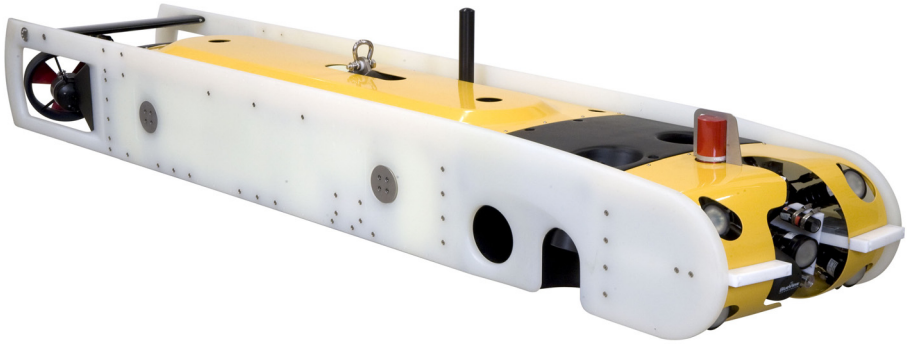
Seaeye Sabertooth

Technical Manual



ISSUE 3

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System Compatibility Issues

SAAB SEAEYE Systems utilise major assemblies that may appear, on casual external examination, to be generic items common to all systems in the modern SAAB SEAEYE fleet.

However, the use of increasingly complex technology and the frequent implementation of customer-requested system-specific modifications above baseline specifications may result in a Health and Safety Risk to personnel and damage to equipment and material should such modified equipment be substituted between systems.

CONSEQUENTLY, SEAEYE TECHNICAL DIRECTORATE ADVISE THAT SERIAL NUMBERED MAJOR ASSEMBLIES SUPPLIED WITH A VEHICLE SYSTEM SHOULD AT ALL TIMES REMAIN WITH THAT SYSTEM.

SAAB SEAEYE ARE UNABLE TO ACCEPT RESPONSIBILITY OR LIABILITY FOR EQUIPMENT IF THIS IS NOT OBSERVED.

Should major assemblies (e.g. SI-SCU, SI-PSUs, Junction Boxes, tethers, Software etc) from one system be utilised (as spares provisions or as repair-by-replacement items in the field) on another system, Health and Safety risks to personnel and risks of damage to equipment and material exist.

Operators possessing SAAB SEAEYE ROV Systems who wish to interchange major assemblies between one system and another do so at their own risk. Where any doubt exists as to the compatibility of major assemblies between one system build and another, SAAB SEAEYE may be contacted for advice prior to attempting such operational interchange.

4 OPERATIONAL USE

5 SYSTEM FUNCTIONAL DESCRIPTION

6 CORRECTIVE MAINTENANCE

FIGURES

PREFACE

The purpose of this Technical Manual is to provide the Remotely Operated Vehicle (ROV) maintainer/operator with concise information and instructions on the operating, technical and maintenance aspects of the ROV 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 ROV system that the handbooks are 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 Seaeye Ltd.

The Technical Manual consists of the following:

System Overview - Provides a general description of the main units as an introduction to the system, the ROV system technical specification and any related information.

Operating Information - Provides a description of unit controls and indicators for easy reference. Instructions on how to assemble, install, configure and operate the system.

Functional Description - Provides functional descriptions and block diagrams of the power distribution, video and control systems.

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

Parts Lists - Provides the ROV system parts lists.

Technical drawings and schematics - Provides a description of the system through mechanical drawings and schematics.

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ISSUE STATUS AND AMMENDMENTS

ISSUE STATUS	PAGES AFFECTED	DATE OF CHANGE	REASON FOR CHANGE

Table. 1 Manuual Issue Status

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WARRANTY

Subject to the conditions set out below, the Seller warrants to the Buyer that:

- all Seaeye ROV systems and spare parts will be free from defects in material and workmanship for a period of one (1) calendar year from the date of collection or despatch from the Seller's premises;
- all SM-series thruster units will be free from defects in material and workmanship for a period of two (2) calendar years from the date of collection or despatch from the Seller's premises;
- repair work carried out on Goods (after warranty on the Goods has ended) will be free from defects in material and workmanship for a period of three (3) calendar months from the date of collection or despatch from the Seller's premises.

The above Warranty is given by the Seller subject to the following conditions:

- The Buyer may not assign the benefit of this Warranty;
- The Seller shall be under no liability under this Warranty if the total price for the Goods or, in the case of repairs, Services is not paid by the due date for payment;
- Where any valid claim in respect of any of the Goods or repairs which is based on any defect in material or workmanship is notified to the Seller in accordance with these Conditions and upon return of the defective goods by the Buyer to the Seller's designated site, the Seller shall be entitled, at the Seller's sole discretion, to fulfil its obligations under this Warranty, in respect of any defect in material or workmanship of the Goods or repairs by:-
    - in the case of Goods, replacing the Goods (or the part in question) free of charge or repairing the Goods free of charge;
    - in the case of repairs, re-performing the Services (or the relevant part of the Services) free of charge;
    - but the Seller shall have no further liability to the Buyer;
- The Warranty in respect of any parts replaced or repaired thereunder shall extend only for the Warranty period referred to in this clause 11;
- Should a repair be required at a location other than the Seller's designated site, all additional costs including, but not limited to, travel and subsistence costs, additional freight costs shall be the liability of the Buyer;
- In all cases, including negligence, any costs of salvage and recovery of the Goods shall be the liability of the Buyer;
- The Seller shall be under no liability in respect of any defect in the Goods arising from any drawing, design or specification supplied by the Buyer;
- This Warranty shall not extend to parts, materials or spare parts which the Seller considers as expendables under normal operating conditions;
- The Seller shall be under no liability in respect of any defect which the Seller's investigation and inspection reveals has arisen from fair wear and tear, wilful damage, negligence, abnormal working conditions, failure to follow the Seller's instructions (whether oral or written and including the Buyers failure to train its staff, employees and agents in operation of the Goods

-), failure to have the Goods suitably stored, packed, serviced and maintained in accordance with the Seller's instructions (whether oral or written), misuse or alteration or repair of the Goods without the Seller's written approval;
- The Seller shall be under no liability in respect of any loss suffered by the Buyer arising because of the operator of the Goods failing to take prompt and adequate action in the event of a failure of or fault in the Goods;
- The Seller shall be under no liability under this Warranty in respect of any loss suffered by the Buyer due to incompetent installation of the Goods by or on behalf of the Buyer;
- The above warranty does not extend to parts, materials or equipment not manufactured by the Seller, in respect of, which the Buyer shall only be entitled to the benefit of any such enforceable warranty, or guarantee as is given by the manufacturer to the Seller (if any).

In the event of the Buyer becoming aware of a defect in the Goods and/or a defect or deficiency in the repair Services during the Warranty period, the Buyer shall, within a reasonable period of time after discovery of such defect or deficiency:-

- provide the Seller with written particulars of such defect or deficiency;
- return the Goods purchased or repaired to the Seller, at the Buyer’s expense;
- use its best endeavours to provide to the Seller all information and particulars required and all access and other reasonable facilities necessary to enable the Seller to ascertain and verify the nature and cause of the defect claimed and carry out its Warranty obligations under this clause 11.

All liability under this Warranty ceases at the expiration of the Warranty period specified above.

All Goods sold and manufactured by other manufacturers are sold subject to the manufacturer’s guarantee, which shall be assigned to the Buyer. The Seller, is so far as it is appointed by the agents of a manufacturer to carry out repair work under such guarantees will, where it considers it appropriate, carry out the such repair work on terms agreed by the Seller and the Buyer or authorised representative having regard to the liability of the manufacturer under its guarantee. Notwithstanding anything in this clause, any Goods sold but not manufactured by the Seller are not supplied with any warranty whether express or implied, and each warranty imposed by common law or statute including the warranty of merchantable quality and the implied warranty of fitness for a particular purpose contained in Section 14 of the Sale of Goods Act 1979 is expressly excluded, although the Seller will take every reasonable care in supplying suitable Goods and giving particulars of performance.

Representations and warranties made by any person, including dealers and representatives of the Seller, that are inconsistent or in conflict with the terms of this Warranty (including but not limited to the limitations of liability of the Seller as set forth previously), shall not be binding upon the Seller unless reduced to writing and signed by an officer of the Seller.

General Information

Specifications: SEAEYE reserves the right to change specifications at any time without due notice and without incurring any obligation to incorporate any new features in any of it's previous products, whether or not they have been sold.

Damage in Shipment: Each new product is carefully examined and checked prior to dispatch from SEAEYE's premises. It should be carefully examined and operationally tested on receipt by the receiving party. If the product is damaged in any way, then a claim should be lodged with the carrier. New or repaired product that has been damaged in transit should not be returned to SEAEYE without first obtaining specific shipping instructions from SEAEYE.

Repairs: If any fault develops, the following steps should be taken:

- Notify SEAEYE and give full details of the difficulty. Include in this notification the model type and its serial number. On receipt of this information SEAEYE may elect to either issue service instructions or provide full shipping data for the return of the equipment.
- After shipping instructions are supplied, forward the product(s) prepaid and repairs will be estimated and the client informed prior to any repairs to the fault(s) being carried out.
- The client may then issue SEAEYE an approved purchase order to cover the costs of the repair, if the fault has been caused by misuse or is not under guarantee.

Notes to Readers

Warnings, Cautions and Notes

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

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:

WARNING – Risk of Personal Injury

WARNING – Take precautions against Static Electricity

WARNING – Risk of Electric Shock

WARNING – Heavy Object

WARNING – Moving Parts

WARNING – Chemical Hazard

CAUTION – Wear Protective Equipment

List of abbreviations

A	Ampere
AC	Alternating Current
ADC	Analogue to Digital Converter
ATC	Automatic Tension Control
AUV	Autonomous Underwater Vehicle
BMS	Battery Management System
CAN	Controller Area Network
CCD	Charge-coupled Device
CFE	Customer Furnished Equipment
CP	Cathode Potential
CPU	Central Processing Unit
CWDM	Coarse Wavelength Division Multiplexing
DAC	Digital to Analogue Converter
DC	Direct Current
Deg.	Degree(s)
DGPS	Differential GPS; relative GPS
DVL	Doppler Velocity Log
EPOD	Electronics Pod
FET	Field Effect Transistor
Fig.	Figure
FOR	Fibre-Optic Receiver
GPS	Global Positioning System
GRP	Glass-reinforced Plastic
HCU	Hand Control Unit
Hz	Hertz
IGFET	Insulated Gate Field Effect Transistor
INS	Inertial Navigation System
I/O	Input/Output
JB	Junction Box

Kbd	Kilo baud
LCD	Liquid Crystal Display
LIM	Line Insulation Monitor
MCB	Mains Circuit Breaker
MFIO	Multi-function Input/Output
MMI	Man Machine Interface
MSW	Metres SeaWater
NAV	Navigation Unit
OCB	Operator Control Board
PAN/TILT	Pan and Tilt Unit
PCB	Printed Circuit Board
PDU	Power Distribution Unit
POE	Power Over Ethernet
PPS	Precise Positioning Service
PSU	Power Supply Unit
PWM	Pulse Width Modulated
RAC	ROV Application Computer
ROV	Remotely Operated Vehicle
RTK	Real Time Kinematic
SAC	Surface Application Computer
SCR	Silicon-Controlled Rectifier
SCU	Surface Control Unit
SIT	Silicon-Intensifier Target
SM7	Thrusters
SSRS	Solid-state Rate Sensor
STU	Surface Transformer Unit
SU	Surface Unit
TMS	Tether Management System
Toggle	Change to one of two states. Hardware or Software
VAC	Volts AC
VDC	Volts DC

VGA	Video Graphics Array
W	Watts
WLAN	Wireless Local Access Network

WARNINGS

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the rov system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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.

Danger to personnel and equipment. The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

Danger to personnel and equipment. LIM's (Line Insulation Monitor) do not function as personal safety protection devices. A LIM monitors the status of the system and warns of a potential fault, a 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. Since the vehicle is battery powered, this LIM will not cut power at all.

Danger to personnel and equipment. The vehicle is equipped with a powerful battery. this means that here is always a danger of fatal electric shock. Personnel opening up the vehicle shall have proper training on batteries. The chapter on battery handling shall also be thoroughly read and understood.

Cautions

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Possibility of damage to equipment. Ensure all vent plugs are securely fitted and shut prior to immersing the vehicle.

Possibility of poor vehicle handling. 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.

ENGINEERING ADVICE NOTES (EANs)

The purpose of an engineering advice note is to bring to the operator/maintainer's attention any safety, maintenance or operational related information that may present a threat to health or cause damage to equipment and are to be used in conjunction with the manual.

Any relevant EANs raised after the publication of this handbook will be issued by letter and are to be inserted into this manual.

IMPORTANT ADVICE NOTICE
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) on the ROV.
- 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.
- 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.
- 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 Sabertooth system, the ROV system technical specification and any related information.

1.1 Main Functions and Characteristics

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

Main characteristics:

- Programmable; complete mission can be built in the user interface
- Mobile; the system is designed to be easily packed and moved between locations
- Operational depth of 1200 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 WLAN and fibre-optics
- 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.

1.2 Physical Overview

The system delivery is packed and shipped with mobility in mind using convenient storage boxes.

1.3 System Contents

The system consists of the following major units:

- Surface Control Unit
- Operator's kit including Operators Control Board, monitor, keyboard, mouse, dummy plug set and vehicle keys. Also included is WLAN equipment and transport box
- Vehicle
- Battery charger
- ATC Winch with tether

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

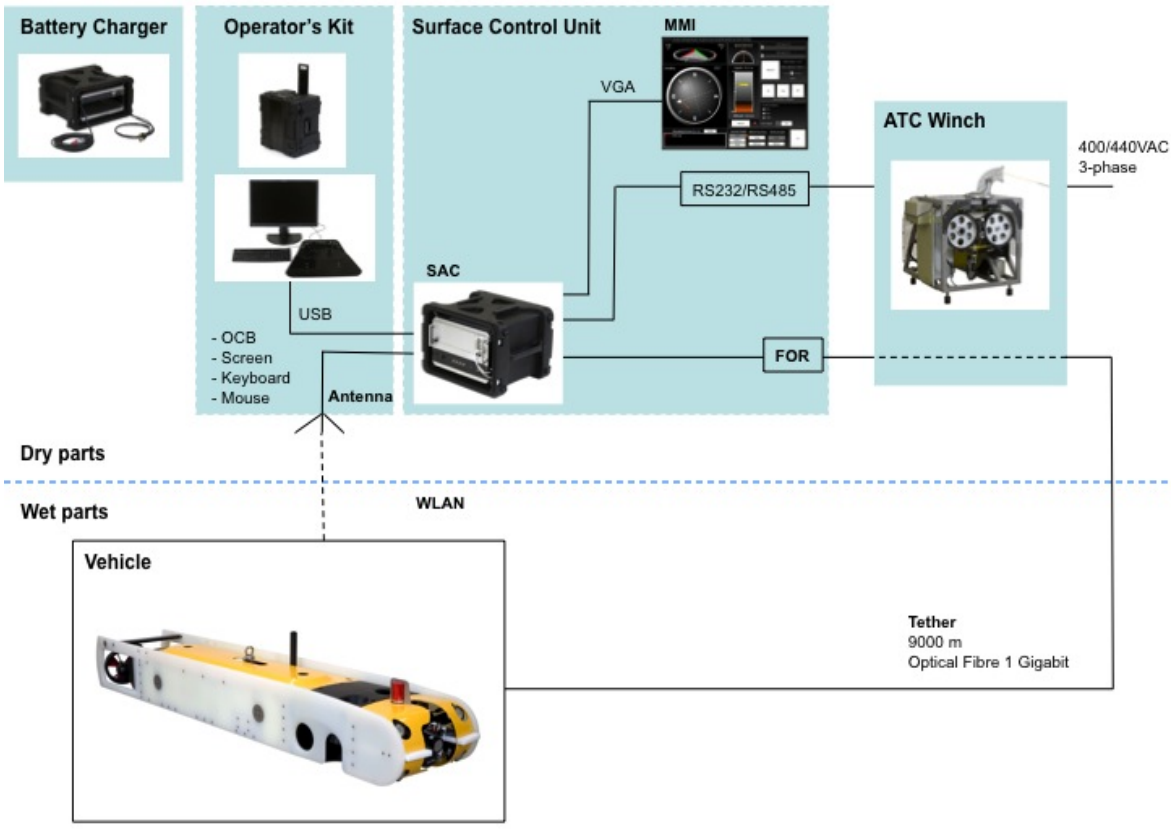

Figure. 1.1 Overview of the Sabertooth system

1.4 Surface Control Unit

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

- Surface Application Computer (SAC)
- Fibre-optic receiver (FOR)

The equipment is mounted in a 19” rack transport box with removable front and rear lids. Only the front lid needs to be removed during normal use.

The SCU has the following interfaces:

- Fibre-optic link to the vehicle via the winch and tether.
- USB interface to the Operators Control Board (OCB).
- USB interface to mouse and keyboard.
- RS485 communication link to the winch for control and data to/from the winch.
- Monitor output for display of the graphical MMI.
- WLAN antenna interface for communication with the vehicle in untethered mode.
- Composite video output for video from vehicle cameras.

1.4.1 Surface Application Computer

The SAC is a CompactPCI computer housed in a 19” aluminum rack. The boards in the rack are the processor board, an Ethernet switch board and an RS232 interface board.

The software in the SAC is doing the following:

- It presents video and data from the vehicle on the MMI.
- It sends control data from the OCB to the vehicle.
- It displays status information from the winch.
- It sends control data to the winch.
- It logs data and record video when desired.
- Missions are created in the Mission Planner and uploaded to the vehicle.
- Video and data can be played back on the MMI Player.

Third-party sonar software can also be run on the SAC.

The Surface Control Unit comprises a Surface Application Computer, SAC, mounted in a 19” rack fitted in a transport box. SAC is the computer for control of the vehicle and the winch. It is also handling the video to the operator.

Figure. 1.2 Surface Application Computer, SAC

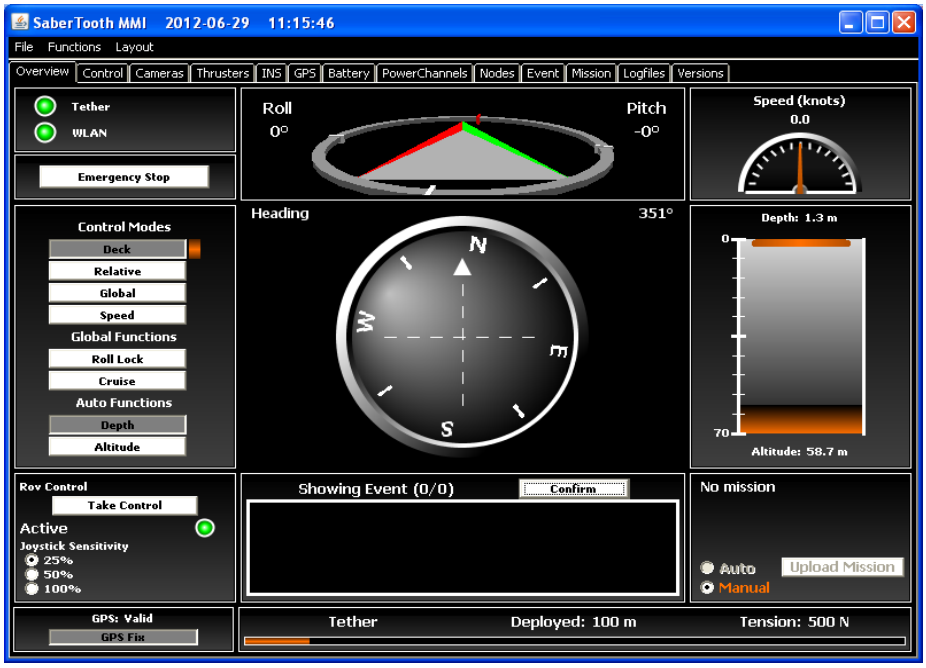

Figure. 1.3 The MMI from where the operator can monitor the status of the vehicle

1.4.2 Fibre-optic Receiver (FOR)

The Fibre-optical Receiver (FOR) converts the optical signal from the vehicle to video and Ethernet. It also converts the Ethernet data from the surface to the vehicle to optical signals.

1.5 Operator's Kit

The Operator´s Kit is delivered in a transport box containing the following:

- Operator Control Board (OCB).
- Monitor, keyboard and mouse.
- WLAN access point with antenna.
- Dummy plug set.
- Vehicle On Key and Vehicle Battle Mode Key.

1.5.1 OCB

Figure. 1.4 OCB

The Operator Control Board, OCB, included in the Operator's Kit, is the device used to control and operate Sabertooth. The OCB is a console with two joystick controls for maneuvering the vehicle during mission and during testing the system (pre-dive check and post-dive check). The unit is powered from the SAC via USB.

1.5.2 Monitor, Keyboard and Mouse

A 24 inch monitor with keyboard and mouse is included in the Operator's kit. The monitor is used to display the MMI 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 SAC.

1.5.3 WLAN 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 WLAN. It can then be programmed to perform an autonomous mission.

The WLAN is of type Ubiquity Bullet Outdoor Radio System.

Figure. 1.5 WLAN

1.5.4 Dummy Plug Set

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

1.5.5 Vehicle Keys

The vehicle is started by connecting a shorting plug, called the start key, to the on/off connector on the vehicle. There is also a battle mode key that can be connected to the battery charger connector on the vehicle. When this is connected the battery management system is not allowed to shut off the vehicle because of a battery warning.

1.6 Vehicle

Figure. 1.6 ROV

The vehicle is constructed from a ruggedized polypropylene and aluminium chassis. It is powered from an internal battery module, which is charged when the vehicle is out of water. Communication and mission planning is done via the tether or WLAN. The vehicle can operate autonomously or manually from the surface control units (MMI and OCB).

The vehicle includes the following:

- Electronics pod
- Thrusters (6)
- Tilt Units (2)
- Lamp Units (6)

- Cameras (3, of which 1 customer furnished equipment)
- Sonars (3, of which 2 customer furnished equipment)
- Depth Sensor
- Doppler velocity log
- Communication unit

1.6.1 Electronics Pod

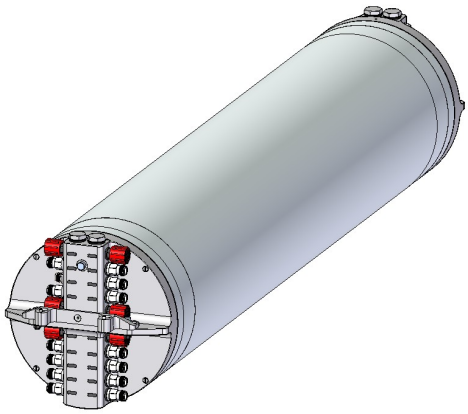

Figure. 1.7 EPOD

The vehicle has a watertight electronics pod (EPOD) designed to provide the housing for the vehicle electronics as well as providing buoyancy.

The EPOD contains:

- Battery module. 10 kWh LiPo Battery with Battery Management System (BMS)
- Navigational instrument (Phins INS)
- Video servers (2)
- DC/DC converters (3)
- Leak detectors (2)
- Earth fault supervisor
- Fibre optic transmitter
- ROV Application Computer (RAC)
- Ethernet switches (4)
- Voltage switches, 24 V and 250 V

Connections:

- Battery management and charging
- Lamps
- Doppler
- Thrusters

- Cameras
- Sonars
- Depth sensor
- Optional tools

1.6.2 Thrusters

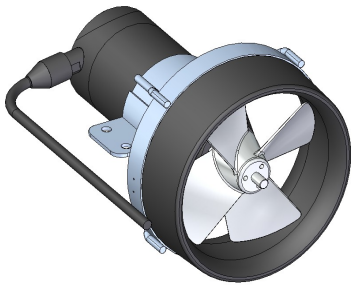

Figure. 1.8 SM4 Thruster

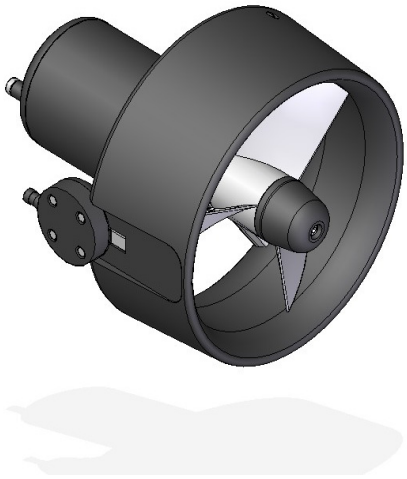

Figure. 1.9 SM9 Thruster

The Sabertooth uses six DC brushless thruster motors. Four of type SM4 and two of type SM9, for propulsion.

1.6.3 Tilt Unit

The tilt unit T35N is a high torque, oil filled, tilt platform. The unit is manufactured from anodised aluminium with the tilt positional information being displayed graphically on the MMI.

1.6.4 Lamp Units

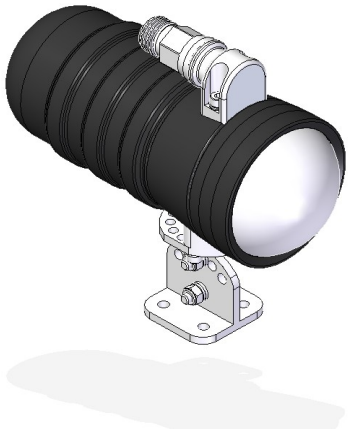

Figure. 1.10 LED lamp unit

Sabertooth has six LED lamp units of type 11A. The lamps are fitted on the vehicle frame, five at the front including one tiltable, and one fixed lamp at the back. 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.

1.6.5 Cameras

Figure. 1.11 Kongsberg camera

Three cameras are mounted on the vehicle. One of them are customer furnished equipment. The two included cameras are mounted at the front and at the back. These are of type Kongsberg OE14-110.

The Kongsberg units are robustly constructed with a tough marine grade aluminium alloy pressure housing rated to 3,000 metre operation as standard. Very compact dimensions make the cameras ideally suited for ROV manipulation and tooling applications. Auto shuttering, together with a wide AGC range give excellent light compensation a minimum cost. The lack of any moving parts and robust construction makes the camera extremely resistant to shock and vibration.

The customer furnished camera is a Tritech Osprey.

1.6.6 Sonar 1

Figure. 1.12 Sonar Imagenex 881L

Included at the front of the vehicle is an Imagenex 881L profiling sonar used for obstacle avoidance during autonomous operations is mounted. It is a mechanically scanning sonar programmed to work with the frequency 675kHz.

Using the 10Mbit Ethernet interface the RAC uses this sonar to make a picture of the vicinity. If the RAC detects an obstacle in automatic mode it will slow down and try to steer the vehicle around the obstacle and then join the track behind it.

Because of the limited scanning speed smaller obstacles may not be detected in time if the programmed speed is higher than 3 knots. To avoid interference with the other sonars, the profiling sonar is turned off in manual mode.

1.6.7 Sonar 2 (CFE)

At the back of the vehicle there is a place for an optional sonar according to customer demands. The sonar is of type Imagenex 881L.

1.6.8 Sonar 3 (CFE)

At the front of the vehicle there is a place for an optional, tiltable sonar according to customer demands. The sonar is of type Blueview.

1.6.9 Depth Sensor

The depth sensor Digiquartz 8CB2000-I provides precise water pressure measurements.

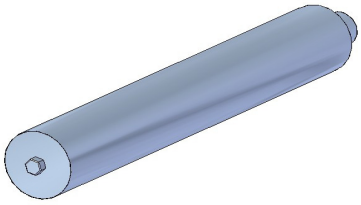

Figure. 1.13 Depth sensor

1.6.10 Doppler Velocity Log

The Doppler Velocity Log (DVL) is an RDI Workhorse Navigator WHN 1200, working with a frequency of 1,200 kHz. The DVL measures both speed over ground as well as altitude. This information is fed into the Phins INS.

Figure. 1.14 Doppler Velocity Log

1.6.11 Communication Unit

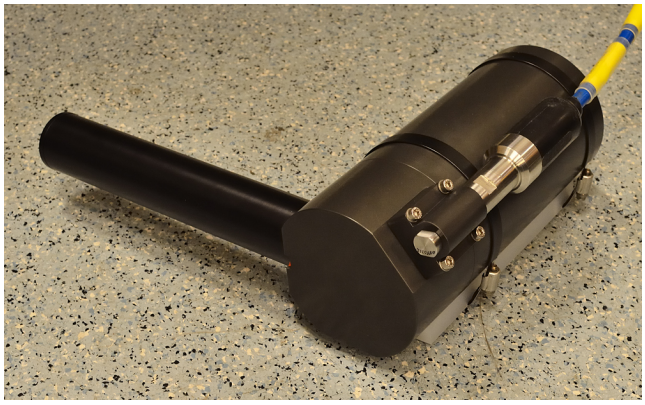

Figure. 1.15 Communication unit

The communication unit consists of:

- GPS with antenna
- WLAN client with antenna, PicoStation M2-HP 2.4 GHz Hi Power 802.11N Outdoor Radio System
- Leak sensor

The antennas are mounted inside an arm that can be mounted either in an upper or lower position.

When the vehicle is on surface the GPS receives correct coordinates and time sync pulse (PPS) and sends this to the IMU.

If the vehicle is used without tether it can be controlled via WLAN. If there is no tether communication detected the WLAN communication will start automatically if in range. Apart from video most functions are available with WLAN communication.

1.7 Battery Charger

Figure. 1.16 Battery Charger mounted in dedicated box

Sabertooth has an external battery charger of type Brusa NLG5 mounted in a 19” rack with relays and connections. It is mounted in a dedicated, mobile box.

1.8 Winch with Tether

1.8.1 Winch

The winch has Automatic Tension Control, ATC. The ATC winch is a fully computerized winch controlling the tension in the ROV tether and the transported length of the tether cable.

The ATC winch consists of a storage drum journalled in bearings at one side and mounted in a stainless steel frame. The tether cable motion control and thereby tether cable length and tension control is facilitated by a capstan device. Both the drum and the capstan wheels are separately driven by electrical AC servo motors.

The tether cable leaves the winch through a top mounted cable guide that can be turned in any direction. This feature makes it possible to use the ROV on both sides of the ship without turning the winch around.

Figure. 1.17 ATC Winch

1.8.2 Tether

Figure. 1.18 Tether stored on winch

The fibre-optic tether connects the vehicle to the dry parts of the Sabertooth system. The tether supplies the vehicle with the means to transmit data and video signals between the ROV and the surface units.

The tether is stored on the drum of the ATC winch. The lower end of the tether is connected to the ROV via a cable wheel for relief at the inlet. The upper end is connected to the optical slip ring at the ATC winch. The slip ring at the ATC winch is connected to the Fibre Optic Receiver (FOR) in the Surface Control Unit.

The tether is 9000 m of length.

