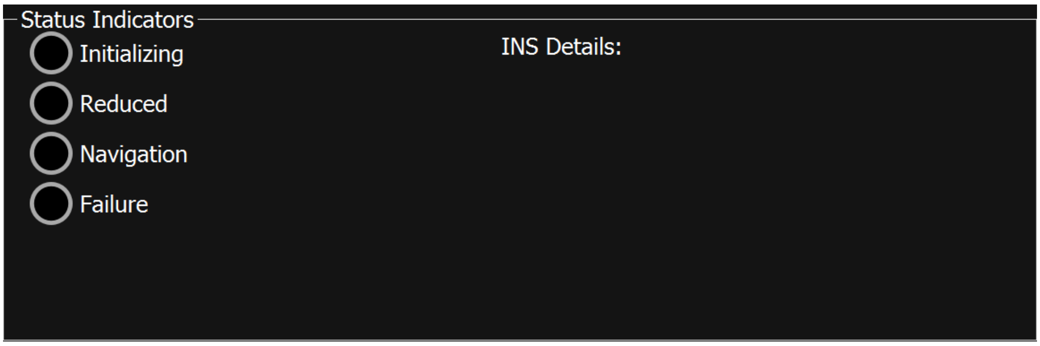


**Figure 2.85: Status Indicators**

| Control / Indicator | Description |
|---|---|
| Initializing | Indicates that the INS is in start up mode, which means true heading alignment is performed or the INS is waiting for a start position. |
| Reduced | Indicates that the INS is in reduced mode, which means the INS is not in full performance.<br><br>See information in INS Details and/or active events for more information on why this mode is active. |
| Navigation | Indicates that the INS is in full navigation mode. |
| Failure | Indicates that the INS is in failing mode for some reason. |
| INS Details | Displays INS type specific information, such as internal modes or other INS type specific parameters.<br><br>The information provided depends on the general system INS mode (Initializing, Navigation etc). |

#### 2.8.8.2.3. Version

Version displays the Current firmware / software version used in INS.


**Figure 2.86: Version**

#### 2.8.8.2.4. Sensors In Use

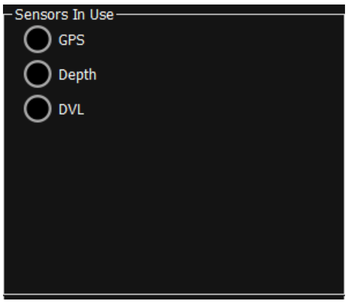


**Figure 2.87: Sensors In Use**

| Control / Indicator | Description |
|---|---|
| GPS | Indicates if INS is using GPS sensor data (green) or not (black) to aid the navigation filter.<br><br>The reason for the INS not using the sensor could be multiple. For example, the sensor data is not available, or the data is available but the corresponding "use sensor" option is off (INS Control), or the data could have been rejected by the INS for some reason. |
| Depth | Indicates if INS is using pressure (depth) sensor data (green) or not (black) to aid the navigation filter.<br><br>The reason for the INS not using the sensor could be multiple. For example, the sensor data is not available, or the data is available but the corresponding "use sensor" option is off (INS Control), or the data could have been rejected by the INS for some reason. |
| DVL | Indicates if INS is using DVL sensor data (green) or not (black) to aid the navigation filter.<br><br>The reason for the INS not using the sensor could be multiple. For example, the sensor data is not available, or the data is available but the corresponding "use sensor" option is off (INS Control), or the data could have been rejected by the INS for some reason. |

### 2.8.8.3. DVL

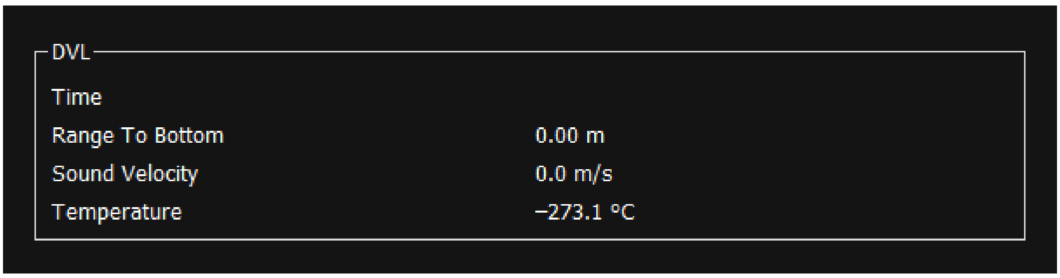


**Figure 2.88: DVL**

| Control / Indicator | Description |
|---|---|
| Time | Displays the Current time |
| Range To Bottom | Displays the Vehicle altitude above seabed |

| Control / Indicator | Description |
|---|---|
| Sound Velocity | Displays the Measured/calculated velocity of sound |
| Temperature | Displays the Measured water temperature |

### 2.8.8.4. GPS

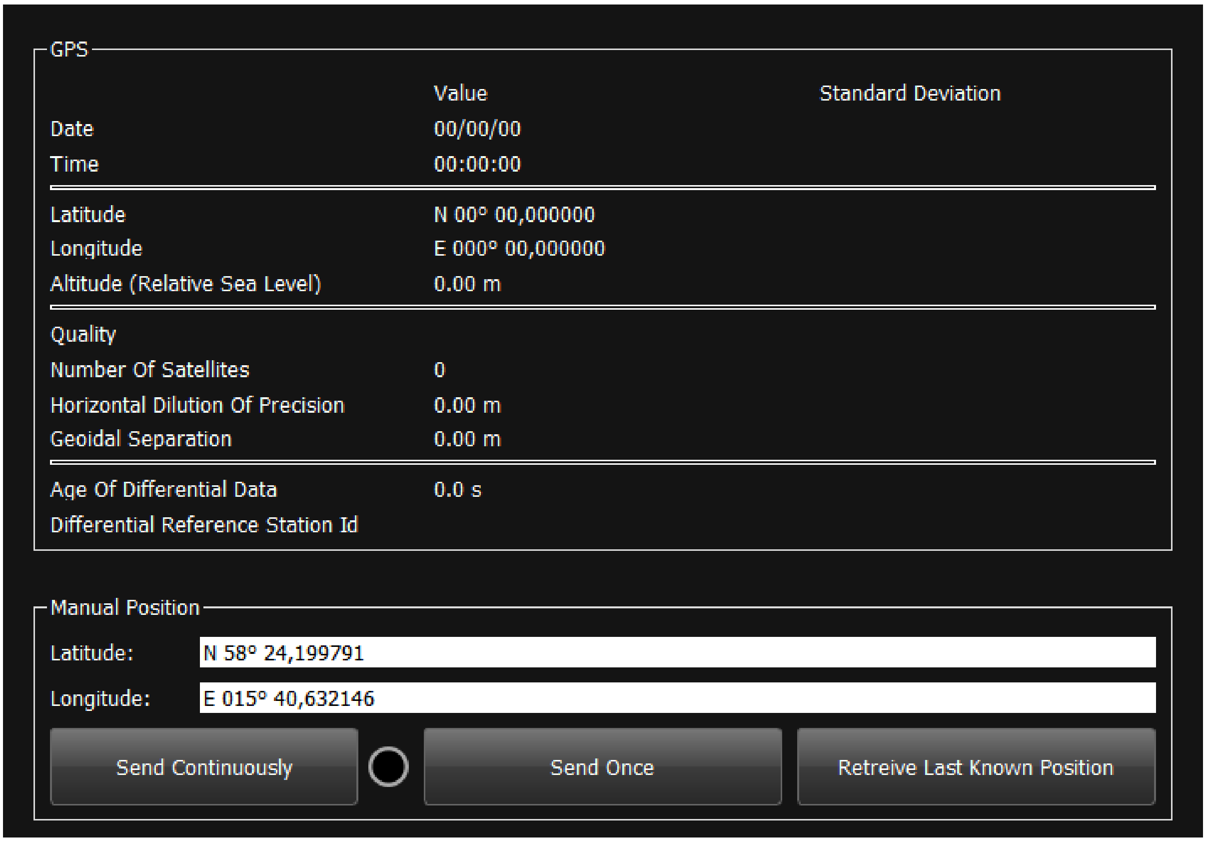


**Figure 2.89: GPS**

#### 2.8.8.4.1. GPS Data

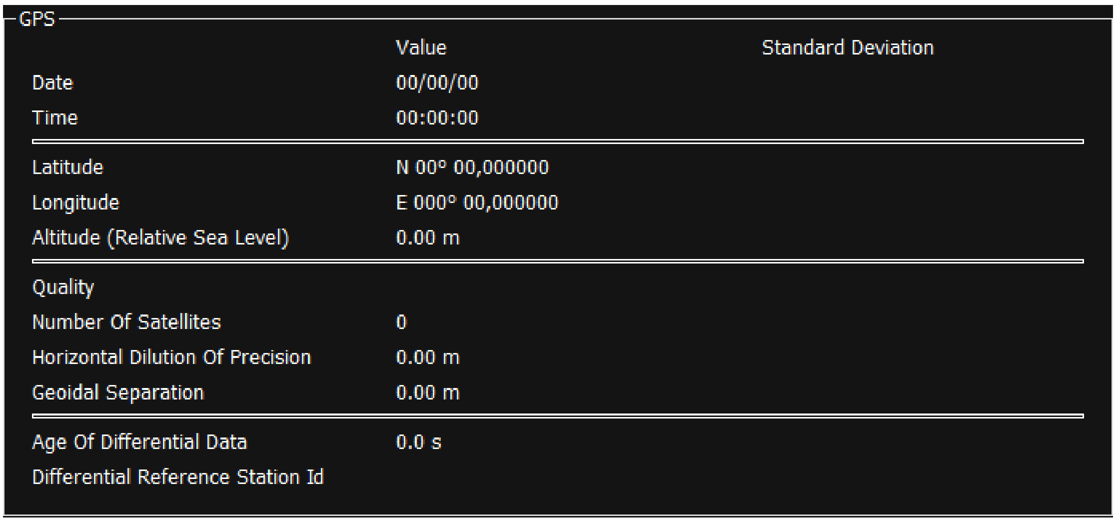


**Figure 2.90: GPS Data**

| Control / Indicator | Description |
|---|---|
| Date | Displays the Current date |
| Time | Displays the Current time |
| Latitude | Displays the Vehicle latitude |
| Longitude | Displays the Vehicle longitude |
| Altitude (Relative Sea Level) | Displays the Altitude difference from sea level |
| Quality | States whether the GPS has a position fix (1 or 2) or not (0) |
| Number Of Satellites | Displays the Number of satellites observed |
| Horizontal Dilution Of Precision | Displays a measure of uncertainty in determination of position |
| Geoidal Separation | Displays the difference between ellipsoidal surface and mean sea level |
| Age Of Differential Data | States how old data from differential station is |
| Differential Reference Station Id | Displays the Id of station used for differential GPS enhancement |

#### 2.8.8.4.2. Manual Position

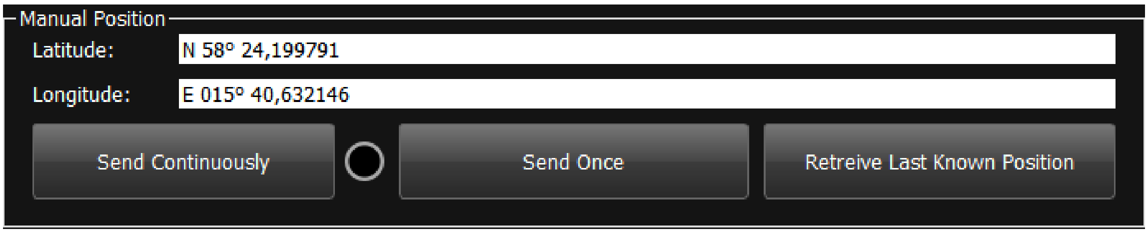


**Figure 2.91: Manual Position**

| Control / Indicator | Description |
|---|---|
| Send Continuously | Sends manual position to INS, continuously. |
| Latitude | Manual input position latitude value. |
| Longitude | Manual input position longitude value. |
| Send Once | Send manual position to INS, once. |
| Retrieve Last Known Position | Update input values with the last known vehicle position. |

#### 2.8.8.5. Vehicle Depth Sensor

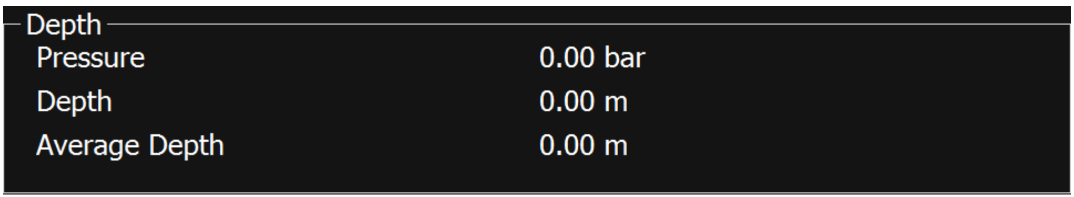


**Figure 2.92: Depth**

| Control / Indicator | Description |
|---|---|
| Pressure | Displays the measured pressure |
| Depth | Displays the momentarily measured depth |
| Average Depth | Displays the low pass filtered depth |

### 2.8.8.6. USBL

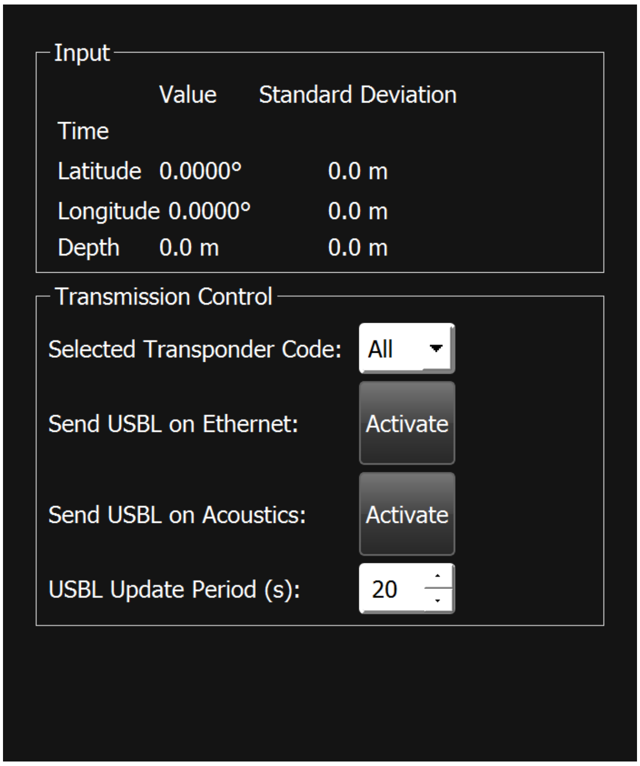


**Figure 2.93: USBL**

#### 2.8.8.6.1. Input

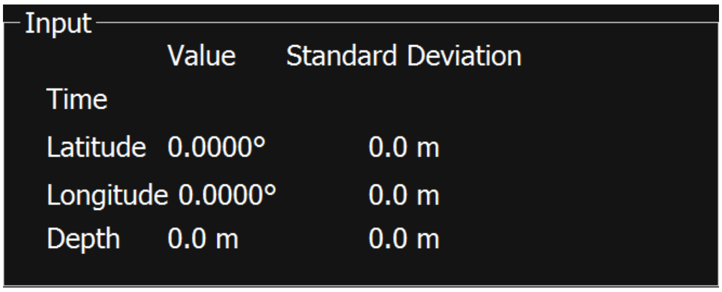


**Figure 2.94: Input Data**

| Control / Indicator | Description |
|---|---|
| Time | Displays the Current time |
| Latitude | Displays the Vehicle latitude |
| Longitude | Displays the Vehicle longitude |
| Depth | Displays the Vehicle depth |
| Latitude Std. Dev. | Displays the Latitude standard deviation (i.e. uncertainty) |
| Longitude Std. Dev. | Displays the Longitude standard deviation (i.e. uncertainty) |
| Depth Std. Dev. | Displays the Depth standard deviation (i.e. uncertainty) |

#### 2.8.8.6.2. Transmission Control

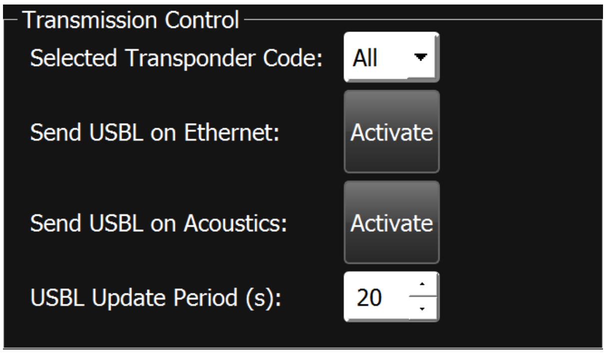


**Figure 2.95: Transmission Control**

| Control / Indicator | Description |
|---|---|
| Selected Transponder Code | Click the drop down arrow to select which transponder(s) to use |
| Send USBL on Ethernet | Activate USBL on Ethernet |
| Send USBL on Acoustics | Activate USBL on Acoustic |
| USBL Update Period | Set the USBL update period |

### 2.8.8.7. Environment


**Figure 2.96: Environment**

| Control / Indicator | Description |
|---|---|
| Gravity | Displays Gravity measurement |
| Temperature | Measured water temperature |
| Atmospheric Pressure | Atmospheric pressure at sea level |
| Sound Velocity in Water | Measured or calculated sound velocity in water |
| Salinity | Measured or set water salinity |
| Water Current Heading | Direction of the water current |
| Water Current Speed | Speed of water current |
| Water Density | Measured water density |

### 2.8.9. Tactical View


**Figure 2.97: Tactical View**

#### 2.8.9.1. Tactical View Map

The following symbols and information can be found in the grid:

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- Vehicle (yellow) - Destination Waypoint - Vehicle position uncertainty (blue ellipse on vehicle).
- GPS position (inside the vehicle).
- Vessel (green) - Vessel position uncertainty (blue ellipse on vessel).
- An estimation of where the tether is located, the line between vessel and vehicle.

- Forbidden zones - The sonar's reach as seen from above, shown as a cone from the vehicle. (Not available on all vehicles)
- Obstacles seen by the sonar. (Not available on all vehicles)
- Custom markers created by the user.
- Current size of each square in the grid. If the user zoom out, the grid size will change from 5 m to 10, 20, 50, etc.
- Latitude/Longitude of the mouse pointer id displayed when hovering inside the grid.

Right-click in the map to open a menu with two options:

- "Go To Here" commands the vehicle to go to the position the user clicked on. The vehicle will keep the current depth while traveling to the point.
- "Create Marker" opens a dialog to create a new marker at the position, with the same depth as the ROV is currently on. The new marker gets an auto-generated name "Marker n", where n counts up for each new marker.

#### 2.8.9.2. Vehicle Position

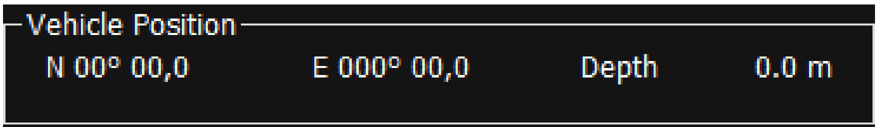


**Figure 2.98: Vehicle Position**

| Control / Indicator | Description |
|---|---|
| Latitude | Displays the Vehicle latitude |
| Longitude | Displays the Vehicle longitude |
| Depth | Displays the Vehicle depth |

### 2.8.9.3. Points

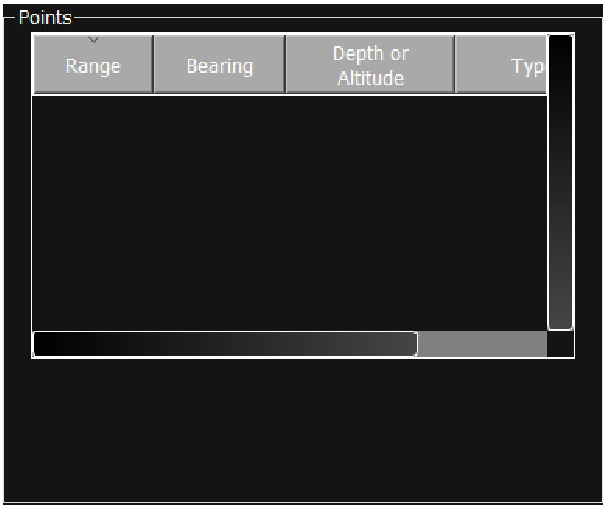


**Figure 2.99: Points**

| Control / Indicator | Description |
|---|---|
| Points | List of items in the Tactical View. The range is the distance to the vehicle. |
| Details | Details for the selected item are shown below the items list |

### 2.8.9.4. Markers

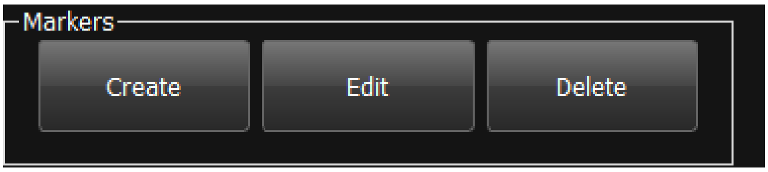


**Figure 2.100: Markers**

| Control / Indicator | Description |
|---|---|
| Create | Create a marker item in the map |
| Edit | Edit the selected marker |
| Delete | Delete the selected marker |

### 2.8.9.5. Go To Point

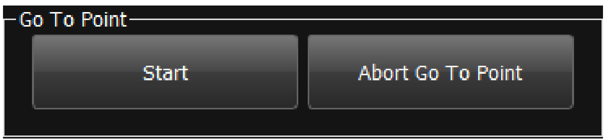


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**Figure 2.101: Go To Point**

| Control / Indicator | Description |
|---|---|
| Start | Command the vehicle to go to the selected point. This is a semi-autonomous operation that requires the pilot to monitor the vehicle during travel. |

| Control / Indicator | Description |
|---|---|
| Abort Go To Point | Aborts the current go to point action. This will cause the vehicle to stop at the current position and return control to the pilot. |

### 2.8.9.6. View Controls

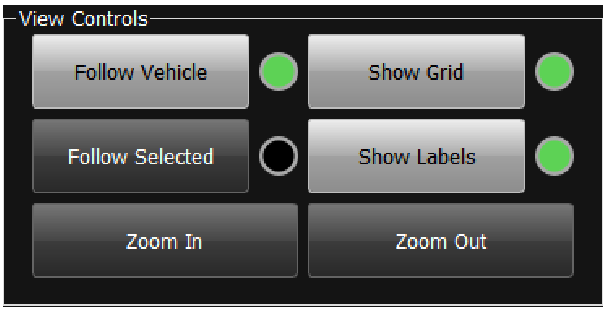


**Figure 2.102: View Controls**

| Control / Indicator | Description |
|---|---|
| Follow Vehicle | Centre view around the vehicle |
| Follow Selected | Centre view around selected item from the Points list |
| Show Grid | Show a grid in the map |
| Show Labels | Show a label next to items in the map |

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## 2.8.10. Acoustics


Figure 2.103: Acoustics

List of tabs:

- Control
- Status
- Advanced

### 2.8.10.1. Acoustics Control

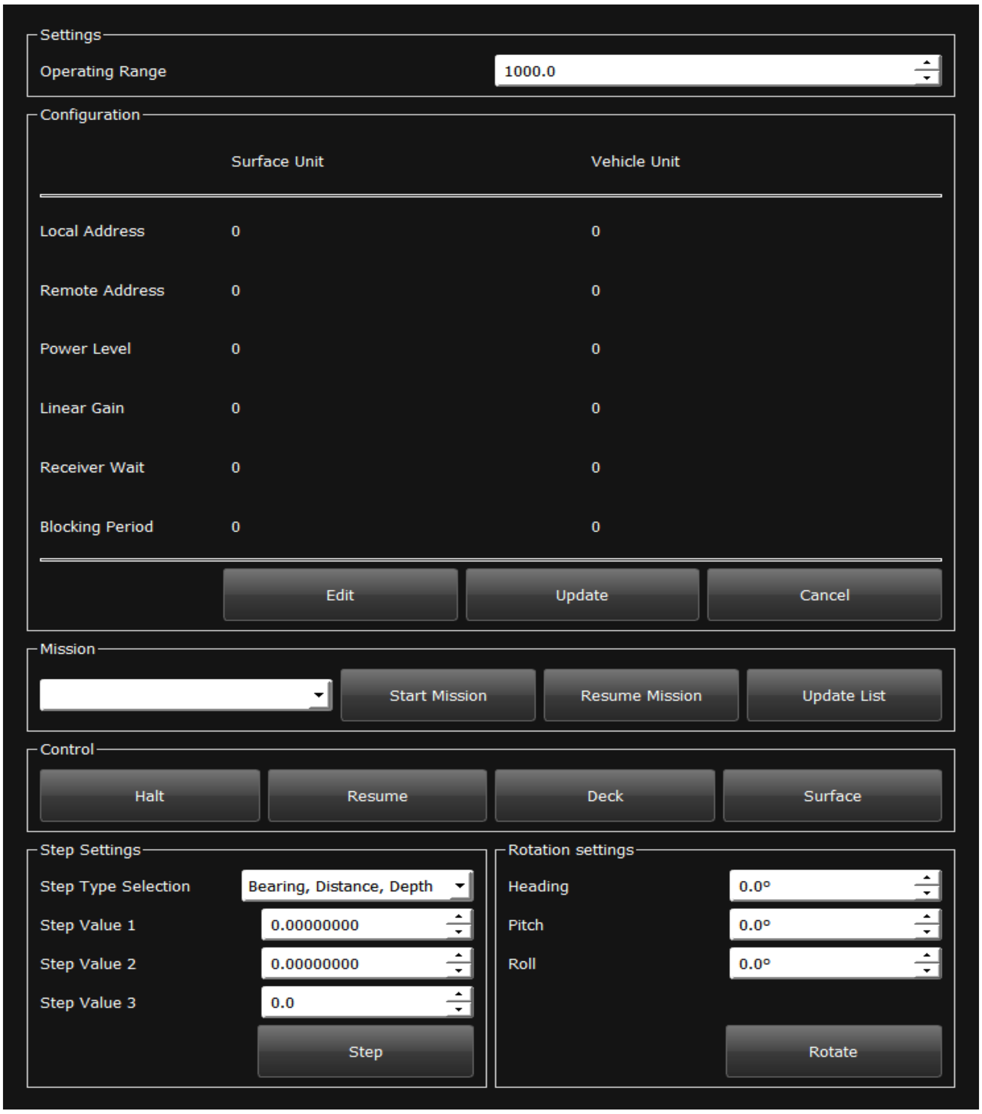


**Figure 2.104: Acoustics Control Tab**

#### 2.8.10.1.1. Settings


**Figure 2.105: Settings**

| Control / Indicator | Description |
|---|---|
| Operating Range | Select expected maximum operating distance |

### 2.8.10.1.2. Configuration

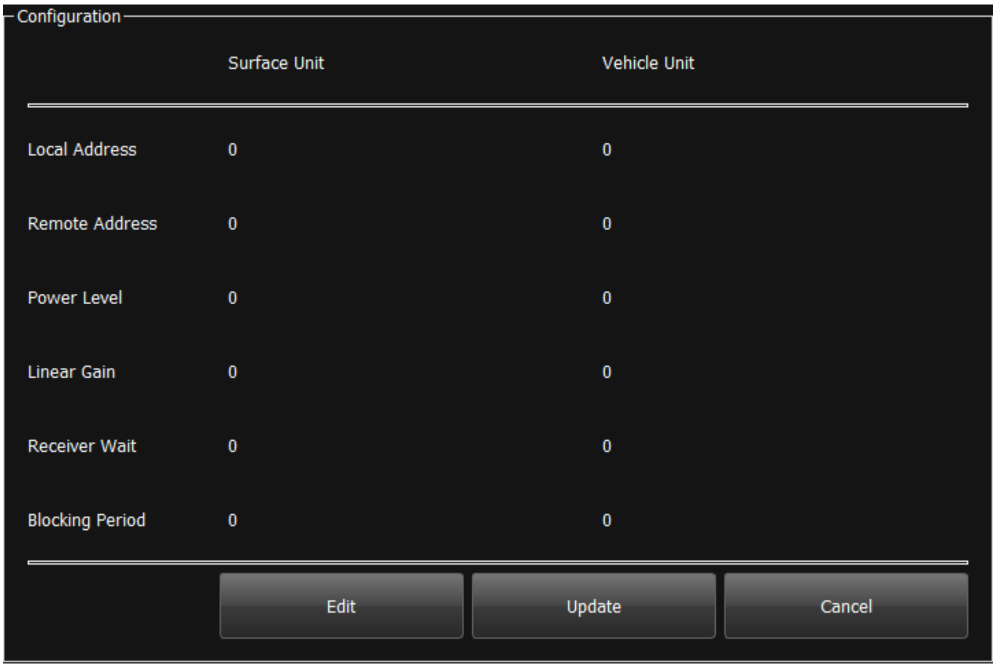


**Figure 2.106: Configuration**

| Control / Indicator | Description |
|---|---|
| Edit | Edit the configuration |
| Update | Update the configuration with edits made |
| Cancel | Cancel editing the configuration |
| Surface Local Address Output | Displays Surface side receiving address |
| Surface Remote Address Output | Displays Surface side sending address |
| Surface Power Level Output | Displays Surface side power level |
| Surface Linear Gain Output | Displays the linear gain setting on the surface side |
| Surface Receiver Wait Output | Displays the wait period setting on the surface side |
| Surface Blocking Period Output | Displays the blocking period setting on the surface side |
| Vehicle Local Address Output | Displays Vehicle side receiving address |
| Vehicle Remote Address Output | Displays Vehicle side sending address |
| Vehicle Power Level Output | Displays Vehicle side power level |
| Vehicle Linear Gain Output | Displays the linear gain setting on the vehicle side |
| Vehicle Receiver Wait Output | Displays the receiver wait setting on the vehicle side |
| Vehicle Blocking Period Output | Displays the blocking period setting on the vehicle side |

### 2.8.10.1.3. Mission

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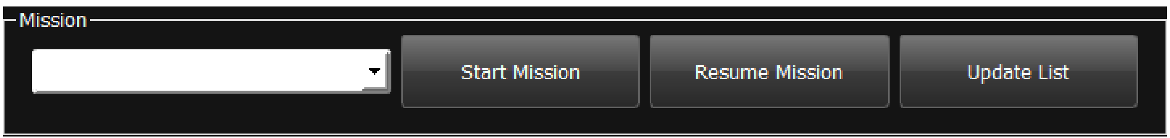


**Figure 2.107: Mission**

| Control / Indicator | Description |
|---|---|
| Mission Selection | Select the relevant mission from the drop down list to use before the Start or Resume Mission is pressed. |
| Start Mission | Send command over acoustic link to start the selected mission |
| Resume Mission | Send command over acoustic link to resume the selected mission |
| Update List | Update the list of selectable missions.<br><br>Note: Only first 8 characters of the mission name will be sent. Make sure to name a mission accordingly. |

### 2.8.10.1.4. Control

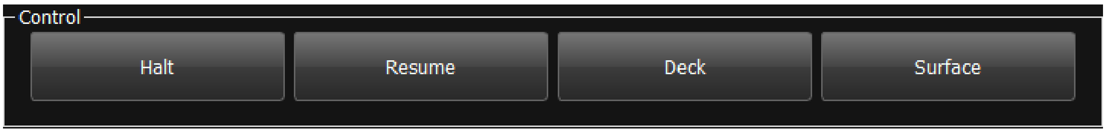


**Figure 2.108: Control**

| Control / Indicator | Description |
|---|---|
| Halt Mission | Send command over acoustic link to halt the execution of the current mission (execution can be resumed) |
| Resume Mission | Send command over the acoustic link to resume execution of the current mission |
| Deck | Set the vehicle to Deck Mode. |
| Surface | Send a command for the vehicle to surface. |

### 2.8.10.1.5. Step Settings

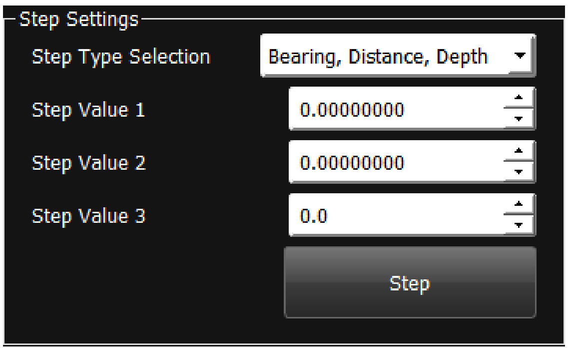


**Figure 2.109: Step Settings**

| Control / Indicator | Description |
|---|---|
| Step Type Selection | Click drop down arrow to select a choice of steps.<br><br>If an attitude type is selected, this will be disabled. The step type name will correspond to each step value field. Example: For North/East/Depth, the step value 1 would be north, step value 2 would be east and step value 3 would be depth.<br><br>Available step types: None (this will unlock the attitude type selection), North, East, depth Bearing, distance, depth. Bearing is relative north. Latitude, Longitude, depth |

| Control / Indicator | Description |
|---|---|
| Step Value 1 | Value 1 for step type, see description in step type selection for more details. |
| Step Value 2 | Value 2 for step type, see description in step type selection for more details. |
| Step Value 3 | Value 3 for step type, see description in step type selection for more details. |

### 2.8.10.1.6. Rotation settings

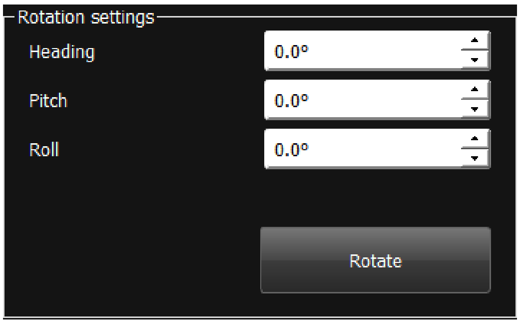


**Figure 2.110: Rotation settings**

| Control / Indicator | Description |
|---|---|
| Heading | Set the Heading value |
| Pitch | Set the Pitch value |
| Roll | Set the Roll value |
| Rotate | Rotate any vehicle movements. If the Vehicle is on the move, it will stop and set the attitude on current location. |

A

### 2.8.10.2. Acoustic Status

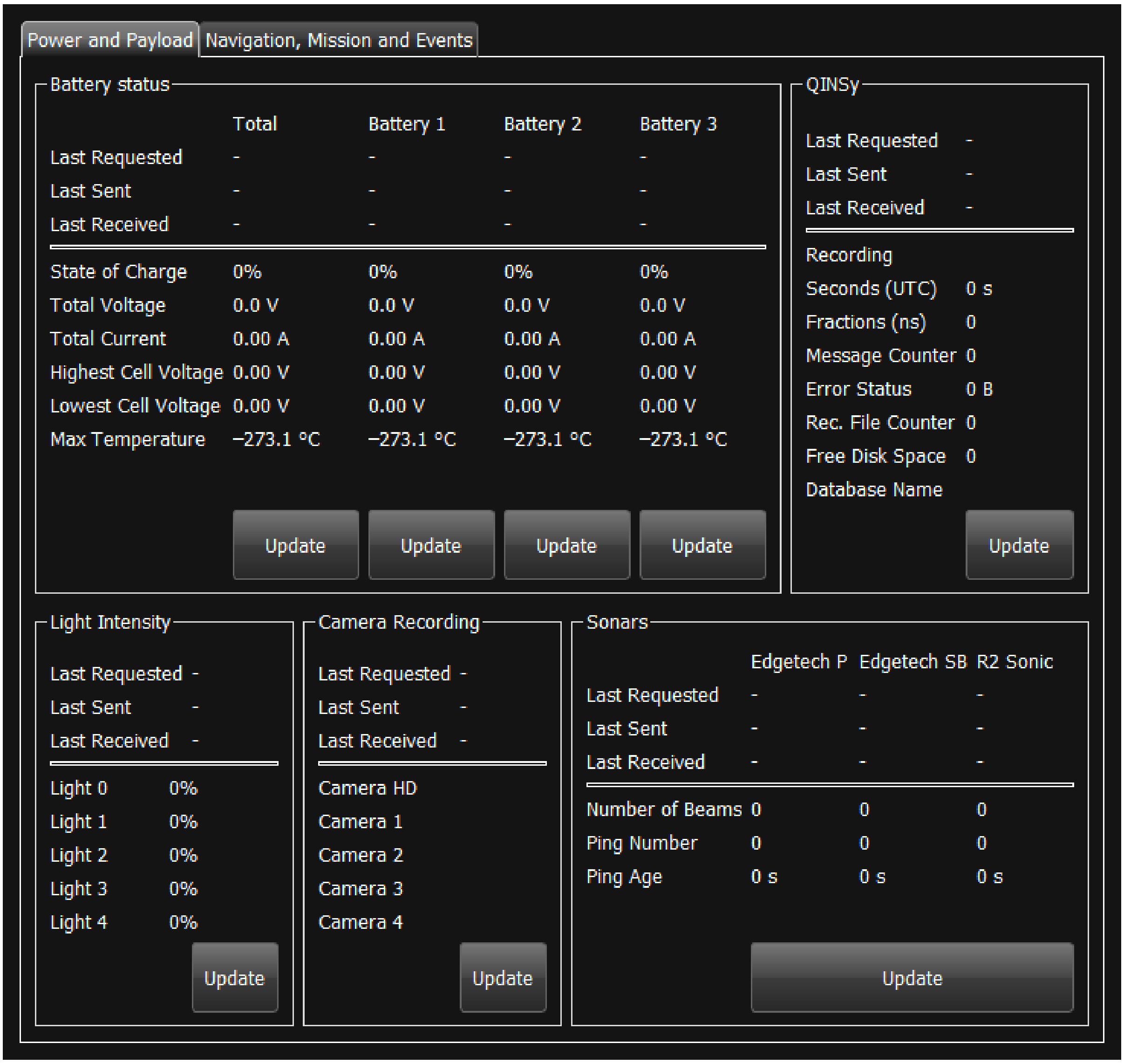


**Figure 2.111: Status**

List of tabs:

- Power and Payload
- Navigation, Mission and Events

### 2.8.10.2.1. Power and Payload


**Figure 2.112: Power and Payload**

### 2.8.10.2.2. Battery status

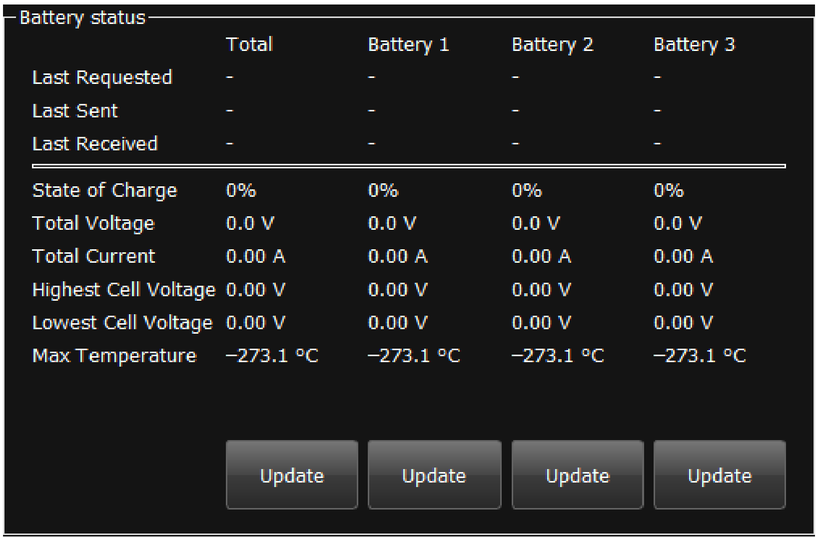


**Figure 2.113: Battery status**

| Control / Indicator | Description |
| --- | --- |
| Last Requested | Displays the time that a user last requested an update for:<br>• Total<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Last Sent | Displays the time that the last update request was sent over the acoustic link for:<br>• Total<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Last Received | Displays the time that the updated values were last received over the acoustic link for:<br>• Total<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| State of Charge | Displays a summary of the charge in %, where 0 indicates 'completely discharged' and 100 indicates 'fully charged':<br>• Total<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Total Voltage | Displays the average present voltage of:<br>• Total (of all batteries)<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Total Current | Displays the sum of electric current presently drawn from: |

| Control / Indicator | Description |
|---|---|
| | • Total (of all batteries)<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Total Highest Cell Voltage | Displays the highest voltage presently reported by any cell in:<br>• Total (of all batteries)<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Total Lowest Cell Voltage | Displays the lowest voltage presently reported by any cell in:<br>• Total (of all batteries)<br>• Battery 1<br>• Battery 2<br>• Battery 3 |
| Total Max Temperature | Displays the highest temperature presently reported by:<br>• Total (of any battery)<br>• Any part of Battery 1<br>• Any part of Battery 2<br>• Any part of Battery 3 |
| Update | Click the appropriate Update button to request an update of all status information for:<br>• Total (all batteries)<br>• Battery 1<br>• Battery 2<br>• Battery 3 |

### 2.8.10.2.3. QINSy (optional)

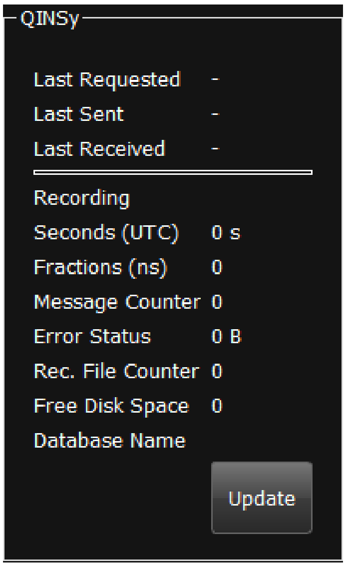


**Figure 2.114: QINSy**

| Control / Indicator | Description |
|---|---|
| QINSy Last Requested | Displays the time that a user last requested an update |

| Control / Indicator | Description |
|---|---|
| QINSy Last Sent | Displays the time that the last update request was sent over the acoustic link |
| QINSy Last Received | Displays the time that the updated values were last received over the acoustic link |
| Recording | Indicates whether recording is active |
| Seconds (UTC) | QINSy UTC time in whole seconds since 1970 |
| Fractions (ns) | The number of nanoseconds since last whole second |
| Message Counter | Unique incrementing message counter |
| Error Status | Error code expressed in hexadecimal notation<br><br>-- Bit 0: I/O status Positioning Systems -- Bit 1: I/O status Gyro Compasses -- Bit 2: I/O status Pitch, Roll and Heave Sensors -- Bit 3: I/O status Sonars (SBE, MBE, SSS) -- Bit 4: I/O status PPS/Time Sync -- Bit 5: I/O status Other |
| Recording File Counter | Number of databases written since start-up of QINSy |
| Free Disk Space | Free disk space in MB |
| Database Name | Name of database where QINSy recordings are stored |
| Update | Click the Update button to request an update of QINSy status |

### 2.8.10.2.4. Light Intensity

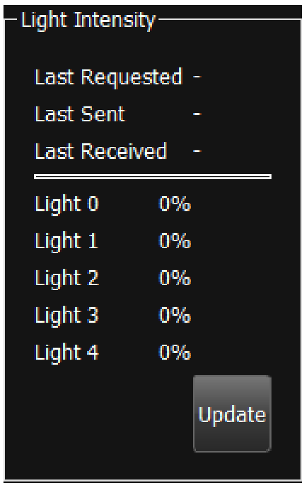


**Figure 2.115: Light Intensity**

| Control / Indicator | Description |
|---|---|
| Light Last Requested | Displays the time that a user last requested an update for the lights |
| Light Last Sent | Displays the time that the last update request was sent over the acoustic link |
| Light Last Received | Displays the time that the updated lights status was last received over the acoustic link |
| Lights 0, 1, 2, 3, 4 | Displays the Light intensity in percent for each Light.<br><br>100% is full intensity. |
| Update | Click the Update button to request an update for all the lights |

### 2.8.10.2.5. Camera Recording

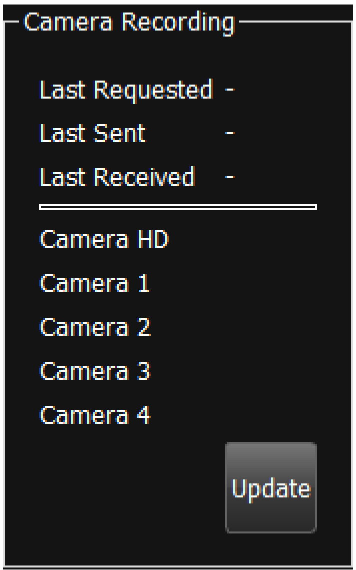


**Figure 2.116: Camera Recording**

| Control / Indicator | Description |
|---|---|
| Camera Last Requested | Displays the time that a user last requested an update for the cameras |
| Camera Last Sent | Displays the time that the last update request was sent over the acoustic link |
| Camera Last Received | Displays the time that the updated camera status was last received over the acoustic link |
| Camera HD, 1, 2, 3, 4 | Indicates whether the camera is recording. |
| Update | Click the Update button to request an update for all the cameras |

### 2.8.10.2.6. Sonars

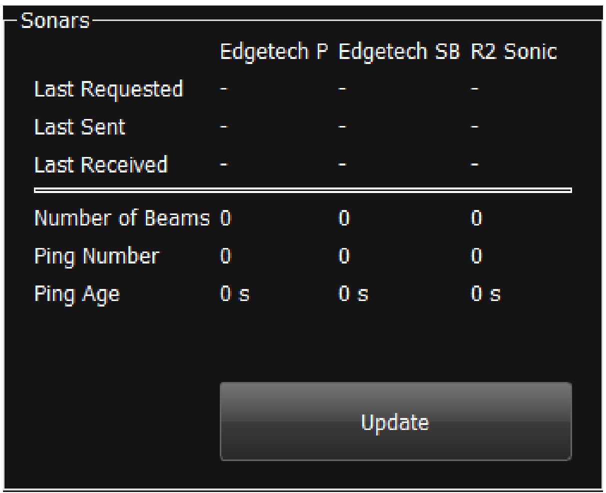


**Figure 2.117: Sonars**

| Control / Indicator | Description |
|---|---|
| Sonar Last Requested | Displays the time that a user last requested an update for the fitted sonars |

| Control / Indicator | Description |
|---|---|
| Sonar Last Sent | Displays the time that the last update request was sent over the acoustic link |
| Sonar Last Received | Displays the time that the updated status was last received over the acoustic link for the fitted sonars |
| Number of Beams | Indicates the number of beams each fitted sonar uses |
| Ping Number | Displays a counter for each of the fitted sonars. The counter displays an incremental count for each ping. |
| Ping Age | Displays the number of seconds since the last ping was sent for each fitted sonar |
| Update | Click the Update button to request an update for all the sonars |

### 2.8.10.2.7. Navigation, Mission and Events

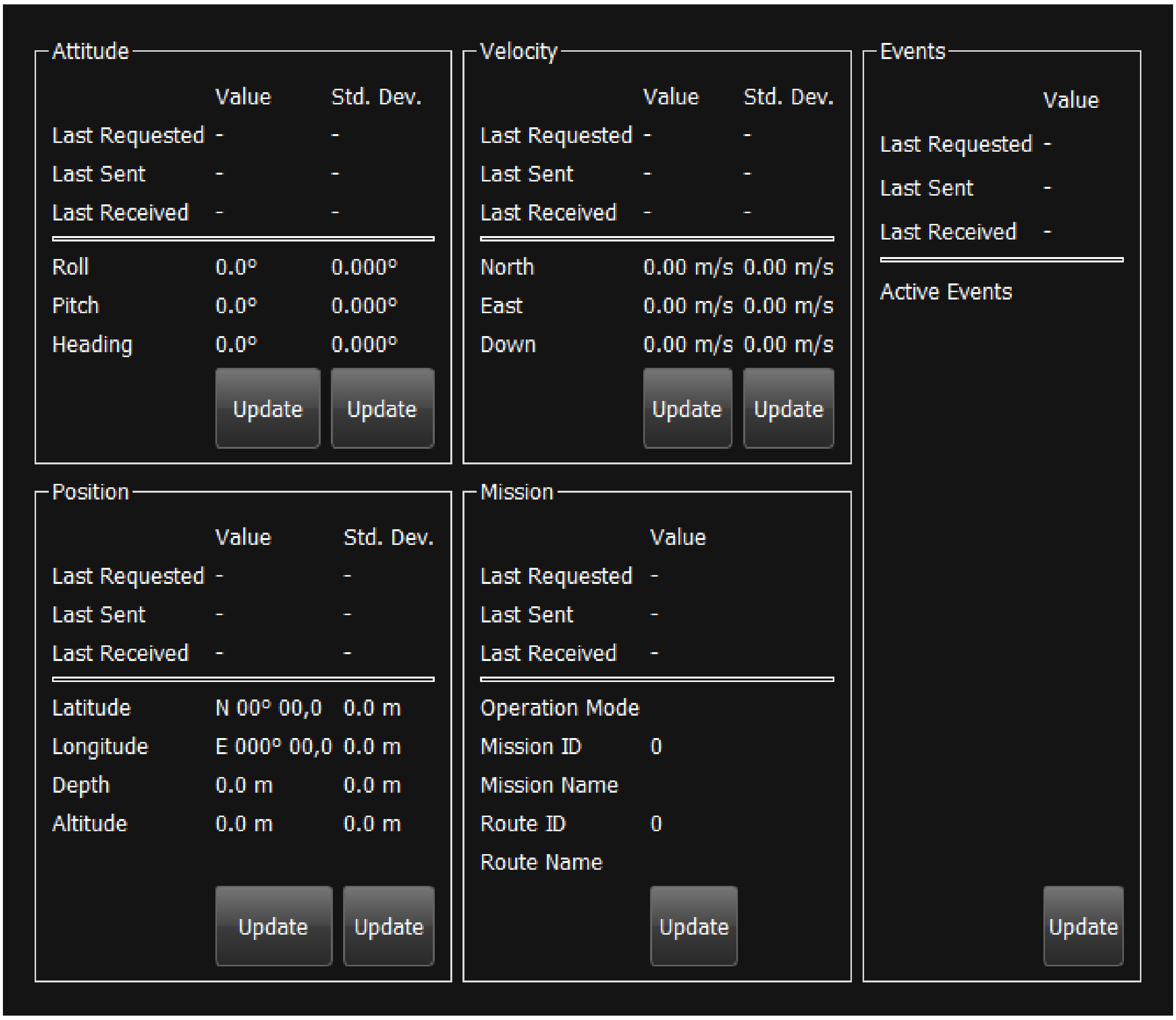


**Figure 2.118: Navigation, Mission and Events**

### 2.8.10.2.8. Attitude


**Figure 2.119: Attitude**

| Control / Indicator | Description |
|---|---|
| Attitude Last Requested | Displays the time that a user last requested an update for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Attitude Last Sent | Displays the time that the last update request was sent over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Attitude Last Received | Displays the time that the updated status was last received over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Roll | Displays the angle of roll, i.e. clockwise rotation around the vehicle's length axis. Displays the following information for the angle of roll:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Pitch | Displays the angle of pitch, i.e. nose-up rotation. Displays the following information for the angle of pitch:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Heading | Displays the Heading direction (in degrees), i.e. the direction in which the vehicle points. This is not necessarily the same as the direction in which the vehicle is moving. Displays the following information for the Heading:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Update | Click the appropriate Update button to request a status update for:<br>• Value<br>• Standard Deviation (Std. Dev.) |

### 2.8.10.2.9. Position

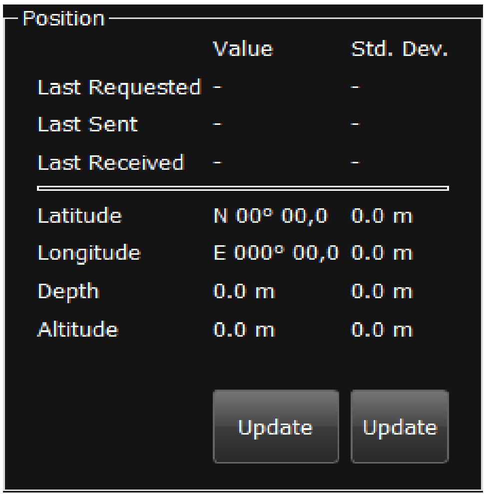


**Figure 2.120: Position**

| Control / Indicator | Description |
|---|---|
| Position Last Requested | Displays the time that a user last requested an update for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Position Last Sent | Displays the time that the last update request was sent over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Position Last Received | Displays the time that the updated status was last received over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Latitude | Displays the Latitude position (North / South). Displays the following information for the Latitude<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Longitude | Displays the Longitude position (East / West). Displays the following information for the Longitude:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Depth | Displays the distance between the vehicle and the surface. Displays the following information for the Depth:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Altitude | Displays the height of the vehicle above the seabed. Displays the following information for the Altitude:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Update | Click the appropriate Update button to request a status update for: |

| Control / Indicator | Description |
|---|---|
| | • Value<br>• Standard Deviation (Std. Dev.) |

### 2.8.10.2.10. Velocity

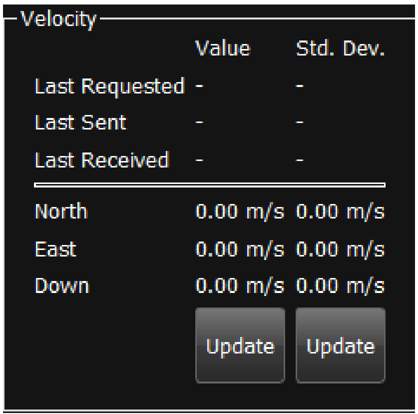


**Figure 2.121: Velocity**

| Control / Indicator | Description |
|---|---|
| Velocity Last Requested | Displays the time that a user last requested an update for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Velocity Last Sent | Displays the time that the last update request was sent over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Velocity Last Received | Displays the time that the updated status was last received over the acoustic link for:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| North | Displays the velocity in the Northward direction. Displays the following information for the Northward Velocity:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| East | Displays the velocity in the Eastward direction. Displays the following information for the Eastward Velocity:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Down | Displays the velocity in the Downward direction. Displays the following information for the Downward Velocity:<br>• Value<br>• Standard Deviation (Std. Dev.) |
| Update | Click the appropriate Update button to request a status update for:<br>• Value<br>• Standard Deviation (Std. Dev.) |

### 2.8.10.2.11. Mission

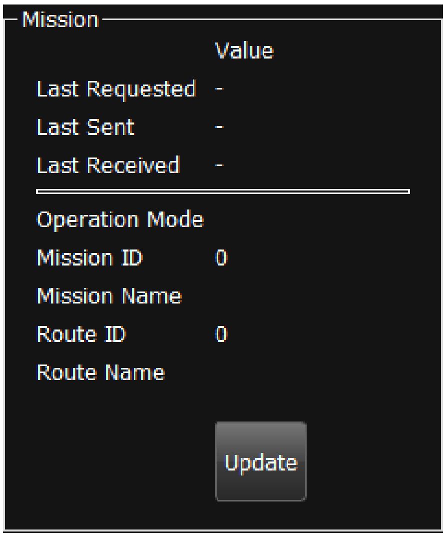


**Figure 2.122: Mission**

| Control / Indicator | Description |
|---|---|
| Mission Last Requested | Displays the time that a user last requested an update for: |
| Mission Last Sent | Displays the time that the last update request was sent over the acoustic link for: |
| Mission Last Received | Displays the time that the updated status was last received over the acoustic link for: |
| Operation Mode | Indicates the current operating mode of the vehicle |
| Mission ID | Displays the ID of the mission that is running |
| Mission Name | Displays the Name of the mission that is running |
| Route ID | Displays the Route ID that the vehicle is currently on |
| Route Name | Displays the Name of the Route that the vehicle is currently on |
| Update | Click the Update button to request a status update. |

### 2.8.10.2.12. Events

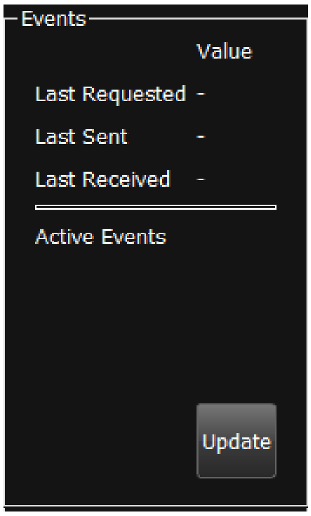


**Figure 2.123: Events**

| Control / Indicator | Description |
|---|---|
| Events Last Requested | Displays the time that a user last requested an update |
| Events Last Sent | Displays the time that the last update request was sent over the acoustic link |
| Events Last Received | Displays the time that the updated status was last received over the acoustic link |
| Active Events | Indicates the current active events |
| Events 1-14 | Displays the Event Names when active |
| Update | Click the Update button to request a status update |

A

### 2.8.10.3. Advanced

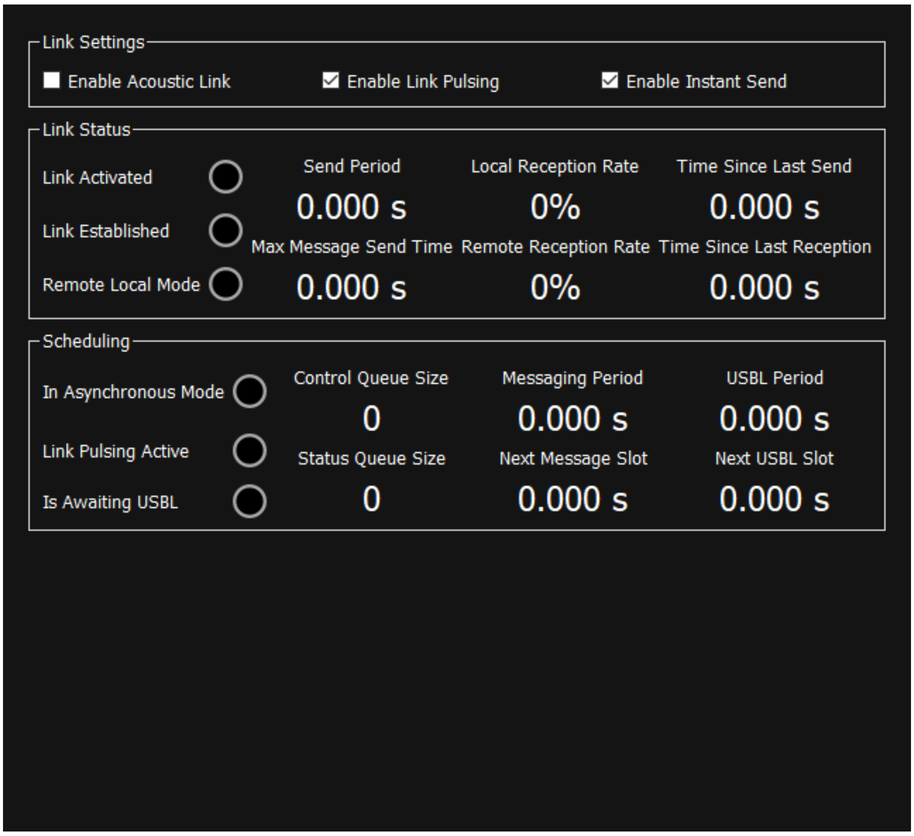


**Figure 2.124: Advanced**

#### 2.8.10.3.1. Link Settings


**Figure 2.125: Link Settings**

| Control / Indicator | Description |
|---|---|
| Enable Acoustic Link | Select to enable or disable the acoustic link |
| Enable Link Pulsing | Select to enable keep-alive signalling on the link |
| Enable Instant Send | Select to enable a Send without waiting for the next slot in communication |

A

#### 2.8.10.3.2. Link Status

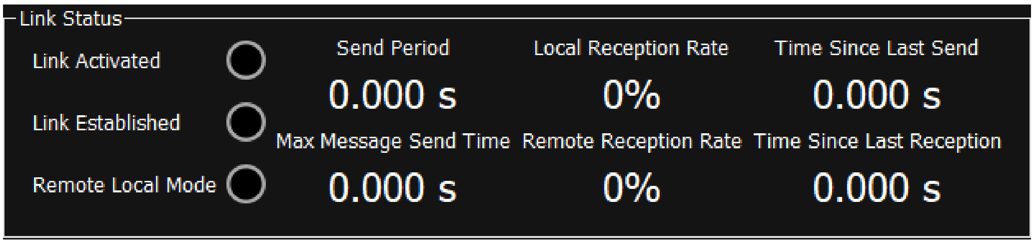


**Figure 2.126: Link Status**

| Control / Indicator | Description |
|---|---|
| Link Activated | Indicates if the acoustic link is set to active or not |
| Link Established | Indicates acoustic link has been established |
| Remote Local Mode | Indicates if the vehicle software is currently in local mode, i.e. performing a docking operation |
| Send Period | Displays the time between start of two send operations |
| Max Message Send Time | Displays the maximum time expected to send a full message on the acoustic link |
| Local Reception Rate | Displays the rate between correctly received and missing data on the surface side |
| Time Since Last Send | Displays the time in seconds since a message was last sent over the acoustic link |
| Time Since Last Reception | Displays time in seconds since a message was last received on the acoustic link |

#### 2.8.10.3.3. Scheduling

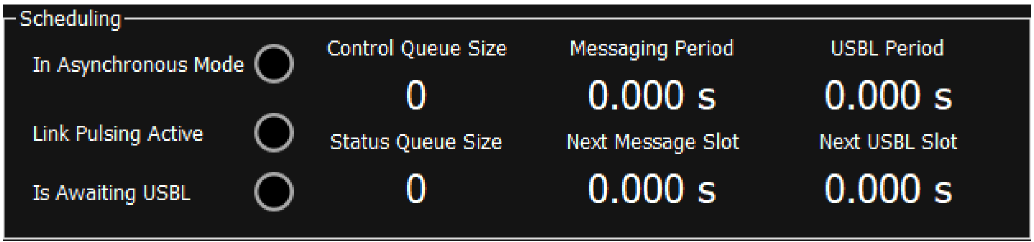


**Figure 2.127: Scheduling**

| Control / Indicator | Description |
|---|---|
| In Asynchronous Mode | Indicates whether messages are being sent directly on reply from the vehicle as opposed to at regular intervals. |
| Link Pulsing Active | Indicates whether link pulses are being sent on the link when no other communication is prioritized |
| Is Awaiting USBL | Indicates if messaging is currently suspended since a USBL pinging is expected |
| Control Queue Size | Displays the number of control requests currently queued to be sent to the vehicle |
| Status Queue Size | Displays the number of status requests currently queued to be sent to the vehicle |
| Messaging Period | Displays the period between sends on the channel |
| Next Message Slot | Displays time remaining until the next message will be sent |
| USBL Period | Displays the period that the USBL system is expected to operate at |

| Control / Indicator | Description |
|---|---|
| Next USBL Slot | Displays the time remaining until the next USBL message is expected from the USBL system |

## 2.8.11. Menus

### 2.8.11.1. Exit

Exit the user interface. Note that the vehicle and any other user interface will still be running.

### 2.8.11.2. Settings

#### 2.8.11.2.1. Depth Calibration

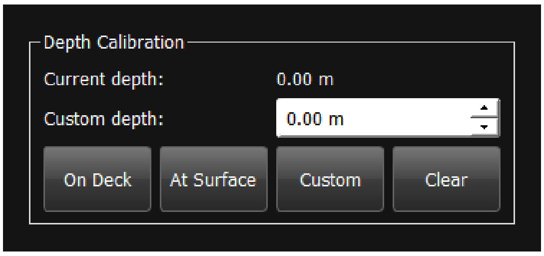


**Figure 2.128: Depth Calibration**

| Control / Indicator | Description |
|---|---|
| Current depth | Displays the measured depth of the vehicle |
| Custom depth | Select the Input value for custom depth calibration |
| On Deck | Use this option when the system depth calibration is performed with the vehicle on deck.<br><br>On Deck calibrates the system depth by setting to 0 m and compensating for distance from pressure sensor to "top" of vehicle, which should give depth equal to 0 m when vehicle is put in water (if vehicle buoyancy is correct). |
| At Surface | Use this option when system depth calibration is performed with vehicle in water at surface.<br><br>Same as using custom depth calibration with 0 m. |
| Custom | Sets system depth to custom input value. |
| Clear | Clear current system depth calibration. |

#### 2.8.11.2.2. Trigger Configuration

Configure the trigger board.

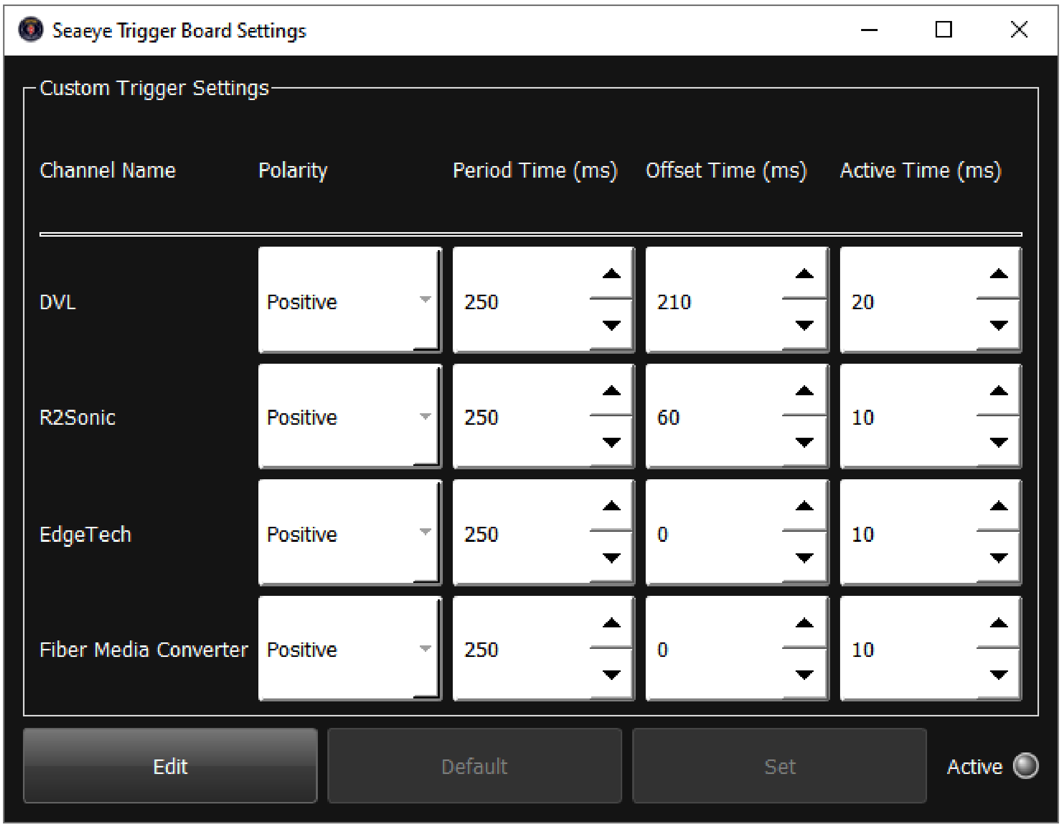


**Figure 2.129: Trigger Board Settings**

| Control / Indicator | Description |
|---|---|
| Edit | Edit to change values |
| Default | Set to a default value |
| Set | Set saves the new values |
| Active | Light indicator is green when the trigger board is active |
| Polarity | Polarity can be positive or negative |
| Period Time Ms | This is how long each cycle takes. This needs to be the same or in multiples between channels otherwise conflicts can occur. |
| Offset Time Ms | From each cycle, this is a time each channel wait until it sends out a trigger pulse |
| Active Time Ms | Time saying how long each trigger pulse should be. |

A

#### 2.8.11.2.3. Salinity Calibration

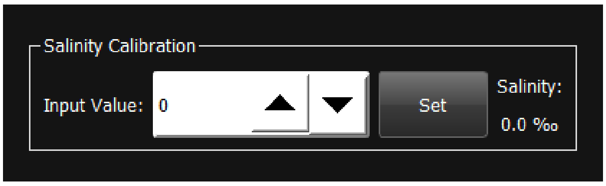


**Figure 2.130: Salinity Calibration**

| Control / Indicator | Description |
|---|---|
| Input Value | Use the arrows to set the salinity value. If there is no set Input Value, the system will use the data from the SVS unit. |
| Set | Press Set to save the value in the edit box as the new salinity in the system for the DVL |
| Salinity | Displays the set value for salinity (%). |

#### 2.8.11.2.4. Minimum Altitude


**Figure 2.131: Minimum Altitude**

Minimum Altitude will be set in respect to DVL performance. Refer to the appropriate manufacturer's manual for guidance.

| Control / Indicator | Description |
|---|---|
| Min. Altitude Limit arrows | Use the arrows to select the minimum altitude |
| Set | Press Set to save the new altitude limit |
| Min Altitude Limit | Displays the set minimum altitude |

### 2.8.11.2.5. LBL Configuration

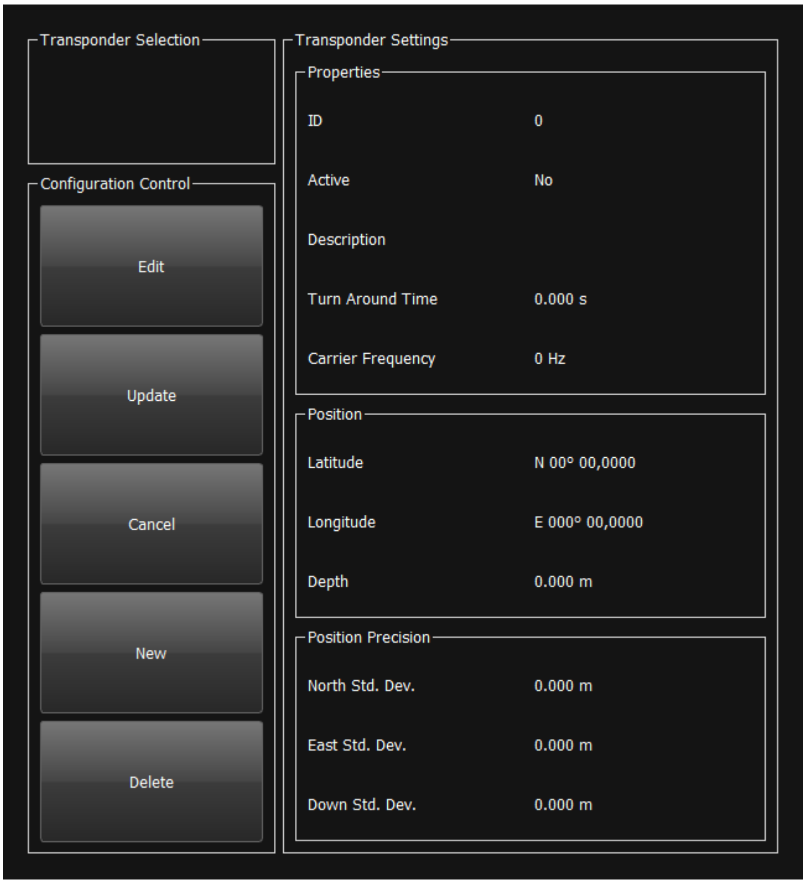


**Figure 2.132: LBL Configuration**

| Control / Indicator | Description |
|---|---|
| Transponder Selection | Selects the LBL beacon to view or edit |
| ID | Displays the address of the beacon used as its ID |
| Active | Shows if the beacon should be in range. Select Yes if you want to range the transponder during this operation and No otherwise |
| Description | A description that can be added to distinguish this beacon from others |
| Turn Around Time | Displays the turn around time (TAT) of the beacon |
| Carrier Frequency | Displays the carrier frequency of the beacon |
| Depth | The measured depth of the beacon |
| Latitude | The measured latitude of the beacon |
| Longitude | The measured longitude of the beacon |
| Down Std. Dev. | The standard deviation of the beacon position measurement in the down direction |
| North Std. Dev. | The standard deviation of the beacon position measurement in the north direction |
| East Std. Dev. | The standard deviation of the beacon position measurement in the east direction |
| Edit | Press to edit the information for the beacon |
| Update | Press to update the information about the beacon to the currently set values |
| Cancel | Press to cancel the modification process and go back to the previously set val- |

| Control / Indicator | Description |
|---|---|
| | ues |
| New | Press to add a new beacon |
| Delete | Press to delete the selected beacon |

### 2.8.11.3. Layout

#### 2.8.11.3.1. Reset

Reset the user interface layout to the factory default.

#### 2.8.11.3.2. Load Settings

Load a layout from file.

#### 2.8.11.3.3. Save Settings

Save the layout (placement of tabs and subwindows) to file.

### 2.8.11.4. Help

#### 2.8.11.4.1. Version

Displays the software version.


**Figure 2.133: Version...**

#### 2.8.11.4.2. Open Source Licenses

Displays the licenses of the open source software that the vehicle software is using.

A

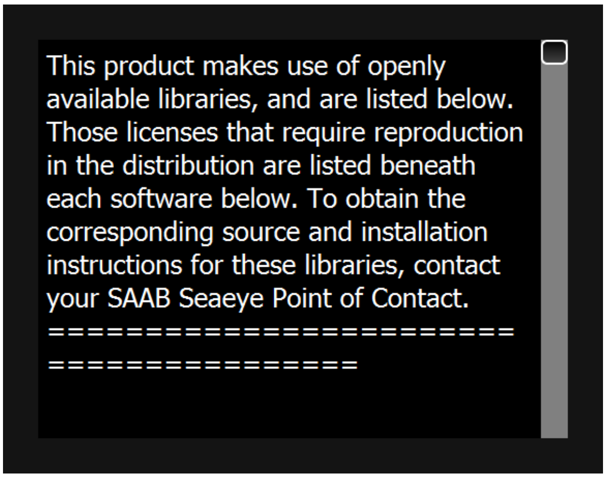


**Figure 2.134: Open Source Licenses**

#### 2.8.11.4.3. Open source licenses

Displays the licenses of the open source software that the vehicle software make use of.

### 2.8.11.5. Service

#### 2.8.11.5.1. Port Control

This windows lists the customer configurable ports on the system.

The default port is the main port used by the software. Port settings can be either read only or changeable.

For editable settings, press the edit button and commit the changes with the apply button. Incorrect settings on the default port could affect vehicle performance / functionality. Some settings are persistent between restarts and saved to the settings folde. Remove the file to revert back to the default settings.

Mirror ports are auxiliary ports that can be attached to system configured ports. Mirror ports will mirror the input received on the default port to the mirror ports remote addresses. Some default ports allows external input. If a port allows external input, an attached mirror port can be configured with a local address where data can be sent, which will then be retransmitted by the default port to its remote address.

A

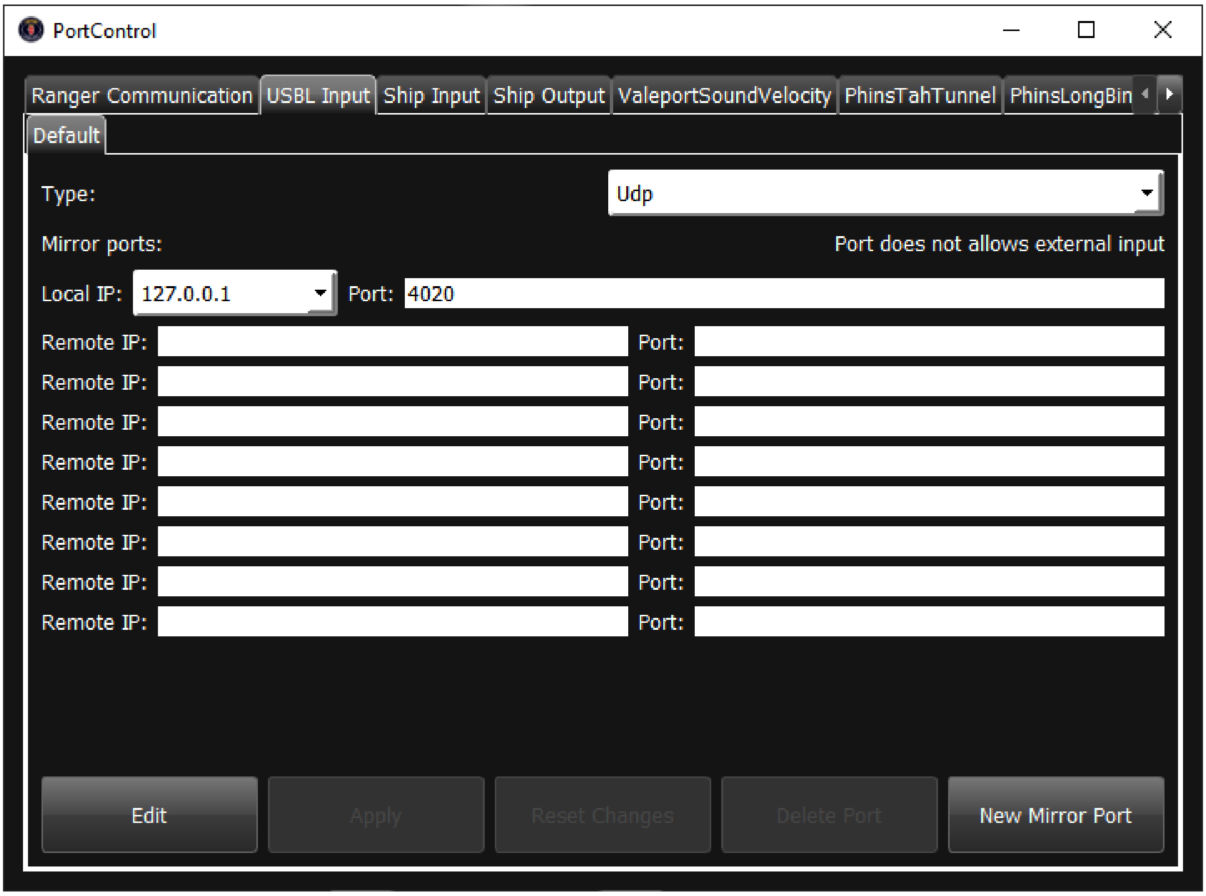


Figure 2.135: Port Control

### 2.8.11.5.2. Power

### 2.8.11.6. Battery Interfaces

To view the status of a specific Battery Management System (BMS1 to BMS3), open a web page for the relevant battery.