1.9 Technical Specification

1.9.1 Surface Communication Unit

Depth (closed box)	699 mm
Width (closed box)	737 mm
Height (closed box)	495 mm
Weight (closed box)	34 kg
Voltage	Single phase 100 – 240 VAC
Frequency	50/60 Hz
Power Consumption	Max 250W
Operating temperature	0 to 50 degrees C
Storage temperature	-20 to 80 degrees C

1.9.2 Operator's Kit

Depth (closed box)	692 mm
Width (closed box)	737 mm
Height (closed box)	489 mm
Weight (closed box)	33 kg
Voltage	100 – 240 VAC
Frequency	50/60 Hz
Power Consumption	Max 50W

1.9.3 Battery Charger

Depth (closed box)	699 mm
Width (closed box)	737 mm
Height (closed box)	406 mm
Weight (closed box)	38 kg

Charging power	3.3 kW (reduced power below 200 VAC input)
Voltage	Single phase 100 – 264 VAC
Frequency	50/60 Hz
Power Consumption	3.7 kW
Operating temperature	-25 to 70 degrees C

1.9.4 Vehicle Equipment Specification

Length	3720 mm
Width	700 mm
Height	520 mm
Weight - In air - In water	 645 kg Slightly positive buoyant
Operational depth	1200 m
Forward speed	> 4 knots
Lateral speed	0.8 knots
Vertical speed	0.8 knots
Battery capacity	10 kWh
Power consumption - No thrust - At 3 knots	 Approximately 225 W Approximately 2 kW
Operating temperature range - Deck operations - Battery charging - Water operations	 -20 to +50 degrees C 0 to +40 degrees C 0 to +30 degrees C
Storage temperature range	-40 to +70 degrees C

1.9.5 ATC Winch Specification

Dimensions	Width	1355 mm
	Height	1395 mm
	Depth	1425 mm
Weight		400 kg
Power supply	Voltage	3-phase 380 - 440 VAC
	Frequency	50 - 60 Hz
	Power	8 kVA
	Current rating	20 A
Operating temperature range		-30 to +50 degrees C
Storage temperature range		-30 to +50 degrees C
Performance	Max. speed	2.7 m/s
	Min. tension	50 N
	Max. tension	>2000 N
	Tension error in auto mode (constant speed)	+/- 20 % or +/-50 N
	Brakes	Fail safe brakes
Environment	Ingress Protection	IP 56 (IP 67 optional)
Capacity	Drum	12,000 m @ Ø 3.8 mm
Interfaces	Link	RS 485
	Intercom	Optional
Cooling requirements		Natural convection and radiation

1.9.6 System Block Diagram

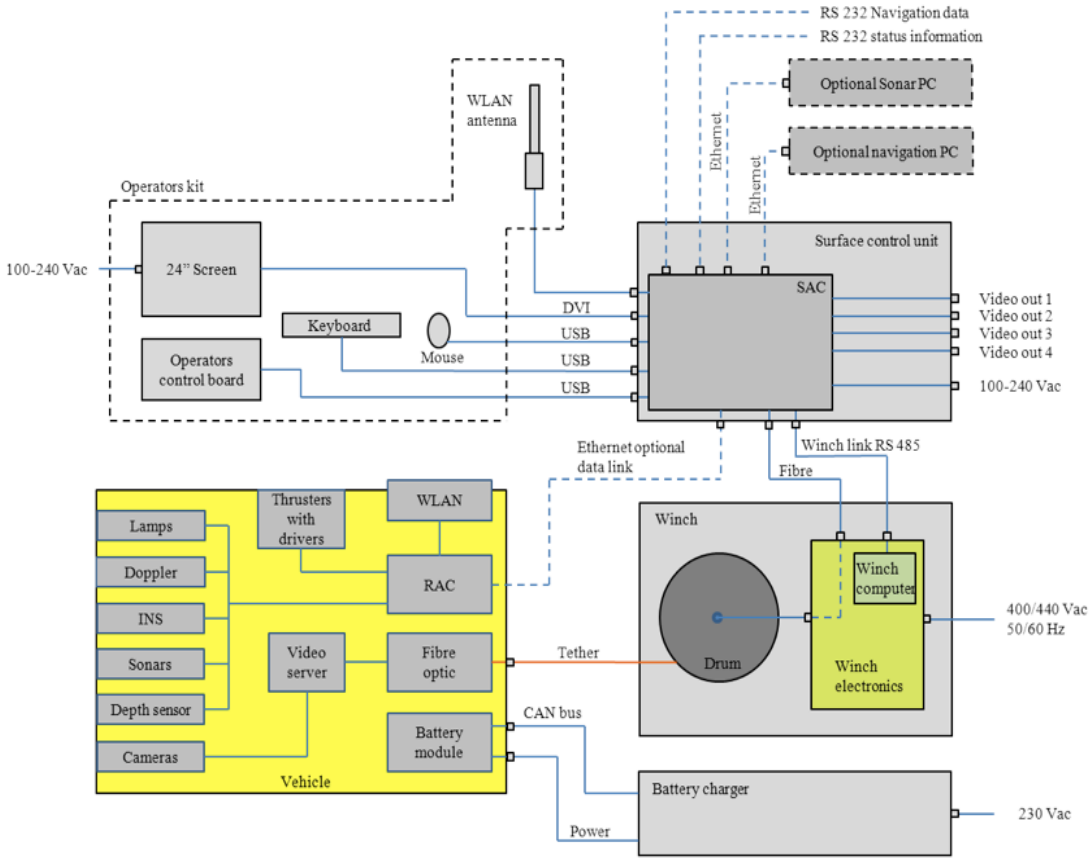

Figure. 1.19 System block diagram

CHAPTER 2

CONTROLS,

INDICATORS AND

CONNECTIONS

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2. CONTROLS, INDICATORS AND CONNECTIONS

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

2.1 Introduction

The system includes the following controls, indicators and connections:

- Operator Control Board (OCB)
- MMI Control Software
- MMI Player Software
- Battery Charger
- Winch Manoeuvring Board
- Winch Connections
- Surface Control Unit
- Vehicle

Their functions are listed in the following tables.

2.2 Operator Control Board

The Operator Control Board (OCB) is used for operating the vehicle. See Figure 2.1 together with table 2.1 for description of joysticks, switches etc.

Figure. 2.1 OCB

It is possible to use other control devices like a game pad or a joystick to control the vehicle. The device has to use a standard USB HID interface, and further software configuration is probably necessary.

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. It is important to realize that both pitch and roll behaves in a similar way. That is, pushing the thumb lever forward will 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, likewise to the depth control, automatically hold the current pitch angle. The roll function is equivalent to that of the pitch control. Never use the joysticks as “on/off switches”, use them cautiously. See Figure. 2.4 illustrating the operation of the left hand joystick in GLOBAL and RELATIVE mode.
Right joystick	This joystick proportionally controls all horizontal movements (forward/backward, sideways and yaw). See Figure. 2.5 illustrating the right hand joystick movement in RELATIVE and GLOBAL modes.
TILT – DOWN/UP	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Holding the switch forwards tilts the port tilt unit down. Holding the switch backwards tilts the port tilt unit up.
TILT – DOWN/UP	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Holding the switch forwards tilts the starboard tilt unit down. Holding the switch backwards tilts the starboard tilt unit up.
JSTICK - 100%/50%/ 25%	Switch that can be moved forwards and backwards. Spring loaded back to the centre. 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 radio buttons on the screen shows the present selection. This means that clicking twice forwards always selects 100% while clicking backwards twice always selects 25%.

Item	Description
REF ADJ	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Moving in any direction will activate Ref Adj. This means that the present joystick thrust will be added as an offset.
MODE	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Selects the control mode of the vehicle. Clicking the switch forwards or backwards will change the mode between Deck mode, Relative mode, Global mode and Speed mode according to the MMI.
CRUISE – ON/OFF	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Turns cruise mode on/ off. Clicking forwards will turn cruise mode on. Clicking backwards will turn cruise mode off. The present mode is shown on the MMI.
ROLL LOCK – ON/ OFF	Switch that can be moved forwards and backwards. Spring loaded back to the centre. Turns roll lock on/off. Clicking forwards will turn roll lock on. Clicking backwards will turn roll lock off. The present mode is shown on the MMI.
SPEED – INC/DEC	Switch that can be moved forwards and backwards. Spring loaded back to the centre. This step up/down button increase/decrease the Ref Adjust thrust in the X-direction with 5% for each click.
DEPTH – INC/DEC	Switch that can be moved forwards and backwards. Spring loaded back to the centre. This step up/down button give thrust bursts that correspond to depth decrease/increase of approximately 1dm. This control only works in global mode.
YAW	Switch that can be moved to the left and right. Spring loaded back to the centre. This step left/right button gives thrust burst that corresponds to heading decrease/increase of approximately 1°.

Table 2.1 OCB Controls

2.3 MMI Control Software

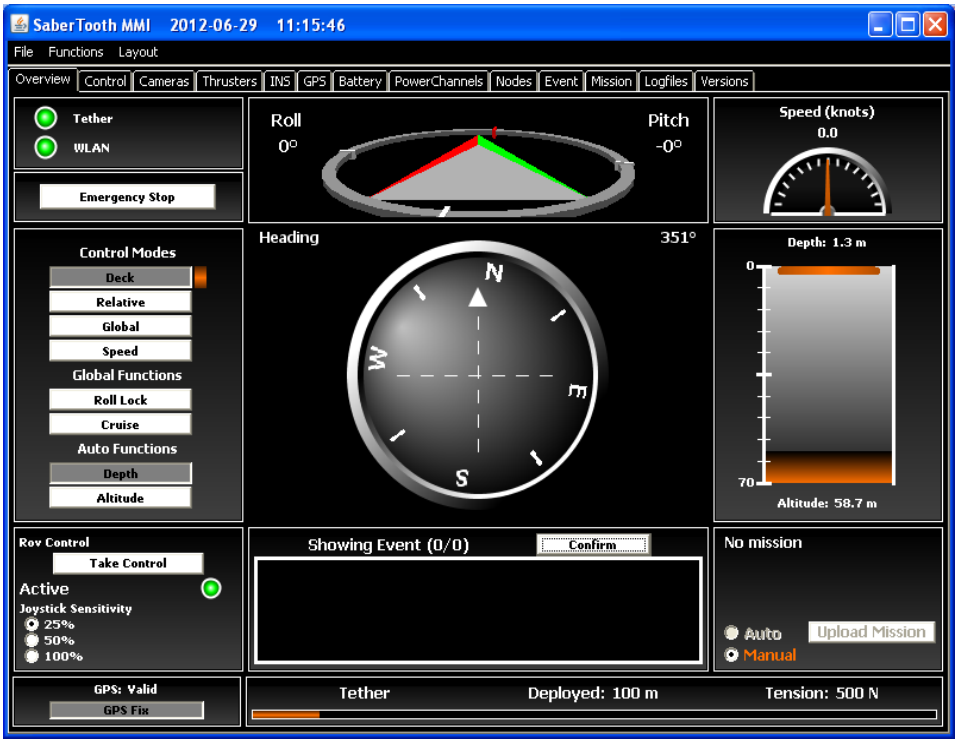


Figure. 2.2 MMI Overview tab

The main view is built up by a main window and a number of tabs:

- Overview
- Control
- Cameras
- Thrusters
- INS
- GPS
- Battery
- PowerChannels
- Nodes
- Event
- Mission
- Logfiles
- Versions

It is possible to drag a tab and drop it at the desktop to view more tabs at the same time.

In the following chapters the different tabs are described.

2.3.1 Overview

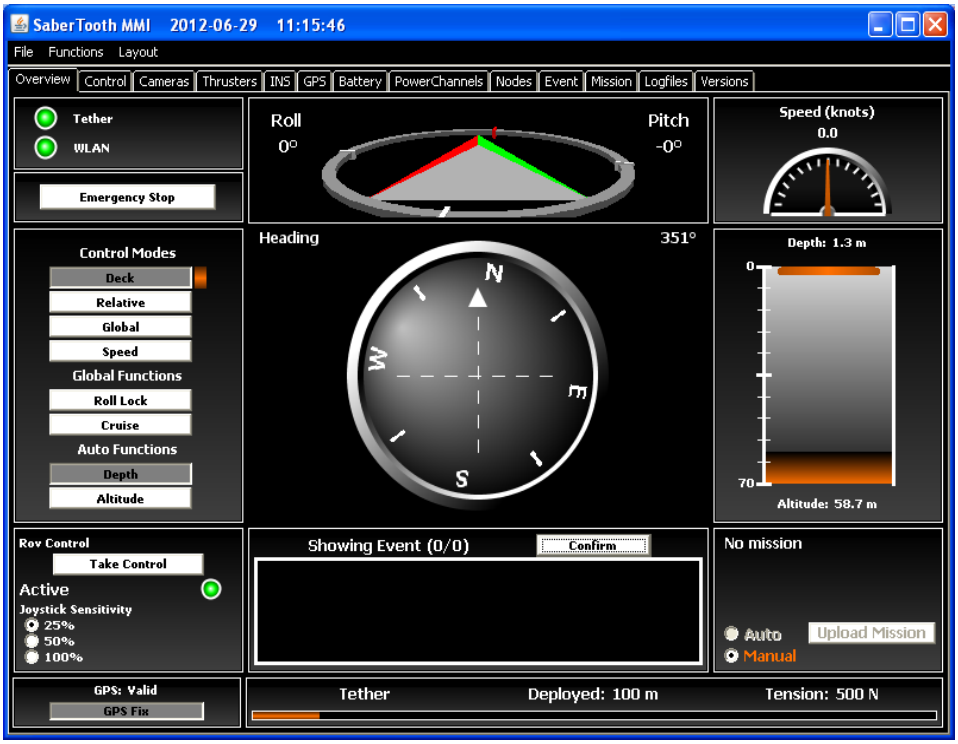


Figure. 2.3 MMI Overview tab

Item	Description
	
Tether	There is tether communication to the vehicle.
WLAN	There is a WLAN link to the vehicle.
	

Table 2.2 MMI Overview tab

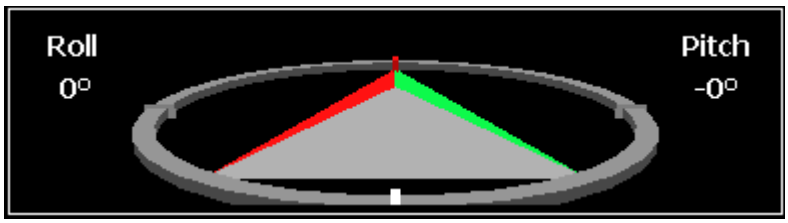
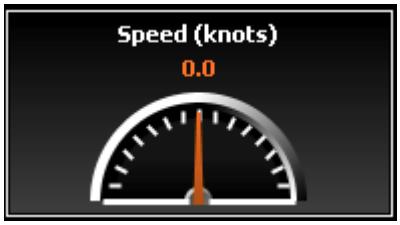
Item	Description
Emergency Stop	Press this button to switch off the power to all the thrusters. The power to the thrusters then has to be switched on with this button again. The thruster power buttons in the PowerChannels tab have no effect when power is switched off with this button.
	
Roll	Vehicle roll angle in degrees. The angle is positive when the vehicle is rolled clockwise seen from the aft. Range ±90°.
Pitch	Vehicle pitch angle. The angle is positive when the vehicle front is pointing upwards. Range ±180°.
	
Speed	Vehicle Speed Over Ground in the vehicle forward direction. This value is calculated using data from the INS with support from the Doppler log. Speed given in knots.

Table 2.2 MMI Overview tab

Item	Description
	
Deck	Deck mode selected. Deck mode is the normal mode whenever the ROV is out of the water (that is, on deck or being launched into the sea). Because the vehicle maintains stability utilizing a closed-loop control system on board the vehicle, it will always try to counteract any changes of movement of the vehicle with its propellers to reach stability. Selecting deck mode disables the attitude sensors to affect the control system on board the vehicle. It will therefore not try to compensate for any movement changes and hence, the propeller revolution will be zero (provided that the joysticks are unaffected). As soon as the vehicle is below the surface, relative mode or global mode should be selected, to enable the attitude sensors to affect the control system, and as such obtain optimal performance of the vehicle. The motors will still react to joystick movements.

Table 2.2 MMI Overview tab

Item	Description
Relative	Relative mode selected. The movement of the vehicle is relative to the vehicle itself. When moving forward, the vehicle will move in the direction of the vehicle, even if it is pointing straight up towards the sea surface. See Figure. 2.4 and Figure. 2.5. Applications taking advantage of this approach may be fast ascend/descend operations. It will thus be, similarly to flying an aeroplane, possible to ascend very quickly to a certain depth by pitching the vehicle to appropriate dive slope, and then move forward. In normal operation, global mode should be used.
Global	Global mode selected. Traditionally ROVs are controlled relative to the operator's definition of the world. The operator working for example onboard a surface ship, experiences the commands forward, backward and sideways as moving strictly in the horizontal plane, that is, as if the vehicle was moving in a plane parallel to the water surface. Similarly, the depth command interprets as a strictly vertical movement relative to the water surface. This definition of controlling the vehicle is referred to as global or absolute movements, since any functional movements of the vehicle are related to the true world. However, since the vehicle exhibits pitch and roll capability, this means that the vehicle will, independently of the current status of pitch and roll, move in relation to the true world definition. See Figure. 2.4 and Figure. 2.5 illustrating global reference movement.

Table 2.2 MMI Overview tab

Item	Description
Speed	Speed control mode. In speed mode the joystick output corresponds to desired speed over ground of the vehicle. The speed is controlled in both the forward/ backward direction and the starboard/port direction. Zero joystick output means that the vehicle will try maintain zero speed over ground even in presence of water currents. The desired roll and pitch angle are set to zero in speed mode.
Roll lock	When global mode is used, roll lock can be selected. When using a joystick the roll angle can easily be changed by mistake when for example the depth is changed. Roll lock disables the roll function and forces the vehicle to obtain zero roll angle.
Cruise	When global mode is used, cruise mode can also be selected. The pitch angle is very important when trying to go fast without drifting away from the set depth. Normally the control system shall not only try to stay at the correct depth but also try to maintain the set pitch angle. In cruise mode the operator leaves the control of the pitch angle to the control system. The control system selects suitable pitch angles to keep the correct depth when going forwards/backwards. When selecting Cruise mode the pitch angle will be set to zero and then stay at zero plus/minus a few degrees. Cruise mode is the normal mode during transit.

Table 2.2 MMI Overview tab

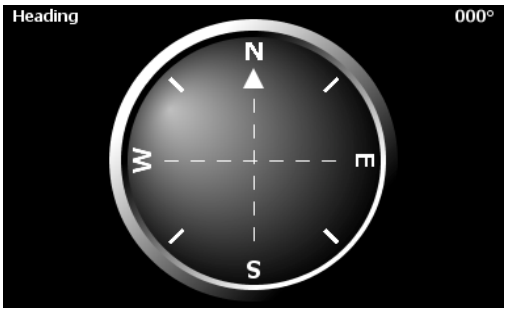
Item	Description
Depth	Vertical mode depth is selected. The selected vertical mode can either be depth or altitude. This selects whether the automatic vertical positioning is relative to the surface or the sea bed. In depth mode the vehicle maintains at a constant depth, provided that no other orders are given.
Altitude	Vertical mode altitude is selected. The selected vertical mode can either be depth or altitude. This selects whether the automatic vertical positioning is relative to the surface or the sea bed. In altitude mode the vehicle maintains at a constant altitude over the sea bed if there are no other orders given. If the Doppler log is out of range the vehicle will use depth positioning. Depth positioning will also be used when the Doppler log is turned off from the MMI.
	
Heading	The vehicle heading is shown both digitally and graphically. On the graphical compass a vector showing speed over ground is also displayed.

Table 2.2 MMI Overview tab

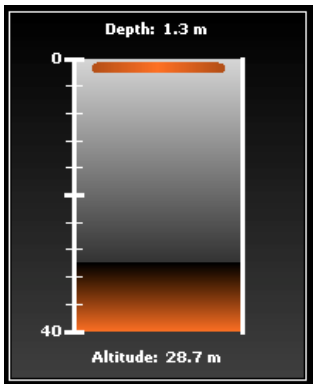
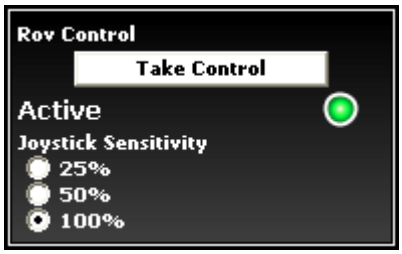
Item	Description
	
Depth	Presents the depth in meters below the sea surface. Sometimes it may be necessary to calibrate the depth. This can be done in the calibration window.
Altitude	Presents the altitude above the seabed in meters relative to the lowest part of the vehicle.
	
Take Control	Makes this MMI active so that the vehicle can be controlled from this MMI. If this button is pressed on another MMI the control is transferred.
Active – green LED	This MMI is active and the vehicle can be controlled via OCB.
Inactive – red LED	This MMI is not active. Click on Take Control to become active.

Table 2.2 MMI Overview tab

Item	Description
Joystick sensitivity 25%	Selects joystick sensitivity 25%. Circumstances may sometimes prove that it is important to be able to move the vehicle at a very low speed. The 25%-100% buttons allow the operator to limit the maximum thrust of the vehicle, having the joystick at its maximum position, to 25, 50 or 100% of the maximum joystick movement available. However, the control systems ability to hold attitude and heading is not affected by this setting.
Joystick sensitivity 50%	Selects joystick sensitivity 50%.
Joystick sensitivity 100%	Selects joystick sensitivity 100%.
	
Showing Event	The errors that are active presently are displayed in this window. The numbers (X/Y) means that there are X active errors displayed and there are Y active errors in total. If Y > X then there are active errors that has been suppressed in the Event tab. All errors can be seen by opening the Event tab. For more info about the error messages, see the Event tab.
Confirm	When a new error message occurs, the frame around Showing Event starts to blink. By clicking confirm you confirm that you have seen the error message, and the frame then stops blinking.

Table 2.2 MMI Overview tab

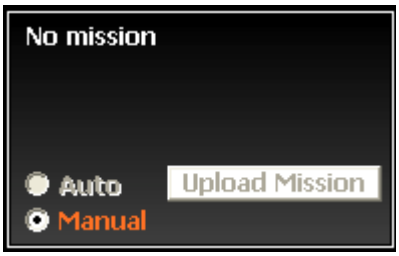
Item	Description
	
Upload Mission	Press this button to upload the mission you have created and prepared under the Mission tab to the vehicle. You can see the name of the mission and its state above the button.
Auto	Start the autonomous mission.
Manual	Drive the vehicle in manual mode.
	
GPS: Valid	The INS is receiving a valid GPS position from the GPS receiver.
GPS: Not Valid	There are three possible reasons for this status: - The GPS receiver does not receive a valid position. A reason could be that the antenna is under water. - The GPS Fix button is not pressed. - The INS does not accept the position from the GPS since there is a too big difference between the calculated position and the new GPS position. This should not happen since if the INS has not received a GPS fix for a long time, the standard deviation is so big that the INS will accept a larger difference between its position and new GPS positions.

Table 2.2 MMI Overview tab

Item	Description
GPS Fix	Press the button for the INS to use the GPS information. When not pressed, GPS is not used by the INS.
	
Tether tension	Tether tension measured by the winch.
Tether deployed	Tether length fed out from the winch.

Table 2.2 MMI Overview tab

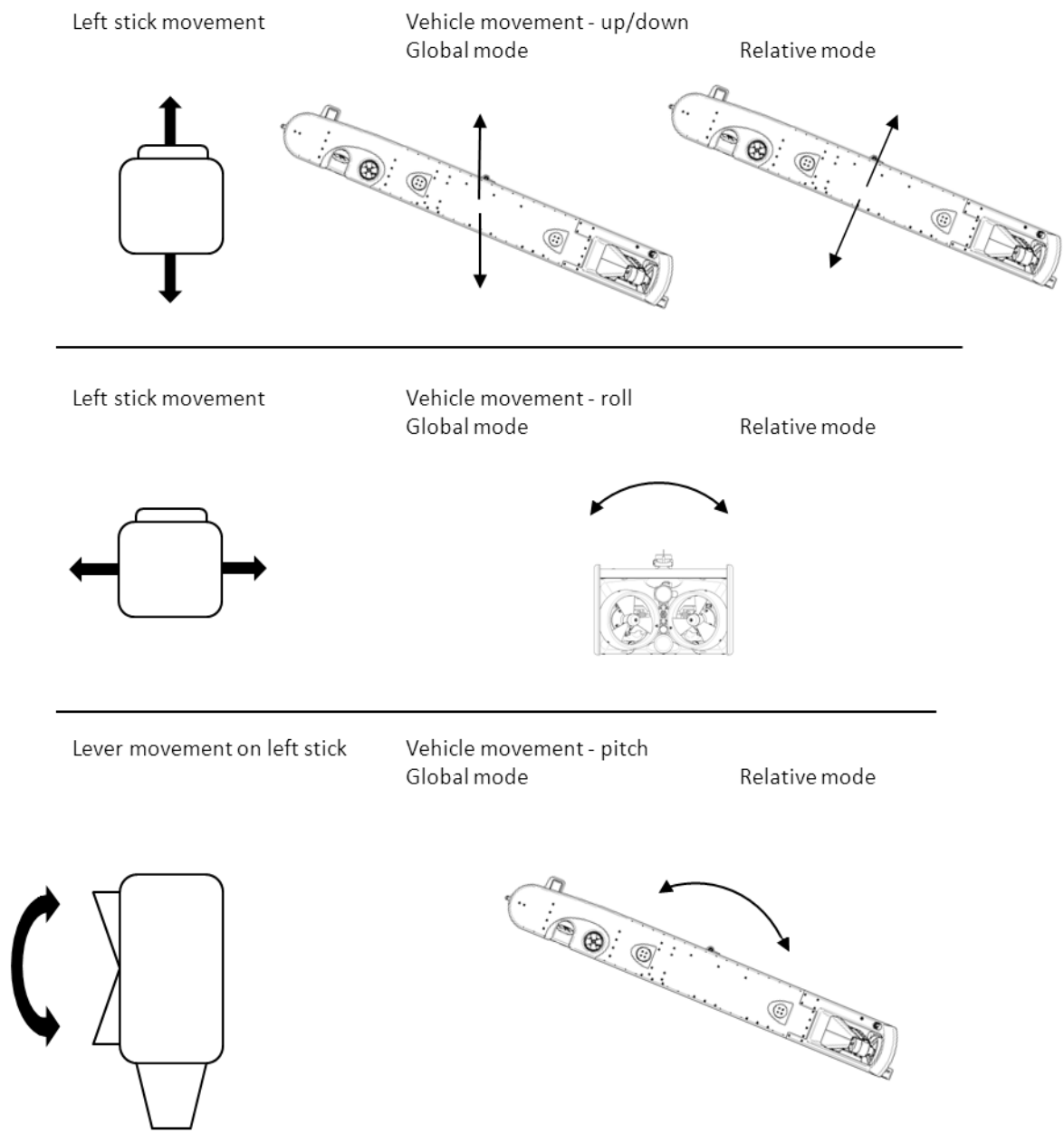


Figure. 2.4 Left joystick movement

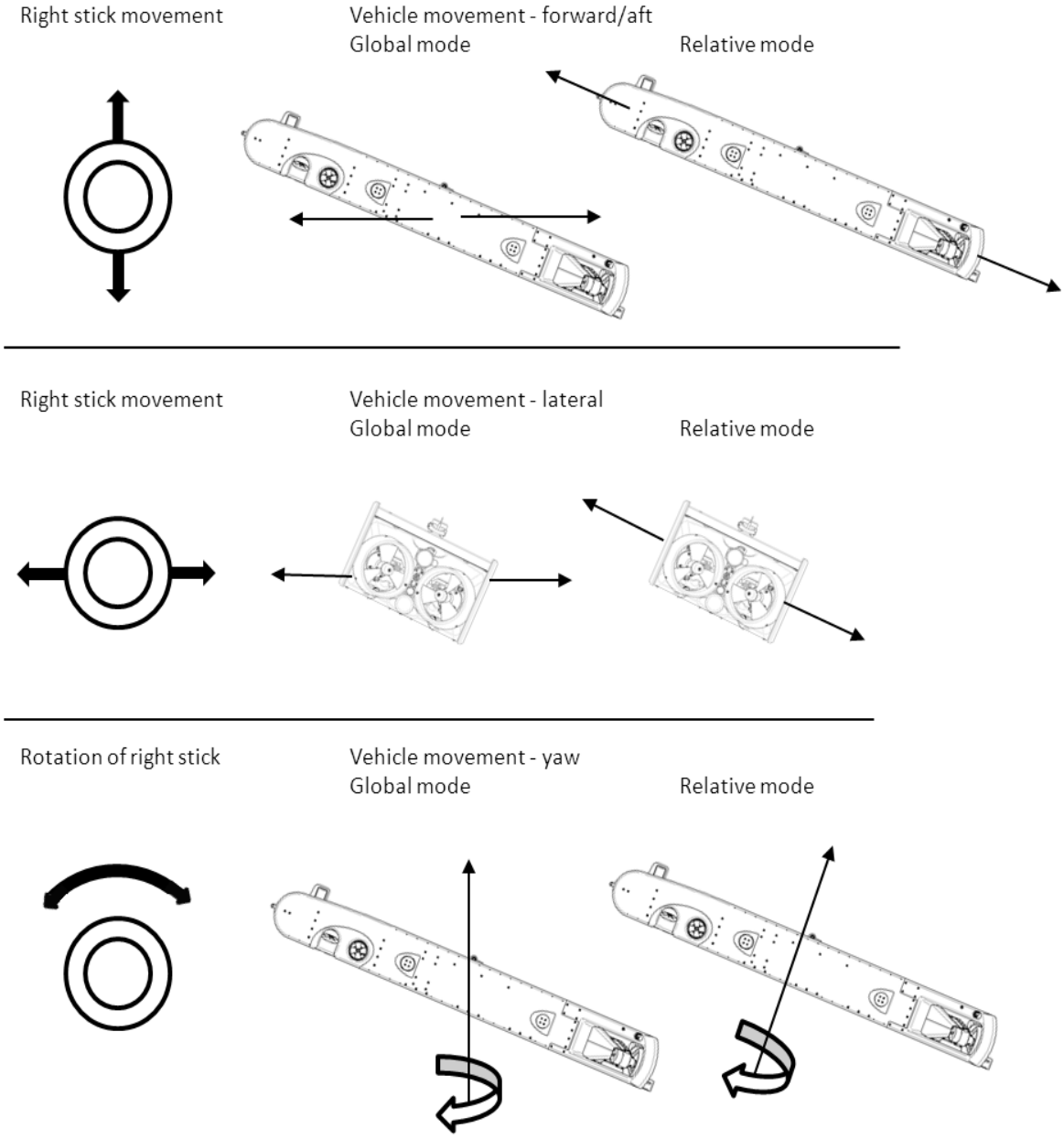


Figure. 2.5 Right joystick movement

2.3.2 Control

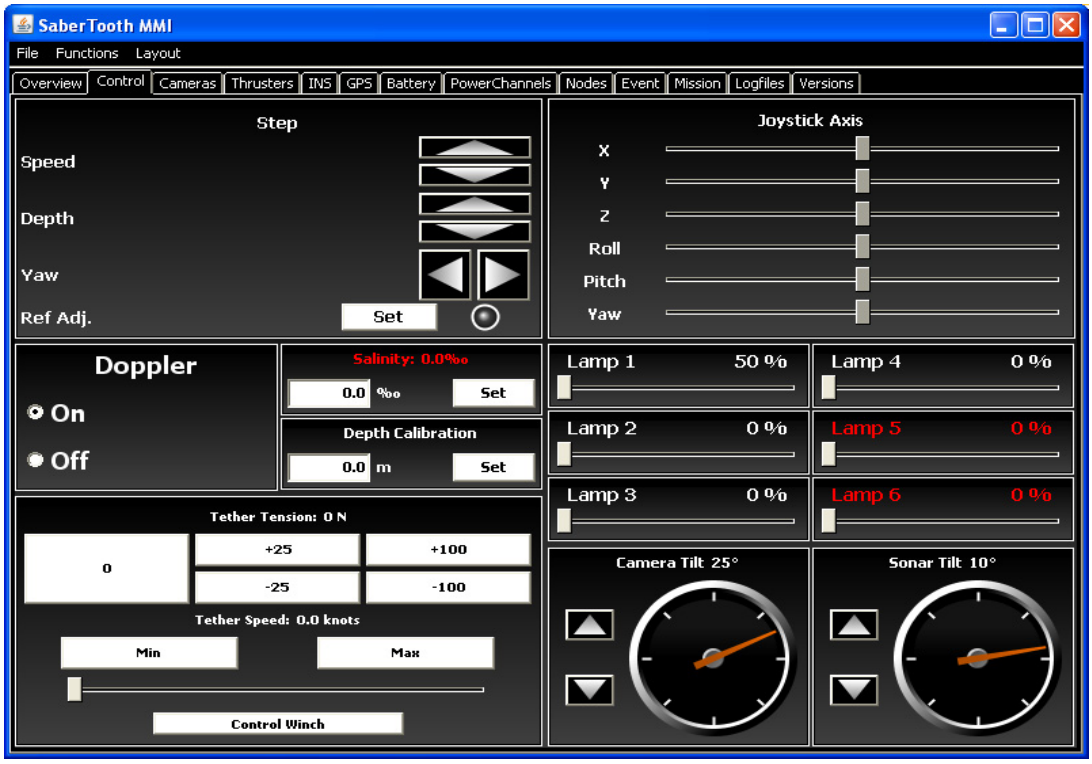


Figure. 2.6 MMI Control tab

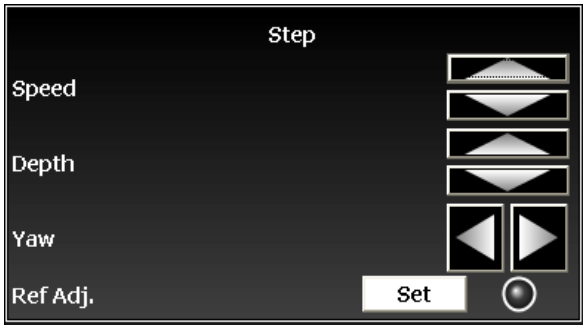
Item	Description
	
Speed	The step up/down buttons increase/ decrease the Ref. Adjust thrust in the X-direction with 5% for each click.
Depth	The step up/down buttons give thrust bursts that correspond to depth decrease/ increase of approximately 1dm. This control only works in global mode.

Table 2.3 MMI Control tab

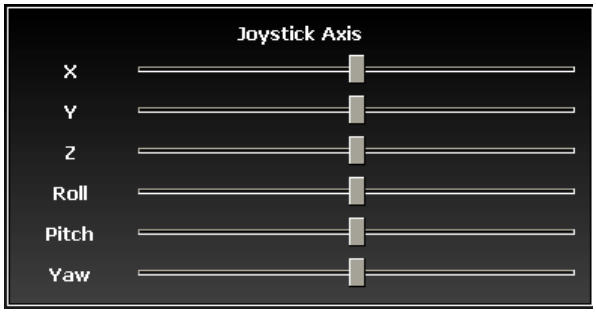
Item	Description
Yaw	The step left/right buttons give thrust burst that corresponds to heading decrease/increase of approximately 1°.
Ref Adj. Set	Activates Ref. Adjust. Activating reference adjust will store the values coming from the joystick in the X and Y-directions. These values will be added to the joystick values and the sum will be sent to the vehicle. This control can be very useful when operating in current water. The operator holds the vehicle still using the joystick and activates Ref. Adjust. By releasing the stick, the vehicle will stay in stationary position (provided the current does not change). The neutral position of the sticks now has a non-zero reference. The joystick can now be used for adding extra thrust in any direction, as required, to make the vehicle move from its stationary position. If Ref. Adjust is activated when the sticks are in neutral position the reference will again be zero and the controls will work as normal.
Ref. Adjusts indicator	Green when there is a non-zero Ref. Adjust value stored. Press Set again with the joysticks in neutral position to turn off. This indicator will also be green when a non-zero Ref. Adjust value has been achieved by using the Step function in the X-direction.
	
X	Shows the value from the joystick in the X-direction. Vehicle forward direction to the right

Table 2.3 MMI Control tab

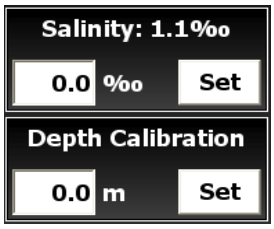
Item	Description
Y	Shows the value from the joystick in the Y-direction. Vehicle lateral starboard direction to the right.
Z	Shows the value from the joystick in the Z-direction. Vehicle down direction to the right.
Roll	Shows the value from joystick roll. Vehicle roll starboard to the right.
Pitch	Shows the value from joystick pitch. Vehicle front pitch down to the right.
Yaw	Shows the value from joystick yaw. Vehicle yaw starboard to the right.
	
On	Turns the Doppler log on. The Doppler log transmits continuously which is good for the accuracy of the INS position. However the sonar can be interfered in this mode.
Off	Turns the Doppler log off.
	
Salinity	Enter the salinity and press Set. This value will still be set after a system restart. In fresh water the salinity shall be set to 0. The salinity is used by the Doppler log to calculate the speed of sound in the water.

Table 2.3 MMI Control tab

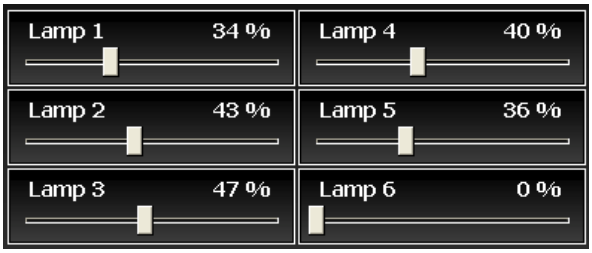
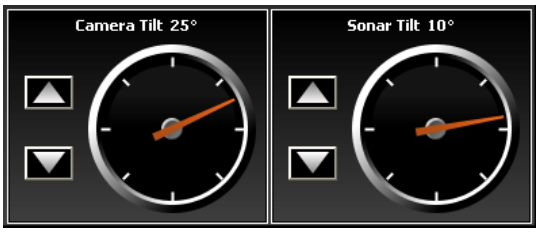
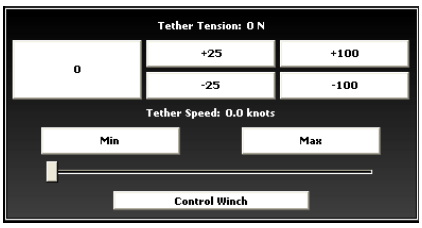
Item	Description
Depth Calibration	Calibrate the depth sensor by entering the present depth in meters and then press the Set-button. This value will still be set after a system restart.
	
Lamp 1 to 6	You can control the lamp power for the individual six lamps with the sliders.
	
Tilt Servo	Control the camera and sonar tilts up and down.
	
Tether Tension	After you have taken control of the winch with the Control Winch button, these buttons apply a tension on the tether of the corresponding force (N).

Table 2.3 MMI Control tab

Item	Description
Tether Speed	After you have taken control of the winch with the Control Winch button, these controls set the maximum speed with which the tether is reeled in. You can select Minimum or Maximum with the buttons, or adjust with the slider.
Control Winch	Press to take control of the winch tension and speed. When unpressed, the winch is controlled from the winch manoeuvring panel.

Table 2.3 MMI Control tab

2.3.3 Cameras

Figure. 2.7 MMI Cameras tab

Item	Description
Record	When pressed the video recording is starting. Press again to stop recording.
Record indicator	Indicates that video is recording.
Show Attitude Values	Toggles between showing the attitude values or not.

Table 2.4 MMI Cameras tab

2.3.4 Thrusters

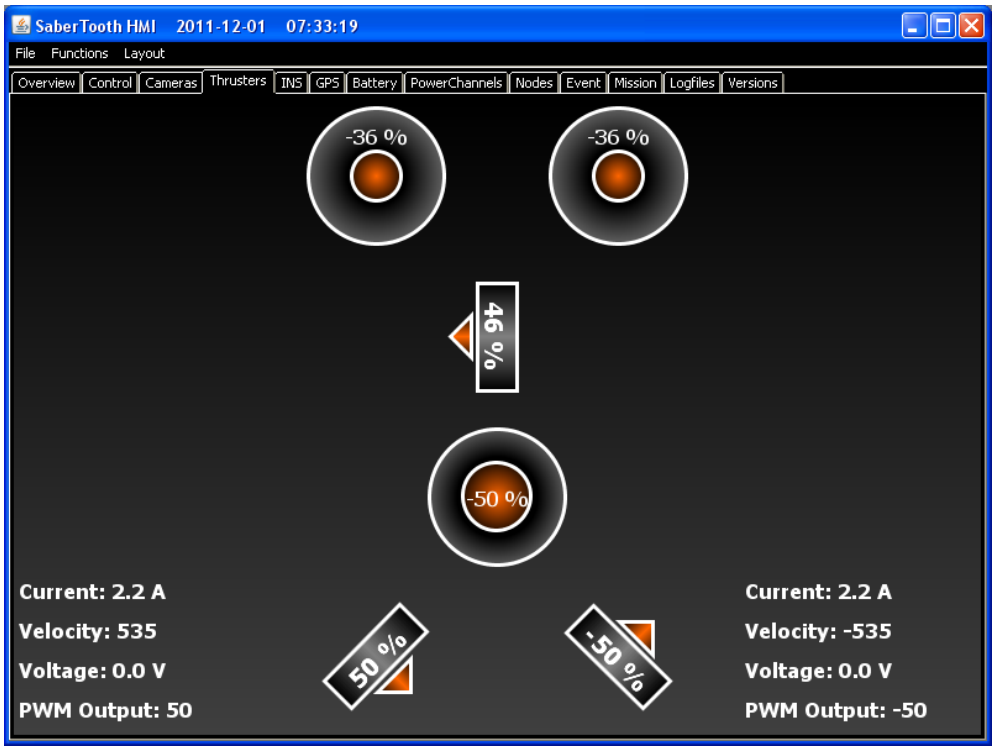


Figure. 2.8 MMI Thrusters tab

Item	Description
Percentage (%)	The pulse width modulation output percentage for the individual SM4 thruster (-100 – +100%). This number is the base for the size of the orange symbol for the thruster.
Current	The current of the individual thruster. (This value only shown for the SM9 thrusters, that is, the two lowermost on the screen.)
Velocity	The velocity (rpm) of the propeller for the individual thruster. (This value only shown for the SM9 thrusters, that is, the two lowermost on the screen.)
Voltage	The voltage for the individual thruster. (This value only shown for the SM9 thrusters, that is, the two lowermost on the screen.)
PWM Output	The pulse width modulation output percentage for the individual SM9 thruster (-100 – +100%). This number is the base for the size of the orange symbol for the thruster.

Table 2.5 MMI Thrusters tab

2.3.5 INS

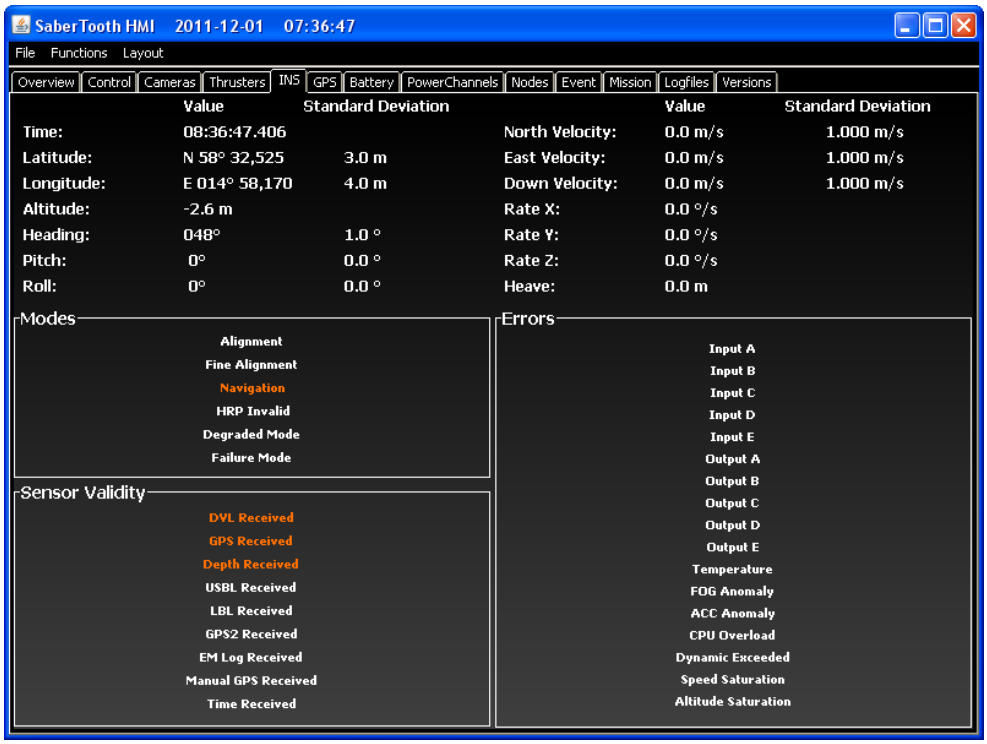
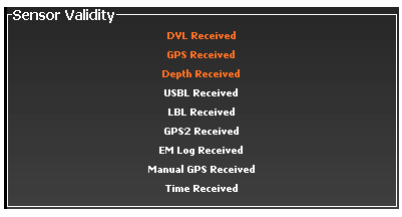
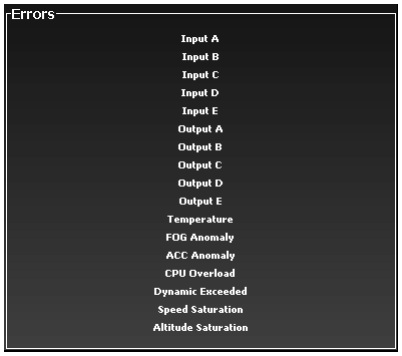


Figure. 2.9 MMI INS tab

Item	Description
	
Time, Latitude, etc	Measured values from the INS with standard deviation.
	
Alignment	The INS is in alignment state where the initial attitude and heading are calculated. This state lasts five minutes after the INS receives the start-up position. During this state there shall be no excessive acceleration of the vehicle. The position and velocity data is not valid in this state.

Item	Description
Fine Alignment	The INS is in fine align state where the accuracy of the attitude and heading is improved. The vehicle can be used but full position accuracy has still not been achieved. To get good accuracy, DVL data and GPS or USBL data shall be provided to the INS. It is recommended to move in stair case shaped tracks or on figures of eight tracks to get good observability of the sensor errors. This state lasts until the INS heading accuracy is below 0.1 degree.
Navigation	The INS is in navigation state where it is ready for navigation with optimal performance. This state is entered when the INS heading accuracy is below 0.1 degree.
HRP Invalid	Heading, roll and pitch angles are not valid from the INS. This flag is set during the Alignment state or if there is a problem with the inertial sensors (FOG Anomaly, Acc Anomaly) or the speed has been saturated.
Degraded Mode	This message is triggered when a fixed number (varying between 1 and 100, depending on the type) of successive occurrences of the same error happen.
Failure Mode	This message is triggered when a fixed number (varying between 3 and 1000, depending on the type) of successive occurrences of the same error happen.
	

Item	Description
Sensor Validity	**DVL Received**: Indicates that DVL data is received by the INS and that the received data is valid. **GPS Received**: Indicates that GPS data is received by the INS and that the received data is valid. **Depth Received**: Indicates that depth data is received by the INS and that the received data is valid. **USBL Received**: Indicates that USBL data is received by the INS and that the received data is valid. (USBL data is not used in the Sabertooth system.) **LBL Received**: Indicates that LBL data is received by the INS and that the received data is valid. (LBL data is not used in the Sabertooth system.) **GPS2 Received**: Indicates that GPS2 data is received by the INS and that the received data is valid. (In Sabertooth GPS2 is only used when positions are entered manually.) **EM Log Received**: Indicates that EM Log data is received by the INS and that the received data is valid. (EM Log data is not used in the Sabertooth system.) **Manual GPS Received**: Indicates that manual GPS data is received by the INS and that the received data is valid. (Manual GPS data is not used in the Sabertooth system.) **Time Received**: Indicates that time data is received by the INS and that the received data is valid. (Time data is not used in the Sabertooth system.)
	
Input X	Input error on port X. (X stands for A, B, etc)

Item	Description
Output X	Output error on port X. (X stands for A, B, etc)
Temperature	Temperature acquisition error (Optical source, ACC and FOG temperatures on sensor board) or temperature measurement out of normal range or temperature variation measurement out of normal range.
FOG Anomaly	There is a problem with a FOG sensor in the INS.
ACC Anomaly	There is a problem with the an accelerometer in the INS.
CPU Overload	The system has not enough calculation power in the current configuration. INS Interface board CPU overload (too much output protocols with too high output rates).
Dynamic Exceeded	Acceleration greater than maximal accepted value or rotation rate greater than maximal accepted value.
Speed Saturation	The speed is higher than 80 knots. The algorithm is frozen. The INS must be restarted.
Altitude Saturation	The altitude is higher than 4000 m.

Table 2.6 MMI INS tab

2.3.6 GPS

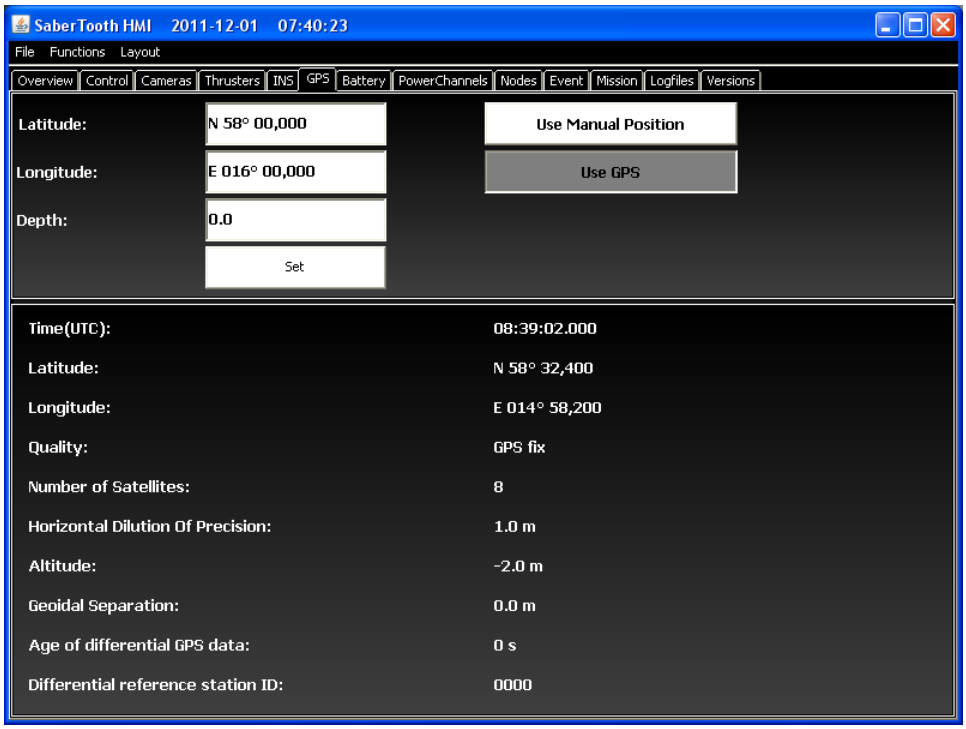
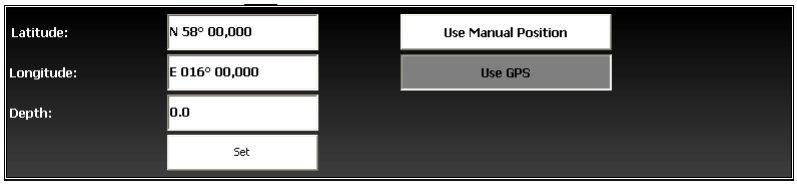
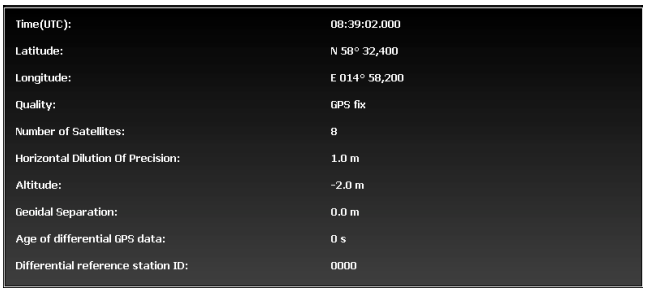


Figure. 2.10 MMI GPS tab

Item	Description
	
Latitude, Longitude	The start position of the vehicle can be set manually if no GPS signals are available. The start position is necessary for the INS system to start the alignment phase. The latitude and longitude are entered as hemisphere, degrees and decimal minutes.
Depth	The depth is entered in meters.

Item	Description
Set	When the Set button is pressed the position is sent to the INS in the vehicle. When the INS once has been given a position, either manually or from the GPS, it will not accept a totally new position. The only way is to reinitialize the INS either by turning the vehicle off and then on again, or to toggle the power to the Phins in the Power Channels window.
Use Manual Position	If the position will be entered manually this button shall be pressed. If this button is pressed the GPS Fix button on the Overview tab will be disabled.
Use GPS	If data from the GPS receiver will be used this button shall be pressed.
	
Time (UTC)	Coordinated Universal Time
Latitude	Latitude in degrees and minutes. N: North, S: South
Longitude	Longitude in degrees and minutes. E: East W: West
Quality	GPS quality indicator (the higher number the better quality): 0 = Fix not valid 1 = GPS fix 2 = DGPS fix 3 = PPS fix 4 = RTK fix 5 = Float RTK fix
Number of satellites	Number of satellites
Horizontal dilution of precision	Quality measure depending on the satellite geometry

Item	Description
Altitude	Antenna altitude
Geoidal separation	Separation in metres between the geoide and the ellipsoide
Age of differential GPS data	(Not used)
Differential reference station ID	(Not used)

Table 2.7 MMI GPS tab

2.3.7 Battery

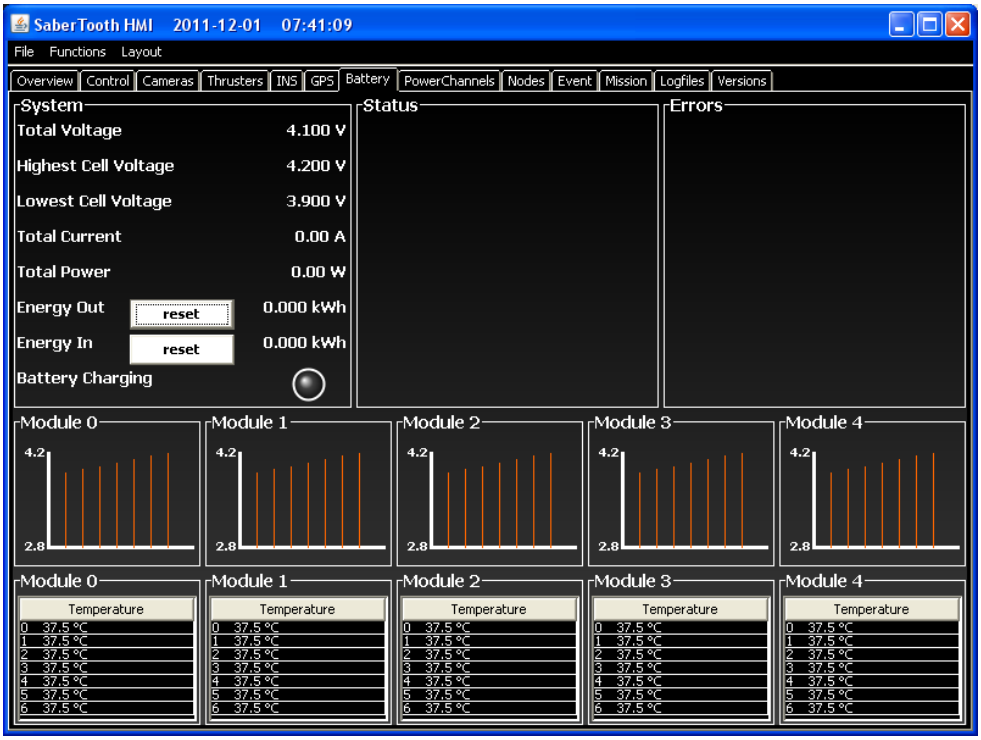
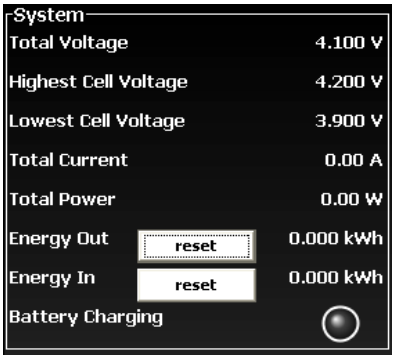


Figure. 2.11 MMI Battery tab

Item	Description
	
Total Voltage	The total battery voltage of all cells connected in series.
Highest Cell Voltage	The voltage of the battery cell with the highest voltage.
Lowest Cell Voltage	The voltage of the battery cell with the lowest voltage.
Total Current	The current consumed from the battery.
Total Power	The power consumed from the battery.
Energy Out	The calculated energy output since the Reset button was pressed.
Energy In	The calculated energy input (charged) since the Reset button was pressed.
Battery Charging	This indicator is lit if there is a current flowing out from the battery charger.
Status 	Reported status from the Battery Management System.
Starting Up	The Battery Management System cards are starting.

Item	Description
Shutting Down	The Battery Management System cards are going to sleep.
Monitoring Battery	The Battery Management System is active and monitors all battery data.
Do Active Control	The battery is on.
Control Charging	The battery is being charged.
Control Discharging	The battery is being discharged.
Equalising Cells	The battery cell voltages are being balanced.
Errors 	Reported errors from the Battery Management System.
Hardware Overvoltage Problem	The Battery Management System reports an overvoltage problem in the battery
Overvoltage Problem	The Battery Management System reports an overvoltage problem in the battery
Hardware Undervoltage Problem	The Battery Management System reports an undervoltage problem in the battery
Undervoltage Problem	The Battery Management System reports an undervoltage problem in the battery
Charge Current too high	The Battery Management System reports that the battery is charged with too high current.
Discharge Current too high	The Battery Management System reports that too much current is consumed from the battery.
Charge Temperature too high	The Battery Management System reports that the battery is too warm to be charged.
Discharge Temperature too high	The Battery Management System reports that the battery is too warm to discharge.
CAN response Failure	The Battery Management System reports problems with the CAN communication.
CAN receive overflow	The Battery Management System reports problems with the CAN communication.

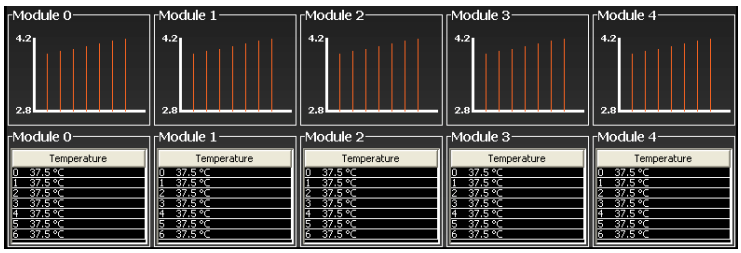
Item	Description
	
Module 0-4 Voltage	The voltages of all individual cells within the respective module.
Module 0-4 Temperature	The temperature of all individual cells within the respective module.

Table 2.8 MMI Battery tab

2.3.8 PowerChannels

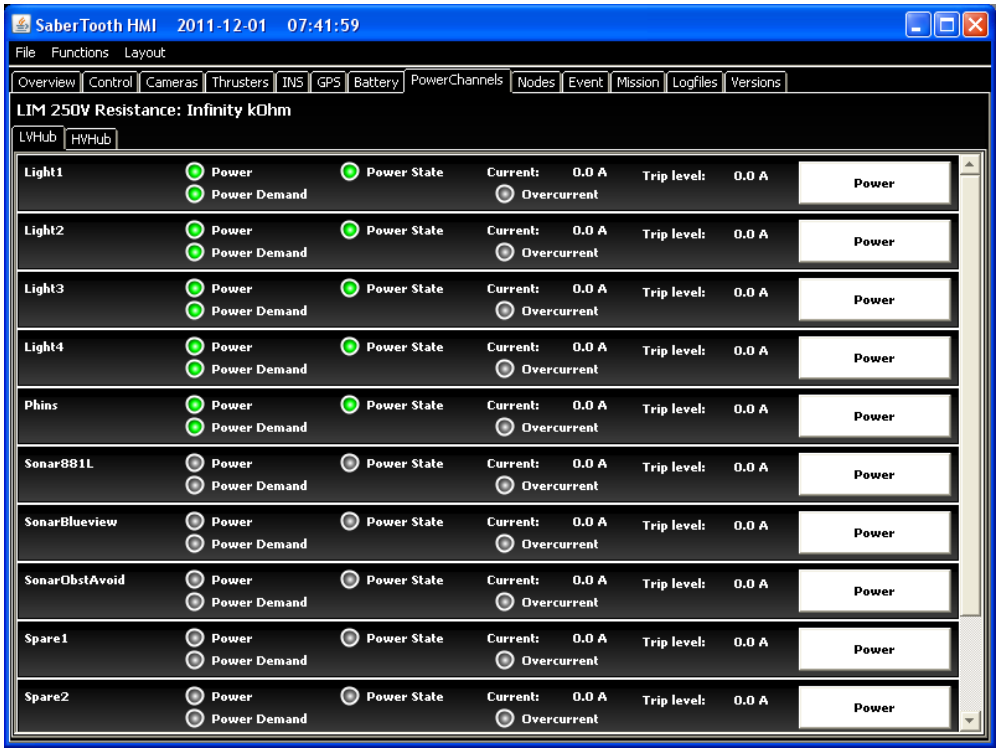


Figure. 2.12 MMI PowerChannels tab

Item	Description
Power	Is green when power is reported connected by the node.
Power Demand	Is green when power on is demanded.
Power State	Is green when power channel is powered.
Current	Current in Ampere drawn by the power channel.
Overcurrent	Is green when current is above trip level.
Trip level	Current trip level in Ampere.
Power button	Connect or disconnect power to the node.
LIM250VResistance	The insulation resistance in Ohm of the 250 VDC power.

Table 2.9 MMI PowerChannels tab

2.3.9 Nodes

Figure. 2.13 MMI Nodes tab

Item	Description
Description	Node description.
Host Number	Castle host serial number of the node.
Key	Identifier of the node.
PCB Number	The Seaeye Printed Circuit Board number of the node.
Firmware Version	Seaeye Castle firmware version.
Library Version	Seaeye Castle library version.
Communication	Status of node communication.
Serial Nr Set Status	Status of the setting of host serial number.
Edit	Is used to change host number on a unit, for example when exchanging lamps.

Table 2.10 MMI Nodes tab

2.3.10 Event

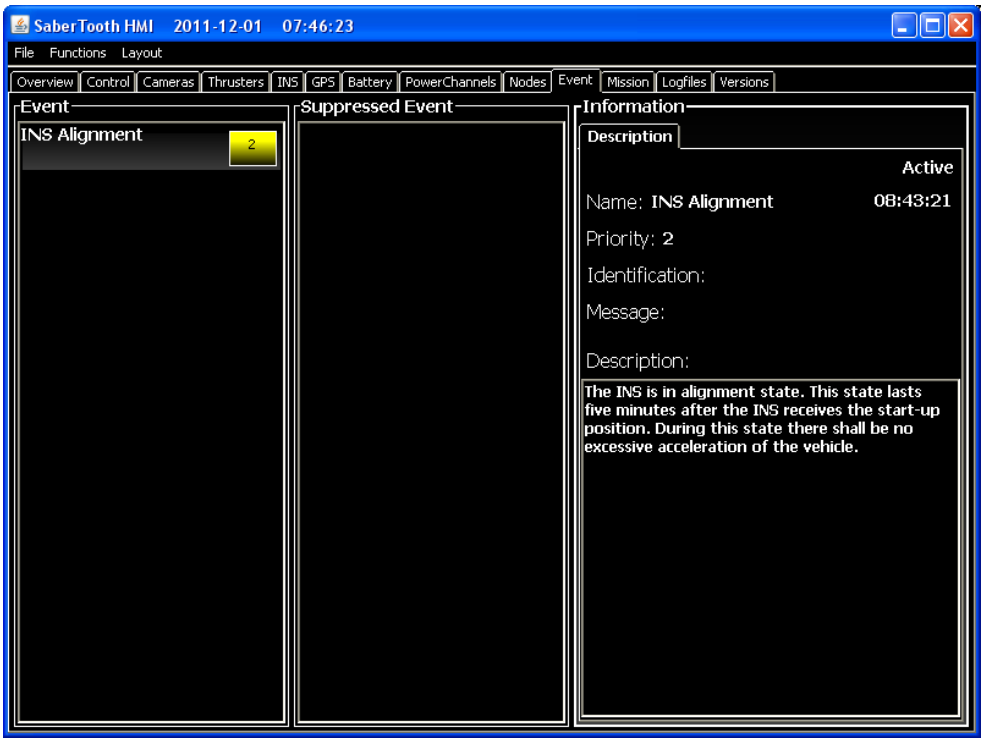


Figure. 2.14 MMI Event tab

Item	Description
Event	Shows a list of all active events with colour coded severity (red = error, yellow = warning) and a figure showing how many times it has appeared. To see a complete list of all possible events, refer to chapter 8.
Suppressed Event	Shows all suppressed events. To suppress an event, right click a message in the Event list and select to suppress it. It will now show up in the Suppressed Event list.
Information	Provides a more elaborate description of the selected event.

Table 2.11 MMI Event tab

2.3.11 Mission

The mission planner is used for planning Sabertooth missions. To do this also a sea chart tool is needed. The sea chart tool is used for making search patterns or tracks by defining waypoints. The waypoints are then imported to the mission planner. In the mission planner other parameters like speed, depth and altitude are set. Also conditions for selecting different actions can be added.

The mission planner is designed for importing tracks and single waypoints in KML (Keyhole Markup Language) file format. For example Google Earth can be used to make tracks which are then imported to the mission planner.

Main Window

When the mission planner is started the main window is opened.

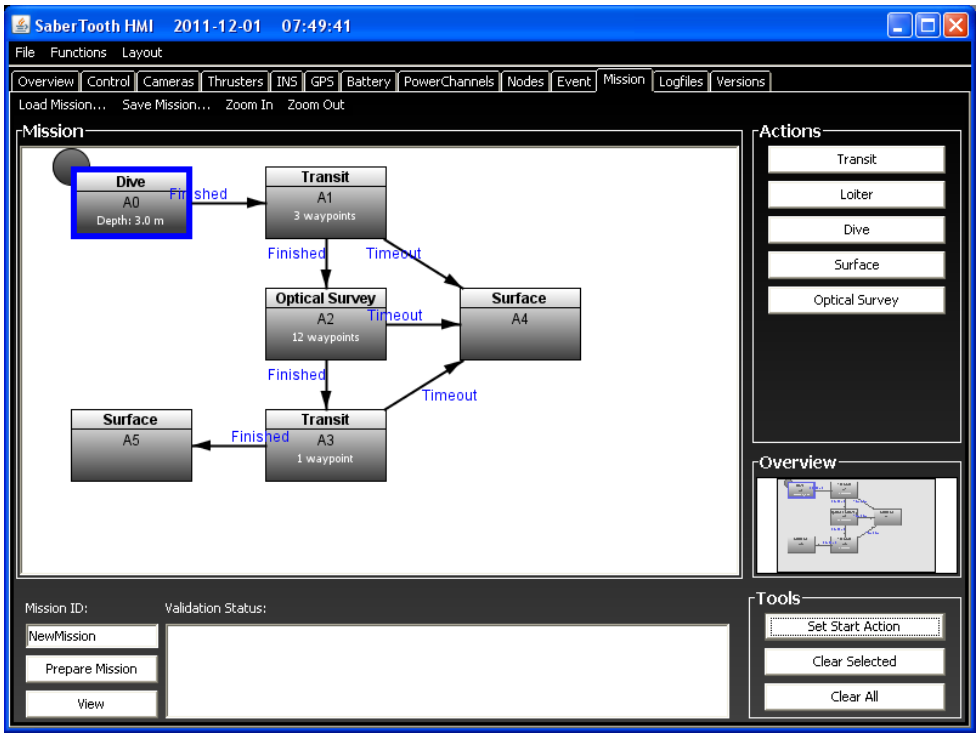
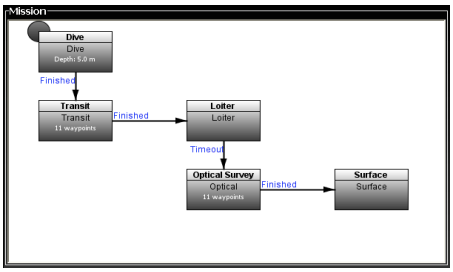


Figure. 2.15 MMI Mission tab

Item	Description
Load Mission... Save Mission... Zoom In Zoom Out	
Load Mission	Loads mission files from disk. Mission files have the format *.mission.
Save Mission	Saves mission files to disk. Mission files have the format *.mission.
Zoom In	Zooms in on the mission canvas. Zoom can also be achieved by holding down the CTRL-key while rotating the mouse wheel.
Zoom Out	Zooms out on the mission canvas. Zoom can also be achieved by holding down the CTRL-key while rotating the mouse wheel.