### 2.8.11.6.1. Communication Quality

### 2.8.11.7. Radio

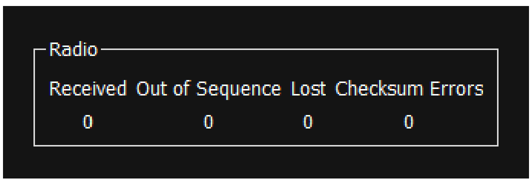


Figure 2.136: Radio

| Control / Indicator | Description |
|---|---|
| Received | Number of packages received since system start |
| Out of Sequence | Number of packages that has been received out of order |

| Control / Indicator | Description |
|---|---|
| Lost | Number of lost packages |
| Checksum Errors | Number of packages that has been discarded due to incorrect checksum |

## 2.8.11.7.1. Joystick Control

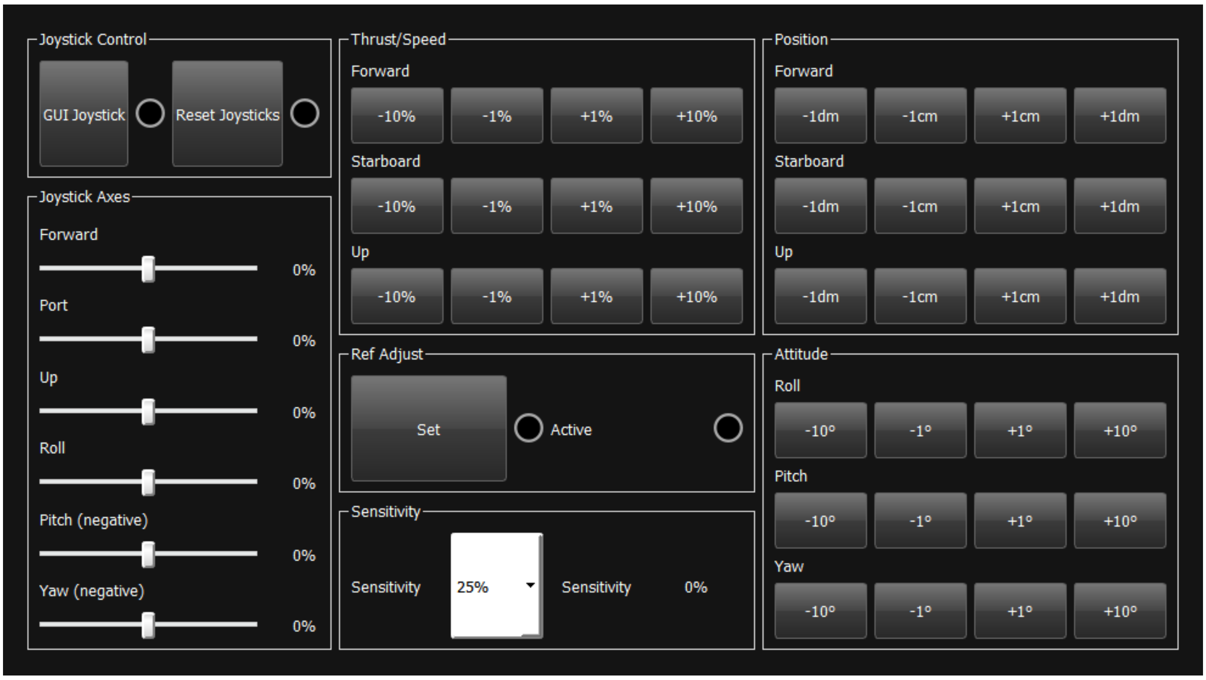


**Figure 2.137: Joystick Control**

| Control / Indicator | Description |
|---|---|
| GUI Joystick | Select to use the virtual joysticks in the GUI instead of the real ones |
| Reset Joysticks | Return all virtual joysticks to their center positions |
| Set | Set an offset to the joystick input. Pressing the button will set the offset to the current input of the joystick. The status indicator indicates if there is a offset applied. NOTE: Offset can be set to zero by pressing the button without any joystick input. |
| Active | Indicates if the joystick offset is active. The offset can be set/reset from the OCB. |
| Sensitivity Dropdown menu | Changes the OCB sensitivity, i.e the scale between joystick and vehicle thrust. |
| Sensitivity | Displays the current Joystick Sensitivity of the OCB. |
| Forward | Forward direction virtual joystick input |
| Port | Port virtual joystick input |
| Up | Upward virtual joystick input |
| Roll | Roll virtual joystick input. Note: Inverted virtual joystick. |
| Pitch (negative) | Pitch virtual joystick input |
| Yaw (negative) | Yaw virtual joystick input. Note: Inverted virtual joystick. |

### 2.8.11.8. Logger

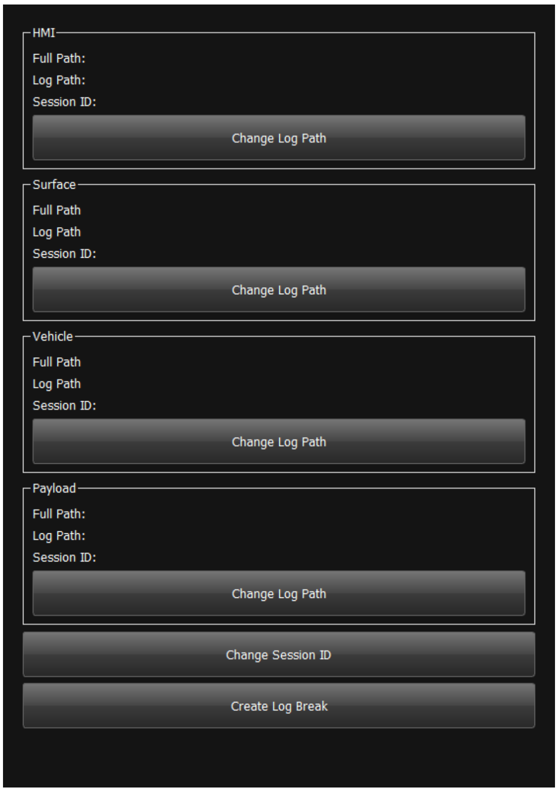


**Figure 2.138: Logger**

| Control / Indicator | Description |
|---|---|
| **For Surface** | |
| Full Path | The full log path for the HMI S/W |
| Log Path | The current log path part for the node. |
| Session ID | The current session ID for the node. |
| Change Log Path | Change the log path part on the logging directory on the HMI node. |
| **For Vehicle** | |
| Full Path | The full log path for the surface S/W |
| Log Path | The current log path part for the node. |
| Session ID | The current session ID for the node. |
| Change Log Path | Change the log path part on the logging directory on the surface node. |
| **For Payload** | |
| Full Path | The full log path for the payload S/W |
| Log Path | The current log path part for the node. |
| Session ID | The current session ID for the node. |
| Change Log Path | Change the log path part on the logging directory on the payload node. |
| **Other Buttons** | |
| Change Session ID | Change the session id for the log directory on all nodes. |
| Create Log Break | Change log folder to a new directory with the current date and time on all nodes. |

#### 2.8.12. HMI Player Software

In the system on the SAC, a Playback HMI can be started, this can be used to playback logged data and video. To start the Playback HMI, double click on the desktop icon "Playback" on the SAC.

Open the Player tab, select the directory where the log files are stored and do the same for video files if they exist.

Set the start time from which the data should be played back from, start the playback and watch the data in the HMI.

The Playback HMI can be started on a separate PC, install the needed programs from the SAC under D:\Configuration\Playback HMI.

### 2.9. Sonars

The following modes can be used with the sonars.

#### 2.9.1. Untethered Mode

In autonomous mode the start of sonar is set in a predefined mission by setting actions in routes, see chapter 3, AUTONOMOUS MISSIONS.

#### 2.9.2. Tethered Mode

For IP addresses and passwords refer to chapter 8. Sonars have real time updates and control through the tether. SAAB or 3rd party software is to be used where applicable.

### 2.10. Communication Vehicle

There are 4 different ways to send messages to the VEHICLE:

- Tether - The Tether (fibre) is always connected directly to SCU
- Wi-Fi - Wi-Fi can be connected to SCU or SCB.
- Radio - Radio must be connected to the SCB
- Acoustic

A Before starting an operation, select either the Tether or SCB. Then, connect the required Ethernet link from either the tether or the SCB into the SCU.

#### 2.10.1. Wi-Fi / Optional Radio

Wi-Fi is a high bandwidth link with short range, communicating the same data as the tether link. It is however a good idea to turn off the HD camera, as the HD feature requires a large portion of the available bandwidth.

When the vehicle is out of Wi-Fi range, the optional radio link will be used instead. The radio link is more limited in bandwidth, therefore only the most important data for vehicle control and status is sent. The radio link can start an autonomous mission already stored in the vehicle.

## 2.11. Vehicle

The following section contains all of the vehicle connections.

### 2.11.1. Vehicle Connectors

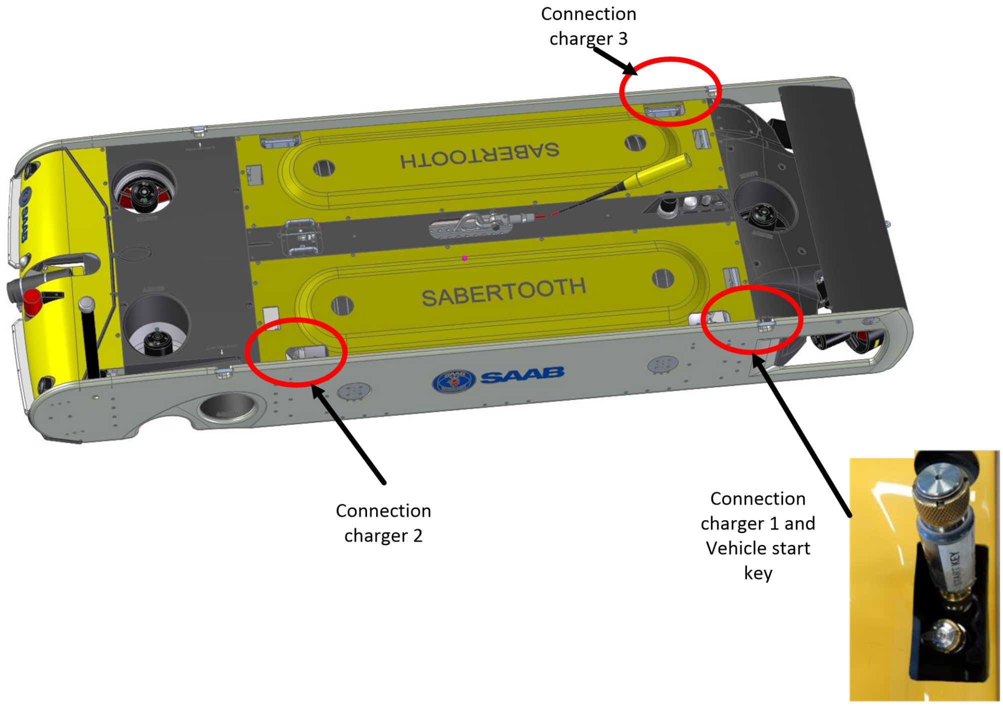


**Figure 2.139: Battery charger and start key connectors**

**Table 2.5: Vehicle charger and start connectors**

| Connection | Function |
|---|---|
| Battery Charger Connectors | When charging the vehicle, the power cables from the battery charger is connected in the locations described above. When not connected to the battery charger the connector must be protected by a cap. |
| Vehicle start connector | This connector is used for turning the vehicle ON and OFF when battery power is used. The vehicle is powered by inserting the Vehicle start key. The connector shall be protected by a cap when the start key not is inserted. When power is from surface, the key does not need to be inserted. |

| | |
|---|---|
| | The start key can be inserted when charging. |

#### 2.11.1.1. Connection of Battery Cables to the Vehicle

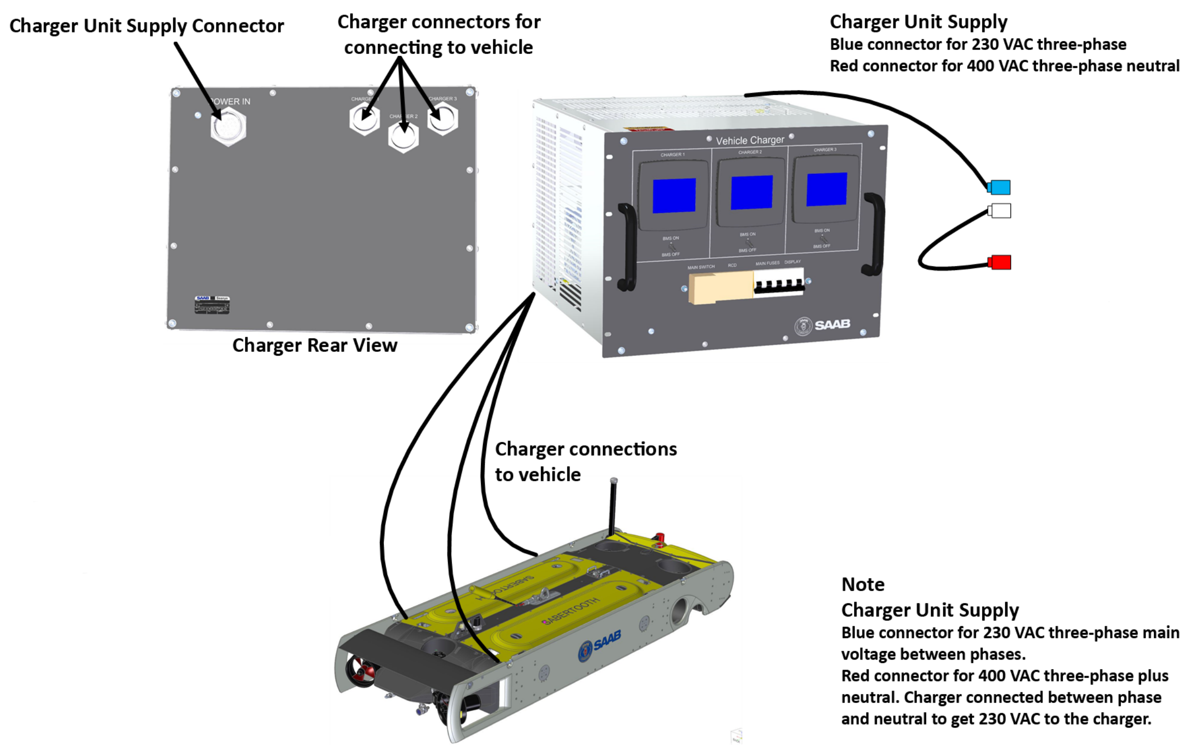


Figure 2.140: Charger connection

#### 2.11.1.2. Starboard Front Connectors

Figure 2.141: Starboard front connections

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Table 2.6: Starboard front connector labels

| Label | Connection | Supply Voltage | Com | Function |
|---|---|---|---|---|
| A1 | FO | N/A | Fibre Optic | Optical fibre between surface and vehicle. |
| A2 | R2SONIC H2 | 48VDC | Ethernet | Wideband echo sounder |

| | | | | |
|---|---|---|---|---|
| A3 | SPRINT NAV | 24VDC | Ethernet | Sprint Navigation |
| B1 | R2SONIC H1 | 48VDC | Ethernet | Multibeam sonar |
| B2 | SER2 | 24VDC | RS232 / RS422 / RS485 | RJE Emergency |
| B3 | SER1 | 24VDC | RS232 / RS422 / RS485 | Argus grip |
| B4 | AVT6 | 24VDC / 48VDC | RS232 | Acoustic and USBL |
| B5 | CAM1+SER3 | 24 VDC | Video / RS485 | Bowtech camera |
| B6 | CAM2+SER4 | 24 VDC | Video / RS485 | Spare camera & control |
| B7 | CAM3 | 24VDC | RS232 | Super Wide Camera |
| B8 | DEPTH1 | 24 VDC | RS485 | Keller Depth Sensor |
| B9 | SSS ET2205 | 48 VDC | Ethernet | Edgetech 2205 sonar |
| C1 | ETH1 | 24VDC | Ethernet | Spare Ethernet |
| C2 | GPS Antenna | | Ethernet | GPS Antenna |
| C3 | WIFI Antenna | | WIFI | WIFI Antenna |
| C4 | Radio | | Radio | Spare |
| C5 | OBST | 24 VDC | Ethernet | Obstacle avoidance sonar |
| C6 | 2GR ULS-500 PRO | 48 VDC | Ethernet | Laser Scanner |
| C7 | Tilt | 24 VDC | Castle 2 | Tilt Unit |
| C8 | mini-SVS | 12 VDC | RS232 | mini SVS |
| C9 | ETH2 | 24 VDC | Ethernet | Spare Ethernet |
| D1 | DATA | 24 VDC | Ethernet | Data Link |
| D2 | LINK | 12 VDC | Ethernet | Link to port pod |
| D3 | LED | 24 VDC | RS485 | LED lamps |

### 2.11.1.3. Starboard Aft Connectors

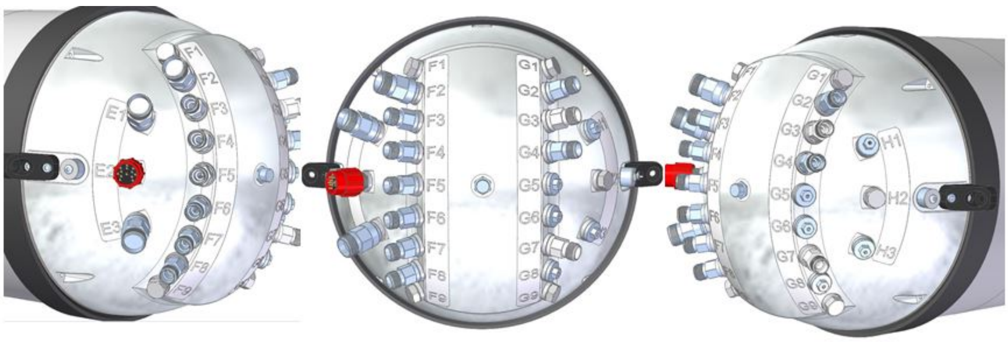


**Figure 2.142: Starboard aft connections**

**Table 2.7: Starboard aft connector labels**

| Label | Connection | Supply Voltage | Com | Function |
|---|---|---|---|---|
| E1 | PPSU | HV | PPSU | PSU power in |

| | | | | |
|---|---|---|---|---|
| E2 | SER | N/A | RS232 | BMS3 & CP |
| E3 | CHG3 | DC± | | Battery charger 3 |
| F1 | Blank | | | Not used |
| F2 | Y | HV | Castle 2 | Y thruster |
| F3 | PYZ | HV | Castle 2 | Port Front YZ thruster |
| F4 | SBYZ | HV | Castle 2 | Starboard Front YZ thruster |
| F5 | POW | DC± | | Battery power from port EPOD, BMS3 ON and enable discharge |
| F6 | Z | HV | Castle 2 | Z motor |
| F7 | SBXY | HV | Castle 2 | Starboard Aft XY thruster |
| F8 | PXY | HV | Castle 2 | Port Aft XY thruster |
| F9 | Blank | | | Not used |
| G1 | Blank | | | Not used |
| G2 | TOOL | HV | Castle 2 | Spare HV Tooling |
| G3 | SPSU | | | PSU Signal |
| G4 | SPM | HV | Castle 2 | Thruster |
| G5 | Blank | | | Not used |
| G6 | Blank | | | Not used |
| G7 | SPT | 24VDC | Castle 2 | Spare tilt |
| G8 | Blank | | | Not used |
| G9 | Blank | | | Not used |
| H1 | Blank | | | Not used |
| H2 | Blank | | | Not used |
| H3 | Blank | | | Not used |

### 2.11.1.4. Port Front Connectors

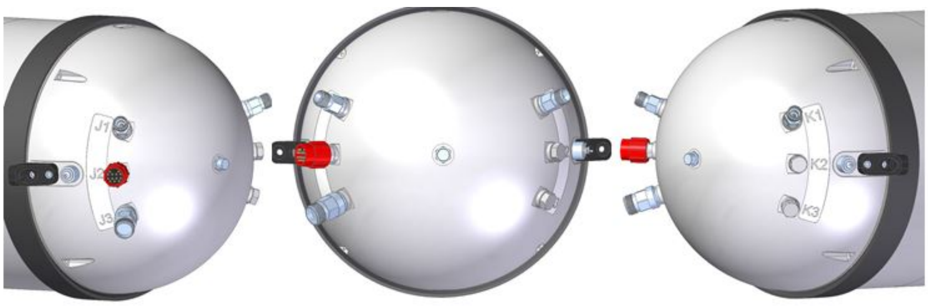


**Figure 2.143: Port front connections**

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**Table 2.8: Port front connector labels.**

| Label | Connection | Supply Voltage | Com | Function |
|---|---|---|---|---|
| J1 | CP | | | Cathodic protection device |
| J2 | LINK | 12VDC | Ethernet | Link to starboard pod |
| J3 | CHG2 | DC± | | Charging connection |
| K1 | CONF | N/A | RS232 | Configuration of BMS1-3 |

| | | | | |
|---|---|---|---|---|
| K2 | Blank | | | Not used |
| K3 | Blank | | | Not used |

### 2.11.1.5. Port Aft Connectors

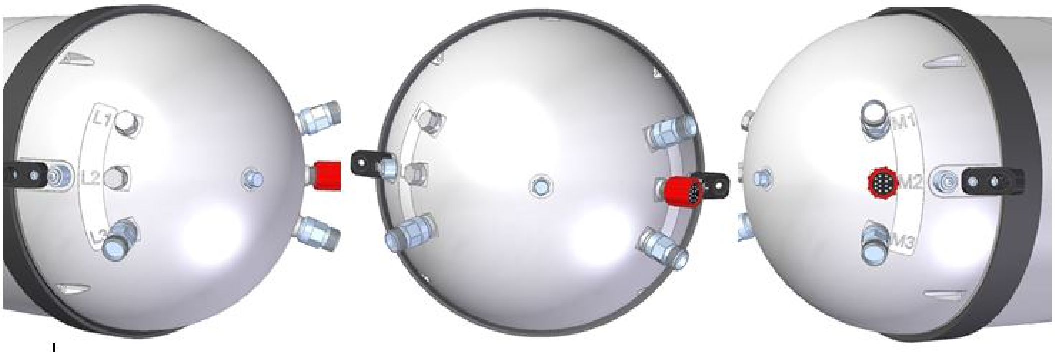


**Figure 2.144: Port aft connections**

**Table 2.9: Port aft connector labels**

| Label | Connection | Supply Voltage | Com | Function |
|---|---|---|---|---|
| L1 | Blank | | | Not used |
| L2 | Blank | | | Not used |
| L3 | CHG1 | DC± | N/A | Charging connection |
| M1 | ON | N/A | | Start Key |
| M2 | SER | N/A | RS232 | BMS3 & CP |
| M3 | POW | DC± | | Battery power to starboard EPOD, BMS3 ON and enable discharge |

### 2.11.1.6. Pin Layout Seaeye M2BH 2-9 pin UW connectors

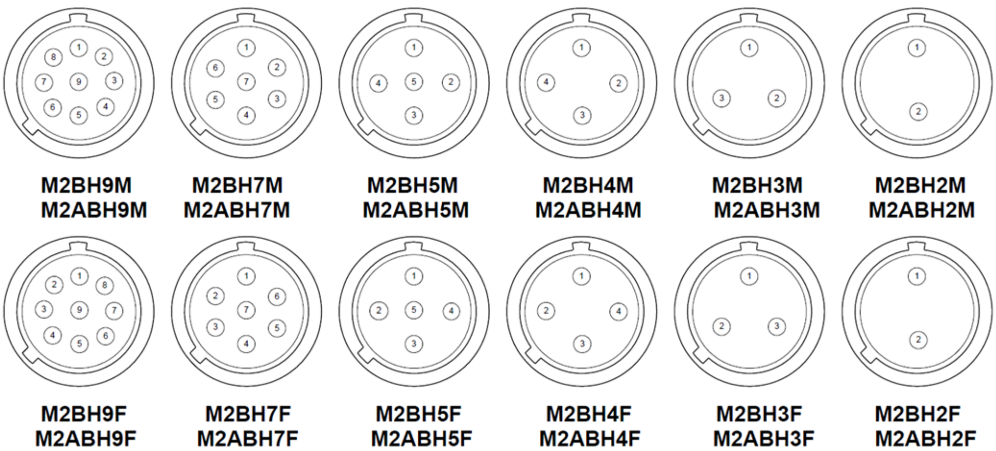


**Figure 2.145: Pin layout Seaeye M2BH 2-9 pin UW connectors**

### 2.11.1.7. Pin layout Seaeye M2BH 13 pin connectors

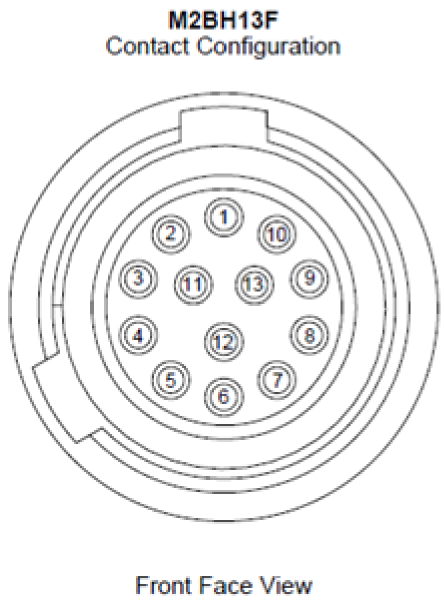


**Figure 2.146: Pin layout Seaeye M2BH 13 pin connectors**

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### 2.11.1.8. Pin layout Seaeye M3BH 12 pin connectors

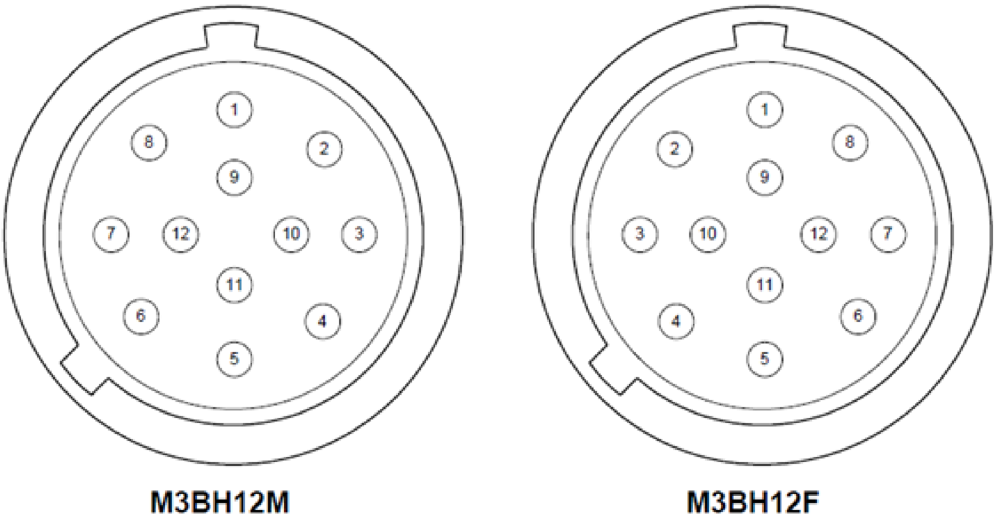


**Figure 2.147: Pin layout Seaeye M3BH 12 pin connectors**

### 2.11.1.9. Pin layout Seaeye M3BH22-ETH pin connectors

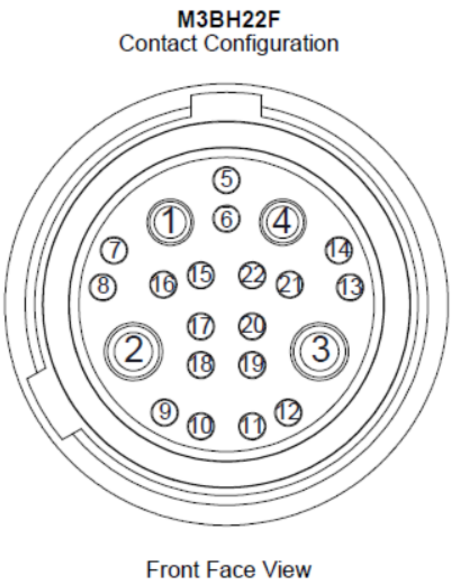


**Figure 2.148: Pin layout Seaeye M3BH22-ETH pin connectors**

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### 2.11.1.10. Pin layout Subconn connectors

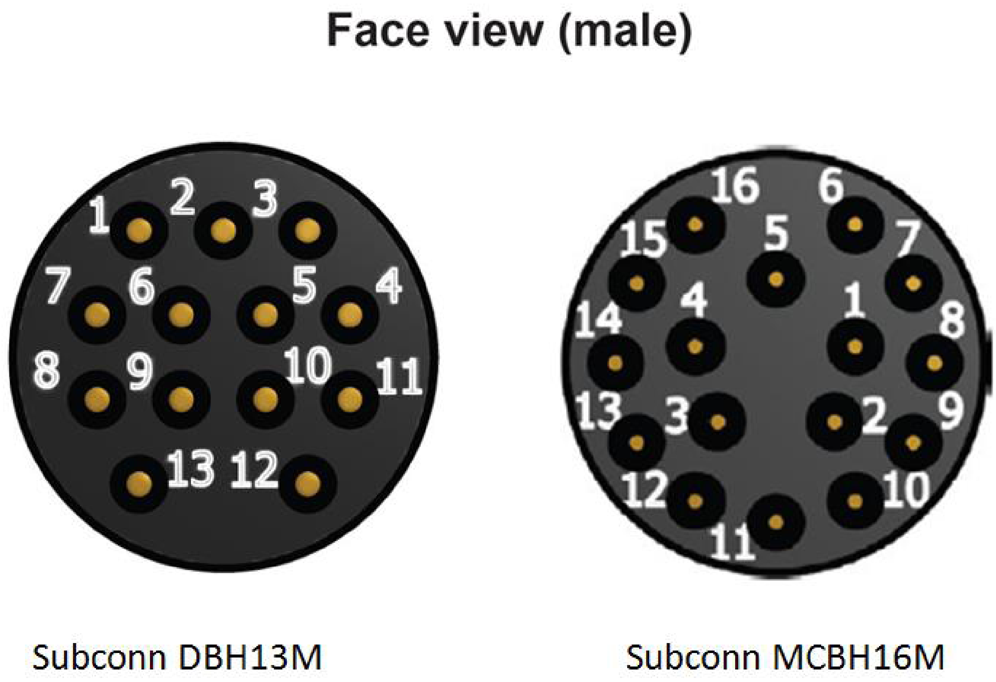


**Figure 2.149: Pin layout Subconn connectors**

# CHAPTER 3

# AUTONOMOUS MISSIONS

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# 3. Autonomous Missions

The vehicle is capable of autonomous missions. This chapter describes how missions are created and edited.

## 3.1. Mission Overview

Autonomous missions are planned in the Mission Planner software. A mission consists of a number of routes that are executed in order. A route describes a task, such as following a waypoint list, inspect a structure or dock in a garage.

A waypoint is a position that the vehicle should go to. Global waypoints describe an absolute position, expressed in longitude and latitude. Local waypoints describe a position relative to the vehicle's position received when entering the local route and are expressed in meters forward and port of the vehicle. All positions and distances are calculated from the centre of the vehicle.

During execution of a route, the vehicle can perform actions such as lighting a lamp or recording video or survey data. If the route has several waypoints, different actions can be defined on each waypoint.

When something unexpected happens during execution, like the battery level going below a certain level or the position quality deteriorating, an event is triggered. For each of these events, the operator can decide what to do to in the Mission Planner.

## 3.2. Common Route Parameters

Certain parameters are common for many or all route types.

### 3.2.1. Depth, Altitude, Minimum Altitude and Maximum Depth

Note that altitude is measured by the downwards facing sonar which has a limited range. Do not set altitudes bigger than 90 m.

If the Depth parameter is set, there will be a corresponding Minimum Altitude parameter. If the vehicle reaches that altitude during a dive, likely because the sea depth at the vehicle's position is less than the requested depth, it will stop. Similarly, when the Altitude is set, there will be a Maximum Depth that the vehicle will not go under.

In Figure 3.1 Altitude with Maximum Depth and Depth with Minimum Altitude. Altitude has been set for the left vehicle, but the vehicle stops at Max Depth. For the right vehicle, Depth has been set, but the vehicle stops at Min Altitude.

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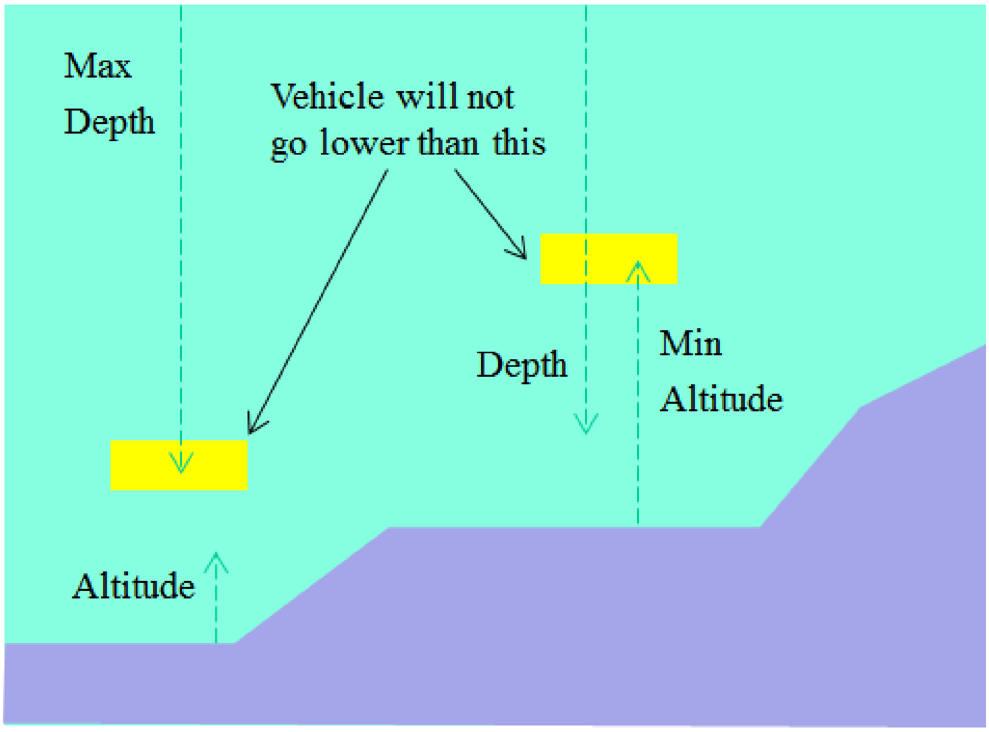


**Figure 3.1: Altitude with maximum depth and depth with minimum altitude**

### 3.2.2. Obstacle Avoidance

Obstacles are given an avoidance area which the vehicle will not enter. If the avoidance area is near or close to a way point, the vehicle will try to reach the way point "hit zone" without moving into the avoidance area.

If the way point "hit zone" is entirely inside the obstacle avoidance area, the vehicle will circle the area until a time out is given.

All routes have Obstacle Avoidance activated by default, that will make the vehicle go around obstacles. However, the obstacle detector might be fooled by things like fish shoals, so if there are no solid obstacles in the route, obstacle avoidance can be deactivated.

## 3.3. Route Types

The following route types are supported. A route can be converted to another type with the same number of points and point type (Global or Local).

A

| Route Type. | Description. | Points. | Point Type. |
|---|---|---|---|
| Dive | Dive as quickly as possible to a given depth / altitude. | None | N/A |
| Surface | Go to the surface as quickly as possible. | None | N/A |
| Dock | Go to a given global starting point, find the garage using transponders and automatically park in the gar- | One | Global |

| | | | |
|---|---|---|---|
| | age. | | |
| Undock | Start in the garage, go straight out a given number of meters and to a given depth / altitude. | None | N/A |
| Sleep | Shut down the thrusters and sleep for a given time. | None | N/A |
| Global Waypoints | Follow a number of waypoints with global coordinates expressed in latitude and longitude. | Unlimited | Global |
| Local Waypoints | Follow a number of waypoints with local coordinates expressed in meters from the first point when entering the route. | Unlimited | Local |
| Grid | Inspect a rectangular area given by a global starting position, the number and length of legs and the space between each leg. | One | Global |
| Go to Structure | Go to a given global starting point, run forward towards a structure and find the given heading against the found structure and the given range to the structure. | One | Global |
| Local Inspection | Go to a given local starting point, go forward to a given distance from the structure to be inspected and then follow the possibly irregular structure a given number of laps. | One | Local |
| Global inspection | Like a local inspection, but with a global starting point. | One | Global |
| Loiter | Run in a circle with given radius and number of laps from the previous position, previous position will be the startpoint not the center. | None | N/A |

### 3.3.1. Dive and Surface Routes

Dive and Surface routes to get as quickly as possible to a given Depth / Altitude or to the surface. The routes have the following parameters:

- Depth / Altitude and Min Altitude / Max Depth (Dive only).
- Dive / surface Speed in knots.
- Hover Time, how long the vehicle will hold after the dive / surfacing.
- Heading in the route.
- Heading at the end of the route.

A When executing a Dive, if we don't have sea bed contact with DVL the vehicle will pitch downwards to be able to use the rear thrusters for maximum dive speed and efficiency. To avoid sprays from the back thrusters, the vehicle will first descend a few meters in a horizontal position, with the given heading. When the vehicle is nearing the sea bed as measured by the obstacle sonar, it will level out to zero pitch, still holding the given heading, and use the altimeter to fine tune the depth.

A Dive route can be used for any depth. If the target depth is only a few meters, the dive route can be omitted since the vehicle will descend horizontally anyway.

.

### 3.3.2. Dock and Undock Routes

NOTE: This is only valid with Avtrak6 and Compatt6.

The Dock route is used to find and dock in an underwater garage, and the Undock route leaves the garage. The position given for the garage doesn't have to exactly match the garage, but it needs to be within the range the AvTrack transponder, about 120 m.

The Dock route has the following parameters:

- Estimated garage position in Longitude and Latitude.
- The Depth / Altitude and Min Altitude / Max Depth the vehicle will maintain while searching.
- Search Speed in knots.
- Dock Altitude, the altitude of the garage's centre.
- Number of Retries the vehicle will do before giving up.
- Left and Right Transponder Id on the garage.

When docking, the vehicle will head towards the given position. When it "sees" the garage transponders, it will head towards the garage and dock.

NOTE: This is a simplified description and the vehicle may do a number of further manoeuvres to pin-point the location of the transponders. See section 3.10, Saber Dock Details for more information.

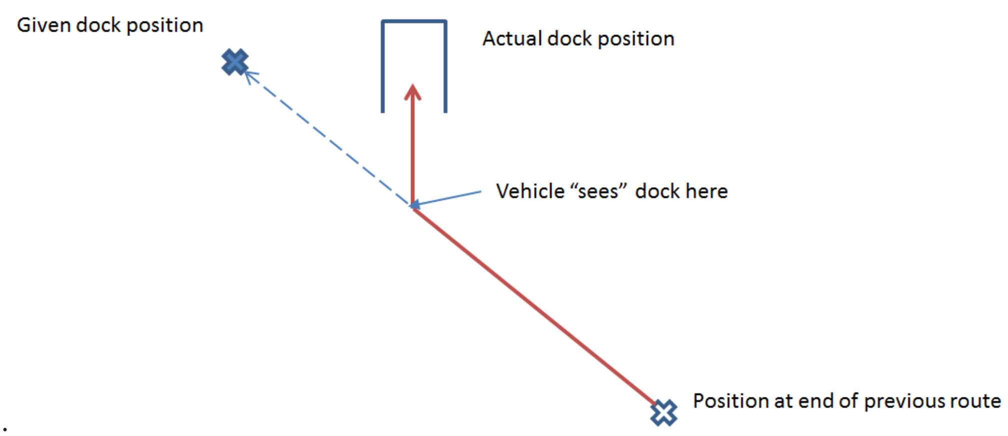


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**Figure 3.2: Docking**

If the pin-pointing fails or the vehicle reaches the given position without finding the garage, the vehicle will do a selectable number of retries. When doing a retry, the vehicle may go to another position if needed. If the vehicle still doesn't find the garage, a Failure event is triggered.

The Undock route has the following parameters:

- Range, how far from the garage the vehicle will go.
- The Depth / Altitude to go to at the end point.
- Number of Retries the vehicle will do before giving up.

When undocking, the vehicle will go straight out from the garage until it reaches the set range and depth / altitude.


**Figure 3.3: Undocking**

### 3.3.3. Sleep Route

The Dock route is used to find and dock in an underwater garage, and the Undock route leaves the garage. The position given for the garage doesn't have to exactly match the garage, but it needs to be within the range the AvTrack transponder, about 120 m. During a Sleep route, the vehicle will simply shut down the thrusters and do nothing for the specified time. The route type is primarily used when the vehicle should charge the batteries between a Dock and an Undock route. Another use might be as a fall-back route for low battery events; since the thrusters are off, very little power will be used. All other power channels will remain on.

The Sleep route has the following parameter:

- Sleep time in seconds.

### 3.3.4. Global and Waypoint Routes

A waypoint route consists of a number of waypoints with position, depth / altitude and other parameters. In the Mission Planner, the waypoint routes are called simply Global and Local. Global routes have absolute positions in longitude and latitude; Local routes have relative positions in meters.

The route has the following parameter:

- Follow Track.

Follow Track is used when a waypoint route is temporarily interrupted, for instance because of a Bad Position event. When the action set in the event has been executed and it's time to resume the waypoint route, the vehicle will return to the point where it was interrupted if Follow Track is enabled, and the next waypoint if not. In figures below, the upper waypoints belong to route 1 (R1), and the lower waypoints to route 2 (R2). When R1 gets interrupted by R2, R1 has follow track activated in the right case.

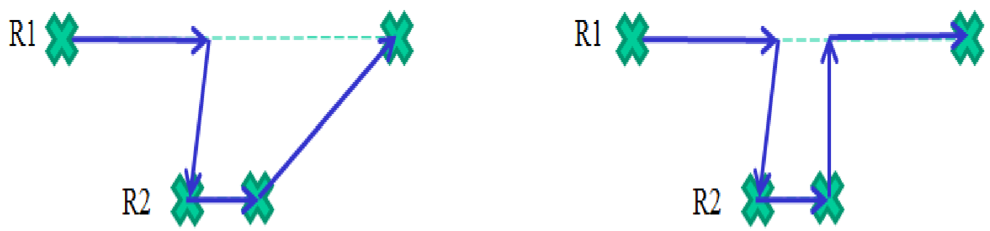


**Figure 3.4: Route 1 interrupted by Route 2, without and with Follow Track**

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Each waypoint has the following parameters:

- Position in Longitude and Latitude, or Forward and Port.
- Depth / Altitude and Min Altitude / Max Depth.
- Speed in knots towards the waypoint.
- Optional Heading, Roll and Pitch towards the waypoint.

- Hover Time, how long the vehicle will remain at the waypoint before going to the next one.
- Hor Prox Radius (horizontal proximity) and Ver Prox Distance (vertical proximity).

Local positions are expressed as Forward (meters straight ahead from the origin) and Port (meters port, to the left, of the origin). The origin and heading of all the coordinates in the route are measured from the position and heading the vehicle had at the end of the previous route, or from where the mission started if this is the first route in the mission.

In other words, if the first waypoint has the coordinates Forward = 10, Port = 0, the vehicle will go ten meters straight ahead from the origin. If the next waypoint has the coordinates Forward = 10, Port = 10, the vehicle will go ten meters port from the first waypoint.

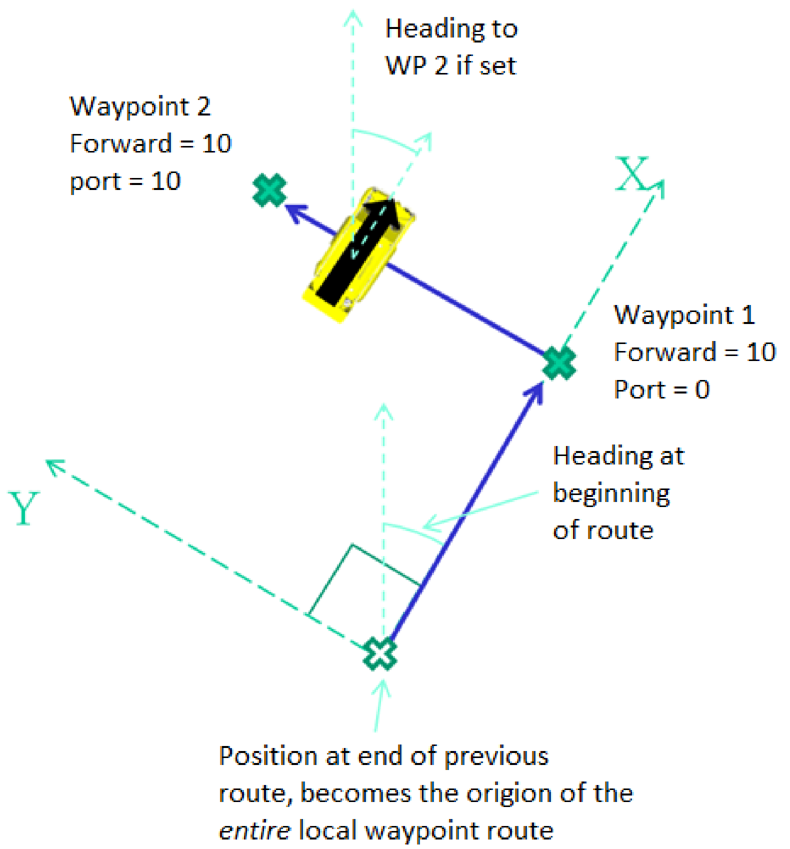


**Figure 3.5: Local Waypoint co-ordinates**

When the vehicle's position is within the Hor Prox Radius and / or the vehicle's depth is within the Ver Prox Distance from a waypoint, it will start manoeuvring towards the next waypoint.

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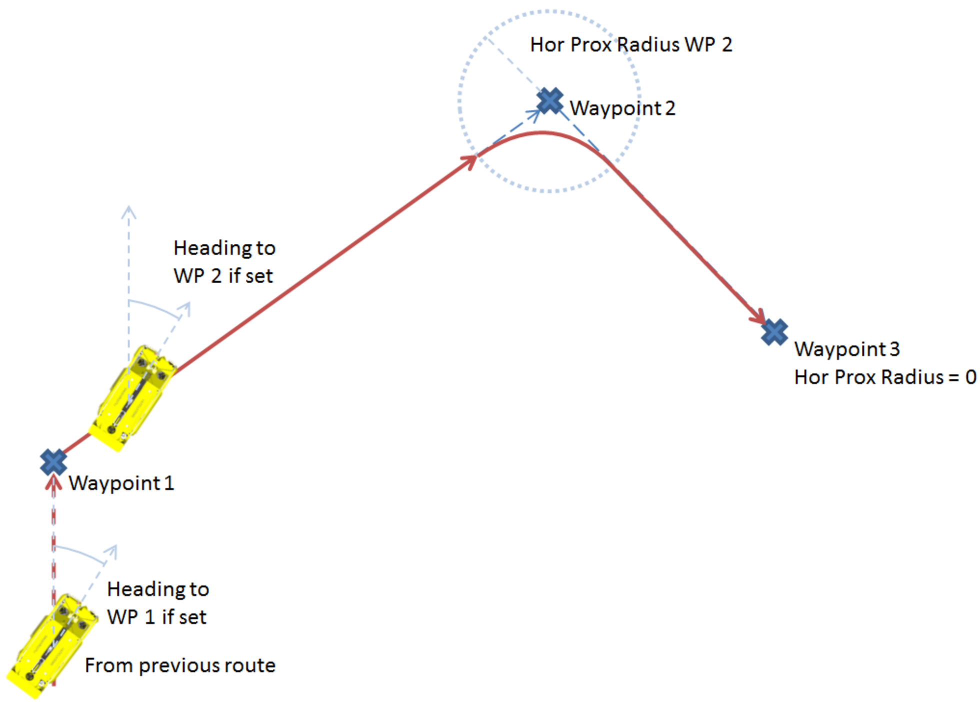


**Figure 3.6: Waypoint routes, heading and proximity radius**

### 3.3.5. Grid Routes

Use a Grid route to survey a rectangular area defined by the leg length, step width and number of legs. The route has the following parameters:

- Starting position Longitude and Latitude.
- Depth / Altitude and Min Altitude / Max Depth during the route.
- Speed in route in knots.
- Heading of the first leg of the grid.
- Surveyed Leg Length.
- Step Width, the distance between legs.
- Number of Legs.
- Port Direction, which way the vehicle will turn at the end of the first leg.

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The vehicle will hold the given speed and heading during each leg.

NOTE: When a leg is completed, the vehicle will manoeuvre outside the defined grid to turn around and obtain correct heading. How far outside the grid the vehicle will go depends on the speed set in the route. As a rule of thumb, the overshoot length in meters is about double the route speed in knots. That is, if the speed is two knot, the overshoot length is about two meters.

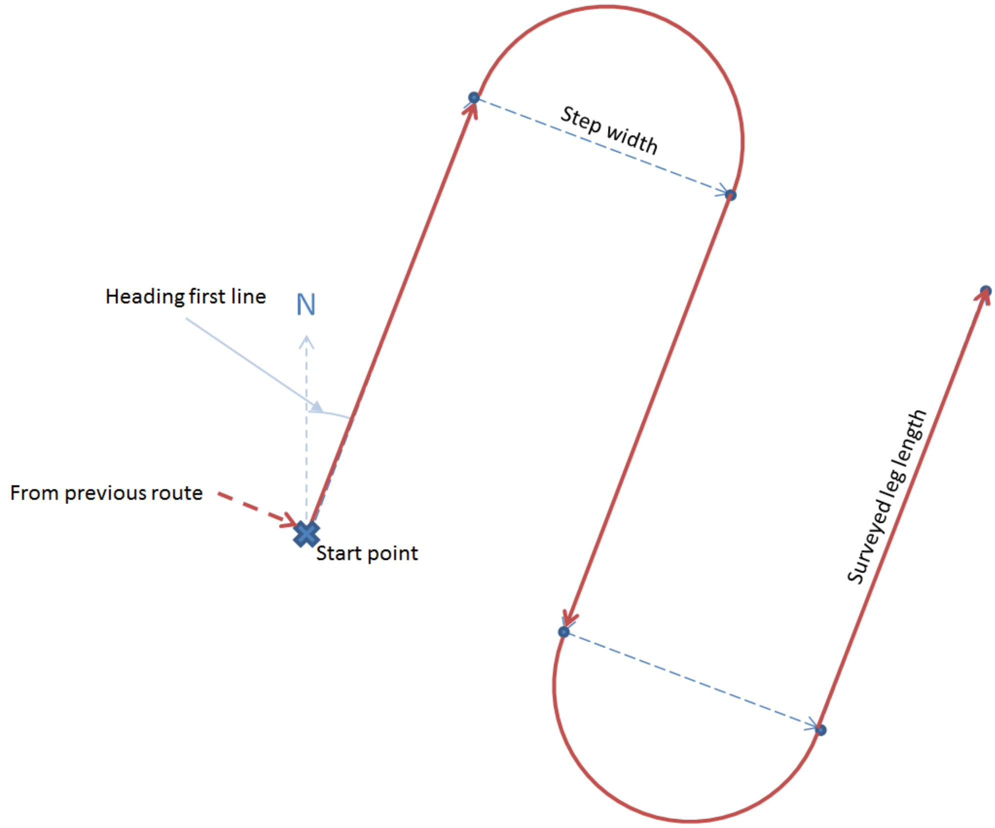


**Figure 3.7: Grid Route**

### 3.3.6. Go To Structure Route

Use a Go To Structure route to steer the vehicle towards an underwater structure. The estimated position of the structure needs only be within a search radius, which is limited by the obstacle avoidance sonar range to 30 m.

The route has the following parameters:

- Estimated position of the structure, in Longitude and Latitude.
- The Depth / Altitude and Min Altitude / Max Depth the vehicle will hold while searching.
- The Speed in knots.
- An optional Heading to the structure.
- A Search Area Radius to limit how far from the estimated position the structure can be.
- A Distance Threshold, the distance the vehicle will keep from the structure.

- A Hover Time, how long the vehicle will remain at the end point.

The vehicle will head towards the estimated position. As soon as it “sees” a structure it will head towards it. When the vehicle reaches the distance threshold, it will rotate around the structure, maintaining the distance, until the vehicle’s heading is equal to the Heading parameter. If the Heading parameter is not set, the vehicle will use the heading it has when it finds the structure.

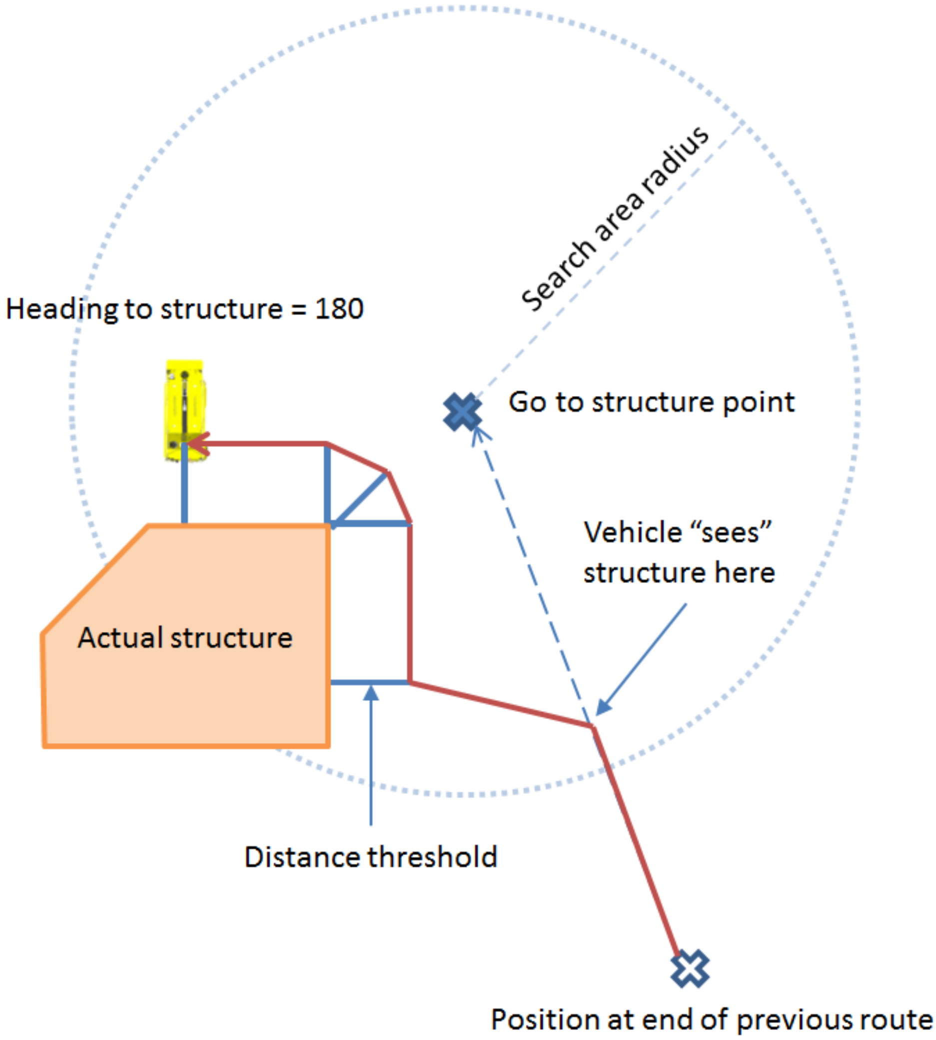


**Figure 3.8: Vehicle finding a structure**

When the vehicle has reached the correct heading, it will go to the midpoint of the structure as seen from that heading and hover there for the set hover time.

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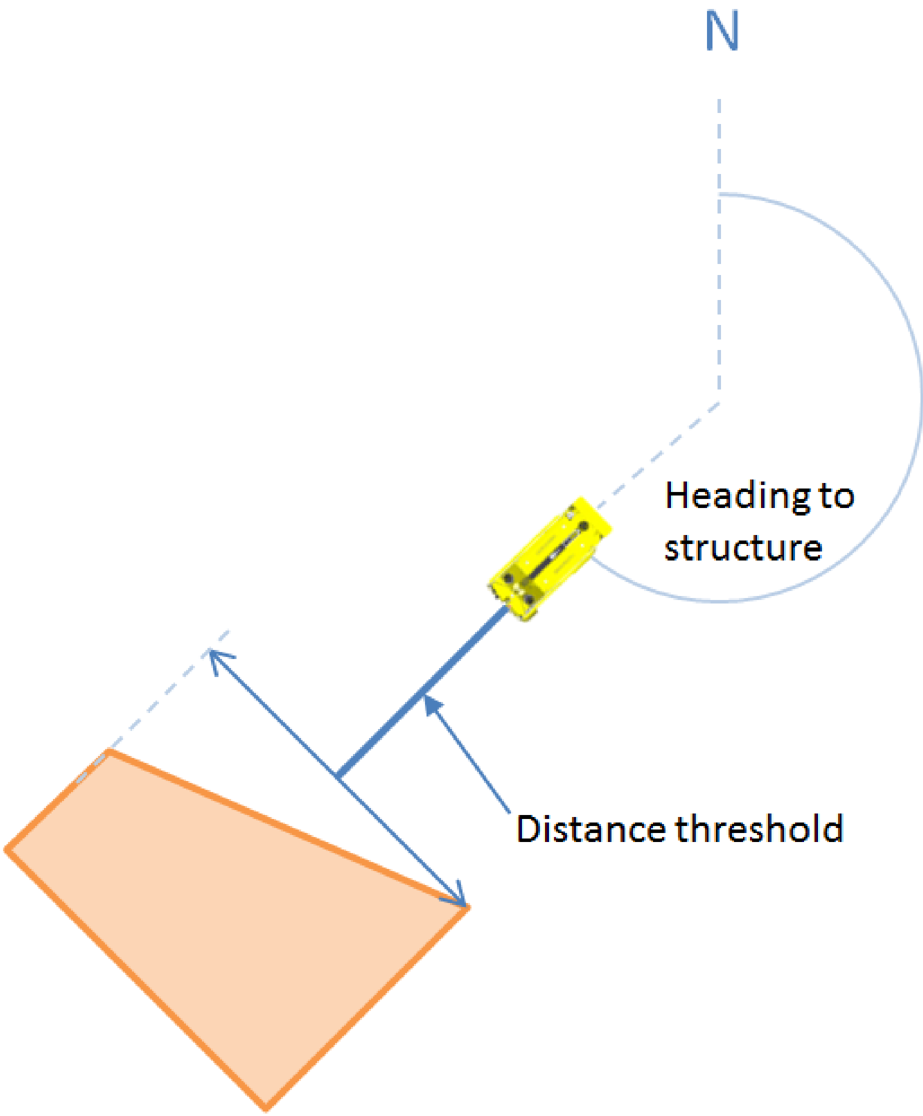


**Figure 3.9: The vehicle finds the midpoint of the structure**

If the vehicle reaches the point of the estimated position without finding a structure, a Failure event is triggered.

### 3.3.7. Local and Global Inspection routes

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Use an Inspection route to make the vehicle circle around a structure a given number of rotations. Global Inspection routes have the position of the structure in longitude and latitude; Local Inspection routes have the position as relative coordinates from the last position in the previous route. A common method if the exact position of the structure to inspect is not known is to first use a Go To Structure route to find the structure and then a Local Inspection route to go around it. Inspection routes have the following parameters:

- A position within the structure, in Longitude and Latitude or Forward and Port from previous position.
- Initial and Final Depth / Altitude.
- Speed in route in knots.
- A Heading to centre point, i.e. from the straight line towards the structure.
- A Distance Threshold, the distance the vehicle will keep from the structure.
- Port Direction, default set, which way the vehicle will circle around the structure.
- Number of Rotations, which may be less or more than one.

The vehicle will head for the given position until it reaches the distance to the structure set in the threshold. Then it will circle around the structure the given number of rotations, maintaining the distance.

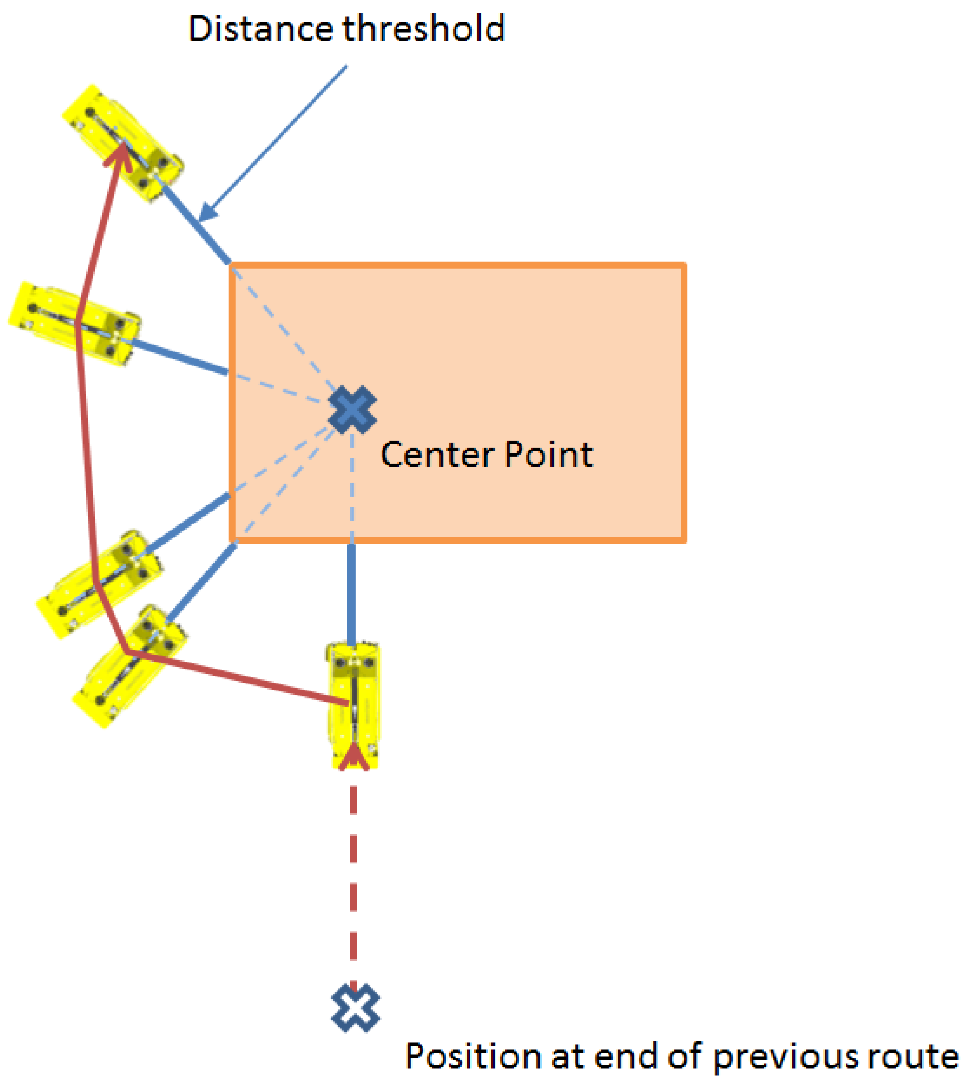


**Figure 3.10: Inpecting a structure**

During the inspection, the vehicle will always head towards the given position. If a differential heading other than zero is set, that angle will be added to the yaw. The angle is limited to 45 degrees. Note that the sonar used to circle the structure is placed in the bow and has a limited field of vision; if a heading other than zero is set, it might make the distance detection less accurate and might lead to a collision.

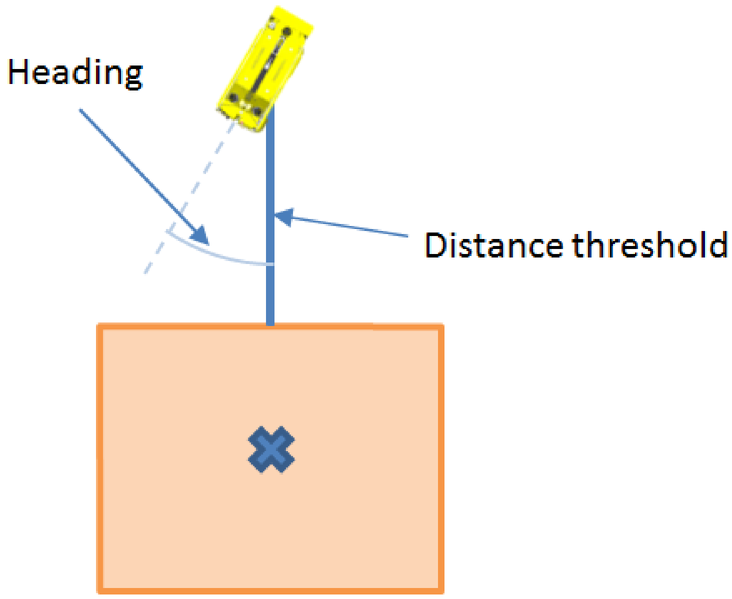


**Figure 3.11: Differential heading to centre point when inspecting**

When the inspection starts, the vehicle will go to the initial depth / altitude. During the inspection, the vehicle will descend / ascend in a spiralling motion around the structure towards the final depth / altitude. If, for instance, initial depth is 10 m and final depth is 20 m, the total depth travelled during the inspection is 20 – 10 = 10 m. If the number of rotations is 2, the vehicle will descend 10 / 2 = 5 m per rotation.

### 3.3.8. Loiter Route

A Loiter route makes the vehicle run in a circle with a given radius. Parameters:

- Loiter Speed in knots.
- Depth / Altitude and Min Altitude / Max Depth.
- The Radius of the circle.
- A The number of Laps, or a number of Seconds to loiter.
- Port Direction, which way the vehicle will turn.

The Loiter circle will start at the position the vehicle has at the end of the previous route.

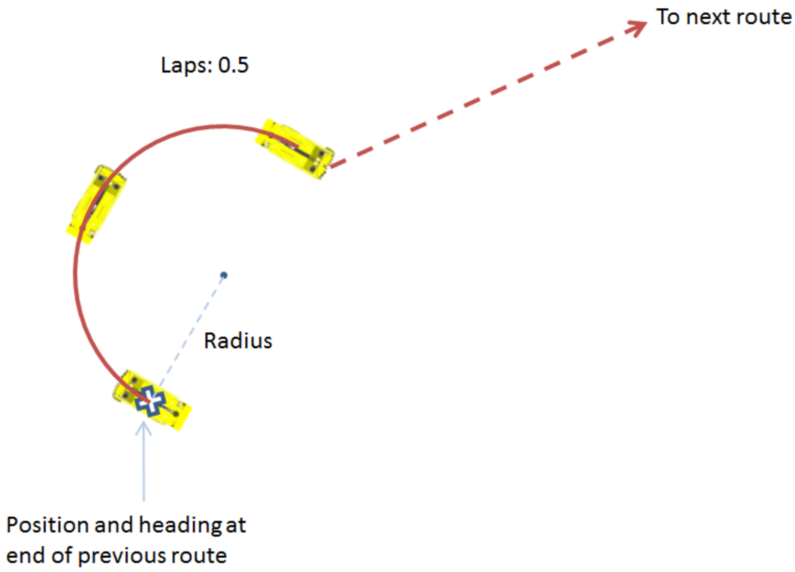


**Figure 3.12: Loiter route**

### 3.4. Controlling Devices

The vehicle can perform actions with the following equipment:

- Four forward facing lights.
- Backward facing light, integrated in the backward facing camera.
- Cameras.
- Sonars.
- Tilt unit.

Each device can be controlled independently. The intensity for each light can be set from 0 to 100%, recording for each camera and sonar can be enabled and other parameters, such as ranges and frequencies, on the sonars can be set, see 3.9.5.

### 3.5. Power Channels

All devices that are connected to an action in the missions are also connected to a power channel, this power channel can be started manually before the mission starts, but if any power channels have not been started beforehand the mission will start the device. Once it has been started it will not be powered off during the mission. It takes some time for the sensors to start up so it is recommended to have it started before a mission is started.

A

### 3.6. Mission Flow and Events

The mission has a normal flow of routes. One route is the Start route and will be the first to execute. When a route is done, the Finished event is triggered and the vehicle will take the action specified in that event, usually go to the next route. If the Finished event has no action, the mission is done.

There are a number of other events defined as well:

| Action. | Description. |
|---|---|
| Finished | The route finished normally. |
| Timeout | The route took longer than the defined timeout limit. |
| Low Battery | The vehicle battery power percentage is less than a defined limit. |
| Bad Position | The calculated position error from the Phins is greater than a set limit. |
| Good position | The calculated position error from the Phins has decreased and is smaller than a set limit. |
| Failure | Another failure has occurred, such as exceeding Min Altitude / Max Depth values, not finding the garage in a Dock route or the structure in a Go To Structure route. |

For each event, the following actions can be specified:

| Action. | Description. |
|---|---|
| Change Route | Start executing another route in this mission. |
| Resume Route | Go back to the previous route. |
| Change Mission | Start executing another mission. |
| Resume Mission | Go back to the previous mission. |

Use the Event editor to specify what to do in each event, as described in section 3.9.8.

If a Failure event is triggered and no action is specified, mission execution stops. If the battery or the position error reach critical levels and no action have been set for that, the vehicle will surface immediately.

It is recommended to always set a Surface route for at least Timeout and Failure on all routes, otherwise the mission will stop, and the vehicle will stay at the position and depth where the event occurred.

A mission typically begins with a Dive or Undock route and ends with a Surface or Dock route.

It is recommended to add an “Low Battery” event in each route in the mission planner with limits as below. The “Low Battery” event should change to a “Surface” route, the “Surface” route need to be set with maximum 2 knots in the mission planner.

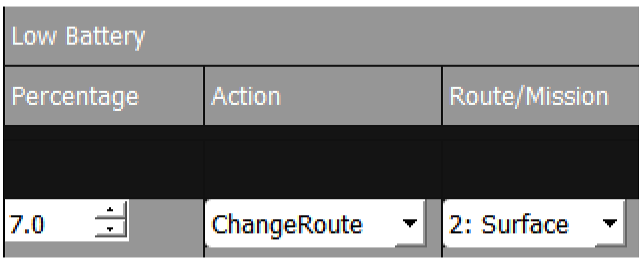

**Figure 3.13: Mission Planner Low battry limit**

7%, 3000m depth

5%, 2000m depth

3%, 1000m depth

2%, 500m depth

NOTE: If the limits are set to lower then recommended, the vehicle might not reach the surface.

## 3.7. Using the Mission Planner

The Mission Planner can be run on any computer.

### 3.7.1. Creating and Deleting Routes and Waypoints

To create a new route, select route type in the drop-down box and click the "Add route" button, or right-click in the Action, WP or Event editor tab and select "New route".

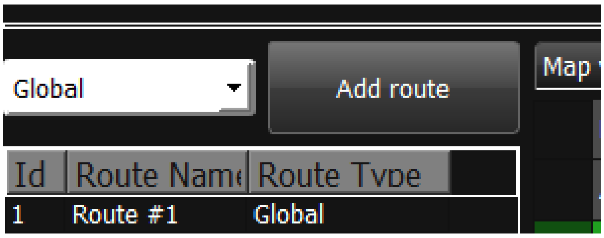


**Figure 3.14: The Add route drop down and button**

To delete a route, right-click on it in the Action, WP or Event editor tab and choose "Delete route".

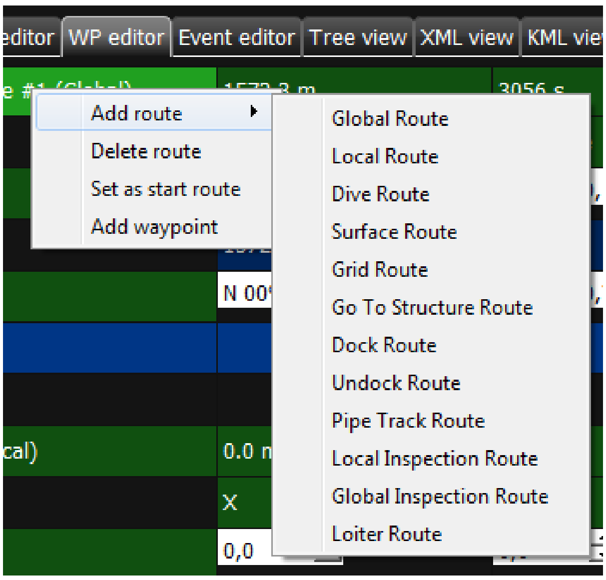

**Figure 3.15: Adding and deleting routes**

To create a waypoint, click the “Waypoint editor” tab, right-click on a route and choose “Add waypoint” or right-click on a waypoint and choose “Add waypoint before” or “Add waypoint after” as needed.

### 3.7.2. Map View

Mission Planner contains a Map view, a graphical view of the mission. The map view is considered read-only; dragging waypoints is currently not supported. Instead, use the Waypoint editor to edit positions.

For routes with global positions, the waypoints are plotted on the map. Routes with local or no waypoints are also visible, but will appear to have no waypoints. For such routes, the route name on the map is followed by the text “(not plotted)”.

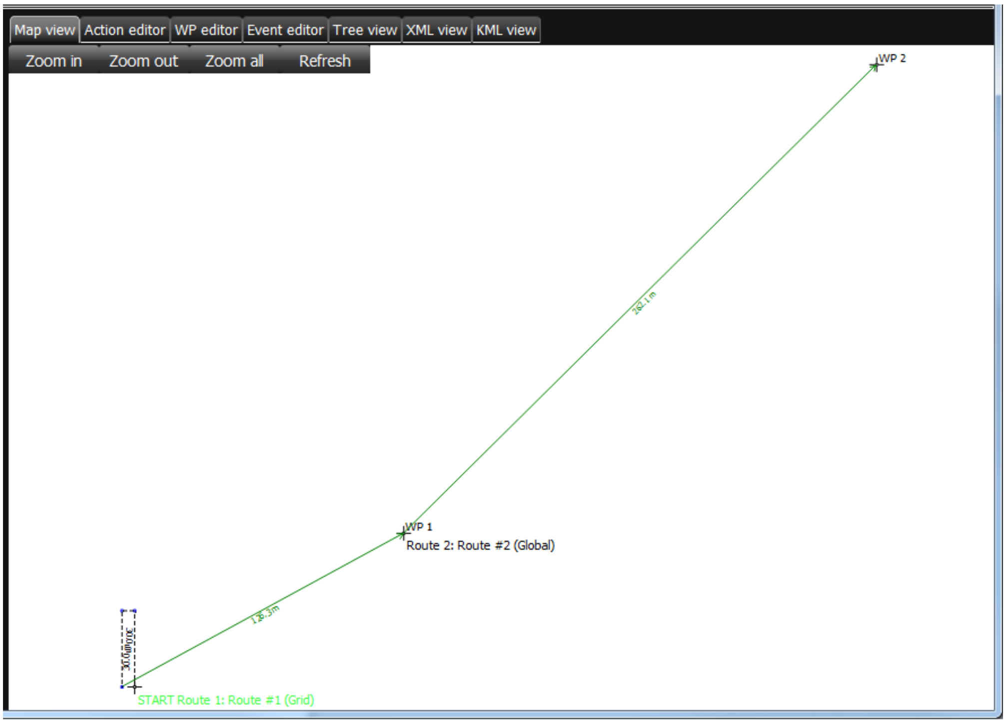


**Figure 3.16: Map view**

### 3.7.3. Table Based Editors, Overview

The Mission Planner contains three tables for editing actions, waypoints and events. To edit a value, click on the value, enter a new value and click somewhere else in the table to set it.

Certain parameters can have several names where only one can be active, such as Depth and Altitude. Switch between them with the drop-down box.

Some parameters, such as heading, roll and pitch towards a waypoint, are optional. They will only be included in the mission if the corresponding check box is checked.

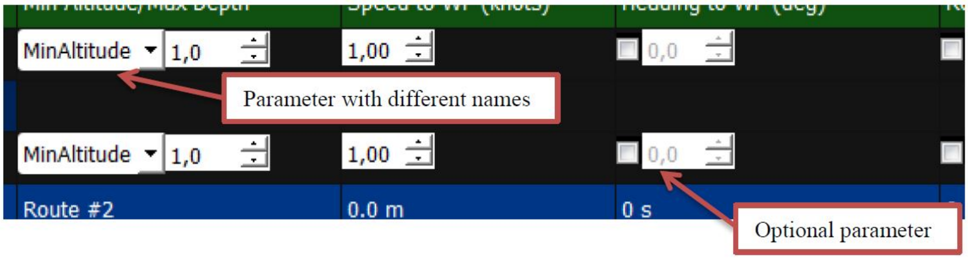


**Figure 3.17: Special parameters**

All tables contain some calculated information:

- For each route, the estimated length and execution time, the timeout time for the route (expressed as a percentage if possible), and the minimum and maximum depth and altitude in the route.
- At the end of each route, the name of the next route if set, and the estimated length, time and heading to the next route.
- For routes with several waypoints, the estimated length, execution time and heading of each leg.
- At the end of the mission, the estimated total length and time in routes, between routes and a grand total.

Note that all lengths are calculated as horizontal movements only. Changes in depth are not included, so a local route that makes the vehicle go forward ten meters will have a length of ten meters regardless of whether the waypoints are on different depths.

The Mission Planner cannot calculate the length and time for certain route types, e.g. Inspection routes where the length and time depends on how large the inspected object is. In these cases, the length and time are followed by a plus sign, e.g. “123.0+ m”.

NOTE: If an obstacle avoidance occurs during a mission, the calculated time from the mission planner will no longer be accurate.

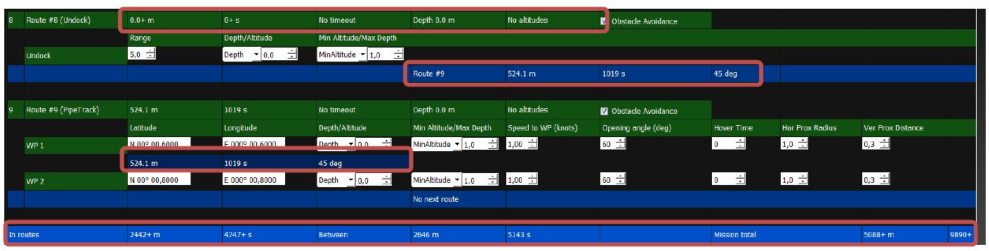

**Figure 3.18: Estimated length, times and headings**

### 3.7.4. The Action Editor, Using Lamps, Cameras etc

The action editor is where camera recordings, lamp intensities etc. are set.

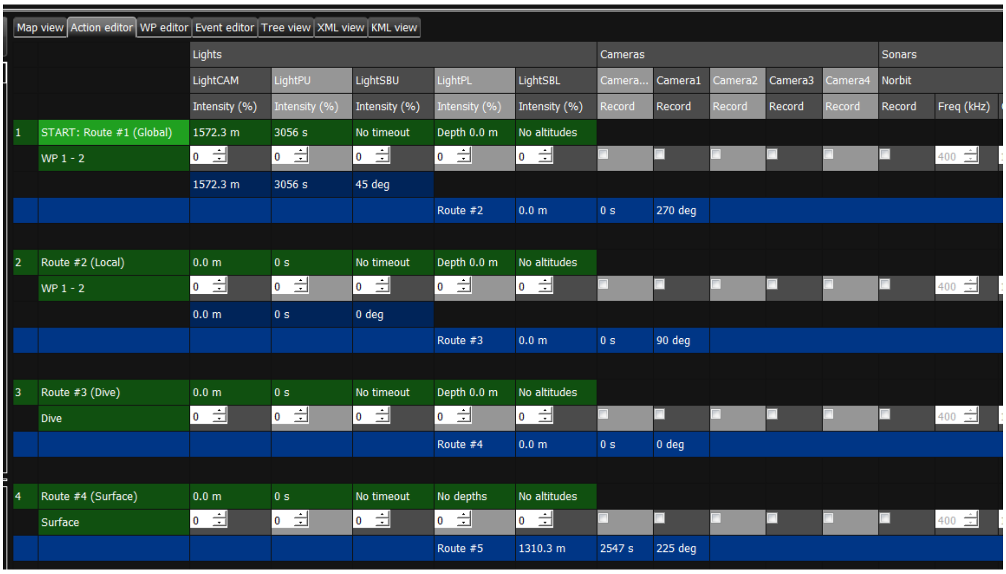


Figure 3.19: Action editor

### 3.7.5. The Waypoint Editor, Editing Waypoints

Use the waypoint editor to set absolute or relative positions, depths, headings and other parameters. Right-click to add or delete waypoints.

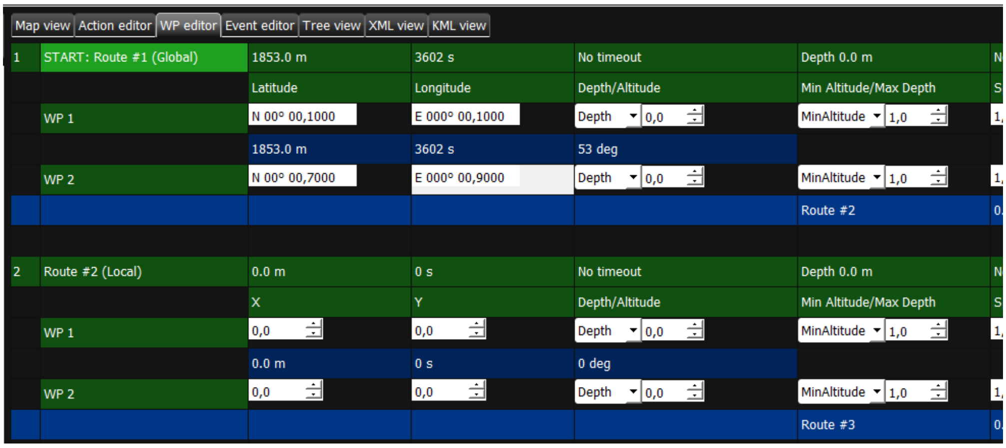


Figure 3.20: Waypoint editor

As a default obstacles avoidance is available for missions. The below warning will appear if an altitude on a waypoint is given.

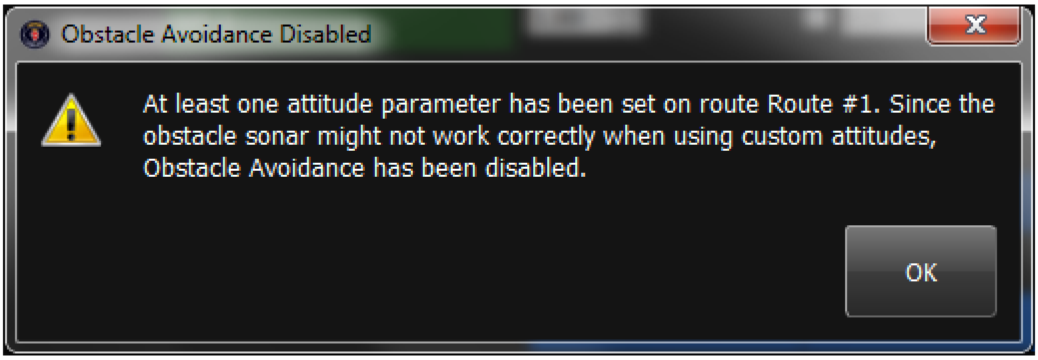


**Figure 3.21: Mission Planner Warning**

If it is expected that the mission area has several obstacles, the following recommendations should be taken under consideration:

- Have the mission in shorter routes
- Add timeouts on the route (In the Event editor tab)
- Move on to the next route in the mission if a timeout occurs
- Increase the proximity radius on the way point

### 3.7.6. The Event Editor, Setting Start Route and Defining Mission Flow

Set the Start route by right-clicking on the route and choose “Set as start route”. For each route in the normal flow, set the Finished Event to Change Route and specify the next route. Set actions for the other events as needed.