Item	Description
	
Mission canvas	The mission canvas is used for displaying the mission. A mission consists of a number of actions tied together with exits. The start action is indicated with a circle at the top left corner.
 The action buttons are used for placing new actions on the mission canvas. Click on an action button and then on the mission canvas to create a new action.	
Transit	The vehicle travels along a number of waypoints. Depth or altitude as well as speed are set. The camera/sonar tilt angle is set to 0°.
Loiter	The vehicle slowly moves in a circle around its present position at its present depth. The radius of the circle is 10 meters and the speed is 0.5 knots.
Dive	The vehicle dives at its present position to the set depth.
Surface	The vehicle goes to the surface at its present position and raises the antenna. The vehicle tries to stay at a depth of 0.3m.

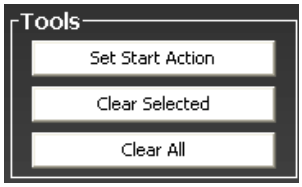
Item	Description
Optical Survey	The vehicle travels along a number of waypoints. Depth or altitude as well as speed are set. Video is recorded.
	
Set Start Action	Sets the presently selected action to be the start action.
Clear Selected	Removes the presently selected actions/ exits.
Clear All	Clears the whole mission canvas.
	
Mission ID	The name of the mission is entered here.
Upload Mission	The mission is uploaded to the RAC. The MMI displays the Mission ID of the uploaded mission.
View	Displays the mission XML-file generated by Mission Planner.
Validation Status	The Mission Planner will continuously validate the mission for correctness. Any errors are shown here. It is only possible to view, save and upload a valid mission.

Table 2.12 MMI Mission tab

Action Handling

Action	Result
Left click an action.	The action is selected and can be manipulated using the buttons in the Tools frame.
Right click an action.	A small menu appears with the choices: - Set as start action - Remove - Edit
Double left click an action.	The edit window of the action is opened.
Double left click the name of an action.	The name of the action can be changed. Since the name of the action is displayed on the MMI it can be useful to have descriptive names.

Table 2.13 Mission Planning Action handling

Action Edit Window

The edit windows of transit actions and optical survey action are identical.

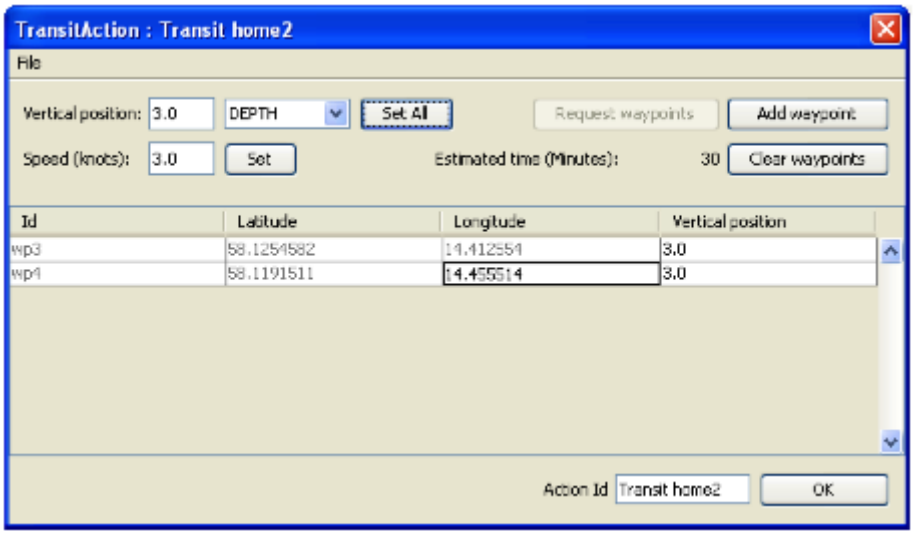


Figure. 2.16 Action Edit window for a transit action

Item	Description
File/Load action	Loads a saved action. Actions are of the file type *.action.
File/Save action	Saves an action to disk.
File/Load KML waypoints	Loads waypoints in the form of a KML file. KML files can for example be created in Google Earth.
Vertical position	By entering a value and pressing the button Set All it is possible to set the vertical position of the whole track. However, it is also possible to set different values for different waypoints. The choice if the values shall be interpreted as depth or altitude is the same for the whole track.
Speed (knots)	Sets the travel speed for the whole track.
Request waypoints	This function is presently not implemented. It is intended to be used if the mission planner is integrated more closely with a sea chart tool.
Add waypoints	Adds new waypoints to the list below.
Clear waypoints	Removes all waypoints.
Estimated time	The estimated time to travel the track. The speed Set button must be clicked for the value to be updated.
Waypoints	Each waypoint consists of a name and a latitude and longitude in degrees. It also has a vertical position in meters.
Action Id	The name of the action.

Table 2.14 Action Edit window

Surface and Loiter actions can not be edited. For Dive actions only the depth can be set.

Exit Handling

Exits are created by holding down the CTRL-key and left clicking an action. While still holding down the CTRL-key and the left mouse button the mouse is moved to the destination action before the mouse button is released. When the mouse button has been released the dialogue windows for choosing exit type is opened.

These are the exit types that can be set by the operator. All types of actions can not use all types of exits. To set the parameters of the exit type the exit is double clicked.

Item	Description
Finished	When the action is finished the exit is triggered. An action is seen as finished when the vehicle is at a depth and distance close enough from the end point. The distance from an end point is depending on the set speed. This exit type has no parameters.
Timeout	The exit parameter is a time in minutes. When this time has passed since the beginning of the action the exit will be triggered.
LowBattery	The exit parameter is percentage of cell voltage where 4.2V corresponds to 100%. The exit will be triggered if the voltage of the cell with the lowest cell voltage falls below the set value. 87% corresponds to a half full battery and 79% corresponds to an empty battery. If the voltage falls below 83.3% the vehicle will go to EmergencySurface regardless of what is set here.
BadPosition	The exit parameter is a position error in meters. The IMU constantly calculates position errors in latitude and longitude. The real error is estimated to be within this position error with a confidence of 68% (1-sigma). If the calculated position error in latitude or longitude is bigger than the set value the exit will be triggered.
GoodPosition	The exit parameter is a position error in meters as defined for BadPosition above. If both the latitude and longitude position errors calculated by the IMU are smaller than the set value the exit will be triggered.

Table 2.15 Action Exit Types

Like actions, exits can be handled on the mission canvas using the mouse.

Item	Description
Left click an exit	The exit is selected and can be deleted using the Clear Selected button in the Tools frame.
Double left click an action	A window opens and the exit parameters can be set. This is not valid for exits of type Finished since this type does not have any parameters.

Table 2.16 Handling action exits

System Actions and Exits

Apart from the actions described above there are a number of system actions that can not be programmed from the mission planner. These are triggered by errors or from an optional UW-modem.

Item	Description
Emergency	The vehicle can not be controlled for some reason. All attitude control is turned off. It is critical that the buoyancy of the vehicle is positive, otherwise the vehicle will sink.
EmergencySurface	The vehicle goes to the surface. It will try to maintain a depth of 0.0 meters. The vehicle attitude and position control is still active.

Table 2.17 MMI System actions

For the Emergency and EmergencySurface actions to become active there are a number of system exits that are triggered by errors or other conditions. These conditions can not be changed by the user.

Exit Type	Next Actions	Triggered by
BadLatLongQuality	EmergencySurface	Calculated latitude or longitude error is bigger than 50 meters. The error is defined with 68% confidence (1-sigma).
BadVelocityQuality		Calculated forward or port velocity error is bigger than 0.5 meters/second. The error is defined with 68% confidence (1-sigma).
BatteryCriticalLevel	Emergency	The lowest cell voltage is below 81% charge as defined by LowBattery exit above.
BatteryLinkError	EmergencySurface	The RAC has no communication with the Battery Management System (BMS).
BatteryLowLevel	EmergencySurface	The lowest cell voltage is below 83.3% charge as defined by LowBattery exit above.
DVLError	EmergencySurface	The DVL is reporting an error.
INSError	Emergency	The INS reports an error.
LargeRollPitch	EmergencySurface	The roll or pitch angle is bigger than 45°.
Leak	EmergencySurface	One of the leak sensors has detected a leak in the vehicle.
NoAttitudeSpeedData	Emergency	Heading and speed are missing. RAC software error.
NoCastle2Data	Emergency	No data is received from the Castle2 serial bus.
NoDVLData	EmergencySurface	No data is received from the DVL.

Exit Type	Next Actions	Triggered by
NoINSData	Emergency	No data is received from the INS.
NoOccupancyGridData	EmergencySurface	No data is received from the obstacle avoidance sonar system.
NoProfilerData	EmergencySurface	No data is received from the obstacle avoidance sonar.
NoSpatialData	Emergency	Attitude, velocity and position data are missing. RAC software error.
NoThrusterCmdData	EmergencySurface	No thrust command data is received from the control software unit. RAC software error.
NoTrackCtrlData	Emergency	No track control data is received. RAC software error.
Proximity	EmergencySurface	The altitude is less than 2.0 meters.
ThrusterError	Emergency	There is an error in a thruster or communication with a thruster failed.
ToFarFromTrack	EmergencySurface	The distance to the track is more than 100 meters.

Table 2.18 MMI System exits

2.3.12 Logfiles

This window is used for downloading log files and video files from the RAC in the vehicle or log files from the SAC in the surface unit.

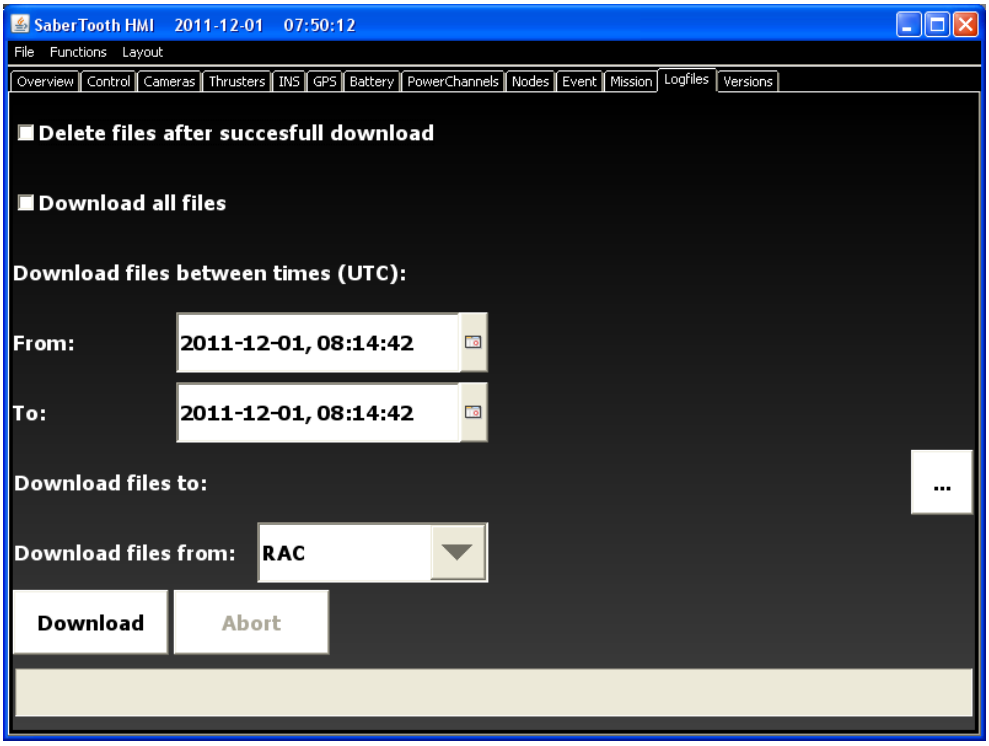


Figure. 2.17 MMI Log files tab

Item	Description
Delete files after successful download	If this box is ticked the downloaded files are deleted from the place it is being downloaded from (RAC or SAC).
Download all files	If this box is ticked all log files and video files are downloaded.
Download files between times (UTC): From	Select start date/time for the files to be downloaded. The files are selected from their creation time. It can therefore be necessary to give a time up to an hour before the interesting time.
Download files between times (UTC): To	Select end date/time for the files to be downloaded.
Download files to	Select the disk and directory to which the files will be downloaded.

Item	Description
Download files from	From the drop-down list select place (RAC or SAC) to download from. In tethered mode the RAC log files are a subset of the SAC log files. In untethered mode there is a bigger difference between the log files. The SAC log files shows what the operator saw during the mission while the RAC log files shows that the vehicle recorded during the mission.
Download	Press Download to start the downloading.
Progress meter	This meter shows the progress of the downloading.

Table 2.19 MMI Log files tab

Observe! – Files should only be downloaded when the vehicle is on deck. The processor load on the RAC and the SAC during download may affect the control of the vehicle.

2.3.13 Versions

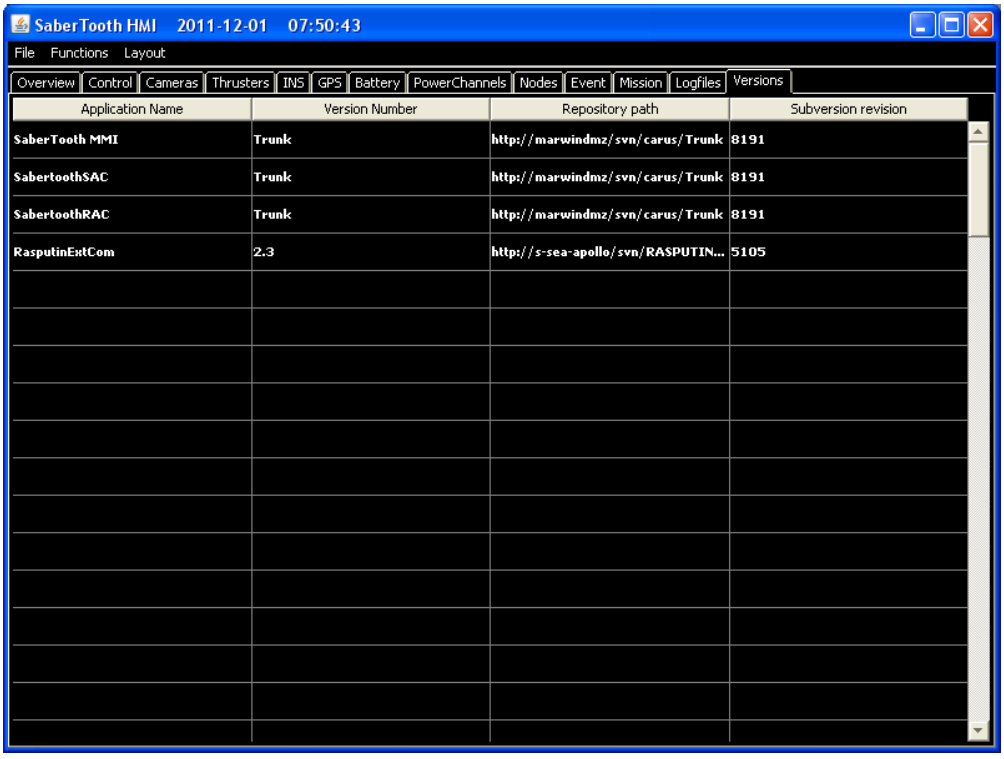


Figure. 2.18 MMI Versions tab

Item	Description
Application Name	Name of the different programs.
Version Number	Program version.
Repository path	Saab use only.
Subversion revision	Saab use only.

Table 2.20 MMI Versions tab

2.3.14 Menu Selections

File

Exit: Select Exit to close the Sabertooth MMI.

Functions

System time: Shows the time of the Surface Application Computer (SAC) and the ROV Application Computer (RAC). The time of the computers are synchronized through NTP. To change the time of the system close all SAC application software including the MMI and set the time through the Windows clock on the SAC. Start the SAC application software again and restart the vehicle. The RAC computer will then set its time from the SAC.

Communication: Opens a window showing communication quality between the surface and the vehicle. The number packets lost during transmission is shown. This is intended for error diagnose purposes.

Lights:
Load settings: Loads previously saved settings for the lights.
Save settings: Saves the current positions of the light slide bars on the Control tab.

Layout

Reset: Resets the layout of the MMI. All MMI windows will return to their default position inside the main window.

Load settings: Loads a previously saved screen layout of the MMI windows.

Save settings: Saves the current screen layout of the MMI windows.

2.4 MMI Player

The MMI Player is started by clicking the MMI Player icon on the desktop. The MMI Player looks almost identical to the normal MMI. The difference is the text PLAYBACK and that the background has a shade of dark green. There is also an extra tab called “Player”.

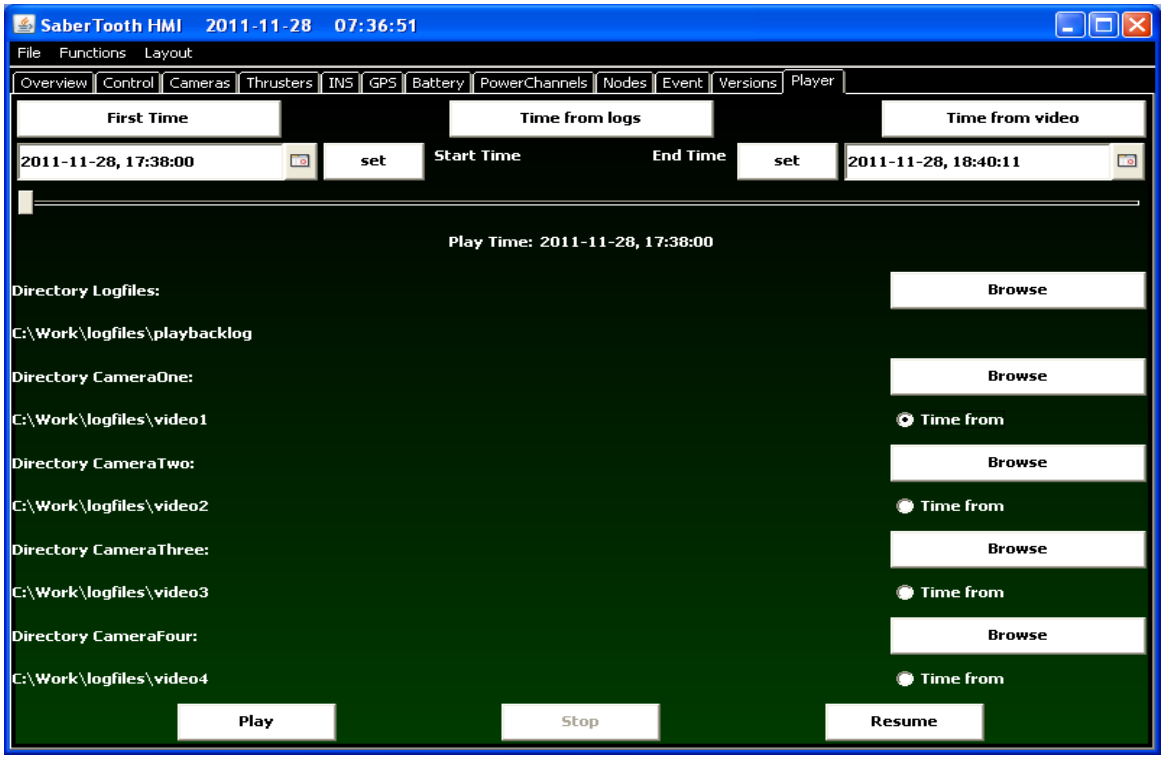


Figure. 2.19 MMI Player

Like on the normal MMI other tabs can be opened to view what happened during the mission. Observe that control data that come from the MMI or OCB are not recorded. This means for example that the Control Mode buttons on the MMI Player primary screen do not show how the buttons were set during the mission. However, the indicators to the right of the buttons show the mode of the vehicle during the mission.

Item	Description
Start and End time	Selects from which time the log files shall be played back. The button on the right opens up a calendar.
First time	Sets the time to the beginning of the first recorded file in the selected directories.
Time from logs	Sets time to the beginning of the log file that is selected.

Item	Description
Time from video	Sets time to the beginning of the video file that is selected for the camera that you tick “Time from” for.
Directory Logfiles	Selects directory for log files. The files can be either SAC files or RAC files.
Directory CameraOne to CameraFour	Selects directory for video files for the respective camera. Make sure to select the video directory that corresponds to the log files.
Play	Start playing log files and video from the date and time selected above.
Stop	Stops playback.
Resume	Resumes playback from when it was stopped.

Table 2.21 MMI Player

2.5 Battery Charger Controls, Indicators and Connections

Figure. 2.20 Battery Charger Front Panel

Figure. 2.21 Battery charger controls, indicators and connections. At the arrow you can see some of the indicators in the mirror

Control/indicator/connection	Function
The following LED indicators on the Brusa charger are viewable in the mirror:	
Connected	The charger is connected to power supply
Red LED: Note!	Charger malfunction. This is lit because of one of the following reasons: - Main switch off - Over-temperature - Mains overvoltage - Battery not connected - Internal charger fault - PRO-signal used when updating firmware is high
Yellow LED: Low	Not used in CAN mode.
Yellow LED: Medium	Not used in CAN mode.
Green LED: High	Not used in CAN mode.
Connectors:	
230 VAC Input	Power supply connector on a 9 meter cable. The connector is a 3-phase + neutral + safety ground 400 V/ 16 A power connector according to international standard IEC 60309. Even though the connector is a 3-phase connector only one phase 230 VAC is used. The charger is configured to charge with 3.3 kW. The charger can be used with an input voltage down to 100 VAC but then the charger will work with reduced power.
Vehicle Power	Battery charger power cable to the vehicle. This shall be connected to the vehicle BC connector when charging the batteries. The connector is a 5-socket Seaeye UW connector on a 9 meter cable.
Vehicle CAN	Battery CAN bus cable to the vehicle. This shall be connected to the vehicle's on/off connector (OF) when charging the batteries. The connector is a 12 pin Seaeye UW connector on a 9 meter cable.
Controls, indicators and connections at the front panel:	

Table 2.22 Battery Charger Controls, Indications and connections

Control/indicator/connection	Function
Power on/off switch	Turns the battery charger on/off. If the vehicle is connected and in need of charging the charging will begin as the battery charger is turned on. When the battery is fully charged the charging will stop automatically. This can be noticed since the fan in the charger is only running during charging.
BMS Reset on/off	Reset of the BMS in the vehicle. If the vehicle Battery Management System for some reason has ended up in an error state, it can be reset with this switch when the Vehicle CAN cable is connected.
CAN 120 ohm on/off	Termination resistance on the CAN bus. The default value is ON, and shall be used if nothing is connected to the CAN bus connector. If you connect anything on the CAN bus, for example a computer, you should have termination on the unit and set this switch to OFF.
CAN	CAN bus connector. To be able to see the communication of the BMS and the battery charger, a computer can be connected here. For example a CAN/Ethernet converter can be used to connect the computer. Apart from analyzing the CAN messages directly REAP Systems PCTool software can be used to monitor the battery status and change BMS parameters. Make sure to handle the CAN termination according to above.
RS232	RS232 interface used for configuration of the Brusa battery charger. Brusa Chargestar software can be used for configuration of the charger. This software can be freely downloaded from www.brusa.biz.

Table 2.22 Battery Charger Controls, Indications and connections

Control/indicator/connection	Function
Vehicle on indicator	Lit when the vehicle is connected to the charger and it is powered on.
Vehicle on/off	The vehicle is usually turned off during charging. However, this switch enables the possibility to have the vehicle turned on. To prevent too high starting current the vehicle can only be turned on as the charger is started. To start the vehicle this switch is held in the on position as the charger is turned on using the power on/off switch. The vehicle will switch off automatically after 10 hours or when the power to the charger is turned off.

Table 2.22 Battery Charger Controls, Indications and connections

2.6 Winch Manoeuvring Panel

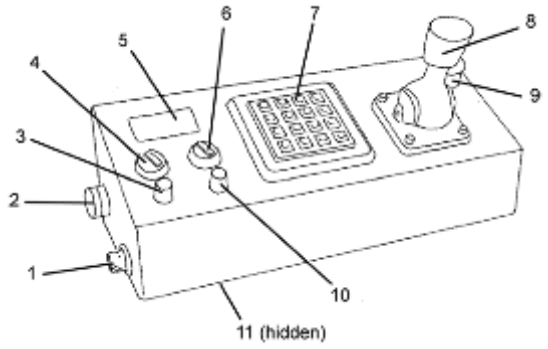


Figure. 2.22 ATC Winch Manoeuvring Panel

Control/indicator	Function
1. Optional Intercom connector	Not mounted on Sabertooth.
2. Main power on/off button	Switches power on and off. When on, an indication lamp is lit inside the button.
3. TENSION potentiometer	Sets the tension reference value in auto/tension or auto/ length mode.
4. MAN/AUTO switch	Switches between manual and automatic modes.

Table 2.23 ATC Winch manoeuvring panel controls and Indications

Control/indicator	Function
5. LCD	Displays winch status, messages and menus.
6. TENSION/LENGTH switch	In automatic mode this switches between constant tension and constant length modes.
7. Keyboard	Used for input of values and menu choices.
8. Control stick	In manual mode used for feeding in and out tether cable. In auto/length mode this changes the length reference value.
9. EMERGENCY STOP button	Emergency stop of motors. The computer is unaffected.
10. MAX SPEED potentiometer	Limits the tether “hauling in” speed in auto/tension and auto/length mode.
11. POCB connector	Not used.

Table 2.23 ATC Winch manoeuvring panel controls and Indications (Continued)

2.6.1 Mode selection

The ATC winch can be operated in four different modes:

- Manual mode
- Auto/tension mode
- Auto/length mode
- Remote mode

Manual Mode

Manual mode is chosen by setting the **MANUAL/AUTO** switch in the **MANUAL** position. In this case the **TENSION/LENGTH** switch is disabled.

The potentiometers change the max. speed and chosen tension, respectively, but these values have no affect in manual mode. The manoeuvring stick controls the tether cable tension. If pulled inwards, towards the operator, the cable tension will be increased for pulling in the tether. When pushed outwards, away from the winch operator, the breaking capstan torque will be released, and, if there is a pulling force present at the tether, the tether cable will be pulled out. This function eliminates the problem of slack between the drum and the capstan wheels and thereby spinning capstan wheel rubbing the tether.

The maximum tension when hauling in the tether cable is the maximum specified tension of the winch.

Warning! Make sure that no personnel are near the rotating parts and the tether before driving the winch.

Auto/tension Mode

This mode is chosen by setting the switches **MANUAL/AUTO** switch and the **TENSION/ LENGTH** switch into **AUTO** and **TENSION** positions, respectively.

The tension potentiometer sets the tether cable tension to be held by the winch. If the force pulling the cable is greater than the potentiometer set value, cable will be fed out from the winch. If, on the other hand, no force is pulling the cable, the winch will haul in the cable.

The value of the **MAX SPEED** potentiometer limits the speed of tether cable while hauling in only. In this mode the manoeuvering stick is disabled.

Warning! Be careful when entering the auto/tension mode. check that the set tension is proper before switching over.

Auto/length Mode

By setting the switches **MANUAL/AUTO** and **TENSION/LENGTH** switch into **AUTO** and **LENGTH** positions, respectively, the automatic mode for constant tether cable length is chosen.

The potentiometers **MAX SPEED** and **TENSION** changes the values of chosen tension and max. speed, respectively. The manoeuvring stick changes the chosen tether cable length. By pushing the stick forwards the length will be increased and tether cable will be fed out if there is a small force pulling the cable outwards and the actual tether cable length is less than the reference value. Oppositely, if the manoeuvring stick is pulled backward, the reference length will be decreased. In this case the tether cable will be pulled in if the set value becomes less than the actual cable length.

The tension in auto/length mode is determined by the TENSION potentiometer for lengths less than the reference value. When exceeding the reference length, the tension is increasing linearly to the maximum specified tension. Thereby, the real value of the length might differ from the reference value (the set length) with tenths of meters. Be careful since the winch is usually stronger than the ROV.

Warning! When entering the auto/length mode the reference value of the length will be set to the actual length. Thus, there will not be any abrupt changes in the operation when changing to auto/length mode. Minimum tension is controlled by the tension potentiometer.

Remote Mode

The winch can be set to allow remote mode from the winch keyboard. In this mode the winch will be controlled by commands via the serial winch link.

If the winch link goes down temporarily, the winch will automatically return to the mode set on the control panel during that time. If the power to the winch is shut off when operating in remote mode, it will stay in remote mode when power comes back.

Remote mode control is described in the MMI chapter.

2.6.2 The LCD

The LCD continuously shows information about the winch status, tether cable status and possible warnings. The LCD always shows the following information:

- Actual cable tension (N)
- Actual cable length fed out (m)
- Preset value of cable tension (N)
- Preset value of cable length to be fed out (m).

In remote mode the LCD shows:

- An indication of remote mode operation.
- Actual control mode (manual, tension or length) and preset values of tension or length.

2.6.3 Menu System

When entering the menu, the LCD shows the main menu and the sub-menus as shown in figure 4:

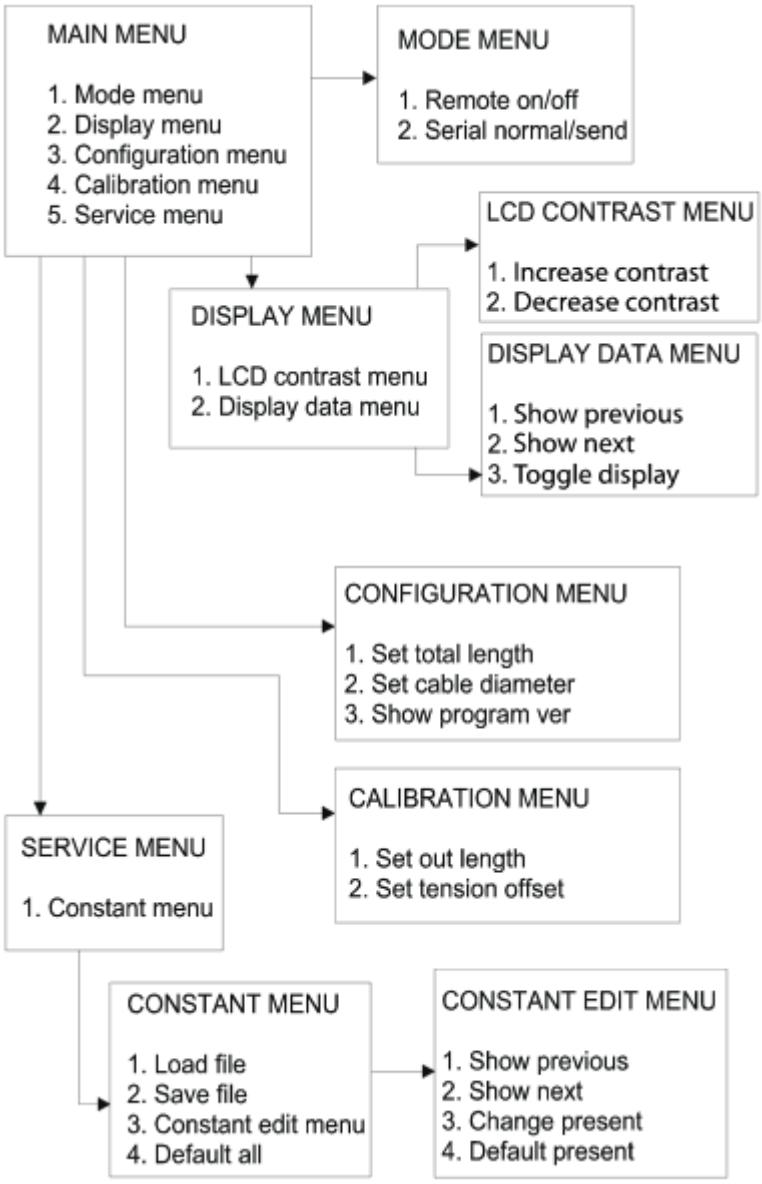


Figure. 2.23 The menu system including all levels of sub-menus

Choice	Function
1 Mode menu	Enters a submenu (see the following description).
2 Display menu	Enters a submenu (see the following description).

Table 2.24 Main menu

Choice	Function
3 Configuration menu	Enters a submenu (see the following description).
4 Calibration menu	Enters a submenu (see the following description).
5 Service menu	Enters a submenu (see the following description).

Table 2.24 Main menu

Choice	Function
1 Remote on/off	Enables and disables remote mode. When remote mode is disabled a remote controller (in this case the SAC) cannot take control over the winch. When enabled the remote controller can take control at any time. In remote mode the winch operator can override the remote mode and take control by pressing 0 on the keyboard.
2 Serial normal/send	Changes between normal and send mode for the serial link. In normal mode the winch only sends a reply on the serial link when it has received a message from a remote controller. In send mode the winch sends a message once per second and ignores incoming messages. Send mode is usually only used for faultfinding purposes.

Table 2.25 1 Mode menu

Choice	Function
1 LCD contrast menu	Enters a sub menu (see the following description). The contrast can also be changed directly from the keyboard, see section 3.4 Keyboard.
2 Display data menu	Enters a sub menu (see the following description).

Table 2.26 2 Display menu

Choice	Function
1 Increase contrast	Increases contrast voltage. Use Increase/Decrease contrast to get optimal contrast at the present temperature.
2 Decrease contrast	Decrease contrast voltage. Use Increase/Decrease contrast controls to get optimal contrast at the present temperature.

Table 2.27 1 LCD contrast menu

Choice	Function
1. Show previous	Show previous data variable and its value.
2. Show next	Show next data variable and its value.
3. Toggle display	Selects/unselects if the variable shown below shall be displayed on the normal display, that is, when the menu system is not used. A * will be shown in front of the data variable if it is selected to be displayed. If several data variables are selected they will be shown one after the other.

Table 2.28 2 Display data menu

Choice	Function
1 Set total length	Shows the presently stored total tether length in meters. By pressing CLR is possible to enter a new total length. The fed out tether length is calculated using the drum movements. Since the drum has several layers of tether it is necessary to know the total length to make a correct calculation.
2 Set cable diameter	Shows the presently stored tether diameter in millimeters. By pressing CLR it is possible to enter a new value. This value is used to make a correct calculation of fed out tether length.
3 Show program ver	Shows the present program version.

Table 2.29 3 Configuration menu

Choice	Function
1 Set out length	Shows how much tether is fed out for the moment. The value is in meters. By pressing CLR it is possible to enter a new value.
2 Set tension offset	Shows the presently stored tension offset in Newton. By pressing CLR it is possible to enter a new value. The load cell amplifier is calibrated during manufactory, but if the zero offset for some reason has changed somewhat it is possible to enter a small offset here. For proper function the tension shown on the display should be 0 ±5 N when the tether is not touching the load cell.

Table 2.30 4 Calibration menu

Choice	Function
Constant menu	Enters a submenu (see the following description).

Table 2.31 5 Service menu

Choice	Function
1 Load file	If constants have been changed the old setting is retrieved by selecting this choice.
2 Save file	Saves a new constant setting permanently. Even if the winch is turned off and on again the new setting will be used.
3 Constant edit menu	Enters a submenu (see the following description).
4 Default all	Changes all constants to the default values selected during manufactory. If constants have been changed by mistake first select Default all and then Save file. The winch will then use the default constants, even after a shut down.

Table 2.32 1 Constant menu

Choice	Function
1 Show previous	Displays the previous constant and its value.
2 Show next	Displays the next constant and its value.
3 Change present	Change the constant presently displayed. If Save file is not used after the change, the old setting will be used after a shut down.
4 Default present	Change the constant presently displayed to its default value. If Save file is not used after the change, the old setting will be used after a shut down.

Table 2.33 1 Constant edit menu

2.6.4 Keyboard

The keyboard is used for entering the menu, changing the setup or changing the mode. The function of every key is shown in tables below.

Key	Function
ENT	Opens the menu.
8↑	Increases the LCD contrast voltage.
2↓	Decreases the LCD contrast voltage.
Ø	Remote mode stop (used for emergency brake of remote mode).

Table 2.34 1 Menu Closed

Key	Function
ENT	Up one menu level; closes menu from main menu.
Digit + ENT	Choice of menu.
Digits + ”.” + ENT	Value input.
C	Gives minus sign “-” (used for negative constants).
CLR	Erases last character.

Table 2.35 1 Menu Open

2.7 Winch Connections

Figure. 2.24 Winch Connections

Connection	Function
1 – Optical fiber connection to SCU	Fibre-optic connector for the optical vehicle link. This connector shall be connected to the fibre-optic converter in the SCU.
2 – RS485 link to SCU	RS485 link for information from the winch and control of the winch. This is connected to the SAC.
3 – Input power	400/440 VAC 3-phase power to the winch. The attached 1 meter cable is equipped with a 3-phase + neutral + safety ground 400V/16A power connector according to international standard IEC 60309.
4 – Tether to vehicle	The 9 km long fibre-optic tether is connected to the vehicle.

2.8 Surface Control Unit Connections

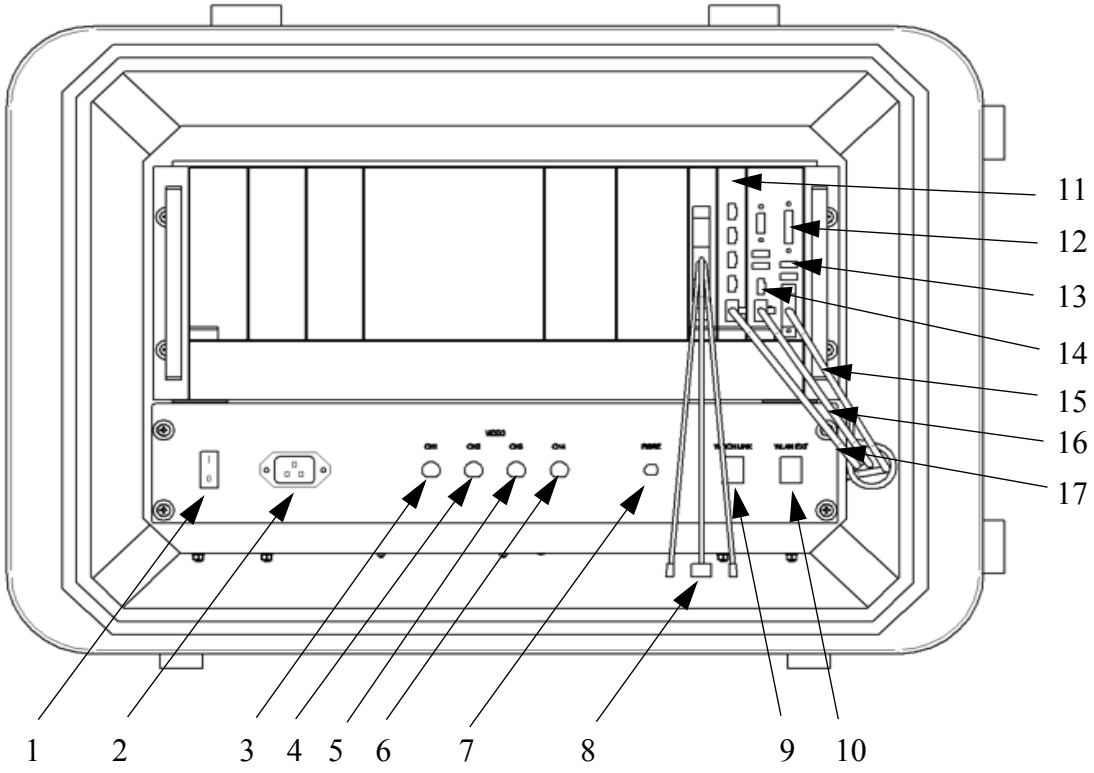


Figure. 2.25 Surface Control Unit Connections

Connection	Function
1 – Power on/off switch	Power switch to the SCU.
2 – Power input connector	100-240 VAC power input connector for supply of the SCU.
3 – Video output 1	BNC connector with video from Focal unit channel 1. Connected to UW connector C1 in the vehicle (OE14-110 camera on front tilt).
4 – Video output 2	BNC connector with video from Focal unit channel 2. Connected to UW connector C2 in the vehicle (aft OE14-110 camera).
5 – Video output 3	BNC connector with video from Focal unit channel 3. Connected to UW connector C3 in the vehicle (Tritech camera on front tilt).

Connection	Function
6 – Video output 4	BNC connector with video from Focal unit channel 4. Connected to UW connector C4 in the vehicle (no camera connected).
7 – Fiber-optic input	Fiber-optic ST connector for the vehicle tether link. Shall be connected to the winch.
8 – Serial data outputs	The serial board is equipped with a cable with four connectors: 1 – RS232 link sending navigational data in the packet $CATNA to be used by external equipment. See separate interface specification. Configured as COM3. 2 – RS232 link sending status information in the packet $CATST to be used by external equipment. See separate interface specification. Configured as COM4. 3 – No MX module fitted on serial board. 4 – No MX module fitted on serial board.
9 – Winch link connector	RS485 link connector to be connected to the winch so that the SAC can read data from the winch and have the possibility to control the winch. Even though RS485 is transmitted, a standard 8P8C connector is used so that a standard Ethernet cable can be used for the connection to the winch.
10 – WLAN antenna connector	Standard Ethernet 8P8C connector that is connected to the WLAN antenna when the vehicle shall be run in untethered mode.
11 – Ethernet switch	This Ethernet switch is connected to the vehicle subnet. This means that any of the unused connectors can be used if one wants to make a direct connection to the vehicle (without tether or WLAN). This can be useful for faultfinding or for downloading data without a tether connected.
12 – Monitor DVI output	DVI output that is connected to the computer monitor.
13 – USB connectors	USB connectors that are used for connecting mouse and OCB.

Connection	Function
14 – External Ethernet connection	Ethernet connector that an external LAN (or Internet) can be connected to. This is a subnet separate from the vehicle and WLAN subnets. DHCP is enabled so that this LAN connection can acquire an IP address from the external LAN. A KLM server is set up so that an external computer running Google Earth can acquire the vehicle position this way. There is also a folder shared on this LAN connection so that tracks created in Google Earth can be saved in this folder and then imported to the mission planner.
15 – Winch link connection	Connection between the computer COM1 port and the RS485 converter used for winch communication. This connector is not to be disconnected.
16 – Ethernet WLAN connection	Connection to the Ethernet connector on the SAC used for communication with the WLAN antenna. This connector is not to be disconnected.
17 – Ethernet vehicle connection	Ethernet connection between the SAC and the fiber-optic converter. This connector is not to be disconnected.

2.9 Vehicle Connectors

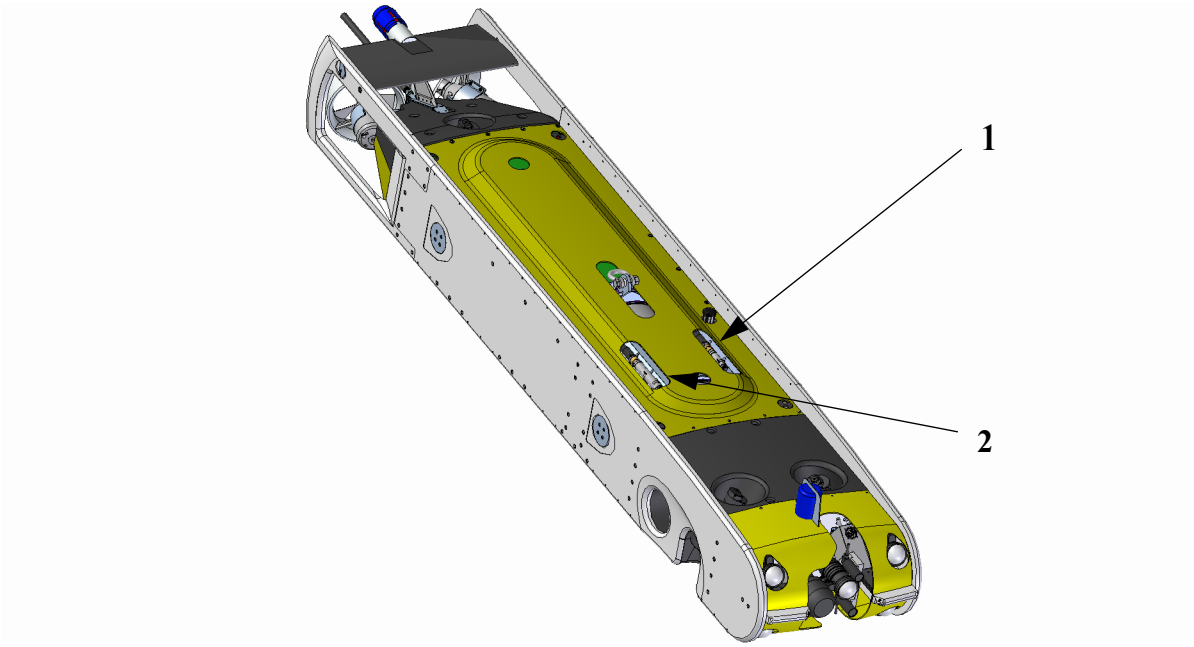


Figure. 2.26 Vehicle Connectors

Connection	Function
1 – BC Battery Charger Connector	When charging the vehicle the Vehicle power cable from the Battery charger is connected here. When not connected to the battery charger the connector shall be protected by a cap. It is also possible to connect the Battle Mode key to this connector. The Battle Mode key prevents the battery management system to disconnect the batteries even if there is an error. **Observe!** The battery cells and the vehicle can be damaged if there is a fault in the battery system when the Battle Mode key is connected. The Battle Mode key shall only be used when it is very important that the vehicle does not shut off.
2 – OF On/Off connector	When charging the vehicle the Vehicle CAN cable from the Battery charger is connected here. This connector is also used for turning the vehicle on and off. The vehicle is powered on by inserting the Vehicle On key. The connector shall be protected by a cap when there is nothing connected. **Observe!** When inserting the Vehicle On key first move the connector shell back. Insert and remove the key straight, firmly and quickly. If there is too long time between mating of different pins in the connector the battery fuse in the vehicle may blow.

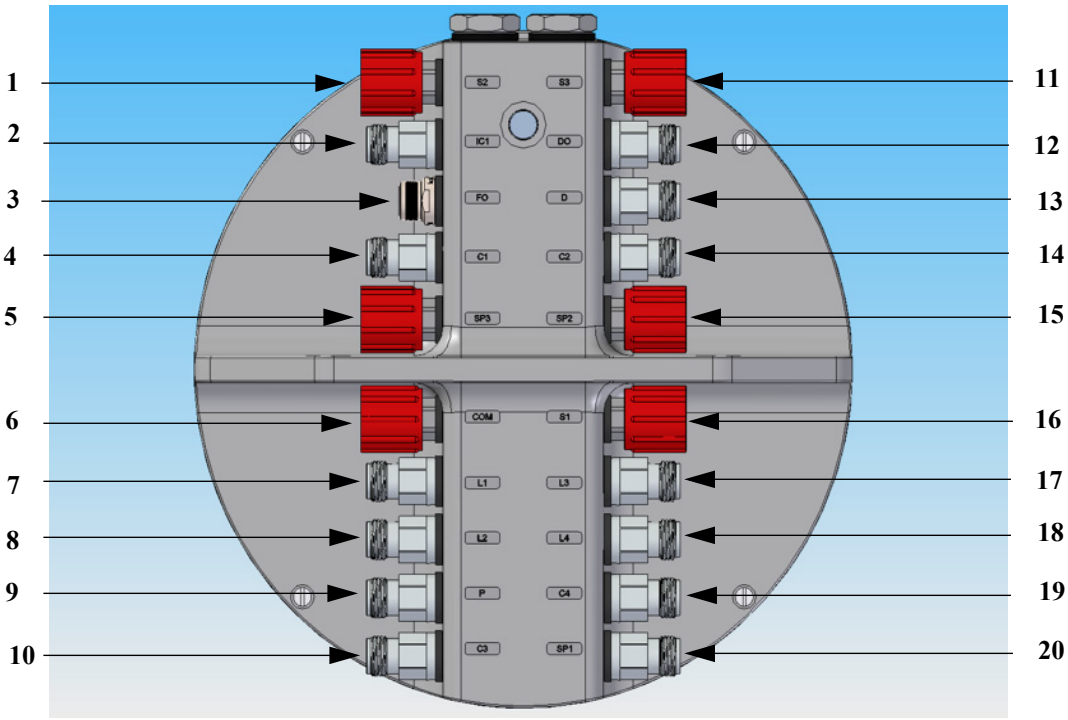


Figure. 2.27 Electronics tank, front lid

Connection	Function
1 – S2 Sonar 2 connector	Connected to aft 881L sonar. Transfers Ethernet and 24V DC.
2 – IC1 Interconnection connector	Connection to the aft lid connector IC2. Transfers CAN and Castle2 communication as well as 24V DC.
3 – FO Fiber optical connector	Single mode connection to the tether. Only one fiber is connected inside.
4 – C1 Camera 1 connector	Camera input connected to video server port 1 and Focal video channel 1. Outputs 24V DC. Connected to OE14-110 camera on tilt unit.
5 – SP3 Spare 24V + Ethernet connector	Spare connector with 24V DC and Ethernet. Sonars or other equipment can be connected here. Since the vehicle Ethernet subnet can be accessed here it is possible to connect the SAC for faultfinding or data downloading.
6 – COM Communication unit connector	Connected to communication unit. Transfers GPS link, Ethernet for WLAN, 12V DC and leak indication. There is also radio modem connection that is presently not used.
7 – L1 Lamp 1 connector	Connected to the front upper starboard LED lamp. Transfers Castle2 and 24V DC so other Seaeye units can be connected here.

Connection	Function
8 – L2 Lamp 2 connector	Connected to the front upper port LED lamp. Transfers Castle2 and 24V DC so other Seaeye units can be connected here.
9 – P SVP connector	Connector for an optional SVP70 sound velocity probe. Supplies 12V DC. RS232 link is connected to INS.
10 – C3 Camera 3 connector	Camera input connected to Focal video channel 3. Outputs 24V DC. Connected to Tritech camera on the tilt unit.
11 – S3 Sonar 3 connector	Connected to Blueview sonar. Transfers Ethernet and 24V DC.
12 – DO Doppler connector	Connected to RDI Doppler log. Transfers 24V DC to DVL and RS232 link to INS.
13 – D Depth sensor connector	Connected to Digiquatz depth sensor. Transfers RS232 link and 24V DC.
14 – C2 Camera 2 connector	Camera input connected to video server port 2 and Focal video channel 2. Outputs 24V DC. Connected to the aft OE14-110 camera.
15 – SP2 Spare 24V + Ethernet connector	Spare connector with 24V DC and Ethernet. Sonars or other equipment can be connected here. Since the vehicle Ethernet subnet can be accessed here it is possible to connect the SAC for faultfinding or data downloading.
16 – S1 Sonar 1 connector	Connected to Obstacle avoidance sonar. Transfers Ethernet and 24V DC.
17 – L3 Lamp 3 connector	Connected to the front lower port LED lamp. Transfers Castle2 and 24V DC so other Seaeye units can be connected here.
18 – L4 Lamp 4 connector	Connected to the front lower starboard LED lamp. Transfers Castle2 and 24V DC so other Seaeye units can be connected here.
19 – C4 Camera 4 connector	Camera input connected to Focal video channel 4. Outputs 24V DC. Extra camera can be connected here.
20 – SP1 Spare 24V + RS232	Spare connector with 24V DC and RS232 link connected to RAC.

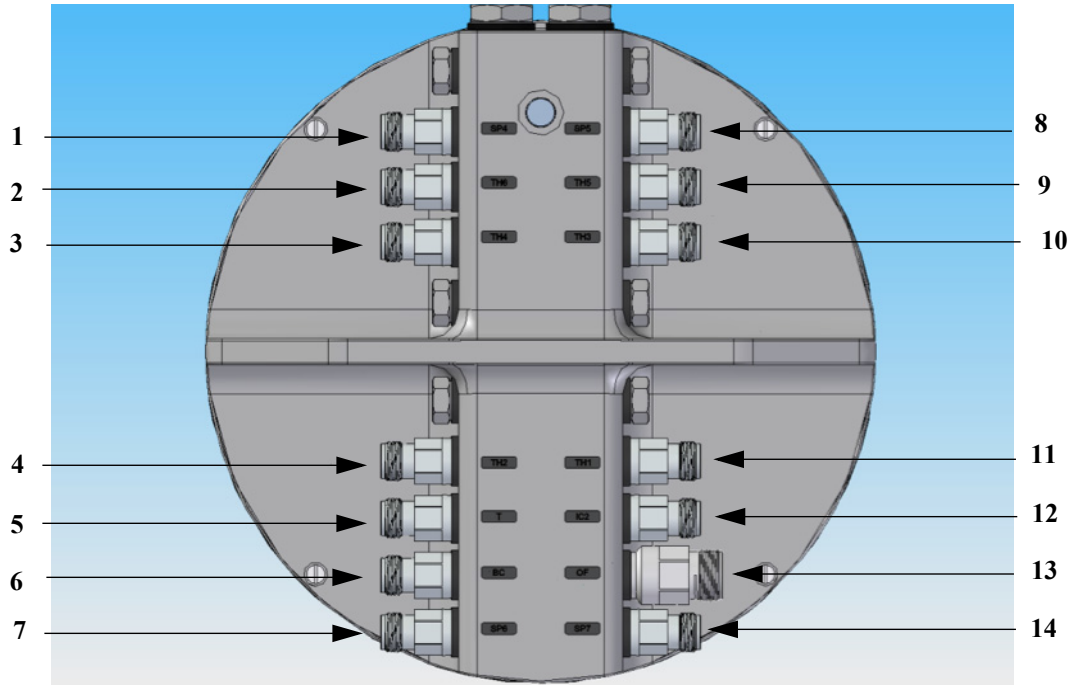


Figure. 2.28 Electronics tank, aft lid

Connection	Function
1 – SP4 Spare 24V + Castle2 connector	Spare connector transferring 24V DC and Castle2. Connected to LED lamp on front tilt unit.
2 – TH6 Thruster 6 connector	Connected to aft Z SM4 thruster.
3 – TH4 Thruster 4 connector	Connected to front port YZ SM4 thruster.
4 – TH2 Thruster 2 connector	Connected to aft port SM9 thruster.
5 – T Tools connector	Spare tools connector transferring 250V DC and Castle2 bus.
6 – BC Battery charger connector	Connected to an extension lead so that the connector can be reached from the top of the vehicle. Transfers 250V DC to the battery. Also contains Battle Mode key detection.
7 – SP6 Spare 24V + Castle2 connector	Spare connector transferring 24V DC and Castle2. Connected to port tilt unit.
8 – SP5 Spare 24V + Castle2 connector	Spare connector transferring 24V DC and Castle2. Connected to aft LED lamp.
9 – TH5 Thruster 4 connector	Connected to front Y SM4 thruster.
10 – TH3 Thruster 3 connector	Connected to front starboard YZ SM4 thruster.
11 – TH1 Thruster 1 connector	Connected aft starboard SM9 thruster.

Connection	Function
12 – IC2 Interconnection connector	Connection to the front lid connector IC1. Transfers CAN and Castle2 communication as well as 24V DC.
13 – OF On/off connector	Connected to an extension lead so that the connector can be reached from the top of the vehicle. Transfers CAN bus and several relay loops for battery control.
14 – SP7 Spare 24V + Castle2 connector	Spare connector transferring 24V DC and Castle2. Connected to starboard tilt unit.

2.10 IP Addresses

The different units in the system have the following IP addresses.

- SAC: 10.73.100.248 + 10.73.200.249 (WLAN)
- Videoserver1: 10.73.100.201
- Videoserver2: 10.73.100.202
- Profiling sonar: 10.73.100.190
- WLAN SCB: 10.73.200.100
- WLAN Vehicle: 10.73.200.110
- RAC: 10.73.100.244 + 10.73.200.245 (WLAN)
- CANView Ethernet: 10.73.100.180
- Castle2 Gateway YZ: 10.73.100.71
- Castle2 Gateway Aft: 10.73.100.72
- Castle2 Gateway Front: 10.73.100.73
- Phins: 10.73.100.222

CHAPTER 3

ASSEMBLY AND

INSTALLATION

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3. ASSEMBLY AND INSTALLATION

This Chapter details the instructions for receipt and installation of the Sabertooth ROV 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.

3.1 Introduction

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, Chapter 7) 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 been incurred during operational use, allowing the operator to rectify them and ensuring the vehicle can be stored operational and ready for its next dive.

3.2 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 LTD. immediately.

Prior to dispatch a stringent Quality Control Inspection is carried out. A copy is contained with the vehicles record document, however it is recommended that the contents is examined for any damage that may have occurred during transit.

It is recommended that all packaging and packing cases be retained for subsequent storage, transportation or return-to-works.

3.3 Adverse Effects of Extreme Climatic Conditions

Saab Seaeye Ltd. Technical Department advises that extremes of temperature and climate can adversely affect the performance of all systems in the Seaeye Fleets. In some cases, extreme climatic conditions can cause irreparable damage to sensitive electronic components.

A particular risk is the subsea equipment (ROV, 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”.

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.

3.4 Preparations

3.4.1 Unpacking

Some of the parts are delivered in boxes. Notice how the parts are packed. Handle the emballage and boxes with care.

3.5 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:

- Winch = 400–440 VAC
- Battery charger = 100–260 VAC
  If the voltage is below 200 VAC the battery charger needs to be reconfigured according to Saab instructions.
- SCU = 100–240 VAC

3.6 Connection

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.

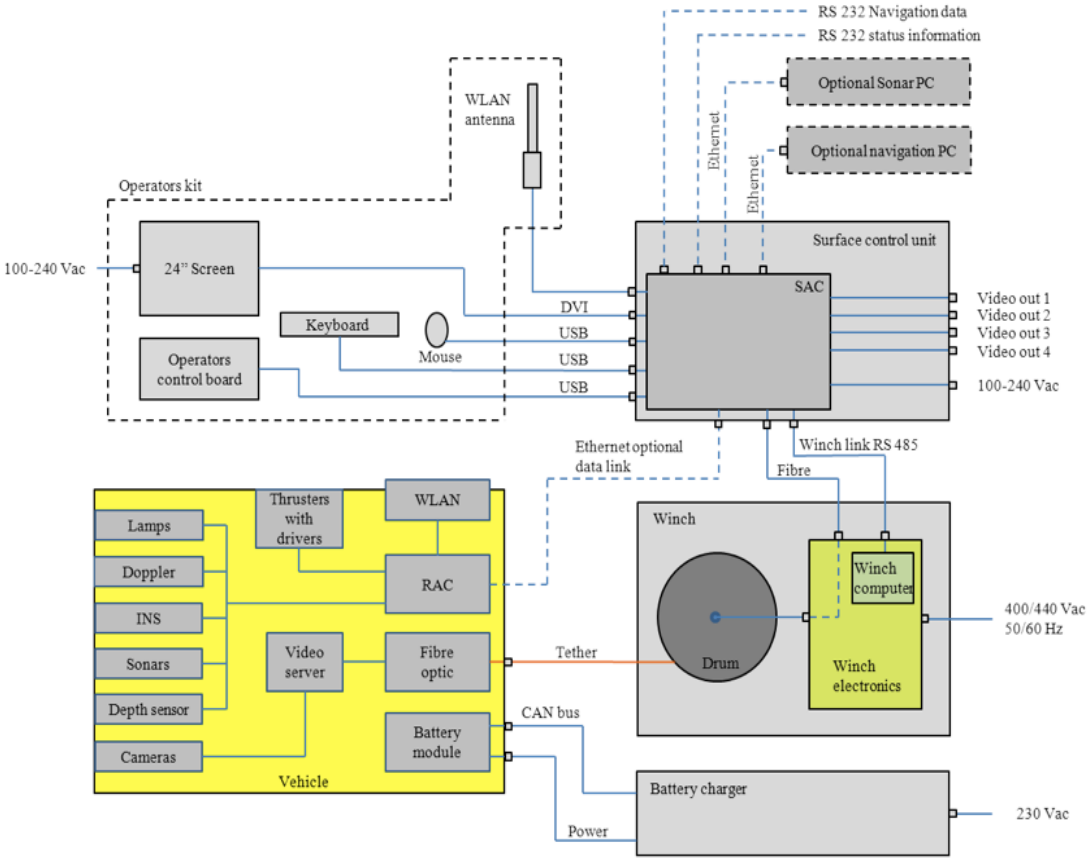

Figure. 3.1 Connection drawing

3.6.1 Connecting the Winch

1. The winch can pull approximately 2500 N and must be securely fastened.
2. Keep the winch on the pallet and secure the pallet, or remove the winch from the pallet and bolt it to the surface.
3. Check the following on the control panel.
   - Power ON/OFF switch in OFF position
   - Emergency stop activated (pressed)
   - MAN/AUTO switch in MAN position
   - TENSION/LENGTH switch in TENSION position
   - TENSION potentiometer fully counterclockwise (minimum tension)
   - MAX SPEED potentiometer fully counterclockwise (minimum speed)
4. Loosen the tether so that it is prepared to be pulled out when the winch is started.
5. Check that no foreign material (packing material, etc.) is in the capstan.
6. Check that the tether is properly reeled on the capstan.

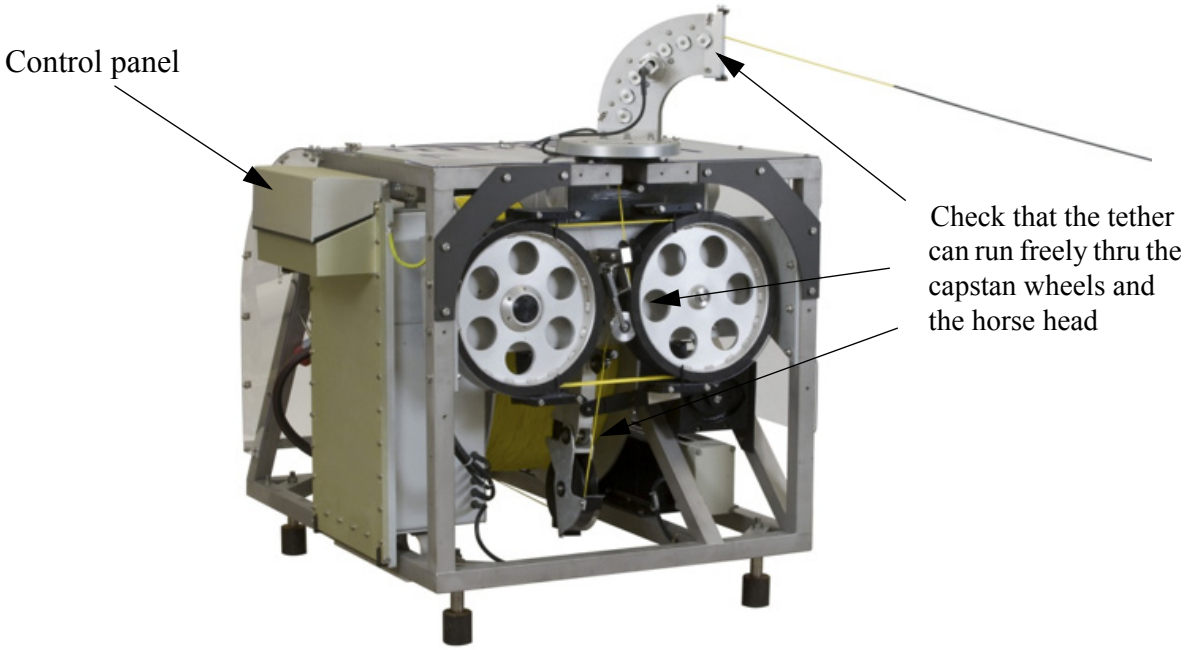

Figure. 3.2 Connecting the winch

7. Connect the 400/440 V AC 3-phase power supply to the winch. Before connecting, check the GND connection between the input connector GND pin to the winch frame and the electronics box.

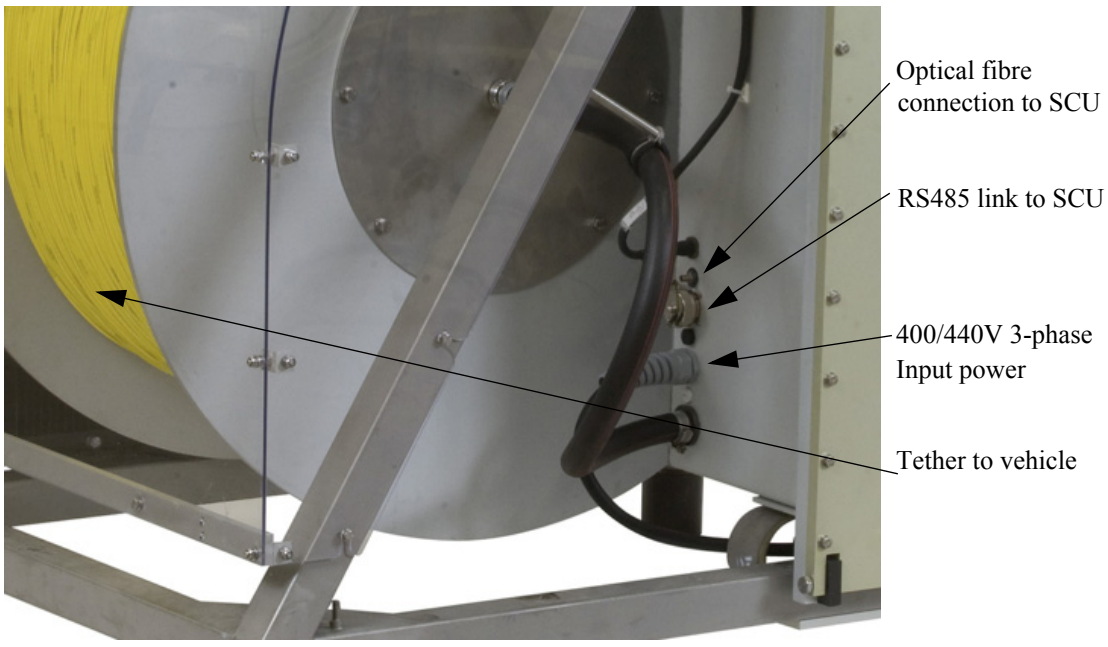

Figure. 3.3 Connectors on the winch

8. Switch on the winch by pressing the “POWER” button, it is lit when pressed. After approximately 10 seconds the LCD screen will be lit.