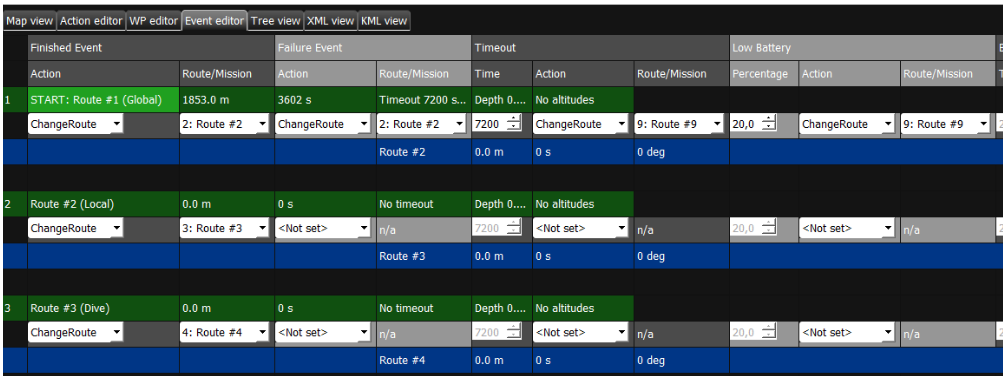


**Figure 3.22: Event editor**

### 3.7.7. The Route Pane, Converting Between Route Types and Renaming Routes

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Rename or convert routes by double-clicking on the route name or route type in the route pane. Note that routes can only be converted to other route types with the same number of points and point type, see section Route Types.

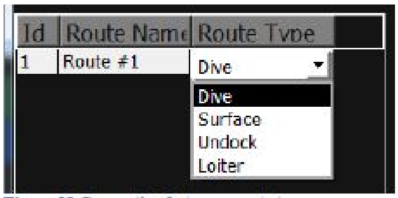


**Figure 3.23: Converting between route types**

### 3.7.8. The Properties Pane, Setting Parameters on Multiple Waypoints

The properties pane is an alternative to editing parameters directly in the table based views. It is particularly useful if a parameter needs to be changed in many routes or waypoints at the same time, such as changing the depth of all waypoints in a route or enabling recording from a camerain an entire mission.

To use the properties pane, click on a parameter in a table. Select several parameters by holding Ctrl or Shift while clicking. Click on a route title to select all parameters in that route. Click on a waypoint title to select all parameters in that waypoint. Click on a parameter heading to select all parameters in that column.

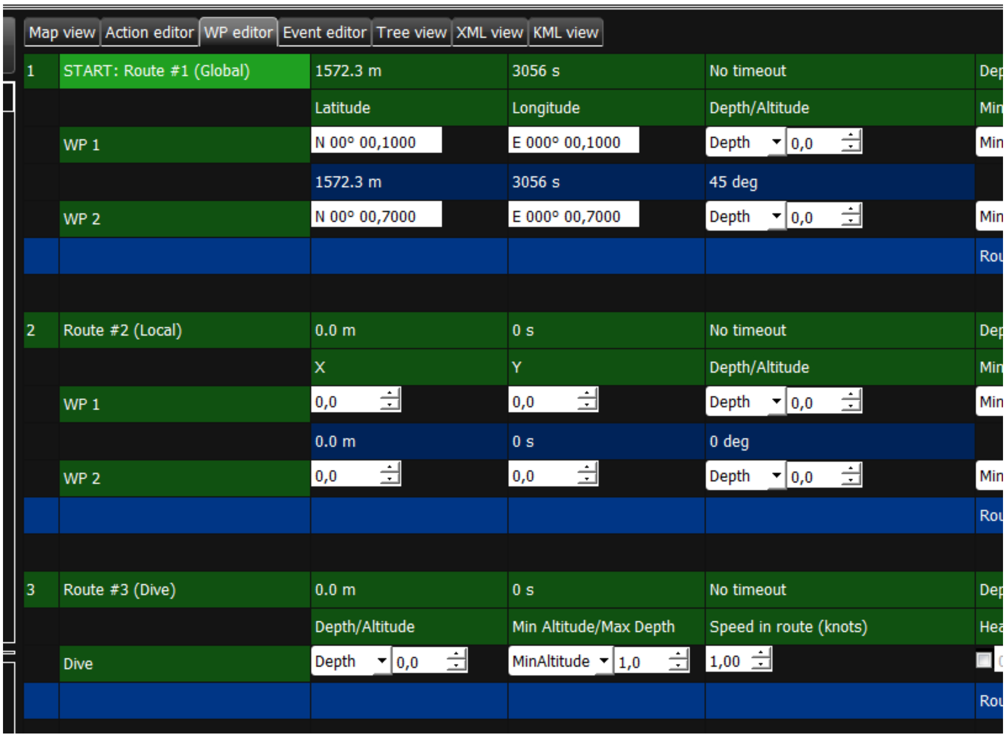


**Figure 3.24: Different ways of selecting parameters.**

When the parameter(s) that should be changed are selected, change them in the properties pane and click Apply. Clicking Clear changes will reset all selected parameters in the properties pane to their original values.


**Figure 3.25: Properties pane.**

NOTE: If several fields with the same parameter (e.g. Latitude) are selected and their values are different, the value in the properties pane will read "<different>". Also, if an optional parameter which is enabled in some selected fields is selected, the corresponding check box will be partly filled. When such a value or check box is changed and applied, all selected fields will get the same value.

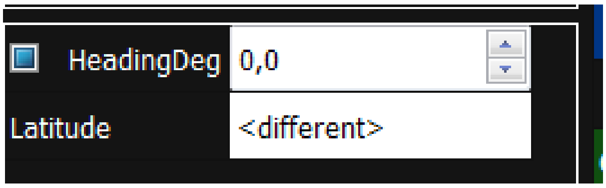


**Figure 3.26: Partly filled check box, and parameter with different values.**

### 3.7.9. Saving and Loading Missions

Save and load missions with the buttons. The file name (without the path and the .mission extension) will also become the mission name, as used by the Change Mission event action and displayed in the vehicle HMI.

### 3.7.10. Importing KML

The Mission Planner can import routes and points from a KML file created in another mapping program. KML files can contain Line strings or Points. They might have different names in the mapping software, for instance Paths and Placemarks.

To import a KML file, click the "Import KML…" button and choose a file. Line strings (Paths) will be imported as Global routes and Points (Placemarks) as Dock routes. The imported routesm can be converted to other routes with the same number of points and point type, see section The Route Pane.

Note that the Mission Planner requires all routes in the KML file to have different names to be able to tell them apart. Also note that if a mission is open in the Mission Planner and a KML file with one or more routes that have the same name as an existing route is imported, the positions of that existing route will be overwritten by the positions from the KML file.

### 3.7.11. Exporting KML

Click the “Export KML…” button and choose a file name. All routes in the normal flow will be included in the KML export. Note however that if the first (and following) routes have local points (as opposed to global), the route will still be included in the KML file as a placemark (the KML term for a collection of points) with zero points. The mapping software may or may not show that route at all. Also note that most routes are only shown as one point. For instance, a Dock route will only show the start position, not the garage.

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# CHAPTER 4

# ASSEMBLY AND INSTALLATION

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# 4. Assembly and Installation

This chapter details the instructions for receipt and installation of the Sabertooth Vehicle system. On completion of installation a series of installation tests are carried out prior to the vehicles first operational dive. The installation tests ensure that the system is working correctly and allows the operator to become familiar with the units and controls.

## 4.1. Introduction

This chapter details the instructions for receipt and installation of the Sabertooth Vehicle system. On completion of installation a series of installation tests are carried out prior to the vehicles first operational dive. The installation tests ensure that the system is working correctly and allows the operator to become familiar with the units and controls.

The system has been set up for the equipment supplied, however after repair or maintenance the system may require setting up, compensating or reconfiguring. The installation and installation tests are to be carried out whenever the system is relocated or the input supply changed.

Before and after the vehicle is launched, the Pre and Post Operational Checks (Task 1 and 2) are to be carried out and considered MANDATORY. The Pre Operational checks ensure that before diving, the vehicle is ready in all respects to dive. The Post Operational Checks are designed to detect any defects or damage that may have occurred during operational use, allowing the operator to rectify them and ensuring the vehicle can be stored operational and ready for its next dive.

## 4.2. Receipt

Unpack the system in a dry clean environment and check the contents and serial numbers against the delivery note. Should any discrepancy be noted, contact SAAB SEAEYE, immediately.

## 4.3. Adverse Effects of Extreme Climatic Conditions

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SAAB SEAEYE Technical Department advises that extremes of temperature and climate can adversely affect the performance of all systems in the SAAB SEAEYE fleets. In some cases, extreme climatic conditions can cause irreparable damage to sensitive electronic components. A particular risk is the subsea equipment (vehicles, etc.) and black anodised enclosures, which if left exposed to direct sunlight (especially in equatorial latitudes and the tropics) may experience destructive temperatures. Similarly, equipment left exposed in Polar Regions will suffer performance degradation and/or irreparable damage. Operators should also be aware of the risk of condensation when moving equipment from cold areas into warmer locations. Operators are therefore advised to provide adequate protection against extremes of climate. When equipment is to be left exposed to direct sunlight, shade is to be provided (by means of tarpaulin covers or shelters, for example) and consideration should be given to frequent temperature monitoring and the provision of artificial cooling if necessary. In freezing conditions, subsea equipment is to be protected from direct exposure and if possible stowed "indoors".

**CAUTION - Damage can occur to equipment exposed to extremes of climate:**

Do not expose to direct sunlight for prolonged periods. Do not expose to freezing conditions for prolonged periods. If equipment is to be stowed exposed to the elements, always provide adequate covering/ shelter/ shade.

## 4.4. Preparations

The following is a list of preparations that need to be carried out for installation and assembly.

### 4.4.1. AC Input Voltage Check

Prior to system connection a series of tests are required to ensure that the AC input voltages are correct for system operation.

Ensure that the surface equipment is to be set up in the area the system is to be operated, in a dry and clean environment.

Check that the following voltages are correct:

- SCU Single phase 230 VAC 50/60 Hz.
- Battery charger = 230 VAC three-phase 50/60 Hz or 400 VAC 32A three phase with neutral 50/60 Hz.
- SCB = 230 VAC 50/60 Hz.
- Monitor 230 VAC 50/60Hz
- PSU cabinet 400/440 VAC 32A three phase 50/60 Hz.

**WARNING - DANGER OF ELECTRIC SHOCK:**

DISCONNECT AND LOCK THE 3-PHASE POWER SUPPLY BEFORE OPENING THE CABINET.

- PCU upper cabinet: The transformer for internal power can be set for 400 or 440 VAC operation. The connection in wiring terminal WT6 at the bottom of the cabinet is to be set according to drawings below. WT6:1 or WT6:2 should be connected depending of the supply voltage. The terminals can be reached by removing the screws on the front and tilt down the front plate.

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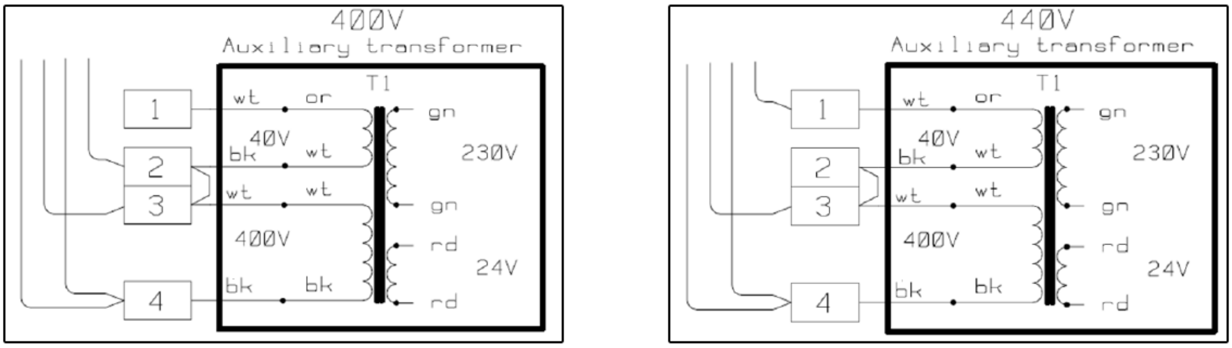


**Figure 4.1: 400 / 440 VAC Connection to PCU**

### 4.4.2. Connections

Connect the system according to the figure below except for the battery charger.

When connecting the system, if possible start in the vehicle end and work your way up to the operator's console. In that way no one can switch ON the system while working with the vehicle.

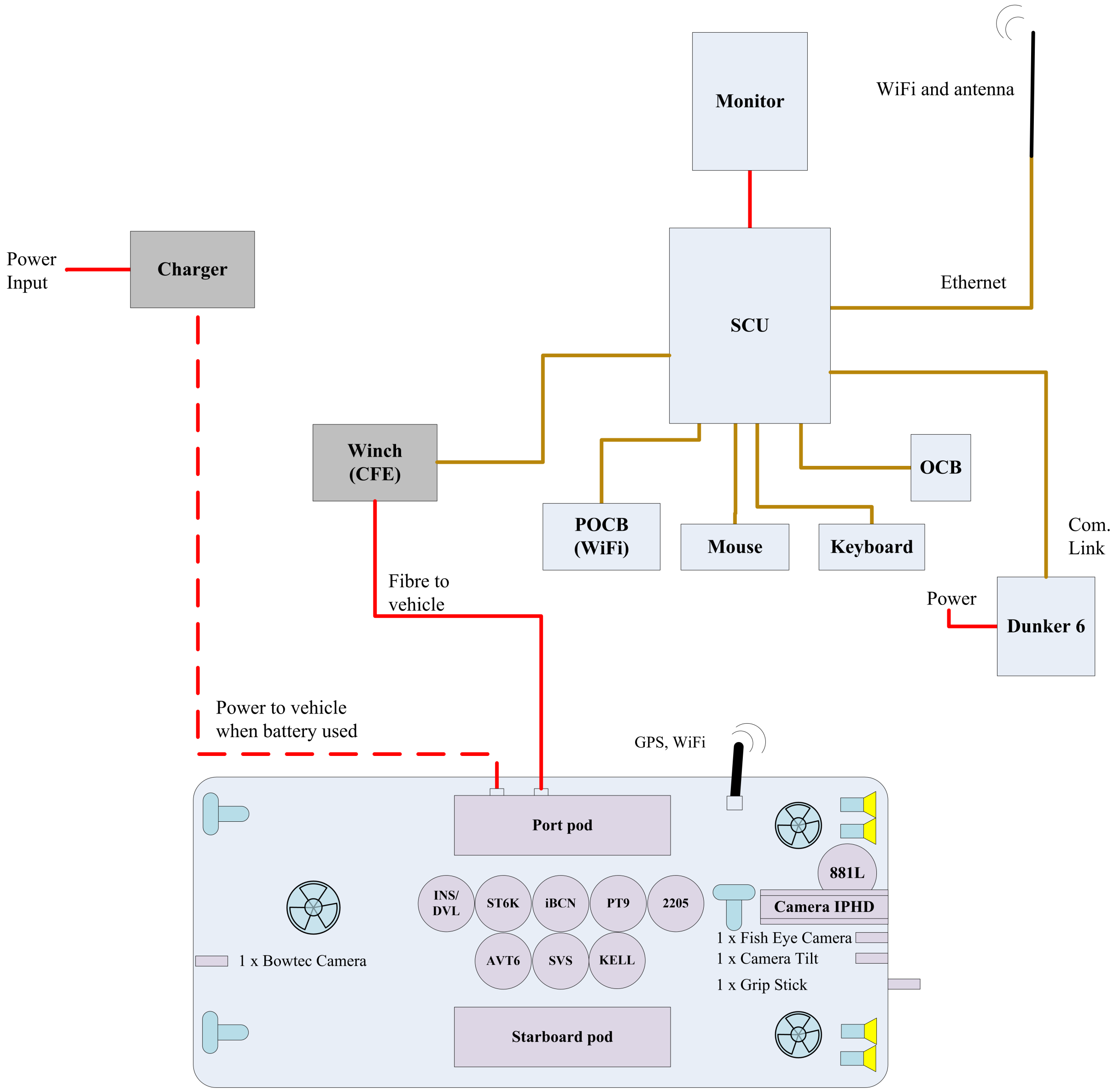


**Figure 4.2: System connection**

Before starting to connect the system make sure that the main power to the system is switched OFF / disconnected and locked.

### 4.4.2.1. Connecting the SCU

WARNING! DO NOT USE SHIELDED ETHERNET CABLES FOR THE SCU.

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Do not use USB splitters. Connect the keyboard, mouse, and OCB directly to the computer. If there is a power surge, toggle power to the SAC.

Do not connect random USB memory units. Make sure any USB memory units have been scanned for viruses etc. before connecting.

1. Connect the Keyboard and mouse.
2. Connect the OCB and POCB.

3. Connect the monitor(s).
4. Check that the POWER switch is off and connect the power supply.

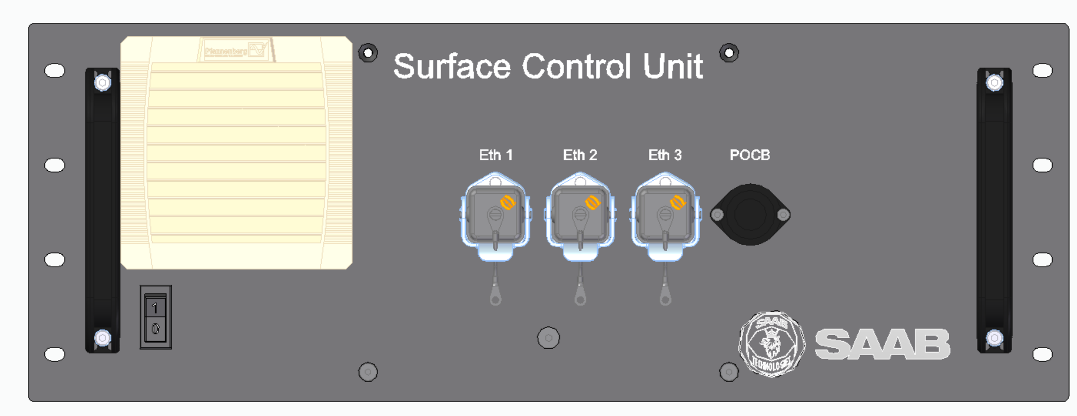


**Figure 4.3: Connections on front of the SCU**

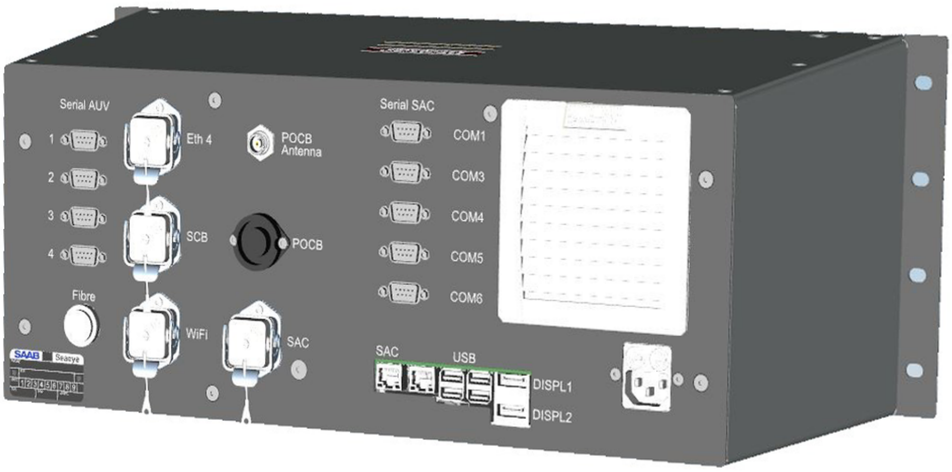


**Figure 4.4: Connections on rear of the SCU**

#### 4.4.2.2. Connecting the PSU (if applicable)

**WARNING - DANGER OF ELECTRIC SHOCK:**

DO NOT CONNECT ANY 3-PHASE POWER TO THE PSU YET.

1. Connect the HV deck cable from the winch to the output filter in the PSU cabinet.

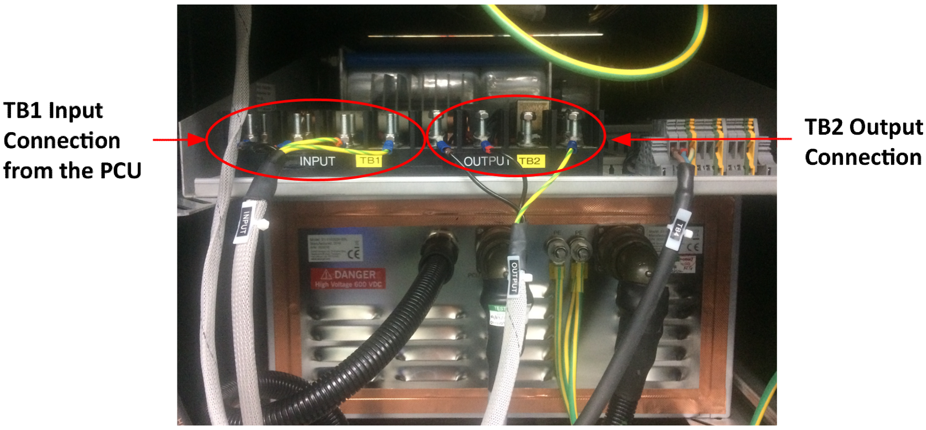


**Figure 4.5: HV Output Connections**

2. Check that the PSU and PCU main power switches are switched OFF and connect the 3-phase main power to the Main power control unit in the PSU, it is the unit under the battery charger. Check that the Battery charger main power switch is switched OFF and connect the main power to the charger.

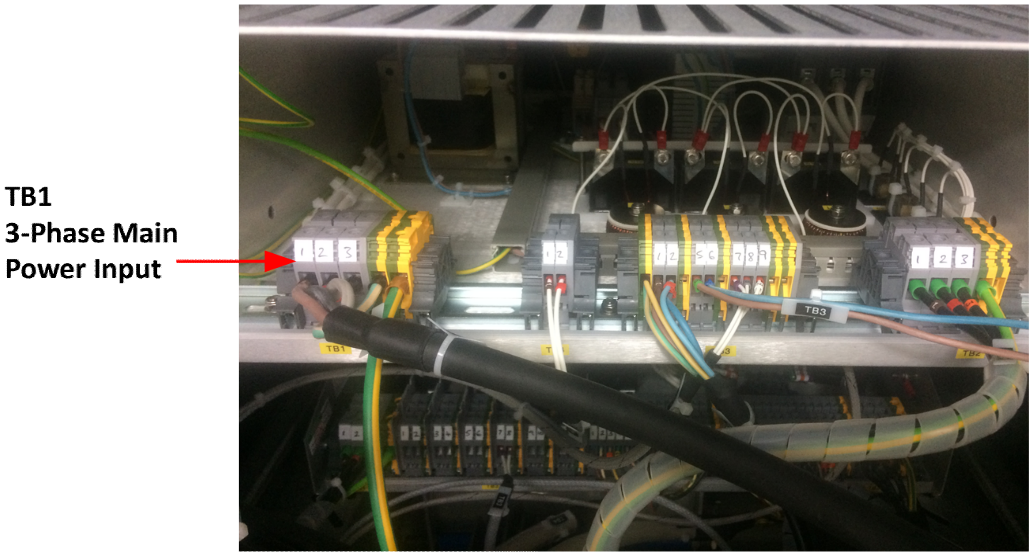


**Figure 4.6: Connect 3-Phase Main Power**

#### 4.4.2.3. Connecting the SCB (if applicable)

1. Connect the Wi-Fi and the radio antennas.
2. Connect the Ethernet cable from the SCU.
3. Check that the POWER switch is off and connect the power to the power input.

NOTE: It is important not to have the fibre link and the Wi-Fi connected at the same time.

#### 4.4.2.4. Connecting the Acoustic Com

1. Connect the Dunker6 SCU main com port to the Sabertooth SCU unit com port COM5.
2. If a USBL system is available, connect its PSIMSSB data output to SCU com port COM3.
3. Attach two Compatt6 transponders on the garage.

## 4.5. Acoustic com installation and configuration

The acoustic components consist of one AvTrak6 on vehicle, one Dunker6 on the ship. There may also be an external ship USBL system and LBL (Sonardyne Compatt6) network on sea floor.

### 4.5.1. Acoustic Com HW Configuration

New acoustic components need to be configured to match the functionality used in Sabertooth. Configuration is performed using Sonardyne Terminal 6G Lite SW. If doing so on the Sabertooth system, ensure that the main application is not running as that will otherwise occupy the com port.

#### 4.5.1.1. Terminal 6G Lite

Terminal 6G Lite is a tool for Sonardyne AvTrak6, Dunker6 and Compatt6. Refer to Sonardyne installation media for setup.

Terminal 6G is also installed on the Sabertooth system on RAC and SAC for monitoring and configuration of the AvTrak6, Dunker6 and Compatt6.


**Figure 4.7: 6G Terminal Lite**

Go to tab Manual Commands. Press connect. Use the default settings, except the COM port that needs to match the COM port used to connect to the Sonardyne equipment.

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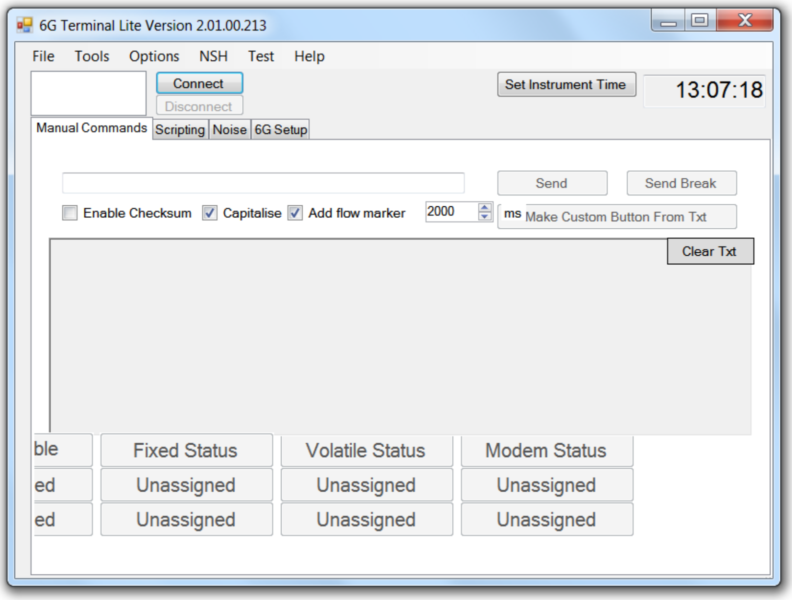



Once connected, type the command to send in the field and press the Send button.

#### 4.5.1.2. Firmware and functionality level

Prior configuring a unit, make sure it has the correct functionality installed. Use Terminal 6G Lite to connect to the device. Send FS command to retrieve the needed information.

<FS

>FS:2909,U004E56,FL001F,FV3.05.00.05,PV1.11,TDR;MF;OMNI;187;181;166,T-10;40;AC0.25,PR35000;AC0.100

In example above we read

Firmware Version: FV3.05.00.05

Protocol Version: PV1.11

Functional Level: FL001F

Protocol version should be 1.11. For functional level and FW version see table below. Note that functional level is bitmapped.

| | Functional level | Firmware version |
|---|---|---|
| AvTrak6 | At least 1F | At least 3.05.00.05 |
| Dunker6 | At least 9 | At least 3.05.06.12 |
| Compatt6 | At least 5A | At least 3.05.07.09 |

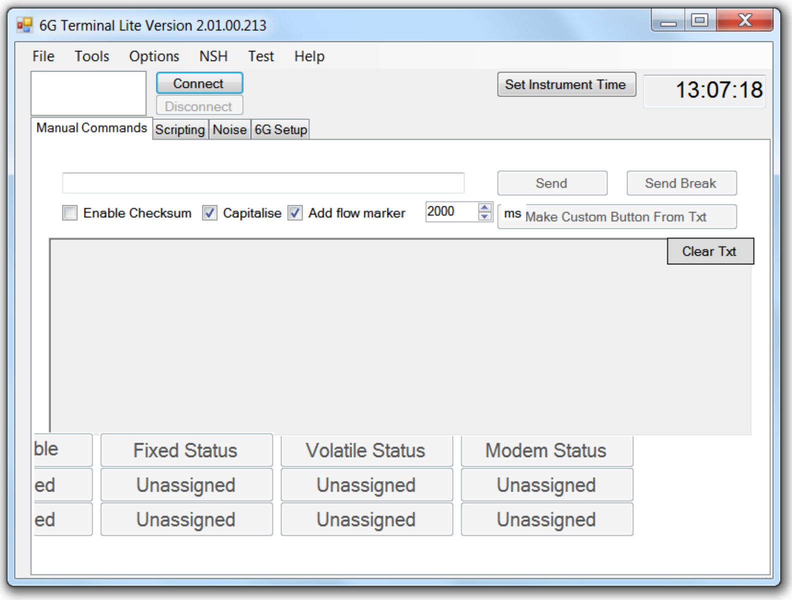
If FW is faulty it needs to be upgraded. Use Sonardyne document QSG-UP-8300-00-A2 Type 8300 Transponders Firmware Upgrade Guide for procedures of upgrading the FW using Sonardyne GP Bootloader SW.

If functionality level is faulty, an update key needs to be retrieved from Sonardyne. It is entered through the Terminal 6G interface as a command.

Known limitations with old firmware used in this system:

- Acoustic data transfer will not function. AvTrak6 and Dunker6 firmware and FL are critical.

Go to tab Manual Commands. Press connect. Use the default settings, except the COM port that needs to match the COM port used to connect to the Sonardyne equipment.




Once connected, type the command to send in the field and press the Send button.

### 4.5.1.3. Settings Configuration

The different acoustic components need different settings. Those are handled individually further down.

In some cases it is necessary to change the unit's acoustic address. Possible reasons for changing the address are: Already occupied address by other unit in that water volume; Address change due to interaction with other older units; other address range is required in order to use a more robust telemetry. To change the address, the current address and the unit's ID is required.

Send the following command:

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<SC:Uhhhhhh,ADaaaa

hhhhhh is the unit ID and aaaa is the address to set. Example setting unit 004D0C to address

2001:

<SC:U004D0C,AD2001

Note: Unit ID can be obtained using the same mnemonic:

<SC.

Note: USBL utilizing Ranger1 system requires acoustic address of the vehicle AvTrak6 to be in the 101-1514 range, e.g. 1001, in order for that system to be configured to find the AvTrak6.

Go to tab Manual Commands. Press connect. Use the default settings, except the COM port that needs to match the COM port used to connect to the Sonardyne equipment.

#### 4.5.1.4. AvTrak6 Settings

Send the following commands to the AvTrak6 using 6G Terminal on the RAC:

CS:TAT200,BLK100,RXW4800,TXW180,NPL181,TPL181,LG6,CIS0,AT8,EC1,EU1,RSP0,PPR0

MS:P0,TS1,ICT512,MST0,MR0,SM1,FQ0,DD512,MD1024,UD256

PORT:P0;BR9600;CF0;RS232

SC:Uhhhhhh,STR;CS;MS

hhhhhh is the unit ID. It is obtained by the SC command.

#### 4.5.1.5. Dunker6 Settings

Send the following commands to the Dunker6 using 6G Terminal on the SAC:

CS:BLK100,RXW4800,TXW100,NPL187,TPL187,LG6,CIS0,AT8

MS:P0,TS1,ICT512,MST0,MR0,SM1,FQ0,DD512,MD256,UD256

PORT:P0;BR9600;CF0;RS485

SC:Uaaaaaa,STR;CS;MS

TS parameter configures the telemetry scheme. TS1 = 200 bps, TS2 = 400 bps and TS3 = 900 bps. TS3 is required if using USBL as the PHINS requires data no older than 10s.

The Dunker6 is connected to its SCU which in turn is connected to the surface application computer at com port 2.

### 4.5.2. SW Configuration

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SW configuration is done through the HMI. It is important that surface unit is in contact with the vehicle by a connection other than the acoustic link. Do these configurations on land, as rebooting the system may be required.

#### 4.5.2.1. Basic Configuration

These settings are the core of the acoustic communication. If faulty set it may be impossible to communicate with the vehicle acoustically.

In order to do these configurations you need the following:

- Ship units acoustic address (Dunker6).
- Vehicles acoustic address (AvTrak6).
- Power/gain settings suitable for the mission.

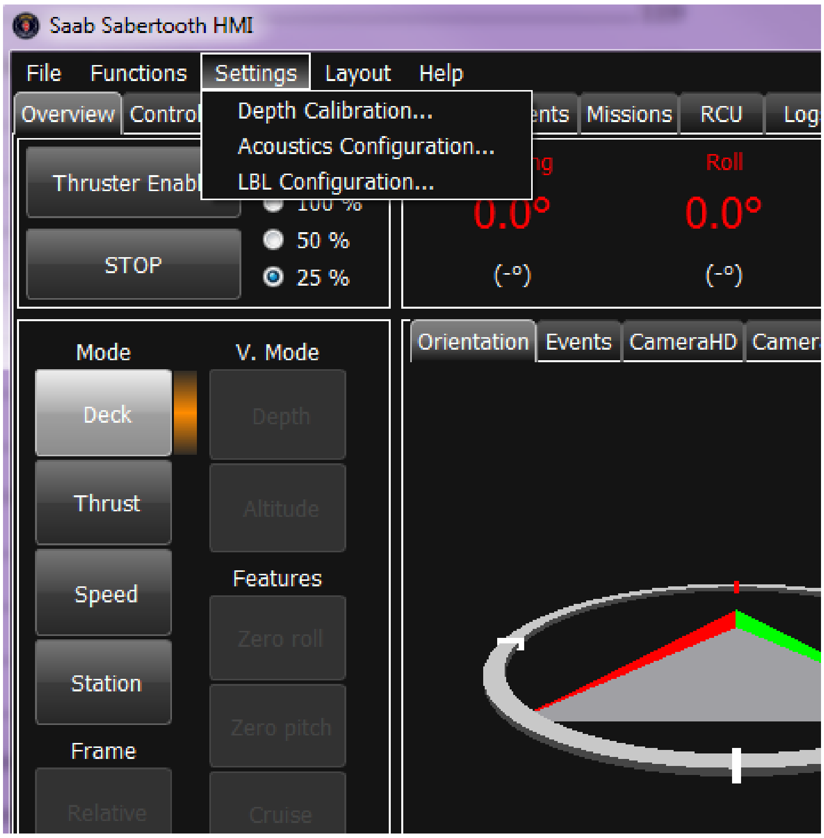


**Figure 4.8: HMI basic configuration settings**

Go to the Acoustics Configuration section under Settings in HMI.

Set Ship (surface) and vehicle (underwater unit) acoustic address as configured in the HW configuration. Set the power and gain setting on either side for the Ship-vehicle communication to match the environment and mission conditions.

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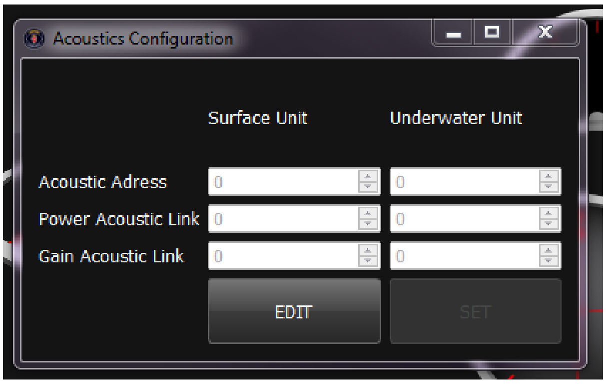


**Figure 4.9: Acoustic Configuration**

Different Sonardyne equipment has different possible settings. To check a unit, use Terminal 6G Lite to send command FS

>FS:2908,U004E6D,FL001F,FV3.05.00.05,PV1.11,TDR;MF;OMNI;187;181;166,T-10;40;AC0.25,PR35000;AC0.100

The unit in the example above can only set power to 166, 181 and 187. Setting above max will result in max. Setting below min will result in error. All other settings round up to closest legal setting.

Gain can be set in discrete steps as follows: 0, 6, 14, 20, 26, 34 or 40 dB. Gain settings deviating from these will be round to closest.

In general, these are the possible power settings for this system unless a unit is replaced:

- Surface unit (Dunker6) 166, 187, 190, 193, 196
- Underwater Unit (AvTrak6) 166, 181, 187

#### 4.5.2.2. USBL

USBL data from an external USBL system may be sent continuously to the vehicle. It is important that the data is in a format the system supports, e.g. PSIMSSB.

The USBL system needs to be connected to com port 3 of the surface application computer and have interrogation rate high enough to get updates frequently enough, but not too often as it may impede acoustic communication link. 15 s intervals is recommended.

The system will automatically enter USBL mode when USBL data is present, except when docking. Do not forget to turn USBL ranging off when docking, as the data will not update.

#### 4.5.2.3. LBL

LBL functionality requires that operator has loaded the transponder data into the GUI. These settings are stored on file which may be reused. Defined transponders can be deactivated in the system without deletion. The file is found on D:\Carus\settings on the RAC.

Note: Vehicle needs to be connected in order for LBL data to be stored. Acoustic connection only will not suffice for this operation.

Go to the LBL Configuration section under Settings in HMI.


**Figure 4.10: LBL Configuration**

Only transponders set active will be interrogated during operation. To add, remove or modify the transponders, press Edit. When done, press Set to store the changes.

### 4.5.3. Acoustic Configuration Troubleshooting

Some common root causes:

- Dunker6 SCU is not connected or is not powered on.
- Address mismatch between HW configuration and SW setup.
- Incorrectly configured acoustic units.
- Power/gain setting is not adjusted for the environment/mission.
- Old firmware in a unit.
- USBL connected to the wrong COM port.
- Acoustic interference / bad acoustic environment.

## 4.6. Vehicle charging and installation test

Charge the batteries. For information, see "BATTERY CHARGING" in the Preventative Maintenance chapter.

Perform a Pre dive test. For information, see "PRE-DIVE CHECK" in the Preventative Maintenance chapter.

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# CHAPTER 5

# OPERATIONAL USE

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# 5. Operational Use

This chapter describes the main operations when using the system, like how to turn it on and off. How to Pilot the vehicle using the HMI and OCB is described in chapter 2.

## 5.1. Warnings

The following warnings must be read and understood before operating the Sabertooth VEHICLE system.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

NEVER CONNECT OR DISCONNECT CABLES TO OR FROM EITHER THE SURFACE UNIT OR THE VEHICLE WHEN THE CABLES ARE LIVE. THIS PRACTICE IS BOTH POTENTIALLY DANGEROUS AND IT REDUCES CONNECTOR LIFE THROUGH ARCING

**WARNING - DANGER OF ELECTRIC SHOCK:**

DO NOT CONNECT ANY 3-PHASE POWER TO THE PSU YET.

**WARNING - DANGER OF ELECTRIC SHOCK:**

DISCONNECT AND LOCK THE 3-PHASE POWER SUPPLY BEFORE OPENING THE CABINET.

**WARNING - DANGER TO PERSONNEL:**

DO NOT LOOK DIRECTLY AT LED LIGHTS WHEN ILLUMINATED.WEAR PROTECTIVE GLASSES. LED LIGHTS PRODUCE AN INTENSE WHITE LIGHT THAT CAN CAUSE DAMAGE TO THE EYES.

**WARNING - DANGER TO PERSONNEL AND EQUIPMENT:**

ALWAYS CHECK THE SECURITY, SUITABILITY AND CONDITION OF ALL LIFTING EQUIPMENT.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

ONLY TRAINED PERSONNEL FULLY AWARE OF THE DANGERS INVOLVED SHOULD INSTALL AND CONNECT POWER SUPPLIES FOR THE SYSTEM.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

NEVER CONNECT OR DISCONNECT CABLES TO OR FROM EITHER THE SURFACE UNIT OR THE VEHICLE WHEN THE CABLES ARE LIVE. THIS PRACTICE IS BOTH POTENTIALLY DANGEROUS AND IT REDUCES CONNECTOR LIFE THROUGH ARCING

**WARNING - POSSIBILITY OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE ROV SYSTEM, MAKE SURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - POSSIBILITY OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE ROV SYSTEM, MAKE SURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

ISOLATE ALL THE UNITS POWER SUPPLIES BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT.

**CAUTION - Danger of damage to equipment:**

Never operate the vehicle near moving ships propellers.

**CAUTION - Damage can occur to equipment exposed to extremes of climate:**

Do not expose to direct sunlight for prolonged periods. Do not expose to freezing conditions for prolonged periods. If equipment is to be stowed exposed to the elements, always provide adequate covering/ shelter/ shade.

**CAUTION - Danger of damage to equipment:**

Keep all O-rings and seal faces clean and free from grit or other matter. Lightly grease with Molycote 111 grease before assembly.

**CAUTION - Possibility of damage to equipment:**

Always complete a pre-dive check before a dive, and post dive check after a dive. These checks are listed in maintenance chapter 7.

**CAUTION - Possibility of poor vehicle handling:**

Make sure that the vehicle trim and ballast is correct after adding or removing equipment. Addition of equipment or poor vehicle ballast or trim will affect vehicle performance.

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## 5.2. Preparations, Calibration, Compensation and Configuration

The system has been factory set up for the equipment supplied, however when equipment is replaced or modified the system may require setting up, compensating or reconfiguring.

### 5.2.1. Calibrating Depth Sensor

1. Navigate to Settings (top left of HMI) and click Depth Calibration.

2. Use one of the following:
   - On Deck
   - At Surface
   - Custom
3. Enter the Z level arm distance (the Z level arm to depth transducer is normally -0,38m if the transducer has not been moved).

Make sure that the depth reading provides a good approximation of 0 m when the vehicle floats in water.

### 5.2.2. How to trim vehicle buoyancy

To ensure optimal performance of the vehicle, it is essential that the vehicle is well balanced, that is, slightly positive buoyant. Depending on the salinity of different waters, the vehicle may prove to be too heavy or to buoyant. Also additional equipment fitted or removed must be compensated for and the vehicle trimmed to the new weight.

A well-adjusted vehicle will have superior performance and use less power. A vehicle that not has correctly adjusted buoyancy will work anyway (if not too bad). But it will have less performance because the thrusters use more power for just holding the pitch, roll and depth.

Always make sure that the vehicle is buoyant; otherwise the vehicle will sink in case of a link failure or power loss.

Coarse checking the buoyancy is done by launching the vehicle and visually checking the buoyancy of the vehicle, while it is in deck mode. The vehicle should slowly come back to the surface and not roll or pitch too much.

For fine checking of the buoyancy, descend to a level where the sea does not disturb the vehicle and perform full 360 DOF manoeuvres to remove all trapped air. Put the vehicle into Deck Mode (DM) and observe the depth/roll/pitch input. Make sure that tether is not affecting the vehicle. If the see is calm, go up to the surface to visually observe the vehicle.

Another useful method is to dive just below the surface and let it stay there in thrust mode, zero pitch and zero roll. Observe if any or all of the three up / down thrusters are working hard to keep the attitude / depth. If so, it is too buoyant or poorly balanced.

An average of 10% thrust down will equal around 10kg.

A **Be aware if in rough seas as the thrusters will work hard for other reasons not just uplift!**

A buoyant vehicle will not stir up that much from the bottom because it will direct the propeller current from the thrusters upwards when holding the depth.

For a full autonomous buoyancy check, make sure the vehicle is intentionally very buoyant, for example +20kg. Execute a mission with way points at +10msw including 90degree pitch and roll to remove trapped air end with sleep 1min and return to surface. Check the playback log thruster use after mission. Repeat the procedure with 10% down thrust. Observe whether the vehicle sinks or floats in sleep route.

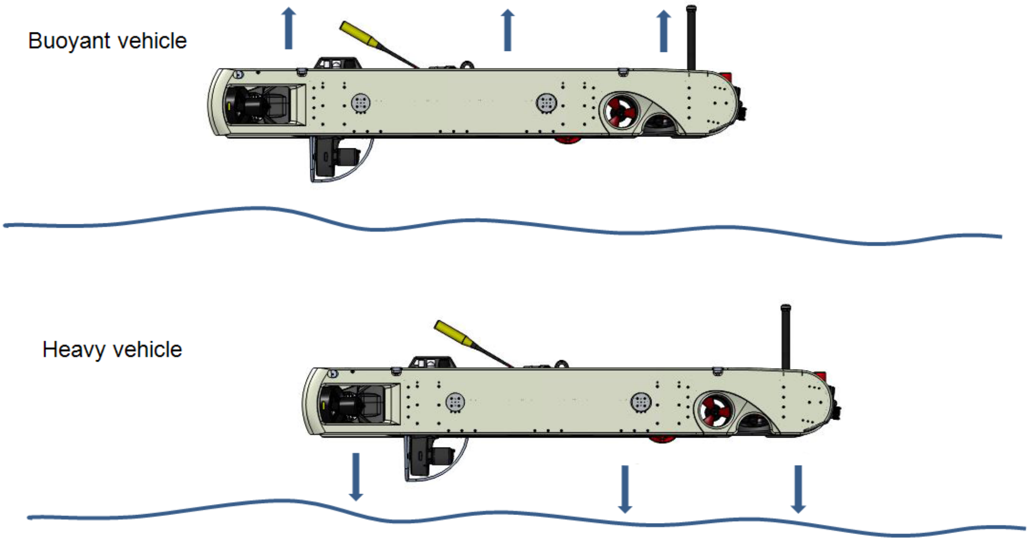


**Figure 5.1: Vehicle buoyancy**

Also check that the vehicle is balanced in Pitch and Roll, it could be floating but not balanced. Check the Pitch and Roll angles in the HMI.

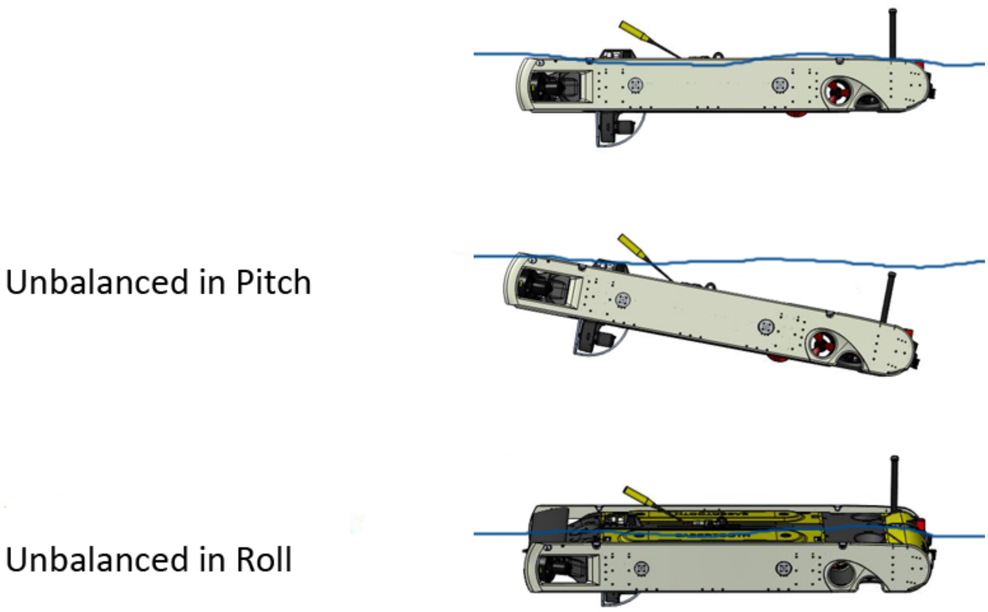


**Figure 5.2: Vehicle balance**

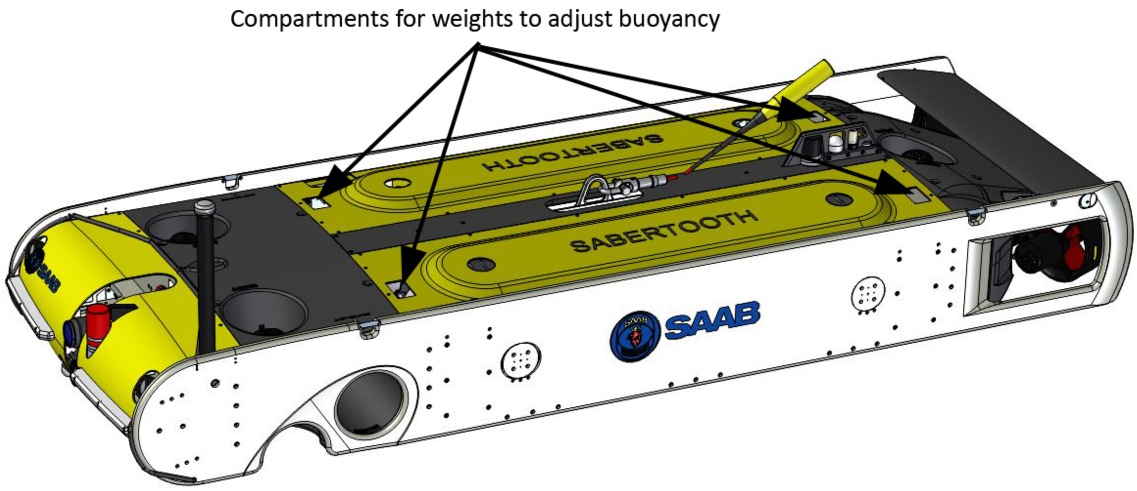


**Figure 5.3: Weight compartments**

If more weights are needed depending on changed configuration, there is space for additional weights in the front.

If more adjustments are needed, it is possible remove the buoyancy round the EPODs.

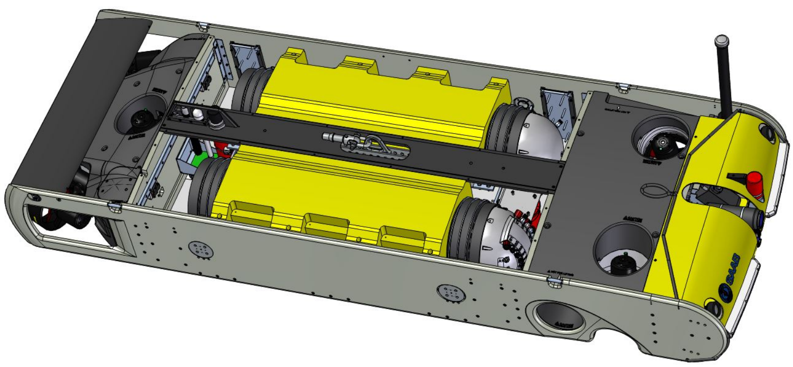

**Figure 5.4: Removing top cover**

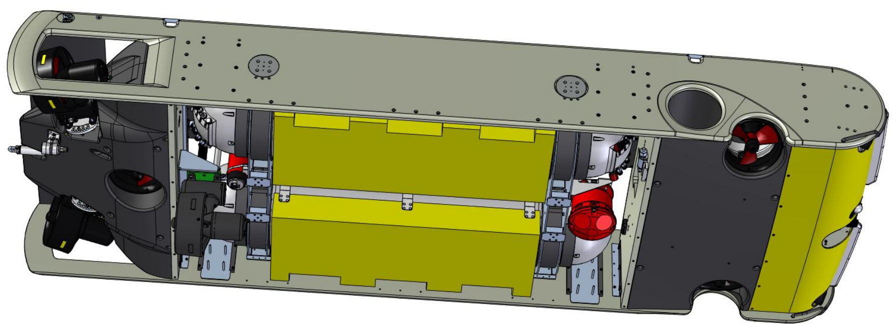

**Figure 5.5: Removing bottom cover**

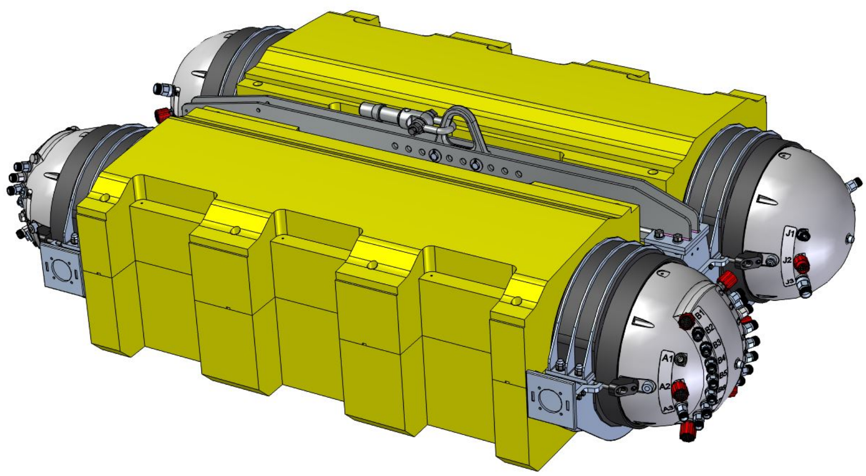

**Figure 5.6: Inner structure no extra buoyancy added**

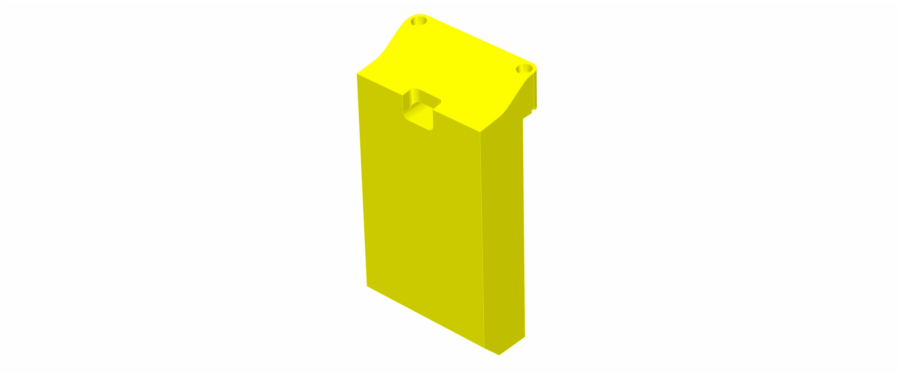

**Figure 5.7: Extra buoyancy**

Extra bouyancy blocks can be used. There are 6 buoyancy pieces in total and each block can give 6.2kg uplift.

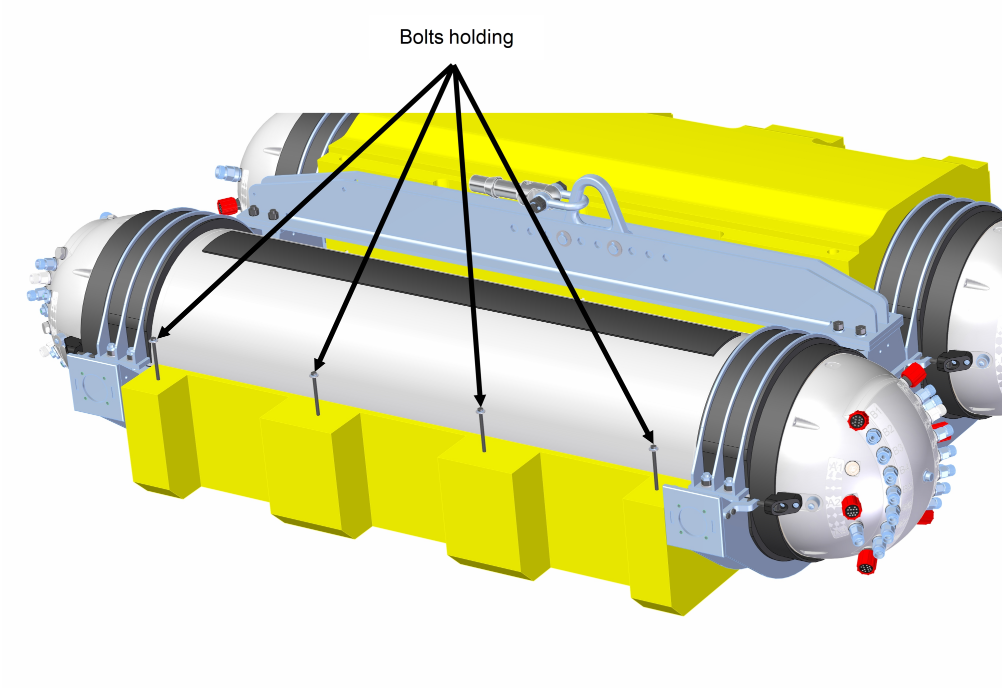


**Figure 5.8: Top buoyancy block removed**

### 5.2.3. Setting water salinity

It is important to know the speed of sound in water to get good accuracy from the Doppler velocity log. The accuracy of the Doppler velocity log in its turn affects the position accuracy of the INS.

If there is no sound velocity probe mounted on the vehicle it is possible to calculate the speed of sound in water using the salinity, temperature and pressure. Temperature and pressure are both measured which leaves salinity as unknown. The salinity can be entered manually in the HMI. To do this the Control tab is selected and the salinity is entered in the appropriate box.

After this the Set button is pressed.

### 5.2.4. Setting system time

The system PCs RAC, PAC and SAC will synchronise during start up if the following procedure is performed.

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1. Start vehicle. This starts the RAC and its software.

2. Start the SAC.

3. Start SAC SW after RAC SW has booted.

4. PAC will time sync when power is turned on.

## 5.3. Power ON procedure - untethered operation

Power the system on according to the following procedure. This is for an untethered operation using the vehicle powered by the battery:

1. Ensure that the system is connected as per the system diagram either using WiFi, tether, or patch cable.
2. Before starting the vehicle, make sure that someone is standing beside the vehicle ready for the PRE-Dive check. Make sure that there is good communication between the pilot and deck personnel. When ready, inform the deck personnel that the vehicle is to be switched ON and that it is safe to start the vehicle.
3. Start the vehicle using the start key. Follow the instructions on the start key.
4. Turn on the power to the SCU after the vehicle. This is important as the vehicle computer time synchronizes with SCU computer.
5. Turn on the power to the Monitors, SCB and POCB.
6. Start the SAC and HMI software located on the desktop.
   Once the values on the HMI change from red to white, then the vehicle and SCU have communication.
7. Always check the Event Log to verify the system integrity.
8. On the Event screen, use “Suppress always” button for optional equipment that is not installed or used on the system.
9. Set the buttons on the HMI in accordance with the following list:

- Overview tab:
    - Thruster disable (The thruster is default disable).
    - All LV HUB channels disabled
    - Joystick sensitivity: 25%.
    - Control Modes: Deck.
    - V. Mode: Depth
- Control tab:
    - Doppler: On. (Check the Event screen for bad DVL data)
    - Lamps: Off

10. Check the communication to the POCB.
11. Switch on the power channels to the thrusters under power tab (HVHub). Switch on the power channels to the cameras, obstacle sonar, and tilt unit under power tab (LVHub).
12. A Press the button "Thruster enable" in the overview window. Check that no propellers are rotating and that the lamps are not lit.
13. Perform a pre dive check making sure that all is working before diving.

## 5.4. Power ON Procedure using PSU

This procedure describes how to power on the system using the PSU only.

1. Make sure that the system is connected as per the system diagram either using WiFi, tether, or patch cable.
2. Make sure that end cap on "Start key" extension lead is assembled.
3. Start the PSU main breaker on the cabinet.
4. Start the SCU.
5. Start the SAC and HMI Software located on the desktop.
6. On the HMI, the PSU values will change display from red to white, the PSU and SCU have communication.
7. On the HMI, activate the PSU "Enable Power". Monitor the events on HMI to observe any PSU errors and warnings that display during start up. Press "Suppress once". After this, the PSU events are no longer listed. If not, check any messages and take action.
8. The vehicle is now on. Always check the event log to verify system integrity.
    a. If there is optional equipment not installed or not used on the system. Use "Suppress always" button.
    b. Always disable LV/HV hub and thruster when not used or away from system.
9. For Time Synchronization, close the Node Manager SAC on SCU. Start the SAC software again in order to get time synchronization with RAC.

### 5.5. Pre-dive procedure

See Task 1, chapter 8.

### 5.6. Mission planning

See chapter 3.

### 5.7. Post dive procedure

See Task 2, chapter 8. To make sure the system is operationally ready for the next dive, always perform a post dive after the mission is completed.

### 5.8. Power OFF Procedure - Untethered Operation

The Power Off procedure is based on what is following after the power off. For example, preparing for a new dive immediately or in several days, or for transit and demobilisation.

Remember if the vehicle needs to be air freighted, the cell voltages must be at 3.5V.

1. Download data and post dive.
2. If direct to a new dive but with a temperature colder than +10°C:
    a. Leave the vehicle on.
    b. Charge the vehicle.
    c. Prepare for the new dive.
3. If the new dive is in a temperature warmer than +10°C:
    a. Power off the vehicle by removing start key.
    b. Charge the vehicle.

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c. Prepare for the new dive.

4. If the vehicle needs to powered off for transit and demobilisation:

   a. Power off the vehicle by removing start key.
   b. Charge vehicle to cell voltage 3.5V.

## 5.9. Emergency procedures

The vehicle system is designed to have an inbuilt robustness to manage disturbances or periodical or random errors that could occur with faulty sensors, bad data, internal noise etc.

For example, if there is a glitch in sensor data that is on or above a stated threshold, the vehicle will take the decision to abort. This type of event will trigger different behaviours in the vehicle. Figure 5.9 shows how the vehicle behaviour is set up in the software.

**Hover**: The vehicle will stay in the water column hovering until a watchdog trips.

**Surface**: The vehicle will directly go to surface and tries to maintain position.

**Float**: The vehicle will go into direct into deck mode “DM”.

**Red box**: Indicates a none recoverable state.

For example, if a prolonged DVL link error occurs this could result in a “Hover” state. If the link error persists when a watch dog runs out, the vehicle condition will change again in accordance with Figure 5.9.

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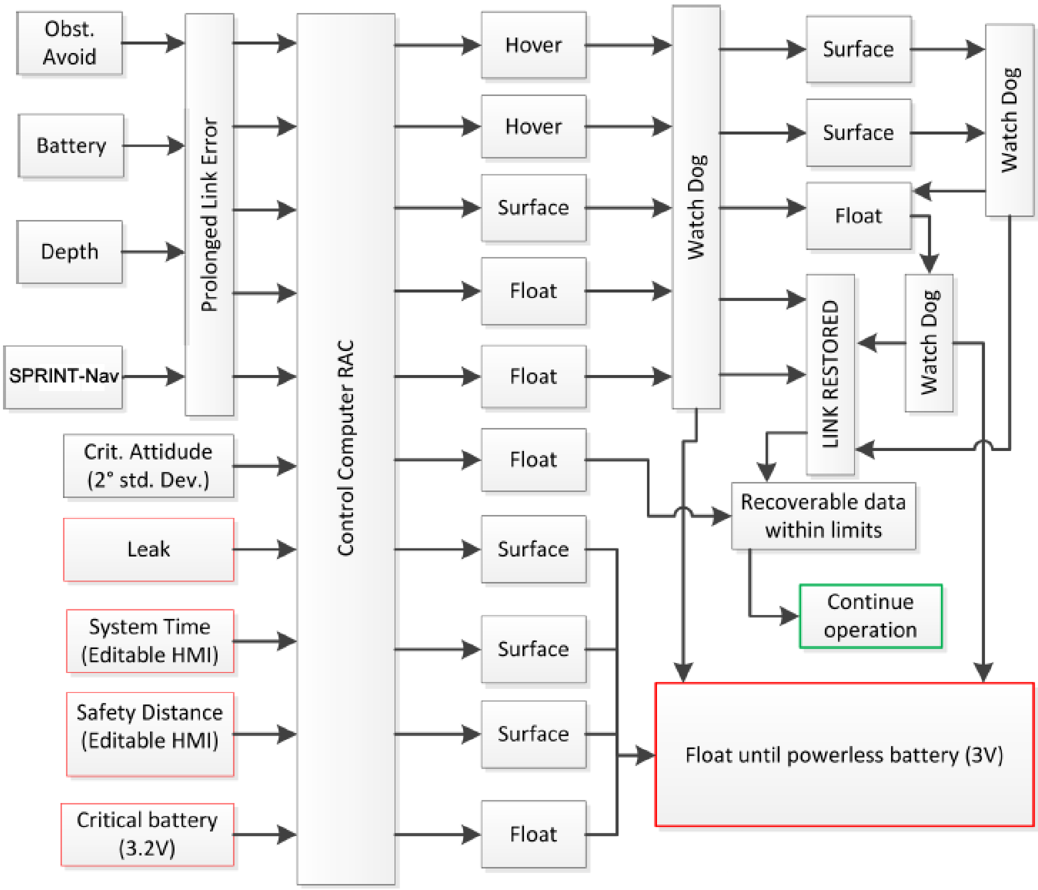


**Figure 5.9: Emergency procedures**

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## 5.10. Power Up Issues

### 5.10.1. Vehicle Does Not Start

If there is no contact with vehicle after start up, do the following in this order and continue to follow this order until root cause is identified and solved.

1. Check that the SCU and the SAC and HMI started up correctly.
    a. Make sure that the correct software is started and is compatible with vehicle software.
2. Check communication with other means fibre, WiFi, radio, and patch cable.
    a. Is there a communication problem between vehicle and SCU? Test by using different communication paths.
3. Check that the battery starts up.
    a. Verify that all contacts looks OK on the Control pins on start key and sockets in extension lead for start key.
    b. Use the Start key as described on it. Listen for two clicks per battery with approximately 5-10 seconds between. Wait a minimum of 1 minute before attempting to power cycle vehicle multiple times.
    c. Use the serial cable SL79-2500 to reach battery on lower level. Check the vehicle diagram for which connector to use on vehicle. The Start key needs to be inserted. Follow the instruction on task “BMS Serial Interface”.
4. Remove the start key connect charger/s, see the section “Battery charger” or the task Charging Battery. Does charger start? If the battery is full, it will not start but should see the battery connects. If the battery is not connected, insert the start key. If the battery is still not connected, continue with step 5.
    a. Using both “BMS on” charger and the start key means the likelihood for BMS on/off signal is not root cause.
5. Open the lid to access electronics front on battery to check 56A fuse. If fuse is blown, replace with special isolated tool. Do a full start up procedure with lid closed but not vacuumed tested. If OK, vacuum test accordingly and close the vehicle.
6. Continue to measure all cables related to battery.
7. Remove the battery and replace with new battery. Configure the spare battery according to the appropriate task.

### 5.10.2. With only PSU Power

1. Check that SCU and that SAC and HMI have started up correctly.
    a. Make sure the correct software started is compatible with the vehicle software.
2. Check that the “power enable” displays green in HMI.
3. If not displaying green, there is no communication between PSU and SCU. Fault find the RS485 link between SCU and PSU.
4. If power enable is green, check the voltage on transformer unit connector PSU.

**DANGER: 350VDC IS PRESENT.**

5. If the voltage is OK, open starboard rear lift and continue to check the cable and check the main capacitor.
6. Power up the PSU and follow the voltage. Where does it stop?

### 5.10.3. Battery Display on HMI is not working

If vehicle is powered, but there is no Ethernet communication from battery to HMI, ping the address of the battery. If no communication, also use the web interface by entering the battery IP address into the web address window. If there is no success to communicate, see "Vehicle Does Not Start" on page 5.14 and follow step3 c. If the serial interface works and BMS reports OK, the most likely root cause are as follows:

- Ethernet connectors on the battery or on the switch are loose.
- Ethernet cables are damaged.
- Power to Ethernet switch.
- Port on Ethernet switch/s are damaged, change to other port. Main Planet switch remember to set up port as original VLAN configuration using Planet web GUI.

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# CHAPTER 6

# SYSTEM FUNCTIONAL DESCRIPTION

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# 6. System Functional Description

This chapter describes the various functions of the Sabertooth system.

## 6.1. Power Supply Unit (PSU)

The PSU is the unit that supplies the vehicle with power when it is not powered with the batteries, it also contain a battery charger that can charge all three batteries at the same time. The charger can be removed and must be placed in the separate box when used “stand alone”.

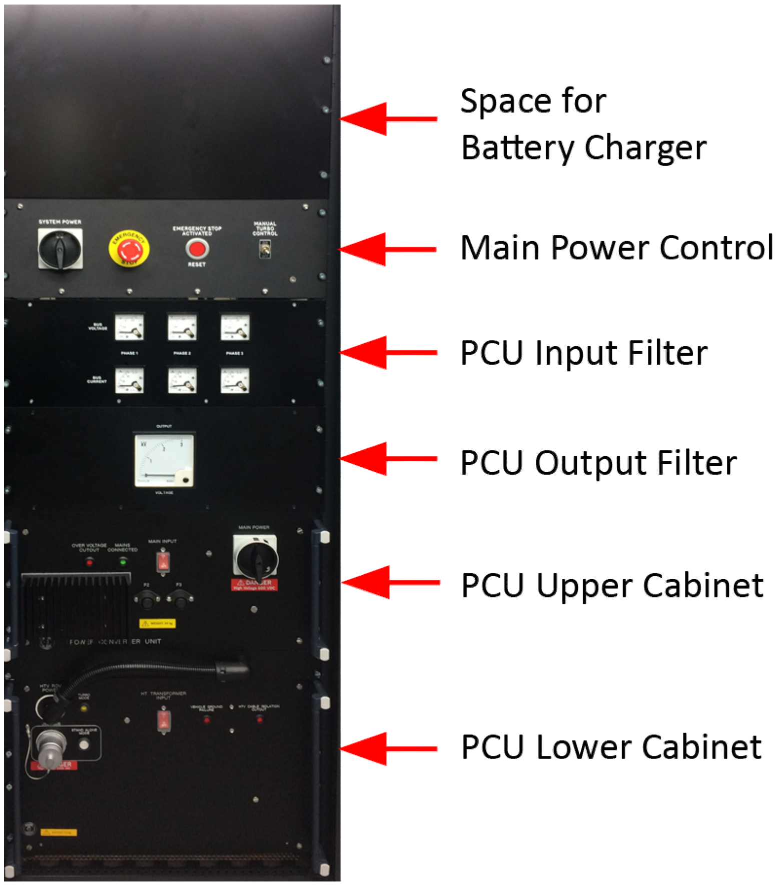


**Figure 6.1: PSU cabinet**

| Unit | Description |
|---|---|
| Battery charger | Used for charging the vehicle batteries. It can charge all three batteries at the same time. |
| Main power control unit | A 3-phase Main power switch turn ON/OFF the incoming main power to the PSU cabinet, except to the battery charger.<br><br>An emergency stop button switches OFF the incoming power when pressed, and the red push button illuminates. The emergency stop |

| | |
|---|---|
| | is reset by turning and pulling out the emergency stop button and pressing the red reset button. Capacitors and chokes for reducing the disturbance on the 3-phase input and the HV output are mounted inside the unit.<br><br>The Manual Turbo Control button allows the operator to manually select the turbo control to ON / OFF. Turbo control should only be set to ON when the vehicle is in the water. Turbo control should be set to OFF when the vehicle is on deck. |
| PCU input filter | Filters the 3-phase Main input to the PCU. Displays the 3-phase Main power voltage and current on the front panel when switched ON by the Main power switch. |
| PCU output filter | Filters the PCU HV output. Display the HV power from the PCU on the front panel. The power out from the PCU is connected to terminal blocks at the rear of the PSU cabinet. The deck cables are connected to the same terminal. |
| PCU upper cabinet | Rectifies and stabilize the main power and via a cable connect the DC voltage to the lower cabinet. |
| PCU lower cabinet | Convert the incoming DC voltage from the upper cabinet into a 800Hz square wave power that is transformed up to 2700V. The reason for the high voltage is that a thinner tether can be used. The cabinet contains insulation and GND sense monitoring circuits. |

### 6.1.1. Main Power Control Unit

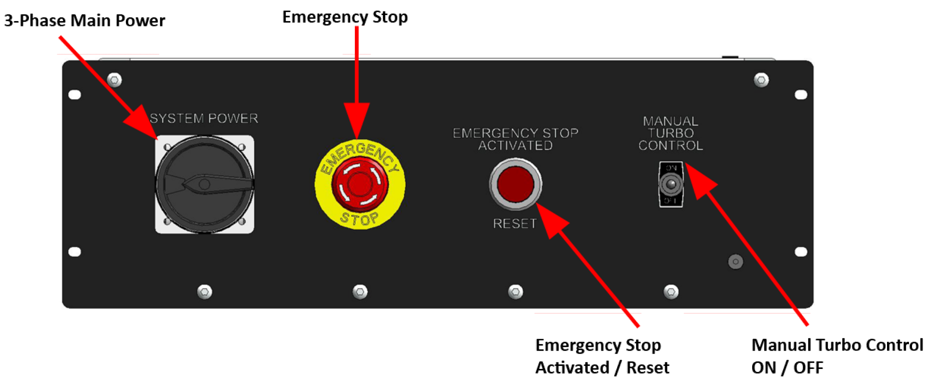


**Figure 6.2: Main power supply unit**

The input 400 / 440V Main power 3-Phase is connected to the Mains power switch, which, via a contactor and the PCU input filter, supplies the PCU. If the emergency stop is pressed the power to the PSU is switched off.

A red push button is lit up if the emergency stop is pressed. To reset the emergency stop first switch off the vehicle in the HMI and then the PCU. Turn and pull out the emergency stop button and push the red button to reset the emergency stop.

**WARNING - DANGER TO PERSONNEL:**

THE EMERGENCY STOP WILL NOT POWER OFF THE VEHICLE IF THE VEHICLE IS POWERED BY THE BATTERY.

The Manual Turbo Control button allows the operator to manually select the turbo control to ON / OFF. Turbo control should only be set to ON when the vehicle is in the water. Turbo control should be set to OFF when the vehicle is on deck.

**CAUTION - Possibility of damage to the vehicle:**

Do not set the turbo control to on when the vehicle is on deck. Using the turbo while on deck can cause damage to the transformer unit due to a heat dissipation issue.

**NOTE: Before restarting, examine why the emergency stop was pressed.**

| Unit | Function |
|---|---|
| MAIN POWER | Switches ON/OFF the 3-phase power to the PSU rack. |
| EMERGENCY STOP | Switches OFF the 3-phase power to the PSU rack. |
| PUSH BUTTON | Illuminates if emergency stop is activated / reset the emergency stop. |
| MANUAL TURBO | Select the turbo control to either ON / OFF. Only select ON when the vehicle is in the water. |

### 6.1.2. PSU Input Filter

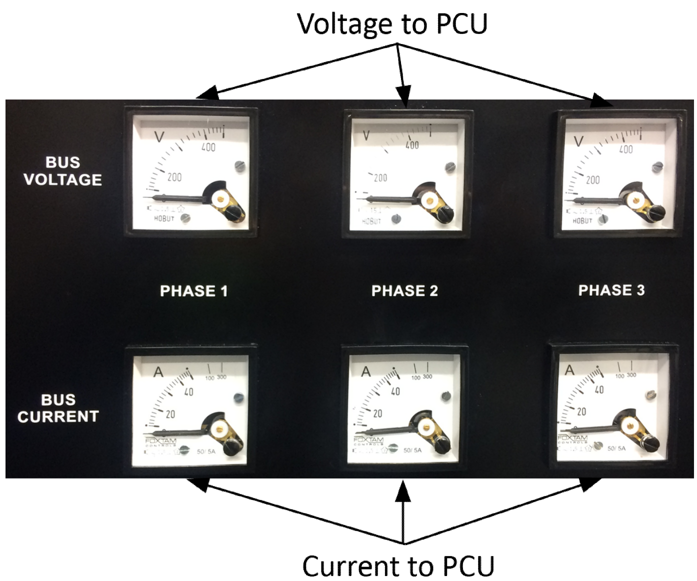


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**Figure 6.3: PSU input filter**

The Main power 3-phase from the Main Power Control unit is connected the PSU input filter. Via ampere and voltmeters the power is connected to a 3-phase input filter unit that is connected to the PCU. The filter is used to reduce disturbance on the incoming 3-phase power.

### 6.1.3. PCU Output Filter

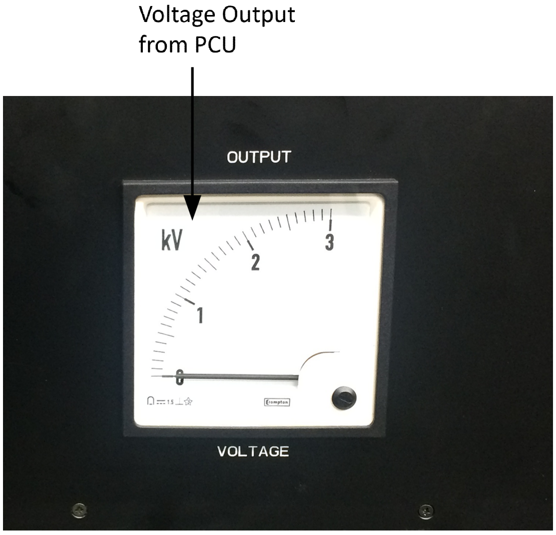


**Figure 6.4: PCU Output Filter**

The HV output from the PCU is connected to a high voltage filter unit and then connected to the deck cable via terminal blocks. A panel instrument display the high voltage level.

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### 6.1.4. Power ON Procedure

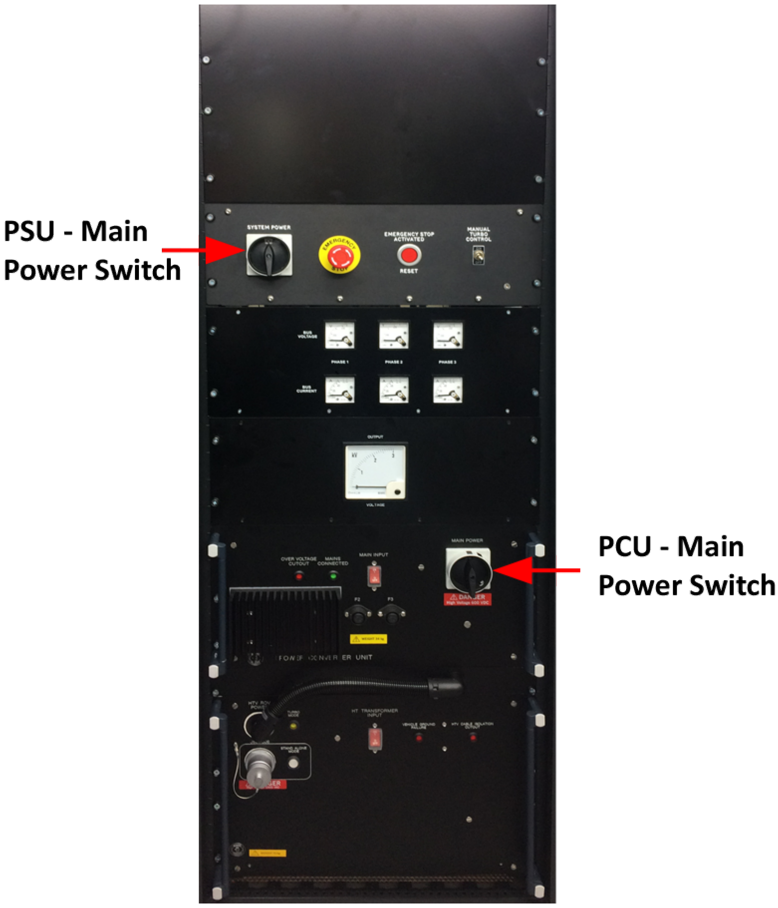


**Figure 6.5: Power ON procedure**

Power on procedure:

1. Check that the vehicle ON/OFF is in OFF position on the HMI.
2. Switch ON the PSU MAIN power switch.
3. Switch ON the PCU MAIN power switch.
4. Check that it is safe to start the vehicle.
5. Switch ON the vehicle in the HMI.
6. Check communication and video.
7. Perform a pre dive check.

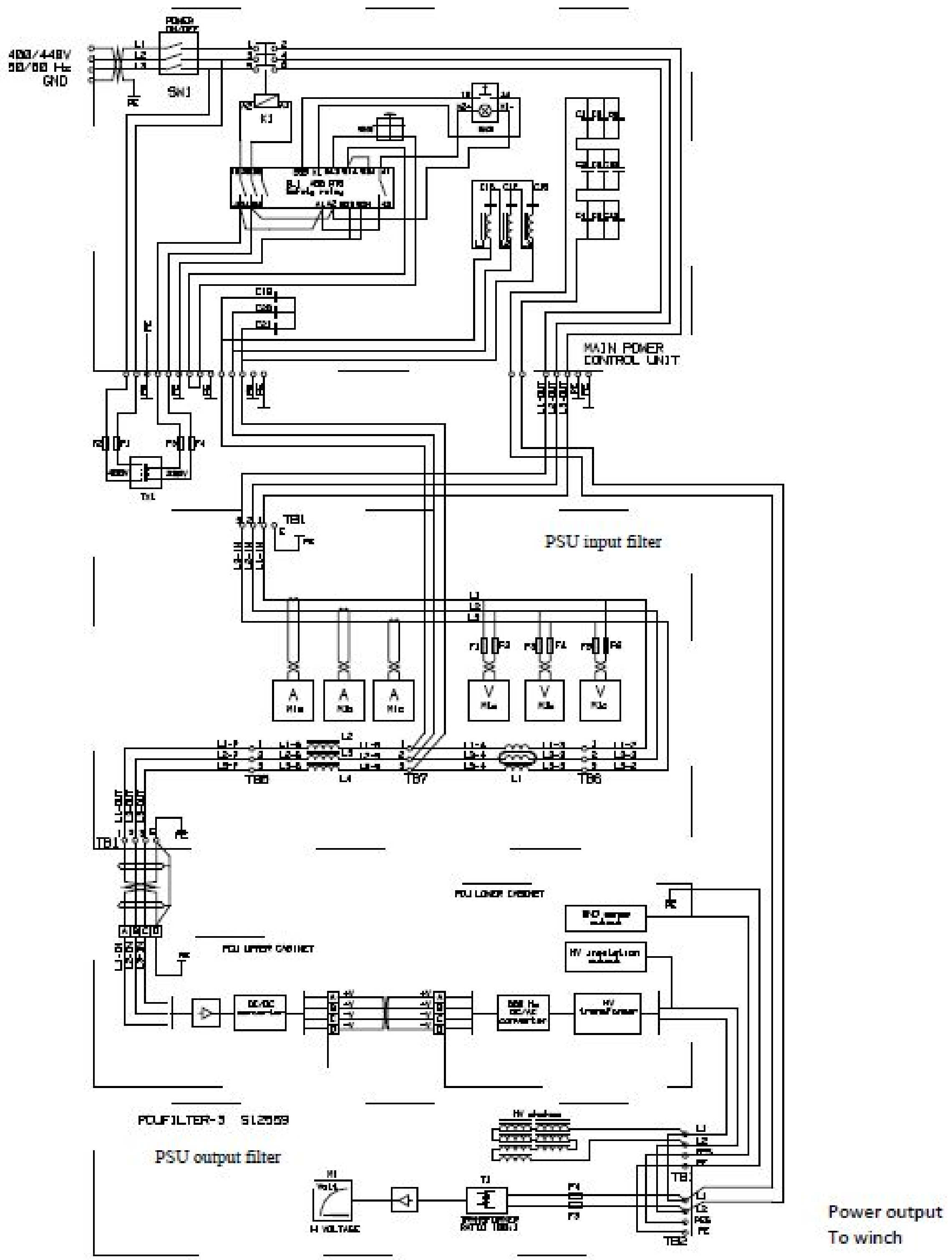


Figure 6.6: PSU Schematic

## 6.2. Battery charger

The stand alone battery charger consists of three chargers that can charge all three batteries at the same time.


**Figure 6.7: Battery charger front and rear views**

The unit is supplied with 230 or 400 VAC three phase connected to the rear panel and has three power outputs for the three batteries.

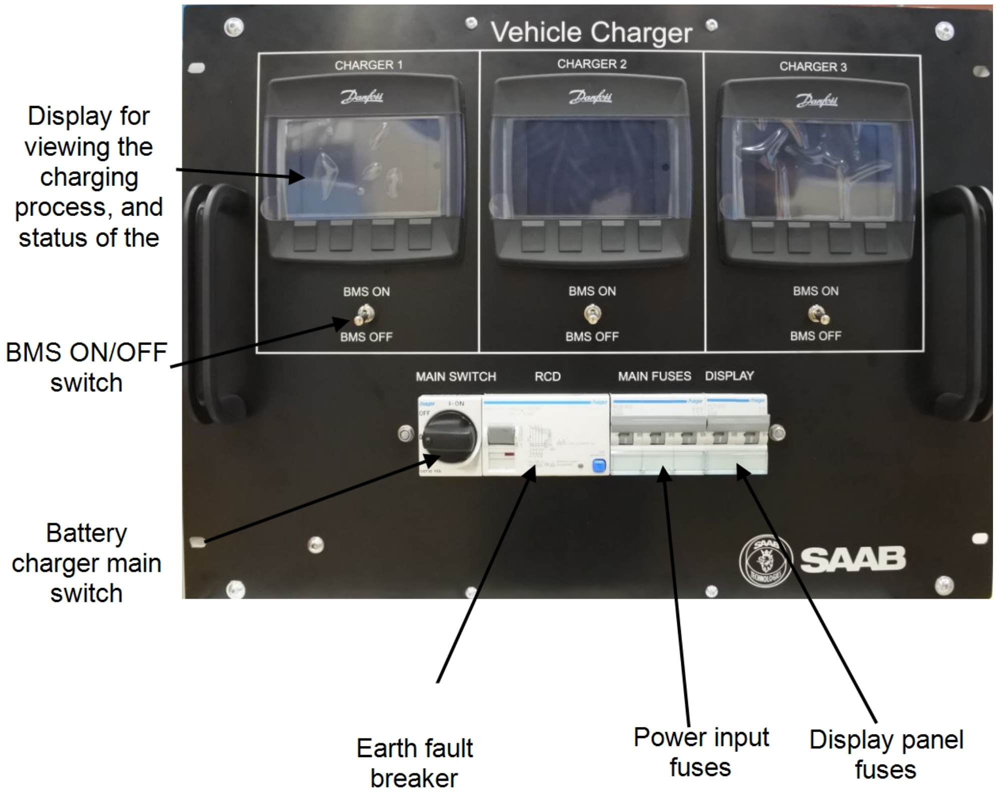


**Figure 6.8: Battery charger front panel**

| Labels on front panel | Function |
|---|---|
| MAIN SWITCH | Switches on the 3-phase main input |
| RCD | Earth fault breaker for the 3-phase main input |
| MAIN FUSES | Fuse for the 3-phase main input |
| DISPLAY | Fuse for the panle display |
| BMS ON/OFF | When switched ON the BMS is started and starts searching after a charger |
| CHARGER 1, 2 & 3 | Display showing the charging process and staus of the connected |

| Labels on front panel | Function |
|---|---|
| | batteries |

The charger consists of three identical chargers, one for each battery. It can be supplied with 230 V three phase or 400 V three phase plus neutral. The charger is connected between phase and neutral to get 230 V to the charger. There are two different power cables, one for 230V supply and one for 400V supply identified by two different coloured adaptors.

The three phase power supply for the chargers is connected on the rear panel.

The power is switched ON by a main power switch on the front panel. An earth fault breaker will switch OFF the power in case of an earth fault between power and GND. After the earth fault breaker there are two circuit breakers, one for the chargers and one for the displays.

Each of the three charger modules communicates with the corresponding battery BMS by means of a CAN bus. The CAN bus handles all information sent between the BMS, the charger module and the associated display. To start the charging each of the BMS switches shall be switched ON. At this point each BMS is starting to search for the corresponding charger module. A charging relay in each battery module in the vehicle is switched ON. When this happens, the battery voltage will charge the output capacitor in the battery charger module through a resistor, and after approximately. 1 sec. a relay in the charger is switched on that will short circuit the resistor and then the charging is started.

When the charging is finished, switch OFF the BMS switches. Switch OFF the charger main power switch and disconnect the charger connectors from the vehicle.

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### 6.3. Surface Communication Box


**Figure 6.9: Surface communication box (SCB)**

The Sabertooth system has several means of communication. When the vehicle is used in untethered mode the communication with the surface equipment can be done using Wi-Fi or a radio modem. The Surface Communication Box (SCB) contains equipment and interfaces for these means of communication.

The SCB contains a Wi-Fi access point and a radio modem. There is an Ethernet serial port server so communication with the radio modem can be done with Ethernet. The SCB also contains power supplies to the different units.

### 6.4. Surface Control Unit (SCU)

The Surface Control Unit (SCU) is the unit at the surface that is responsible for presentation of the HMI, control and communication via the fiber (in the tether cable) to the vehicle or wireless via Wi-Fi or radio modem (SCB).

The SCU consists of:

- Surface Application Computer (SAC).
- Gigabit Ethernet switch with fibre optic SFP
- POCB receiver box for interfacing the POCB.
- Serial port server.
- 24VDC and 12VDC power supply for all internal units

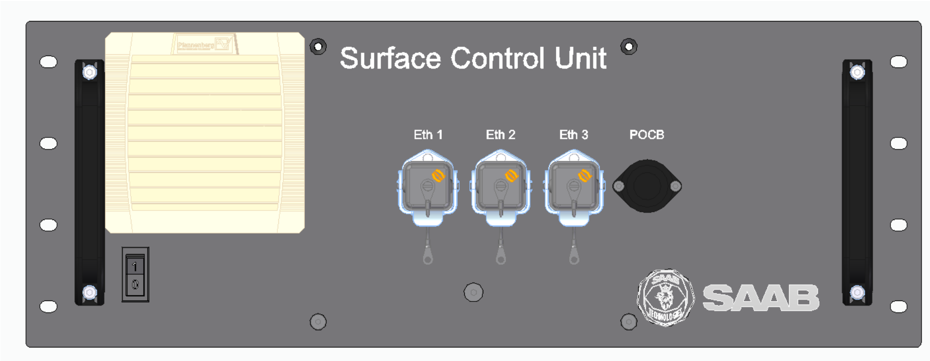


**Figure 6.10: Surface control Unit (SCU)**

The power switch is situated on the front side of the SCU, and fuses are placed in the power inlet on the rear side of the SCU.

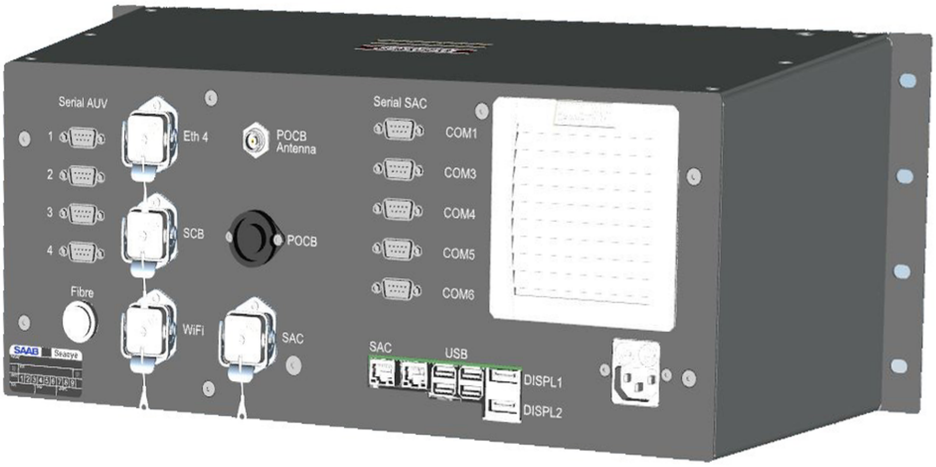


**Figure 6.11: SCU Rear Side**

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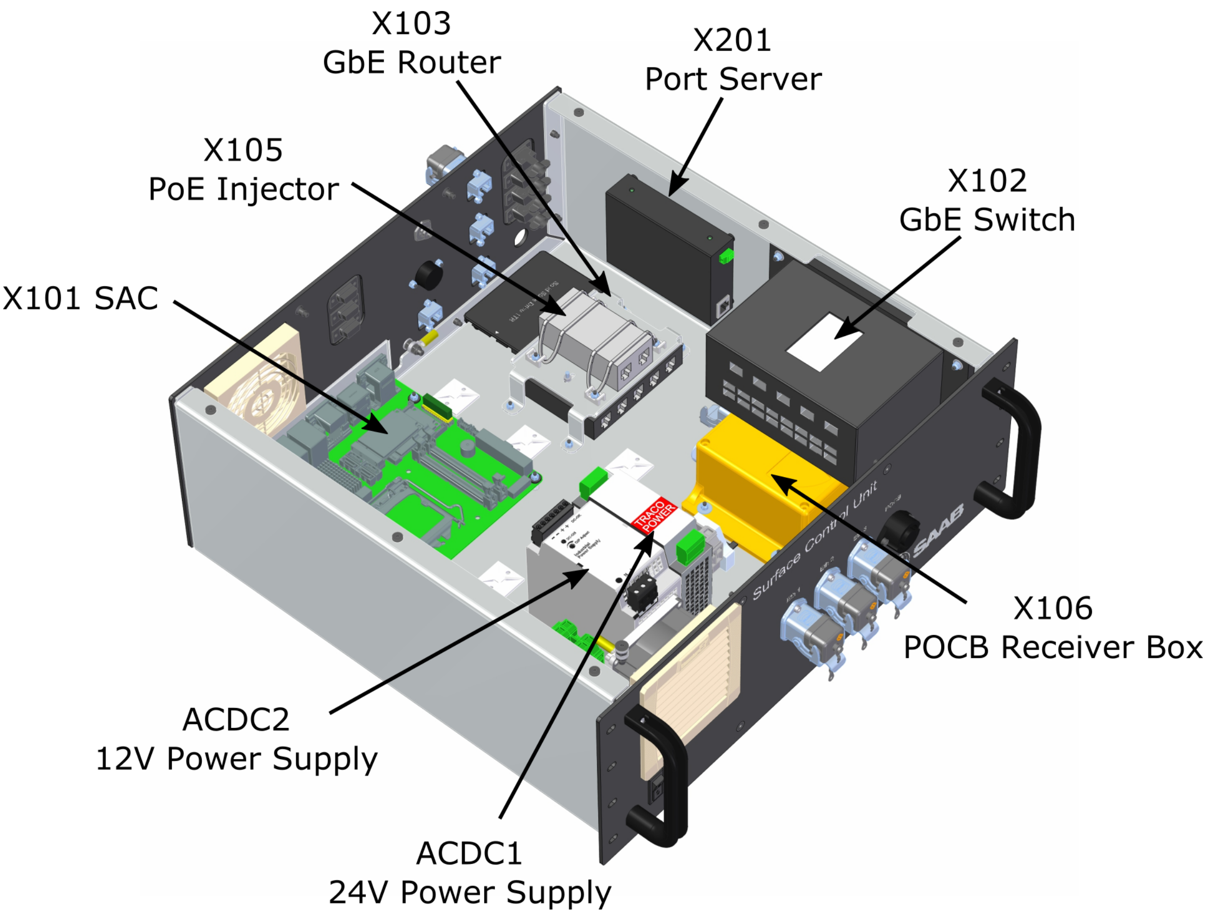


**Figure 6.12: SCU opened**

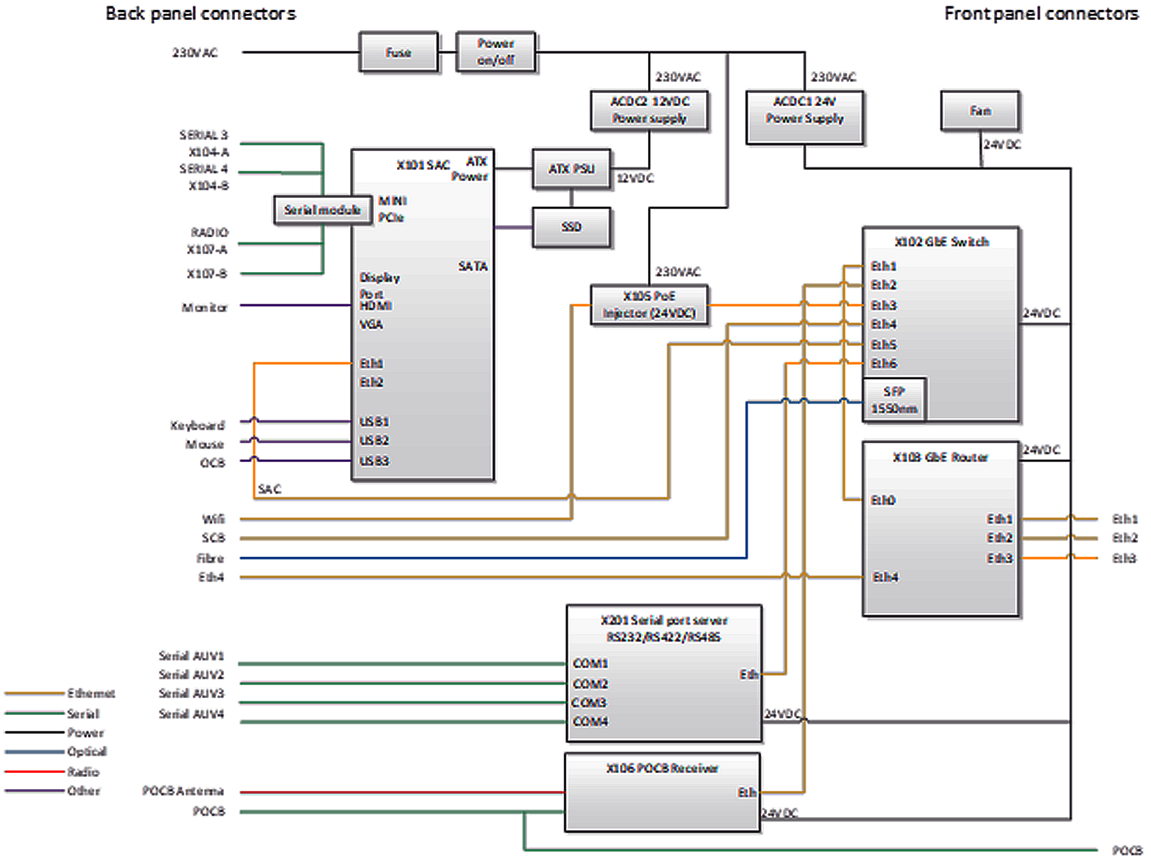


Figure 6.13: Surface control unit (SCU)

## 6.5. Operators Control Board (OCB)


**Figure 6.14: Operators control board (OCB)**

The OCB contains a small processor board that reads the analog joysticks and the digital switches. The information is sent to the SAC using standard Human Interface Device (HID USB protocol in windows) interface over USB. The OCB is also powered from the SAC USB connector.

## 6.6. Portable Operators Control Box (POCB)

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**Figure 6.15: Portable operators control box (POCB)**

The POCB is connected to the SCU via radio. It is used for PRE, POST dive tests and for manoeuvring the vehicle during launch and recovery.

## 6.7. Vehicle Overview

The vehicle is constructed from a chassis of polypropylene (PP). Within this chassis the buoyancy material is mounted at the front and aft. The carbon fibre composite pressure hulls are mounted in the chassis within a stainless steel structural assembly. Additional buoyancy material is mounted around the pressure hulls.

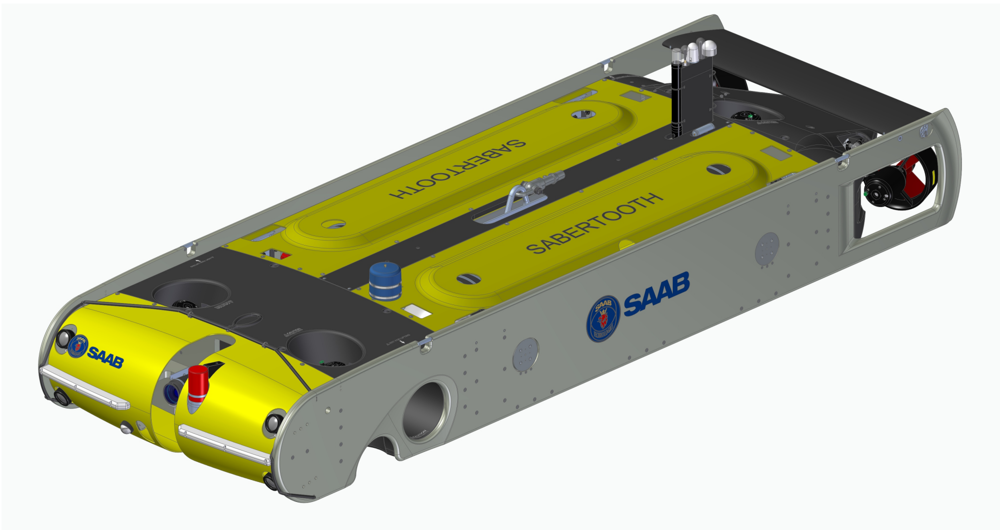


**Figure 6.16: Vehicle**

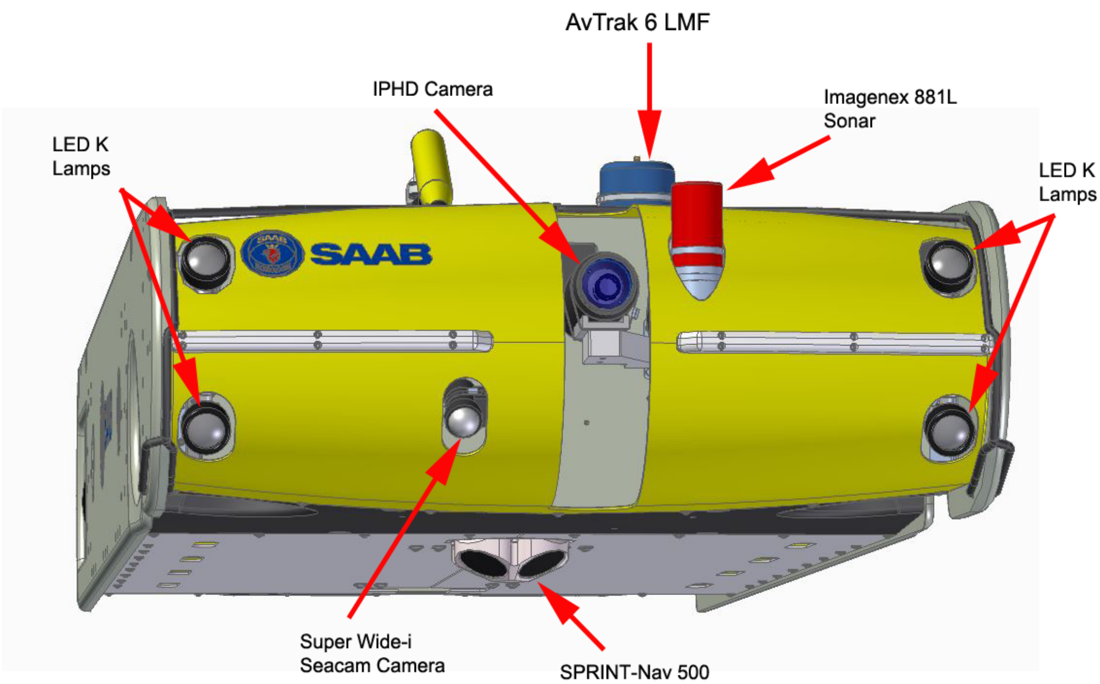


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**Figure 6.17: Vehicle Front**

### 6.7.1. Vehicle Electronics Pods

The vehicle batteries and electronics are housed inside starboard and port Electronic Pods (EPODs). The port hull contains two battery modules and associated power and monitoring electronics. The starboard hull contains the main navigation and control electronics in the front lid and high voltage power management in the aft lid. The starboard hull also contains one battery module.

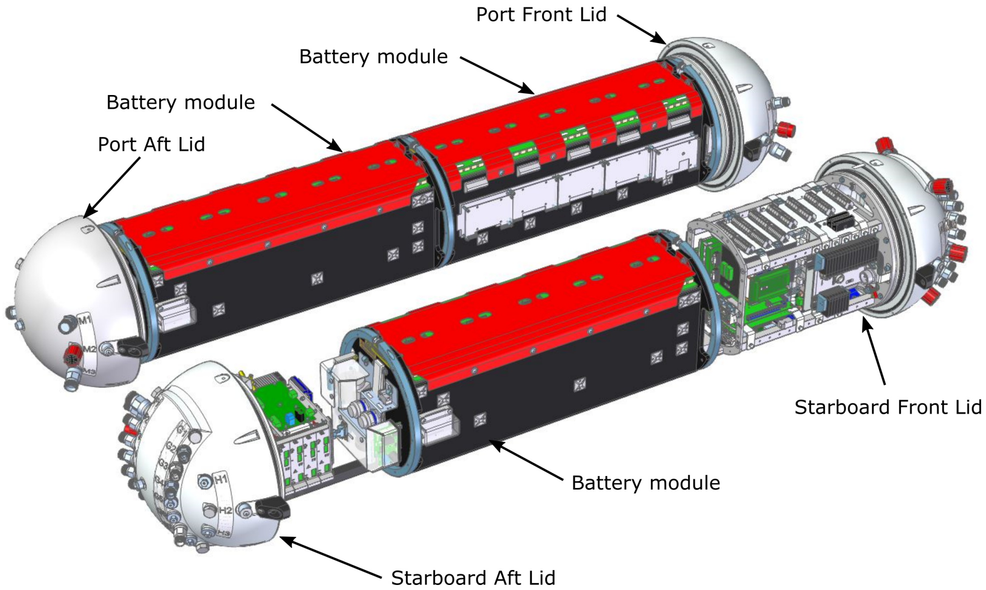


**Figure 6.18: Starboard and Port EPOD internals**

### 6.7.2. Battery Modules

The Sabertooth vehicle is equipped with three lithium polymer battery modules, each consisting of 70 cells connected in serial. The cells are packed together in cell modules consisting of 14 cells each. There are 5 cell modules in each battery module. Since the cells have a nominal voltage of 3.7 V and a capacity of 40 Amp hours (Ah), this results in a total nominal voltage of approximately 260 V and a total nominal capacity of 10 kWh in each battery.

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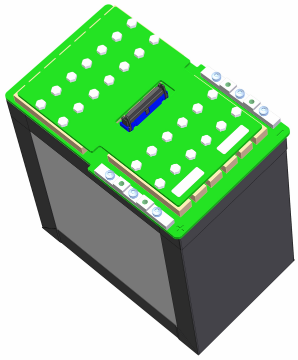

Figure 6.19: Battery cell module

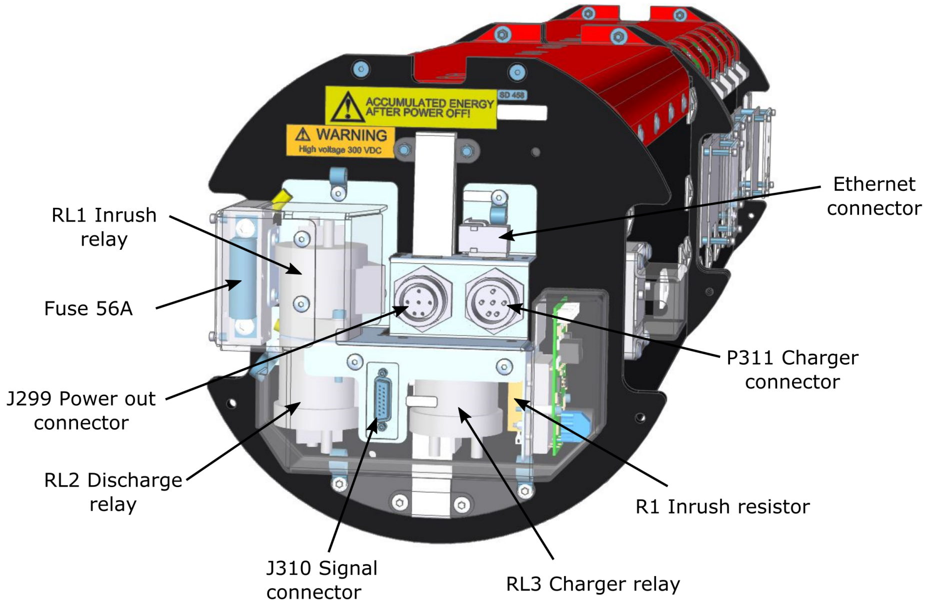


Figure 6.20: Battery overview, connections

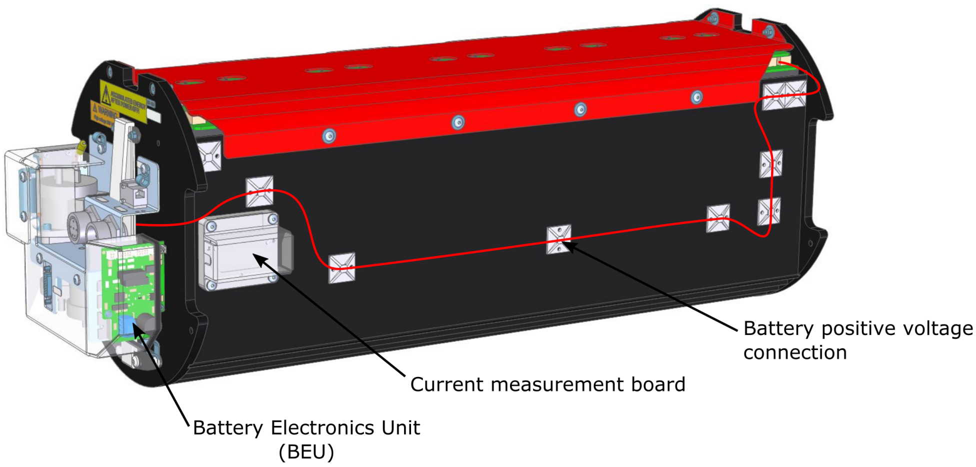


Figure 6.21: Battery right side components

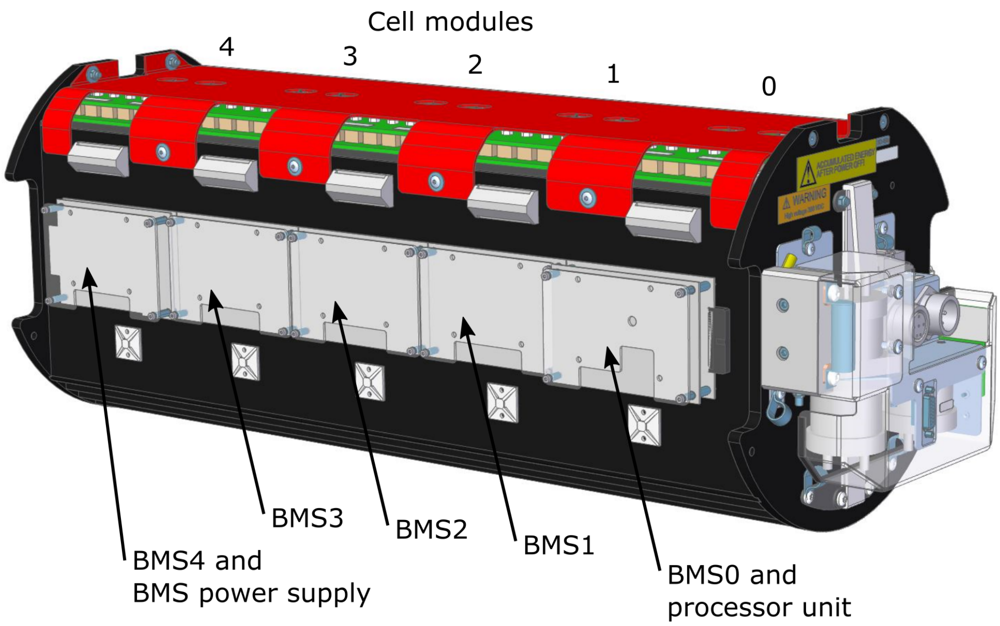


**Figure 6.22: Battery left side components**

The large amount of energy stored in the battery needs to be monitored to ensure safe operation and long battery life. Therefore each cell is monitored by a Battery Management System (BMS) which monitors cell voltages, temperatures and current usage.

If any cell voltage gets too low or any temperature gets too high, the BMS will disconnect the battery output.

To maintain the capacity of the battery the BMS will balance the voltage levels between the individual cells. The target is that all the cells should have the same voltage so the full capacity of the battery can be used. This process is called equalizing.

To save the battery from discharging when not in use, equalizing will stop when any cell voltage gets below a minimum level or when all cells are within a certain limit. These settings are software configurable, but are factory set to 3.7V and 3mV. Normally, there is no need to change these values. The BMS communicates with the vehicle computer by means of Ethernet UDP and with the battery charger via a CAN bus.

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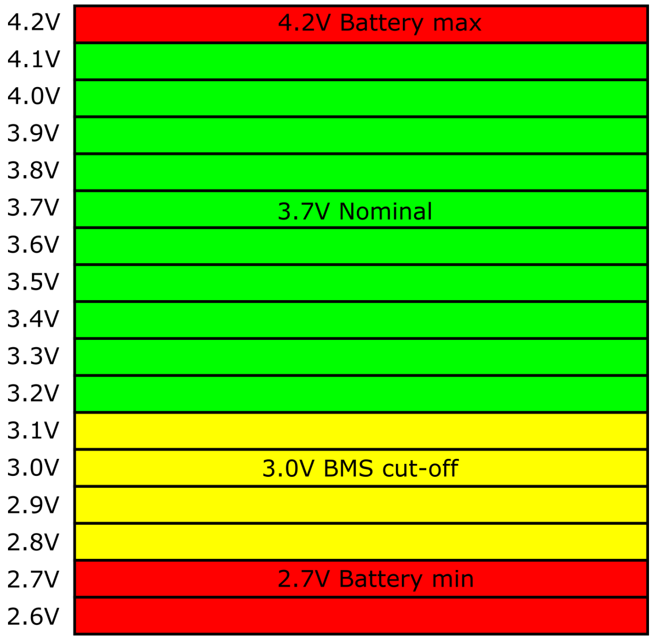


**Figure 6.23: Battery cell voltage levels**

The maximum cell voltage is 4.125 V and the battery is more or less empty at a cell voltage of 3.0V. If a cell voltage comes down to 3.0 V (@>20ºC) the BMS will cut off the power to the vehicle. This is called the Cut off Voltage (CV).

At the CV, the BMS will release the discharge relay. This happens when the cell with the lowest voltage in the battery stack falls below the CV. This is to prevent the battery package from destruction if the cell voltage gets too low. The actual CV is calculated depending on the actual temperature of the cell modules.

A system warning flag is set when the voltage of the lowest cell is 100mV above the CV.

When the vehicle is operated in manual mode, there is no warning if the battery charge is getting low. This has to be checked using the battery window in the HMI. In autonomous mode however, it is possible to trigger actions when the voltage level reaches a set level. There are also two pre-set levels at which the vehicle will first enter Emergency Surface and if the level is getting even lower it will enter Emergency mode.

The maximum and minimum total battery voltage can be calculated using the cell voltages 4.125V and 3.0V (@>20ºC) resulting in the total voltages 290V and 210V. However, the battery is more or less empty at a total voltage of 210V calculated from the cell voltage 3.0V. To save power the BMS will turn off within approximately three minutes after the start key has been removed and the equalizing process has finished.

A When battery discharge is enabled, first relay RL2 is switched on. The battery current flows through resistor R1 which limits inrush current. After approximately 1 second, relay RL1 is switched on, connecting the load directly to the battery. Relay RL3 is switched on when charging the system, connecting the charger to the battery.

NOTE: It is possible to charge the batteries even if the vehicle is ON (start key is inserted).

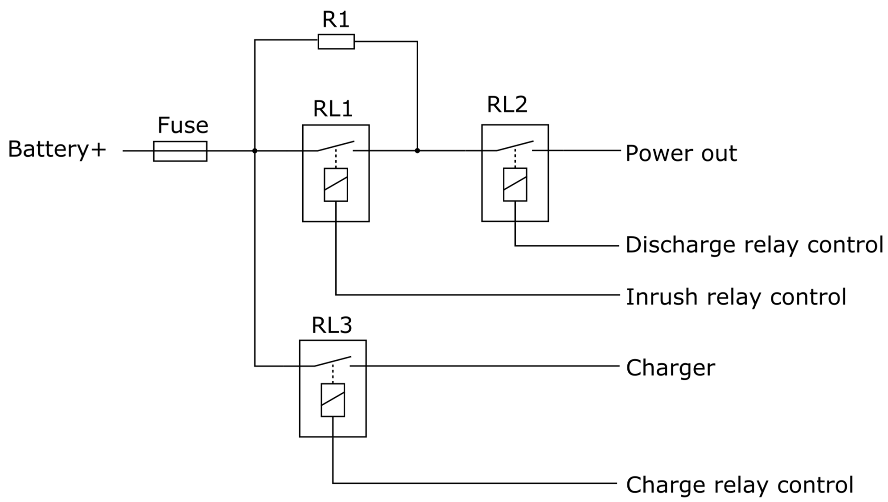


**Figure 6.24: Battery module block diagram**

### 6.7.3. Starboard front lid

The starboard front lid contains the vehicle computers, navigation system, DC/DC converters and power distribution to all sensors and external equipment.

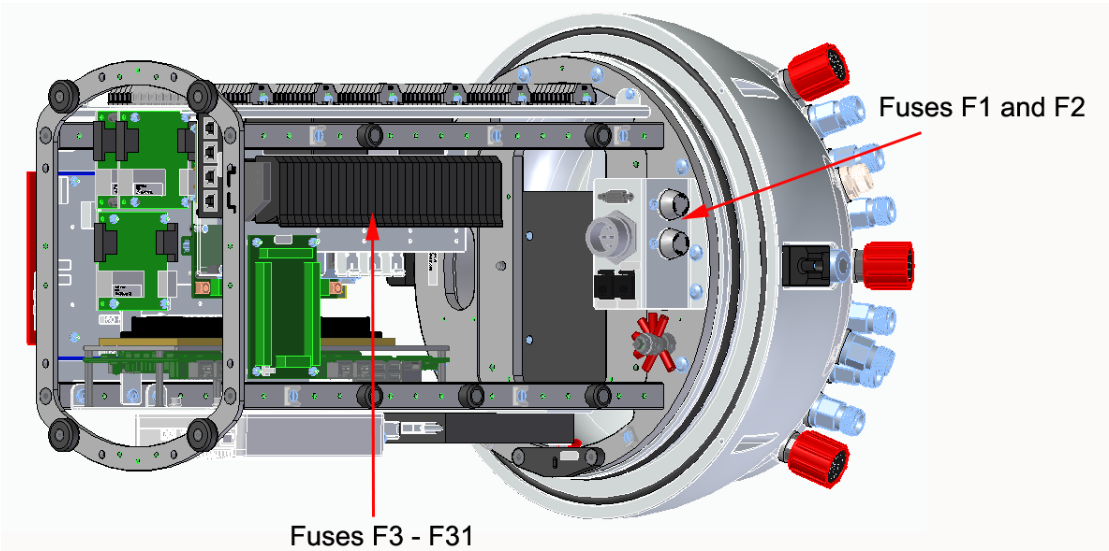


**Figure 6.25: Starboard front lid overview**

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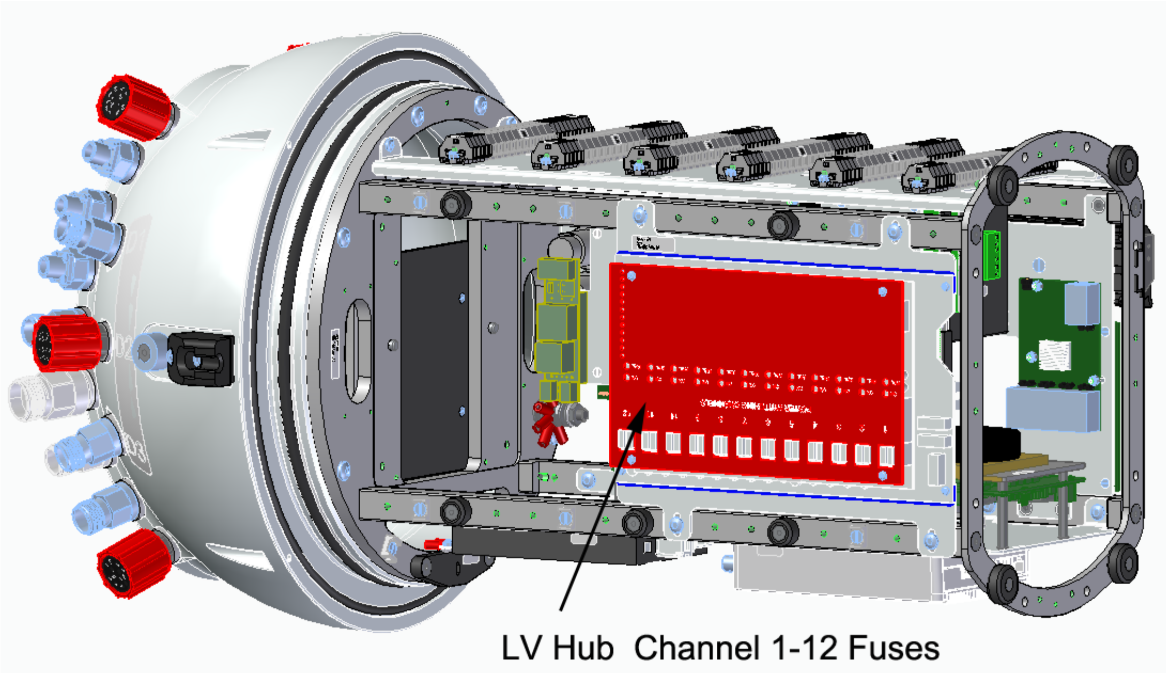


Figure 6.26: Starboard front lid overview

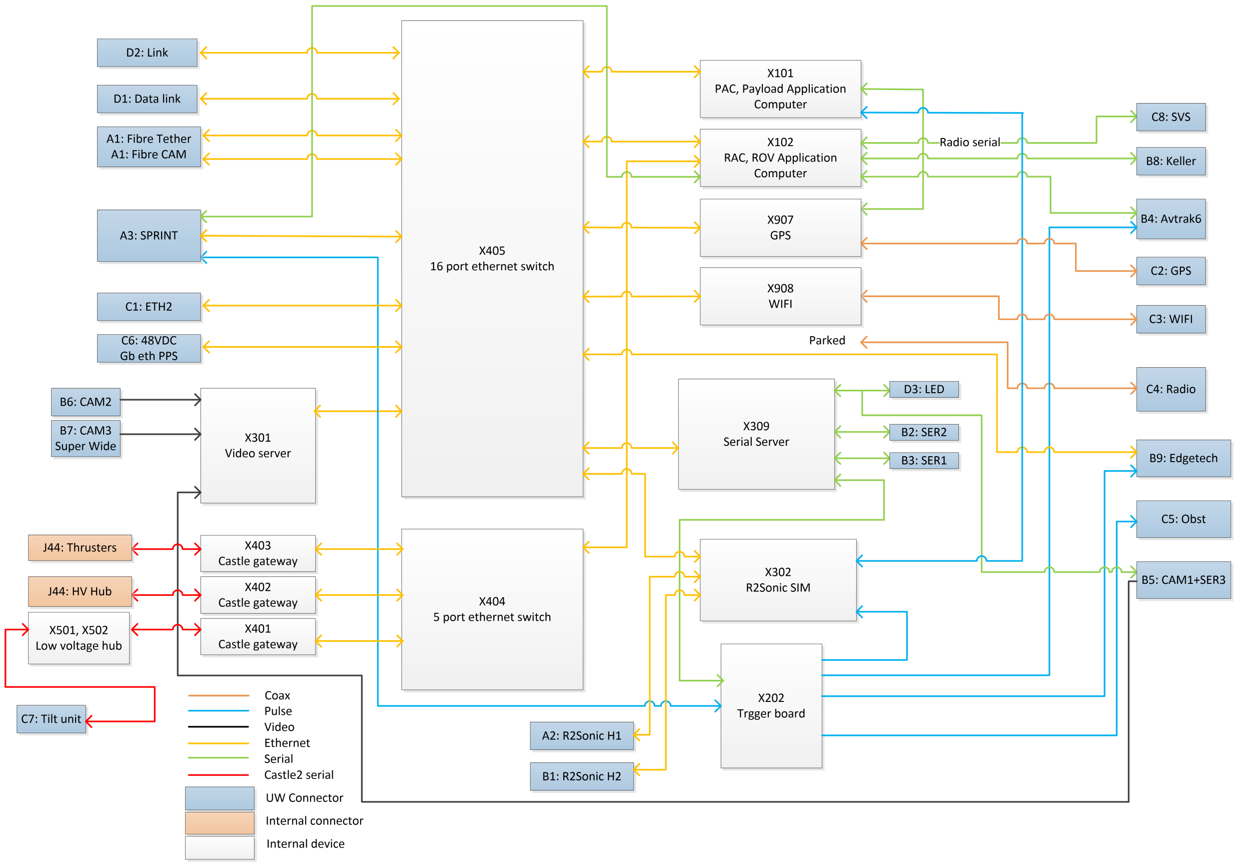


Figure 6.27: Starboard front lid block diagram

### X101 PAC Payload Application Computer

X101 is the computer that runs the sonar/sensor programs. It is a windows 10 industry embedded PC.

NOTE: The chassis of this device is connected to 12V power return, which means it must be electrically isolated from the rest of the chassis.

### X102 RAC ROV Application Computer

RAC is the computer that controls the vehicle. It is a windows 10 industry embedded PC. The RAC runs the Vehicle control system.

NOTE: The chassis of this device is connected to 12V power return, which means it must be electrically isolated from the rest of the chassis.

### X105 Serial Server

The serial server has 4 serial ports that can be configured for RS422, RS485 or RS232. It communicates with the RAC and PAC over the Ethernet network.

### X201 SPRINT-Nav 500

Device X201 SPRINT-Nav 500 is an all-in-one navigation unit that estimates the vehicle position, altitude, velocity, acceleration and attitude. These estimates are used by the control system to stabilize and navigate the vehicle. The SPRINT-Nav 500 combines inertial sensors, a Doppler Velocity Log (DVL) and a high accuracy pressure sensor into a single housing.

### X202 Trigger board

The X202 Trigger board is a programmable 8 channels square wave generator. In this application 5 channels are used for triggering the different acoustic sensors. The purpose of sending trigger signal to acoustic equipment is to ensure that the systems do not interfere with each other by transmitting at the same time. The trigger board is configured from the HMI application.

### X301 Video Server

The video server has 4 input channels which convert the composite video signal of the video cameras to a digital data stream. Each camera has its own IP-address and video server settings. Different compression, formats and frame rates can be set by connecting to the IP-address via a web browser.

### X302 R2Sonic SIM

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The R2Sonic SIM (Sonar Interface Module) controls the power to and converts the trig-pulse for the R2Sonic sonar head(s). It also receives data from GPS and SVS (Sound velocity sensor).

### X501/X502 Low Voltage Hub

The 6198/6180 cards are used for switching power and the castle2 data link on/off to different devices. Commands are sent using the Castle2 bus. The Castle2 bus is not only used for controlling the on/off switches but also handles 3 leak sensors status and is distributed to some connected units. On the top of the board there are fuses to the connected units together with LEDs, which indicate the status of the power switches.

### X401/X402/X403 Castle Gateways

The castle2 gateways convert communication from Ethernet to castle2 communication. Castle2 is a serial bus protocol based on RS485 with one master and many slave nodes. All communication on the bus is initiated by the master. Each gateway is the master of one Castle2bus/net.

### X404, X405 Ethernet switches

X405 is an industrial Gigabit switch with 16 Ethernet ports and 4 SFP module slots. Two of the SFP modules are used for fibre optic communication via UW connector A1 and two modules are used as additional Ethernet ports.

## 6.7.4. Starboard aft lid

The starboard aft lid distributes the high voltage power from the batteries to the thrusters and to the front lid where the DC/DC conveters are located. Power from the starboard battery module is received through EPOD internal cabling and power from the port battery modules is received through UW connector F2: POW. If a transformer unit is used for surface power it is connected to UW connectors in the starboard aft lid.

The external high voltage channels can be individually switched on and off in the HV Hub. Isolation between the high voltage connections and chassis is continuously monitored by a LIM (Line Isolation Monitor).

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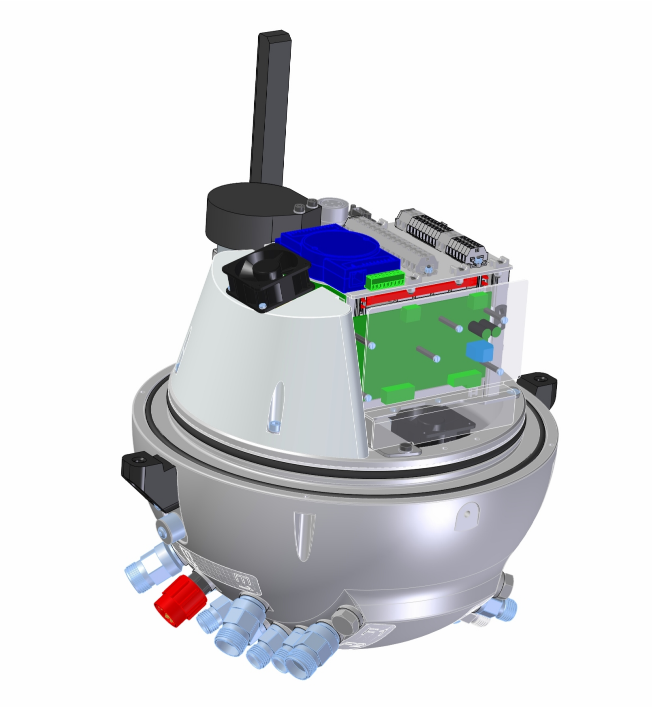

Figure 6.28: Starboard aft lid view 1

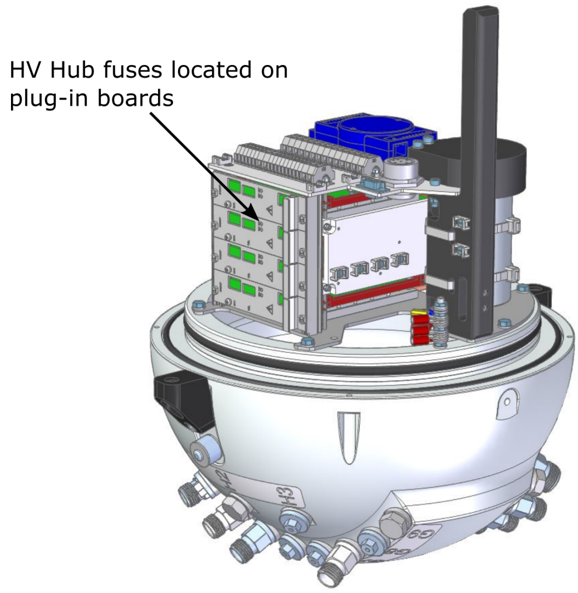


Figure 6.29: Starboard aft lid view 2

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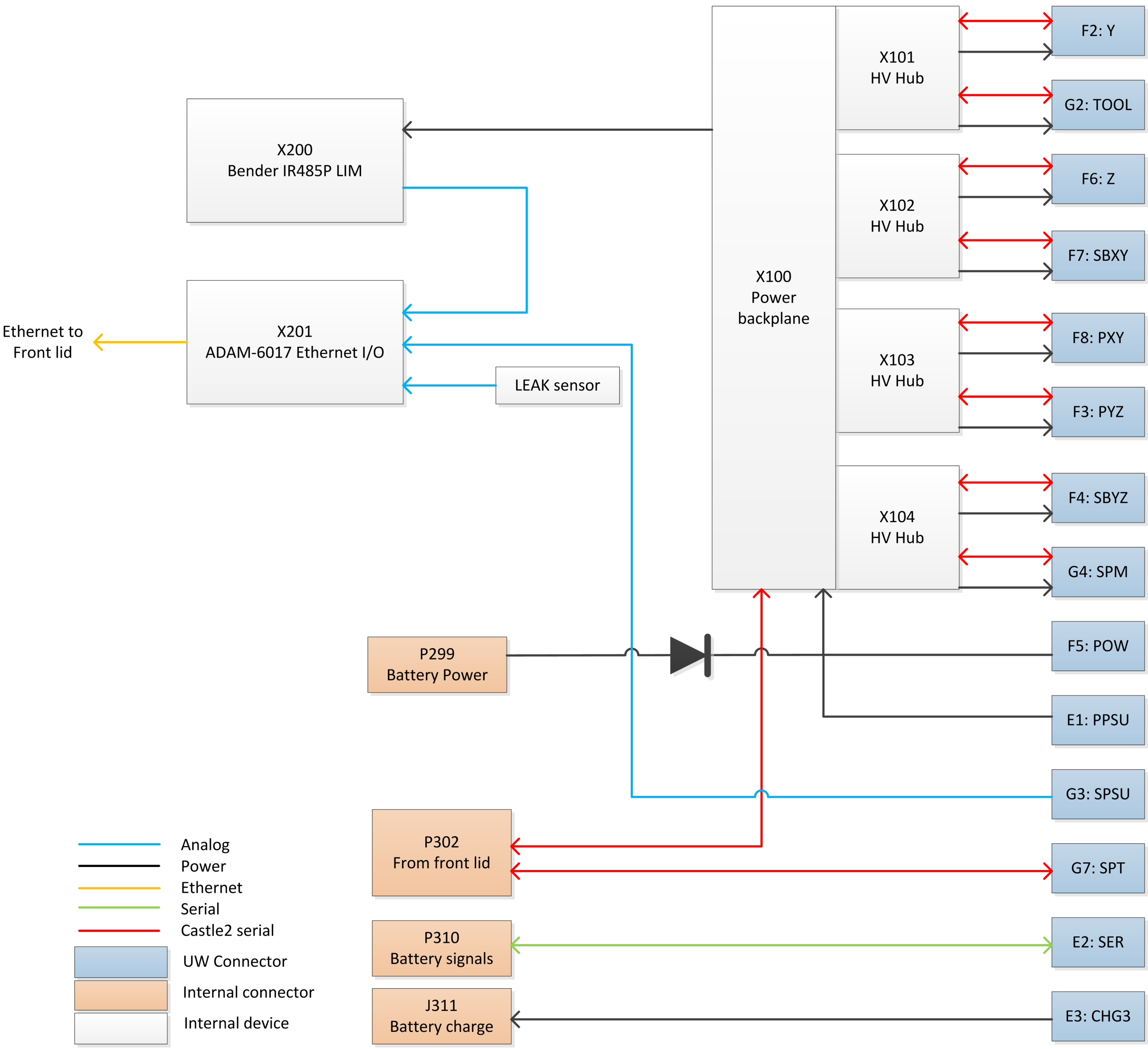


**Figure 6.30: Starboard aft lid block diagram**

## X101/X102/X103/X104 HV Hubs

The HV Hub power switch boards are used to switch on/off the power to the thrusters and other external high voltage devices. Both power and Castle2 telemetry can be switched off in order to completely isolate the external unit. The HV Hubs are inserted into the power backplane which distributes power and telemetry signals.

## X200 Bender IR485P LIM

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The LIM (Line Isolation Monitor) measures the isolation resistance between the high voltage wires and protective earth (PE), i.e. the chassis. If an isolation fault is detected the HMI will show a warning message. The LIM will not automatically shut down the power because of an isolation fault. The operator has the chance to disconnect external equipment from the HMI in order to troubleshoot the source of the isolation fault.

### X201 ADAM-6017 Ethernet I/O

The ADAM-6017 is an analog to digital converter communicating with the rest of the system over Ethernet. It is used to monitor the output of the LIM and the aft lid leak sensor as well as the temperature and leak sensors of the external transformer unit if used.

### 6.7.5. Port front lid

The Port front lid contains an analog to digital converter which is used for monitoring the port EPOD leak sensors as well as sampling data from the external optional CP probe. It also contains connectors for charging the port front battery.

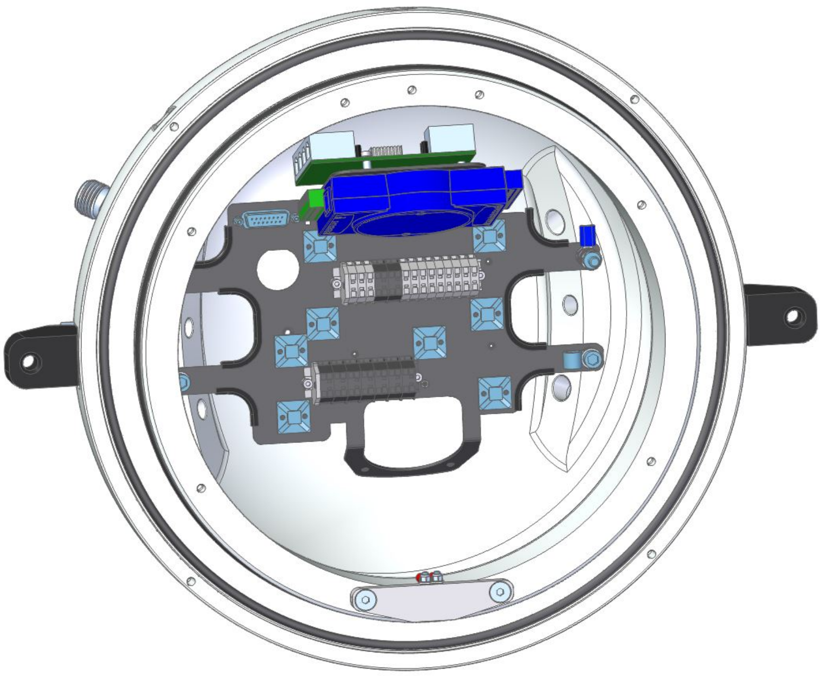

**Figure 6.31: Port front lid**

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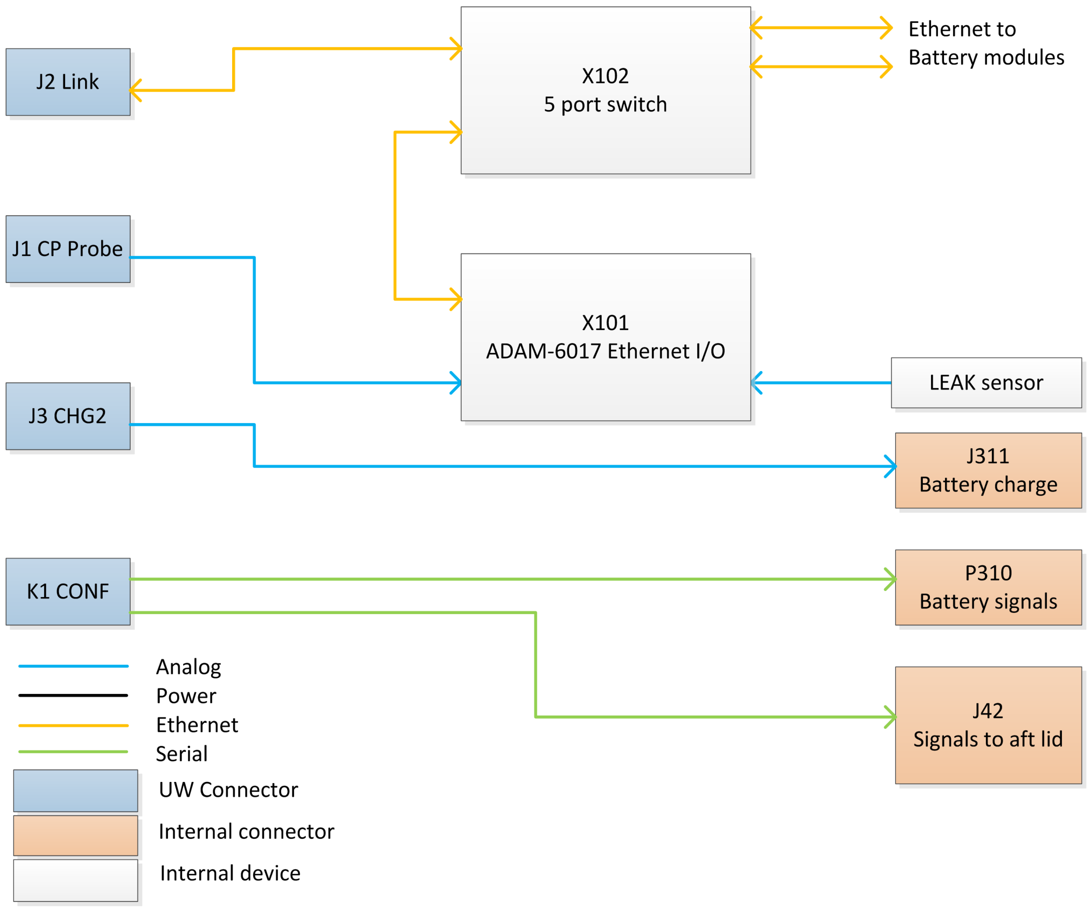


**Figure 6.32: Port front lid block diagram**

### 6.7.6. Port aft lid

Battery 1 and 2 in the port EPOD are via UW connector M3 POW connected to the starboard EPOD.

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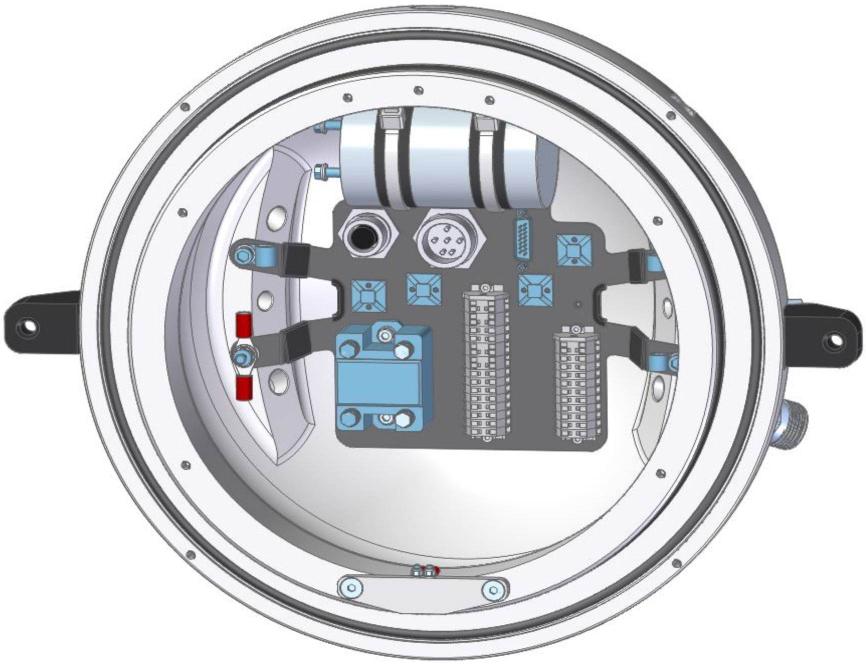

Figure 6.33: Port aft lid

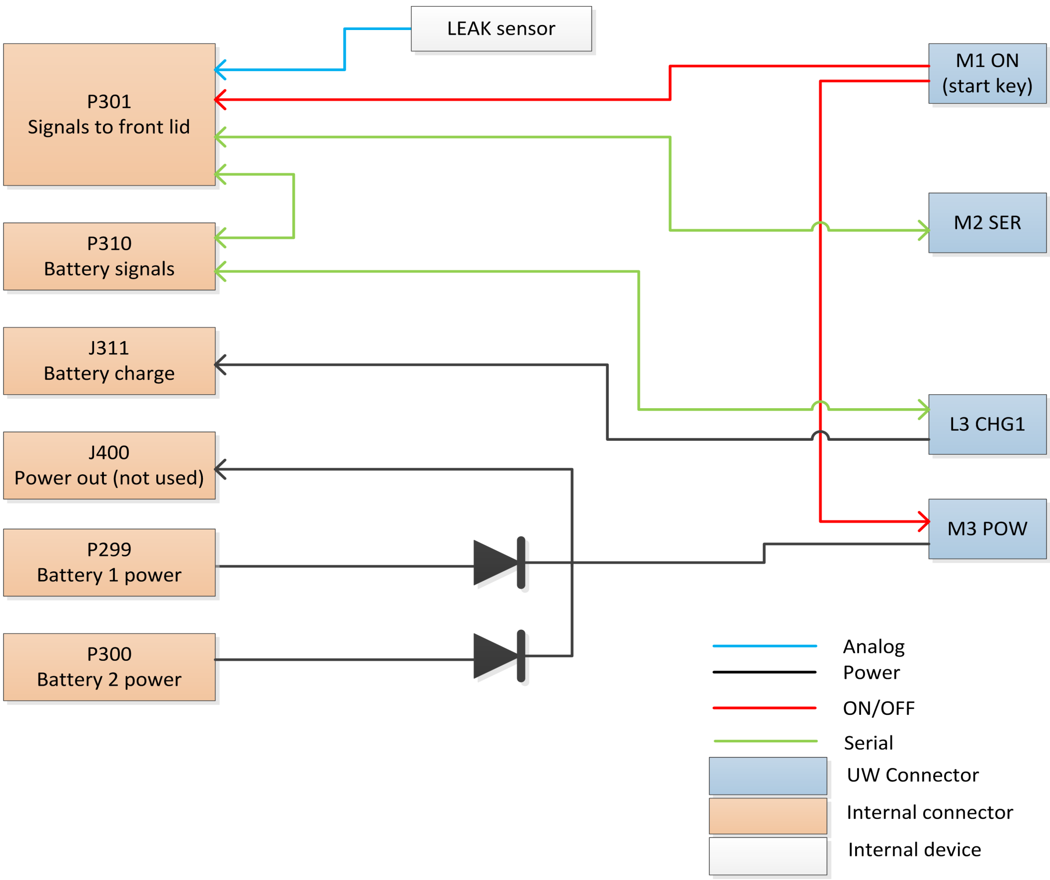


Figure 6.34: Port aft lid block diagram

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# CHAPTER 7

# CORRECTIVE MAINTENANCE

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# 7. Corrective Maintenance

This chapter contains the approved procedures for removal, dismantling, assembling and refitting of equipment necessary for the correct maintenance of the Vehicle system.

## 7.1. Introduction

Where access to equipment and the replaceable units is straightforward, it is not considered necessary to give instructions on dismantling and assembling.

### 7.1.1. Safety Precautions

Lethal voltages are present in all of the units and can be present in cable connections between units and junction boxes. Maintenance can involve contact with substances harmful to health. Before any work is carried out, involving internal access to the units, junction boxes or cable connections, the following warnings and cautions are to be observed.

**WARNINGS.**

**WARNING- DANGER TO PERSONNEL OR EQUIPMENT:**

THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGIZED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION PERSONNEL PRIOR TO ENERGIZING THE DC SUPPLY.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE VEHICLE SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND HAVE TAKEN ADEQUATE PRECAUTIONS..

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE VEHICLE SYSTEM, ENSURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

**WARNING - POSSIBILITY OF TOXIC HAZARDS:**

DURING MAINTENANCE OR REPAIR IT IS POSSIBLE TO COME INTO CONTACT WITH SUBSTANCES HARMFUL TO HEALTH. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS ENSURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL COSHH PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT-ISOLATE ALL THE UNITS POWER SUPPLIES.

## Cautions.

**CAUTION - Danger of damage to PCBs:**

Do not remove or replace PCBs unless the supply is switched off. PCBs must be handled in accordance with electrostatic discharge handling procedures. Damage to PCBs could affect the safe operation of the equipment.

**CAUTION - Danger of damage to equipments:**

When checking connections, care is to be taken not to slacken them, otherwise their watertight integrity may be breached.

**CAUTION - Danger of damage to equipment:**

When using an insulation meter, make sure that the cable under test is disconnected at both ends.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

**CAUTION- Possibility of damage to equipment:**

Make sure that all vent plugs are securely fitted and shut prior to immersing the vehicle. If the vent plugs are not tight, water will enter causing damage to the equipment.

**CAUTION - Possibility of poor vehicle handling:**

Make sure that the vehicle trim and ballast is correct after adding or removing equipment. Addition of equipment or poor vehicle ballast or trim will affect vehicle performance.

A

### 7.1.2. Maintenance Tasks

**Table 7.1: Maintenance Tasks**

| Task No. | Task Description | When carried out |
|---|---|---|
| 1 | Remove and Refit Thruster | To replace a faulty thruster<br><br>To remove a thruster for maintenance |
| 2 | SM9 Thruster propeller | Thruster propeller removal / assembly |
| 3 | SM9 Thruster motor V-seal replacement | As required |
| 4 | SM9 Thruster motor shaft seal replacement | As required |
| 5 | SM9 Thruster Diaphragm replacement | As required |
| 6 | SM 9 thruster Tilt and wing adjustment | When the vehicle have a tendency to pitch or roll |
| 7 | Pressure hull | When removing the EPODs |
| 8 | E-pod opening | When open up the EPOD |
| 9 | Main Pod Lid O-ring Replacement | As required and yearly |
| 10 | Battery handling - for fault situations | Safety and access to the battery modules when there is an issue. |
| 11 | Battery Installation | Used to refit a battery box into an EPOD |
| 12 | Fuse exchange | Fuse exchange when replacing fuses in the system |
| 13 | Spare batteries for Iridium, Strobe light and Acoustic pinger | |
| 14 | Recommended tightening torque | When tightening bolts and nuts<br><br>Nordlock washer<br><br>Trisert inserts-PP |
| 15 | Replacement of Prevco Pressure Relief Valve | O-ring replacement<br><br>After 8 years |
| 16 | POCB Handling | Pre and Post Dive checks<br><br>Monthly Checks<br><br>Storage requirements |

A

## Task 1. SM9 Thruster Remove and Refit

This procedure describes the steps to remove and refit a thruster. This procedure is used to:

- Replace a faulty thruster with a new one.
- Remove a thruster to carry out a maintenance task.

### WARNINGS

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

ISOLATE ALL THE UNITS POWER SUPPLIES BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE ROV SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND WHO HAVE TAKEN ADEQUATE PRECAUTIONS.

**WARNING - POSSIBILITY OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE ROV SYSTEM, MAKE SURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - POSSIBLE EXPOSURE TO CHEMICAL IRRITANTS:**

DURING MAINTENANCE OR REPAIR, IT IS POSSIBLE TO COME IN CONTACT WITH SUBSTANCES THAT MAY CAUSE SKIN OR EYE IRRITATIONS. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS MAKE SURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL CHEMICAL SAFETY PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**WARNING - DANGER TO PERSONNEL AND EQUIPMENT:**

MAKE SURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION AND PERSONNEL PRIOR TO ENERGISING THE DC SUPPLY. WHEN THE SYSTEM DC SUPPLY IS ENERGISED, THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING.

### CAUTIONS

A

**CAUTION - Danger of damage to PCBs:**

Do not remove or replace PCBs unless the supply is switched off. PCBs must be handled in accordance with electrostatic discharge handling procedures. Damage to PCBs could affect the safe operation of the equipment.

**CAUTION - Danger of damage to equipment:**

Make sure all cable connections are tight. If the connections are loose, water may enter the connection and cause damage.

**CAUTION - Danger of damage to equipment:**

When using an insulation meter, make sure that the cable under test is disconnected at both ends.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

### Remove a Thruster

1. Make sure that all power to the ROV is powered off and isolated.
2. Depending on the thruster being accessed, remove the appropriate covers to access the attachment point.
3. Disconnect the thruster cable.
4. While supporting the thruster, remove the bolts that attach the thruster to the bracket.
5. Remove the thruster.

### Refit a Thruster

1. Depending on the location, position the thruster on the support bracket and refit the relevant bolts and washers.
2. Make sure that the thruster is installed with equal play between the thruster nozzle and the cutout in the buoyancy. To align correctly, position the bolts in the slotted holes as shown below.

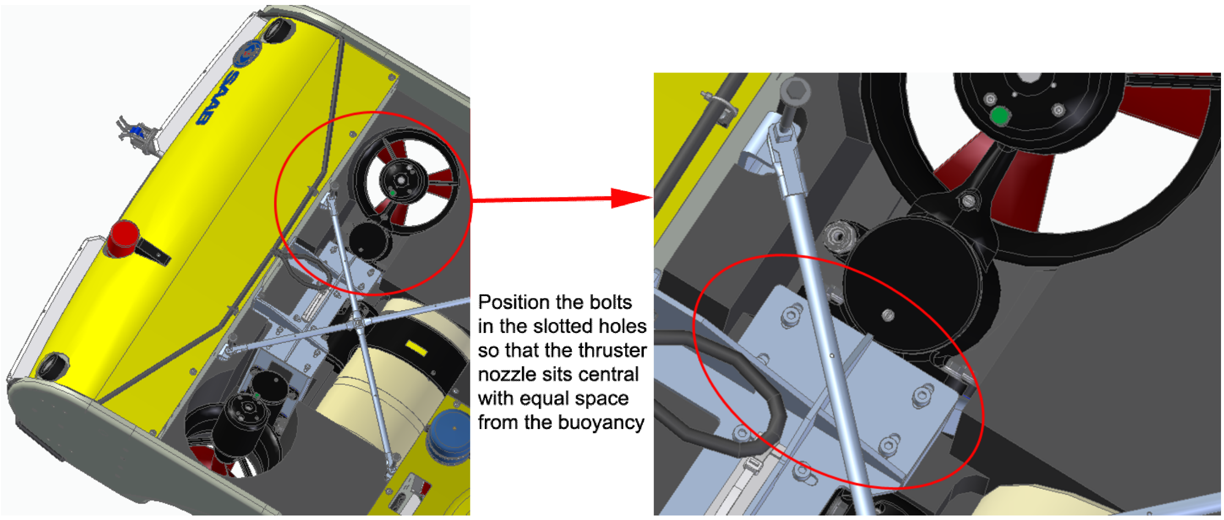



**Figure 7.1: Aligning the Thruster to the Buoyancy**

3. Use a mulitmeter to check that SM9 Aluminium chassis is not electrically connected to SS bracket.

4. Check the thruster insulation to determine the integrity of the motor cables. For information, see the SM9 Thruster Insulation Test procedure.
5. Connect the thruster cable.
6. If required, check the angle and pitch of the thruster. For more information, see the procedure on adjusting the pitch and angle.
7. Power up the system and carry out any functional tests.

A

## Task 2. Thruster Propeller removal

NOTE: There may be variations of the propellers used on the SM9 thrusters (aluminium or plastic). The steps covered in this procedure are relevant to other variants.

Proceed as follows:

1. Using a wooden dowel, wedge the propeller to prevent it from turning.
2. With the propeller wedged, remove the spinner retaining screw, spring washer and plain washer, and remove the spinner.

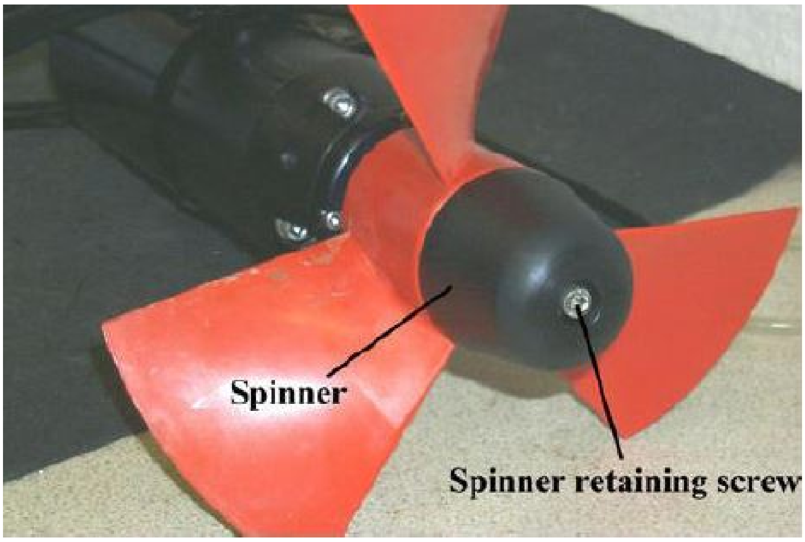



**Figure 7.2: Thruster boss**

3. With the propeller wedged, remove the M16 Nylok nut from the propeller shaft and discard.
4. Fully extend the legs of the puller tool and fit to the propeller with three M5 screws ensuring the jacking off bolt is located centrally on the propeller shaft.

A

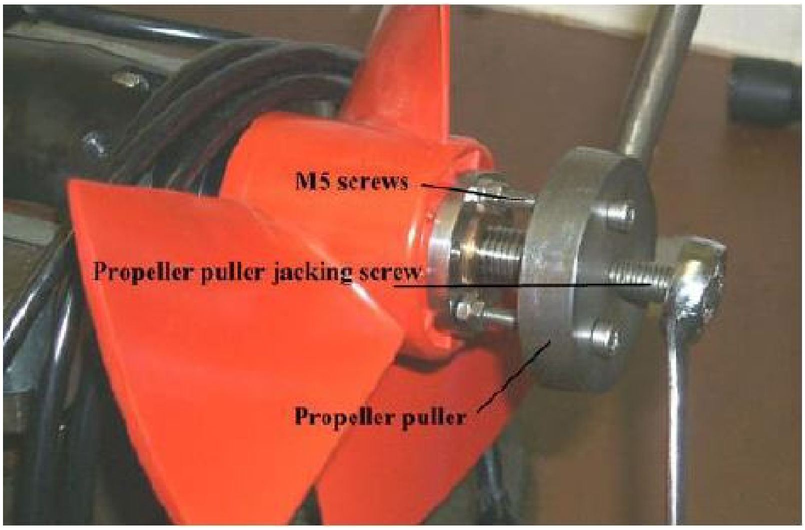



**Figure 7.3: Thruster propeller removal**

5. Slowly tighten the Propeller Puller tool until the propeller "breaks" free, taking care not to misplace the propeller shaft Woodruff key and remove the propeller.
6. Remove the Propeller Puller tool from the propeller. Remove the Woodruff key from the shaft and retain.

NOTE: In exceptional circumstances, the Woodruf key may stick in its groove. It must be removed carefully to avoid damage to the shaft by initially attempting to rock the key by lightly tapping with a hammer and centre-punch. If all attempts to remove the key fail, it will have to be levelled with a grinding wheel to facilitate further dismantling. The complete shaft will then have to be replaced.

### Task 2.1 Assembling

Proceed as follows:

1. Refit propeller to the motor shaft ensuring the Woodruff key is in place.
2. Wedge the propeller to prevent it from turning.
3. Apply a small amount of Loctite LB 8023 Anti Sieze grease to the threads, fit a new M16 Nylok nut to the motor shaft and torque to 27 Nm.
4. With the propeller still wedged fit the spinner and secure using the M6 retaining screw, spring washer and plain washer.
5. Examine the thruster whip and connector for damage. Lubricate the connector plug thread forms and O-ring with Molykote 111 grease.

A

# Task 3. SM9 Thruster Motor V-Seal Replacement

## WARNINGS:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT- ISOLATE ALL THE UNITS POWER SUPPLIES.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE VEHICLE SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND HAVE TAKEN ADEQUATE PRECAUTIONS..

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE VEHICLE SYSTEM, ENSURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - POSSIBILITY OF TOXIC HAZARDS:**

DURING MAINTENANCE OR REPAIR IT IS POSSIBLE TO COME INTO CONTACT WITH SUBSTANCES HARMFUL TO HEALTH. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS ENSURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL COSHH PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**WARNING- DANGER TO PERSONNEL OR EQUIPMENT:**

THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGIZED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION PERSONNEL PRIOR TO ENERGIZING THE DC SUPPLY.

## Cautions:

**CAUTION - Danger of damage to PCBs:**

Do not remove or replace PCBs unless the supply is switched off. PCBs must be handled in accordance with electrostatic discharge handling procedures. Damage to PCBs could affect the safe operation of the equipment.

**CAUTION - Danger of damage to equipments:**

When checking connections, care is to be taken not to slacken them, otherwise their watertight integrity may be breached.

**CAUTION - Danger of damage to equipment:**

When using an insulation meter, make sure that the cable under test is disconnected at both ends.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

Proceed as follows:

1. With the propeller wedged, remove the spinner retaining screw and remove the spinner.
2. With the propeller wedged, remove the M16 Nylok nut from the propeller shaft and discard.
3. Fully extend the legs of the puller tool and fit to the propeller with three M5 screws ensuring the jacking off bolt is located centrally on the propeller shaft.
4. Slowly tighten the Propeller Puller tool until the propeller .“breaks.” free taking care not to misplace the propeller shaft Woodruff key and remove the propeller.
5. Remove the Propeller Puller tool from the propeller.
6. Gently prise the two V-Seals from the shaft and discard.
7. Scrupulously clean the shaft and dry.
8. Lubricate the V-seals with Molykote 111 grease.
9. Fit new V-seals to the motor shaft, seal skirt first, carefully lifting over the woodruff key taking care not to damage or distort the seals. Ensure the seals sit squarely on the shaft seal cap.

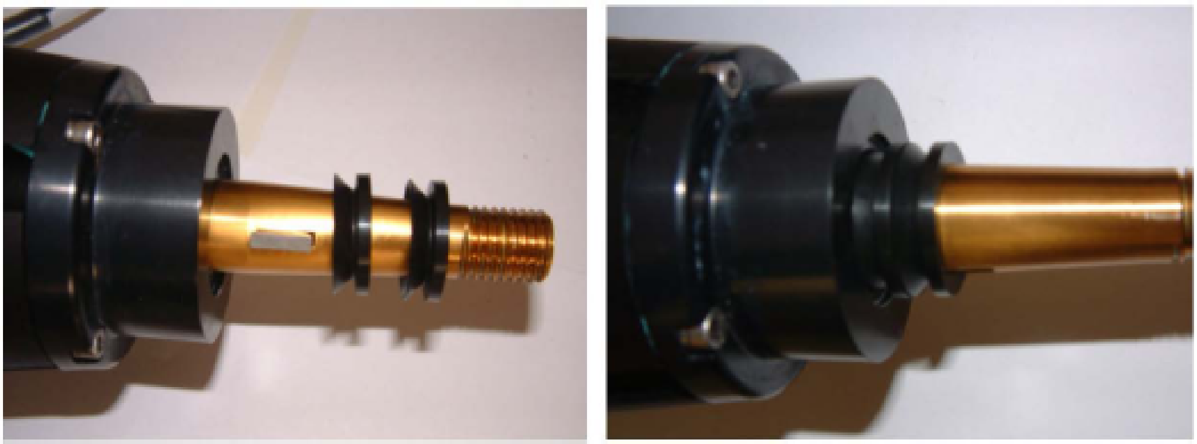


**Figure 7.4: Thruster shaft V seals**

10. Refit propeller to the motor shaft ensuring the Woodruff key is in place.
11. Wedge the propeller to prevent it from turning.
12. Fit a new M16 Nylok nut to the motor shaft and torque to 27 Nm.
13. With the propeller still wedged, fit the spinner and secure using the M6 retaining screw.
14. Remove the wedge.