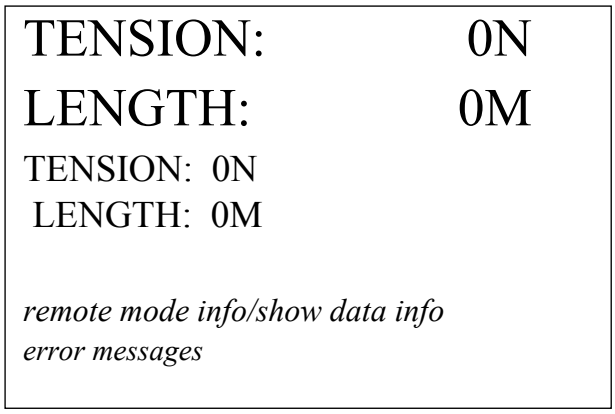

Figure. 3.4 LCD screen on the winch

9. Pull out the emergency stop. The motor drivers will start. Be prepared to push the emergency stop again if any strange sound or abnormal behaviour occurs.
10. Push the joystick forward to be able to pull out the tether.
11. Pull out the amount of tether needed to connect the vehicle.
12. Switch off the power to the winch.

3.6.2 Connecting the SCU

1. Connect the optical fibre and the RS485 link from the winch to the SCU.
2. Connect the DVI out to the monitor.
3. Connect the mouse and the OCB.
4. Connect the WLAN antenna.
5. Connect the video camera outputs if desired.
6. Check that the POWER switch is off and connect the power to the power input.

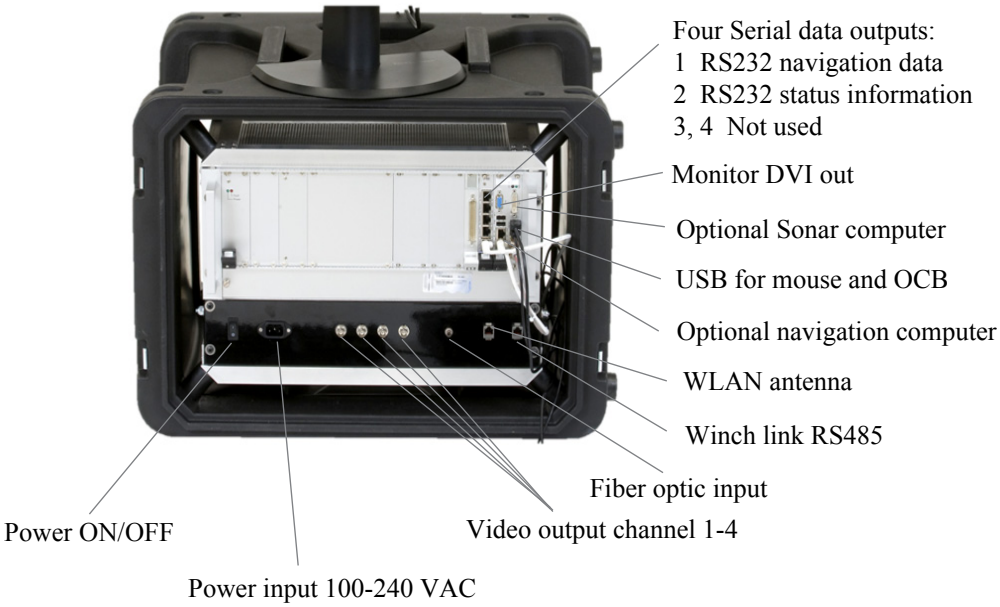

Figure. 3.5 Connections on the SCU

3.7 Battery Charging and Installation Test

Charge the battery according chapter 7 task 8.

Perform System test according to chapter 7 task 1.

CHAPTER 4

OPERATIONAL USE

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4. OPERATIONAL USE

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

4.1 Warnings

The following warnings must be read and understood before operating the Sabertooth ROV System.

WARNING:

Warning. Keep fingers, loose clothing, ropes etc. away from the thrusters when the ROV is powered up. Do not operate the ROV, with unguarded thrusters, near swimmers or divers. The propellers are powerful enough to cause serious harm.

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

CAUTIONS:

Do not operate the thrusters when the ROV is out of the water. The propeller bearings rely on the surrounding water for lubrication. When doing pre-dive checks, simply move the joystick away from the centre position and allow it to self-centre immediately. This will give sufficient movement of the thrusters to check direction of rotation.

Do not look directly into the lights. The lamps are very powerful and your eyes can get damaged.

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

Ensure the tether connectors are clean and dry before connecting. Protect connectors from physical damage and dirt when not in use, replace protective caps when disconnected.

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.

Always protect the ROV from being struck by or swept into boat hulls, docksides or other hazards, especially during launch and recovery.

⚠ Never operate the ROV near moving ships propellers.

⚠ Always check the security, suitability and condition of all lifting equipment.

4.2 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 re-configuring.

4.2.1 Calibrating Depth Sensor

With the vehicle in air, calibrate the depth sensor by entering the depth = 0 meters and then press the Set button under the Control tab in the MMI.

4.2.2 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, since the vertical propellers will not have to compensate heavily to hold a constant depth. However, always make sure that the vehicle is buoyant; otherwise the vehicle will sink in case of a link failure or power loss.

❗ The vehicle is better too buoyant than too heavy. This is especially important when using the vehicle untethered.

Ideally, the buoyancy of the vehicle should be adjusted until the top of the vehicle is barely visible at the surface. The vehicle is normally delivered positively buoyant (in fresh water), since it is far more easy to make it heavy than to make it buoyant.

Checking the buoyancy is done by launching the vehicle and visually checking the buoyancy of the vehicle, while it is in deck mode. Since air is often trapped inside the hull, dive 1-2 meters and observe the behaviour, while in deck mode. The vehicle should slowly come back to the surface and not roll or pitch too much.

Another useful method is to dive just below the surface and let it stay there in cruise mode. 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 badly balanced.

The buoyancy is adjusted by adding or removing lead bars in the four lead compartments, see Figure. 4.1. Underneath the top lid it is also possible to add lead plates next to the lead compartments.

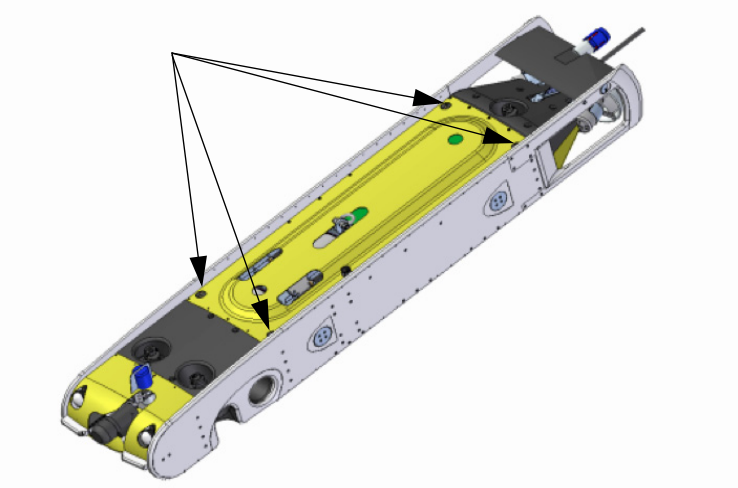

Figure. 4.1 Lead compartments

To quicker find the correct amount of lead weights when to use the vehicle in a different salinities the table below can be used.

Salinity	No. of 900g weights at the front	No. of 900g weights at the aft
0 %	(mounted at factory)	(mounted at factory)
0.5 %	+1	+1
1 %	+3	+2
1.5 %	+5	+3
2 %	+6	+5
2.5 %	+8	+6
3 %	+10	+7
3.5 %	+12	+8
4 %	+14	+9
4.5 %	+16	+10

Table 4.1 Lead weights at different salinities

4.2.3 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 MMI. To do this the Control tab is selected and the salinity is entered in the appropriate box. After this the Set button is pressed.

4.2.4 Setting system time

Setting the system time of the SAC and the RAC is done from the menu button Function/ System Time at the top of the MMI. To set the RAC system time the vehicle must be started and have communication to the SCU.

! Observe that the SAC and RAC applications will be restarted when setting the system times. Never do this when operating the vehicle.

4.3 Power ON procedure - tethered operation

Power the system on according to the following procedure:

1. Ensure that the system has been fully set-up in accordance with the procedures in chapter 3.
2. Turn on the power to the Surface Control Unit, not to the vehicle.
3. Start the CARUS and MMI programs on the SAC by double clicking the icons on the desktop.
4. Take control using the MMI by clicking the button Take Control.
5. Check the MMI so that the text Tether and WLAN in the Overview tab is white. If the text is red the MMI has no contact with the CARUS application. There should also not be any other unexpected error messages shown.
6. Set the buttons on the MMI in accordance with the following list:
   - **Overview tab**
   - Joystick sensitivity: 100%
   - Control Modes: Deck
   - Global functions - Cruise: Off
   - Global functions - Roll Lock: Off
   - Auto Functions: Depth
   - **Control tab**
   - Doppler: On
   - Lamps: Fully turned off
7. Check that the following is set on the winch control panel:
   - MAN/AUTO switch: MAN position
   - TENSION/LENGTH switch: TENSION position
   - TENSION potentiometer: Fully CCW (min tension)
8. Check that no foreign objects have fallen into the horse head, capstan mechanism, pendulum mechanism, belt transmission or onto the drum. Also check that the tether is properly reeled on the capstan.
9. Switch ON the winch by pressing the “POWER” button, it is lit up when pressed. After approx. 10 sec. the LCD screen will be lit.

10. On the overview tab of the MMI check that the error message Winch Link is not shown on the MMI and that the text in the tether information box is not red (Tether, Deployed, Tension).

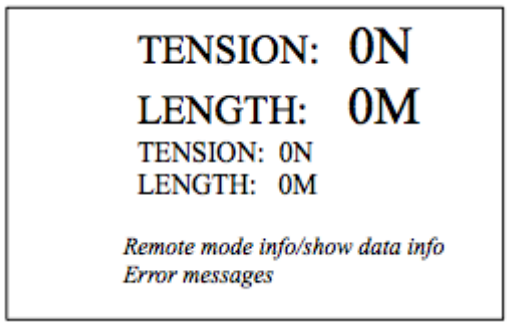

Figure. 4.2 MMI display

11. Push the joystick forward and check that it is possible to pull out the tether.
12. Gently pull the joystick towards you to check that it is possible to reel in tether.
13. Turn the power to the vehicle on by connecting the start key to connector OF on the vehicle. After approx. half a minute the ROV Link Error on the MMI shall disappear, the Tether indicator shall go green and red data like roll and pitch on the MMI shall go white. Also camera pictures shall appear on the MMI.

! When inserting the Start Key first move the connector shell back. Insert and remove the key straight, firmly and quickly. If there is too long time between mating of different pins in the connector the battery fuse in the vehicle may blow.

14. Ensure that no propellers are rotating and that all lamps are OFF.

NOTE. The vehicle can be used in battle mode, in which the BMS warnings about low battery voltage are ignored and it is possible to continue driving the vehicle until the battery is empty. To be able to do that, use the battle mode key beside the start key.

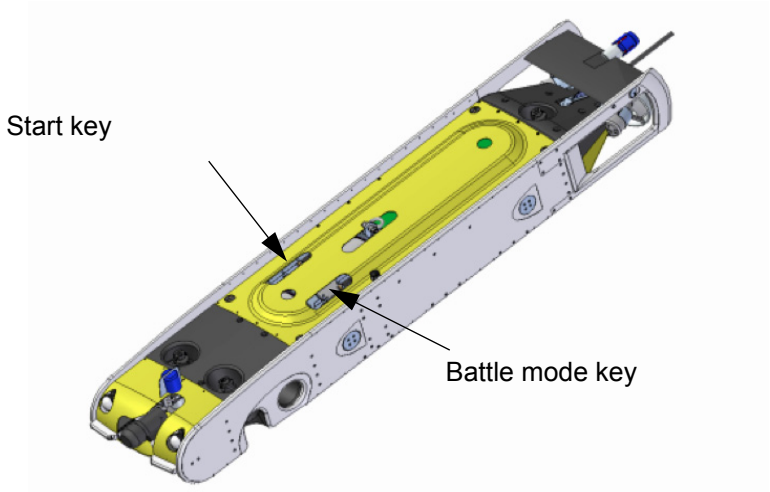

Figure. 4.3 Battle mode and start keys

15. INS Alignment is shown on the MMI for approximately five minutes after the vehicle have been started. During this time the vehicle shall be as stable as possible
16. After approximately five minutes INS Alignment disappears and is replaced with INS Fine Align. All INS related errors that were shown shall disappear except No DVL data to the INS when the vehicle is on deck.

4.4 Power ON procedure - untethered operation

Power the system on according to the following procedure:

1. 1. Ensure that the system has been fully set-up in accordance with the procedures in chapter 3.
2. Turn on the power to the Surface Control Unit, not to the vehicle.
3. Start the CARUS and MMI programs on the SAC by double clicking the icons on the desktop.
4. Take control using the MMI by clicking the button Take Control.
5. Check the MMI so that the text Tether and WLAN in the Overview tab is white. If the text is red the MMI has no contact with the CARUS application. There should also not be any other unexpected error messages shown.
6. Set the buttons on the MMI in accordance with the following list:
   - **Overview tab**
   - Joystick sensitivity: 100%
   - Control Modes: Deck
   - Global functions - Cruise: Off
   - Global functions - Roll Lock: Off
   - Auto Functions: Depth
   - **Control tab**
   - Doppler: On
   - Lamps: Fully turned off

7. Turn the power to the vehicle on by connecting the start key to connector OF on the vehicle. After approx. half a minute the ROV Link Error on the MMI shall disappear, the WLAN indicator shall go green and red data like roll and pitch on the MMI shall go white. There is no camera picture transmitted when using WLAN.

! When inserting the Start Key first move the connector shell back. Insert and remove the key straight, firmly and quickly. If there is too long time between mating of different pins in the connector the battery fuse in the vehicle may blow.

8. Ensure that no propellers are rotating and that all lamps are OFF.

NOTE. The vehicle can be used in battle mode, in which the BMS warnings about low battery voltage are ignored and it is possible to continue driving the vehicle until the battery is empty. To be able to do that, use the battle mode key beside the start key.

9. INS Alignment is shown on the MMI for approximately five minutes after the vehicle have been started. During this time the vehicle shall be as stable as possible
10. After approximately five minutes INS Alignment disappears and is replaced with INS Fine Align. All INS related errors that were shown shall disappear except No DVL data to the INS when the vehicle is on deck.

4.5 Pre-dive procedure

See Task 1 in chapter 7.

4.6 Mission planning

The following description assumes a separate computer with Google Earth is connected to the SAC. See further details regarding the MMI in chapter 2.

1. Create a number of actions in the Mission planner tab in the MMI.
2. Set one of the actions to be the start action.
3. Create a track in Google Earth and save the track in KML format in the shared folder on the SAC.
4. To import the track to an action (transit or optical survey), double left click the action in the Mission planner to open the Action Edit window.
5. Select File/Load KML waypoints in the Action Edit window and then select the file that was saved from Google Earth.
6. When the mission is complete press the key Prepare Mission in the Mission planner.
7. Upload the mission to the vehicle by pressing the key Upload Mission on the Overview tab in the MMI.
8. When the vehicle is in a suitable position close to the start point select Auto on the Overview tab in the MMI to start executing the mission.

4.7 Post-dive procedure

See Task 2 in chapter 7.

4.8 Power OFF procedure

When the operation is finished, perform the following procedure to turn OFF the system:

1. If the Battle Mode Key is used remove it from the BC connector. Attach the protection lid to the connector.
2. Turn off the vehicle by removing the Start Key from connector OF. Attach the protection lid to the connector.

! When removing the Start Key first move the connector shell back. Insert and remove the key straight, firmly and quickly. If there is too long time between mating of different pins in the connector the battery fuse in the vehicle may blow.

3. Turn off the winch with the power ON/OFF switch on the winch manoeuvre panel.
4. Turn off the SAC by shutting down Windows the normal way.
5. Turn off the SCU with the power ON/OFF switch on the SCU front panel.
6. Rinse the vehicle with fresh water.

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CHAPTER 5

SYSTEM FUNCTIONAL DESCRIPTION

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5. SYSTEM FUNCTIONAL DESCRIPTIONS

This chapter, with the aid of block diagrams, describes the various functions of the Sabertooth system.

5.1 Surface Control Unit

The Surface Control Unit (SCU) is the unit at the surface that is responsible for control and communication. The SCU consists of:

- Surface Application Computer (SAC)
- Fiber-optic receiver for Ethernet (including streaming video)
- Fiber-optic receiver for video
- Coarse Wave Division Multiplexer (CWDM)
- RS485/RS232 converter for communication with the winch
- Power Over Ethernet (POE) supply used for powering the WLAN access point and its antenna

Figure. 5.1 Surface Communication unit together with display, keyboard and OCB.

The SCU block diagram in figure 5.2 shows the connection between the different units. The fiber-optic system is deeper described in the vehicle chapter.

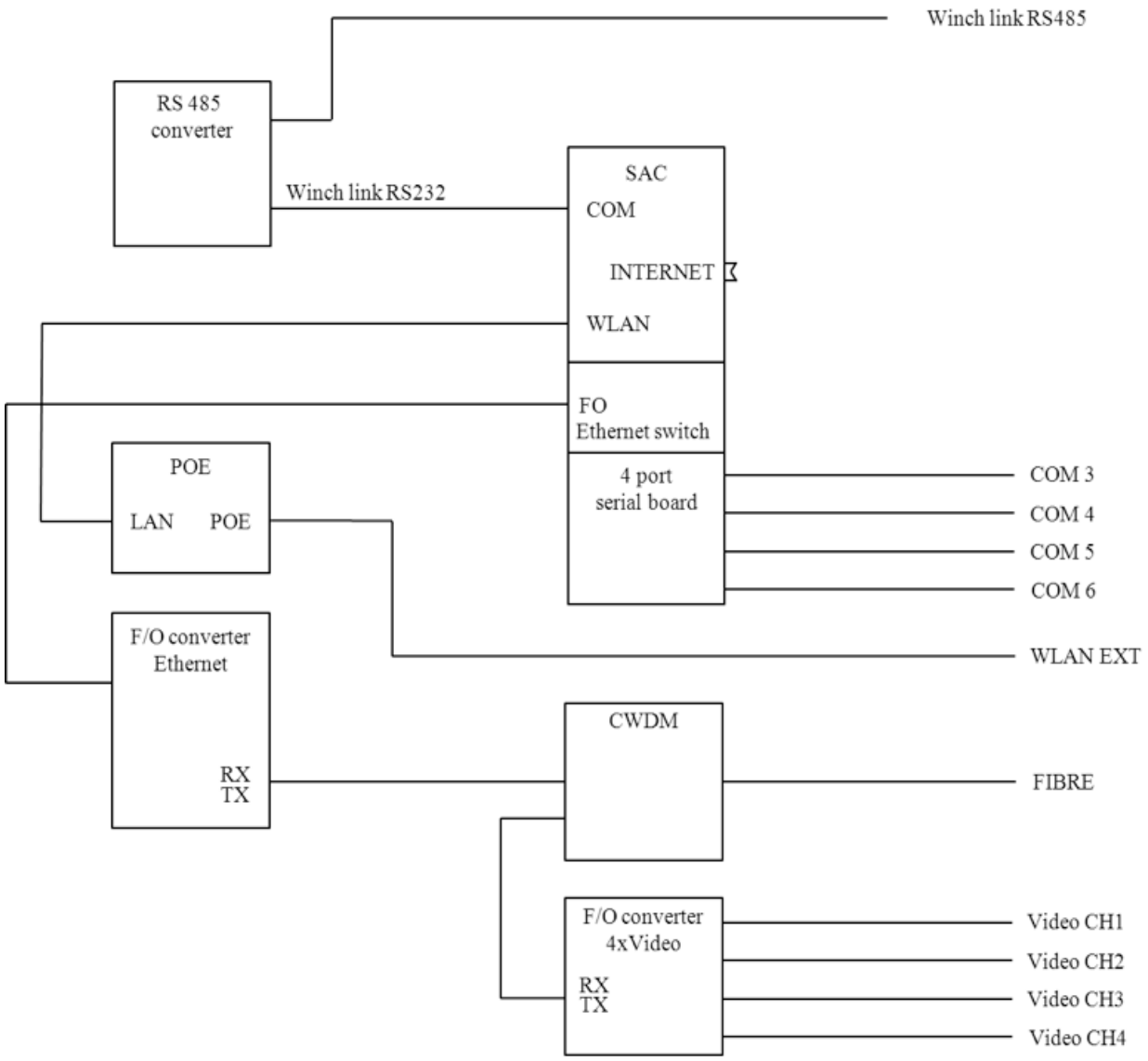

Figure. 5.2 SCU block diagram

Beneath the SAC the rest of the equipment in the SCU is mounted. Figure 5.3 shows these parts seen from the rear side of the SCU.

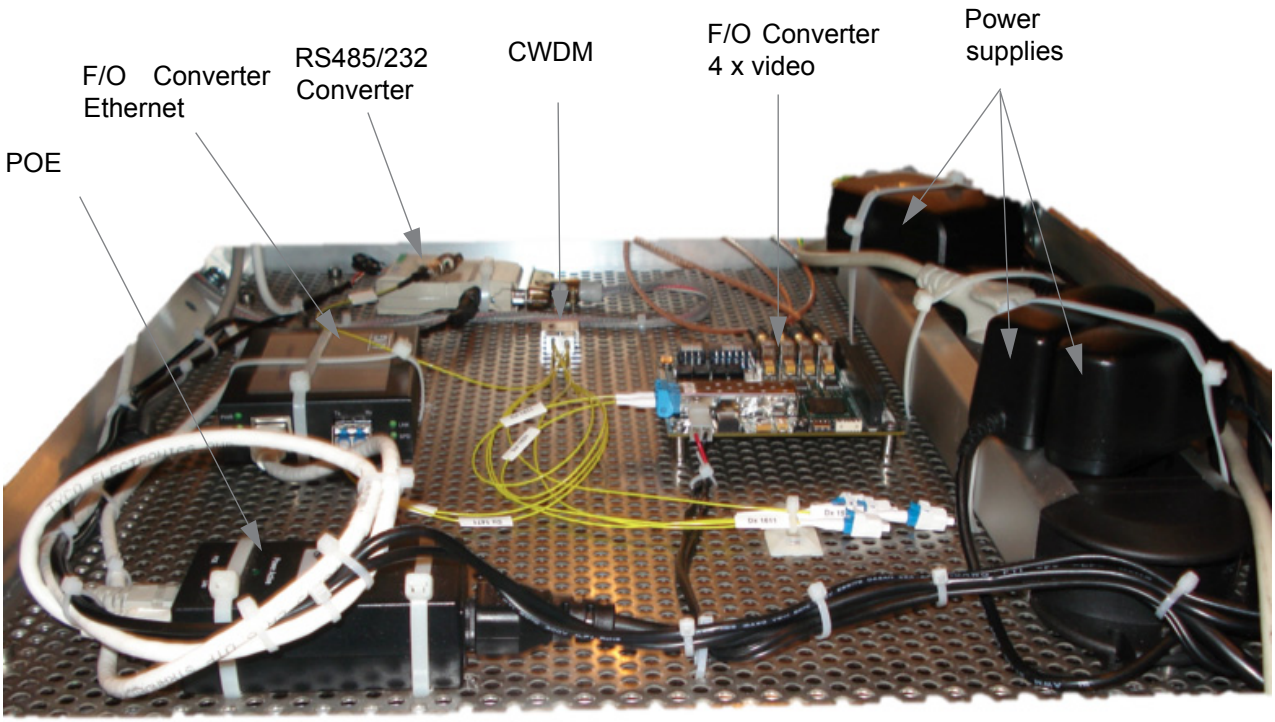

Figure. 5.3 SCU internals seen from behind

5.2 Operator´s kit

The Operator´s kit consists of the following:

- Operators Control Board (OCB) USB, type 2
- Computer display
- Keyboard
- Mouse
- WLAN Bullet M2
- WLAN antenna
- Start key
- Battle mode key
- Dummy plug set

From these parts only the OCB requires some more information. 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) interface over USB. The OCB is also powered from the SAC USB connector.

Since most PC-joysticks and gamepads also are using HID, any of these can be used to control the vehicle. However, it will probably be necessary to make changes to the file Configuration.xlm under the MMI/Configuration folder to get desired function from the different joystick axis and switches.

Figure 5.4 shows the inside of the OCB.

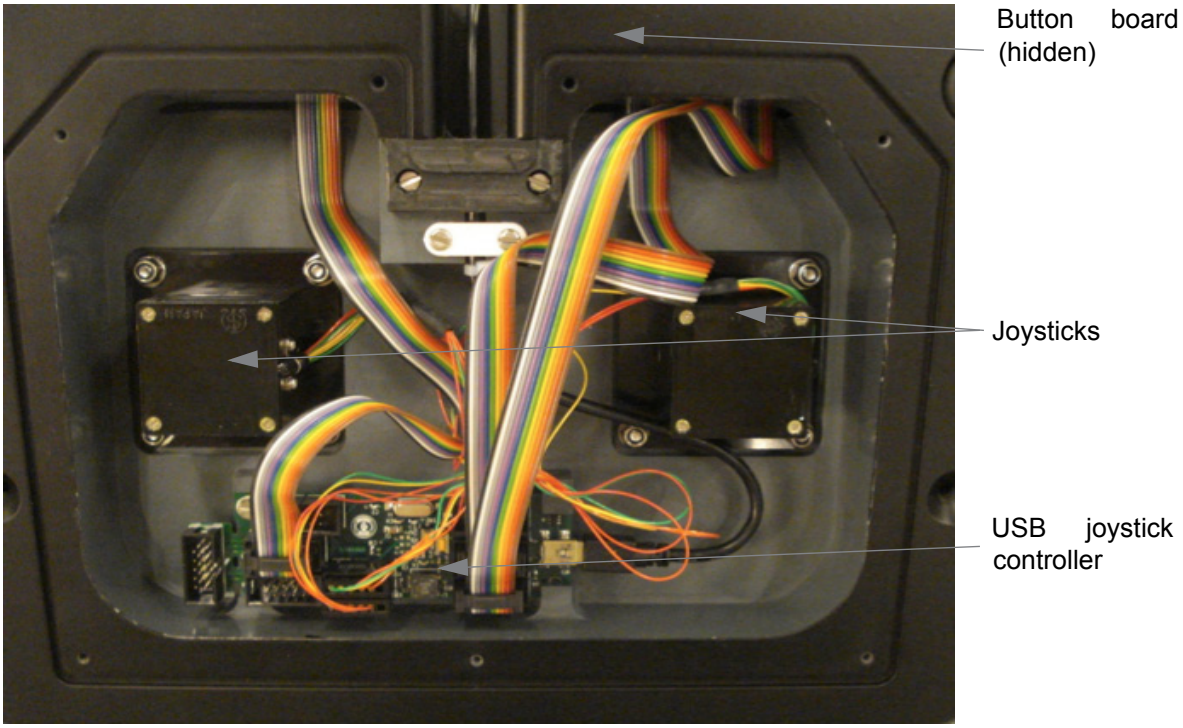

Figure. 5.4 OCB inside seen from below

5.3 Vehicle

5.3.1 Vehicle overview

The vehicle is constructed from a chassis of polypropene (PP). Within this chassis the floating material is mounted at the front and aft. The aluminum pressure hull is mounted in the chassis with a suspension of stainless steel. See figure 5.5, 5.6 and 5.7 for the main parts of the vehicle.

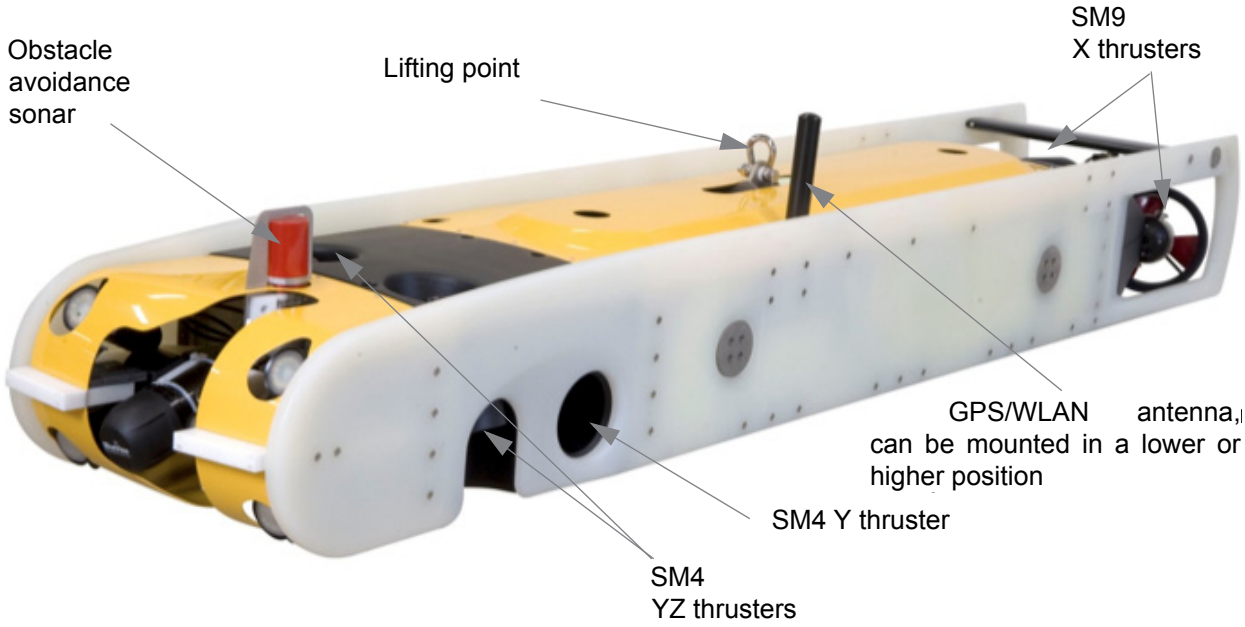

Figure. 5.5 Sabertooth vehicle

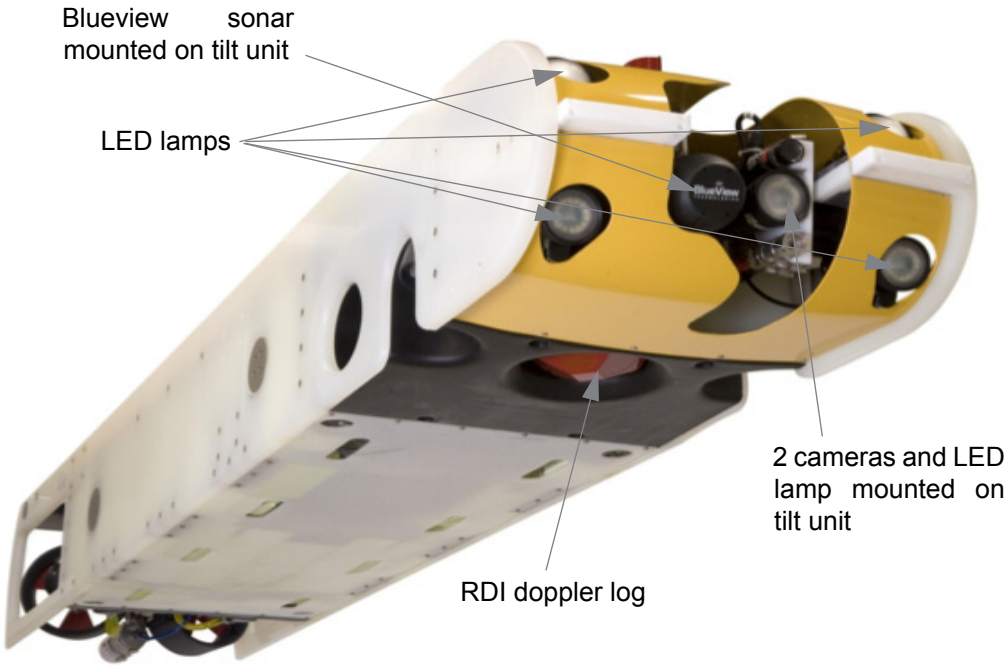

Figure. 5.6 Sabertooth vehicle

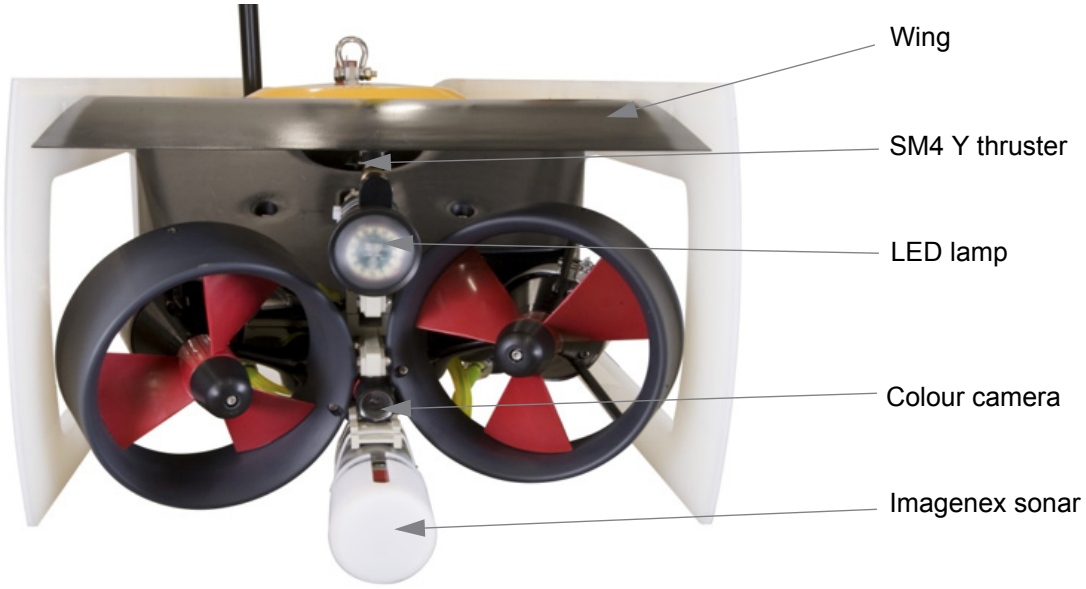

Figure. 5.7 Sabertooth vehicle seen from aft

From the aft it is possible to see that the SM9 X thrusters have different pitch. This is to compensate for the propellers having the same rotational direction. It is also possible to change the common pitch of the thrusters to compensate for the drag of extra equipment mounted on the vehicle. Also the wing pitch can be calibrated for the same reason.