A

# Task 4. Replace the SM9 Motor Shaft Seal

## Frequency of Task

As required.

## Introduction

This task describes how to remove and replace the shaft seal on an SM9 motor. This procedure is applicable to SM9 thruster variants and assumes that the thrusters have been removed from the vehicle.

NOTE: Images used show SM9-3 thrusters.

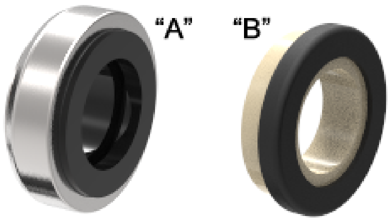



**Figure 7.5: Shaft Seal Parts "A" and "B"**

Tools Required

- Common tools
- Silicone grease
- Wooden dowel
- Propeller puller tool
- COSHH0004-SS04 Ambersil Amberklene FE10 Spray
- COSHH0275 P-80 Rubber Lubricant Emulsion
- COSHH0247 - Loctite LB 8023
- Shaft seal fitting tool HT00286
- Cap seal fitting tool HT00285
- Nitrile Gloves

A

Parts Required

- Shaft seal (TH140)
- V-seals (VASEAL0020)

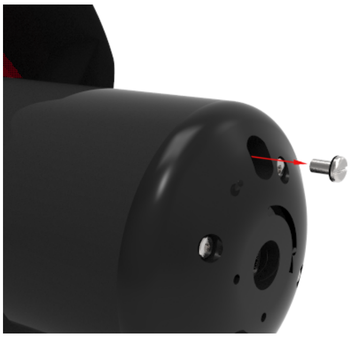
**Replace the Shaft Seal**

For part numbers, refer to the relevant General Assembly drawings for the SM9 thruster.

NOTE: Some thrusters are fitted with either aluminium or plastic propellers. The images in this procedure show plastic propellers.

NOTE: Make sure there is a clean container for collecting the oil and that a fresh supply of Mobilect 39 oil is available.

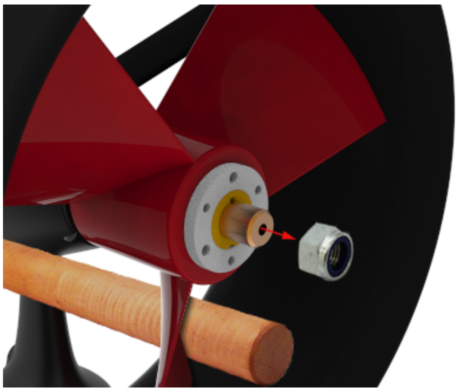
1. Open the highest bleed screw hole of the motor and allow oil to escape under the pressure of the compensator spring. Flow will cease when internal pressure reaches the current atmospheric pressure. Close the bleed screw.



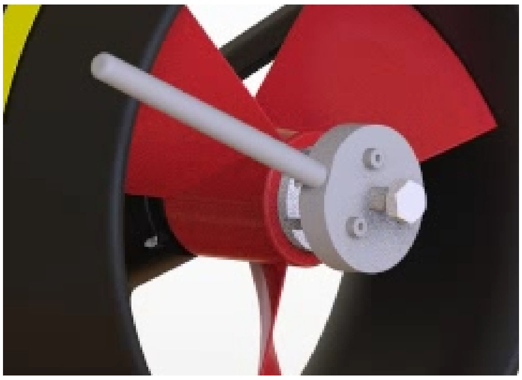
2. For an ROV thruster, remove the thruster propeller. Use a wooden dowel to wedge the propeller to prevent it from turning. With the propeller wedged, remove the M6 x35 retaining screw (STF019), plain washer (STF012) and spring washer (STF025) then remove the spinner.

3. With the propeller wedged, remove the M16 Nylok nut (STF135) from the propeller shaft and discard.

A



4. Attach the Propeller Puller tool to the propeller using the three M5 screws. Make sure that the Propeller Puller screw is centred in the propeller shaft.

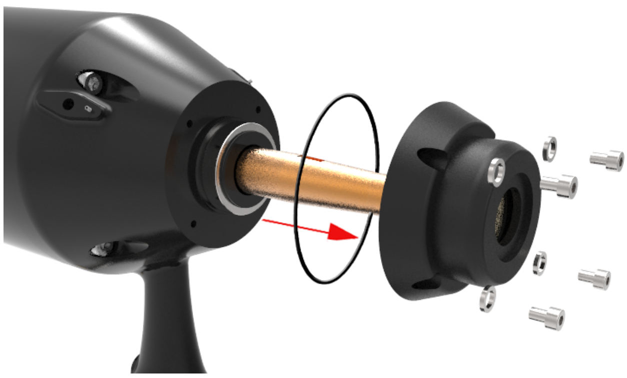


5. Slowly tighten the Propeller Puller screw until the propeller “breaks” free. Take care not to misplace the propeller shaft Woodruff key (K1-10).
6. Remove the Woodruff Key.

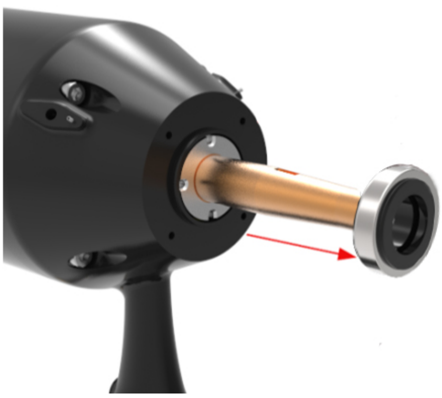
7. Remove the two V-seals (VASEAL0020) from the shaft and discard.

A

8. If required to aid access to the shaft seal, remove the nozzle assembly:
    a. Support the thruster and carefully remove the socket screws and washers that secure the nozzle to the thruster.
    b. Remove the nozzle assembly. Make a note of the position of the grooved nozzle stays.
9. Remove the four screws (STF065) and washers (STF023) securing the Seal Retainer (P10463) to the Main Bearing Housing.



10. Remove the O-ring (200134) and discard.
11. Remove the old Shaft Seal Part "A" from the shaft.



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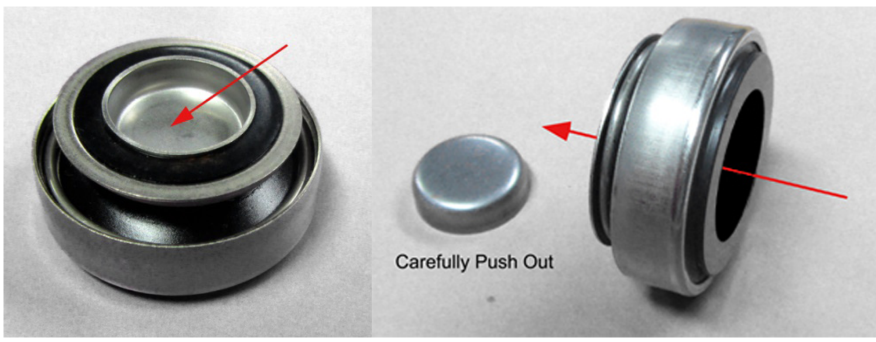
12. Carefully remove the shaft seal Part "B" from the Seal Retainer using a 20 mm nylon rod taking care not to damage the Seal Retainer or the housing assemblies. Discard the old Shaft Seal.


NOTE: Wear Nitrile gloves during the entire fitment of the new Shaft Seal components.

13. Before fitting a new TH140 shaft seal, ensure that both the shaft and shaft seal cap are completely free of debris and remnants of old the old shaft seal.
14. Remove the new Shaft Seal from its packaging. Inspect sealing regions on both shaft and shaft seal cap for imperfections, scratches, dust or damage that may allow water ingress. Thoroughly clean using Amberklene.
15. Remove the protective metal insert from the seal as shown (use the small blue foam square provided as a barrier to avoid contamination of the seal with dirt or grease).




16. Apply a little P-80 Lubricant to the inner surface of the ceramic faced component of the Shaft Seal “A” and to the shaft, then using the HT00286 Seal fitting tool push the seal into position on the shaft.

NOTE: The seal must be installed with the ceramic face uppermost.

A

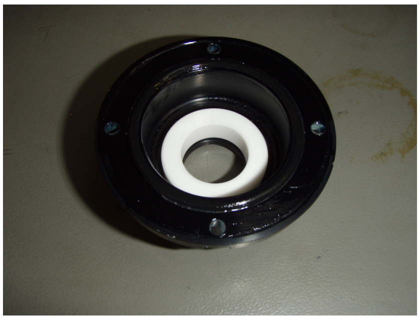
NOTE: Use Amberklene solvent to remove all traces of lubricant from the seal and, in particular, from the ceramic face.

17. Apply a little P-80 Lubricant to the outside of the Shaft Seal Part "B" and to the inside of the shaft seal cap and install the component in the cap.
18. A tool is available (HT00285) to hold the seal prior to fitting into the cap shown.

19. Place the seal part "B" in the centre of the recess on the top of the tool.
20. Lower the Seal Retainer and press down over the seal evenly to push the seal into its correct position, as shown.

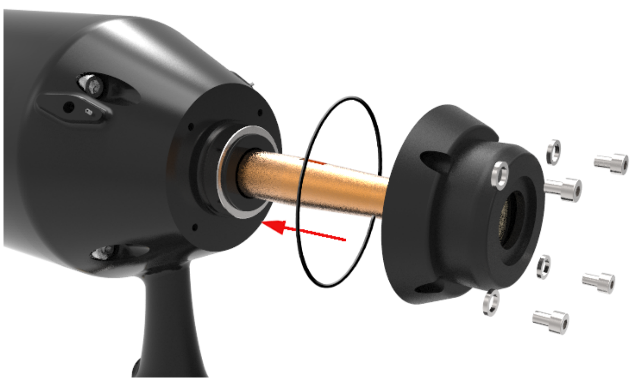
A

21. Confirm full and square insertion.
22. Use Amberklene solvent to remove all traces of lubricant from the seal and, in particular, from the ceramic face.

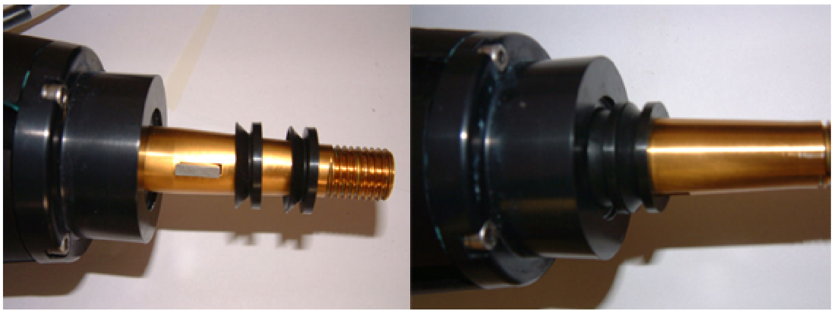


23. Use Amberklene solvent to remove all traces of lubricant from the Seal Retainer.
24. Apply silicone grease (Molykote 111) to the O-ring and, taking care not to contaminate the white ceramic insert, install the O-ring in the groove in the Seal Retainer.
25. Apply Loctite LB 8023 to the threads of the M4x12 screws and fit the Seal Retainer to the Main Bearing Housing using the screws and spring washers. Slide over the shaft without touching the M16 threaded area of the shaft or any of the smooth section of the shaft to prevent any damage to the inner face.

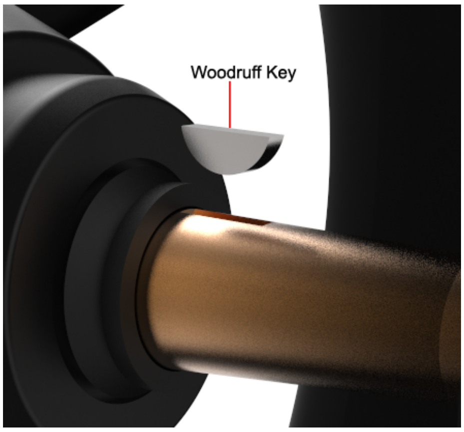
A



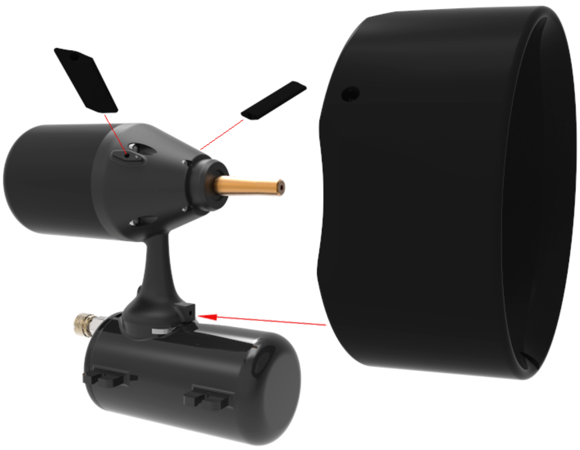
26. Apply just enough silicone grease to the two V-seals to make them look wet and fit them to the motor shaft, skirt first, i.e. with the V section of both seals towards the thruster body. Ensure that the seals sit squarely on the shaft Seal Retainer.



27. Place the Woodruff key in the slot in the motor shaft.

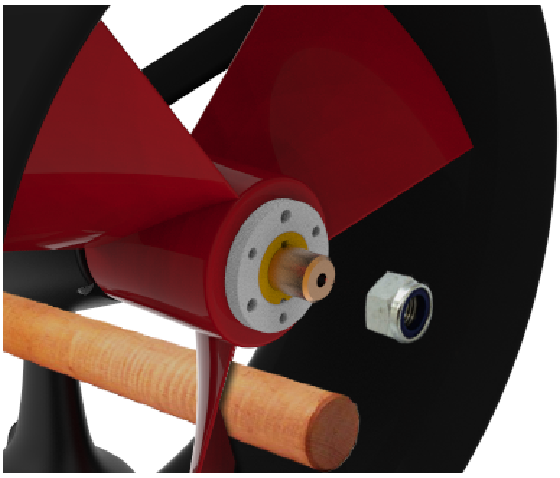



28. Support the thruster and carefully refit the nozzle stays and Nozzle in the correct position.



29. Secure the nozzle stays and nozzle to the bearing housing using the screws and washers.
30. Fit the propeller to the motor shaft ensuring that the Woodruff key is still in place.
31. Using a wooden dowel, wedge the propeller to prevent it from turning.
32. Apply Loctite LB 8023 to the thread of the motor shaft.

33. Fit a M16 Nylok nut to the motor shaft and torque to 20 lb/ft. (27Nm).



34. Refit the spinner using the M6 screw (with Loctite LB 8023 applied to the screw thread) and washers.

35. Remove the wooden dowel.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

36. Fill with Mobilect 39 oil (see Thruster Oil Level Check and Replenishment).
37. Re-install the thruster onto the ROV system and run thruster in both forward and reverse for 1 minute at 100 volts or approximately 20% thruster and observe oil level for any leaks.

A

# Task 5. SM9 Thruster Diaphragm Replacement

## Frequency of Task

As required.

## Introduction

This task describes how to remove and replace a diaphragm on an SM9 thruster.

NOTE: Thruster images may differ depending on the SM9 variant. The steps are relevant for all SM9s.

## Tools Required

- Common tools
- Molykote 111 grease
- Diaphragm puller tool P10674
- Locking pin
- Loctite 243
- COSHH0247 - Loctite LB 8023
- Oil fill hand pump (Part no P10520) with hose and quick disconnect adapters
- Tissues to clean any oil spills

## Parts Required

- SM9 Diaphragm Service Assembly P13673 (see drawing S13673 in the Parts List Chapter.)
- Dunlop 2000 Adhesive

## Task 5.1 Remove the Diaphragm

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT-ISOLATE ALL THE UNITS POWER SUPPLIES.

A

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE VEHICLE SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND HAVE TAKEN ADEQUATE PRECAUTIONS..

**WARNING - POSSIBILITY OF TOXIC HAZARDS:**

DURING MAINTENANCE OR REPAIR IT IS POSSIBLE TO COME INTO CONTACT WITH SUBSTANCES HARMFUL TO HEALTH. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS ENSURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL COSHH PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**CAUTION - Danger of damage to Thruster Motor:**

Do not operate the Thruster Motor in air for longer than one minute.

1. Remove the thruster from the vehicle.
2. Lie the thruster propeller-side down.
3. Screw the Diaphragm Puller Tool into Diaphragm Spring Retainer.

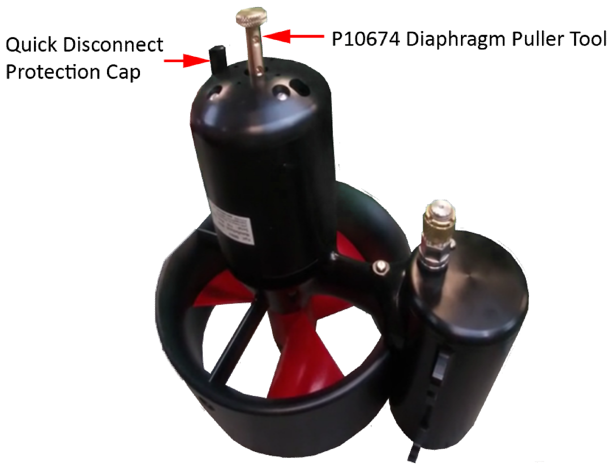



**Figure 7.6: Diaphragm puller tool**

4. Remove the bleed screw.
5. Unscrew and remove the Quick Disconnect Protection Cap.
6. Connect the P10520 Oil Fill kit to the quick disconnect on the thruster.

A

**Figure 7.7: Oil Fill Kit fitted**

7. Raise the Fill Kit handle and release the blue pressure release valve to allow the oil to drain out of the thruster into the Fill Kit bottle. Note that the diaphragm puller tool will drop down as the oil is removed.
8. Disconnect the Fill Kit connection from the Quick Disconnect on the thruster. Wipe the thruster clean.
9. Unscrew and remove the Diaphragm Puller Tool from the Diaphragm Spring Retainer.
10. Hold down the Diaphragm Spring Retainer as it is spring loaded. Remove the four M5 countersunk screws from the Diaphragm Spring Retainer.
11. Remove the Diaphragm Spring Retainer and set aside.
12. Remove and inspect the spring. If damaged, replace the spring.
13. Remove the four countersunk screws and remove the Diaphragm Retainer.

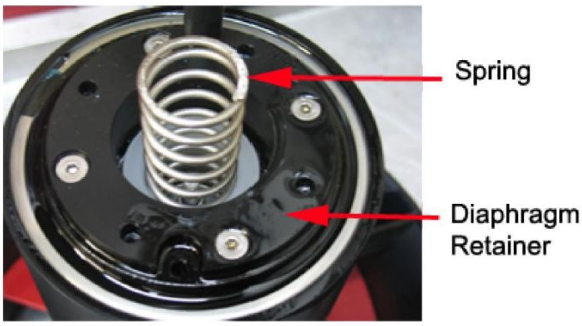



**Figure 7.8: Spring and diaphragm retainer**

A

14. Remove the Diaphragm Piston Assembly and separate the Diaphragm Piston from the Diaphragm.

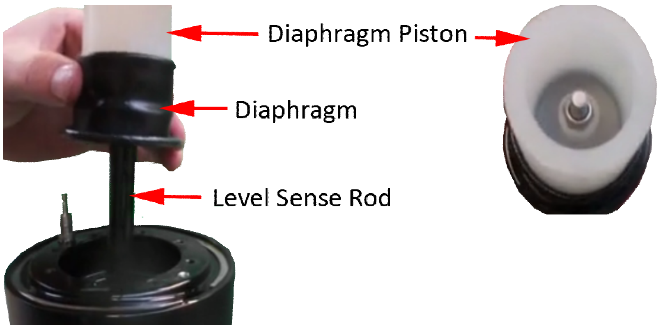



**Figure 7.9: Diaphragm Piston Assembly**

15. Unscrew the Level Sense Rod from the base of the Diaphragm Former. Set the Level Sense Rod aside.
16. Discard the diaphragm and the attached Diaphragm Former.


**Figure 7.10: Diaphragm assembly**

17. Prepare the Diaphragm and the Diaphragm Former using the instructions on the drawing S13673 in the Parts List chapter.
18. Reassemble the Level Sense Rod and the new diaphragm by screwing the Level Sense Rod into the base of the Diaphragm Former.
19. Lubricate the Diaphragm seal face with silicone grease.
20. Insert the Diaphragm assembly into the thruster body slowly to avoid any residual oil to spray out. Make sure that the groove on the Level Sense Rod is aligned correctly with the body pin inside the rotor support.

A

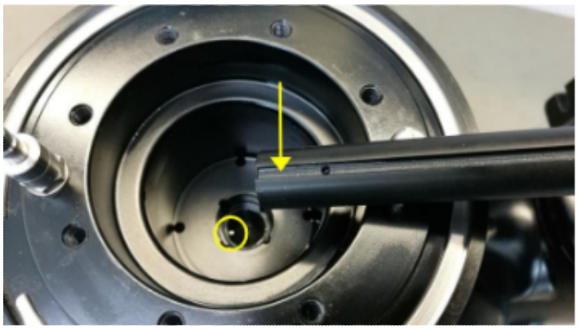


**Figure 7.11: Level Sense Rod Alignment**

21. Insert the Diaphragm Piston into the Diaphragm.
22. Check the condition of the O-ring on the bleed screw. Discard and replace if necessary.
23. Apply Silicone grease to the O-ring.
24. Insert and tighten the bleed screw.
25. Place the Diaphragm Retainer over the Diaphragm Piston Assembly. Make sure that the Diaphragm Retainer is lined up with the bleed screw, screw holes and the Quick Disconnect.
26. Apply Loctite 243 to the ends of the four M5 button screws.
27. Insert washers and M5 button screws and tighten the screws to 2Nm into the Diaphragm Retainer.
28. Insert the spring.
29. Apply Loctite 243 to the four M5 button screws.
30. Push down on the Diaphragm Spring Retainer, insert the washers and the four M5 button screws. Tighten the four M5 screws to 2Nm.
31. Refill the oil as described in Thruster Oil Level Check and Replenishment procedure.

A

## Task 6. SM9 Thruster Tilt adjustment and pitch angle adjustment

If the vehicle has a tendency to roll or to change depth when going forwards quickly, the X / Y motor angles can be adjusted.

1. Remove the top aft buoyancy block.
2. Remove the bolts to adjust the motor angle.

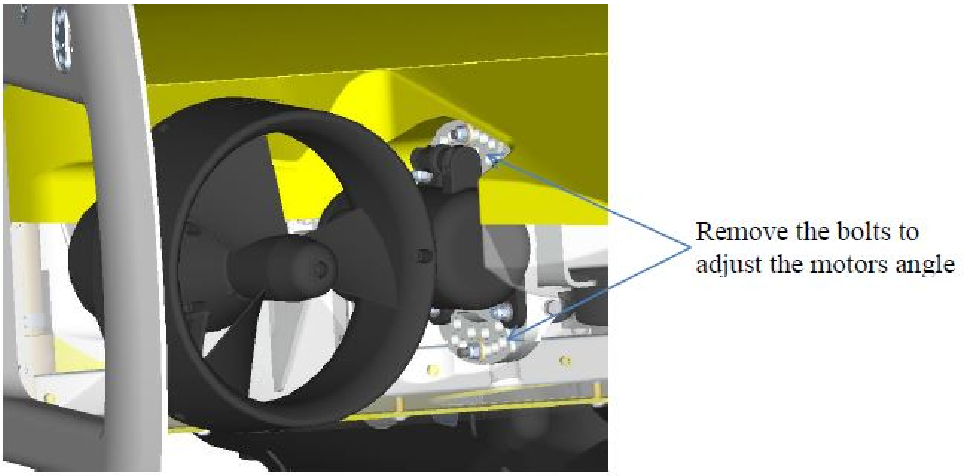



**Figure 7.12: Thruster tilt adjust**

3. Adjust the pitch angle of the wing to compensate for problems to stay at the same depth.

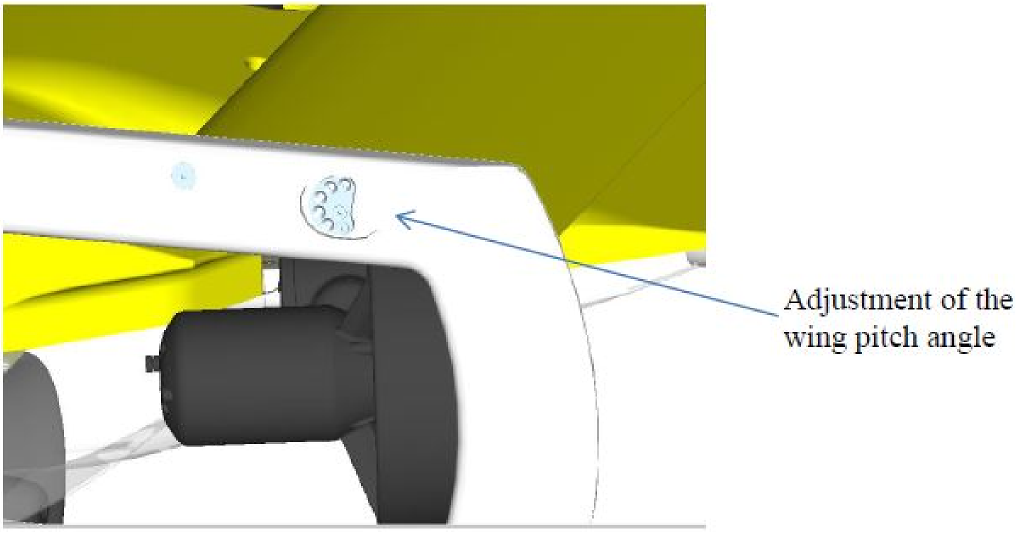



**Figure 7.13: Wing pitch angle adjust**

A

# Task 7. Pressure Hull

## Task 7.1 Removal

**Proceed as follows:**

1. Remove the screws holding the top covers, the mid board and remove the cover and mid board.

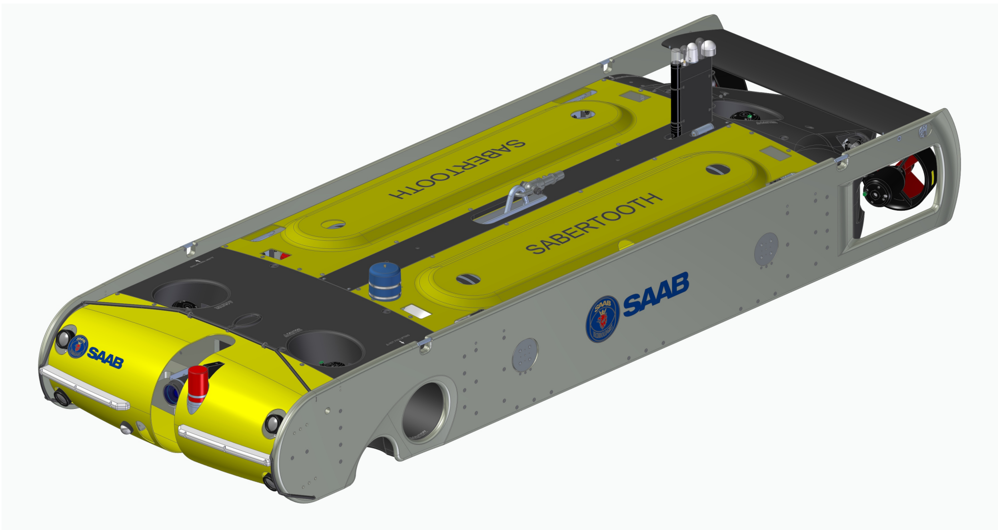



**Figure 7.14: Top lid removal**

2. Connect a lifting hook and lift to remove the weight from the side holders to be able to remove them. Remove the 4x side holders connecting inner structure to plastic frame and lift up.

**CAUTION- Possibility of damage to equipment:**

Be careful not to catch and damage any cables when lifting the EPODs. Make sure that the UW cables to the EPOD lids are not damaged during lifting.

3. Mount the side holders back on both sides on the EPOD again. Put four service supports on the plastic sides and lower the EPODs so that the side holders rest on the service supports.

A

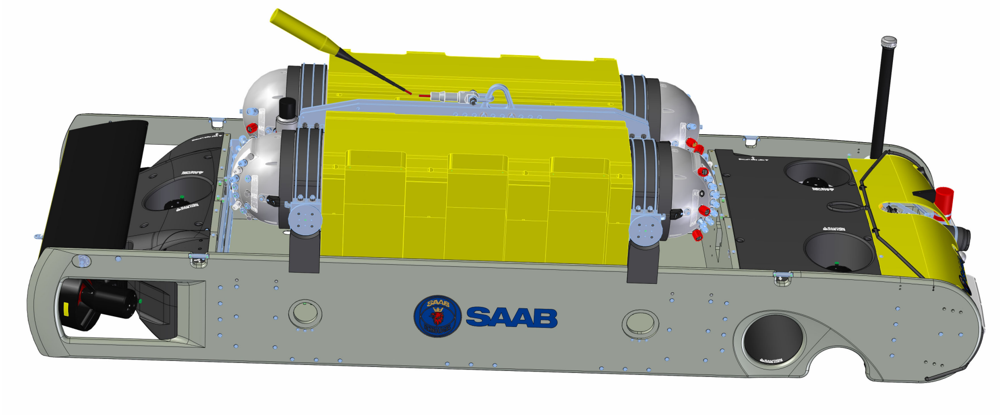



**Figure 7.15: Lift up E-Pods**

A

## Task 8. E-pod opening

1. Make sure the PSU and AUV are switched OFF and no chargers are connected. Lock and remove the start key and keep it in a safe place.
2. Disconnect the PSU UW cables to the starboard aft lid.
3. Lift up the E-PODs before starting to open the lids.

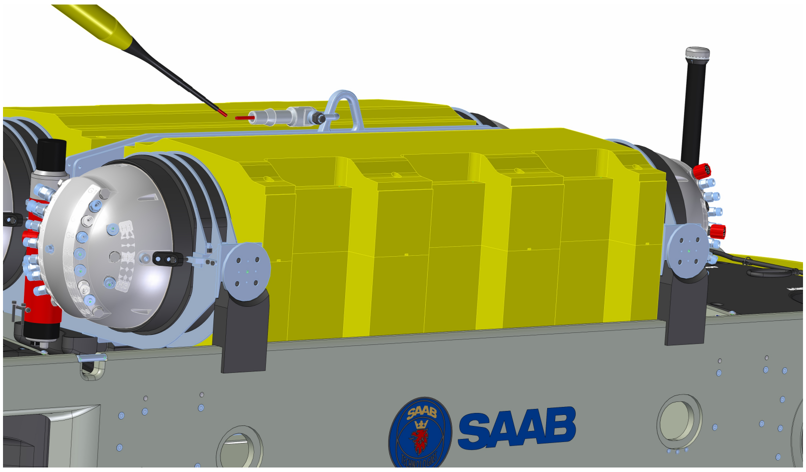


**Figure 7.16: E-PODs lifted**

NOTE: Before opening the E-POD, open the air bleed screw to release the pressure inside the E-pod.

4. Remove the UW cables.
5. Remove the 2x M8 screws that secure the lid.

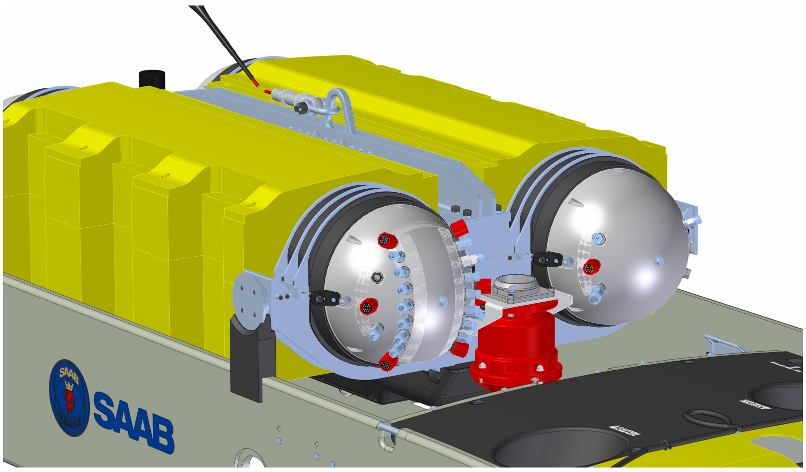


**Figure 7.17: Bolts holding the plate**

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6. On all lids there are four holes with an inner thread that are used when a lid needs to be removed.
7. The plastic screws 05-1206042 Allen key screw M6X40, PEEK, SPE-C that are used can be found in the Tool kit 01-4162604.

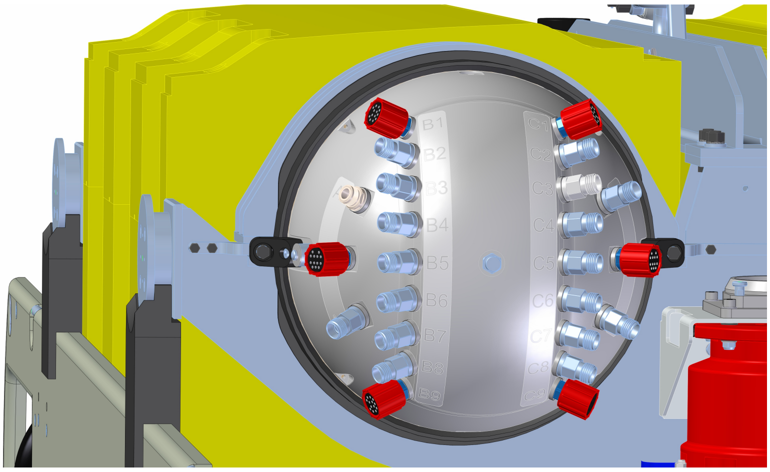

**Figure 7.18: Holes for plastic screws**

8. Mount the four screws and tighten them just a little bit each time in an X configuration (seeFigure 7.19), starting with 1 then 2, 3 and 4 and back to 1 again. To make sure to pull the lid straight out.

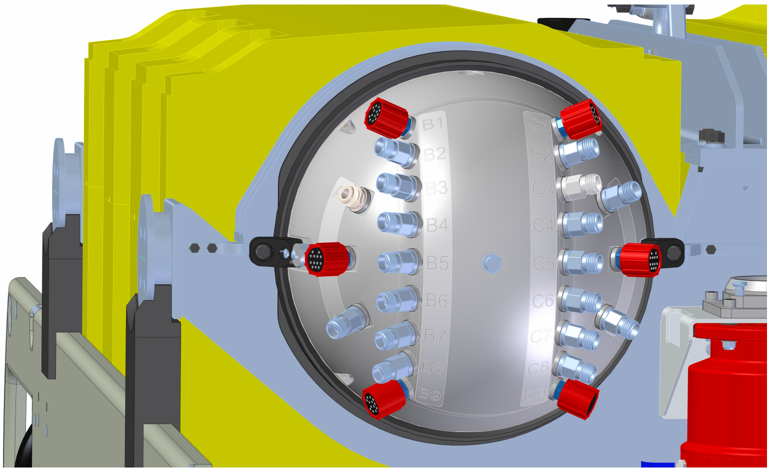

**Figure 7.19: Mount for four screws**

9. Pull out the lid by hand when it has loosened. Remove the plastic screws when the E-POD is opened, they should not be left on the lid.

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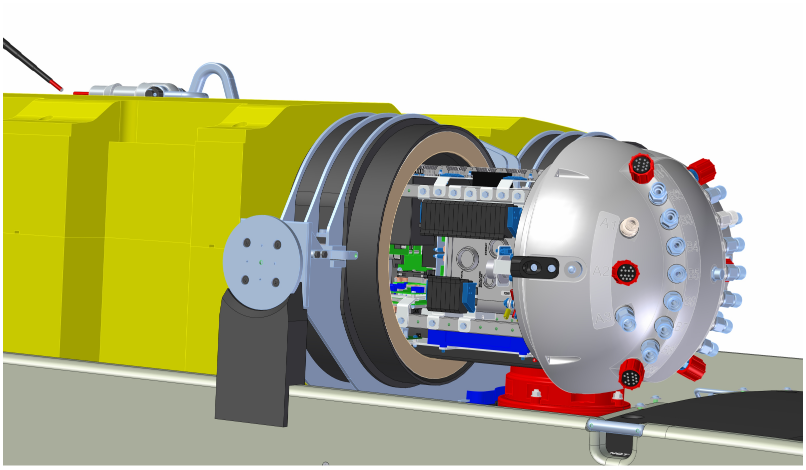

**Figure 7.20: Pulling out the E-Pod lid**

10. The STBD front lid is shown as an example, perform the same way with the other lids.

    NOTE: Whenever the EPOD's water tight integrity has been disturbed, always perform a vacuum test prior to diving.

    NOTE: During maintenance, store the silica gel bag in a plastic bag. When maintenance is finished, place the original or a new silica gel back into the EPOD before closing.

A

## Task 9. Main Pod Lid O-ring Replacement

The main pressure pods seals are vital for the integrity of the pressure housing and get exposed when carrying out any tasks that require the opening of the pod. Therefore these seals should be checked and replaced as necessary after every task that requires the pod to be open and yearly as part of regular maintenance.

### Frequency of Task

As required

1 yearly.

### Introduction

This task describes how to remove and replace the Main pod seals.

### Tools Required

- Common tools.
- Silicone grease.
- Amberklene.

### Parts Required

- 06-6000032 - O-ring 304.17x6.99 NBR 90 shore A
- 06-6000015 - Glass filled back up ring, Ø326.3x5.8x2.5 (only at the 8th year of use)
- 06-0000178 - O-ring 354.97x5.33

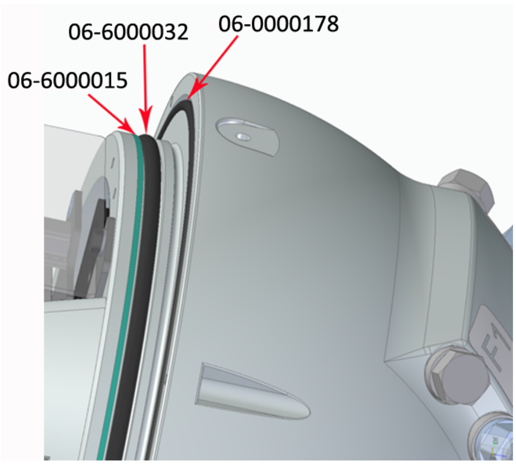


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**Figure 7.21: Pod O-rings and Back up Ring**

### Procedure

1. With the pod open, remove the seals that need to be replaced (do not use any metallic tools) and discard.

2. Check for corrosion or damage on all sealing surfaces, both on the lid and the mating surfaces on the tube. If there are any that scratches cross the O-ring groove or corrosion marks on the sealing surface, contact Saab support for guidance.
3. Smear a sparing amount of silicone grease on to the new piston O-ring, 06-6000032, and place into the corresponding groove, taking care not to introduce any contaminants such as hair or dirt.
4. Fit the new back up ring, 06-6000015.
5. Smear a sparing amount of silicone grease on to the new face O-ring, 06-0000178, and place into the corresponding groove, taking care not to introduce any contaminants such as hair or dirt.
6. The pod lid can now be refitted to the tube.

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## Task 10. Battery Handling

**BEFORE ACCESSING THE BATTERY MODULES, READ THE SAFETY INSTRUCTIONS FOR THE BATTERY IN THE PREVENTATIVE MAINTENANCE CHAPTER.**

The following tasks describe how to handle the battery depending on the situation.

**General battery handling rules**

- Only electrical skilled persons that have knowledge of the battery design are allowed to work with the battery.
- Always handle the battery as if it is fully charged.
- Only place the cell modules on a soft material outside the battery box. Especially the corners which can be easily be damaged.

**The following applies to battery cells**

- Cells shall not be bent.
- Soldering on cell connections is not allowed.
- Ensure the polarity is correct, especially when a cell is reconnected to a cell module.
- Never pull the cell connections as these can easily come off.

**The following safety equipment shall always be available close to the battery**

- High voltage insulating gloves.
- Powder extinguisher.
- At least two persons shall be present during work on the battery.
- Ensure good house keeping around the battery at all times.
- Do not work on the battery if you are tired or stressed.
- Ensure that the battery is well protected and secured if outside vehicle.
- Always measure the voltage in the power connectors before doing any work on the battery to make sure the contactors have opened properly.
- A External equipment connected to the battery shall have isolated power supply. For example it is preferable to use a laptop when a computer is to be connected to the BMS.
- To minimise the risk for short circuit it is not allowed to wear for example watches, rings or necklace when working on the battery.
- All tools used when working on the battery shall be electrically insulated.

- Use high voltage insulating gloves when working on the battery poles. Only work on one pole at any time, keep your hands dry.
- Personnel with heart disease shall not work in the battery.

**Task 10.1 Battery short circuited by an object**

As an example, if the battery is short circuited by a tool, the battery will heat up and can eventually catch fire. This may take some time since the battery can supply up to 400 A, momentarily. As there is a delay this should give the operator enough time so the stuck tool can be removed with an insulated tool.

1. Take the battery outside at least 20 meters from the closest building.
2. Monitor the battery from a distance of at least 15 meters for two hours.
3. If nothing happens during this time, the battery can be disassembled to cell module level (14 cells) and investigated.

**Task 10.2 Battery short circuited by a person**

Coming in contact with both poles can cause serious injury or death. Follow the general handling rules to prevent this.

1. Assess the situation and call for help.

**DO NOT TOUCH THE CASUALTY IF THEY'RE STILL IN CONTACT WITH THE ELECTRICAL SOURCE AS YOU ARE AT RISK OF ELECTROCUTION.**

2. Turn off the source of electricity to break the contact between the electrical supply and the casualty.
3. If an operator gets electrocuted and cannot free them self, a second person needs to get the injured person loose from the battery. Use insulating gloves when doing this!

**Task 10.3 Internal short circuit inside the battery**

Over time, pure lithium can gather on the electrodes resulting in a short circuit. The only way to detect this is to check the if temperature sensors are detecting a high temperature. Normally, the temperature should not exceed the ambient temperature within the vehicle by more than 20° C. If an internal short circuit is detected, follow the procedure for a short circuit caused by an object.

**Task 10.4 Short circuit caused by water inside the pressure hull**

A **PLEASE USE CAUTION WHEN RECOVERING THE VEHICLE!**

**DANGER TO PERSONNEL AND EQUIPMENT.**

If saltwater has leaked into the electronic pods explosive oxhydrogen gas might have been generated.

## Task 11. Battery Installation for EPODs

The EPOD tubes are constructed from either carbon (rated to 3000 msw) or hard anodized aluminium (rated to 1200 msw) and the end caps are hard anodized aluminium.

The 10 / 12 kW battery box weighs approx. 90 / 110 kg. The battery box is constructed from thermoplastic, which is a soft material and could easily be damaged by particles such as stones, metal or other particles. In order to avoid damage, always place the battery boxes on a clean surface.

**CAUTION- Danger of damage to the Battery and Battery Housing:**

Be very careful when removing and refitting the EPOD Battery Boxes. The material used for the Battery Boxes is a relatively soft material and could be damaged during removal and installation.

Always use the proper lifting gear and use the lifting handles on battery box. Make sure that the battery boxes are placed on a clean surface and avoid any mechanical impact on the BMS boards and also the electronics.

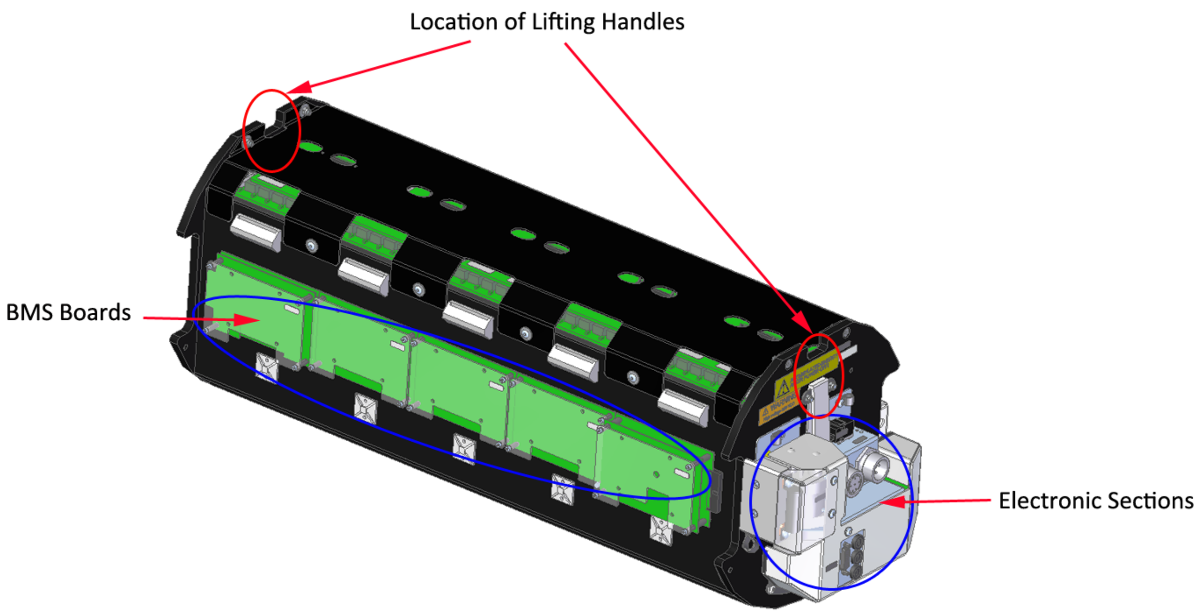


**Figure 7.22: Battery Box Sections and Lifting Handles**

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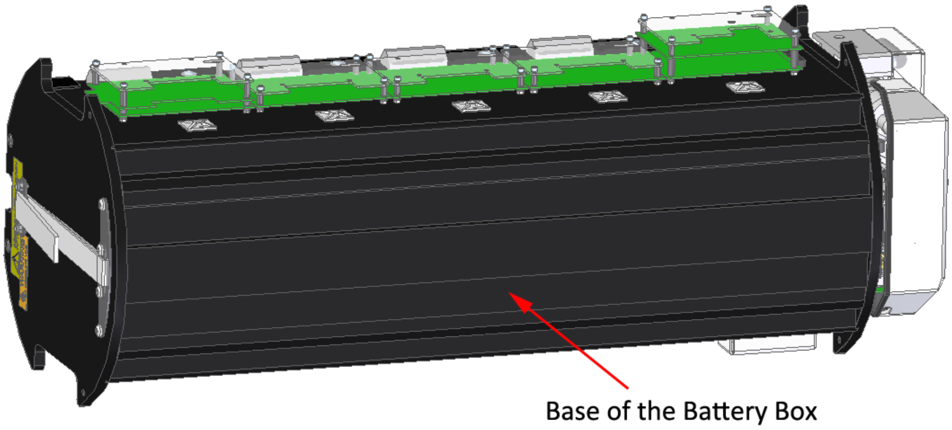


**Figure 7.23: Base of an EPOD**

The Battery Box is locked in the EPOD by Tension Rings.

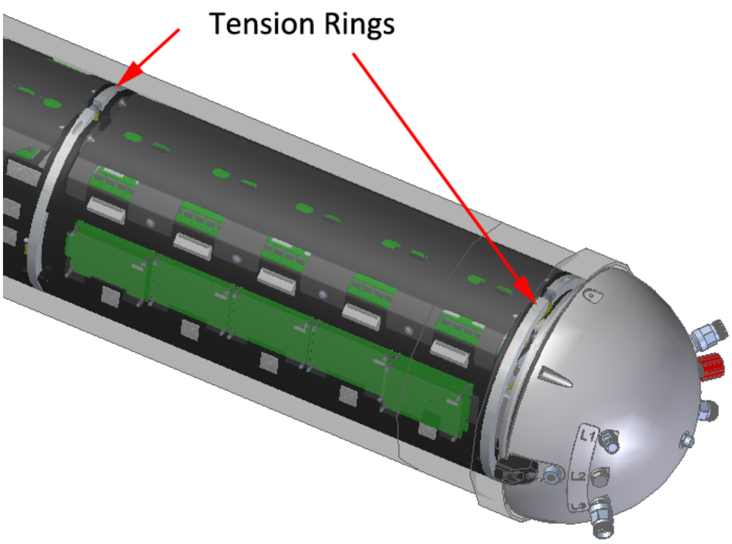


**Figure 7.24: Tension Rings inside EPOD**

### Installation Procedure

**This procedure assumes that the EPOD has been opened (see relevant task in this chapter) and the battery removed.**

1. Position the battery top cover facing upward.
2. Align the battery box with the locking / positioning pins of the rear tension ring. Make sure that the locking pins are pushed into the battery box.

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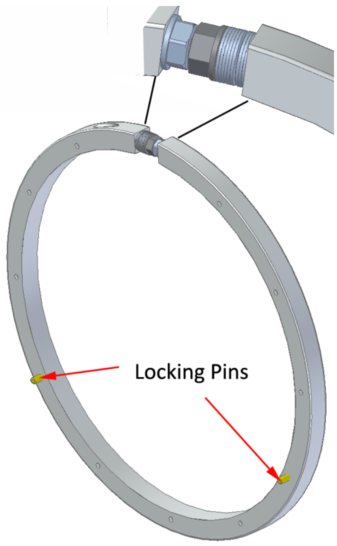


**Figure 7.25: Locking Pins on Tension Ring**

3. To lock the tension ring in place, push the Tension ring against the battery box and use a 2 x 13 mm open hex keys to lock the tension ring to the tube. Turn the nuts until the cup spring washer assembly is completely flattened.
4. Check that everything is secure by pulling the tension ring and make sure there is almost no gap between the tension ring and the battery box.
5. Route the interconnection cables for the Fore and Aft lids as described below:

    a. For the Double Hull Sabertooth Starboard side and also for a Single Hull Sabertooth, the interconnection cables are routed on the starboard side.

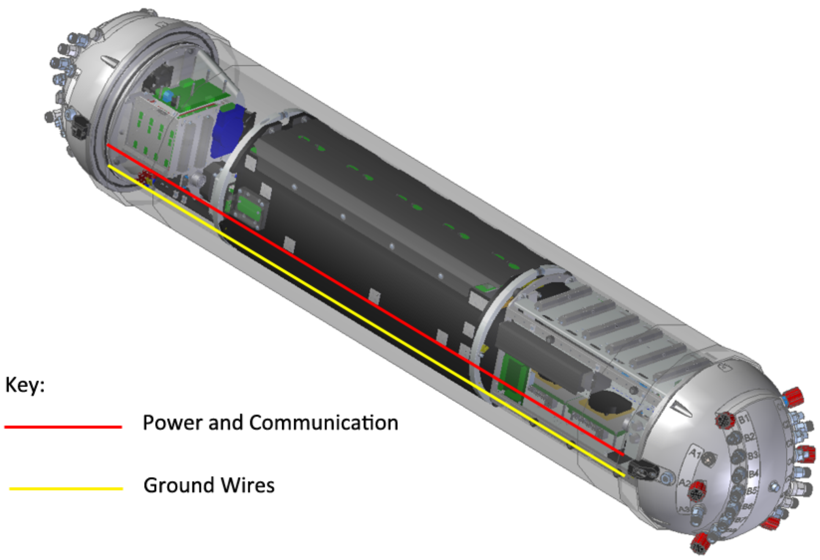


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**Figure 7.26: EPOD Interconnect (Starboard)**

    b. For the Double Hull Sabertooth Port side, the interconnect cables are routed on top of the batteries except for the ground wire, which is place on the port side of the batteries.

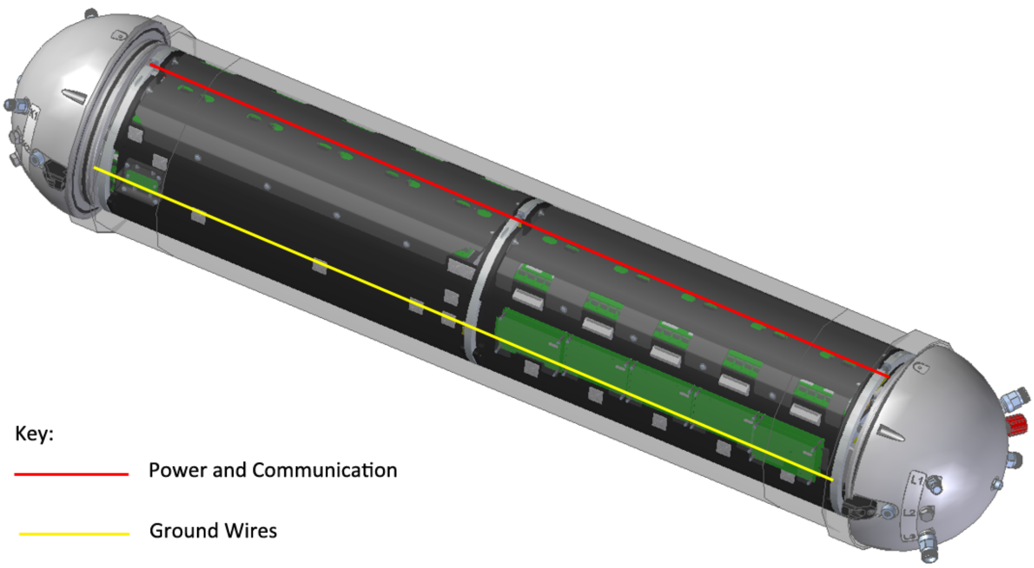


**Figure 7.27: EPOD Interconnect (Port)**

6. When closing the lids, make sure that there are no cables squeezed between lid rear end “plastic spacer/s” and the tension ring. The plastic spacers are used to provide extra safety in case the tension rings become loose. To avoid trapping any cable, place any excessive cable on the side of battery box and adjust the cables while closing the lid.

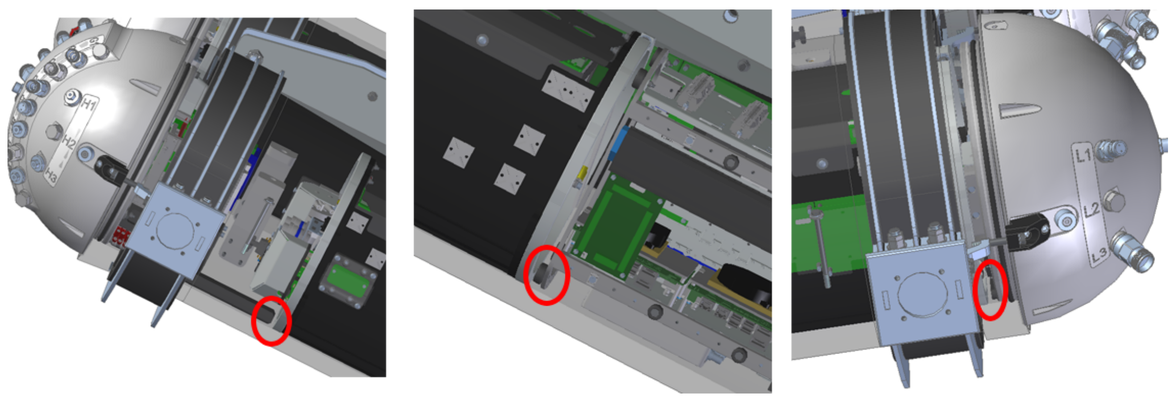

**Figure 7.28: Examples of the Spacer Locations**

When assembling the lids fully, hand tighten the last 4-5 mm of the screws. Using a metal shell connector as a handle, wobble the lid to see if tight. This can help ensure that there are no cables caught in between the lid and the EPOD body. If using the screws, try to be as gentle as possible and if it feels hard to continue, remove the lid and check the cables.

# Task 12. Fuse Exchange in the system

## Task 12.1 SCU

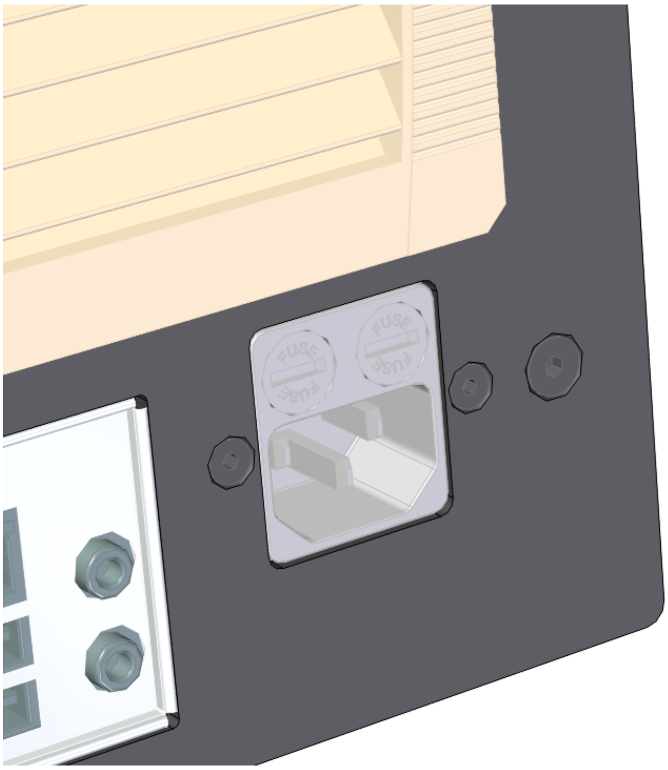

**Figure 7.29: SCU fuses**

| Item | Current rating | Type |
|---|---|---|
| Main power fuse. | T4A slow. | 5x20 Part no 03-0811004 |

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### Task 12.2 Vehicle Battery Fuses

**Table 7.2: Battery Fuses**

| Item | Current rating | Type |
|---|---|---|
| Battery main fuse F1<br><br>(red circle in image below) | 56A high speed | HRC high speed Part No. 03-0814056. |
| Electronics fuse F2-F4<br><br>(blue circle in image below) | 315mA | Fuse 1kV 6.3x32 mm Part No. 03-600090 |

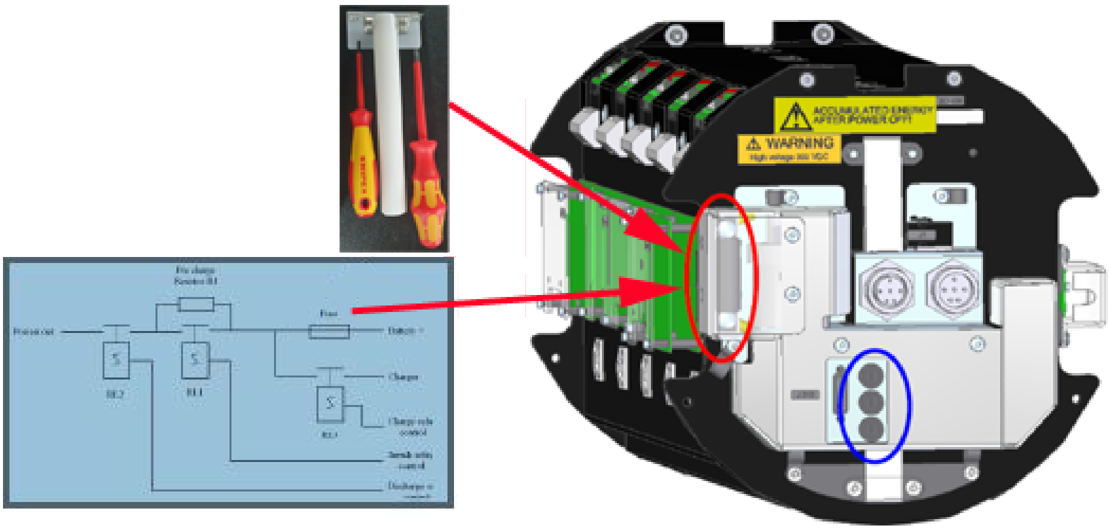


**Figure 7.30: Battery Fuses and Isolation Holder Tool**

To replace the battery fuse proceed as follows:

1. Remove start key and charger before opening lid.
2. Remove all connectors to electronics plate.
3. Secure and isolate loss connectors so they cant short circuit or damage o-ring surfaces.
4. Remove the transparent plastic cover to fuse use isolated tool.
5. Remove broken fuse by grabbing it with special isolated fuse holder tool (see above image).
6. Use isolated Torx tool to remove screws holding the fuse.
7. Place the new fuse in isolated holder tool.
8. Position the fuse and secure the fuse with the Torx screw.
9. Assemble the plastic cover.
10. Reconnect all cables. Make sure to properly tighten.
11. Make sure the o-ring surfaces are clean and greased before closing lid.

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### Task 12.3 Cell Module Fuse Replacement

All the cells in the battery are individually fused. In the extremely unlikely event that these fuses are tripped, they will need to be replaced for the BMS / battery system to work. The fuses are listed below and are included in the fuse set provided with the system.

| Item | Current rating | Type |
|---|---|---|
| Surface Mount Fuse | 500mA | Part no 03-0819013 |

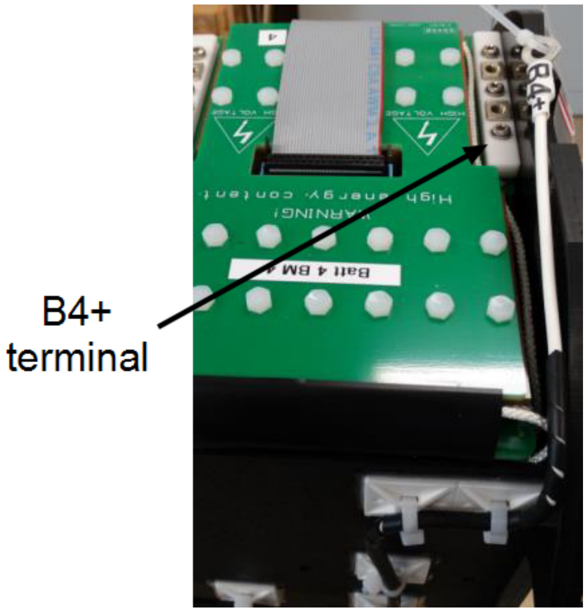


**Figure 7.31: Terminal on the battery**

Before replacing cell module PCB fuses:

1. Remove B4+ and B0- on battery (isolate loose ring terminal shoes).
2. Remove all flat ribbon cables on top of cell modules.
3. Remove all interconnection cables between cell modules B0+ to B4-.

**Assembly of SMD fuses on the cell module PCB**

1. Use a digital multimeter (resistance check) to confirm that the fuse is faulty .
2. Cover the cell module + and - with insulation tape as shown in Figure 7.32.
3. Install the blanking plug on to PCB ribbon connector.
4. To minimise the risk of heat and solder damaging the PCB or cells, protect the sides of the top card PCB with 50mm insulation tape (indicated by the red dots inFigure 7.32).

**Figure 7.32: Cell Module with protective insulation tape fitted**

5. Carefully clean around the faulty fuse with isopropanol alcohol to remove the conformal coating.
6. Remove the faulty fuse using a soldering iron.

NOTE: Take extra care to not damage the cells, spacer or PCB through heat transfer.

7. Carefully clean the solder pads with isopropanol alcohol.
8. Use a digital multimeter (resistance check) to confirm that the new fuses are ok before assembly.
9. Solder the new fuse in place. Be careful not to cause any heat transfer damage to the Cell, Spacers or PCB.
10. Clean the new fuse and PCB with isopropanol alcohol.
11. If available, cover the new fuse with conformal coating.
12. Remove the insulation tape fitted earlier.
13. Reconnect PCB ribbon connector.

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### Task 12.4 Vehicle STB Front Lid Fuses.

**Table 7.3: STB Front Lid Fuses 1 and 2**

| Item | Current rating | Type |
|---|---|---|
| Front lid fuses F1 and F2 | 5A | 10x38mm, Part No. 03-6000045 |

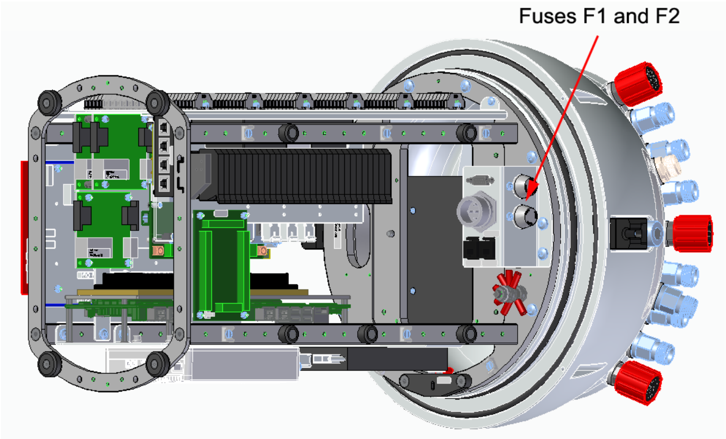


**Figure 7.33: Front lid fuses F1 and F2**

**Table 7.4: STB Front Lid DC/DC Converter Fuses**

| Item | Current rating | Type |
|---|---|---|
| 24 / 48 VDC/DC converter fuses | 4A 450VDC | 03-6000481 |
| 12 VDC / DC converter fuse | 12V Typ SMD 20A | 03-6000889 |

There is one fuse mounted on the DC/DC converter PCB for each converter.

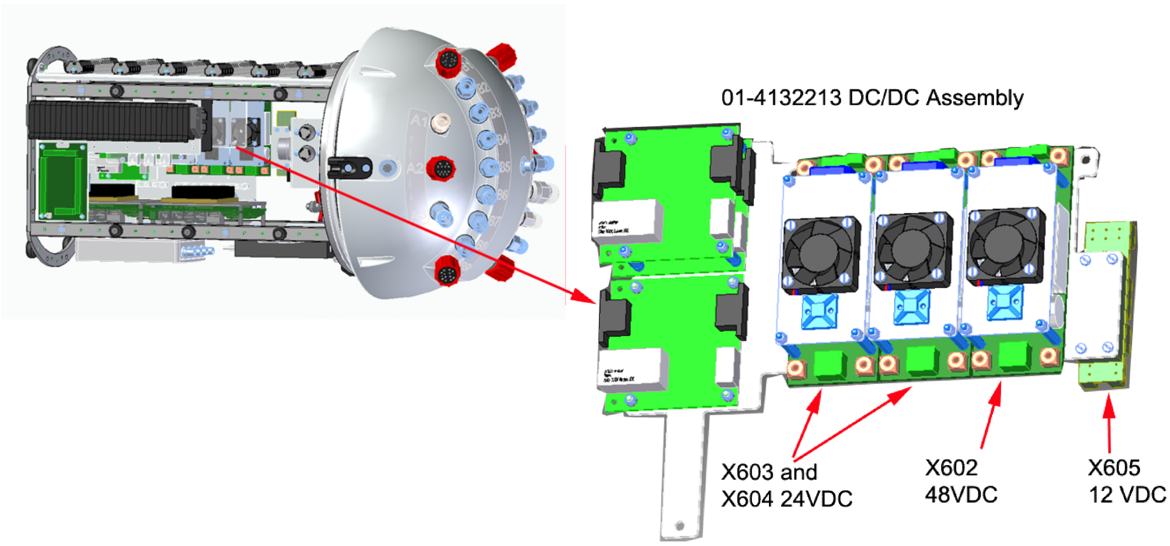


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**Figure 7.34: Front lid fuse DC/DC converters**

Table 7.5: STB Front Lid Output Fuses

| Item | Current rating | Type |
|---|---|---|
| F3-F31 | T5A | 5x20mm Littlefuse 218005 250V |

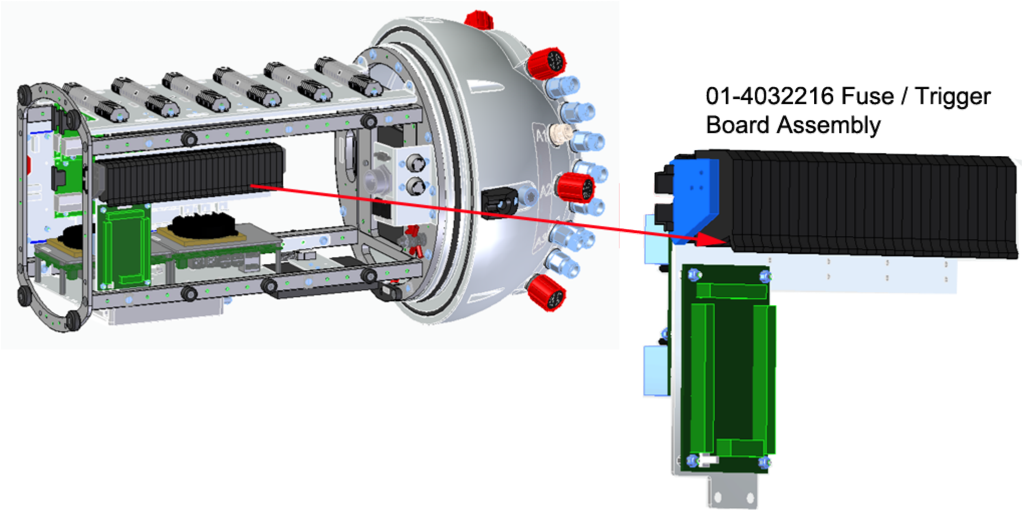


**Figure 7.35: Front Lid Output Fuses**

Table 7.6: STB Front Lid - LV Hub Fuses

| Item | Current rating | Type |
|---|---|---|
| Fuse | 5A | 125-6785-450 Fuse auto 125VDC Blade mini |

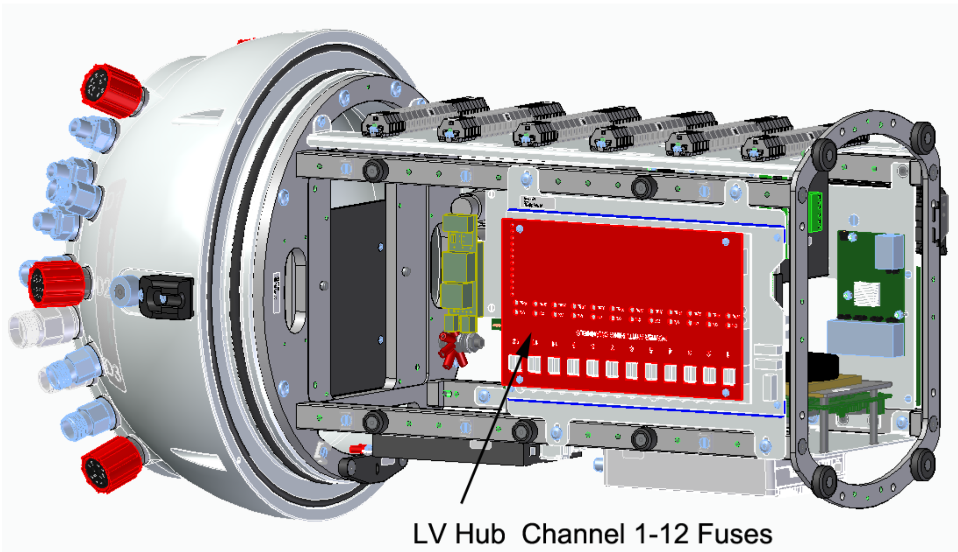


**Figure 7.36: LV Hub Fuses**

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Fuses for low voltage to consumers.

## Task 12.5 Vehicle STB aft Lid Fuses.

Table 7.7: Fuses HV Hubs

| Item | Current rat- | Type |
|---|---|---|

| | ing | |
|---|---|---|
| F2-F5 on each HV Hub board | 10A | 5x20mm Part no 1865977 |

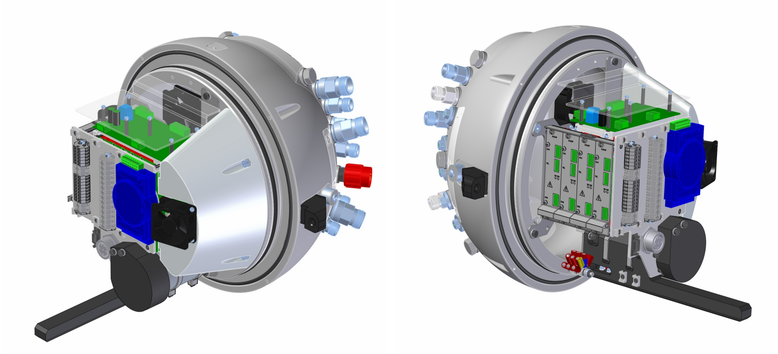

**Figure 7.37: Fuses HV Hubs**

Fuses on the HV Hub boards.

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### Task 12.6 PSU Fuse Exchange

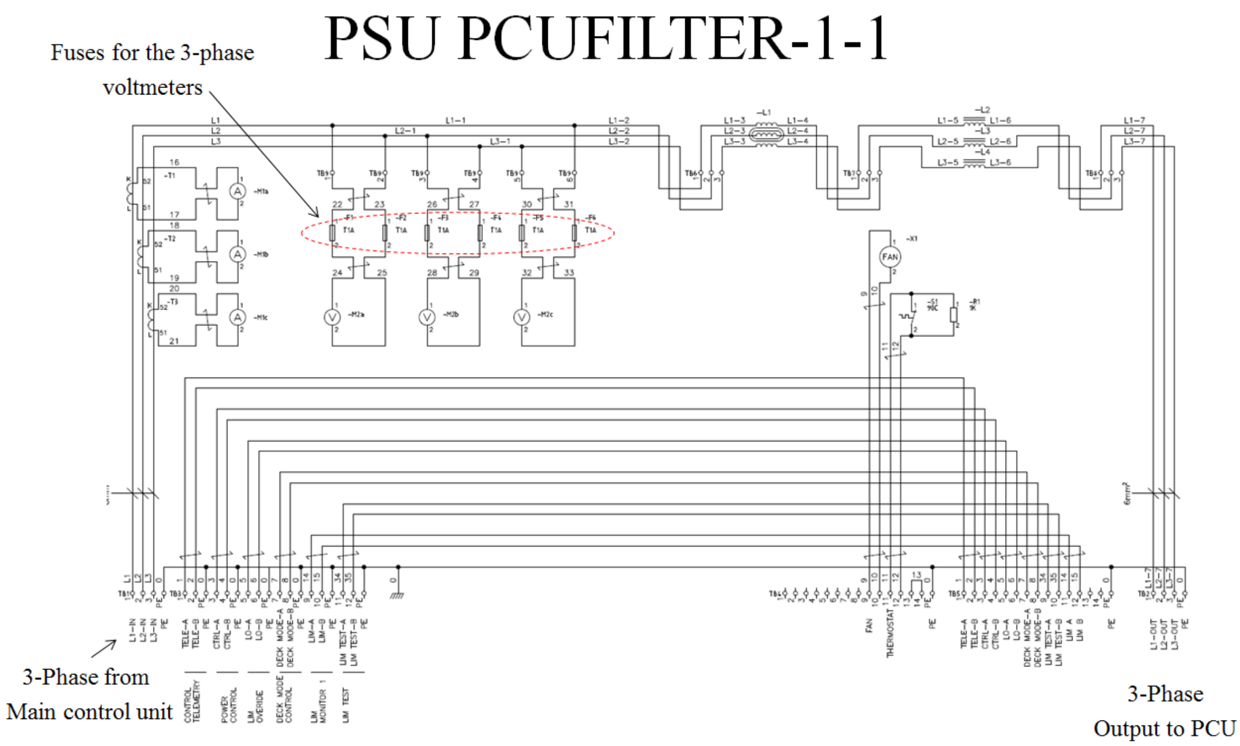


**Figure 7.38: PSU PCUFilter-1-1 Fuses**

| Item | Current Rating | Type |
|---|---|---|
| Voltmeter fuse | 1A slow | 6.3 x 32 mm, Part No.:03-0811422 |

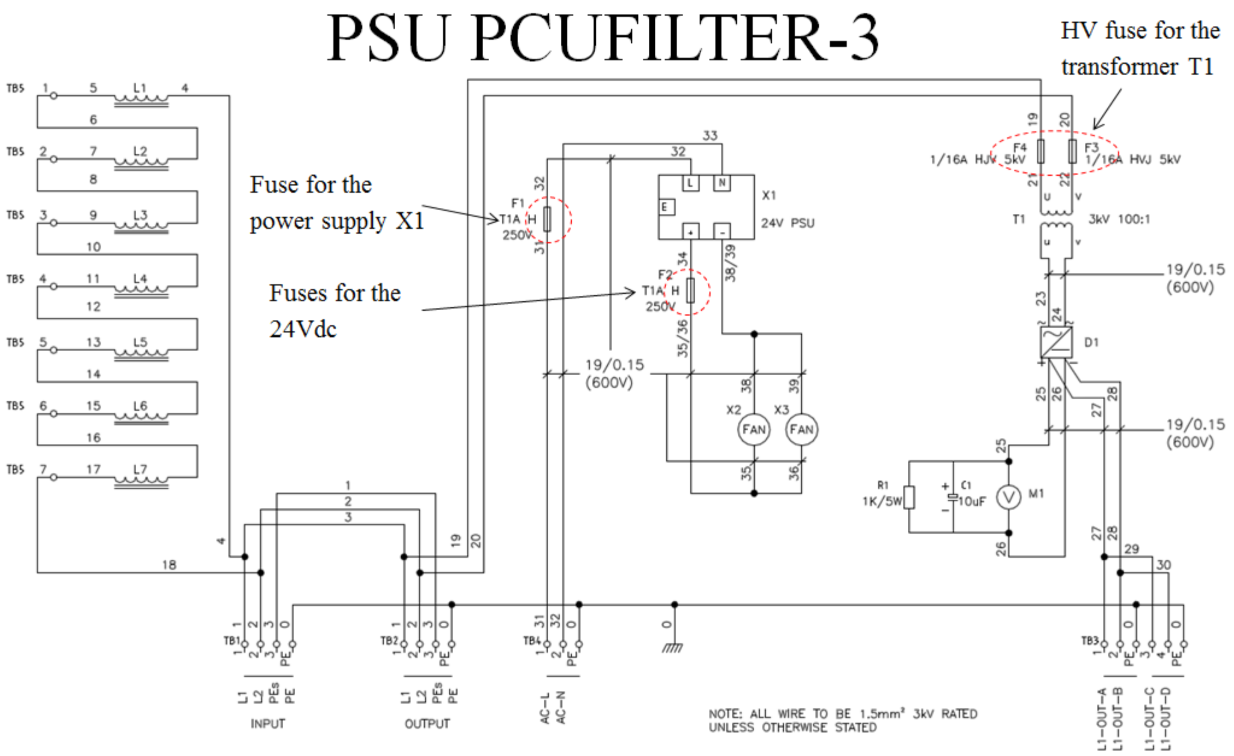


**Figure 7.39: PSU PCUFilter-3 Fuses**

| Item | Current Rating | Type |
|---|---|---|
| Power supply fuse | 1A slow | 5 mm x 20 mm Part no. F520T1A |
| 24 Vdc fuse | 1A slow | 5 mm x 20 mm Part no. F520T1A |
| HV fuse transformer | 0,5A | 5.5kV 142.2 x 20.6 mm Part no. 5-5AMWNA0-5E |

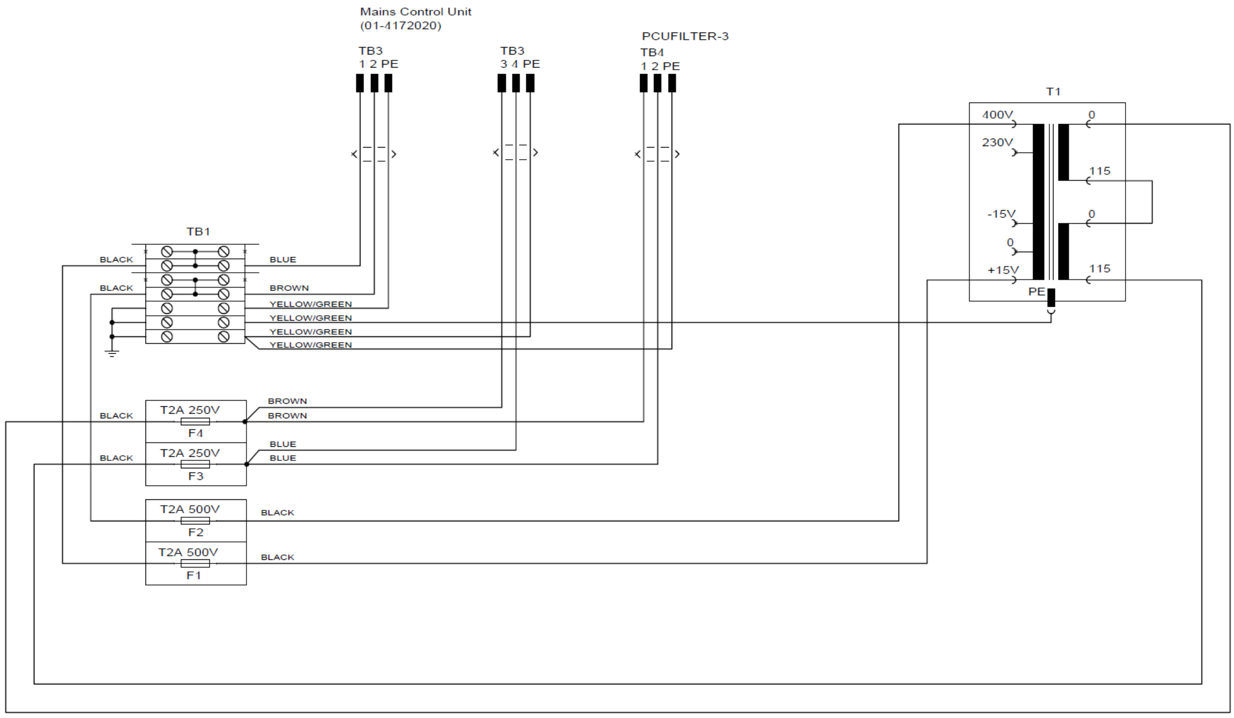


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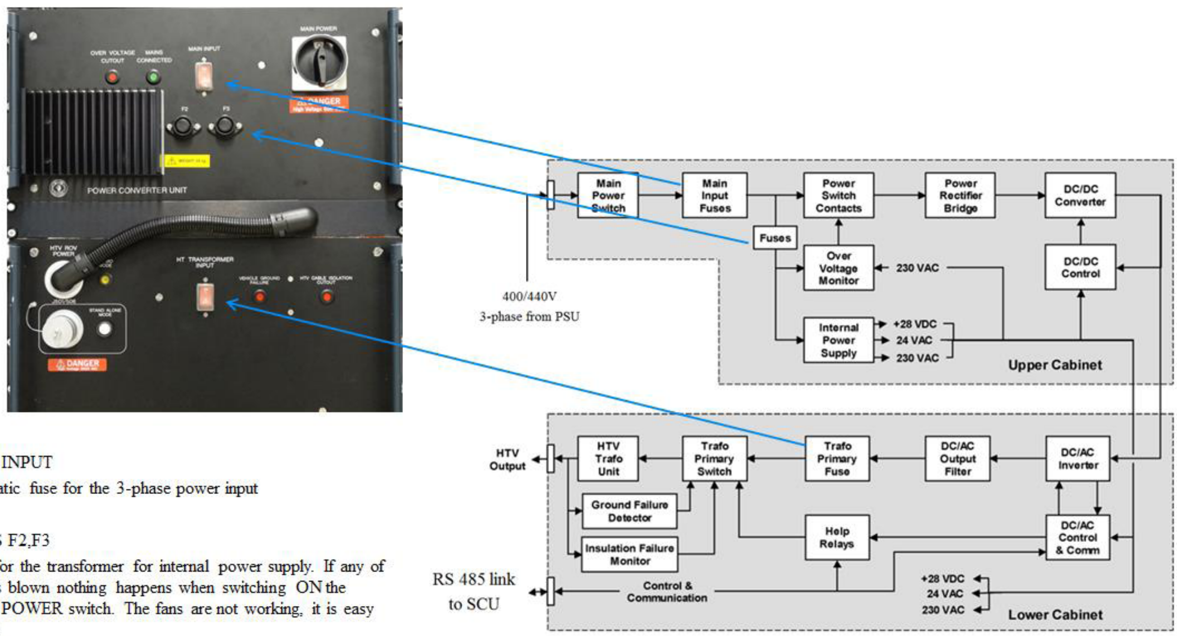
**Figure 7.40: PSU Back Panel Fuses**

| Item | Current Rating | Type |
|---|---|---|
| 400 V Power supply fuse | T2A | F1, F2 Ceramic T2A H 500V 6.3 x 32 mm, Part Number 414-033 |
| 230 V Power supply fuse | T2A | F3, F4 Ceramic T2A H 250V 5 x 20 mm Part Number 533-749 |




MAIN INPUT
Automatic fuse for the 3-phase power input

FUSES F2,F3
Fuses for the transformer for internal power supply. If any of these is blown nothing happens when switching ON the MAIN POWER switch. The fans are not working, it is easy to hear.

HT TRANSFORMER INPUT
Automatic fuse for the HV transformers.

**Figure 7.41: PCU Fuses**

| Item | Current Rating | Type |
|---|---|---|
| F2, F3 | 1A slow | 10.3 x 38.1 Part no: 03-0814031 |

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## Task 13. Spare batteries for Iridium, Strobe light and Acoustic pinger

Iridium part No: 93-1000018 CR123A Lithium battery 3V.

Strobe light: 93-1000019 C type battery 3,6V.

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## Task 14. Recommended tightening torque

Always follow the recommended tightening torque except when differences are specified on the drawing. Always check the drawing before tightening.

The drawings 20-4162801, 20-4162803, and 20-4162666 contain other torque values than those listed below.

**Table 7.8: Torques Settings**

| Bolt/Nut | | |
|---|---|---|
| Size | Tightening torque [Nm]. | |
| M3 | 0,9 | |
| M4 | 2 | |
| M5 | 4,1 | |
| M6 | 7 | |
| M8 | 17 | |
| M10 | 33 | |
| M12 | 57 | |
| Nordlock washer | | |
| Size | Tightening torque [Nm] | |
| M6 | 8,4 | |
| M8 | 20 | |
| M10 | 39 | |
| M12 | 68 | |
| Trisert Inserts - plastic framework & buoyancy | | |
| Size | Tightening torque [Nm]. | Where used. |
| M4 | 1 | Brackets inside pressure hulls |
| M5 | 2 | Front bracket to cowlings Charger whip brackets |
| M6 | 3,5 | Front, top & bottom cowlings/covers Extra thruster Inner buoyancy blocks Stabilising wing Iridium/Beacon/Strobe bracket Locking bar transformer unit Cover for transformer unit cut-out extra square lead weights CP probe assembly stop blocks (used if inner buoyancy removed). |
| M8 | 6 | Extra thruster & bracket Outer buoyancy blocks Bottom covers. |

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## Task 15. Prevco Relief Valve replacement

Each pod has a 10PSI Prevco relief valve fitted at positions G5 and L1. Occasionally, it may be required to remove the unit for O-ring Maintenance. It is also necessary that the valve is replaced every 8 years.

1. To maintain or replace, use a 3/4inch spanner to loosen off the valve.
2. If maintaining, check the o-rings for damage or deterioration.
3. If replacing, simply discard and move on to refitting step 4.
4. Before fitting new O-rings, inspect the sealing surfaces of both the valve and vehicle pod, checking for scratches, dirt and corrosion (clean / repair these before continuing).
5. Smear a small amount of O-ring grease on each of the new seals and fit to the valve.
6. Apply a small amount of Loctite 254 (approx 2 - 3ml) on to the female thread of the Vehicle pod valve location (G5 or L1).
7. Screw in the refurbished / new valve.
8. Tighten the valve to 55-75 inch/lbs as per manufacturer's recommendation.

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# Task 16. POCB Handling

The Portable Operator Control Board (POCB) is intended for use when the vehicle is in close proximity to the operator, which is usually during LARS operations. The unit is housed in a rugged IP65 console, nevertheless there are certain precautions that should be taken during handling and storage of the unit.

## Task 16.1 Cordless Radio

If a cordless radio version is used, set up the antennas and test communications and limits during the mobilization. Placement of the antenna is crucial for good communication.

NOTE: If there are bad communication areas, mark them in the situation plan and avoid using the POCB in these areas. Alternatively, relocate the antenna to a more suitable position.

## Task 16.2 Checks

### Daily

A check will be completed through Pre and Post Dive checks, See relevant Tasks in the next chapter.

NOTE: If the POCB is contaminated by seawater, flush it through gently with clean fresh water and allow to dry before retesting the unit.

### Monthly

Complete a close inspection of the unit for the following:

- Corrosion - If corrosion is noted, make sure it does not affect the integrity of the unit
- Dirt and Residue - Clean using only clean fresh water and soft cleaning agent if required
- Wear and Tear - make sure that there is no damage that is likely to compromise the integrity or functionality of the unit

## Task 16.3 Storage

The Unit shall be stored in such a way as to protect against direct sunlight, seawater, rain, and potential damage. This also includes the cable which should also be stored in the same manor

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Note! Rubber and Plastic parts are especially vulnerable to damage from direct sunlight, chemicals and extremes of temperature (hot and cold). These can lead to rapid ageing, cracks and can make the material more brittle and sensitive to damage.

## 7.2. List of Sabertooth System Drawings

Table 7.9: System Drawings

| Part No | System Drawing | Mechanical Drawing | Electrical Drawing | Description |
|---|---|---|---|---|
| 01-4162700 | 33-4162700 | | | System Diagram |
| 01-4162701 | N/A | 20-4162701 | 21-4162701 | Vehicle, Sabertooth DH, 3000msw |
| 01-4162703 | N/A | 20-4162703 | N/A | Structural Assembly |
| 01-4162715 | N/A | 20-4162715 | N/A | Electronics Pod Complete Starboard, 3000m |
| 01-4162711 | N/A | 20-4162711 | 21-4162711 | Front lid starboard assembly |
| 01-4162619 | N/A | 20-4162619 | 21-4162619 | Aft lid starboard assembly |
| 01-4162616 | N/A | 20-4162616 | N/A | Electronics Pod Complete Port, 3000m |
| 01-4162110 | N/A | 20-4162110 | 21-4162110 | Port Aft Lid, EPOD |
| 01-4162612 | N/A | 20-4162612 | 21-4162612 | Port Front lid, EPOD |
| 01-4162723 | N/A | 20-4162723 | 21-4162723 | Surface Control Unit |
| 01-4162620 | N/A | 20-4162620 | 21-4162620 | Vehicle Charger |
| 01-4162635 | N/A | 20-4162635 | 21-4162635 | Operators Control Board |
| 01-4162666 | N/A | 20-4162666 | 21-4162666 | Battery Module Complete |
| 01-4173031 | N/A | N/A | 21-4173031 | Spare Battery Charging Cable |
| 01-5032020 | N/A | 20-5032020 | N/A | Transport Case Battery Module |
| 01-5032021 | N/A | 20-5032021 | N/A | Battery Module Transport Secured |
| SM9-8 | N/A | S17236 | S18479 | SM9-8 Thruster |
| 01-4162642 | N/A | 20-4162642 | N/A | Mast and Antenna System |

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# CHAPTER 8

# PREVENTATIVE MAINTENANCE

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# 8. Preventative Maintenance Tasks

This chapter contains the approved methods by which the maintenance tasks listed are carried out.

## 8.1. Introduction

For safety of personnel and protection of equipment the removal, dismantling, assembling and refitting of equipment must be performed in accordance with the corrective maintenance procedures as detailed in Chapter 7.

## 8.2. Safety Precautions

Lethal voltages are present in all of the units and can be present in cable connections between units and junction boxes. Maintenance tasks can involve contact with substances harmful to health. Before any work is carried out, involving internal access to the units, junction boxes or cable connections, the following warnings and cautions are to be observed.

**WARNINGS:**

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT- ISOLATE ALL THE UNITS POWER SUPPLIES.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE VEHICLE SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND HAVE TAKEN ADEQUATE PRECAUTIONS..

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE SWITCHING ON THE VEHICLE SYSTEM, ENSURE THAT THE SYSTEM IS FULLY ASSEMBLED AND OPERABLE AND NO MAINTENANCE ACTIVITY IS IN OPERATION.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

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THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

**WARNING - POSSIBILITY OF TOXIC HAZARDS:**

DURING MAINTENANCE OR REPAIR IT IS POSSIBLE TO COME INTO CONTACT WITH SUBSTANCES HARMFUL TO HEALTH. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS ENSURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL COSHH PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**WARNING- DANGER TO PERSONNEL OR EQUIPMENT:**

THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGIZED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION PERSONNEL PRIOR TO ENERGIZING THE DC SUPPLY.

## Cautions:

**CAUTION - Possibility of damage to equipment.:**

Under no circumstances are the vehicle epods to be assembled without anti-extrusion rings.

**CAUTION - Danger of damage to PCBs:**

Do not remove or replace PCBs unless the supply is switched off. PCBs must be handled in accordance with electrostatic discharge handling procedures. Damage to PCBs could affect the safe operation of the equipment.

**CAUTION - Danger of damage to equipments:**

When checking connections, care is to be taken not to slacken them, otherwise their watertight integrity may be breached.

**CAUTION - Danger of damage to equipment:**

When using an insulation meter, make sure that the cable under test is disconnected at both ends.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

**CAUTION- Possibility of damage to equipment:**

Make sure that all vent plugs are securely fitted and shut prior to immersing the vehicle. If the vent plugs are not tight, water will enter causing damage to the equipment.

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**CAUTION - Possibility of poor vehicle handling:**

Make sure that the vehicle trim and ballast is correct after adding or removing equipment. Addition of equipment or poor vehicle ballast or trim will affect vehicle performance.

## 8.3. Maintenance Tasks

**Table 8.1: Maintenance Tasks**

| Task No. | Task Description | When carried out |
|---|---|---|
| 1 | Pre dive checks | Pre flight |
| 2 | Post dive checks | Post flight |
| 3 | Replacement of all seals | Every 8 years |
| 4 | Electrical connectors and seals including Metal Shell Connector O-Ring Replacement | When reconnect connectors and seals<br><br>When replacing damaged O-ring |
| 5 | SM9 Thruster oil filling check and replenishment. | Pre and Post-flight. |
| 6 | SM9 thruster motor shaft rotation | Monthly |
| 7 | SM9 isolation test | As required after maintenance. |
| 8 | EPOD vacuum check. | When the EPOD housing vacuum integrity is suspect or after the pod has been opened for maintenance. |
| 9 | Tether Check | No video picture or poor video image.<br><br>No communication to vehicle.<br><br>Insulation or GND Sense failure. |
| 10 | Fibre Tether Wheel Assembly | To improve friction between the wheel and the fibre tether. |
| 11 | Anode Checks and Replacement | Check every month and replace if required. |
| 12 | Battery charging | If not used, at least every 6 months |
| 13 | Spare battery charging | At least every 6 months |
| 14 | Configuration of Battery Charging | When Required |
| 15 | Tilt unit oil check and replenishment | Pre and Post-flight. |
| 16 | Cleaning SCU Fan Filter | 6 Month |
| 17 | System configuration | When configuring the system. |
| 18 | Configuring the Castle Gateway2 6252 PCB. | When required |
| 19 | Windows remote connection | When required |
| 20 | Using Imagenex Obstacle Avoidance Sonar | When required |
| 21 | Changing Frequency of Radio devices (if applicable) | When required. |
| 22 | Sabertooth NMEA Output | When required |
| 23 | Installing ICON Installer | When required |
| 24 | Node Tester | When required |
| 25 | Changing LED ID | When required |
| 26 | Fault Finding | When required |

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|---|---|---|
| 27 | Minimise Interference between Acoustic devices | When required |
| 28 | Configure the SPRINT Nav | When required |
| 29 | USB Hard Drive and USB Flash Memory | When required |
| 30 | Create image for backup | When required |
| 31 | Restore image for backup | When required |
| 32 | Download and Delete Log Files | Regulary |
| 33 | Battery Handling Safety | Safe working practices<br><br>In the case of fire, for transport, or for storage. |
| 34 | Remote Technical Support | When required |

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## 8.4. Maintenance Schedules

The following tables list the recommended schedule for maintenance of the Sabertooth System. This list is a guide and should be backed up with documented pre and post dive checks to ensure the continued reliability of the system.

For the safety of Operators / Maintainers and the equipment, before continuing with any of the below listed Maintenance Routines, ensure that the safety warnings and cautions listed in the Maintenance introduction at the beginning of this chapter have been read and all recommendations are adhered too.

Many of the following functional checks are carried out in the pre-dive checks, but they should also be performed as described in the table below:

**Table 8.2: Vehicle Maintenance Schedule**

| Item No | Task Description | Pre/Post Dive | 1 Mth | 4 Mth | 1 Yr | 18 Mth | 8 Yr |
|---|---|---|---|---|---|---|---|
| 1 | Check system completeness | | | | X | | |
| 2 | Visual inspection for damages | X | | | | | |
| 3 | Close visual inspection for damages<br>• Corrosion<br>• Wear and tear<br>• Cracks<br>• UW Cable integrity | | X | | | | |
| 4 | Flush vehicle and subsea assets with fresh water | X | | | | | |
| 5 | Check/Fill oil in ROV Thrusters | X | | X | | | |
| 6 | Replenish oil in ROV Thrusters | | | X | | | |
| 7 | Rotate ROV Thruster shaft | | X | | | | |
| 8 | Replace Main Epod O-rings and backup-ring | | | | X | | |
| 9 | Replacement of all Vehicle O-rings, isolators and Back up rings | | | | | | X |
| 10 | Leak/Vacuum Test of Epod | | | | X | | |
| 11 | Inspection of underwater cables (replace if necessary) | | | | X | | |
| 12 | Inspection of sacrificial anodes and replace if required | | X | | | | |
| 13 | Battery Overhaul | | | | | X | |
| 14 | Send all ROV Thrusters for factory overhaul | | | | | | X |
| 15 | Complete Battery replacement | | | | | | X |
| 16 | Battery Check and Charging | | | X | | | |
| 17 | Replacement of Prevco relief valve | | | | | | X |
| 18 | Inspect lifting points, chains and shackles (complete load tests if necessary as per local HSE guidelines) | | | | X | | |

**Table 8.3: Surface Units Maintenance Schedule**

| Item No | Task Description | 1 Mth | 12 Mth |
|---|---|---|---|
| 1 | Check condition of sub case and connectors | | X |
| 2 | Check air filters in the SCU and replace if required | X | |
| 3 | Clean and refurbish the PSU | | X |
| 4 | Clean the POCB | X | |

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# Task 1. Pre-Dive Check

## Frequency of Task

Pre-flight

## Introduction.

These checks ensure that the equipment is fully functional, secure and in good working order prior to each operational use. It is recommended that a copy of the check list be used prior to each dive and signed and witnessed by a supervisor.

## Tools Required

The following tools may be required:

- Diaphragm puller tool (Part No P10674)
- Deck communications

## Procedure:

Proceed in accordance with Pre-dive checklist.

**WARNING - DANGER TO PERSONNEL AND EQUIPMENT:**

MAKE SURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION AND PERSONNEL PRIOR TO ENERGISING THE DC SUPPLY. WHEN THE SYSTEM DC SUPPLY IS ENERGISED, THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING.

**WARNING - POSSIBILITY OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

MAKE SURE THAT THE PSU IS SWITCHED ON AND THE START KEY IS NOT INSERTED.

| Pre-Dive checks | |
|---|---|
| Vehicle checks | |
| Check SM9 thruster propellers are secure and free of debris | |
| Check Thruster oil levels using the diaphragm puller tool. Ensure that at least one hole is visible on the puller tool | |
| Check Tilt Unit oil level using the diaphragm puller tool. Ensure that at least one hole is visible on the puller tool | |
| Check Transformer unit oil level using the diaphragm puller tool. Ensure that at least one hole is visible on the puller tool | |
| Check Thrusters and Sonar tilt are free from fouling | |
| Remove all camera lens caps and clean lens with soapy water if necessary | |
| If the EPODs have been opened or the top cover has been removed, confirm that the two airbleed screws (per pod) are tight. | |
| If the top cover has been removed confirm that all unused bulkhead connectors on the EPODS have dummy connectors correctly fitted | |

| | |
|---|---|
| Confirm that all lamp glasses are undamaged | |
| Check that all connectors are properly mated sleeved and all cables secure and clear of propellers and tilt unit | |
| Check that all thrusters, nozzles and buoyancy blocks are correctly fitted and secure | |
| Check that all Cameras are correctly fitted and secure | |
| Check that the additionally fitted equipment is correctly fitted and secure | |
| Check that there are no obvious oil leaks from any of the ROV parts and hoses | |
| If the vehicle has not been used for a month or longer, rotate all the propellers by several turns before switching ON the vehicle | |
| **System start up** | |
| 1. System connected as per system diagram either using WiFi, tether, or patch cable.<br>2. Start vehicle using start key. Following instruction on start key.<br>3. Start the SCU after the vehicle! Important as vehicle computer time synchronizes with SCU computer.<br>4. Start SAC and HMI SW located on desktop.<br>5. Once values on the HMI turns from red to white, the vehicle and SCU now have communication.<br>6. Always check event log to verify system integrity:<br>a. Optional equipment not installed or used on system use “Suppress always” button.<br>b. Always have LV/HV hub and thruster disabled when not used or away from system.<br>7. Check the communication to the POCB.<br>8. Set the buttons on the HMI in accordance with the following list:<br>• Overview tab:<br>• Thruster disable (The thruster is default disable).<br>• All LV HUB channels disabled<br>• Joystick sensitivity: 25%.<br>• Control Modes: Deck.<br>• V. Mode: Depth<br>• Control tab:<br>• Doppler: On. (Check the Event screen for bad DVL data)<br>• Lamps: Off<br>• Activate LV and HV HUB power channels.<br>9. Switch ON the winch and pay out the amount of tether that is needed for launching the vehicle.<br>When testing HMI and OCB from pilot cabin, before starting the vehicle, make sure | |

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| | |
|---|---|
| that there is someone standing beside the vehicle ready for the Pre-Dive check, and that there is good communication between pilot and the deck personnel.<br>10. Check that "Total battery" is at 100%.<br>11. Press the button "Thruster enable "in the Overview window.<br>12. Check that no propellers are rotating and that the lamps are not lit.<br>13. Perform a Pre-dive check making sure that everything is working before diving. | |
| Starting up the vehicle | |
| Check that camera pictures from all cameras are displayed on the monitor | |
| Check that all LINK warning messages have disappeared from the HMI | |
| Check that INS is in Navigation i.e. "green LED". | |
| Check that all thrusters are working by giving thrust in all directions and that the thrusters respond the right way in all directions:<br>• Forward/backwards<br>• Sideways (STB/Port)<br>• Rotate (STB/Port)<br>• Up/down Pitch | |
| Check the camera and sonar tilt mechanism by tilting fully down and up again. | |
| Check that all lights are working<br>**Caution! Be careful not to look directly into the lights.** | |
| Check in the HMI that the battery charge is enough for the planned operation | |
| Pre-Dive check garage | |
| If the garage is to be used, make a visual inspection and check that the spring loaded paddles moves smoothly and not are jammed | |

Pilot/Operator (sign and print)------------------------------------------ Date---------------

Authorised to dive? YES/NO

Supervisor (sign and print)----------------------------------------------- Date--------------

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# Task 2. Post-Dive Check

## Frequency of Task

Post-flight

## Introduction

These checks ensure that any damage that may have occurred during operational use can be repaired and any defects rectified before storage or subsequent operations.

## Tools Required

The following tools may be required:

- Diaphragm puller tool (Part No P10674)
- Deck communications

## Parts Required

No parts required

## Procedure:

Proceed in accordance with Post-dive checklist

| Post-Dive checks | |
|---|---|
| The vehicle should be powered on with Thrust Mode set to DM in the HMI when starting the following checks | |
| Vehicle checks | |
| Prior to applying power to the thrusters, visually check the propellers are clear of debris such as fishing wire or rope.<br><br>Check all thrusters are working by giving thrust in all directions and that the thrusters respond the right way in all directions. Check for strange sounds and vibrations.<br><br>• Forward/backwards<br>• Sideways (STB/Port)<br>• Rotate (STB/Port)<br>• Up/down<br>• Pitch<br>• Roll | |
| Check the camera and sonar tilt mechanism by tilting fully down and up again | |
| Check that all lights are working | |

| Caution! Be careful not to look directly into the lights. | |
|---|---|
| Power Off procedure | |
| If battery powered, Turn OFF the vehicle by removing the start key<br><br>If powered from PSU, Switch OFF the PCU and the PSU<br><br>Mount the protective cover on the ON/OFF connector | |
| If needed spool in tether that not is needed on deck. Switch OFF the winch | |
| Switch OFF the SCU, Monitors, SCB and POCB | |
| Vehicle checks | |
| Rinse the vehicle with fresh water | |
| Check SM9 thruster propellers are secure and free of debris | |
| Check Thruster oil levels using the diaphragm puller tool. Ensure that at least one hole is visible on the puller tool | |
| Check Tilt unit oil level using the diaphragm puller tool. Ensure that at least one hole is visible on the puller tool | |
| Check Thrusters and Sonar tilt are free from fouling | |
| Clean camera lenses with soapy water if necessary and fit lens covers | |
| Check that the air bleed screws on the thrusters are tightened | |
| Remove any debris from the vehicle | |
| Inspect all propellers and nozzles, looking for any possible damages | |
| Check that nothing is loose on the vehicle: thruster, sensors, buoyancy blocks, panels and other parts. Tighten if required. | |
| Confirm ALL lamp glasses are undamaged | |
| Check that all visible connectors are properly mated sleeved and the cables secure and clear of propellers and tilt unit | |
| Battery charging | |
| Charge the vehicle battery if necessary | |

Pilot/Operator (sign and print)------------------------------------------ Date---------------

Authorised to dive? YES/NO

Supervisor (sign and print)----------------------------------------------- Date--------------

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## Task 3. Replacement of all seals

### Frequency of Task

Every 8 years

### Tools Required

- Common tools.
- Silicone grease.
- Amberklene

Rubber and plastic parts are affected by ageing, temperature and environment.

As the O-rings are critical for the integrity of pressure housings and are system critical, Saab recommends that, in addition to the maintenance set out in the following sections, all O-rings, corresponding isolation washers, and backup rings should be replaced every 8 years as part of a planned maintenance schedule (for detailed instruction, refer to the corresponding tasks). During the replacement, all sealing surfaces should be examined for scratches and corrosion. If scratches cross the O-ring surface or corrosion marks are present on the sealing surfaces, contact Saab support for guidance.

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# Task 4. Electrical Connectors and Seals

Where electrical connectors have been disconnected, before reconnecting the plugs and bulkhead connectors are to be examined for damage to the thread forms, O-rings, lead and pins and any dirt removed. Cleaning should only be with Amberklene and the plug and socket assembly thoroughly dried and threads and O-rings lightly coated with Molykote 111 grease before reconnecting. It is advised where maintenance has disturbed units fitted with O-rings that the O-ring be discarded and replaced with a new one. Where this is not possible, the seal and O-ring groove should be cleaned and inspected for damage. O-rings are to be lightly coated with Molykote 111 prior to unit assembly.

The Sabertooth system electronic pods has been designed to operate at full diving depth and is fitted with anti-extrusion rings. The O-ring grooves on the pod have been designed to accommodate both an O-ring and an anti-extrusion ring to prevent O-ring failure. It is therefore essential that the pod be assembled with the anti-extrusion rings fitted to the inboard side of the O-ring.

## Task 4.1 Connectors and Seals Maintenance

### Frequency of Task

As necessary.

### Introduction

There are a number of different types of connectors and seals used on the ROV system. It is important to regularly check the threads, pins, and leads for dirt or damage. O-rings and seal should be checked and replaced regularly.

Tools Required

- Common tools
- Amberklene
- Silicone grease - Molykote 111 (for O-rings), Molykote 44 (for rubber moulded connectors)

Parts Required

- O-rings (there are a number of different O-rings used on Saab Systems. Check that you have the correct O-rings for the system's connectors).

**Table 8.4: O-Ring Descriptions**

| Type | Quantity | Part Number | Description |
|---|---|---|---|
| Size 2 | 1 | 200014 | 12.42mm x 1.78mm Nitrile 70 BS014 |
| | 1 | ORBS014N190Y | 12.42mm x 1.78mm Nitrile 90 O-Ring, BS014, Yellow, used on M2 Metal shell. |
| Size 3 | 2 | 200019 | 20.35mm x 1.78 mm Nitrile 70 O-Ring, BS019 |

| Type | Quantity | Part Number | Description |
|---|---|---|---|
| Size 4 | 1 | | 30.00mm x 2.00mm Nitrile 70 |
| | 1 | | 30.00mm x 2.00mm Nitrile 90 |
| NOTE: Connectors for all Deep Rated (DR) whips are fitted with 2 x Yellow 90 Shore O-rings. | | | |

### Task 4.1.1 Check Electrical Connectors and Seals

1. On disconnected electrical connectors, examine the threadforms, O-rings, leads and pins for damage.
2. For the plugs and bulkhead connectors, remove any dirt and clean with Amberklene.
3. Thoroughly dry the plug and socket assembly prior to reconnecting the plugs and bulkhead connectors.
4. If possible, discard and replace the O-rings during maintenance. If replacement is not possible, perform the following:

- Clean and inspect the seal and the O-ring groove.
- Lightly coat threads and O-rings with silicone grease.

5. Where used, make sure that any Parbak seals or anti-extrusion rings are fitted on the inner side of the O-ring in the O-ring groove.
6. When reconnecting metal shell connectors on the EPODs, tighten the nut and make sure that no threads are visible. If threads are visible, loosen the nut and remove the connector. Check to see if there is any dirt and debris on both the connector threads and the bulkhead. Refit the connector ensuring that no threads remain visible.

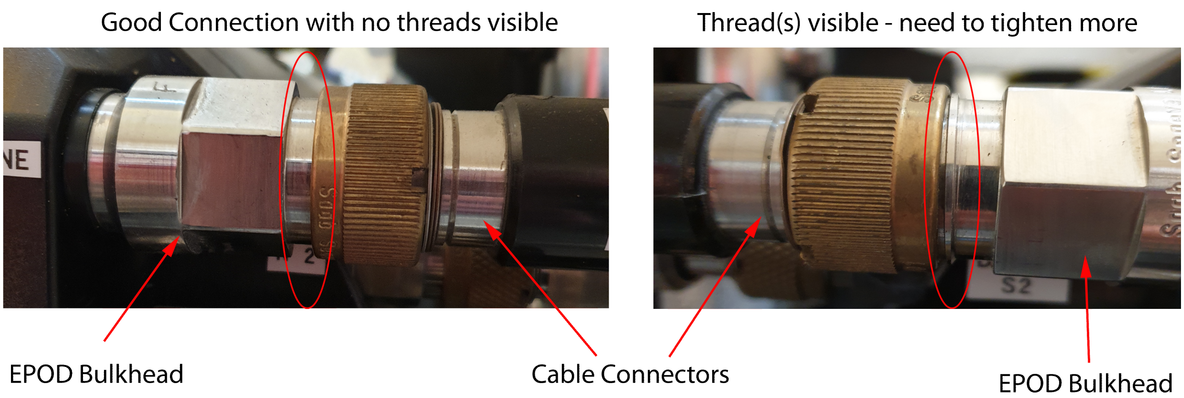


**Figure 8.1: EPOD Bulkhead Connections**

### Task 4.1.2 Replace Metal Shell Connector O-Rings

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**Frequency**

O-rings should be replaced after 50 mate / demate cycles. For example, on the Start key and battery charger extension leads on vehicle.

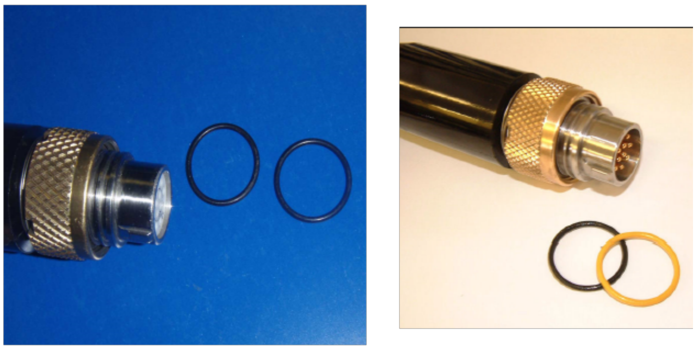

**Figure 8.2: Metal Shell Connector and O-rings**

1. Use a small screwdriver to open the Spiralux washer and slide it along the connector body towards the plug moulding.
2. Pull back the nut towards the plug moulding and remove and discard the O-rings.
3. Clean the O-ring grooves, connector body and nut with Amberklene.
4. Apply a light coating of silicone grease to two new O-rings.
5. Fit the two new O-rings into the O-ring grooves on the connector body.
6. Slide the nut along the connector body past the Spiralux groove.
7. Use a small screwdriver and slide the Spiralux washer along the connector body until it sits in its groove.
8. Perform functional checks for all systems.

### Task 4.1.3 Grease Rubber Moulded Connectors (Where Used)

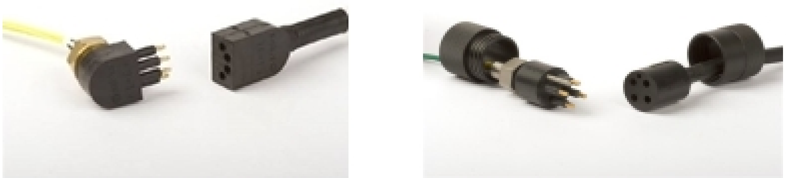

**Figure 8.3: Rubber Moulded Connectors**

There are different types of rubber moulded connectors used (not all are shown here). This procedure describes how to grease the connectors if disconnected:

1. Remove any cable ties if used on the rubber moulded connector.
2. Depending on the type of connector, remove the half shells.
3. Disconnect the rubber moulded connector.
4. Clean the connector faces and pins.
5. For above water (dry mate) connections:
   a. Apply a coating of Molykote 44 silicone grease (1/10th of the socket depth) to the female connector making sure that the inner edges of the sockets are completely covered and a thin layer of grease is visible on the face of the connector.

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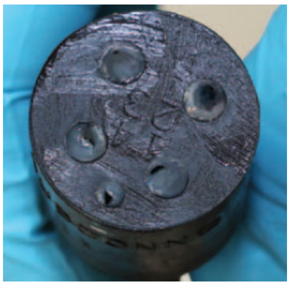

**Figure 8.4: Silicone Grease for Dry Mate Connections**

b. Fully mate the male and female connectors to allow for optimal distribution of the grease on the pins and in the sockets.
c. Remove any excess grease from the connector joint.
d. Disconnect the two connectors and check that there is grease on every male pin.
e. Reconnect the connector.

6. If previously removed, replace the half shells.
7. Attach new cable ties.

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## Task 5. SM9 Thruster Oil Level Check and Replenishment

### Frequency of Task

Pre and Post-flight.

Every 4 months of operational use

Every time oil has been lost from the motor prior to disassembly

### Introduction

The procedure describes how to check the level of the thruster motor oil prior to operational use and how to replenish the oil if required. There are two methods for oil filling:

- Using the hand pump with the motors in situ.
- Using the thruster fill kit with the motors removed from the vehicle.

The thruster motors, SM7, SM8 and SM9, use Mobilect 39 oil. Do **NOT** use any other oils.

### Tools Required

The following tools may be required:

- A non-metallic wedge for wedging propellers
- Diaphragm puller tool (Part No P10674)

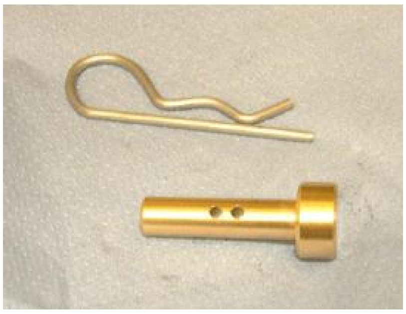

**Figure 8.5: Diaphragm puller tool**

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**Figure 8.6: Oil pump part no P10520**

**Parts Required**

- Mobilect 39 oil
- Clean container for collecting oil

### Task 5.1 Check Oil Level

**WARNING - POSSIBLE EXPOSURE TO CHEMICAL IRRITANTS:**

DURING MAINTENANCE OR REPAIR, IT IS POSSIBLE TO COME IN CONTACT WITH SUBSTANCES THAT MAY CAUSE SKIN OR EYE IRRITATIONS. PRIOR TO ALL MAINTENANCE OR REPAIR TASKS MAKE SURE THAT THE RELEVANT DATA HAZARD SHEETS AND LOCAL CHEMICAL SAFETY PROCEDURES HAVE BEEN READ AND UNDERSTOOD.

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL:**

WHEN THE SUPPLY CANNOT BE DISCONNECTED, FUNCTIONAL TESTING, MAINTENANCE AND REPAIR OF THE ROV SYSTEM IS TO BE UNDERTAKEN ONLY BY PERSONS FULLY AWARE OF THE DANGERS INVOLVED AND WHO HAVE TAKEN ADEQUATE PRECAUTIONS.

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1. Visually examine each motor, motor cable gland and cable, and chassis vicinity for signs of oil leakage.
2. Using the Diaphragm Puller Tool, screw into the motor diaphragm and ensure that the top of the diaphragm cover is between the drilled holes on the tool. For the Y thruster, use a finger to check the location of the holes in the puller tool.

3. If the holes are not visible, carry out the oil replenishment procedure.

   NOTE: If frequent topping up is required, an investigation is required to ascertain the possibility of damage to the motor.

   NOTE: If the oil appears to be cloudy or milky, this is an indication that water has mixed with the oil. Thoroughly investigate the thruster for any possible evidence of water ingress.

**Task 5.2 Replenish the Oil**

NOTE: It is recommended that the motor oil is replenished after 4 months of operational use.

**Task 5.3 Motors remain in situ on the vehicle**

The following steps can be carried out without removing the thruster from the vehicle. Due to the orientation of the Y thruster, it is difficult to see the holes in the diphragm puller tool. Use a finger to check the location of the holes in the puller tool pin in relation to the thruster end cap.

1. Fill the oil pump with clean fresh oil and check that there is no air in the hose.
2. Carefully remove the quick connect cap assembly.
3. Connect the pump to the QD.
4. Insert the Diaphragm puller tool into the motor end cap and screw onto diaphragm threaded stud.
5. Holding the motor securely, carefully and slowly pump oil into the motor until the second locking pin hole is visible above the end cap. For the Y thruster, use a finger to check for the second hole.
6. Release the pressure in the pump wait approx. one minute, check if there is any air coming from the motor and that the puller tool sinks, indicating that the oil is going back to the pump. For the Y thruster, use a finger to check if the puller tool as moved.
7. Fill the motor again until the second locking pin hole is visible above the end cap (or for the Y thruster, use a finger feel the location of the second hole). Insert the locking pin into the second hole and release the pressure in the pump.
8. Disconnect the hand pump from the QD.

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**Figure 8.7: SM9 diaphragm assembly**

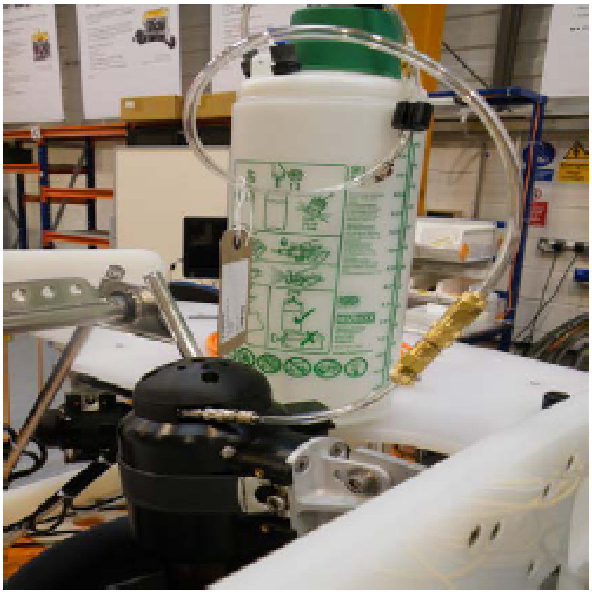

**Figure 8.8: Hand pump connected to motor**

9. Remove the locking pin and observe the puller tool pinholes and ensure that at least one of the holes remains visible. This indicates that the motor is completely filled with oil and purged of air.
10. If the tool "sinks" into the motor end cap repeat the fill procedure.
    If after a repeated fill procedure with no success, the motor may need to be removed and filled with the QD pointing upwards at the highest point.
11. Carefully mount the quick connect cap assembly.
12. Remove the diaphragm puller tool.
13. Clean the motor and area of any oil spillage.

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### Task 5.4 Motor removed from vehicle

1. Fill the oil pump with clean fresh oil check that there is no air in the hose.
2. Carefully remove the quick connect cap assembly.
3. Connect the pump to the QD.

4. Insert the Diaphragm puller tool into the motor end cap and screw onto diaphragm threaded stud.
5. Holding the motor securely with the QD pointing upwards as the highest point.. Carefully and slowly pump oil into the motor until the second locking pin hole is visible above the end cap.
6. Release the pressure in the pump wait approx. one minute, check if there is any air coming from the motor and that the puller tool sinks, indicating that the oil is going back to the pump.
7. Fill the motor again until the second locking pin hole is visible above the end cap, insert the locking pin and release the pressure in the pump.
8. Disconnect the hand pump from the QD.
9. Remove the locking pin and observe the puller tool pinholes and ensure that at least one of the holes remains visible. This indicates that the motor is completely filled with oil and purged of air.
10. If the tool “sinks” into the motor end cap repeat the fill procedure.
11. Carefully mount the quick connect cap assembly.
12. Remove the diaphragm puller tool.
13. Clean the motor and area of any oil spillage.

**Figure 8.9: SM9 diaphragm assembly**

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# Task 6. SM9 Thruster Motor Shaft Rotation

### Frequency of Task

Monthly

### Introduction.

This task prevents the shaft seal and ceramic seal surfaces seizing when the motors are not being used for prolonged periods. This maintenance includes motors fitted and motors held in stores.

### Tools Required

No tools are required

### Parts Required

No parts required

Procedure:

**WARNING- DANGER TO PERSONNEL OR EQUIPMENT:**

THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGIZED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION PERSONNEL PRIOR TO ENERGIZING THE DC SUPPLY.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

Proceed as follows:

- Rotate all motor shafts through several revolutions.

# Task 7. Isolation Test for SM9 Motor

## Frequency of Task

As required after maintenance.

## Introduction

This procedure is required to determine the integrity of the motor cables.

Damage may occur if the isolation test is not carried out correctly.

Tools Required

- Isolation tester

## Insulation Testing

1. Connect the isolation tester. For information, see Figure 8.10.
2. The motor can be insulation tested as follows.
    - Earth to DC (A)
    - Earth to Electronics (B)
    - Electronics to DC (C)
3. The reading must be greater than 200 Mohms.

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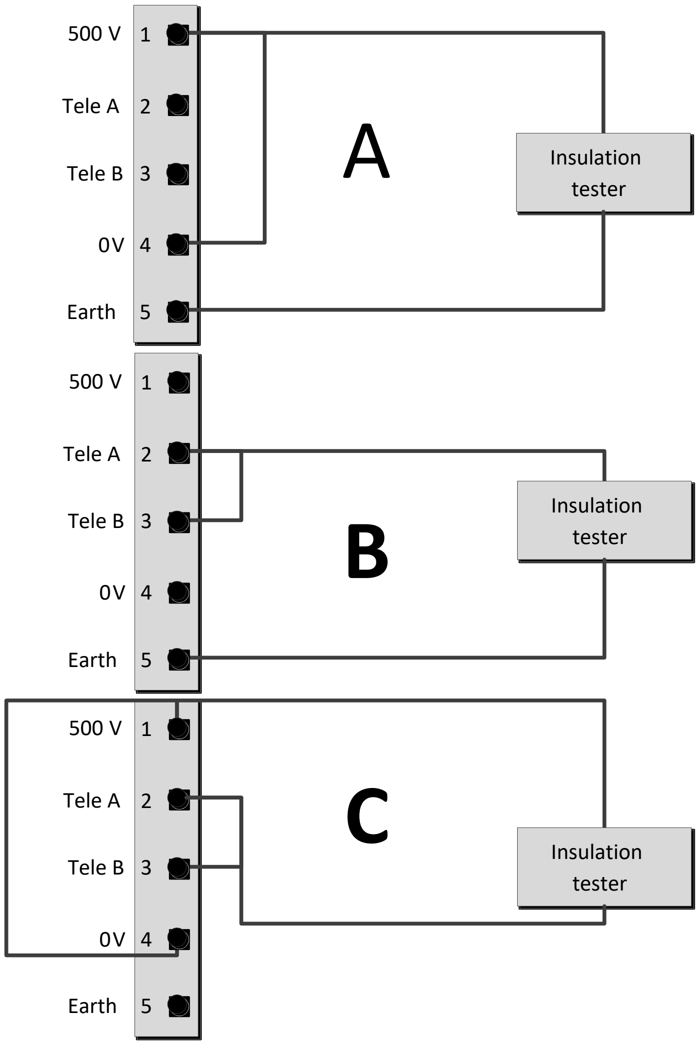


**Figure 8.10: Thruster Isolation Test Setup**

NOTE: Electronic lines must be kept bonded for isolation tests. Damage may occur to electronics if the lines are separated and tested individually.

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# Task 8. EPOD Vacuum Check

## Frequency of Task

When the EPOD housing vacuum integrity is suspect or after the pod has been opened for maintenance.

## Introduction

This procedure describes how to check that the EPOD is water tight. The same procedure can be used for other 1 Atmosphere pressure housings.

## Tools Required

Vacuum pump.

## Parts Required

No parts required.

## Procedure:

**WARNING- DANGER TO PERSONNEL OR EQUIPMENT:**

THE THRUSTER MOTORS MAY OPERATE WITHOUT WARNING WHEN THE SYSTEM DC SUPPLY IS ENERGIZED. ENSURE THAT THE VEHICLE IS CLEAR OF ANY OBSTRUCTION PERSONNEL PRIOR TO ENERGIZING THE DC SUPPLY.

**CAUTION- Danger of damage to the Thruster:**

Do not operate the thruster in air for longer than one minute as this may cause damage to the thruster.

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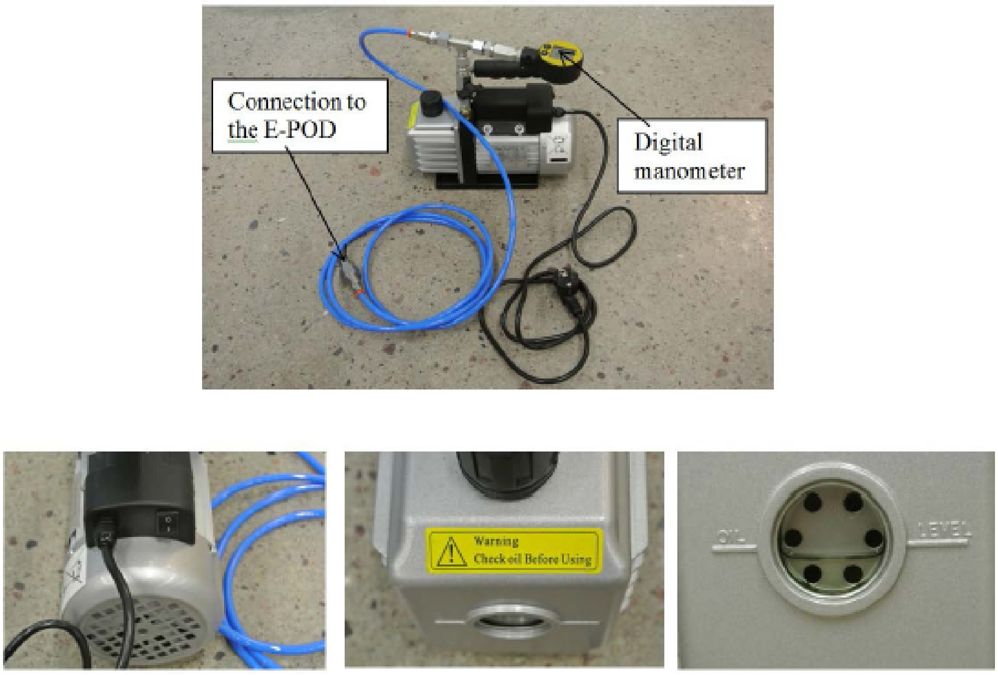


**Figure 8.11: Vacuum pump**

**Proceed as follows:**

1. Unscrew the air bleed screw on the E-pod and connect the hose of the vacuum pump.
2. Open the valve and switch ON the pump and lower the pressure with 0.4 bar, the manometer should show approx. 0,6 bar.

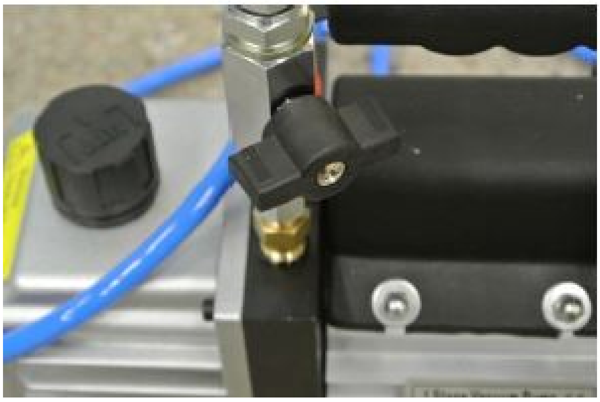

**Figure 8.12: Pump valve open/close**

Valve for opening/closing the connection from the pump to the E-pod.

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**Figure 8.13: Normal/lowered air pressure**

3. Close the valve and turn off the vacuum pump.
4. Wait approximately 10 minutes to let the temperature stabilise inside the EPOD before taking a reading. The temperature will drop inside the EPOD when pumping out the air. The pressure will change when the air gets warmer.
5. Take a reading and wait approximately 30 minutes. The pressure should not change. Depending of what and how much work has been done with the EPOD, the time between the readings maybe needs to be extended to several hours in order to detect a leak. If just a small O-ring to a connector was changed, it could take a longer time to detect a leakage. Extend the time if it is not absolutely sure that the EPOD is not leaking. If a vacuum pump with a digital pressure meter is used, it is easier to detect a pressure change and the test time can be shortened.
6. Check and grease the O-ring with Molykote 111 on the air bleed screw before putting it back on the EPOD. Replace the O-ring if needed.
7. Allow the EPOD to return back to normal pressure. If left with a vacuum, the internal cooling is comprimised.

NOTE: Always dry or replace the SilicaGel bag if the pressure pod has been open before closing.

## Task 9. Tether Check

Test the tether according to example tether.

**Equipment Required:**

- Fibre test tool for measuring the attenuation
- Ohmmeter
- Insulation tester

**Test procedure:**

1. Measure the resistance in the cables according to Table 8.5.
   Resistance values valid for 1000 m tether.

**Table 8.5: Tether resistance values**

| Cable colour | Cable colour | Value |
|---|---|---|
| Blue | Blue | 19 Ω ± 2 Ω |
| Brown | Brown | 19 Ω ± 2 Ω |
| Red | Red | 178 Ω ± 10 Ω |
| Yellow | Yellow | 178 Ω ± 10 Ω |
| Black | Black | 105 Ω +3Ω / -10 Ω |

The black cable has a larger area and is used as a GND cable, the jacket is conductive to get contact with the cable screen, and therefore the resistance differs compared with the red and yellow cables. When connecting a new tether, check that the black cable is conductive to make sure that the cable colours have not changed.

NOTE: Do not mix the black cable with the red and yellow cables as the GND connection with the screen will be lost.

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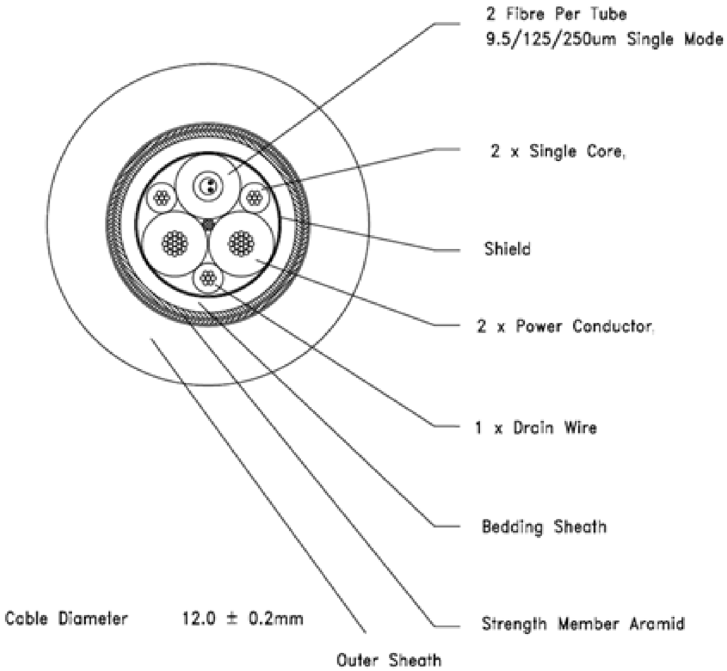


**Figure 8.14: Tether Cable**

**WARNING - DANGER OF FATAL ELECTRIC SHOCK AND DANGER TO PERSONNEL AND EQUIPMENT:**

BEFORE REMOVING OR OBTAINING INTERNAL ACCESS TO THE EQUIPMENT- ISOLATE ALL THE UNITS POWER SUPPLIES.

2. Measure the insulation between the cables.

**Table 8.6: Insulation test**

| Test voltage | Cable colour | Cable colour | Test value |
|---|---|---|---|
| 2.5 kV | Blue | Brown | > 500 MΩ |
| 2.5 kV | Blue | Red | > 500 MΩ |
| 2.5 kV | Blue | Yellow | > 500 MΩ |
| 2.5 kV | Blue | Black | > 500 MΩ |
| 2.5 kV | Brown | Red | > 500 MΩ |
| 2.5 kV | Brown | Yellow | > 500 MΩ |
| 2.5 kV | Brown | Black | > 500 MΩ |
| 500 V | Red | Yellow | > 200 MΩ |
| 500 V | Red | Black | > 200 MΩ |
| 500 V | Yellow | Black | > 200 MΩ |

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NOTE: Discharge the cables after the insulation test.

**WARNING - DANGER TO PERSONNEL FROM LASER EXPOSURE:**

INVISIBLE LASER RADIATION MAY BE EMITTED FROM DISCONNECTED FIBRES OR CONNECTORS. EXPOSURE TO LASER RADIATION CAN CAUSE DAMAGE TO EYES. WEAR PROTECTIVE GLASSES.

3. Measure the attenuation on both fibres from the SCU and from the transformer unit.

| Fibre Measurement | Attenuation |
|---|---|
| Fibre 1 downwards | < 1 dB |
| Fibre 1 upwards < 1 dB | < 1 dB |
| Fibre 2 downwards < 1 dB | < 1 dB |
| Fibre 2 upwards | < 1 dB |

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## Task 10. Fibre Tether Wheel Assembly Guideline

In order for the Tether Wheel to work properly, there needs to be enough friction between wheel and fibre tether. Some fibres have a more rubber like surface but the SAAB standard fibre tether outer jacket is made of a low friction thermoplastic. Therefore, to improve the friction using the SAAB fibre tether, add layers of rubber tape on the outer diameter of item 3 (see Figure 8.15).

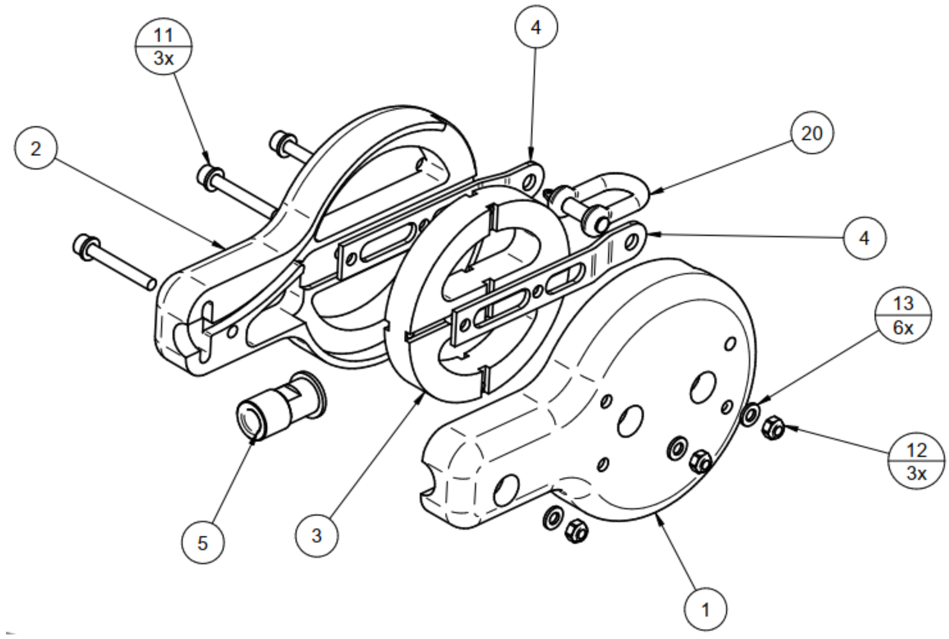


**Figure 8.15: Fibre Tether Wheel**

**Equipment Required:**

- Rubber tape
- 4 x cable ties

**Procedure**

1. Add two layers of rubber tape around the outer diameter of item 3 in Figure 8.15.
2. Use 4 x cable ties through the small holes of item 3 to secure fibre turns on item 3.
3. Adjust the fibre turns so that they are tight to item 3.
4. Tension the cable ties fully and put the cable tie head in the groove cutout so that it is hidden and does not protrude outside item 3.
5. Assemble the unit. Make sure that fibre tether is not squeezed in between item 1 and item 2.

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6. Test to preload the unit after being soaked with water:

    a. Attach item 20 (see Figure 8.15) to a stable point and pull in the tether from item 5.
    b. Pull approximately something with a weight of 20 kg. Make sure you don't bend or get short sharp loops when you pull in fibre.

Tip. Mark the outer jacket with a pencil/tape and monitor after first dives to check that the tether hasn’t moved.

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# Task 11. Sacrificial Anode Check, Clean and Replace

### Frequency of Task

Every 4 months

### Tools Required

- Multimeter
- Sandpaper for cleaning

### Parts Required

- Replacement anodes if required

Sacrificial anodes need to be checked every month using a multimeter to measure the resistance.

All metal will create an oxide layer over time. To get a proper measurement, make sure that the multimeter is in contact with metal. A Pass criteria is less than 1 Ohm.

### Checking an Anode

NOTE: If a sacrificial anode looks new after a number of dives, it is a strong indicator that the anode is not in full contact with the lid.

NOTE: There are two sacrificial anodes per lid.

1. Using the multimeter, measure between two stainless steel bulkheads. Make sure to rub the multimeter probes against stainless steel bulkheads to get a good contact. A normal reading should be less than 1 Ohm.
2. Measure between one of checked SS bulkheads and the sacrificial anode. If the anode is very corroded, it can be difficult to get a good contact. Try to scratch the metal to improve the contact.

### Cleaning an Anode

1. To clean an anode, use sandpaper to remove some of the residue.
2. Check the reading for the anode body with one of the SS bulkhead and make sure that it is less than 1 Ohm.

### Replacing an Anode

The anode should be replaced, when:

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- Anode is reduced by 50%.
- Attachment area for the holding screw or the area against the lid starts to corrode jeopardizing the clamping force of holding screw.

1. Remove the holding screw and remove the anode.

2. Fit a new anode. Use Aqua shield or similar on the holding screw thread and between counter sunk head and anode. This will improve the anode performance and make the electrical connection last longer.
3. Check the resistance.

**Ageing**

As the anode is exposed to harsh conditions as well as general wear and tear, it can become difficult to obtain a good contact between the anode holding screw and the lid. It is important that the sacrificial anode works to protect the lid from galvanic corrosion.

To test:

1. Tap to clear the thread on the M6 screw.
2. Make a dent on the thread hole in the lid to get a good electrical contact.
3. Check the resistance.

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# Task 12. Battery Charging

**Frequency of Task**

Whenever needed.

If not used, at least every 4 months.

**Introduction.**

This task ensures that the battery is fully functional and in good condition prior to each operational use.

The battery should be stored at -20 to +25°C with a cell voltage of approximately 3.7V if it is not in transit or in operation.

A fully discharged battery will give a charging time of approx. 3.5 hours.

**! Observe that battery cells that are allowed to discharge totally may be damaged and will have to be replaced.**

**Tools Required.**

Battery charger

**Parts Required.**

No parts required

**Procedure:**

WARNING - DANGER OF FATAL ELECTRIC SHOCK:

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

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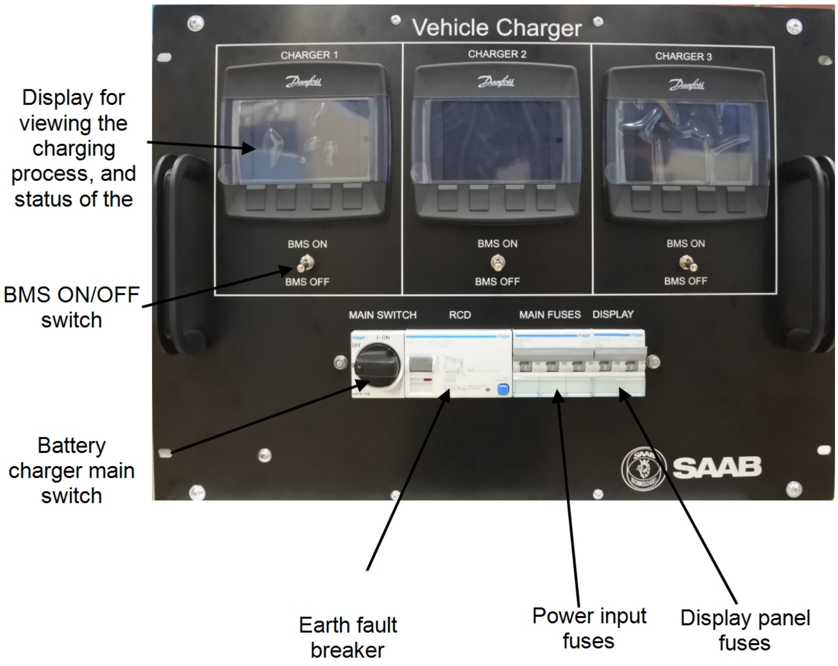


Figure 8.16: Battery charger front

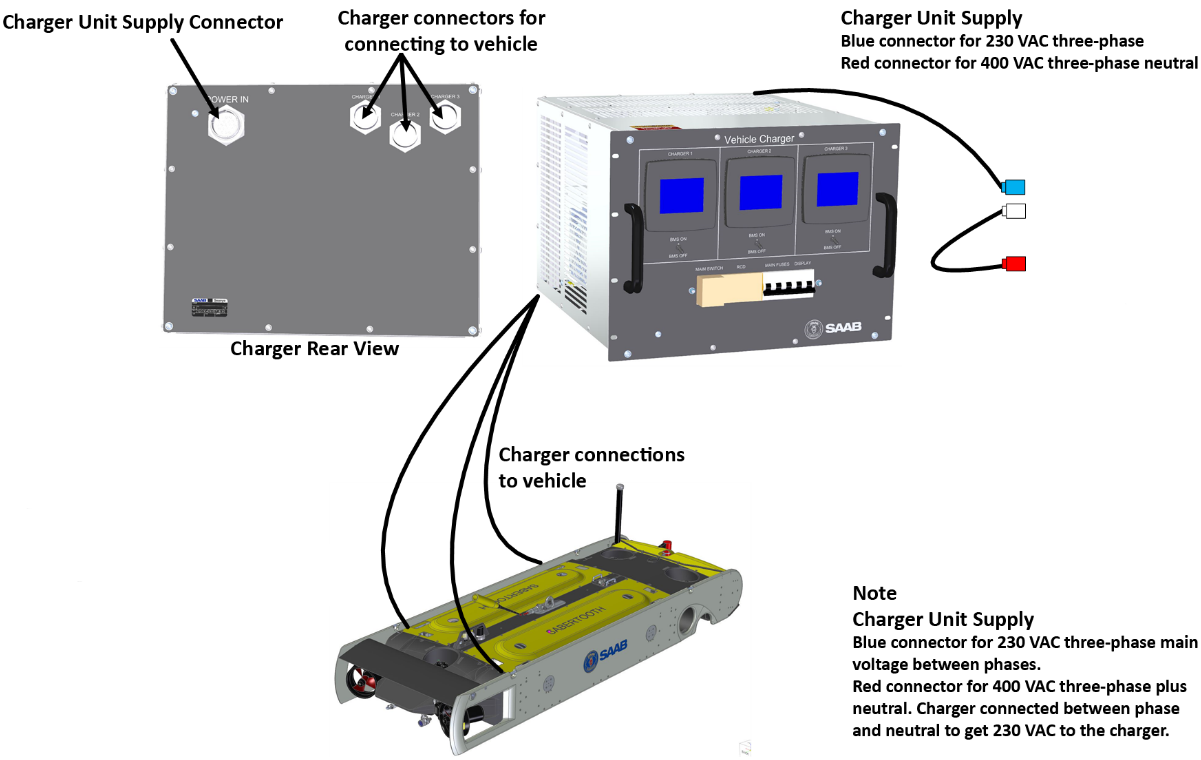


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Figure 8.17: Battery charger connection

**Proceed as follows:**

**Start charging.**

1. Check that the charger main switch is switched OFF.
2. Check that the BMS and CHARGER switches are switched OFF.
3. Connect the charger cables to the rear of the charger and to the vehicle.
4. Depending on the supply voltage, connect the 230 or 400V 3-phase main power cable.
5. Switch the charger main switch to the "ON" position.

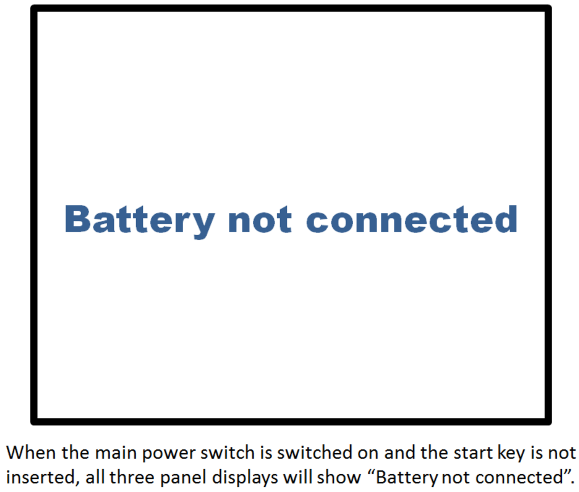


**Figure 8.18: Battery not connected**

6. Switch the BMS switches to ON position. The displays changes from "Battery not connected" to "Searching for connection". The battery output is switched OFF, indicated by "Battery: Output OFF" on the display, if the start key is not inserted.

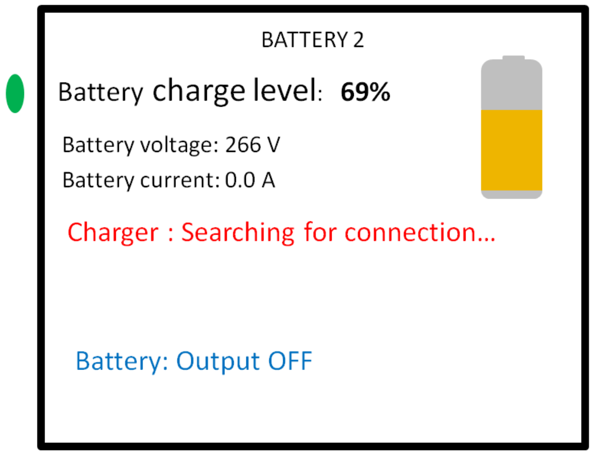


**Figure 8.19: Searching for connection**

7. Switch the BMS ON/OFF position.

A NOTE: If the charge level is less than 40%, continue with charging. If the charge is above 40%, then set main switch to off.

8. When charging has started and the Battery current is positive it means that the current is going into the battery.

9. The colour of the battery symbol on the display will change depending on the charge level of the battery. Red is the lowest charge level and Green is the highest.

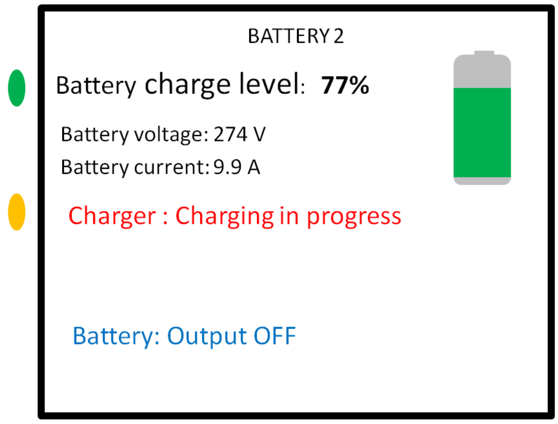


**Figure 8.20: Charging in progress**

10. If start key is inserted, the battery output is enabled and this is indicated by “Battery: Output ON” being shown on the display and a red LED is lit to the left of the text.

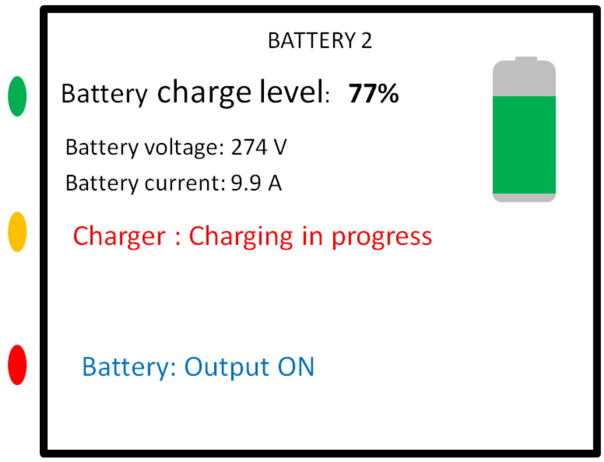


**Figure 8.21: Output ON**

11. Stop charging once battery charge level is 50% with main switch breaker to off.
12. Remove start key if inserted, disconnect charge cables and assemble connector endcaps.

13. When the battery is fully charged.
14. To get more information about the battery whenever the BMS is ON, press the left most button under the display.

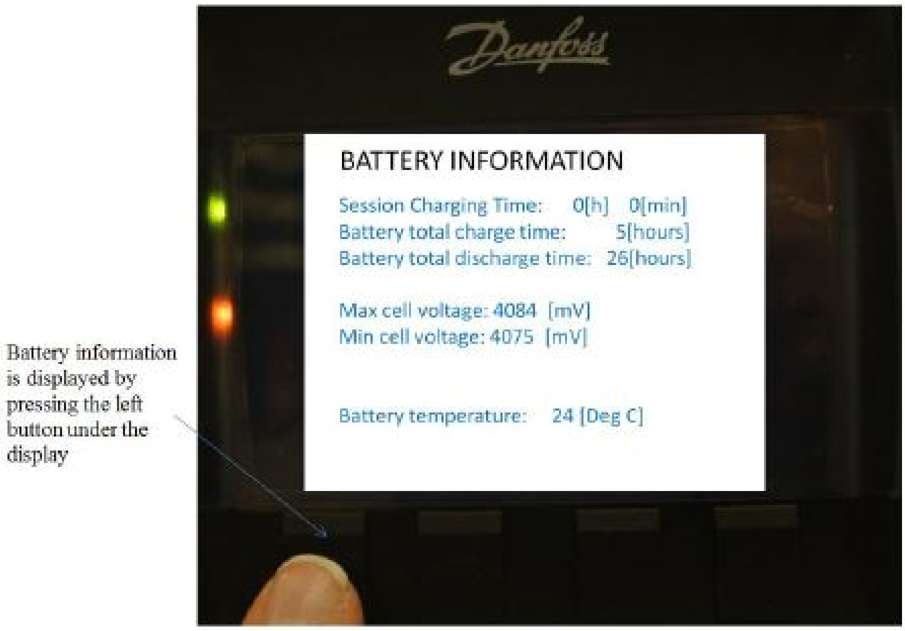


**Figure 8.22: Battery information**

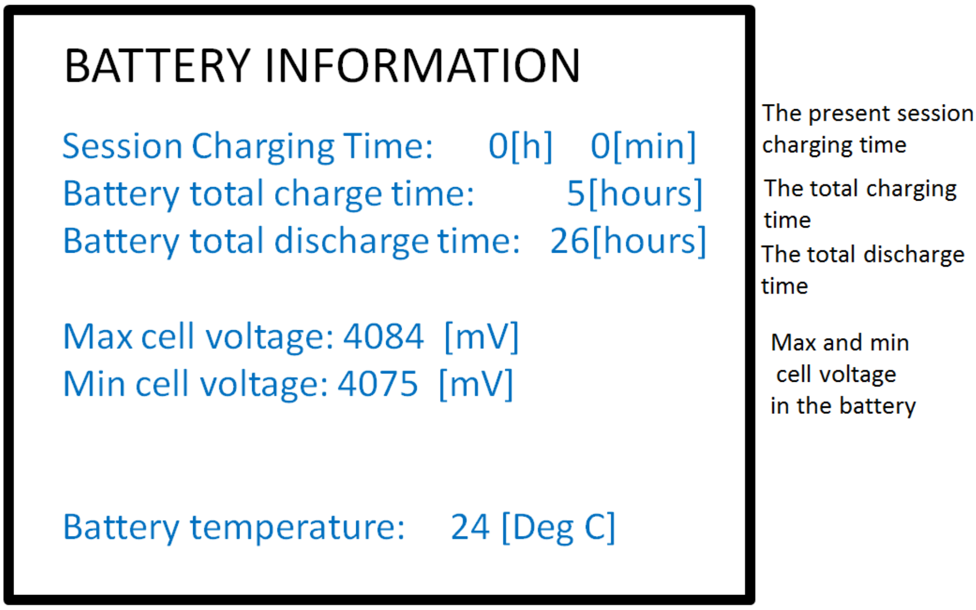


**Figure 8.23: Battery information**

**Table 8.7: Possible text combinations beside the yellow LED (CHARGER INFO)**

| Display text. | Description |
|---|---|
| Charger: No Connection. | The BMS has no connection with the charger inside the unit. |
| Charger: ERROR, restart needed. | Internal fault in the charger. |
| Charger: Charging in progress. | The charger has started charging the battery. |

| | |
|---|---|
| Charger: Charging ready. | The charging is completed. |
| Charger: Charging Pending. | Charging will start in a moment. |
| Charger: Disabled. | Internal fault in charger |
| Charger: Searching for connection. | Shown when the charger is on but connection to the battery has not yet been established |

**Table 8.8: Possible text combinations beside the red LED (BATTERY INFO)**

| No text. | When carried out. |
|---|---|
| Battery: Output OFF | Battery power output relay is OFF. |
| Battery: Output ON | Battery power output relay is ON. |
| Battery: Output ON, Discharging | Battery power output relay is ON and current is drawn from the battery. |
| Battery: BMS ERROR | Internal fault in BMS. |
| Battery: BMS shutdown pending | BMS will shut down in a moment. |
| Battery: Equalizing in progress | Shown when BMS is equalizing the battery cells to the same voltage level. |

NOTE: Make sure that the start key is removed from the vehicle.

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# Task 13. Spare Battery Charging

### Frequency of Task

At least every 6 months

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

NOTE: Battery cells that are allowed to discharge totally will become damaged and will need replacing.

### Parts required:

Battery charger

Charger cable for spare battery: 01-4173031 “Spare battery maintenance charging cable”.

### Visual inspection

1. Make a visual inspection of the battery to check that it is not damaged and that there are no lose cables.

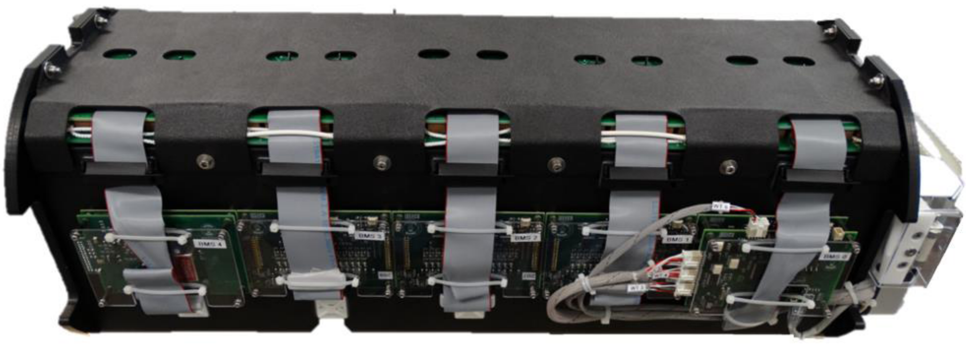

**Figure 8.24: Charging spare battery**

2. Check that the BMS switch on the charger is OFF.
3. Connect the Spare battery maintenance charging cable to the battery, Connectors J310 and P311.
4. Connect the charging cable to the charger. Charge the battery according to the BATTERY CHARGING TASK.

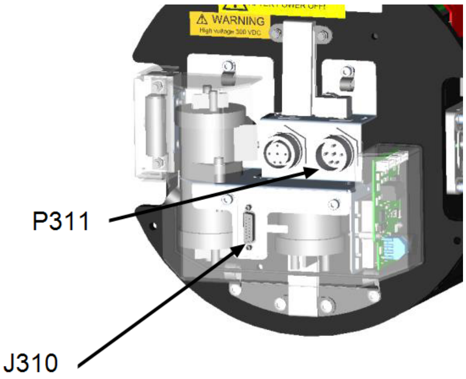


**Figure 8.25: Connect battery**

5. After charging is completed (at 50% SoC - refer to Battery Charging procedure), switch OFF the BMS and CHARGER switches and the charger mains switch.
6. Let the battery equalize, which is finished when all LEDs are extinguished and the blue LED on the processor card has stopped flashing.
7. Switch ON the charger again and charge the battery according to BATTERY CHARGING TASK again.
8. After charging is finished, switch OFF the switches BMS and charger MAIN SWITCH.
9. Let the battery equalise, which is finished when all LEDs are extinguished and the blue LED on the processor card has stopped flashing.
10. If the charging does not start the second time, check that the difference between the maximum and minimum cell voltage is not more than 20mV. This is to make sure that the battery is equalised and can be charged up to full capacity.
11. Switch ON the charger and the BMS switch and press the left button under the display to check the max/min cell voltage on the battery.

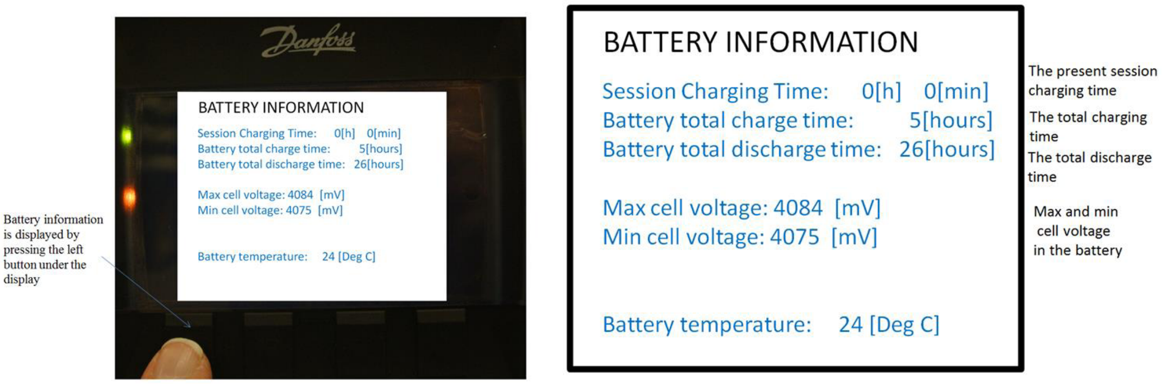


**Figure 8.26: Battery information**

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12. Label the battery with the date that it was charged on and the date for the next charge.
13. Put a cover over the battery to protect it from dust.

# Task 14. Configuration of Battery Module

## Frequency of Task

When the spare battery module is mounted in a vehicle, or when a battery module changes place in a vehicle.

## Introduction.

This task explains how to change the configuration of a battery module

## Tools Required

Serieport tool TeraTerm

## Parts Required

No parts required

Procedure:

1. Connect the SL79-2500 cable to the port front lid connector CONF.
2. Connect the dsub-connector for the battery to be configured to the RS-232 port on laptop (using only battery supply).
3. Start the TeraTermwith the following settings:

**Table 8.9: Terminal Program Start Settings**

| | |
|---|---|
| Baudrate | 115200 Baud |
| Databits | 8 bits |
| Stopbit | 1bit |
| Flowcontrol | None |
| Parity | None |

4. Connect the vehicle charger to the CHG connector for the battery to be configured.

   NOTE: Do not connect the charger to mains power.

5. Wake up the battery module by activating the BMS ON switch on the vehicle charger front panel.
6. Do not connect the RH45 Ethernet connection while configuring the battery.
7. The terminal screen on the computer should look like the text below:

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UART initialized.
Keep BEU ON activated.
Inrush relay opened.
EEPROM twi bus started..
EEProm OK..
Current calibration parameters loaded.

Last Session Error Flags:
System Error Flags: 0x0000

System Warning Flags: 0x0000

BMS HW Serial Number in hex: 00 00 14 64 67 c3

BMS MAC address in hex: 00 40 85 64 67 c3
Watchdog started
Canbus MCP2515 setup OK
Can Handler running
Module Supervisor running
Setup Handler running -- press 'm' for Menu.

-KEYBOARD LOCKED. Press 'k' and then 'b' to unlock.

All Module Selftests OK..
Module: 0 Temperature by SPI
Module: 1 Temperature by SPI
Module: 2 Temperature by SPI
Module: 3 Temperature by SPI
Module: 4 Temperature by SPI
Module Handler running
-- NORMAL..
DeepSleep Counter started..