Figure 5.8 shows the position of the pressure hull inside the vehicle. The pressure hull consists of three main units: Front lid, battery unit and aft lid. See figure 5.9.Font and aft lid do not only refer to the lids themselves but also all the electronics mounted on them.

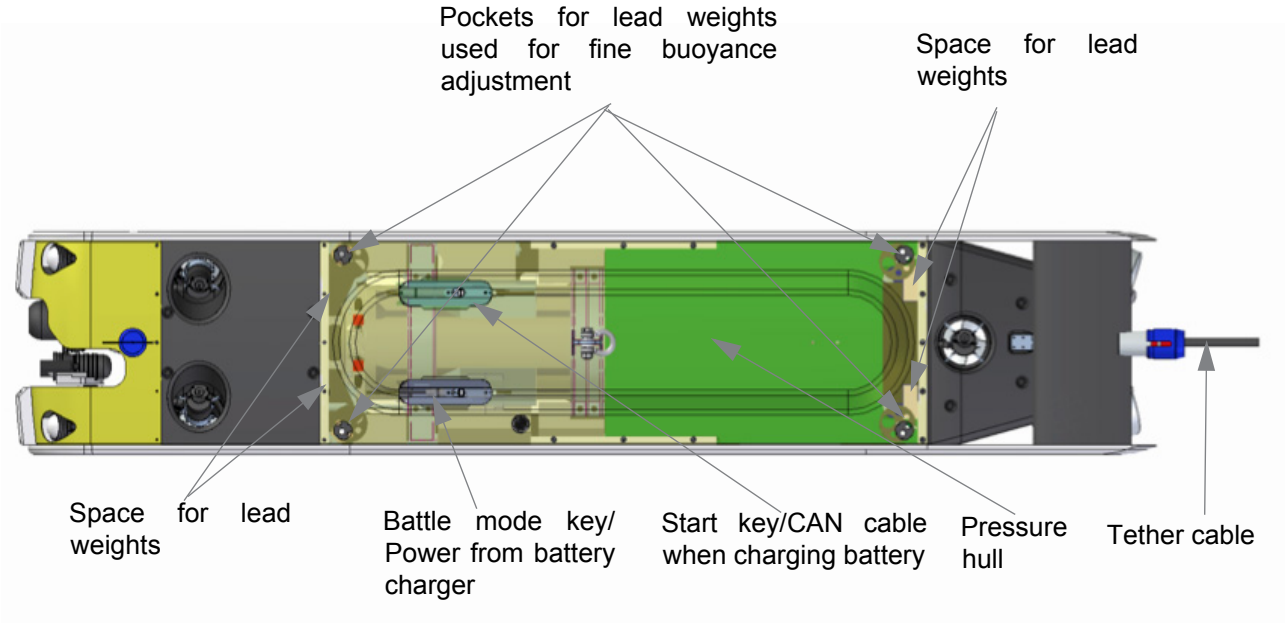

Figure. 5.8 Sabertooth vehicle

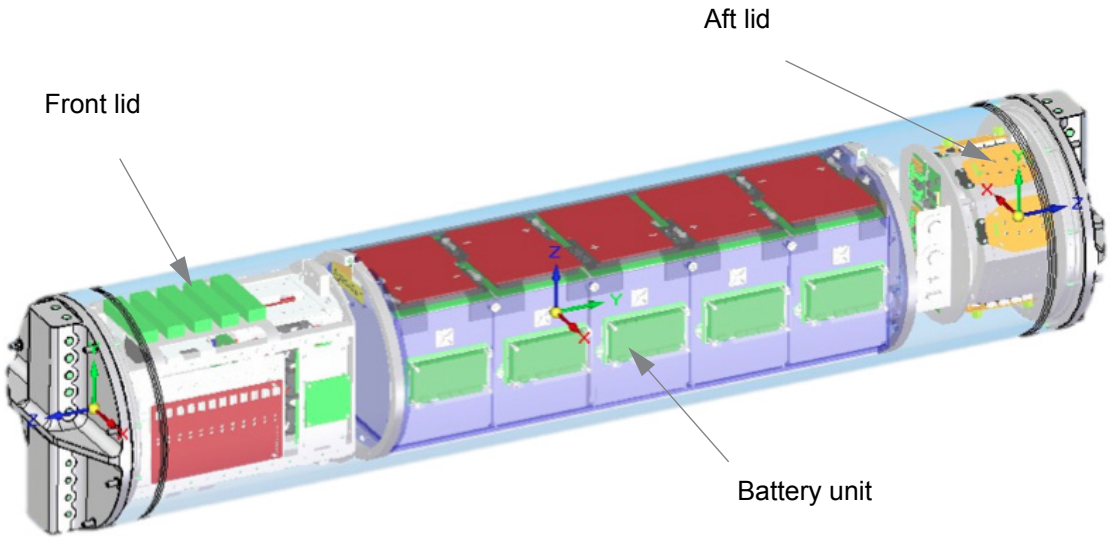

Figure. 5.9 Vehicle pressure hull

5.3.2 Vehicle power distribution

The 250V power distribution from the battery to the DC/DC converters in the front lid and the thrusters are shown in figure 5.10. The battery has a mains fuse mounted inside the junction box to protect the battery. Each Motor, tool and the DC/DC converters are then separately fused.

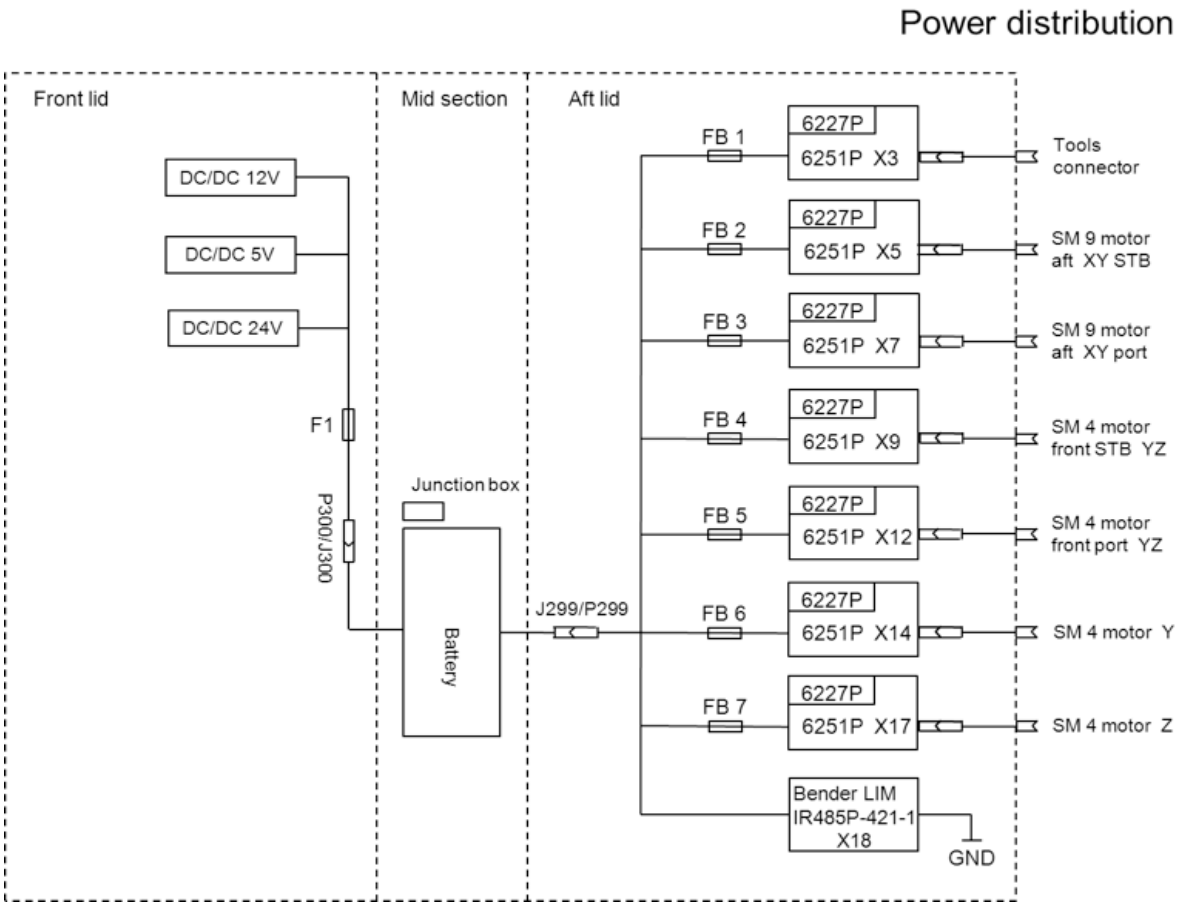

Figure. 5.10 Vehicle power distribution block diagram

The 6251P power switch boards are used to switch on/off the power to the consumers. The bender LIM unit is connected to the 250V system so it can check the line insulation.

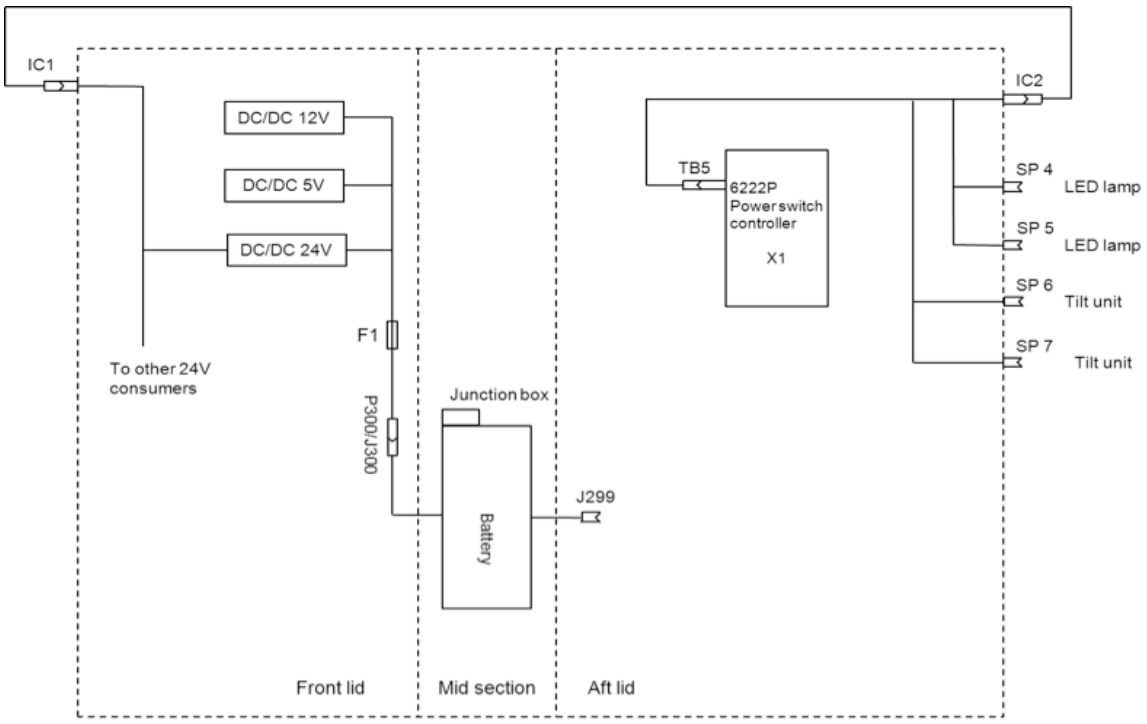

Figure. 5.11 24V DC power from the front lid to the aft lid

As seen in figure 5.11 the aft lid is supplied with 24Vdc through an external UW cable going between the connectors IC1 and IC2. If the cable not is connected, the aft lid will have no 24V.

5.3.3 Battery unit

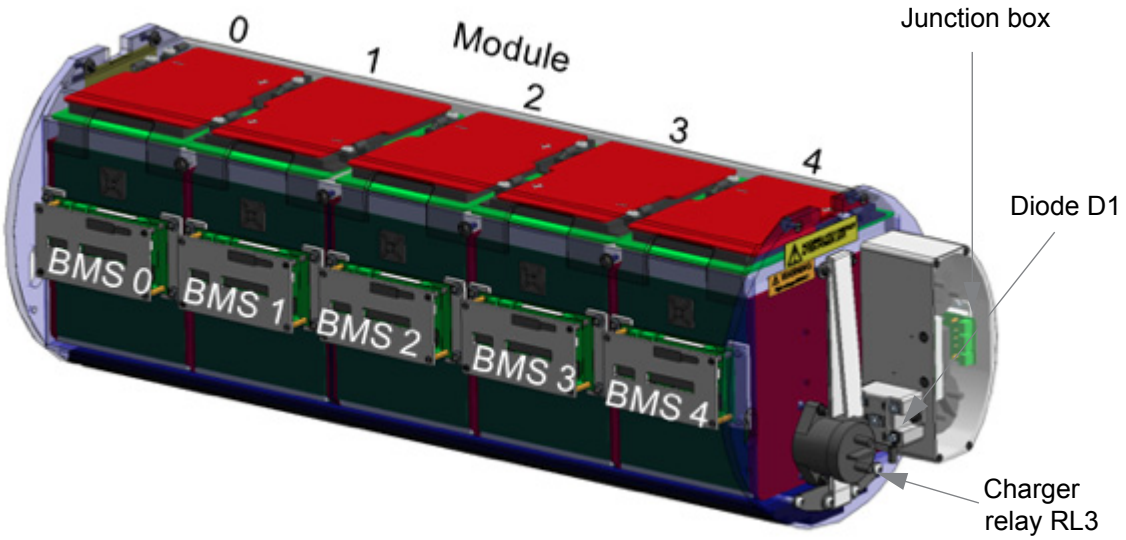

Figure. 5.12 Battery unit consisting of 5 cell modules

The Sabertooth vehicle is equipped with a lithium polymer battery which consists of 70 cells connected in serial. The cells are packed together in cell modules consisting of 14 cells each, see figure 5.13. There are 5 cell modules in the battery unit.

Figure. 5.13 Cell module with 14 cells

The large amount of power stored in the battery needs to be monitored to keep it safe to handle. Therefore each cell module is connected to a Battery Management System (BMS) card which monitors every cells voltage, temperature and how much current is used. These BMS cards communicate with each other and the battery charger via a CAN bus. If any cell voltage drops below 3.0 V, any temperature is too high or too much current is used, the BMS will disconnect the battery.

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

To save the battery from discharging when it is not used, equalizing and monitoring stops when any cell voltage goes below 3.8 V. This BMS state is called deep sleep. The BMS will wake up from deep sleep the next time the vehicle is turned on or charged using the wake up signal in the start key connector.

During deep sleep there is still a small discharge current which will eventually drain the battery from all power, and an empty battery cell is permanently damaged. The design of the BMS cards will also generate some unbalance in the battery while the electronics is in deep sleep. Therefor a separate battery separator card will disconnect the BMS cards from the battery cells when the BMS goes into deep sleep. The battery separator cards are mounted on top of the BMS cards.

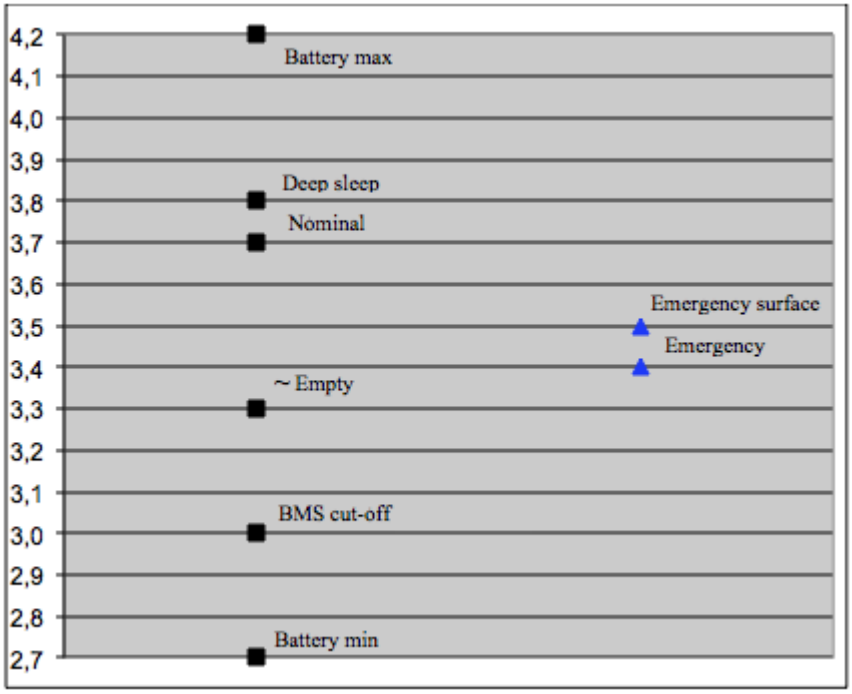

Figure. 5.14 Autonomous actions relative battery cell voltage

The maximum cell voltage is 4.2 V and the battery is more or less empty at a cell volt of 3.3 V. If a cell voltage comes down to 3.0 V the BMS will cut off the power to the vehicle. See figure 5.14.

When using the vehicle 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 MMI. In autonomous mode however, it is possible to trigger actions when the voltage level is reaching 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 also Emergency. Also these levels are displayed in figure 5.14.

Since the cells have a nominal voltage of 3.7 V and a capacity of 40 Ah, this results in a total nominal voltage of 259 V and a total capacity of max 10 kWh. The maximum and minimum total battery voltage can be calculated using the cell voltages 4.2V and 3.0V resulting in the total voltages 294V and 210V. However, the battery is more or less empty at a total voltage of 231V calculated from the cell voltage 3.3V.

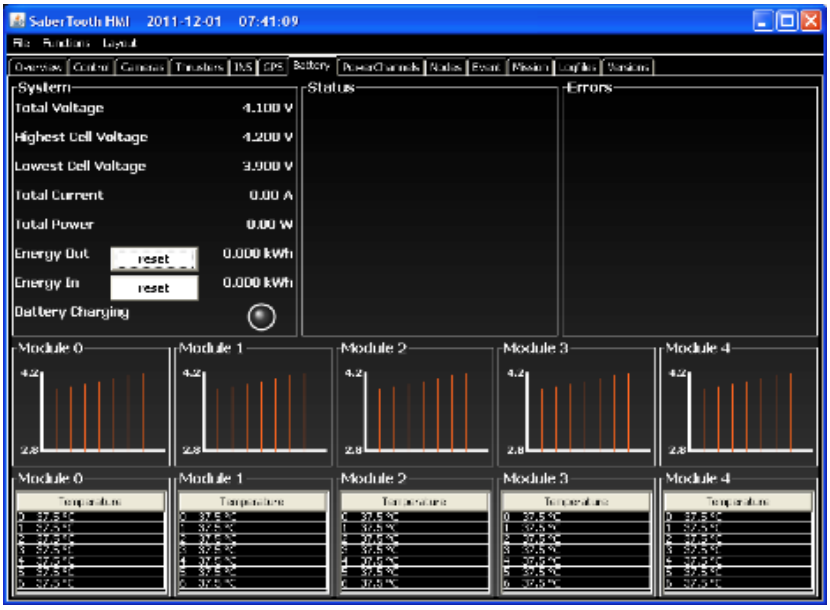

Figure. 5.15 Battery tab in MMI

The junction box on the battery module contains the following:

- A 56A mains fuse for the battery. When replacing the mains fuse it is recommended to disconnect the battery cable connected to the fuse from the battery before changing the fuse.
- RL1 Power ON/OFF relay.
- R1 Pre-charge resistor.
- RL2 Pre-charge relay that is used to short circuit the pre-charge resistor after a short delay.
- DC/DC converter 48V card that is controlling the power on/off relay, pre-charge relay and connection to the Start key and Battle mode key.
- A charger relay RL3 is switched on when charging the batteries. RL1 and RL2 are switched off if the vehicle is not turned on.

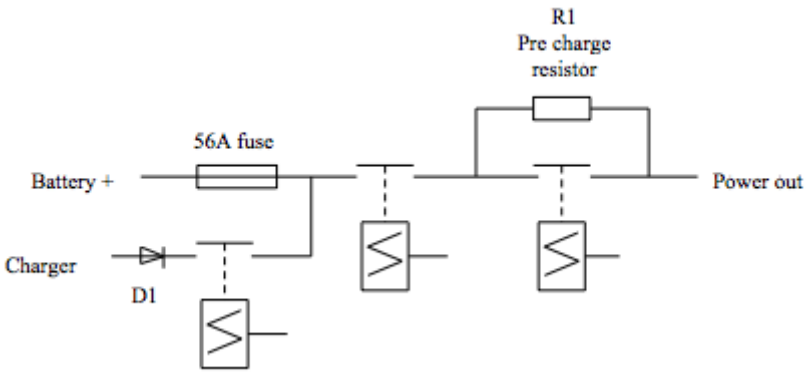

Figure. 5.16 Schematic picture of the battery on/off control

5.3.4 Aft lid

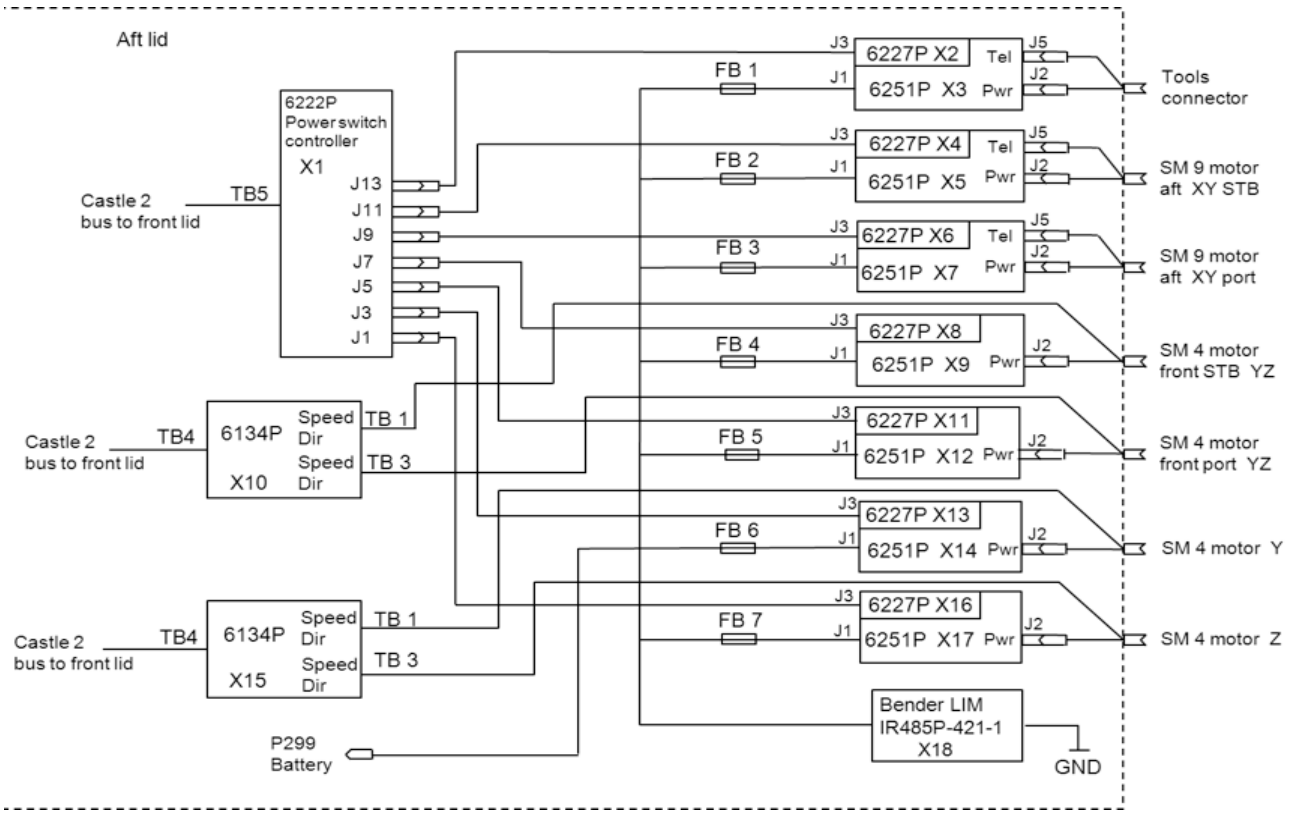

Figure. 5.17 Aft lid block diagram

A schematic view of the aft lid electronics is shown in figure 5.17. Below the main units are described.

6251P HV power switch

The 6251P power switch boards are used to switch on/off the power to the consumers. If a consumer unit is faulty it is possible to isolate the unit using the MMI. For the SM9 thrusters not only the power but also the Castle2 data link will be isolated.

If there is a short circuit in a consumer the 6251P board will isolate the unit automatically. The switching is controlled by the power switch controller 6222P. 6227P is an interface card to the 6251P card.

6222P Power switch controller

The switching is controlled by the Power switch controller 6222P. The signal from the power switch controller is connected to the power switch via a ribbon interface card 6227P. A Castle 2 bus is connected to the 6222P to control it.

6133P/6134P Serial thruster controller stack

These two boards are controlling the speed and direction on the SM4 thrusters. The cabling is connected to the 6134P while the control logic is on the 6133P board. Each stack controls two SM4 thrusters. The commands to the thrusters are coming in on the Castle2 bus. The output of the stack is analog signals for speed and direction.

IR485P-421-1 Bender LIM

The LIM measure the insulation level between battery power and protective earth (PE), i.e. the chassis. If the insulation decreases to less than 500 kOhm the insulation level is shown in the Event window on the MMI. The LIM will not automatically shut down the power because of an insulation fault. The operator has the chance to disconnect external equipment in the MMI to see if the insulation fault disappears.

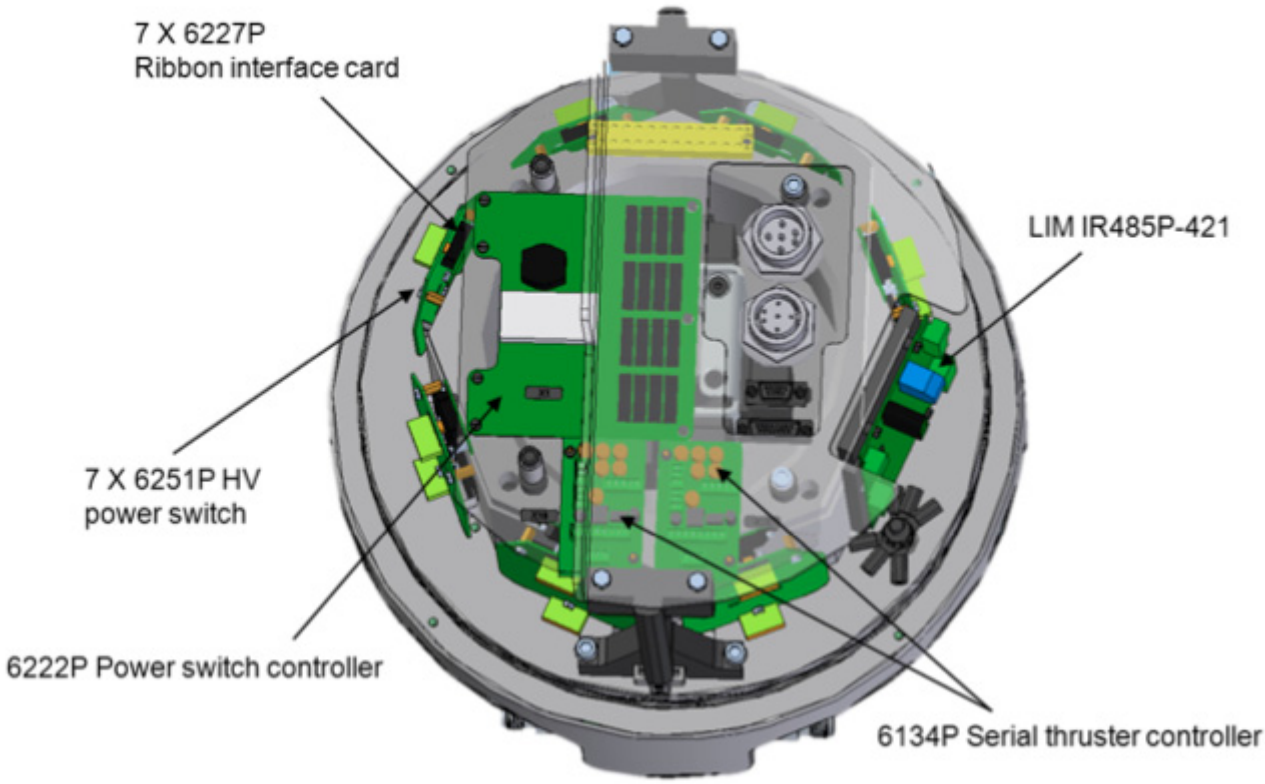

Figure. 5.18 Aft lid mechanical overview

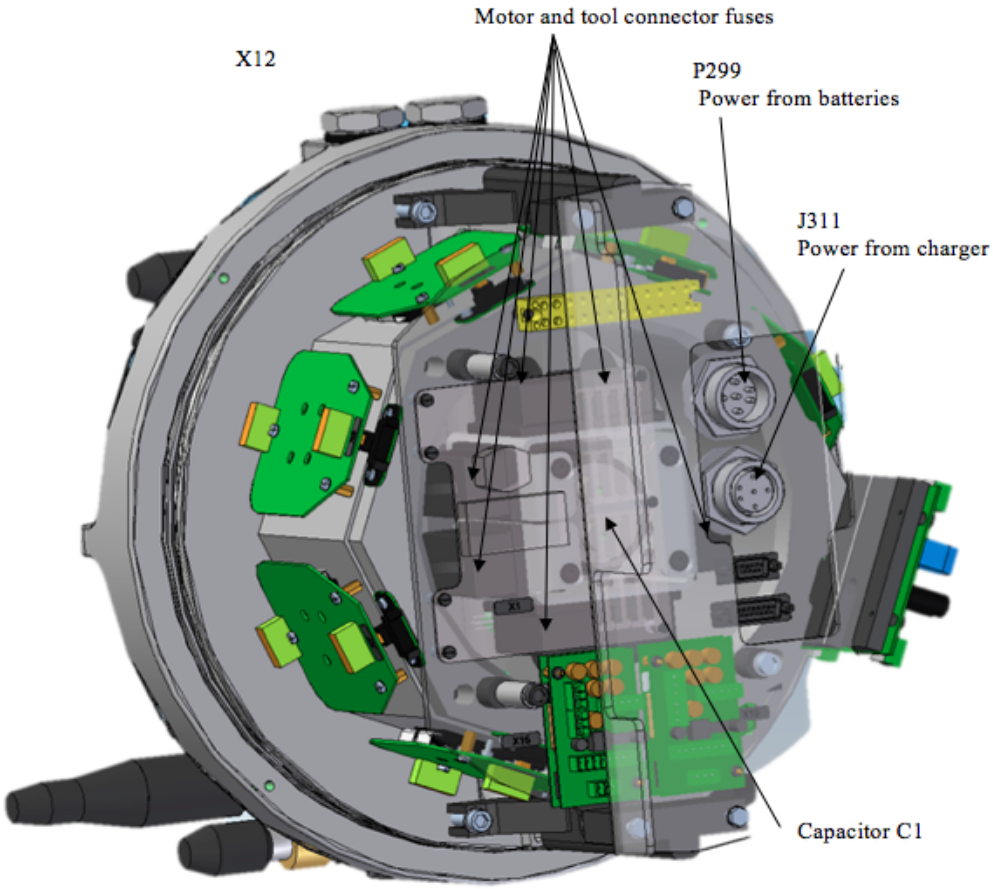

Figure. 5.19 Aft lid fuse placement

5.3.5 Front lid

Apart from the DC/DC converters shown in figure 5.10 and the RAC the main units in the front lid are shown in figure 5.19. Below follows a description of the main parts:

6198P-3-BB Low-voltage supply board

This board together with the 6180P board is mainly used for switching power and data link on/off to different consumers. This board contains the connectors and some driver circuits while the 6189P board has the control logic.