8. Press 'k' and 'b' to unlock the keyboard.
9. Press 'v' to view the BMS setup parameters.
10. The BMS setup menu parameters should look like the text below:

BMS Parameters:

0: Number of BMS modules: 5
1: Number of Cells in module: 14
2: Number of Temperature sensors: 7
3: Rated Battery Capacity in [100mAh]: 400
4: Cell charging voltage limit in [mV]: 4125
5: Max charging current in [100mA]: 100
6: End of charge current in [100mA] steps: 20
7: EOC current Vehicle ON in [100mA] steps: 20
8: Type of Charger: ZEPIA
9: Low current sensor Gain [x1000]: 1000
A: High current sensor Gain [x1000]: 1000
B: Charge Hysteresis in [mV]: 100
C: Max charging time in [minutes]: 300
A D: Min EQ Voltage in [mV]: 3700
E: EQ Voltage diff in [mV]: 3
F: Higher cut off Voltage in [mV]: 3400
G: Lower cut off Voltage in [mV]: 2900
H: Higher cut off Temperature in [C]: 20
I: Lower cut off Temperature in [C]: -20
J: Time to sleep in [seconds]: 180

K: IP address: 192.168.0.180 <- NOTE
L: UDP address to send to: 192.168.0.244 <- Host
M: UDP port to send to: 30010 <- NOTE
N: UDP port to receive from: 30001
O: BMS keep power/vehicle ON: OFF
P: BMS HW revision: 1
Q: SW Serial Number of BMS: 1 <- NOTE

NOTE: The parameter values shown above are the ones that shall be used for Sabertooth BMS #1, the Starboard BMS.

NOTE: The setup menu can be exit by pressing the 'e' key.

11. The three battery modules shall be set up according to the Table below:

**Table 8.10: Battery Module Setup**

| Part. no | BMS position | IP address 'K' | UDP port send 'M' | SW serial # 'Q' |
|---|---|---|---|---|
| 01-4162660 | Starboard | 192.168.0.180 | 18600 | 1 |
| 01-4162661 | Port Aft | 192.168.0.181 | 18601 | 2 |
| 01-4162662 | Port Front | 192.168.0.182 | 18602 | 3 |

NOTE: That is for Parameters 'K' , 'M', and 'Q'. All other parameters are the same for the battery modules.

**CAUTION- Danger of damage to the Battery:**

Be very careful when changing the parameters. If setup parameters are changed, it can lead to a non-functional battery and even destruction in worst case.

NOTE: When changing the parameters it is advised to have a good BMS system knowledge. On any hesitations regarding the change of parameters, contact SAAB for support.

12. When ready, turn off the module by pressing 'z' on the keyboard.
13. Change Example:
    If the IP address for the BMS is to be changed to "192.168.0.181":

    a. Start the BMS as above.
    b. Press 's' for setup.
    c. Press 'K' for IP address, enter 192.168.000.181, press enter.
    d. Press 'y' when system asks if you want to store the new parameter.
    e. Repeat the process for the next parameter.
    f. Then turn off the battery module BMS.

NOTE: The new IP address will not be active until the BMS has completely shut down.

    g. After configuration, put a label with the new IP-address of the module on a free area close to the part number.
14. Connect the Ethernet connector RJ45.

NOTE: Make sure that each is configured to the correct IP address to avoid any IP conflicts.

NOTE: Battery position is locked to its IP address.

**Task 14.1 BMS Serial Interface**

The BMS serial interface is primarily used to configure the battery module or fault find issues e.g. start up or HMI interface problems.

1. Set up and use the serial port settings and serial tools as described in the Task “Configuration of Battery Module”.

**Quick Guide**

Press “k” and “b” – unlock keyboard

Press “v” – view BMS parameters

Press “F” – view battery pack information, Press “F” again to stop viewing.

If you get a normal reading on the battery module, then the module has started up and the root cause to problem is not battery. If there are no / strange readings, the battery has not started up correctly.

In this case, do the following:

1. Check that the error log is empty:
    a. To check the error log, use the PC command ’S’.
    b. If the error log is not empty, use the PC command 'U' to empty the log.
2. Check that the error flags are cleared:
    a. To check error flags, use the PC command ’P’.
    b. If not clear, use the PC command ’B’ to clear the flags.
3. Reset the “Warning current calibration” flag.
    a. Press ’u’ on the PC keyboard followed by ’w’ and according to the instructions on the screen, set the “warning current calibration” flag to zero.
4. Check the error and warning flags.
    a. Press ’f’ on the PC keyboard and make sure that no flags are set.
5. Press “z” turns off BMS. Need new BMS on to start up.

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If the problem is persistent, check error code in BMS 40-4063908 manual and print out error codes plus action taken and send information to SAAB for further assistance.

# Task 15. Tilt Unit Oil Check and Replenishment

## Frequency of Task

Pre and Post-flight

## Introduction..

This procedure checks that the oil level in the Tilt Unit is correct prior to, and on completion of, each vehicle operation. Carry of this procedure on each Pre and Post flight.

**CAUTION- Danger of damage to the Equipment:**

If a unit requires frequent addition of oil, carry out an investigation to see if the unit is damaged.

## Tools required:

- Diaphragm puller tool (Part No TH110)

## Parts required:

- Mobilect39 Oil.
- Oil pump part no P10520

**Figure 8.27: Oil pump**

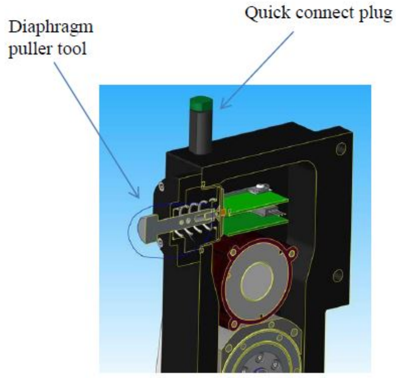


**Figure 8.28: Tilt unit**

**Oil Level Check Procedure**

**Proceed as follows:**

1. Inspect the Tilt Unit for evidence of damage or oil leaks.

**Figure 8.29: Diaphragm puller tool**

2. Using the Diaphragm Puller Tool, screw into the tilt unit diaphragm and ensure that at least one of the two holes is fully visible.
3. If no holes are visible connect the fill pump to the quick connect plug. Before connecting the pump make sure that there is no air in the hose that can be pumped into the tilt unit.
4. Fill oil using the fill pump until two holes are visible on the diaphragm Puller Tool.
5. Insert the locking pin in the second hole. Release the pressure in pump by pulling out the pressure release valve on the pump.
6. Disconnect the pump from the quick connect plug.
7. A Remove the locking pin, observe the puller tool pinholes and ensure that at least one of the holes remains visible. This indicates that the tilt unit is completely filled with oil and purged of air. Should the tool “sink” into the tilt unit end cap repeat the filling procedure. If the tool continues to “sink “after filling again, there could be air inside the unit.

8. If the stud is less than 10 mm below the cover, examine unit for water ingress and damage.

**Oil Level Replenishment Procedure removed unit.**

Proceed as follows:

1. Isolate the power supply to the unit and disconnect the electrical connector.
2. Remove the unit to a suitable flat bench.
3. Using the Diaphragm Puller Tool, screw into the tilt unit diaphragm and ensure that at least one of the two holes is fully visible.
4. If no holes are visible connect the fill pump to the quick connect plug. Before connecting the pump make sure that there is no air in the hose that can be pumped into the tilt unit.
5. Fill oil using the fill pump until two holes are visible on the diaphragm Puller Tool.
6. Insert the locking pin in the second hole. Release the pressure in pump by pulling out the pressure release valve on the pump.
7. Hold the tilt unit so that the quick connect plug is the highest point. Remove the locking pin, then the tool should start to “sink” (maybe the pressure release valve need to be pulled out again).
8. Check if there is air coming into the hose from the tilt unit. If there is air coming into the hose then the unit needs to be filled and drained until there is no air coming into the hose.
9. If no air is coming into the hose, fill until two holes are visible on the diaphragm Puller Tool and insert the locking pin.
10. Disconnect the pump from the quick connect plug.
11. Remove the locking pin, observe the puller tool pinholes and ensure that at least one ofthe holes remains visible. This indicates that the tilt unit is completely filled with oil and purged of air. Should the tool “sink” into the tilt unit end cap repeat the filling procedure. If the tool continues to “sink “after filling again, there could still be air inside the unit.
12. Remove the diaphragm puller tool and mount the end cap on the quick connector plug.
13. Examine the unit for leaks.
14. Clean any oil contaminated parts.
15. Lubricate the Tilt connector with Molycote 111 grease.
16. Refit the Tilt Unit and perform a function test.

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# Task 16. Cleaning SCU Fan Filter

## Frequency of Task

6 Month

## Introduction

This task explains how to clean the fan filter and the exhaust filter on the SCU.

## Tools Required

None.

## Parts Required

No parts required

## Procedure:

1. Behind fan inlet on front panel of the SCU is a filter mesh. Remove plastic cover from the front of the SCU.
2. Remove filter mesh from SCU and vacuum clean or wash filter with clean water then dry.
3. If it is not possible to sufficiently clean the filter mesh, replace it with new one (87x87mm).

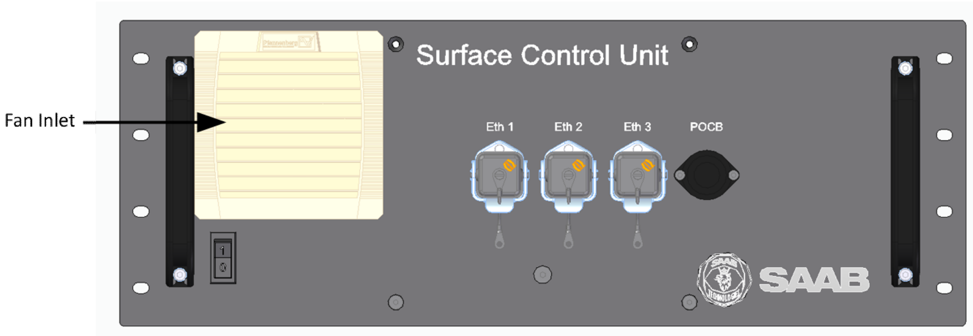


**Figure 8.30: SCU Fan Inlet**

4. Behind exhaust outlet on the back panel of the SCU is a filter mesh. Remove plastic cover from the rear of the SCU.
5. Remove filter mesh from SCU and vacuum clean or wash filter with clean water then dry.
6. If it is not possible to sufficiently clean the filter mesh, replace it with a new one (87x87mm).

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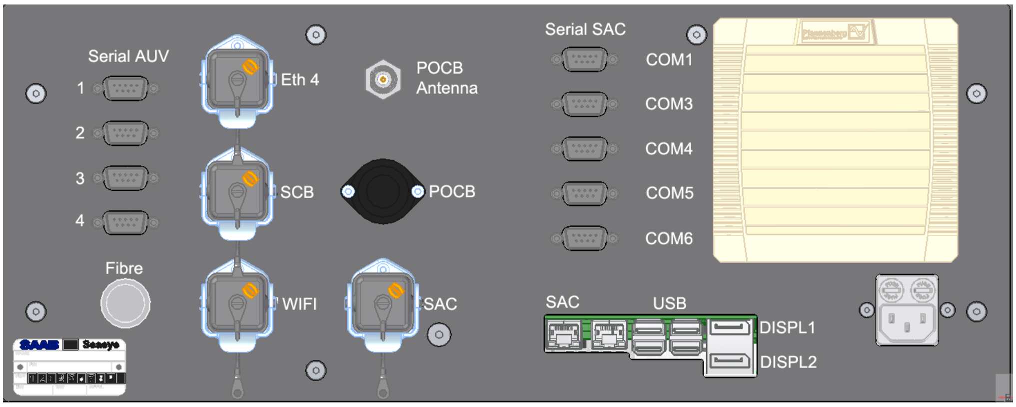


**Figure 8.31: SCU Fan Exhaust Outlet**

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# Task 17. System Configuration

### Frequency of Task

When configuring the system. Refer to individual 3rd party documentation if supplied.

### Introduction

This task identifies and lists the IP addresses and serial ports for connecting various devices.

### Tools Required

None.

### Parts Required

No parts required

### Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

**Table 8.11: IP Addresses**

| Name | IP-Address | | | User | Password | Interface |
|---|---|---|---|---|---|---|
| | VLAN 1 | VLAN 2 | VLAN 3 | | | |
| SAC | 192.168.0.248 | 192.168.100.248 | | Administrator | | |
| RAC | 192.168.0.244 | 192.168.100.244 | 192.168.200.244 | Administrator | | Remote Desktop |
| PAC | 192.168.0.245 | 192.168.100.245 | | Administrator | | Remote Desktop |
| Profiler Imagenex Sonar OA | 192.168.0.130 | | | | | |
| Edgetech 2205 Sonar | | 192.168.100.132 | | Administrator | admin | Remote Desktop |
| R2Sonic Head #1 | | 192.168.100.134 | | | | |
| R2Sonic SIM | | 192.168.100.135 | | | | |
| R2Sonic Head #2 | | 192.168.100.136 | | | | |
| Port server Vehicle | 192.168.0.140 | | | admin | superuser | Device Manager |
| Port server SCB | 192.168.0.141 | | | admin | superuser | Device Manager |
| Port server SCU | 192.168.0.142 | | | admin | superuser | Device Manager |
| Adambox vehicle Port Front | 192.168.0.151 | | | | 00000000 | Adam Utility |

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| Name | IP-Address | | | User | Password | Interface |
|---|---|---|---|---|---|---|
| | VLAN 1 | VLAN 2 | VLAN 3 | | | |
| Adambox vehicle SB Aft | 192.168.0.152 | | | | 00000000 | Adam Utility |
| Wi-Fi SCB | 192.168.0.160 | | | SaabSeaeye | Seaeye | Web browser |
| Wi-Fi Vehicle | 192.168.0.161 | | | SaabSeaeye | Seaeye | Web browser |
| POCB Receiver box | 192.168.0.170 | | | | | |
| BMS Starboard | 192.168.0.180 | | | | | |
| BMS Port Aft | 192.168.0.181 | | | | | |
| BMS Port Front | 192.168.0.182 | | | | | |
| Axis Q7404 Ch1 | 192.168.0.201 | | | root | root | Web browser |
| Axis Q7404 Ch2 | 192.168.0.202 | | | root | root | Web browser |
| Axis Q7404 Ch3 | 192.168.0.203 | | | root | root | Web browser |
| Axis Q7404 Ch4 | 192.168.0.204 | | | root | root | Web browser |
| Axis IP HD Camera | 192.168.0.205 | | | root | root | Web browser |
| Phins III | | | 192.168.200.222 | | | Web browser |
| GPS Receiver | 192.168.0.223 | | | admin | gpsdata | NovAtel Connect |
| Planet Switch Vehicle | 192.168.0.230 | | | admin | admin | Web browser |
| Planet Switch SCU | 192.168.0.231 | | | admin | admin | Web browser |
| EdgeRouterX (SCU) | 192.168.0.254 | | | SaabSeaeye | Seaeye | Web browser |
| Gateway (Spare Tilt) | 192.168.50.71 | | | root | password | Web browser |
| Gateway (HV Hub) | 192.168.50.72 | | | root | password | Web browser |
| Gateway (LV Hub) | 192.168.50.73 | | | root | password | Web browser |

The Ethernet network is separated into three VLANs and no Ethernet traffic can flow between the VLANs.

To be able to access, for example, the Phins III, use Remote Desktop from SAC to RAC, which then can open the Web Interface to Phins III.

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The Ethernet ports on the SCU (Eth1-4) are connected to VLAN 1 and VLAN 2 according to Table 8.12.

**Table 8.12: SCU Ethernet Ports**

| SCU Ethernet Ports | |
|---|---|
| Eth 1 | VLAN 1 |
| Eth 2 | VLAN 1 |
| Eth 3 | VLAN 2 |
| Eth 4 | VLAN 2 |

**Table 8.13: SAC COM ports**

| SAC COM ports | |
|---|---|
| COM1 | PSU/Winch |
| COM3 | USBL In |
| COM4 | NMEA |
| COM5 | Sonardyne Dunker6 (Acoustics) |
| COM6 | Spare |

**Table 8.14: RAC COM ports**

| RAC Com ports | |
|---|---|
| COM3 | Sonardyne Avtrak6 (Acoustics) |
| COM4 | SVS |
| COM5 | SPRINT-Nav |
| COM6 | Depth Sensor Keller |

## Gateways and Node ID

**Table 8.15: Gateways and node ID**

| Description | Node ID | Default powered on |
|---|---|---|
| Gateway 192.168.50.71 (HVHUBAftNet_X402) | | |
| HVHub1 | 160 | true |
| HVHub2 | 161 | true |
| HVHub3 | 162 | true |
| HVHub4 | 163 | true |
| Spare tilt | 192 | true |
| Gateway 192.168.50.72 (ThrusterNet_X403) | | |
| Thruster Z (Depth) | 140 | false |
| Thruster Y (Lateral) | 141 | false |
| Thruster YZP | 142 | false |
| Thruster YZSB | 143 | false |
| Thruster XYP | 144 | false |
| Thruster XYSB | 145 | false |

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| | | |
|---|---|---|
| Thruster Spare | 146 | false |
| Gateway 192.168.50.73 (LVHUBNet_X401) | | |
| LV hub | 100 | true |
| Front tilt | 190 | false |

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# Task 18. Configuring the Castle Gateway 6252 PCB

## Task 18.1 The purpose of 6252 board

The primary function of a 6252 is to connect a bus of RS-485 Seaeye nodes to an Ethernet network. The control software can then communicate with each node on the bus through the 6252 using Saab Seaeye's propriety castle protocol. In this mode the 6252 provides optoisolation of RS-485 interface. Jumper settings have been added to allow future connectivity options and features.

## Task 18.2 Ethernet to isolated RS-485 Castle gateway.

Jumper configuration:

JP1: 1-2, JP3: 1-2, JP4: 1-2, JP5: 1-2, JP6: 1-2, JP7: 1-2.

This is standard mode, which can be used in all ICON vehicles. In this mode, the board is listening to incoming User Datagram Protocol (UDP) request packets and sends Castle commands through the RS-485 interface. Depending on the configuration of JP2, the board may have bi-directional (half duplex) comms (JP: 1-2), or only listen to incoming data to monitor telemetry; the standard fit for control nodes is bi-directional.

## Task 18.3 Configuration.

Before the gateway can be used on the system, its location on the network must be set. To configure a 6252 device simply select a function on the webpage provided by the 6252 board. The options list refers to locations in the block/wiring diagrams for the system. To access the webpage of the spare gateway enter its IP-Address into the browser's address box which is, by default, 192.168.0.77 for all spare boards. Then select. "Function." on the left side menu (See Figure. 6.30), then select appropriate function according to the wiring/block diagram, and apply the change. If the function for the card is missing in the list box, see the function file download chapter below. After the change is applied, the board needs to be rebooted or re-powered. After restart the board will perform the selected function. Only one spare board can be connected to the vehicle network at a time for configuration, otherwise there will be a conflict of IP-Address. In this case the user should refer to the block diagram to find out the correct IP-Address of the 6252 to be changed. After the IP-Address is entered in the browser address bar, and web connection to the gateway is established, the user should proceed as described above.

A **NOTE: Avoid setting two or more gateways on the system with the same function as it will result in IP-Address conflicts, which can be resolved by physically disconnecting one of the conflicting gateways from the network, leaving one gateway connected, and then changing function on the connected gateway to the free location.**

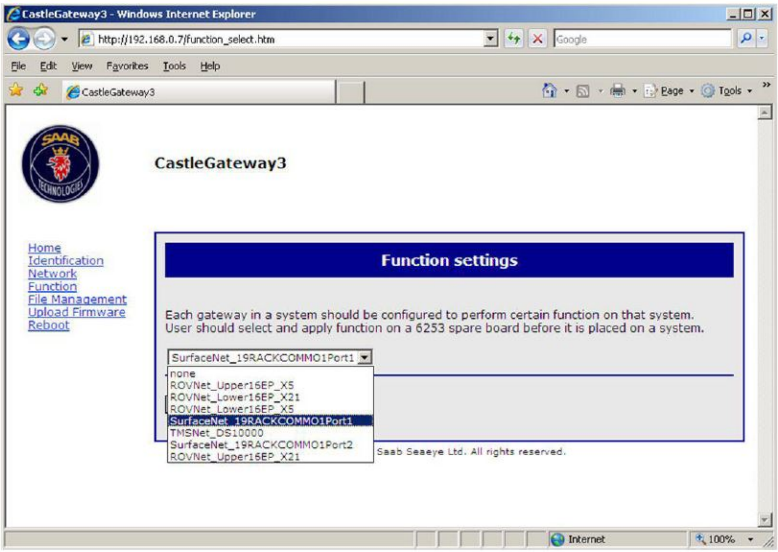


**Figure 8.32: Function selected.**

**Task 18.4 Identification.**

There is an option implemented to help the operator to physically identify the board he is trying to configure/diagnose. Once the website is entered, the user can select "Identification" from the left side menu. When this is selected and applied, a red LED next to the Ethernet connector on the board will start flashing repeatedly until power down, or until identification is de-selected and applied again. This helps to identify the gateway since only one gateway LED will flash, unless more than one board has been instructed to flash the identification LED. Please note that the board will continue flashing even after reboot. The only way to stop it flashing is to power it down or de-select identification and apply it.

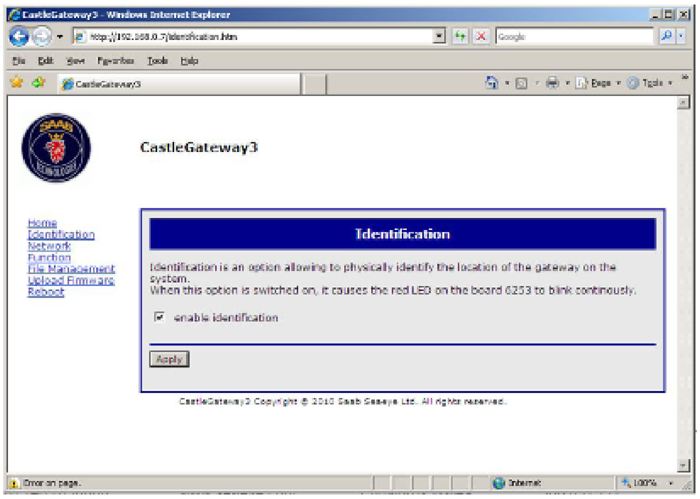


**Figure 8.33: Identification.**

**Task 18.5 Reboot.**

After a function is chosen for the 6252 gateway, the user needs to re-power or reboot the gateway for the changes to take effect. It takes between 12 up to 20 seconds for the gateway to wake up from reboot. After the function is changed, the device will no longer be visible at IP: 192.168.0.77. Instead, it will be accessible at address dependent on the function.

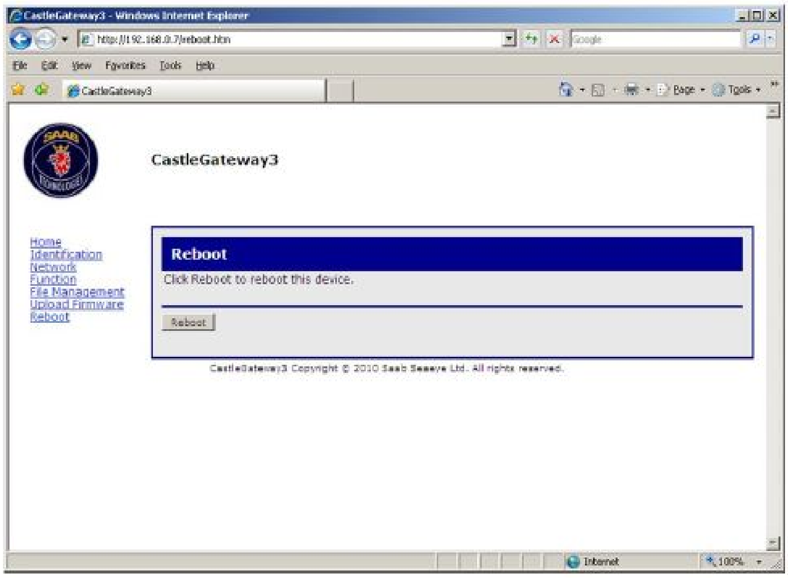


**Figure 8.34: Reboot.**

**Task 18.6 Function file download, File Management.**

In case the function needed not is among the alternatives in the drop down box, you need to download a function file for the gateways of your system. This file is a standard text file. The text file describe which IP-addresses and which ports the gateways will use.

This file will be provided by SAAB and can be found in the configuration folder in the SAC-PC.

To download a new file:

- First of all delete all web history! Important!
  - Choose ‘File Management’ in the menu to the left and click on browse in the file box.
  - Go to the SAC-PC D:\Configuration\Gateways folder.
  - Choose the ‘init’cfg’ file. Click upload on the web browser.
  - Reboot the gateway, see reboot chapter above.
  - After reboot select the desired function and reboot again. The gateway should now have changed to the desired function IP-Address.

# Task 19. Windows Remote Connection

## Frequency of Task

When connecting to the RAC, PAC or Edgetech through the Windows Remote Desktop Connection.

## Introduction

This task explains how to connect with Windows Remote Desktop Connection.

## Tools Required

None

## Parts Required

No parts required

## Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

## Proceed as follows:

From the SAC, it is possible to connect to RAC, PAC and Edgetech through the Windows remote desktop connection:

1. Right click on the remote desktop icon (on the toolbar) on the SAC.
2. Select which PC to connect to. For information, see IP-Address and login in the System Configuration task.
3. The RAC and PAC can be restarted through the remote desktop connection, click Alt+F4 and select restart.

It is possible to copy and paste data from SAC to the remote PC, but it is recommended to use the network folders (example: Transfer on SAC) when the amount of data is big.

If using Wi-Fi or sending a lot of data over tether, it is recommended to zip the files locally first.

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# Task 20. Using Imagenex Obstacle Avoidance Sonar

## Frequency of Task

When using the Imagenex sonar

## Introduction

This task explains how to start the Imagenex sonar software. Refer to individual 3rd party documentation if supplied.

## Tools Required

None

## Parts Required

No parts required

## Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

## Proceed as follows:

The obstacle sonar can be tested with standalone software from the distributor, it can be found on the SAC under:

D:\Configuration\Imagenex\Win881L

Before starting the Imagenex software make sure the software on the RAC is closed otherwise it will be a conflict of the TCP port on the sonar

Double click on “win881L.exe” to start the software

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# Task 21. Changing Frequency of Radio Devices (if applicable)

### Frequency of Task

Every time the system is moved to a new area with new restrictions.

### Introduction

This task explains how to change the frequencies of radio devices.

### Tools Required

None

### Parts Required

No parts required

### Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

**Proceed as follows:**

**SCB:**

1. To access the Radio device in the SCB:
    a. Open the SCB and remove the grey RJ45 contact from the Portserver.
    b. Attach the test cable, which has a female RJ45 connector and a 9 pin female D-Sub connector, to the COM5 in the SAC.
2. Start the SCB and the SAC.
3. On the SAC, browse to: D:\Configuration\SATELLINE Radio\SATEL_Configuration_Manager_v1_4_6
4. Click to start "SATEL_Configuration_Manager.exe".
5. Select tab "Program Preferences".
6. Click on "Check Ports" and select COM05 or the COM port that is used on the PC.
7. Click on "Connect".

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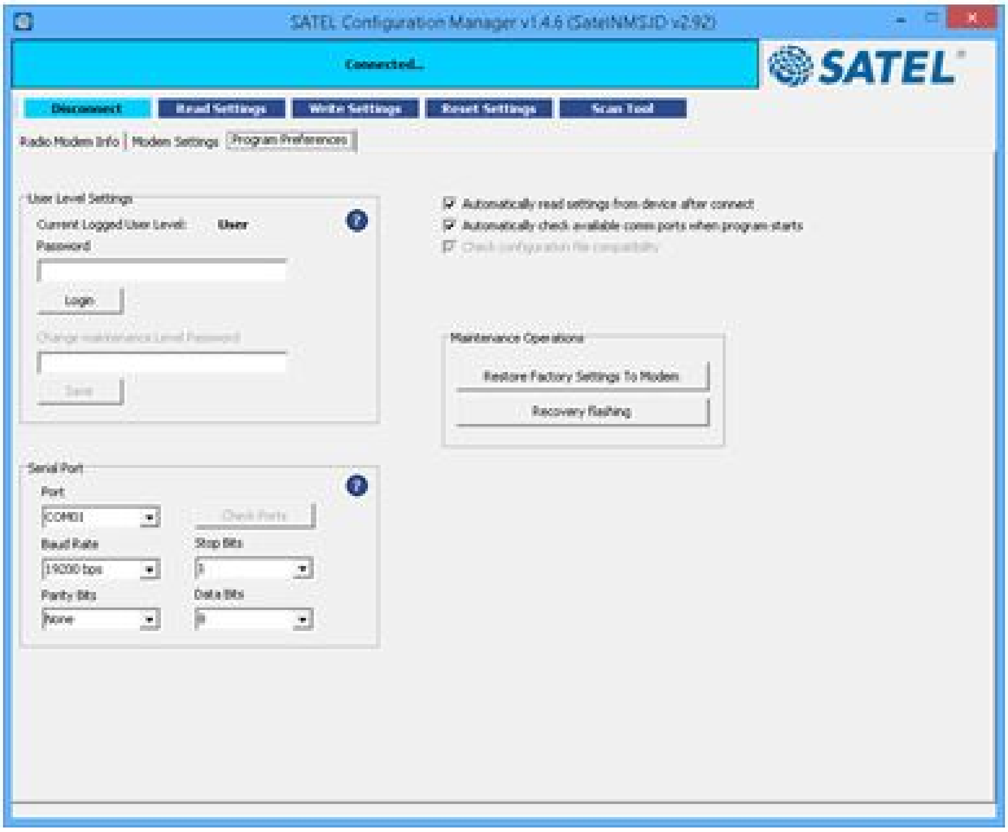


**Figure 8.35: Satel Configuration Manager Window**

8. Open the “Modem Settings” and change the needed parameters.
9. Click “Write Settings”.

If these new settings will be used in a certain area or country it can also be saved to file and loaded from file next time this is needed to be changed.

**Vehicle:**

1. To access the radio device in the vehicle, use the COM2 port on the RAC.
2. Open a remote desktop to the RAC from the SAC.
3. Close down the Saab software to release the COM2 port hold by that software.
4. Start “SATEL_Configuration_Manager.exe” from:
   D:\Configuration\SATELLINE Radio\SATEL_Configuration_Manager_v1_4_6
5. Connect and change the settings as described in the SCB section.

# Task 22. Sabertooth NMEA Output

**Frequency of Task.**

Configuring a COM port for NMEA output

**Introduction.**

This task describes how to configure a COM port for NMEA output

**Tools Required.None**

**Parts Required.**

No parts required

**Procedure:**

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

**Sabertooth NMEA output:**

The log string is provided at a rate of 10 Hz through a RS232 port on the Sabertooth SAC (COM port 4). The RS232 port is configured to use baud rate 57600, 8 data bits, no parity and 1 stop bit.

Log string:

The log string is a simple NMEA ASCII string. The string follows the NMEA 0183 standard regarding format and checksum calculation.

**Table 8.16: NMEA ASCII String**

| Field | Format/unit |
|---|---|
| Header | $AULOG |
| Latitude | Degree and decimal minute DDMM.MMMMM |
| Latitude hemisphere | N or S |
| Longitude | Degree and decimal minute DDDMM.MMMMM |
| Longitude hemisphere | E or W |
| Position Quality (CEP39) | 0.0 – 1000.0 Meter |
| Depth | -100.0 – 10 000.0 Meter |
| Altitude | 0.0 – 10 000.0 Meter |
| Heading | 0.0 – 360.0 Degree |
| Pitch | -90.0 – 90.0 Degree |

A

| | |
|---|---|
| Roll | -180.0 – 180.0 Degree |
| Forward speed over ground | -100.0 – 100.0 Meter per second |
| Port speed over ground | -100.0 – 100.0 Meter per second |
| Upwards speed over ground | -100.0 – 100.0 Meter per second |
| Deployed tether length | -1000 – 100 000 Meter |
| Tether tension | -1000 – 10 000 Newton |
| Camera tilt angle | -100 – 100 Degree |
| Sonar tilt angle | -100 – 100 Degree |
| System time | HHMMSS.SSS |
| Date | DDMMYYYY |
| End character | * |
| Checksum | Two-digit hexadecimal number |
| Carriage Return | \r |
| Line Feed | \n |

Example:

$AULOG,5832.12345,N,01458.12345,E,12.3,6.7,7.8,215.3,0.9,0.4,1.5,0.0,0.0,2200,350,-45,-45,094501.500,14012013*7F

# Task 23. Installing Icon Installer

### Frequency of Task

When required.

### Introduction

Icon Installer is a program Saab use to download software and activate/deactivate write protection on the PC used in the system.

### Tools Required

None

### Parts Required

No parts required

### Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

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### Proceed as follows:

The Icon Installer is located and controlled from the SAC.

It can be started under C:\IconInstaller\IconInstaller.exe

To be able to connect to a remote PC, make sure the vehicle system is started and power channel for PAC is enabled.

Download Software:

Select to what "Computer:" the software should be downloaded to, local is the SAC and remote can be RAC or PAC.

Before downloading any software to a PC, make sure the "Unified Write Filter" is disable, if not click the "Disable" button, the PC selected will then restart and start with disabled write filter.

A Click "Browse…" and select the corresponding zip file from the delivered software from Saab and click "Install", see figure below.

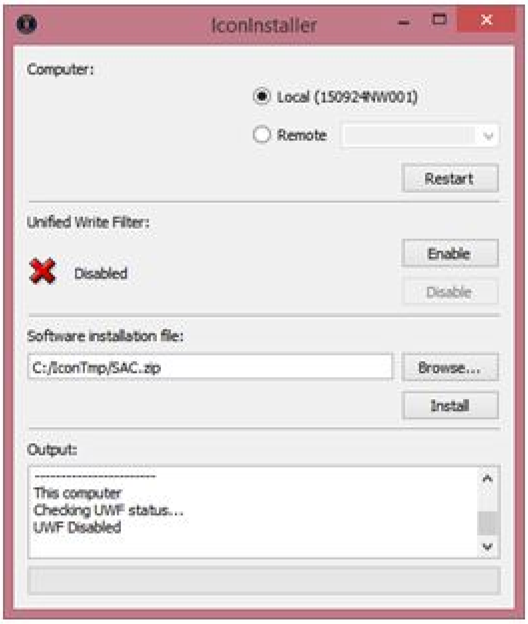


**Figure 8.36: Icon Installer window.**

**Unified Write Filter:**

If something needs to be changed on the RAC or the PAC where the Unified Write Filter is enabled for the C drive, the Icon Installer can be used to enable and disable the Unified Write Filter.

Start the Icon Installer, select RAC or PAC in the "Remote" selection.

Click "Disable" to disable the write filter, see figure below.

Do the changes on the RAC or PAC and then enable the write filter.

A

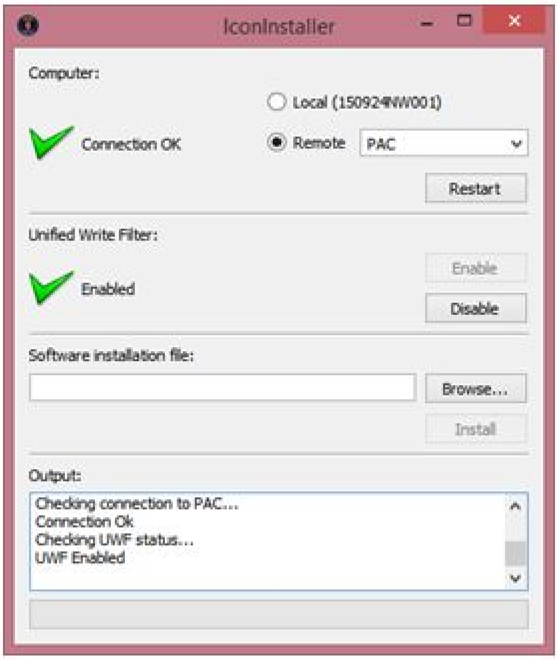


Figure 8.37: Unified write filter window

A

# Task 24. Node Tester

## Frequency of Task

When required.

## Introduction

The node tester program is a stand-alone program which is used to test nodes on the Castle2/ICON bus. It is also used to change the node ID for a node, which must be done when replacing a card or a thruster with a spare part.

## Tools Required

None

## Parts Required

No parts required

## Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

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## Node ID list:

There are three different gateways in the system, which all have different nodes connected to them, Each node has a different node ID. See the System Configuration Task in this chapter for a list of the gateways and node ID.

## Changing node ID:

1. Turn off the vehicle (remove the start key).
2. Replace the faulty device in the system.
3. Turn on the vehicle.
4. Start the SAC but don’t start any software.
5. Start remote desktop to the RAC.
6. If any software is started on the RAC close it.
7. On RAC start NodeTester from D:\Configuration\NodeTester.
8. Select “Gateways” tab, set “IP Network:” to “192.168.50.” and click “Find gateways”. A
9. The search for gateways takes a long time, so if the gateway is known beforehand the correct IP-Address can be set in “:location” and then click “Select”.
10. Double click on the wanted gateway, see figure below.

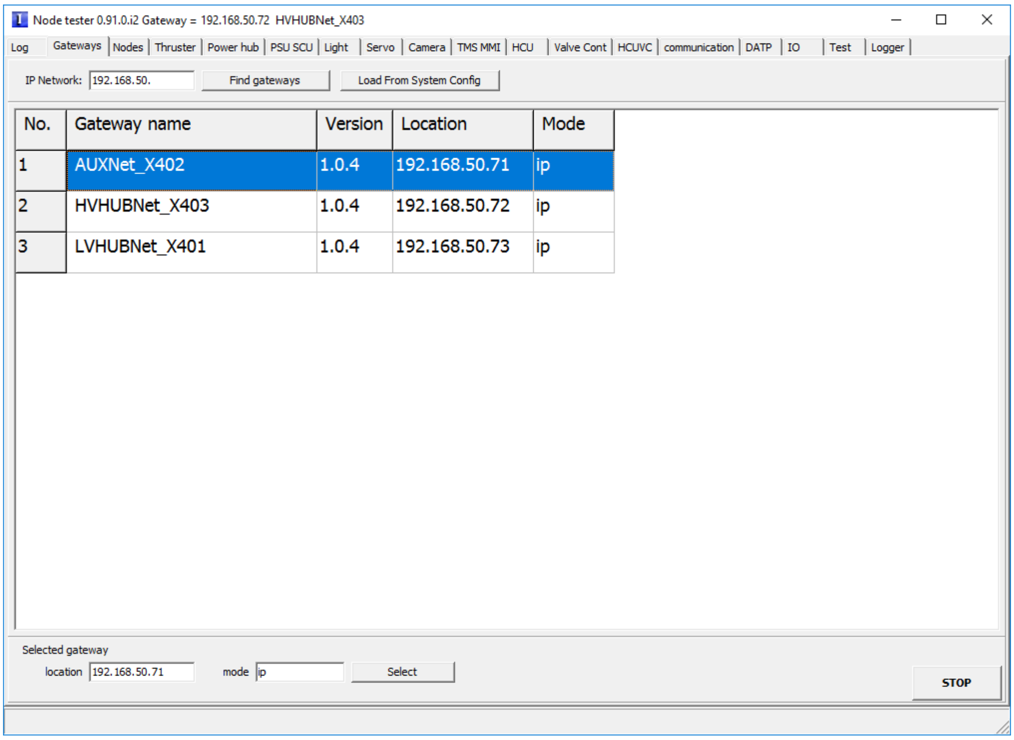


**Figure 8.38: Select Gateway**

Under the Nodes tab, the program scans for all nodes connected to this gateway. Some nodes need to be powered up before it can be found (see System Configuration task - a node that requires power to be identified, the Default powered on column lists it as false).

If the required node needs to be powered up, double click on the “Node type” under the tab. Nodes that have “HV Hub” or “low voltage hub” in the name, have a power control that will open the tab “Power hub”.

11. Under the “Power hub” tab check all the channels, see figure below.

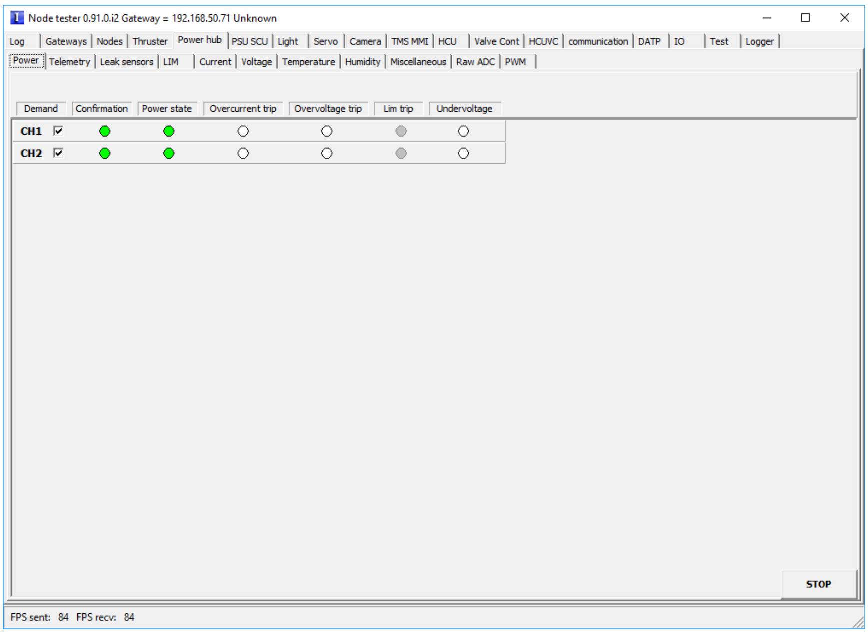


**Figure 8.39: Power tab**

12. Change to “Telemetry” tab and check all the channels, see figure figure below.

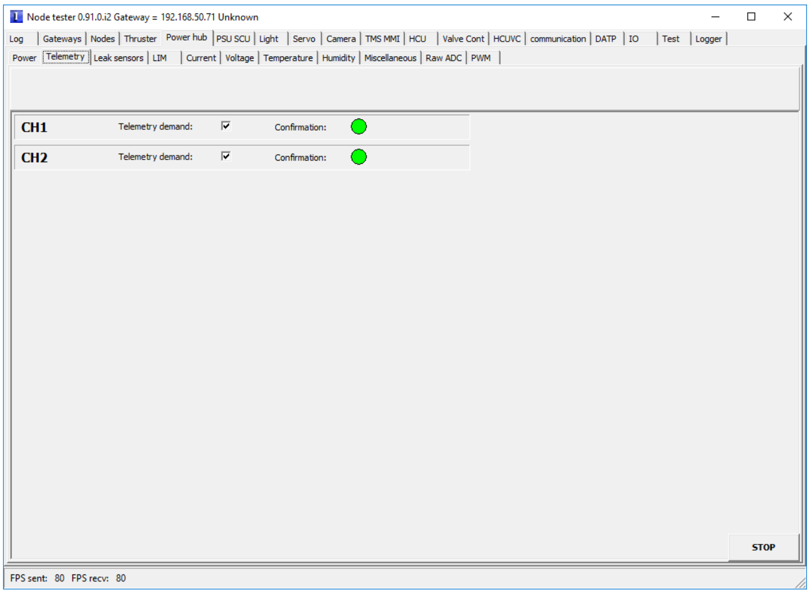


**Figure 8.40: Telemetry tab**

13. Change back to tab “Nodes” and click “Find castle nodes”.
14. If it is a thruster id change, the power to the thrusters are on the HV hub but the thruster nodes are controlled by another Gateway so then we first change the power and telemetry as above, then go back and change the Gateway and click "Find castle nodes".
15. Mark the new node and click “Node programming”.
16. Enter the node ID and click OK (as listed in the System Configuration Task).

17. Enter the same PCB number that can be seen in yellow text in the text behind the dialog and click "OK", see figure below.

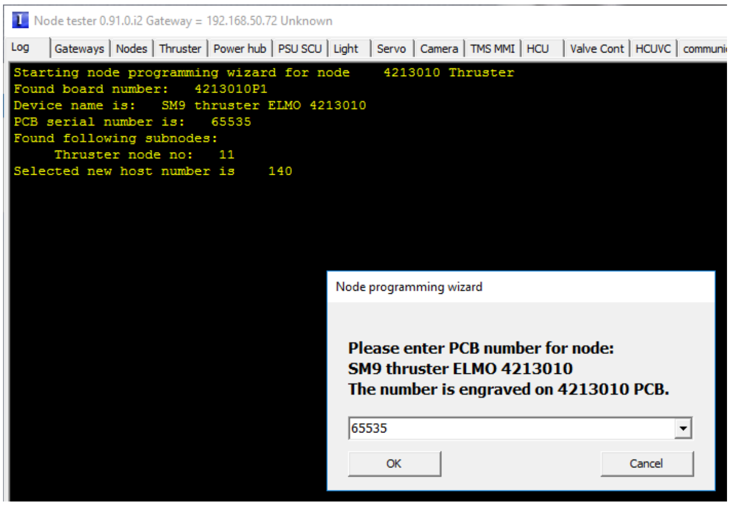


**Figure 8.41: PCB Number**

18. Go back to Node tab and click "Find castle nodes".
19. Check that the new node ID displays.
20. Double click "HV Hub" or "low voltage hub" and uncheck all power and telemetry channels.
21. Turn off Node Tester.
22. Restart the system and see if the new device is working as supposed.

**Thruster control:**

To control a thruster from the NodeTester program:

1. Double click on the relevant thruster "Node No." on the HVHUBNet_X3 gateway.
2. Change the "Mode:" to be "Volt Compensated : Speed" and then start the thruster by dragging the slider -100% to +100%. To quickly stop the thruster, press the "Zero" button, see figure below.

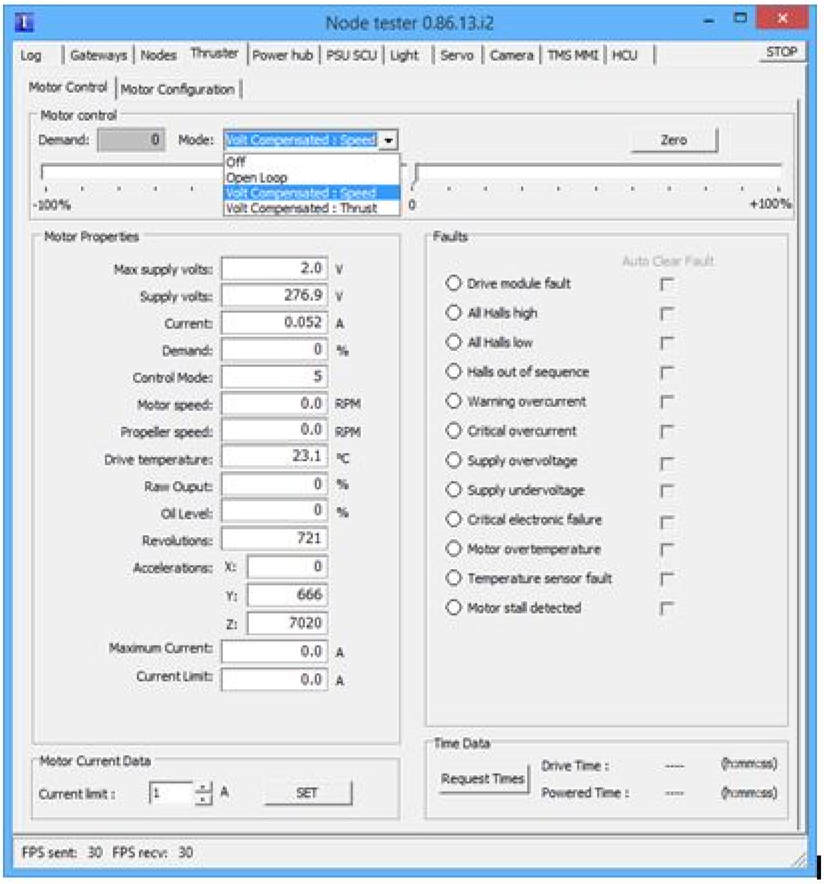


**Figure 8.42: Thruster control**

**Tilt control:**

1. To control the tilt from the NodeTester program, double click on the “Node No.” 339 in the LVHUBNet_X2 gateway.
2. Change the slider -100% to 100% to start moving the tilt, to easy stop the tilts movement press the “Zero” button, see figure below.

A

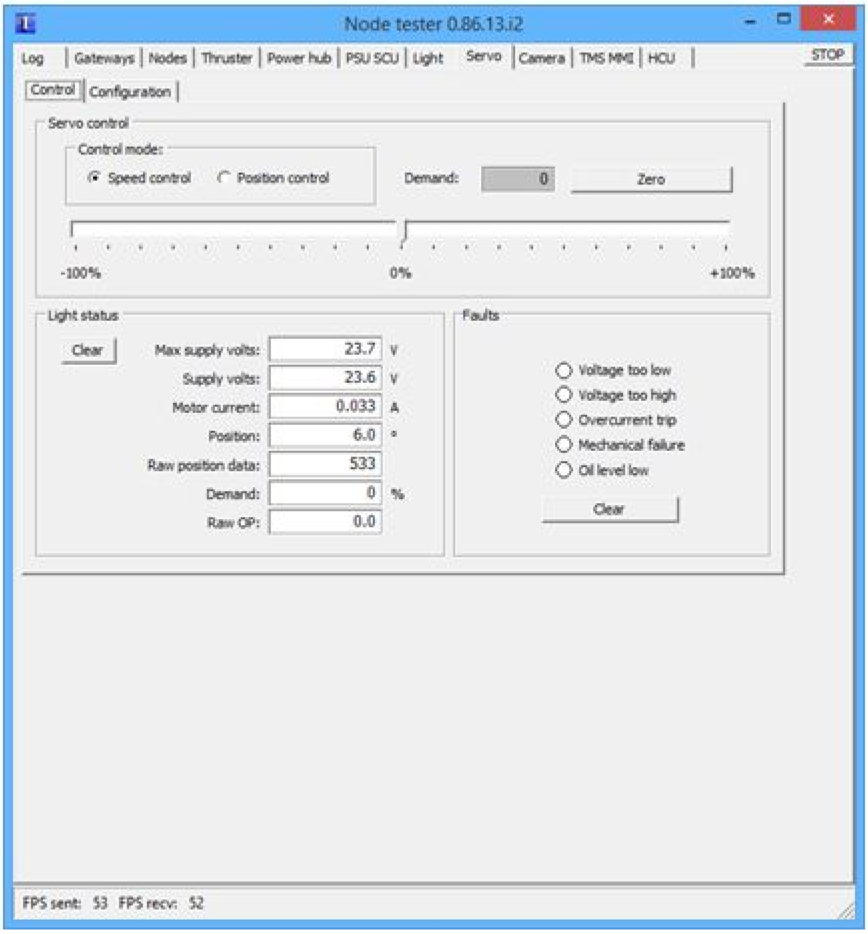


**Figure 8.43: Tilt control**

# Task 25. Changing LED ID

## Frequency of Task

When required.

## Introduction

The Bowtech lamps have an individual ID which corresponds to the place on the vehicle.

## Tools Required

None

## Parts Required

No parts required

## Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

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## LED Lamp ID:

- Spare part set LED lamp has ID 1.
- Upper port LED lamp has ID 2.
- Upper starboard LED lamp has ID 3.
- Lower port LED lamp has ID 4.
- Lower starboard LED lamp has ID 5.

Only one broken lamp can be changed at a time, since all spares will have the same ID.

After each swap with a broken lamp, the ID will need to be updated according to the list above.

## Changing LED light ID:

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1. Start the system and allow all lamps to be powered up from the HMI.
2. Open the RAC PC in a window with remote desktop from the SAC PC.
3. Close the RAC program by closing node manager.
4. Start the “TCP_UDP” program in the D:\Configuration\TCP_UDP folder on the RAC PC. See figure below.

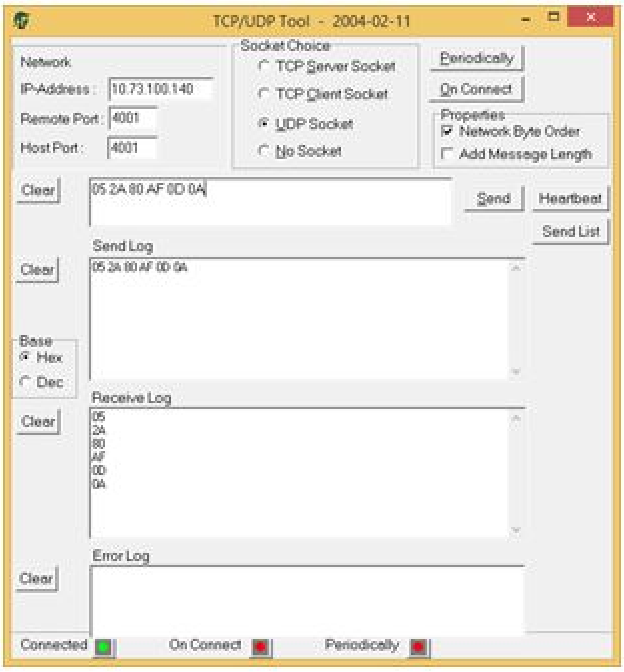


**Figure 8.44: TCP_UDP folder**

5. In the TCP UDP program, first select the **No Socket** button, and then set the IP-Address to 192.168.0.140, remote port to 4001, and host port to 4001.
6. Select the **UDP Socket** button. The round green indicator for connected in lower left corner should now be green. We are now connected against the Portserver in the vehicle.
7. To change lamp ID, enter (or copy and paste in) the text for the desired command from the table below into the Send field in the TCP/UDP program and then press the **Send** button to the right of the send field in the TCP/UDP program.
   Once the **Send** button has been pressed, the **Send Log** field should display the same text previously entered in the **Send** field. The **Receive Log** field should also display the same text as in the **Send** field, but the data is shown on separate lines.

In Figure 8.44the command is to set the 'lamp ID 5 on 50%' using the text 05 2A 80 AF 0D 0A in the **Send** field. The Receive Log field confirms that it has been received by the lamp.

**Table 8.17: Text and commands**

| Text | Command |
|---|---|
| 01 27 02 24 0D 0A | Change ID from 01 to 02 |
| 01 27 03 25 0D 0A | Change ID from 01 to 03 |
| 01 27 04 22 0D 0A | Change ID from 01 to 04 |
| 01 27 05 23 0D 0A | Change ID from 01 to 05 |

A

8. Test the new ID by addressing the lamp with its new ID and set the light to 50%. This is done by typing (or copy and paste in) the text for the desired command from Table 8.18 into the send field in the TCP/UDP program and then press the "Send" button.

**Table 8.18: Text and commands**

| Text | Command |
|---|---|
| 01 2A 80 AB 0D 0A | lamp ID 1 on 50% |

| | |
|---|---|
| 02 2A 80 A8 0D 0A | lamp ID 2 on 50% |
| 03 2A 80 A9 0D 0A | lamp ID 3 on 50% |
| 04 2A 80 AE 0D 0A | lamp ID 4 on 50% |
| 05 2A 80 AF 0D 0A | lamp ID 5 on 50% |

To turn off the lamp, use the text and command from Table 8.19.

**Table 8.19: Text and commands**

| Text | Command |
|---|---|
| 01 2A 00 2B 0D 0A | lamp ID 1 off (on 0%) |
| 02 2A 00 28 0D 0A | lamp ID 2 off (on 0%) |
| 03 2A 00 29 0D 0A | lamp ID 3 off (on 0%) |
| 04 2A 00 2E 0D 0A | lamp ID 4 off (on 0%) |
| 05 2A 00 2F 0D 0A | lamp ID 5 off (on 0%) |

9. If by mistake the wrong ID is set, use the text in the Table 8.20 to set the ID back to ID 1 and test the light as described in step8.

If the lamp lights up, it is configured and ready to use.

**Table 8.20: Text and commands**

| Text | Command |
|---|---|
| 02 27 01 24 0D 0A | Change ID from 02 to 01 |
| 03 27 01 25 0D 0A | Change ID from 03 to 01 |
| 04 27 01 30 0D 0A | Change ID from 04 to 01 |
| 05 27 01 31 0D 0A | Change ID from 05 to 01 |

A

# Task 26. Fault Finding

## Frequency of Task

When fault finding.

## Introduction

The following are useful to find faults in the system:

- vehicle schematic 21-4162701
- starboard aft lid schematic 21-4162619
- starboard front lid schematic 21-4162711
- port front lid schematic 21-4162612
- port aft lid schematic 21-4162110
- Starboard front lid block diagram in Chapter 6 of this manual
- Starboard aft lid block diagram in Chapter 6 of this manual

## Tools Required

None

## Parts Required

No parts required

## Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

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## Fault finding by pinging:

A The command ping is a good way to check the communication to a device in the system, to see where it stops. To use the “ping” command a cmd prompt needs to be started, this can be done by pressing Windows+r on the keyboard and then type in “cmd” and press enter. In the prompt write “ping 192.168.xx.xx” and press enter, see figure below.

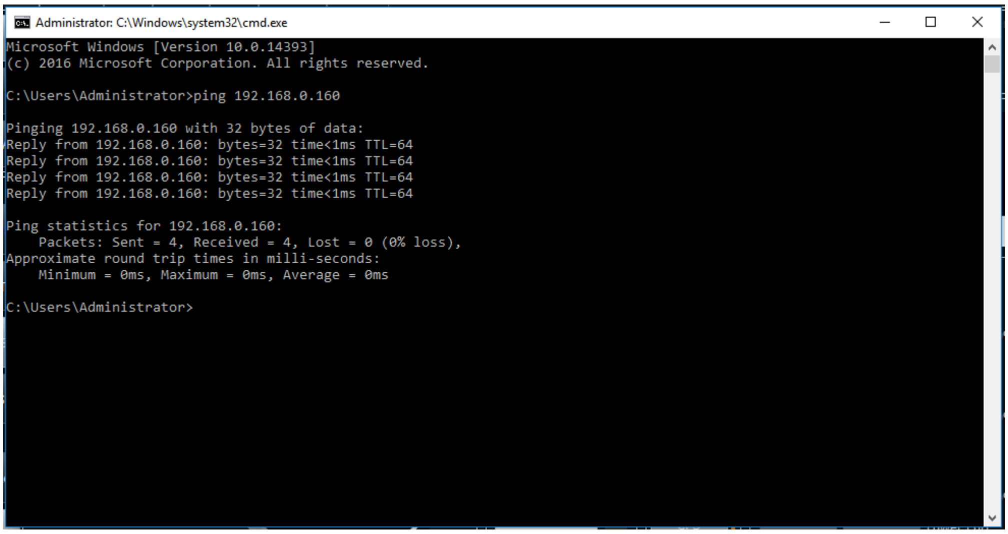



**Figure 8.45: Pinging**

To see the IP-Addresses in the system, see the System Configuration Task in this chapter.

Notice that from the SAC it is not possible to ping the subnet on the RAC that are on “192.168.50.x” so to be able to ping the gateways you need to be on the RAC, this can easy be done by remotely from the SAC connect to the RAC and from that remote desktop connection start a ping command

If the device can be pinged, but still not working as supposed some of the devices can be checked by a web browser or a program from the customers, this information should be found in this document.

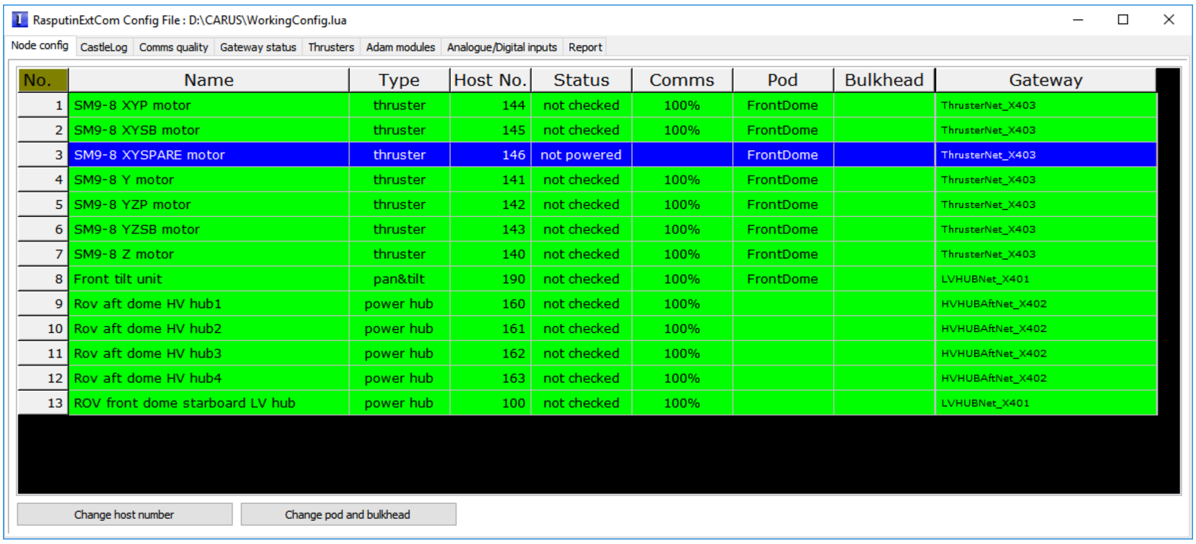
**27.2 RasputinExtCom:**

It is possible to get some information about the systems performance for some of the devices in a program on the RAC, open a remote connection to the RAC and have the system up and running and click on the program “RasputinExtCom”

The Rasputin window shows all Castle2 nodes status and change the colours of each nodes line according to the communication status. If a node starts to turn red, communication under 30-40%, it is a clear indication of something is wrong in the system

Usually the Rasputin program shows all green and some orange lines. When powering up motor nodes the colours will change from deep red to green/orange figure below.

A



RasputinExtCom Config File : D:\CARUS\WorkingConfig.lua

Node config | CastleLog | Comms quality | Gateway status | Thrusters | Adam modules | Analogue/Digital inputs | Report

| No. | Name | Type | Host No. | Status | Comms | Pod | Bulkhead | Gateway |
|---|---|---|---|---|---|---|---|---|
| 1 | SM9-8 XYP motor | thruster | 144 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 2 | SM9-8 XYSB motor | thruster | 145 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 3 | SM9-8 XYSPARE motor | thruster | 146 | not powered | | FrontDome | | ThrusterNet_X403 |
| 4 | SM9-8 Y motor | thruster | 141 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 5 | SM9-8 YZP motor | thruster | 142 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 6 | SM9-8 YZSB motor | thruster | 143 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 7 | SM9-8 Z motor | thruster | 140 | not checked | 100% | FrontDome | | ThrusterNet_X403 |
| 8 | Front tilt unit | pan&tilt | 190 | not checked | 100% | FrontDome | | LVHUBNet_X401 |
| 9 | Rov aft dome HV hub1 | power hub | 160 | not checked | 100% | | | HVHUBAftNet_X402 |
| 10 | Rov aft dome HV hub2 | power hub | 161 | not checked | 100% | | | HVHUBAftNet_X402 |
| 11 | Rov aft dome HV hub3 | power hub | 162 | not checked | 100% | | | HVHUBAftNet_X402 |
| 12 | Rov aft dome HV hub4 | power hub | 163 | not checked | 100% | | | HVHUBAftNet_X402 |
| 13 | ROV front dome starboard LV hub | power hub | 100 | not checked | 100% | | | LVHUBNet_X401 |

Change host number | Change pod and bulkhead

**Figure 8.46: RasputinExtCom**

A

# Task 27. How to Minimise Interference between Acoustic Devices

### Frequency of Task

When required.

### Introduction

When using multiple sonars it is recommended to use trigger to avoid acoustic interference. During the sensor integration of Sabertooth some recommendation can be made in respect of inspection sonars, R2Sonic, EdgeTech 2205, Imagenex 881L (obstacle avoidance) and DVL interfering with each other.

The recommended starting point should be to always trigger all acoustic sensors at the same time. It is important to try to have all sensors on same ping rate.

### Tools Required

None

### Parts Required

No parts required

### Procedure:

**WARNING - DANGER OF FATAL ELECTRIC SHOCK:**

THIS VEHICLE IS EQUIPPED WITH A POWERFUL BATTERY. THIS MEANS THAT THERE IS ALWAYS A DANGER OF FATAL ELECTRIC SHOCK. PERSONNEL OPENING UP THE VEHICLE SHALL HAVE PROPER TRAINING ON BATTERIES. THOROUGHLY READ AND UNDERSTAND THE INFORMATION ON BATTERY HANDLING IN THE MAINTENANCE SECTIONS OF THE MANUAL BEFORE DOING ANY WORK ON THE BATTERIES.

### General:

Free running inspection sonars will both pick up and create noise. For a specific mission, it is important to identify what sensor data is the most important for that mission and plan accordingly. The principle to use as few sensors as possible simultaneously will save power and reduce risks of interference.

NOTE: As a rule of thumb as to not interfere with obstacle avoidance sonar, always tilt other forward looking sonar's to an approximate angle of 30° to avoid false obstacle targets.

### EdgeTech 2205:

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The finding is that it looks quite immune to forward looking sensors like inspection sonars and the other way around.

**R2Sonic2024:**

If the inspection sonars independent of tilt angles are used in the same frequency as used on the R2Sonic one get interference on the R2Sonic but not the other way around. If R2Sonic survey data is the primary objective, do not use a free running multibeam inspection sonar at the same time.

**Inspection Sonar:**

If sonar frequency is set to multiple of DVL frequency, the inspection sonar may pick up some noise.

**Obstacle Avoidance (OA):**

If sonars are phasing in same direction and are close to OA frequency, they can affect or be affected by OA. It is crucial that this tested before installing a new multibeam so as to not affect performance of OA sonar on autonomous mode.

**DVL**

The DVL can be a source of acoustic noise and most likely will need to use acoustic trigger settings to reduce the affect on high performance sonars.

**Acoustic trigger:**

The system includes an acoustic trigger board. Its purpose is to maximise sensor performance and reduce risk of interference. Default factory settings are 4Hz (period time of 250ms). Other settings are possible but one need to verify new settings that it not gives negative effects in the system or sensor performance. Every change here need to be calculated in respect of ping rate (period time), speed of sound in water and sonar range

**Some Guidelines**

**Period time:**

- All sensors used simultaneously shall have the same periodic time.

- If using another value than 250ms. Questions to be asked are sonar ranges required and possible effects on navigation accuracy.

**Offset time:**

- Normally if integrating a completely new sensor never used before. The starting point is to start to ping all the sensors simultaneously and work from there. DVL normally shows up directly if there is an issue.

A

**Polarity & Active time:**

- Use recommendation as stated by the sensor manufacture.

Below is the default trigger setting to get clear data with R2Sonic/Edgetch2205/DVL.The offset setting of DVL compared to EdgeTech2205 give sonar system an acoustic clear window of 210ms before DVL ping and a new cycle starts.

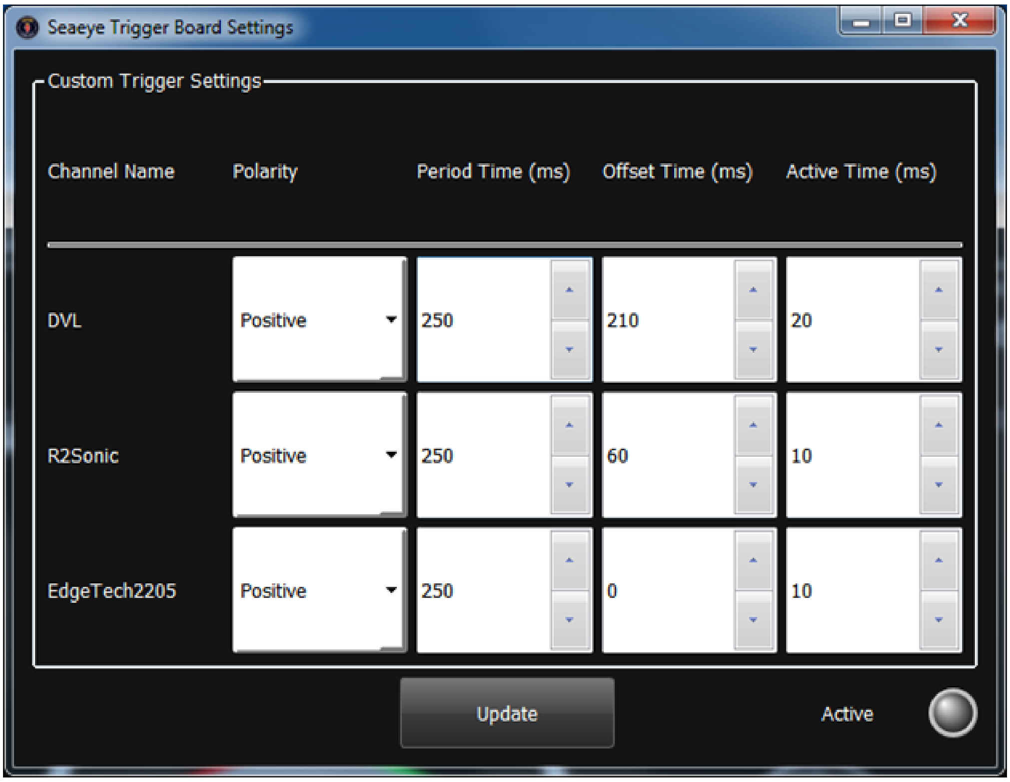


**Figure 8.47: Trigger board settings**

Factory setting as example to calculate max ranges

Speed of sound: v=1500m/s only as an example value

Ping rate: 4Hz (T=250ms)

Ranges: D [m]

NOTE: Always calculate the total sound travelled distance per ping out/in.

V=2xD / T => D=(VxT)/2

On EdgeTech2205 lowest frequency 230 kHz that has the longest range and enter values from default setting.

D = (1500x0.25)/2=187,5m range

If the operator enters more than 187,5m range in the mission planner or EdgeTech GUI with the above settings, the sonar will ignore trig pulse. If that enters before the corresponding time of desired range in this case it will fire the next trig pulse giving 2Hz ping rate.

NOTE: To get good SSS data one should be 10% altitude of desired range so 187,5 m equals around 18m altitude.

Ensure the DVL is finished within 40ms of each ping of the EdgeTech2205. This will prevent noise interfence between the devices, this can be done in the DVL settings.

The DVL arrays are angled 30° from horizontal plane giving travelled distance total:

V=D/T=>D=VxT=1500x0,04=60m

D = 2x (Altitude / cos 30°) => Altitude=(D x cos30°)/2=~26m

With the setting above the operator could fly 26m above seabed level before risk of DVL interference in EdgeTech SSS data. Tthere may be some delays from EdgeTech ping to when it starts listening that can expand the 40ms.

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# Task 28. Configuration of SPRINT NAV

## Frequency of Task

When required

## Introduction

This task explains how to connect, download log files and change settings to the INS SPRINT-Nav.

## Tools Required

Lodestar – program from Sonardyne

## Parts Required

No parts required

## Task 28.1 Connect to SPRINT-Nav

The SPRINT-Nav is connected to the Vehicle both with Serial and Ethernet interfaces.

- Serial: COM5 on the RAC PC
- Ethernet: IP: 192.168.100.222 Port: 4000

To connect to the SPRINT-Nav while Saab SW is running, the Ethernet interface should be used. When Ethernet connection isn't working or a reset to factory default is needed, the Serial interface should be used.

1. Start the Lodestar program from the SAC or the RAC. If the Serial Interface is being used, the Lodestar must be started from the RAC (see step 5).
2. Click **Connect** (see Figure 8.48).

A

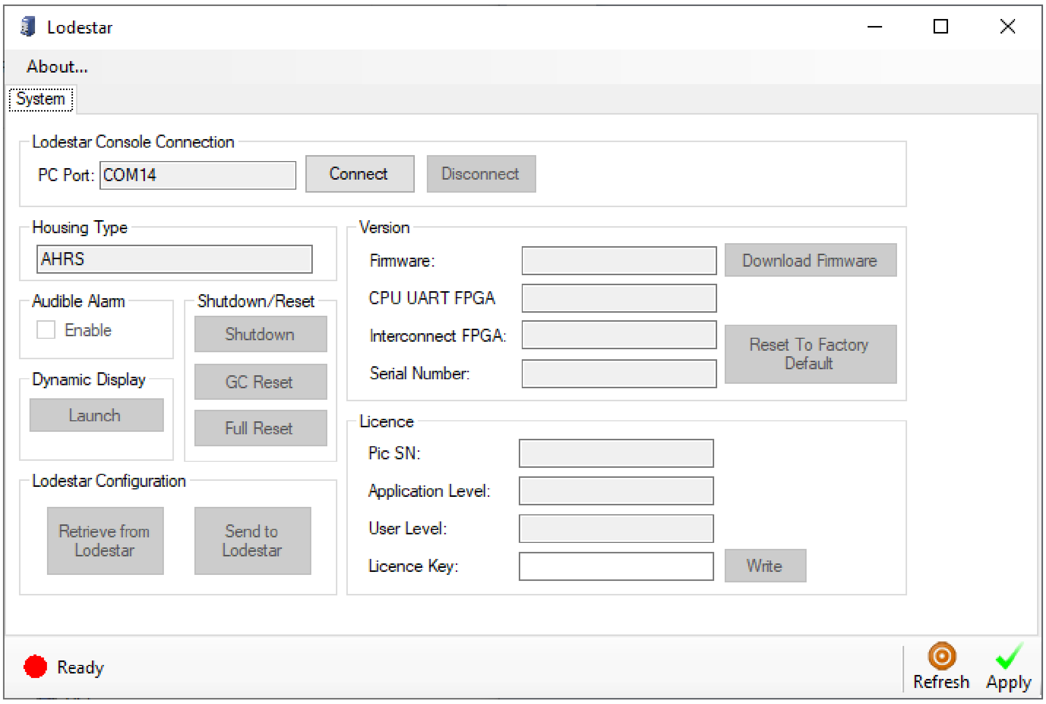



**Figure 8.48: Lodestar Connection**

3. Set the following settings for the Ethernet connection:

   a. **IP Address:** set to 192.168.100.222.
   b. **Socket Id:** set to 4000.
   c. Make sure **Multiplexed** is unchecked.
   d. Click **OK**.

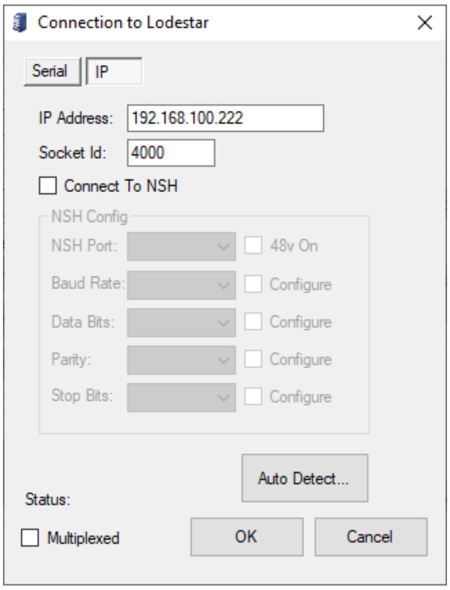



**Figure 8.49: Lodestar Settings for Ethernet**

4. If connection couldn't be established, ping 192.168.100.222 and make sure the INS is started and reconnect again.

5. If connection to serial interface is needed, start Lodestar on RAC and set the following:

    a. **Comm Port:** to COM5
    b. **Baud Rate:** to 115200
    c. Make sure **Multiplexed** is checked.
    d. Click **OK**.

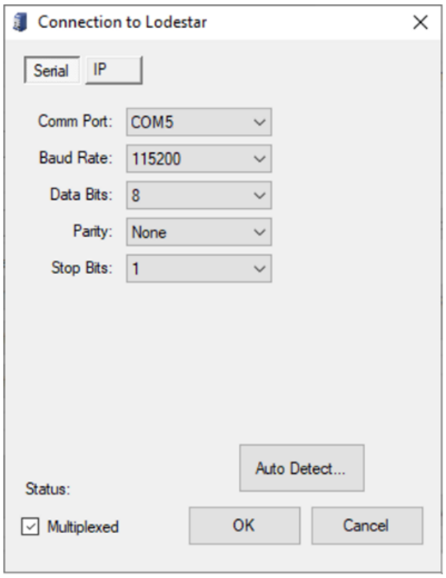



**Figure 8.50: Lodestar Settings for Serial**

### Task 28.2 Change Settings

1. On the INS Settings, click on the tab **E1**, to view the current Ethernet ports being used by the SPRINT-Nav. If required, you can remove a unwanted port:

    a. Select the port to remove.
    b. Click **Remove** (see Figure 8.51).

Ⓐ

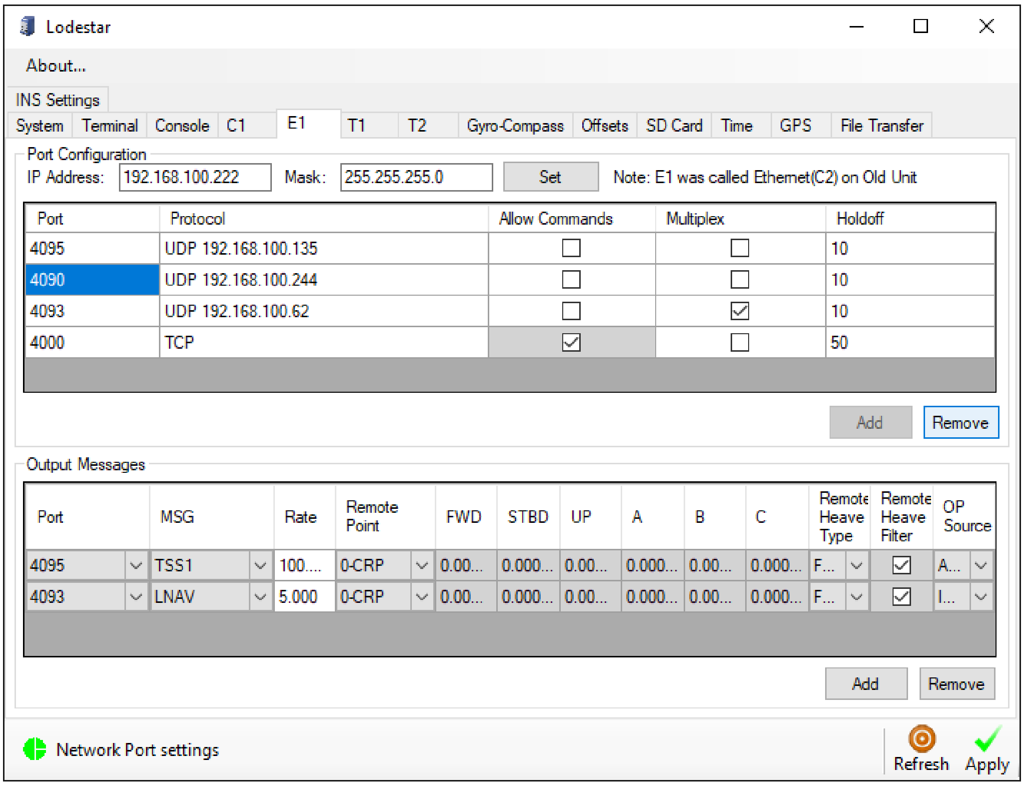



**Figure 8.51: Lodestar E1 Tab**

NOTE: On this screen, you can see if the “Multiplex” is being used or not on the port, If multiplex used, it means more than one message could be used on port and then Sonardyne will use 10 02 as a separator between messages in the same “message” so to speak.

NOTE: On this screeen, you can see if the port connected allows commands to change the settings inside the INS.

2. To add a new port or change settings for the SPRINT-Nav, open the tab **Terminal** (see Figure 8.52).

Ⓐ

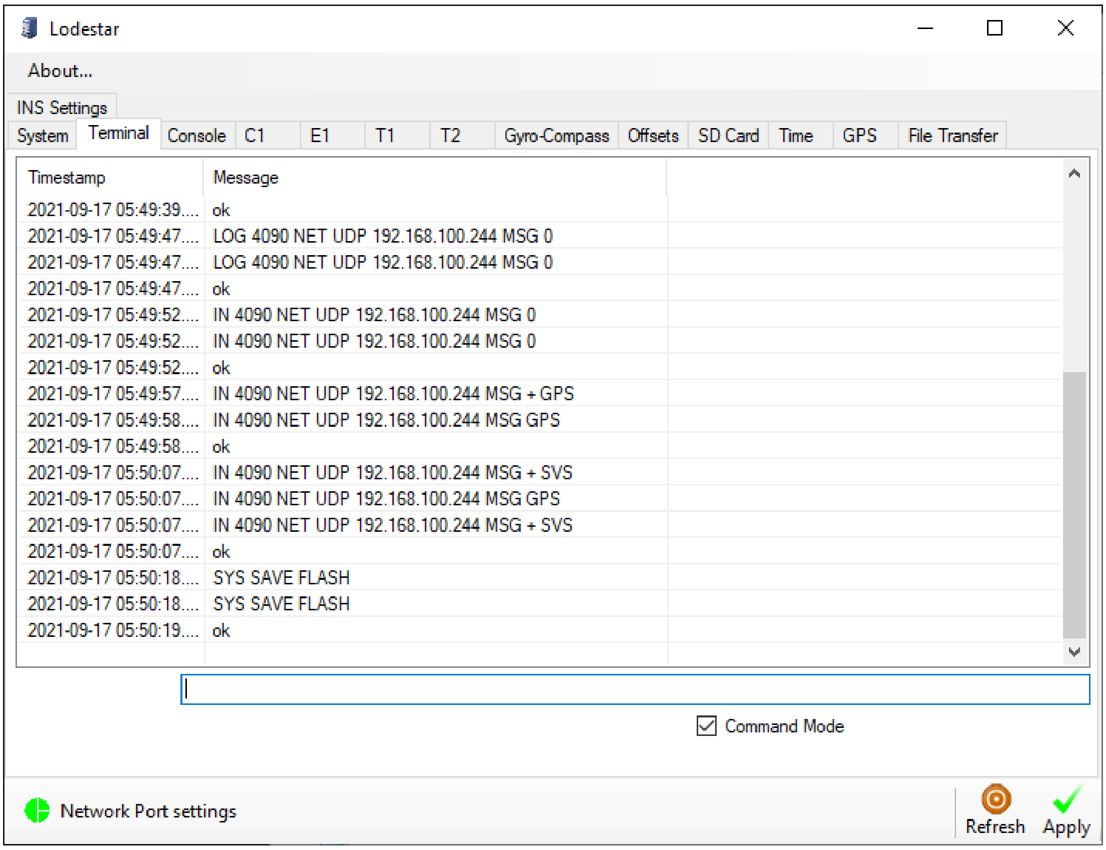



**Figure 8.52: Terminal Tab**

3. Make sure **Command Mode** is checked. Type the commands you want to change in the edit box above the **Command Mode** checkbox.
4. Press Enter after each command to send them to the SPRINT-Nav.

NOTE: Saab has stored the commands used when setting up the INS before delivery, but these can easily be changed depending on the use of SPRINT-Nav. It can be USBL changes or the port messages sent from SPRINT-Nav that needs to be changed.

5. Save the commands used for different operations so they can be used again. The commands should be saved on the RAC under D:\Configuration\SPRINT-Nav.
6. To save the changes, end by sending **SYS SAVE FLASH**.

### Task 28.3 Download Log Files

Downloading files from the SPRINT-Nav can only be done through the Ethernet interface and when not using Multiplex, like the Ethernet port we are using.

1. Connect to SPRINT-Nav on Ethernet as previously described.
2. In the INS Settings, click the tab **File Transfer**.
3. Click the button "**…**" and select a folder on the RAC to download the files to.
4. Browse to the correct date under "Lodestar SD Card Explorer" and select the wanted file.

5. Click **Upload to PC** (see Figure 8.53).

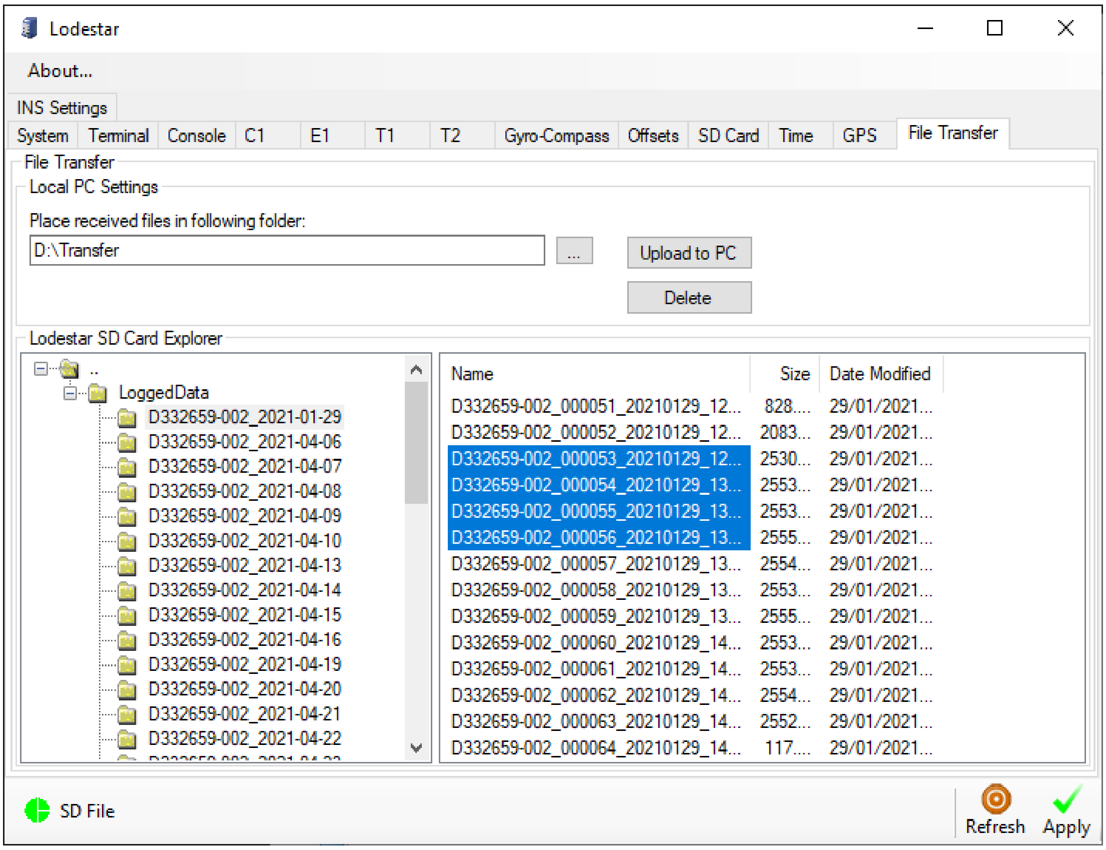



**Figure 8.53: File Transfer**

6. If the download fails after a while, repeat the procedure.

# Task 29. USB Hard Drive and USB Flash Memory

### Frequency of Task

When required

### Introduction

With each system, there is a USB hard drive, which can be used for different tasks. The main purpose is to be a backup storage containing images, software and configuration files of the system.

It can also be used when creating an image.

With each system, there is also a USB flash memory, this should only be used when restoring a backup image, it is a bootable device for Windows 10.

### Tools Required

No tools required

### Parts Required

No parts required

### Procedure:

### Description:

The USB hard drive is delivered with the software on the system under:

Software\YY-MM-DD\Version\

The USB hard drive is also delivered with all Configurations from RAC and SAC

Configuration\SAC\Configuration

Configuration\RAC\Configuration

The USB hard drive is also delivered with image backups:

Image Backup\PAC\2018-10-15\WindowsImageBackup

Image Backup\SAC\2018-10-15\WindowsImageBackup

Image Backup\RAC\2018-10-15\WindowsImageBackup

A

# Task 30. Create Image for Backup

## Frequency of Task

When required

## Introduction

This Task explains how to create an image of the computers in the system using Windows 10.

RAC and PAC can create and image over the network so we don’t need to open the Vehicle, SAC can create the image direct to a USB hard drive.

When creating image over Wi-Fi it takes long time.

## Tools Required

No tools required

## Parts Required

USB Hard Drive

## Procedure:

## Proceed as follows:

1. Right click on the Windows button on the PC that need an image created, select “Control Panel” and in the Control Panel click on “File History”.
2. Click on “Create a system image”, see figure below.

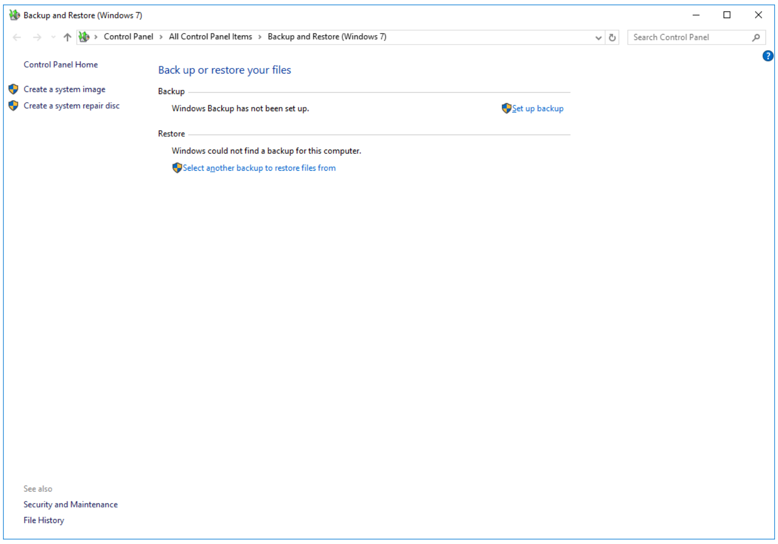



**Figure 8.54: Backup and restore window**

3. If the image should be created on a USB hard drive select “On a hard disk” and select the connected USB hard drive, make also sure that the connected USB hard drive doesn’t

have any folder named “WindowsImageBackup” before the image backup starts.If the image should be created on a network location select “On a network location” and click “Select…”, see the figfure below.

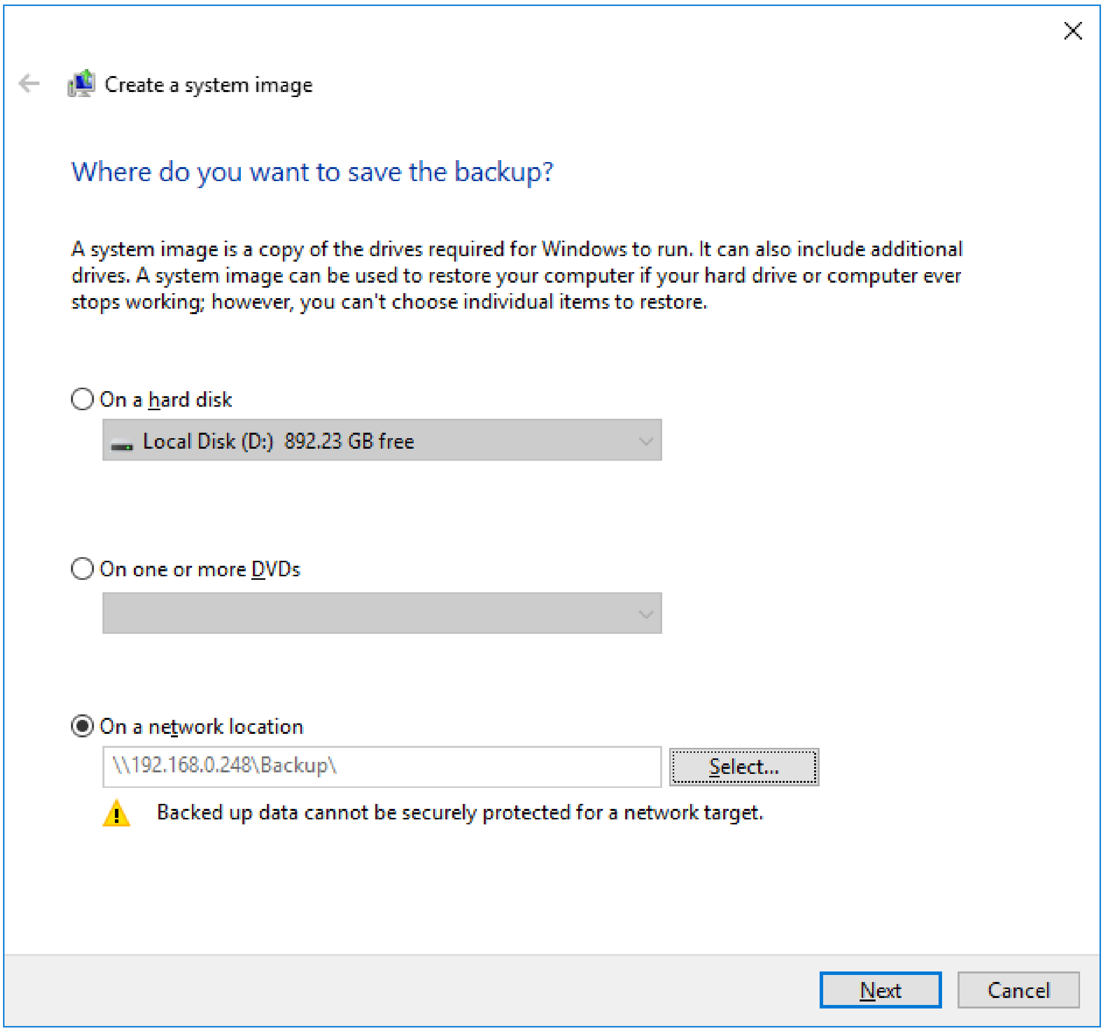



**Figure 8.55: Save to a Network Location**

4. Set the ”Network Location:” to the SAC IP-Address and the Backup folder, set the “Username:” to Backup and “Password:” to SaabSeaeye, see figure below.

A

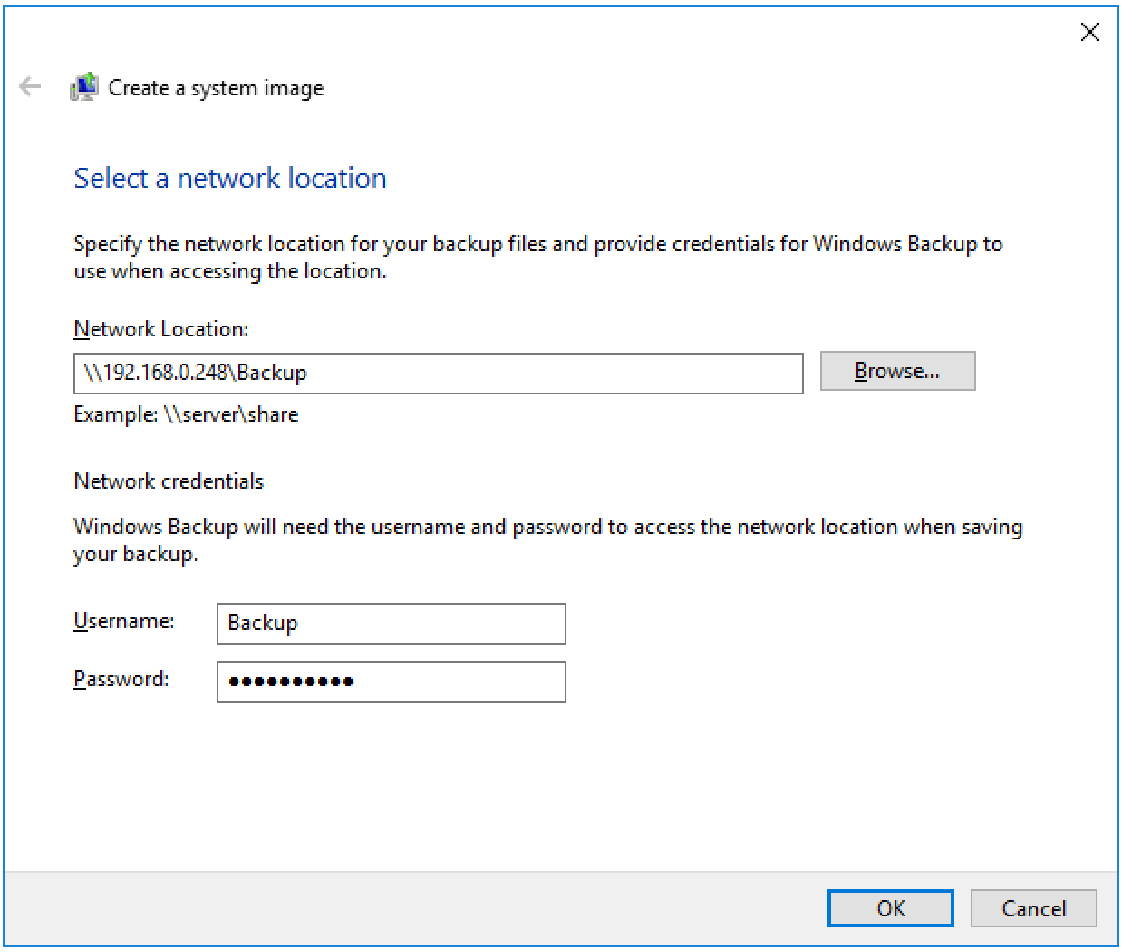



**Figure 8.56: User name and Password Window**

5. Click ”OK”
6. Click ”Next”
7. Select the D: partition and click “Next”
8. Click “Start backup”, see figure below

Ⓐ

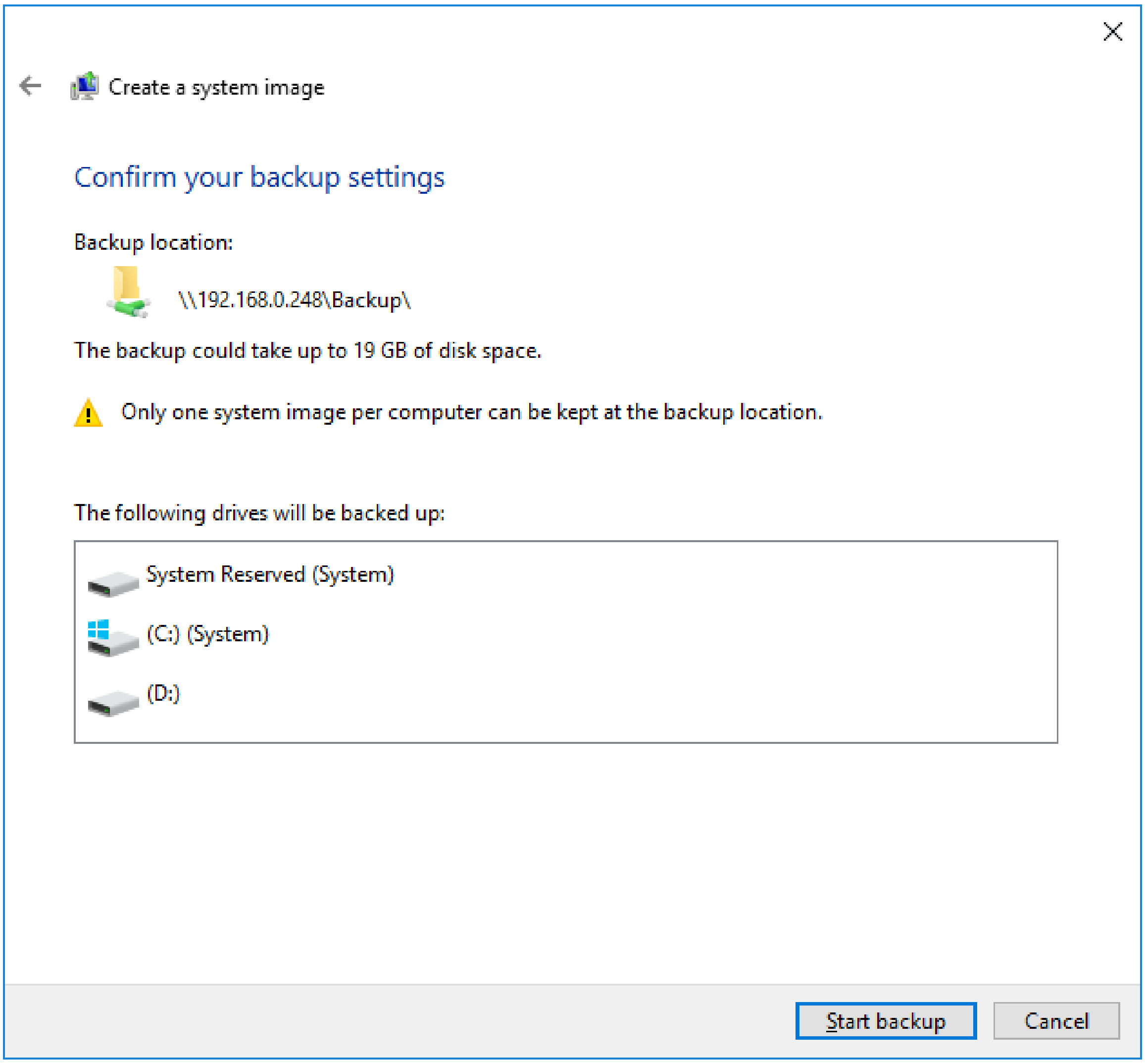



**Figure 8.57: Start Backup**

9. Wait for the backup to finish and click “Close”.
10. The image folder created “WindowsImageBackup” is now located under D:\Backup on the SAC or direct in the root on the used USB hard drive, this folder should now be moved to the USB hard drive delivered with the system, create a new folder under the correct folder with today’s date, for example “Image Backup\PAC\2018-10-15\WindowsImageBackup”

## Task 31. Restore Image for Backup

### Frequency of Task

When required

### Introduction

This Task explains how to restore an image to any of the computers in the system using Windows 10.

The task needs to be done using the physical PC with a monitor, keyboard and mouse; it cannot be done over the network.

### Tools Required

Monitor, keyboard and mouse.

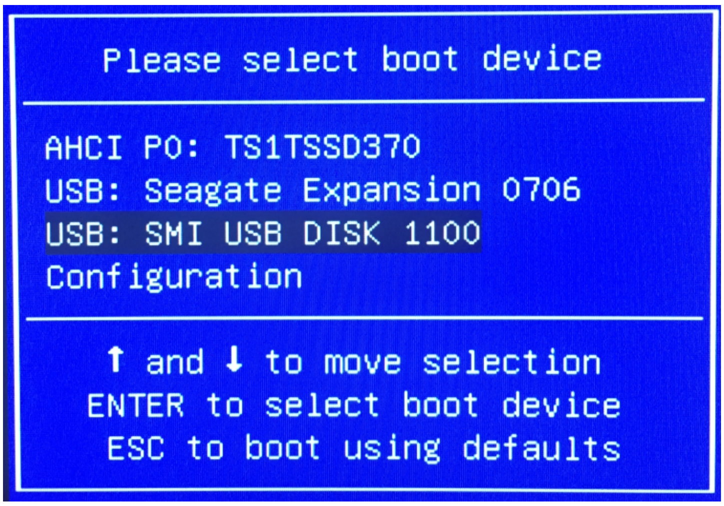
### Parts Required

USB Hard Drive

### Procedure:

### Proceed as follows:

1. Put the image to restore to a system on a USB hard drive, it has to be direct under the root of the USB hard drive, and have the name "WindowsImageBackup".
2. Connect the USB hard drive directly to the PC that should get the image.
3. Connect a bootable USB flash drive with Windows 10 media to the PC and press F11 during boot to be able to select the Windows 10 media device to boot from, see figure below.




A

**Figure 8.58: Select boot device**

4. Click "Next" when Windows installation is shown, see figure below.

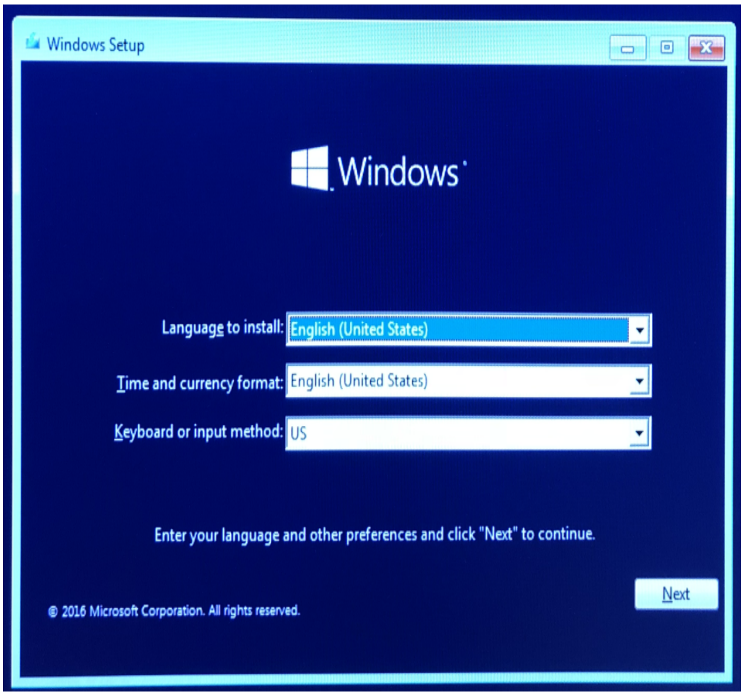



**Figure 8.59: Windows Installation**

5. Click ”Repair your computer”, see figure below.

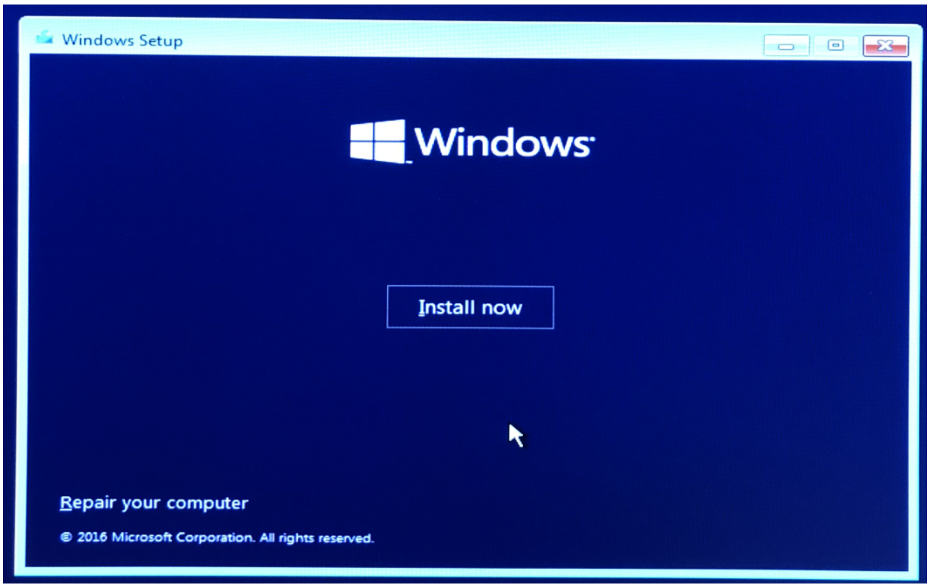



**Figure 8.60: Repair Computer**

6. Click ”Troubleshoot”, see Figure 8.61.

A

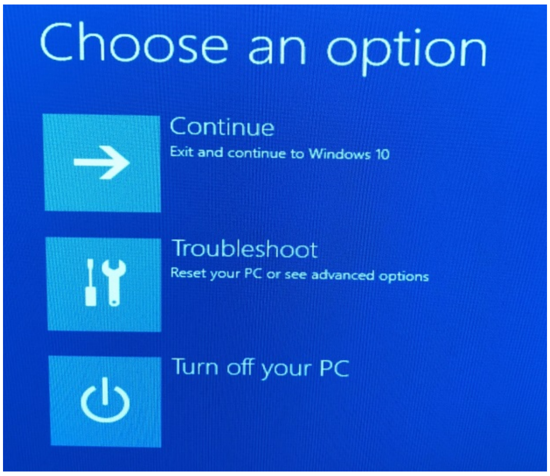



**Figure 8.61: Select Troubleshoot**

7. Click ”System Image Recovery”, see figure below.

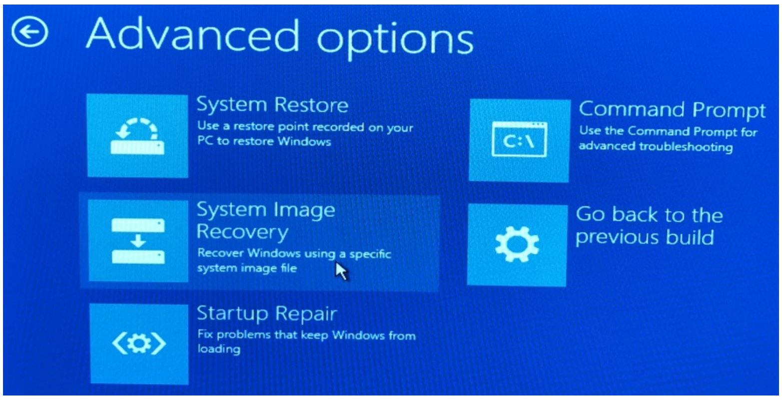



**Figure 8.62: Advanced Options**

8. Click “Windows 10”, see figure below.


**Figure 8.63: Choose Operating System**

A

9. Select “Select a system image”.
10. Click “Next”.
11. Select the location for the image and click “Next”, see figure below.

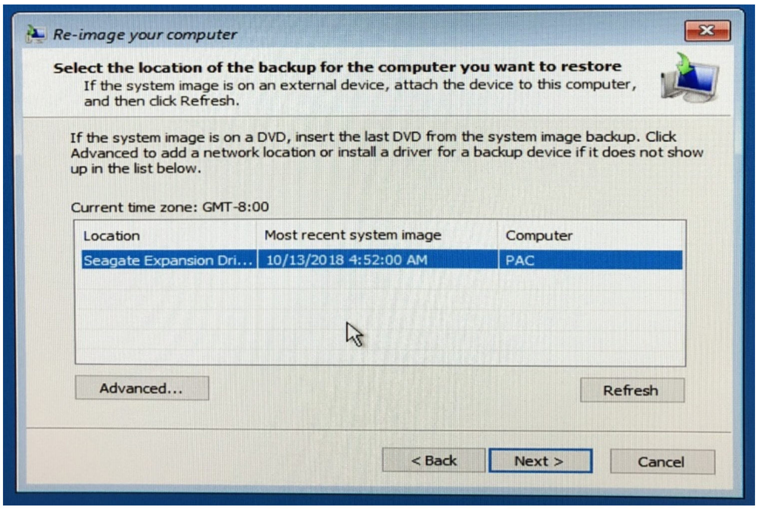



**Figure 8.64: Select Location of the Backup to be Restored**

12. Select the backup from the location and click “Next”, see figure below.

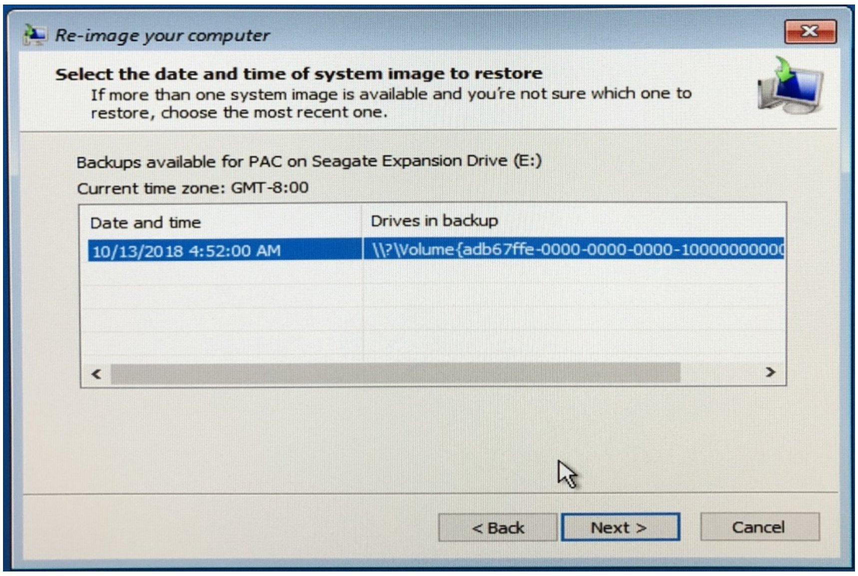



**Figure 8.65: Select Date and Time**

13. Make sure “Format and repartition disks” are checked.
14. Click “Exclude disks”.
15. Check the USB device with the Windows 10 installation.
16. Click “OK”, see figure below.

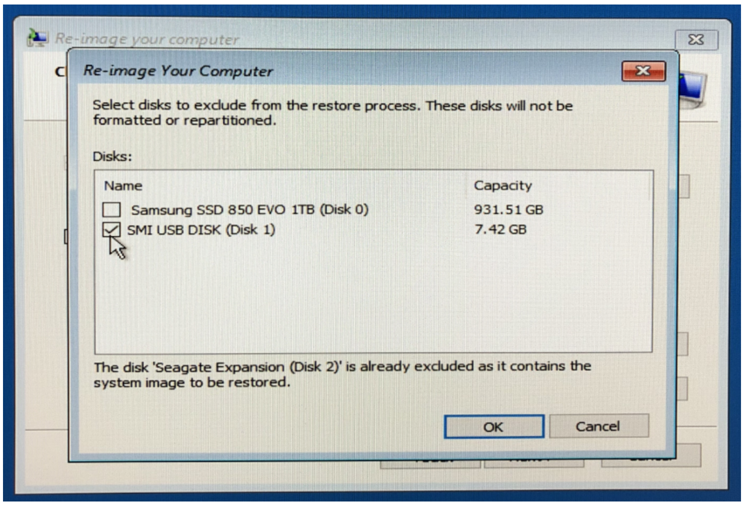



**Figure 8.66: Exclude from Restore**

17. Click “Next”.
18. Click “Finish”.
19. Click “Yes”, see figure below.

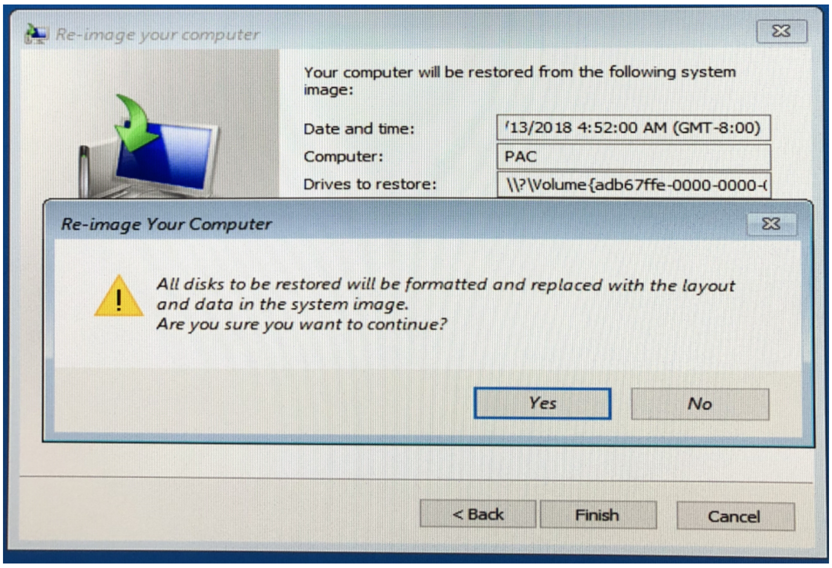



**Figure 8.67: Confirm restore**

20. Wait while it is restoring and click “Restart”.

A

# Task 32. Download and Delete Log Files

### Frequency of Task

Regularly

### Introduction

This task explains how to download and delete log files from the system.

It is recommended to routinely download and delete log files from the system. This task can be after each mission or at the end of the day, week, or month, as long as it is done regularly.

It is important is not to fill up the hard drives too much as it will affect the performance of the system. The recommendation is to have a routine so that as little data as possible is store on the Sabertooth system hard drives.

### Tools Required

None

### Parts Required

No parts required

### Procedure:

- Use the SAC Transfer folder under the D: drive as the temporary container of the log files from each PC.
- Once all files are in the transfer folder, connect a USB drive to the SAC and download the files to the USB drive.
- Transfer the files on the USB drive on to a network drive or similar, delete the files from the system.

It is also recommended to download data while connected to the fibre or deck cable. Using the Wi-Fi is also possible, but it will take a long time.

When downloading log files, it is also recommended to zip the files before starting the transfer to the SAC.

Sometimes, it is enough to save the survey/sensor data, so then the system files generated can be deleted direct from the drive without downloading.

A From the SAC, there are network drives to the log area on the RAC and PAC. These can be used to download and delete files. It is also possible to remote directly from the SAC to RAC and PAC and download / delete files that way. Log files are stored under D:\Log on all PCs.

In order to delete all files, the software needs to be closed. In order to close the software, you will need to remote into the RAC and PAC and close the software from there and then it is possible to delete all files. When closing the software, you can't control the power to the sensors, so you might want to download these files first, but if the power was on to the device, it will remain on until power is off for the system or the software is restarted.

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# Task 33. Battery Handling Safety Instructions

## Frequency of Task

Required for safe working practices, in the case of fire, for transport, or for storage.

## Introduction

According to cell manufacturer, the cell voltage is equal to the following:

~3.5V equal 30% SoC
~3.6V equal 40% SoC
~3.7V equal 50% SoC
~3.8V equal 60% SoC

The cell manufacturer voltage applies for transport, storage and overrules the SAAB HMI.

The lithium-polymer battery is a robust and safe technology when its application is properly designed and maintained. The Sabertooth battery has redundant safety features during charge and discharge.

The battery is monitored by the BMS when connected. The BMS monitors the battery current, voltage, and temperature during discharge and charging. If a fault / accident occurs within the cell or cell modules, no BMS protection is available. The section "UN regulation limits and test methods" describes testing and expected behaviour in extreme conditions.

The cells used are from the highly skilled cell manufacturer, Kokam. The cells, SLPB90216216, are certified according to UN 38.3 (File: KQ13-RG06-01R0). The certification allows cells to be transported by air. SAAB has certified a cell module consisting of 14 cells in series according to UN 38.3 (File: 2221610KAU-003). This allows the cell module to be transported by air if packed according to air regulation for dangerous goods containing lithium batteries under regulation UN 3480.

For the transport of the battery in the vehicle by train, sea or road, regulation UN 348 applies. Please note that specific country regulations may apply.

SAAB recommends, regardless of transport method, that the battery is drained to ~3.5 V cell voltage. With this cell voltage, numbers of studies have proven that Lithium batteries cannot experience thermal runaway.

Always store battery in -20 to +25°C and ~3.7 V cell voltage, if not mobilized to minimize ageing and premature drainage.

Kokams recommendation for use, storage and charging etc shall be followed at all times.

A Trained fire fighting personnel with appropriate protective equipment for handling Lithium batteries shall be available during operations.

NOTE: Water is one of the most effective mediums to take control of Lithium battery fire as it will cool and reduce concentration of hazardous gases.

**Safe Working Practices for Sabertooth whilst mobilized on vessel:**

- The vehicle must be stored on deck, protected from any external heat sources and ensuring that the temperature in the pressure hulls does not exceed 60°C.
- Keep the vehicle away from fire sensitive areas and do not block fire extinguishing equipment or escape routes.
- The vehicle must be within reach of a crane or dedicated 'A' Frame for quick launch in to water.
- If the system is a 'free flying' vehicle, attach an extended lifting device (metal not synthetic) to the vehicle lifting hook. Park the extended lifting device on the side of the vehicle for latching to a crane hook, creating the possibility to off load the vehicle from the vessel in the event of fire.
- In the event of a fire, the flames will protrude from the pressure hull in the areas indicated by Red Arrows in the below image.

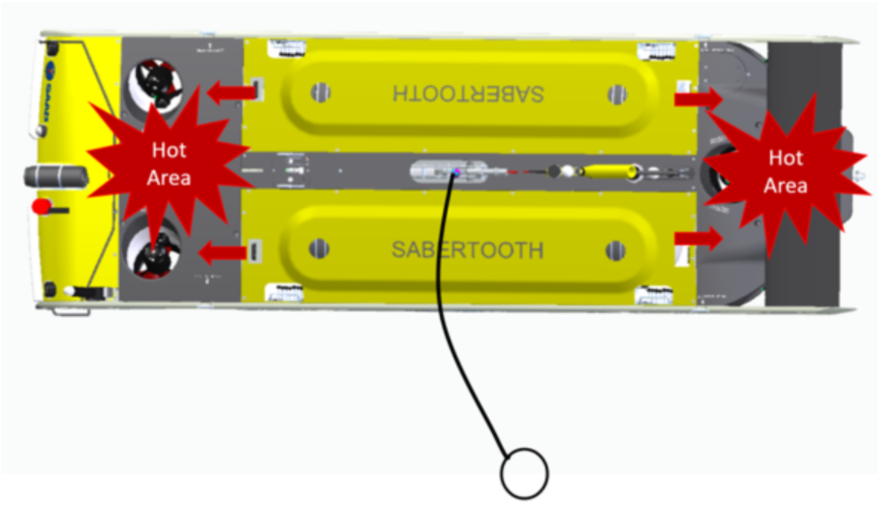


**Figure 8.68: Vehicle with extended lifting device and hot areas shown**

- If the system is a 'free flying' vehicle, it must be ballasted with an additional 20 kg of ballast to ensure that the vehicle will stay submerged when off loaded from the vessel in a fire emergency.

NOTE: The additional ballast will need to be removed before any operational dive and refitted after.

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- If it is unsafe or not possible to off-load the vehicle in a emergency situation, then a firehose and water supply must be readily available to cool down the vehicle at all times.
- After missions charge the batteries as follow:
  - ~3.5 V if to be transported

- ~3.7 V if to be stored
- Fully charged if new operation within 24h

**Safe Working Practices for Sabertooth whilst in storage:**

- The vehicle must be stored in a well vented storage area. The temperature in the pressure hulls must not exceed 60°C.
- It must be stored in a cordoned of area with a >3 meter perimeter from the vehicle.
- The vehicle must not be stored in an area where other activities are taking place.
- The vehicle must be kept away from fire sensitive areas and not block any fire extinguishing equipment or escape routes.
- If batteries are handled outside of the vehicle, all guidelines regarding the storage conditions and handling of the batteries from the cell maufacturer must be adhered to.
- Keep away from fire hazardous goods or fire sensitive areas.
- In the event of a fire, only dedicated fire rescue teams should attempt to extinguish the vehicle All other personnel must leave the area in a calm and safe manner.

Attention! Always treat a battery with respect. Make sure it is protected against different threats especially when outside the vehicle.

**Tools Required**

- Multimeter
- Isolated Hex Head key

**Parts Required**

- Spare battery maintenance charging cable 01-4173031

### Task 33.1 Transporting the Battery by Air

To transport the Sabertooth battery module by air, the battery module must be disassembled into cell modules. The cell modules must be fitted in special battery boxes to comply with UN requirements. The battery boxes must be packed according to IATA packing instruction 965 general and 1A, classification according to 3.9.2.6.

NOTE: The battery must be discharged to 3.5 V cell voltage.

A A Sabertooth battery module consists of five cell modules. There are up to 3 battery units per vehicle. This gives a total of 15 cell modules plus spares.

### Task 33.1.1 Disassembly of Battery Module to Cell Modules

Refer to the following battery module drawings:

- Mechanical – 20-4162666
- Electrical – 21-4162666

**CAUTION - Danger of damage to equipment:**

Always use isolated tools and isolation gloves. Use only one hand when possible. Do not wear conductive material such as watches or necklaces etc. when working on the battery.

1. Make sure that battery is charged to max 3.5 V capacity.
2. Remove the battery module from vehicle. Use a belt on battery box when handled outside the vehicle/pressure pod.
3. Place the battery module securely on a hard work surface so that it is away from environmental threats.
4. Remove the battery module top cover (item 4 on the mechanical drawing 20-4162666).
5. Remove battery (+) on cell module 4. Isolate terminal ring.
6. Remove battery (-) on cell module 0. Isolate terminal ring.
7. Remove interconnection cables between modules 0-1, 1-2, 2-3, 3-4 and in this order.

**CAUTION- Danger of damage to Equipment:**

Each cell module has a voltage below 60 VDC, but improper handling might cause a short circuit, which could damage equipment or create fire etc.

8. Remove the flat ribbon cable from cell module starting from 4-0.
9. Measure the cell modules voltage and mark the cell module. The marking shall include which battery module the cell module belongs to and also the position in the battery module.

### Task 33.1.2 Assemble the Cell Module into the Battery Box for Air Transport

Refer to the following mechanical drawings:

- 20-5032020 - Transport case battery module
- 20-5032021 - Battery module transport secured

1. Disassemble item 004 (x1) and item 002 (refer to the drawing 20-5032020).
2. Assemble the cell module from above with (+) facing the removed item 004 (from step 1).
3. Assemble items 005, 100, 020, 030, 115 on cell module (+) pole.
4. Assemble item 004 then item 002.

### Task 33.1.3 Pack the Battery Box for Air Transport

A Shipment, packing, packing material need to comply with UN3480 regulation, IATA packing instruction according 965 general and 1A, classification according to 3.9.2.6.

### Task 33.1.4 Reassembly of Battery Module after Shipment

Refer to the following drawings:

- Mechanical – 20-4162666
- Electrical – 21-4162666

1. Inspect the cell module for any damages that may have occurred during transport. If there are any problems, contact SAAB.
2. Measure the cell module voltages and compare with the values noted before shipment. If more than 2V difference between values, contact SAAB.
3. Assemble the cell modules in the reversed order as described in see "Disassembly of Battery Module to Cell Modules" on page 8.106. Position the modules in the same position as before shipment. This allows control of cell modules if some has been replaced etc.
4. Once the battery module is complete, connect the battery module to charger using cable 01-4173031. If all looks OK on the charger, start charging to 3.7 V.
5. During charging, assemble the next battery module.
6. When the battery module is charged to 3.7 V with no errors, assemble battery module to vehicle.
7. If the battery module is not going to be fitted in the vehicle, store the battery away from threats such as mechanical, electrical, environmental (temperature, sun light, rain, seawater etc).

## Task 33.2 Battery Safety Information

### Task 33.2.1 UN Regulation Limits and Test Methods

The cells and cell modules are certified and tested to UN 38.3 regulations.

Kokam have tested and approved cells according to T1-6 and T8. T7 as is applied only on battery packs. Battery cell “SLPB90216216”, File: KQ13-RG06-01R0.

SAAB have tested all cell modules (14 cells) according to to T1-5 and T7. T6 and T8 which applies only to cells. Cell module “Battery pack 14s1p”, File: 2221610KAU-003, Test house Intertek Deutschland GmbH.

Below is an extraction from UN manual of test criteria for lithium batteries. The purpose of the test is to show the cell will not catch fire, explode, leak or vent during or after the tests.

- T1- Altitude simulation (fully charged and fully discharged)

  Test cells and batteries shall be stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature (+20 ±5°).

- T2 - Thermal test (fully charged and fully discharged):

  Test cells and batteries are to be stored for at least six hours at test temperature equal to +75 ±2 °C, followed by storage for at least twelve hours at a test temperature equal to -40±2°C. The maximum time interval between test temperature extremes is 30 minutes. This procedure is to be repeated 10 times, after which all test cells are to be stored for 24 hours at ambient temperature (+20 ±5°C).

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- T3 - Vibration (fully charged and fully discharged):

The vibration shall be a sinusoidal wave form with a logarithmic sweep between 7Hz and 200Hz and back to 7Hz traversed in 15 minutes.
Repeat this cycle 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell.
One of the directions of vibration must be perpendicular to the terminal face the logarithmic frequency sweep is as follows:
From 7Hz a peak acceleration of 1 gn is maintained until 18Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8gn occurs (approximately 50Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200Hz.

- T4 - Shock

Each cell or battery shall be subjected to a half-sine shock of peak acceleration of 150 gn and pulse duration of 6 milliseconds. Each cell or battery shall be subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions of the cell or battery for a total of 18 shocks. However, large cells and large batteries shall be subjected to a half-sine shock of peak acceleration of 50 gn and pulse duration of 11 milliseconds. Each cell or battery shall be subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions of the cell or battery for a total of 18 shocks.

- T5- External short circuit (the cell pole are hard connected)

The cell or battery to be tested shall be temperature stabilized so that its external case temperature reaches +55 ±2°C and then the cell or battery shall be subjected to short circuit condition with a total external resistance of less than 0.1 ohm at +55 ±2°C. Test cells and batteries are to be stored for at least six hours at test temperature equal to +55 ±2°C. This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to +55 ±2°C. The cell or battery must be observed for a further six hours for the test to be concluded.

- T6 - Impact

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The test sample cell or component cell is to be placed on a flat surface. A 15.8 mm diameter bar is to be placed across the centre of the sample. A 9.1 kg mass is to be dropped from a height of 61 ± 2.5 cm onto the sample. A cylindrical or prismatic cell is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 15.8 mm diameter curved surface lying across the center of the test sample. A prismatic cell is also to be rotated 90 degrees around its longitudinal axis so that both the wide and narrow sides will be subjected to the impact. Each sample is to be subjected to only a single impact. Separate samples are to be used for each impact.

- T7 – Overcharge

Charge 2x max charge current and 1.2x max charge voltage.

- T8 - Forced discharge

Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12V D.C. power supply at an initial current equal to the maximum discharge current specified by the manufacturer. The specified discharge current is to be obtained by connecting a resistive load of the appropriate size and rating in series with the test cell. Each cell shall be forced discharged for a time interval (in hours) equal to its rated capacity divided by the initial test current (an Ampere).

- Other test performed by cell manufacture to show that the cells are safe and robust.
    - Over charging more than 3x nominal voltage (12V) and max allowed charge current 80A during 2h. No fire, explosion or venting during or after test appeared.
    - Nail penetration on charged and discharged cell. Sharp object, nail inserted through the cell creating a short circuit. No fire, explosion or venting during or after test appeared.

**Task 33.2.2 Safety during Charging**

During charging, the worst case scenario is fire or explosion. The Sabertooth battery is designed with multiple safety functions to prevent this.

- The BMS controls the charger and can stop the charger by software commands.
- If the charger doesn't respond to this, the BMS will act on the charging relay to stop charging.
- The BMS has redundant SW and HW monitoring that will act on the charging relay to stop charging.
- If the BMS fails to stop charging by software or hardware or if the RL 3 has a malfunction, the charger will shut down when the target value exceeds +1%.
- The Charger will automatically stop charging if CAN communication fails from BMS.
- The charger has a main 32A fuse and on the battery there is a fast 56A fuse. Both fuses are well below the battery cells max allowed charge current, which is 80A maximum.

A Kokam have done tests to prove cell safety with charging a cell continuous for 2h and three times the nominal voltage (12V) and a charge current of 80A without catching fire or exploding.

### Task 33.2.3 Safety during Discharge

During discharge the worst case scenario is fire or explosion. Another aspect is with deep discharge, the cells can be permanently damaged. The Sabertooth battery is designed with multiple safety functions to prevent this.

The maximum current taken from vehicle battery in the standard configuration is approx. 30A, which equals approximately 7.7kW at nominal voltage. The battery cell can deliver 200A continuous and 320A in peak current so a temperature raise in battery due to a high load is not a problem.

Safety functionalities during discharge:

- The BMS can act on the discharge relay if the voltage drops below the cut off voltage.
- The BMS senses over-temperature and can act on the discharge relay if the battery temperature goes to high.
- The battery module fuse is 56A and is of a rapid type.
- All the outputs, inside and outside the vehicle, are internally fused to prevent short circuit.

The BMS will draw a small amount of power when connected to the battery. Always follow the storage procedure and never leave the battery with lower cell voltage than 3.5V.

**CAUTION - Danger of damage to equipment:**

Never leave the battery with the lowest cell below 3.5 V. Always charge up to a minimum of 3.7 V for the lowest cell.

### Task 33.3 Emergency Procedures

If an incident occurs on the platform, during storage or transport, the people in command must prioritise personal safety first and equipment damage second.

Extreme events can affect the battery and this can be dangerous for the people around it. The Sabertooth battery is a lithium-polymer battery with high stored energy. The lithium-polymer cell technology contains components in itself, such as oxygen and fuel, to continue burning. There are fire extinguishers of AVD type for Lithium batteries that can be used in an early stage or on single cells.

If the battery is burning: Evacuate and seal of the room/space, to stop the toxic gas/smoke from spreading.

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### Task 33.3.1 Fire or Extreme Heat near the Battery or Vehicle

If possible take the battery / vehicle away from the vicinity of the fire or strong heat. If not possible, stay clear of the battery and monitor until the conditions have gone back to normal

+24h.

When the vehicle or battery is safe, check the battery for damages before connecting the battery test cable and checking the battery status. If the battery has been contaminated with smoke, the recommended action is not to use it.

### Task 33.3.2 Major Mechanical Impact

If the battery is dropped from a high altitude during loading of equipment or other high impact incidents and the status of the battery is unknown, do the following:

1. Immediately move the vehicle or the battery to a non-critical building or a non-critical area outside.
2. Rope-off an area of 20m and leave the vehicle or battery to rest for a minimum of 6h.
3. Connect and start the vehicle with the “start key” or use the battery test cable to monitor the status on the battery.
4. If it is all OK, remove the rope and move the vehicle / battery to the original location.
5. Let the equipment rest for an additional 18h and then check the status again if OK.
6. Disassemble the battery to cell module level.
7. Check for bends, cracks other damages due to the high impact. Pay extra attention to the cells' corners and tabs. If OK, reassemble and start the battery.
8. Check the battery with SW tool and if OK, it is safe to use.

### Task 33.3.3 Subsea Vehicle Event

The battery modules are located in a 1 atm pressure housing. The most likely events are a complete flooded main pressure hull or a small leak.

If water intrusions are in the magnitude of 5-10L, one should consider that hydrogen gas may have been produced inside the pod.

#### Flooded Main Pressure Hull

NOTE: The Prevco Relief Valve will ensure that no external pressure is above 10 PSI.

In the event of a complete flooded main pressure hull (most likely due to an implosion of the pod or a major leak due to a collapsed o-ring), it is unlikely that there will be any build up of internal pressure due to the nature of the leak.

A If the port pod is flooded, a magnitude of 30L of water can enter. The vehicle will probably be operational with port pod flooded. Hydrogen gas will be produced but will evacuate through the leak during ascension. Most likely issue due to flooding is that no pressure is built up in the pod. Look on the HMI connected to the vehicle Wi-Fi at the surface for the errors reported. Port leak?

- Recover vehicle to trolley
- Remove port side top cover
- Secure rear or front lid with wood or equivalent between lid and plastic frame

- Loosen air bleed screw
- Let it bleed for 1 minute
- Remove lid and let water out.

**WARNING - DANGER TO PERSONNEL AND EQUIPMENT**

Hydrogen gas may be present in the pod, which may cause a potential fire hazard. Do not use any tool or equipment that could ignite the Hydrogen gas in close proximity to vehicle.

If the starboard pod is flooded, a magnitude of 70L of water can enter. It is likely that the vehicle will quickly become non-operational due to the flooded main electronics such as the low voltage power supplies and computers. The vehicle will sink to the sea floor, hydrogen gas will be produced but will evacuate through the leak opening and be replaced with water until chemical / electrical / mechanical conditions are in balance. Recover the vehicle with an ROV and follow the above procedure.

Do not reuse the electronics or battery if it has been flooded with seawater.

**Small Leaks inside the Main Pressure Hull**

A more likely event is small leaks that can occur normally due to damaged or degenerated o-rings, dirt on or corroded o-ring surfaces. Normally this kind of leak can be seen during the vacuum test. If this event occurs during the dive, the four leak detectors, one in each end of main pressure pods, will trigger the RAC to go to emergency surface. Around 1-5 cl is enough to trigger the leak detectors if the vehicle is in normal attitude. Once the vehicle is at the surface, connect to it via Wi-Fi and follow the procedure as described in the see "Flooded Main Pressure Hull" on page 8.112.

The most common cause of a small leak is a damaged or deteriorated o-ring or o-ring seal. In Sabertooth, there are a lot of sealing surfaces especially on the starboard lids.

Recommended procedure:

1. Vacuum check the hull that reports a leak. Is the leak detectable using vacuum? If yes continue, if no Helium or other methods need to be used.
2. Replace one lid to “tool lid” then vacuum test. Vacuum OK = leak on replaced lid.
3. If no, replace other lid then vacuum test. Vacuum OK = leak on replaced lid.
4. If no, the leak is on pressure hull.
5. Once identify leak on the unit, lid 1 or lid 2 or pressure hull.
6. On the lids, disassemble the connectors, replace the o-rings and reassemble the connectors.
7. If the pressure hull is leaking, check o-ring surfaces for scratches/dirt etc. Replace where necessary.

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Attention! Always replace o-rings when connectors have been disassembled.

**Task 33.4 Battery Maintenance**

The Sabertooth battery should be checked at a minimum of every 18 months to ensure a good and safe function. It is advised to also perform these checks when preparing any battery for air transport. The main checks are as follows:

- Start Sabertooth system
- Check HMI battery tab:
    - Has no baterry errors
    - Document all cell voltages using print screen
- Shutdown vehicle and dismount battery modules from main pressure pods.
- Carry out mechanical and electronic checks associated with the sabertooth battery system:
    - Check for loose items
    - Using a calibrated Multimeter, check and document total voltage for each battery module

NOTE: If the main voltage differs more than ±3V contact SAAB AB.

- Dissassmble the battery modules into cell modules as described earlier in this Task.
    - Remove cell module from battery box
    - Place cell modules on a stable surface with soft covering to protect the cell module corners
    - Remove PCB top cover from cell module
    - Measure all cell voltages on each of the cell modules
    - Compare measured cell values with the print screen from the HMI

NOTE: If the individual cell differs more than ±0.1V, contact SAAB AB.

- Examine cell modules and interior battery box
- Check for wear especially cell module bottom corners

A NOTE: If there is a hole in the black tape making cell visible (aluminium coloured), thoroughly inspect and if needed remove the tape to check that no hole is in the pouch (cells Aluminium casing).

**Attention! If a hole in the cell pouch is discovered, do not use this module cell. Contact SAAB AB for more information.**

- After inspection, replace the black tape with new (if it was removed)

- Check for corrosion on connections of PCB, cables and exposed cell tabs
    - Document and share with Saab if any abnormal wear, corrosion or damage
- Check all cell connections are to the correct torque (2 Nm)
- Check the function (RL1, RL2, RL3, DC/DC conv., BMSs etc).
- Check for damages on cables and contacts.
- Check the capacity status.
    - Charge to 4.125V.
    - Discharge with known load to 3.3V.
    - Calculate energy and capacity.

The cell manufacture states the following cycle life of 1400 cycles (4.2-3V at 23°C, charge/discharge=1cycle) with more than 32Ah capacity (80% DOD). The work life for this technology depends on the usage, environmental conditions of the systems. SAAB recommends replacing battery if capacity is below 80% DOD.

- After the battery check, place a label on the battery box showing:
    - Date of test
    - Name on test performer
    - Capacity when tested and the last capacity
    - Approval signature
- After completing test, charge to:
    - 3.5 V cell voltage if to be transported
    - 3.7 V cell voltage if to be stored in -20 to +25°C
    - Fully charged only if mobilized and planned operations are within 24h

**Task 33.5 Battery replacement**

Battery replacement maybe required after time due to the amount of usage, length of storage, charge cycles, charge/discharge levels, temperatures or environmental conditions. In such circumstances Kokams recommendations of battery handling shall be followed such as:

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If the battery shows signs of degredation in performance as stated in the Battery Maintenace section. eg:

- more than 1400 charge cycles
- Capacity less than 80% DOD

In the above situations all battery modules in the build shall be replaced.

If the battery shows physical degredation, eg: corrosion or wear. Conact SAAB for technical assistance and guidance on the appropriate actions.

If during maintenance cell/s are found to have a hole in the pouch (cell casing), that specific cell module shall be replaced.

NOTE: Replacing indivdiual one or several cells within a cell module is strictly prohibited.

SAAB recommends that even if the cells appear to be in good physical working order, that all cell modules shall be replaced every 8 years.

This recommendation is made due to the fact that the normal environment of an underwater vehicle is quite extreme in respect to changes in temperature, handling, storage, shipping and operations including shock loads through LARs operations.

### Task 33.6 Long Term Battery Storage (BMS Disconnected)

The Lithium-polymer battery shall be stored with cell voltages 3.7V per cell during long time storage with the BMS not connected. The lithium-polymer battery can be stored for 1 year unattended with BMS not connected and the temperature kept within -20 to +25°C. The capacity can be affected during long term storage because of the aging process inside the cell.

### Task 33.7 Long Term Battery Storage (BMS Connected)

If stored as a complete battery and the BMS connected, the maximum storage time is 4 months with a 3.7V cell voltage.

**CAUTION - Danger of damage to equipment:**

Never leave the battery with the lowest cell below 3.5 V. Always charge up to a minimum of 3.7 V for the lowest cell.

The worst case scenario is if the cell voltage drops below 2.7 V during long term storage. The cells are permanently damaged and can not be used. If the battery is always charged when the cell voltages are lower than 3.5 V and the recommendations stated here are followed, there is a low risk that the cells will drop below 2.7 V. If the Cell voltage drops below 2.7 V, it is possible that the battery has been subject to environmental conditions outside its specification or that the cells have aging problems.

**WARNING - DANGER TO PERSONNEL AND EQUIPMENT**

Always replace battery cells that are below 2.7V. Do not try to recharge the battery cells. Lithium-polymer cells may catch fire or explode!

The battery modules shall be stored in its dedicated battery box inside the vehicle pressure hull. If battery modules and spare battery modules are placed outside, they should be mechanically secured and in a protected area away from dangerous environments such as trucks, sun light, high/low temperature, rain, gases, seawater, humidity etc. The same precautions apply to cells and cell modules. Cells and cell modules must be placed on soft material to protect the cell exterior.

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# Task 34. Remote Support

## Frequency of Task

As and when required

## Introduction

This task provides you the information to allow technical support to remote into the system to provide technical support when there is a problem.

## Tools / Parts Required

- Separate PC with Windows 10 installed (virus checked). Do NOT use the SAC or other system PC.
- Internet access and a local network adapter to connect to the system

## Procedure:

Depending on who is providing the support and what device needs to be accessed, there are different ways to connect to the SCU.

The SCU has the following:

- Eth1 and Eth2 connected to VLAN 1
- Eth3 and Eth4 connected to VLAN 2

For more information, see the Task - System Configuration.

1. Set the IP-Address of the separate PC depending on the connection to either VLAN 1 or VLAN 2:

- VLAN 1: 192.168.0.252
- VLAN 2: 192.168.100.252

2. Technical support can now reach the device requiring support by:

- direct from the separate PC
- or if needed, start a remote desktop and connect to SAC, RAC or PAC with User: Administrator and a blank password. For more information, see the Task - Windows Remote Connection.

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If technical support are installing programs during the support session on the SAC, RAC and PAC, remember to remove them if not needed, as we want small changes as possible in the system. The RAC and PAC is write protected, so if the supporter does make changes, they will be removed after recycling the power.

If the system isn't working after support, reinstall the SAC, RAC and PAC with previously created images (see Task - Create Image and the Task - Restore Image).

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# CHAPTER 9

# DATA SHEETS

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# 9. Data Sheets

The following are manufacturer's data sheets that have been provided for the Sabertooth System.

- Valeport MiniSVS Sound Velocity Sensor
- Sonardyne SPRINT-Nav 500
- Bowtech LED-K-series Lamps
- DeepSea Super Wide-i SeaCam
- Sonardyne AvTrak 6 LMF Acoustic Navigation unit
- Bowtech ST6K-SPHS Emergency Beacon
- Poseidon GNSS Antenna
- Keller Series 33X Pressure Transmitter
- Imagenex 881L Sonar

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# CHAPTER A

# APPENDIX

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# A. Guidelines

The following information is to provide the operator with a number of guidelines for various aspects of the system.

## A.1. Guidelines – Mechanical

- To maintain the long life of the equipment, it is crucial to flush the system with fresh water after every dive. However, this will not remove sea water in all the cavities and joints.
- Always lubricate all screws to panels, buoyancy blocks, stabilizing wing and other joins that are disassembled often. Make sure to do this on a regular basis or at a minimum once every month. Never mount a screw that has a bad thread, always replace.
- If inserts are worn out or have come loose, fit a new insert. Check screw and use lubricate before assemble.
- A good practice is to always secure a screw by hand for the first turn before using an electrical tooling. Have the smallest torque set on electrical tooling and tighten the last turn by hand. Remember, a lot of inserts are in brass and are of self tapping type into plastic. If too high torque is used and the screw is threaded wrongly, the inserts can turn in the plastic and, in the worst case, damage the joint.
- Make sure that, after opening a SS bracket securing an inner structure to the plastic frame. the “Nordlock” washer is correctly assembled.
- Lubricate threads on metal UW connector brass sleeves once every 6 months. Make sure that O-rings are okay. Do not use other lubrication on O-rings than the stated Molykote.
- Be aware of sharp edges on brass metal sleeve on metal connectors during assembly and disassembly.
- Avoid dropping cable metal shell connectors (e.g. extension cable for charging and start key) on a hard surface. This can damage the stainless ring making the connector difficult to connect and risking an improper seal.
- Don’t open Nylock nuts if not required. The Nylock nuts should be replaced with new ones to maintain the thread locking functionality.
- A If corrosion is detected on the lids or other aluminium parts (except for the XY thruster arms or LED lamp foot as they are initially not surface treated), do the following:
    - Clean with de-ionized water and ethanol / isopropanol. Leave to dry.

    - If have access to Alodine or other chromate product - Use a small file to access the metal surface. Treat the metal with Alodine and leave it to dry. Use Epoxy paint over the area and at least a minimum of 10mm out from the damage.
    - If Alodine is not available, use Epoxy paint directly on the damaged area with a minimum of 10 mm coverage.
- Follow the guidelines for specific torque settings for fasteners stated in this document.
- Check the blade of the propeller. If damaged, the blade can create a noise and also loses performance.
- Check for loose items. If certain items are consistently coming loose, investigate the vibration on deck, vibration on the vehicle, or check for faulty thruster. Replace old Nylock nuts. Clean and use new Loctite. Tighten hose clamps as the tension can release after long term use.
- For new hose clamps, always cover with shrink hose to reduce risk of galvanic corrosion between the hose clamp and the attached part. Use self-vulcanized tape to improve friction.
- If flat head screws are used, be careful not to accidentally scratch the surface or surroundings as flat heads don't centre tool.
- All scratches on aluminium parts will lead to corrosion and should be sealed immediately as explained above.
- Suspected abnormal corrosion must be addressed directly. Use a multimeter to check resistance and identify if a large cathodic surface (SS, Ti) is in contact with aluminium. Try to remove the electrical contact between the parts. If not possible, try to reduce area exposed with epoxy paint on both or one surface.
- The Sabertooth vehicle consists of lots of exposed plastic parts. Plastic will suffer from UV light. To increase the lifetime of the plastic parts, use a tarpaulin to protect vehicle in sunny areas.
- In sunny warm areas, avoid keeping the vehicle on the deck for longer periods of time. If possible, use a tarpaulin or provide shade using a tent or roof.
- In cold areas, use a heated tent or tarpaulin to cover vehicle in order to maintain the vehicle residual heat, but avoid excessive heat while charging before next dive. Keep batteries around 15-30°C to improve battery capacity.
- A Remember that thermal expansion with dissimilar material joints can cause some challenges. The following lists the areas where thermal expansion can be an issue starting with the most affected materials:
    - Thermoplastics; plastic frame, panels
    - Aluminium; lids and thrusters

- Titanium; Sprint.
- Stainless; lifting frame, brackets.
- Carbon fibre; Tubes.

## A.2. Guidelines – Integration of Equipment on the Sabertooth System

The Sabertooth system is a flexible platform with spare and configurable interfaces that can be integrated to various sensors, software and tooling.

Here are some guidelines for the integration of new equipment or software on to the Sabertooth system.

**Vehicle**

- Be aware of dissimilar metals. The vehicle's aluminium lids can be affected if metals such as Titanium, Stainless Steel and Brass are in electrical contact with the lid. Always check, with a multimeter, that there is no electrical contact between the equipment.
- Make sure that the equipment chassis is not in contact with the communication signal ground. This can create ground loops that severely affect the overall performance.
- Do not use shielded Ethernet cables in the vehicle since this can create unwanted ground loops.
- The PAC computer is for customer specific application. The RAC should never be tempered with.
- The user can attach equipment to the plastic frame or to the dedicated attachment point on the SS structure (see interface drawing of max load and hole pattern). Use aqualube on screws to minimize the risk of damaging the thread, as the SS joints are sensitive to jamming. Do NOT drill or remove material on the SS structure.
- Do NOT exceed 2000 kg total weight and always make sure that the vehicle is balanced both in air and in water with the configuration attached.

**Top Side**

- The SCU and SAC are designed for the Sabertooth system only. The SAC computer should not be treated as a normal PC. Do NOT install any applications and software on the SAC. The SAC does not have anti-virus or a firewall and should not be connected to the internet.
- A When connecting USB memory to the SCU, make sure it is trusted and contains no malware.
- Only unshielded Ethernet cables should be used when connecting to the SCU to avoid unwanted ground loops.

- Do not connect Ethernet equipment using multi-cast as this can jam the Ethernet network.
- The Sabertooth system uses VLAN to protect sensitive equipment within the system. Do NOT tamper with it.
- Saab has intentionally made this an open system to make it easy to work with. However, this also requires that if new features or equipment is added to the system, a proper integration testing is needed to make sure that system performance is not jeopardized.

### A.3. Guidelines – Ground and Shield Sensitive Equipment

Internally on the Sabertooth vehicle there are a number of COTS units used and a number of electrical components that need to be isolated from chassis ground. Normally these are isolated using none conductive thermo plastic bracket, but for some, plastic screws and washer. The following is a of sensitive equipment:

- RAC, PAC and its comports if metal chassis are used
- Serial server
- Video server
- Radio modem
- GPS modem
- WiFi modem
- PC SIM module R2Sonic

If replacing parts with new spares, make sure that it is correct assembled and uses the correct fasteners. If new equipment is introduced, make sure that the above list of equipment are still isolated from vehicle ground using a multi meter.

Don’t use shielded RJ45 Ethernet cables within the system. Shielded Ethernet connectors can create unwanted ground loops. If there are noise problems, start by connecting the shield connected in one end. Please contact SAAB for support for further assistance.

### A.4. Guidelines – Acoustics, Considerations and Set Up

The following information covers information when acoustic devices are used on the Sabertooth system. The systems used are the Dunker6 and AvTrak6.

A It is best to start the RAC and SAC with AvTrak6 and Dunker6 already connected and started . Check in the GUI under the Acoustic tab that they have the correct address to each other.

To change the address of a unit, use the 6G Terminal Lite program installed on the SAC and RAC.

1. On the SCU, connect to COM5 to access Dunker6.
2. On the RAC connect to COM3 to access AvTrak6.
   SAABs default addresses are:
   - Dunker6 address 2706.
   - AvTrak6 address 2711.

Please check Sonardyne manual for more input regarding addresses and corresponding frequencies.

Avoid addresses that correspond to frequencies that are close to 16.7 kHz and the harmonics to this. This is the thrusters switch frequency and it can create noise that degrades the system performance.

The Saab software will automatically find the address being used when the system starts, so there is no need to change software if using another address than above. It is good practice though to start and check that the address is correct in the GUI before launch of system.

With mobilization, it is a good practice to test Dunker and Avtrak communication in air by placing the Dunker close to Avtrak, almost in physical contact. Please visit Sonardyne manual for further guidance.

When the acoustic system is checked in air. Prepare an autonomous acoustic trial mission, or better, use a 100 m fibre patch cable. If possible, do first test at around 150 m water depth to get DVL bottom lock during the tests. If deep water conditions, remember that the INS will start to drift quite fast without USBL, GPS or DVL bottom track. Plan the test accordingly. For deep water conditions, the USBL is crucial to get position accuracy during descent and safe operation.

Some additional information to consider:

- Deep water - with no USBL, no DVL bottom track, the INS position will quickly start to drift substantially. This position drift can cause big problem if the mission/test are planned in respect to this.
- The Avtrak and Dunker systems need to have free line of sight to work to the optimum. Plan accordingly in terms of the vehicle position in relation to Dunker. If directional Dunker or Avtrak are used they are more vulnerable good alignment.
- To avoid noise always to trials below 10msw. It is best at 30msw or deeper. The ship noise and other noises will decrease with depth.
- Shallow water less than 300m is more challenging especially if its flat seawater.
- Use correct range settings for planned test set up.
- If omni Dunker or Avtrak versions are used, these are a little more vulnerable to ambient noise.

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- If problem with noise, use all cable on the Dunker winch to move away from the source and place vehicle underneath the Dunker by 20m. Make sure that it works in air again to rule out HW or SW problem. Do a noise plot in air using 6G terminal Lite SW. To use 6G SW, stop the Saab window “acoustic unit” as Saab sw has comport. Once finished close 6G Sw and stop Saab “acoustic unit” again. Start the acoustic unit again and check it has the comport. Do this on both the Dunker (from SAC) and Avtrak (from RAC).

- Do a noise plot in water and compare results: Are there any frequencies or amplitudes that differ from in air noise plots? Possible to remove noise? Set other addresses on Dunker and Avtrak to avoid noisy area?

If there are still problems, check the Sonardyne manual to fault find and contact their support.

- When on a mission, always follow the above information if the communication becomes poor.

- Is there another noise picture/source when maybe when ship is moving other speeds? Is there a free line of sight between Dunker-Avtrak?

### A.5. General Guidelines – Operational

When running a mission, it can be good idea to turn off the USBL update after getting a good position update with DVL bottom track if:

- For example during patch test or if sensors like LIDAR are used. The USBL is critical during the descent and to update navigation during long surveys but can make the position “jumpy” in short perspective.

- If running a mission on a known seabed and flying on high altitudes, the obstacle avoidance can be switched off in the mission planner. This is to avoid fish schools or other animals that will harm sensor data.

- It is good practice to check obstacle avoidance is working on deck before a dive. If the auto mission is initiated and the obstacle avoidance (OA) sonar doesn’t switch on / give any sensor data (the mission control will power on OA sonar automatically):

    - If no OA data, the vehicle will go to the emergency mission that the operator selected.

    - Check the sonar on deck with thruster mode disabled, power on OA and look in HMI sonar tab.

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- The obstacle avoidance sonar is a profiler with an opening angle of approx. 2° vertically and 20° horizontally. In order to not detect the seabed as a target, the standard range 30m will decrease with altitude. When very close to seabed, the detection range will be very limited and more sensitive to pitch and roll as this will fool the sonar to get seabed as obstacle.

- Plan with the margin that anything below a cell voltage 3.4V can be seen as empty. Beyond this, the battery voltage will drop fast with high power demand and can lead to vehicle power shut down.
- With an empty battery, the normal behaviour during operation, is for the vehicle to power down. When it does, all demands like thruster etc shut down and the battery voltage recovers and vehicle starts up again. If the vehicle starts up, disable thrusters and anything that the vehicle can live without to save power. If the vehicle is heavy, go directly into Deck Mode (DM) at 25% and use only upward thrust. You will have very little time in this position, use a grappling hook or other means to secure the vehicle to the surface asset.

**Autonomous Mission and Planning**

Always start with a dive route regardless of depth or altitude. It is the most efficient and fastest way even if you are on correct depth / altitude.

After the dive route, you plan your mission and then end the mission with a surface route so a mission could look like this:

Dive -> Global -> Grid -> Grid -> Global -> Surface

Surface is always trying to reach the surface (depth 0m) and can't be used for anything else.

To make it easier to analyse, extra surface routes can be added. If a route timeouts, the change route will be the extra surface route. Once the vehicle is at surface before taking manual control, read what route is executed. If "extra surface" one knows directly, that it has failed to complete mission.

Remember when adding routes in the mission planning tool, they are by default attached to each other so the last surface route added is not required if the mission goes well and will need to be removed from the route sequence under Events in the Mission Planner.

Example of mission:

| | |
|---|---|
| Dive | Timeout and failure to SurfaceStartFails |
| Global | Timeout to SurfaceStartFails |
| Grid | Timeout to SurfaceStartFails |
| Grid | Timeout to SurfaceEndFails |
| Global | Timeout to SurfaceEndFails |
| Surface | |
| SurfaceStartFails | |
| SurfaceEndFails | |

A Remember that when routes are removed from a mission, the link between the routes is cut off. To restore a link between routes, go to the Events tab.

Important! The grid route and the resume command will make the vehicle resume at the grid start point.

The dive will be executed where vehicle is, when the autonomous mission starts. If no heading is set, it will dive in the heading that it is oriented. The normal procedure is to manually control the vehicle to a safe distance and a heading that give free line of sight between ship USBL and vehicle transponder with vehicle vertical. If the vehicle USBL transponder is on top of the vehicle, it shall point towards the ship before dive. If fixed heading set in the dive route, the ship needs to be positioned to get USBL free line of sight with vehicle in vertical orientation.

After dive completed, the vehicle will go to a waypoint.

Good practice is to have a first waypoint with zero speed. Then set a time out and good position conditions for abort or continue mission. This is to make sure that USBL position updates work and navigation solution is good before mission is executed.

Surface will be executed where the vehicle is, when initiated. The vehicle will actively try to maintain at the surface and its position. So if the mission fails, the vehicle will surface and stay at this position, as long as the vehicle is in autonomous mode. During recovery, if failed to put the vehicle into manual, be aware of rotating thrusters etc.

For the recovery, move the ship into a good position for wireless communication. The pilot should check the battery, thruster demands and if suspects that the vehicle is heavy, use the correct manual emergency mission. Only go to manual, once the ship, crew and pilot are ready. If the battery is good, the pilot always order vehicle up (vehicle heavy and to get antennas as high up as possible) and if required change to a manual emergency mission. If wireless communication is broken, the vehicle will enter your defined manual emergency mission directly.

**Emergency Mission with Tether**

When running with tether in manual mode, remember to set what emergency mission you want the system to use if the communication is lost.

Being in Deck mode (DM) and in Manual mode, does not trigger the emergency mission.

If DM behavior is required, execute a Sleep mission with appropriate timer instead.

When starting the system, there will always be three predefined missions to select, where a "Predefined: Surface" is the default, and means that if the communication between the SAC and the RAC is missing, the vehicle will start ascending to the surface. So, if the software on the SAC is turned off or fibre communication is lost, this will happen.

The predefined missions are:

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- Predefined: Surface – Goes to surface and hovers there for 1 hour then sleeps
- Predefined: Hover – Stays hovering on the position for 1 hour then sleeps
- Predefined: Sleep – Sleeps, dead, starts floating around without thrusters

Run a downloaded mission:

It is also possible to download autonomous missions and then use any of these to start running when the communication is lost.

Important: The above will not happen if the vehicle is in Deck Mode. So, if you use DM to save energy, for example to ascend and just pay in with winch. Create a sleep mission with appropriate timer. Then, if loss of communication, the vehicle will enter emergency mission. If it is a sleep mission and the winch is paying in the vehicle, there is no attitude control. The vehicle stability is dictated by tether length, depth, slant range, speed and hydrodynamic effects. The operator needs to pay attention especially if the vehicle is increasing depth, so it does not hit the sea floor.

### A.6. Time Synchronization and PPS

The INS set its time from the ZDA originated from GPS receiver. Sprint, ZDA from RAC on UDP and PHINS, serial from GPS.

When the RAC software starts, it will synchronize the PC time with ZDA from the GPS receiver on UDP.

SAC surface software needs to be started after RAC to time sync. SAC will take the time from the RAC and set the PC time.

Power on PAC after RAC, SAC, or restart PAC using “ALT+F4” to get the time synchronized.

To make sure the time is correct on the RAC and the SAC:

1. Remote into the RAC and turn off or close the NodeManager for the Vehicle.

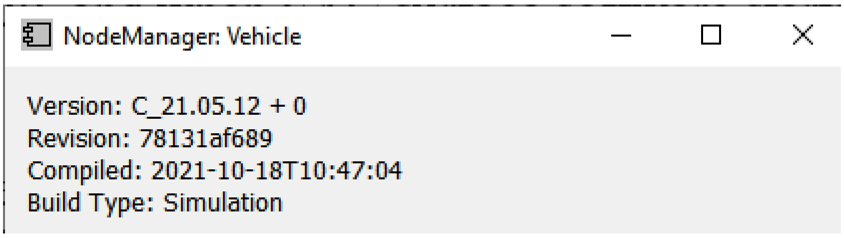


**Figure A.1: NodeManager: Vehicle**

2. Start the RAC software again by double clicking on the “Carus” shortcut on the desktop. The NodeManager should start again with the VehicleSystemTimeUnit component running.

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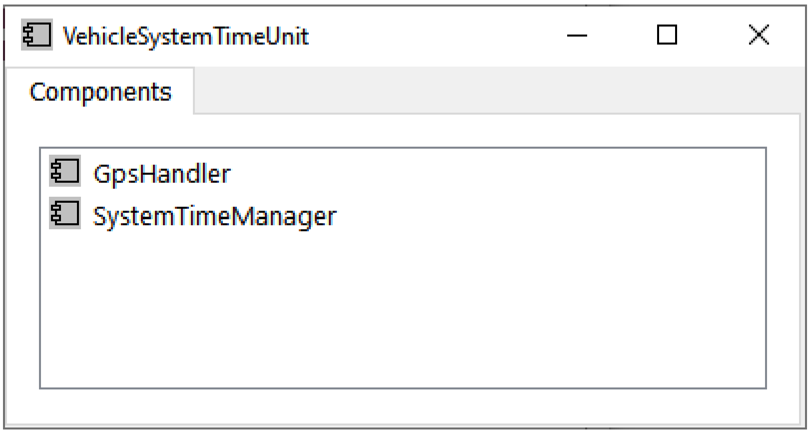


**Figure A.2: NodeManager: VehicleSystemTimeUnit**

The “VehicleSystemTimeUnit” screen should disappear within one minute. This means that we have received ZDA from the GPS on UDP and that the RAC has set a new time on the PC.

3. On the SAC, close the NodeManager for surface and close the HMI, restart the software on the SAC by using the shortcut for Surface and HMI on the desktop.
   The time should now be synchronized.

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