6180P Aux daughter board

6180P is a daughter board sitting on top of 6198P-3-BB. 6180P communicates using the Castle2 bus. The Castle2 bus is not only used for controlling the on/off switches but is also distributed to some connected units.

On the top of the board fuses to the connected units can be found together with LEDs indicating of the status of the power switches.

The following units are connected to the 6198P-3-BB/6180P stack:

- 4 x LED lamps (24V + Castle2)
- 4 x Camera connectors (24V + zoom/focus control via Castle2)
- Phins INS (24V only)
- Doppler log (24V only)
- Spare serial connector (24V only)
- Communication unit (24V only)
- Obstacle avoidance sonar (24V only)
- Imagenex sonar (24V only)
- Blueview sonar (24V only)
- 2 x spare Ethernet connectors (24V only)
- Leak sensor (front lid sensor + communication unit sensor)

The power switches are controlled from the MMI.

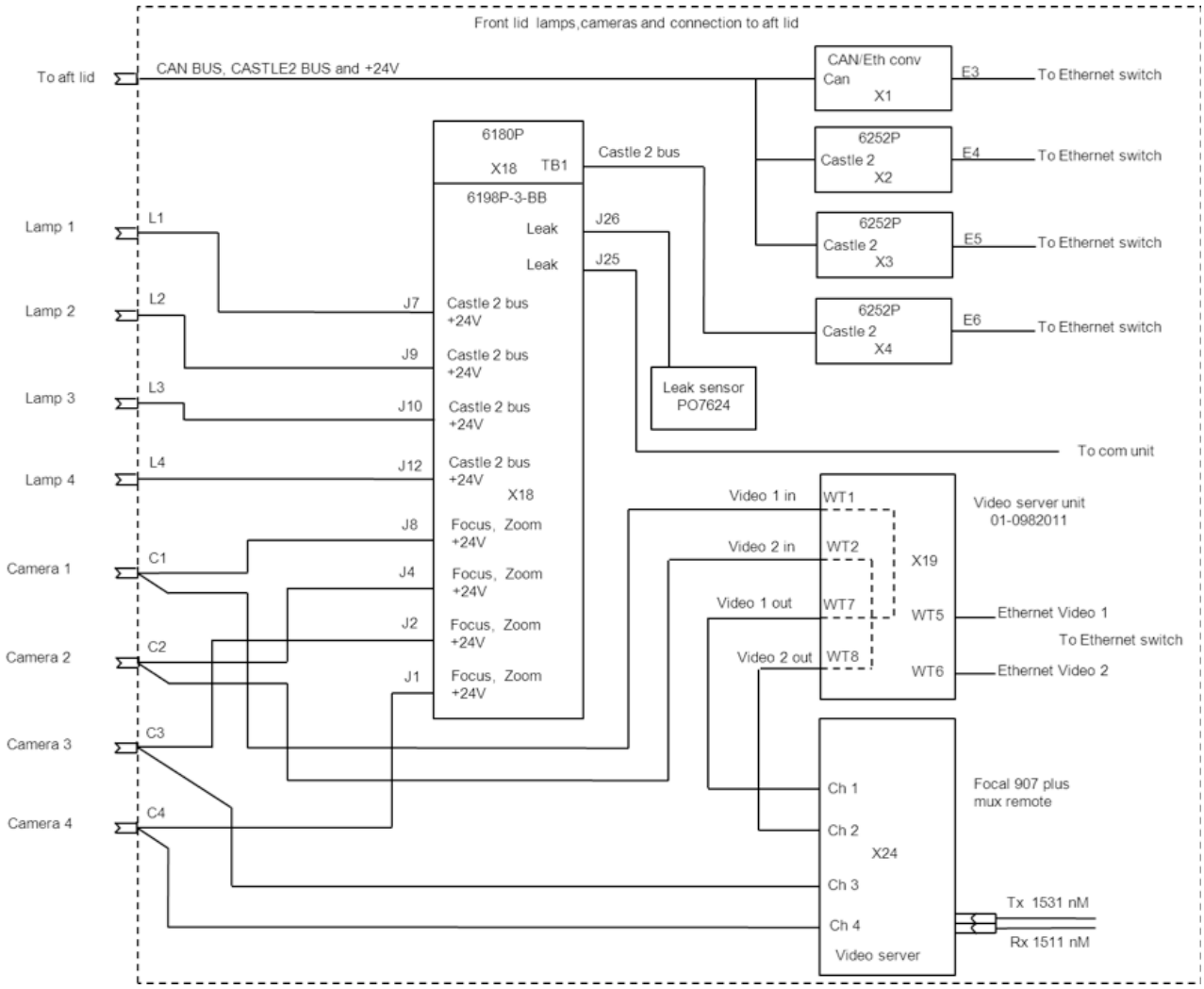

Figure. 5.20 Front lid block diagram

CAN/Ethernet converter

The CAN/Ethernet converter is used by the RAC so that it can read battery status from the BMS. The CAN bus goes on the outside of the hull to the aft to get connected to the battery module.

6252P Castle2 gateway board

The basic function of 6252P is to provide conversion from Ethernet based UDP/IP which is understandable by the RAC and SAC to Castle2 protocol over RS485 which directly connects to all castle nodes such as lights, thrusters, servos, power hubs. There are three separate Castle2 buses in the vehicle, one in the front and two to the aft lid. The reason is to keep the update rate on the bus up.

Video server unit

The Video server unit consists of two AXIS 243SA video servers. Two of the cameras composite signals are sent to the video servers and are sent out as motion JPEG over Ethernet. The signals are also sent out from the video servers as composite signals to a Focal 907 F/O converter to be sent up on the fiber. The third camera is only connected to the F/O converter. See figure 5.20.

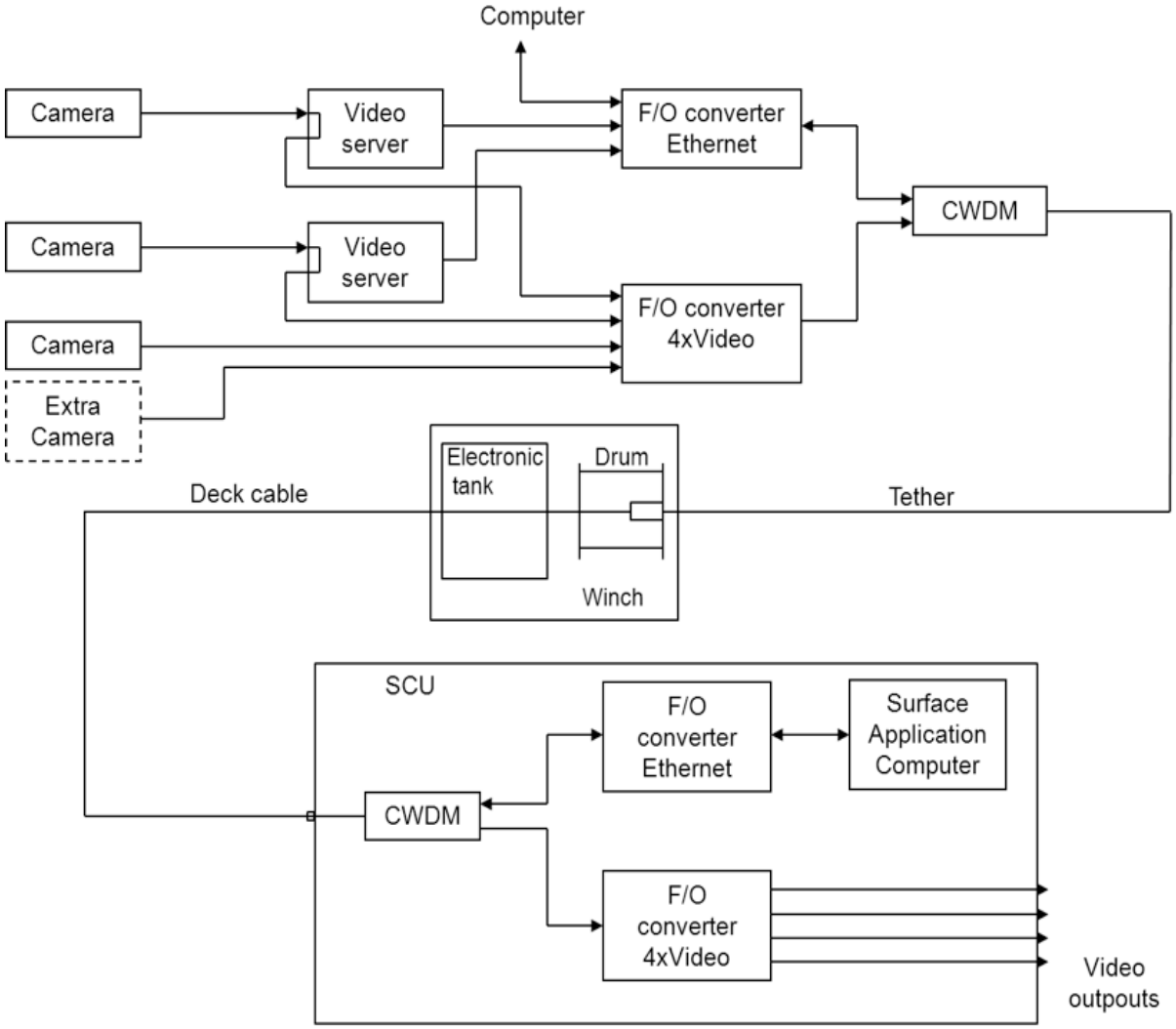

Figure. 5.21 Video system

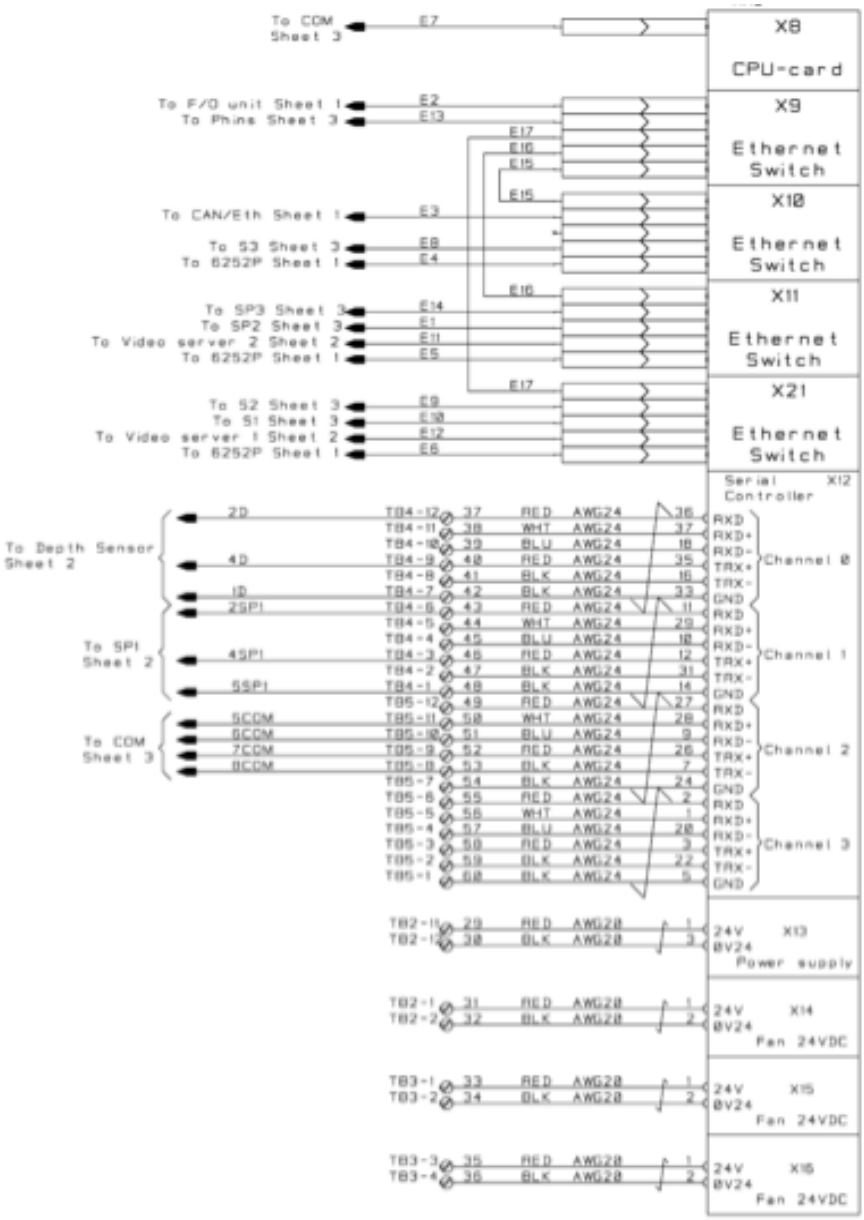

Figure. 5.22 ROV Application Computer (RAC)

The vehicle is controlled by the ROV Application Computer (RAC) which is mounted in the front lid. The RAC consists of the following cards, see figure 5.22:

- CP307 processor card with hard disk
- CP932 Ethernet switch (x4)
- CP346 Quad serial controller
- 75W Power supply
- 24V Fans (x3

CompactPCI CP307 processor card with hard disk

The CP307 is a CompactPCI-compatible processor card with a 1.2GHz Core Duo processor. On this processor card there are two disks mounted, a 2.5” SATA hard disk and a CompactFlash disk.

The RAC has XP Embedded installed. To make sure the vehicle can be turned off at any time without corrupting data on the disk HORM (Hibernate Once, Resume Many) has been used. This means that a hibernation image is stored on the write protected CompactFlash disk. Whenever the computer is powered on it will start in the state defined by the hibernation image on the CompactFlash disk. The hard disk is used for storing log files and recorded video.

CompactPCI CP392 Ethernet switch

CP932 is a six-port 1Gbit Ethernet switch with one port connected directly to the computer and the rest of the ports on the front side. Except for the WLAN bridge all Ethernet units inside the vehicle are connected to the four Ethernet switches.

CompactPCI CP346 Quad serial controller

CP346 is a serial controller card with four UARTs. It is used by the RAC to communicate with the depth sensor. The wiring is prepared for connection with an RS232 device at spare connector SP1 and an optional radio modem in the communication unit.

CompactPCI 75W power supply

The power supply is specially made for CompactPCI and has the necessary output voltages 3.3V, 5.1V and 12V. The input voltage is 24V DC.

Figure 5.22 explains the structure of the software running in the SAC and RAC. When the CARUS program is started in the SAC a node manager in CARUS in its turn starts several instances of the CARUS program. Each instance shows up as CARUS processes in the Windows Task Manager. These CARUS processes are called component groups and are running a number of components each. When the CARUS processes are stared an XML-file selects which components shall be running in each CARUS process/component group. In figure 5.22 LOGGER, KML and RELAY are examples of components running in a component group.

In the SAC also the MMI java program is running. This program is handling the communication with the OCB and displays the MMI on the screen.

In the RAC the same CARUS program is used but there are other components running in these component groups. One can see that there is one component communicating with the Phins while another is communicating with the Doppler Velocity Log. In the RAC there is also a separate program RasputinExtCom which is handling all communication with the Castle2 devices like thrusters, LED lamps etc.

All communication between components is using a middleware called OPS which automatically makes sure that the information is received by the correct component. This means that if the link between the RAC and SAC is working a component that used to be running on the SAC can be started on the RAC instead without making any software changes.

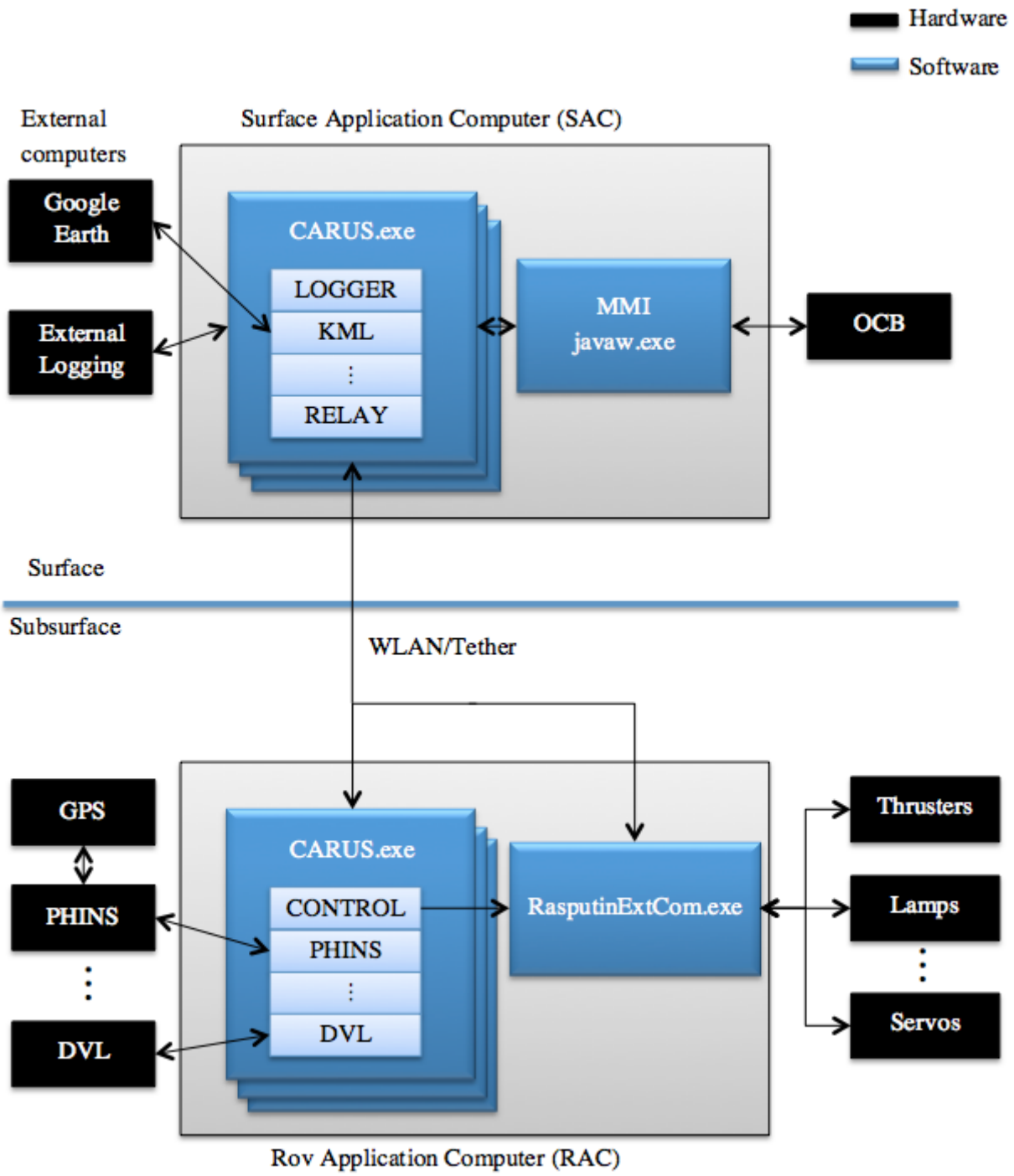

Figure. 5.23 Software structure

See figure 5.24- 5.26 for the physical placement of the different units in the front lid.

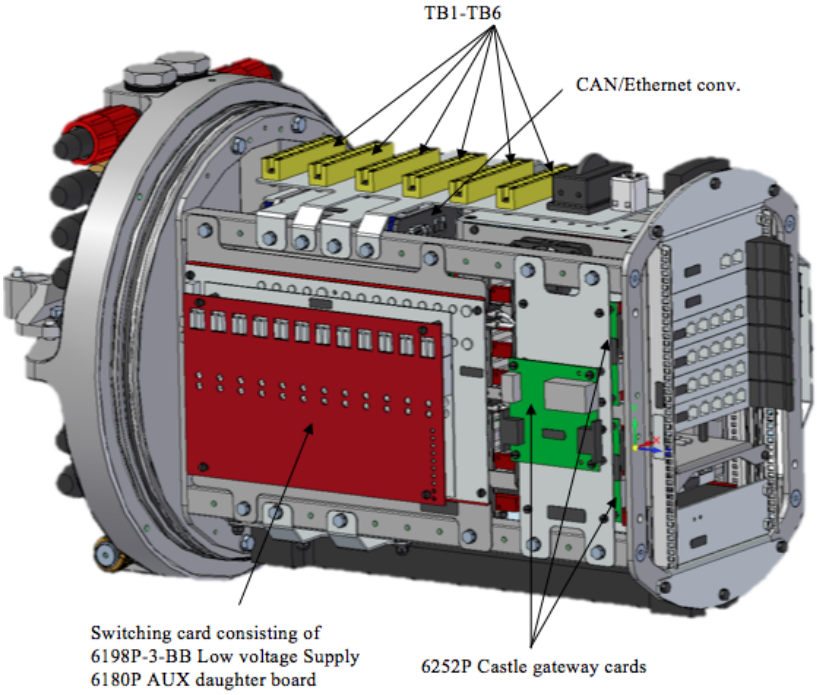

Figure. 5.24 Front lid mechanical overview

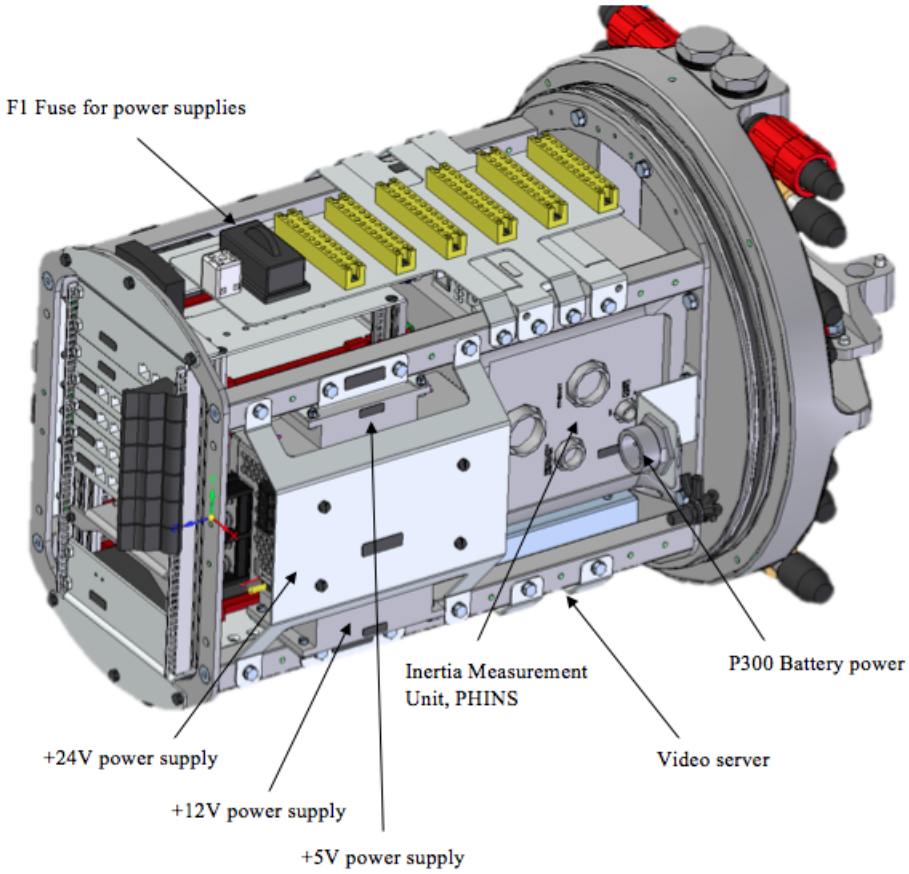

Figure. 5.25 Front lid mechanical overview

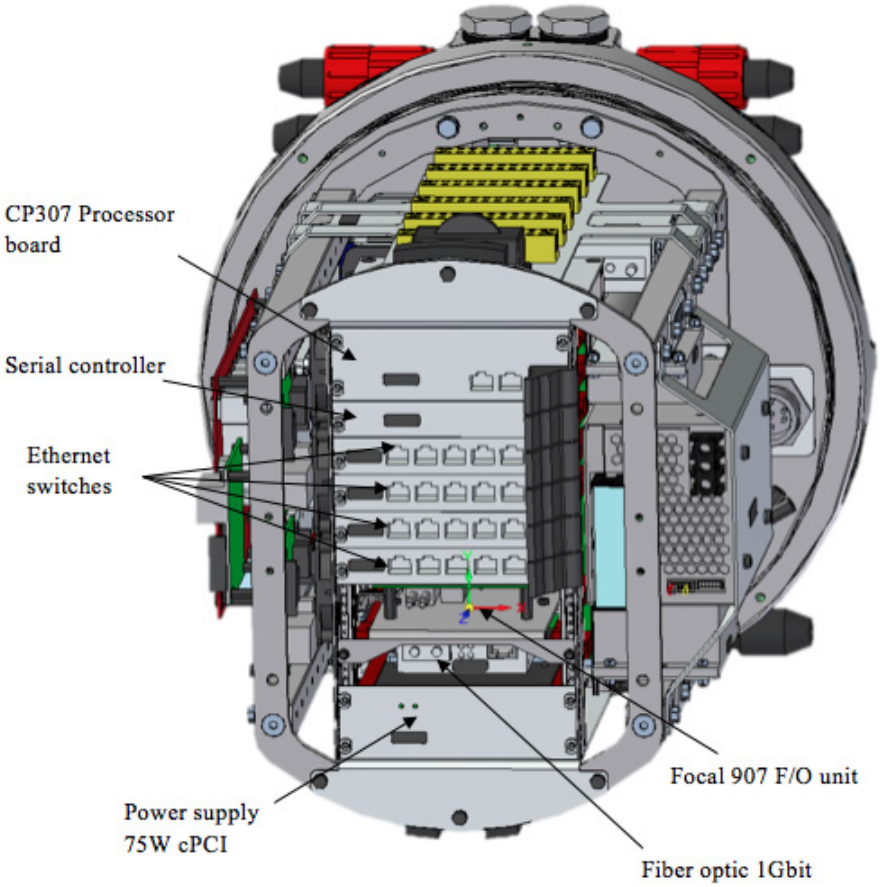

Figure. 5.26 Front lid mechanical overview

5.4 Battery charger

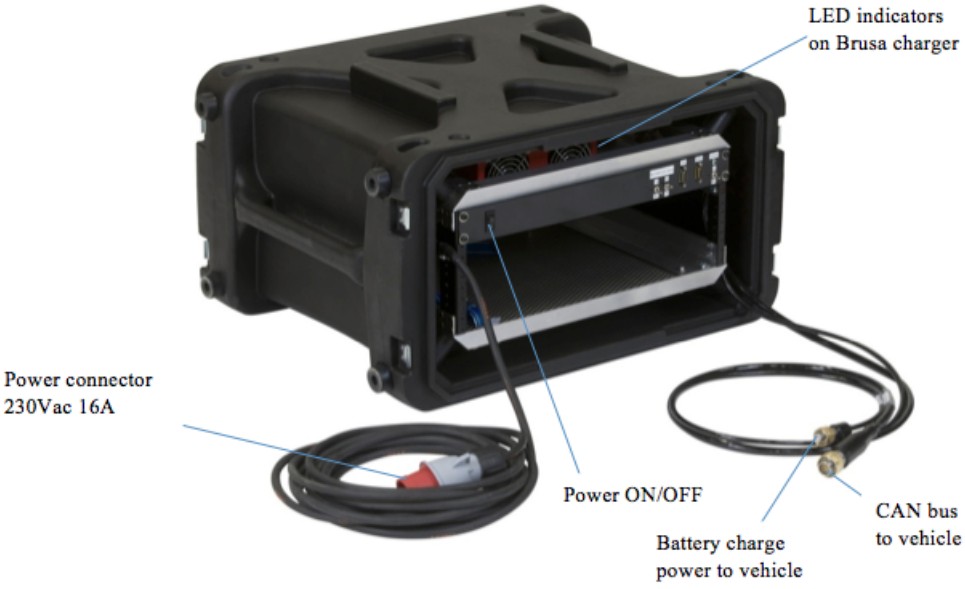

Figure. 5.27 Battery charger

The battery charger is a Brusa NLG512 charger built into a protective case together with some supporting electronics. The case is done so there shall be room to store the cables inside the case below the Brusa charger. When using the charger both the front and aft lid shall be removed so there is enough air circulation.

The block diagram of the battery charger is shown in figure 5.27. Apart from the Brusa charger there are a number of relays, some normal and some with timing delays. The relays are used to properly control the relays inside the battery unit.

The vehicle is usually turned off during charging. However, the Vehicle on/off switch enables the possibility to have the vehicle turned on. To prevent too high starting current the vehicle can only be turned on as the charger is started. To start the vehicle this switch is held in the on position as the charger is turned on using the power on/off switch. The vehicle will switch off automatically after 10 hours or when the power to the charger is turned off.

If it would be possible to turn the vehicle on/off at any time during charging there is a risk that the 56A battery fuse would blow since the pre-charge circuitry does not work during charging.

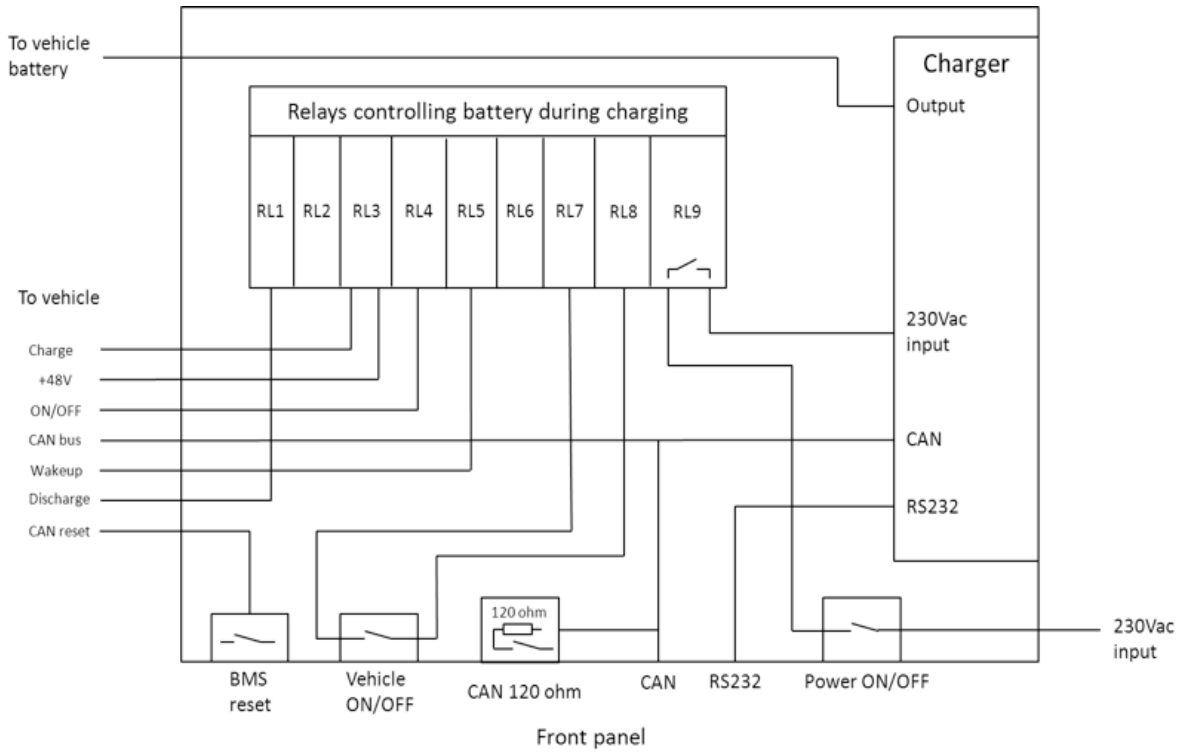

Figure. 5.28 Battery charger block diagram

5.5 ATC Winch

Functionally, the ATC winch mainly consists of two operating parts:

- The capstan device
- The storage drum.

The capstan device pulls the tether cable inwards and outwards. This is the powerful part of winch doing most of the work.

The storage drum stores the part of the tether cable not used in the water. The drum motor is controlled only to haul the tether cable inwards preventing slack in the tether between drum and capstan wheels.

To layer the cable even on the winch drum there is a pendulum arm which moves back and forth along the winch drum. The cable passes through the wheel.

The ATC winch is operated from the manoeuvring panel integrated in the electronics box. The manoeuvring panel has a protecting lid.

See figure 5.29 and 5.30. There are three deck cables coming to the winch:

- The winch power cable
- The link cable from the SCU
- The fibre optic ROV links

The fibre optic cable is only fed through the electronics box and via the slip ring to the tether.

The three phase power supply is fed through the main switch (SW4) and fuses (F1-F3) to a contactor (RL1) that switches on if the emergency stop and the overvoltage relay are not activated. The three phase power, supplies transformer (TR1-TR3) that gives a three phase 220 VAC voltage to the servo motor drivers.

Two of the phases are fed through fuse F4 and F5 to the electronics transformer.

The winch electronics transformer gives approx. 230 VAC to a DC supply feeding the controlling computer and other low voltage DC equipment.

The computer collects input data from drivers, sensors and the manoeuvre panel and returns proper control signal to the drivers. If driver bus voltage is increased above a certain level, for example by motor power generation, the drivers will shunt power out to the external clamp resistors.

The only cable leaving the winch is the tether cable.

It is recommended but not necessary to connect the protective earth to the winch frame at a position below the slip ring unit, see mechanical drawing.

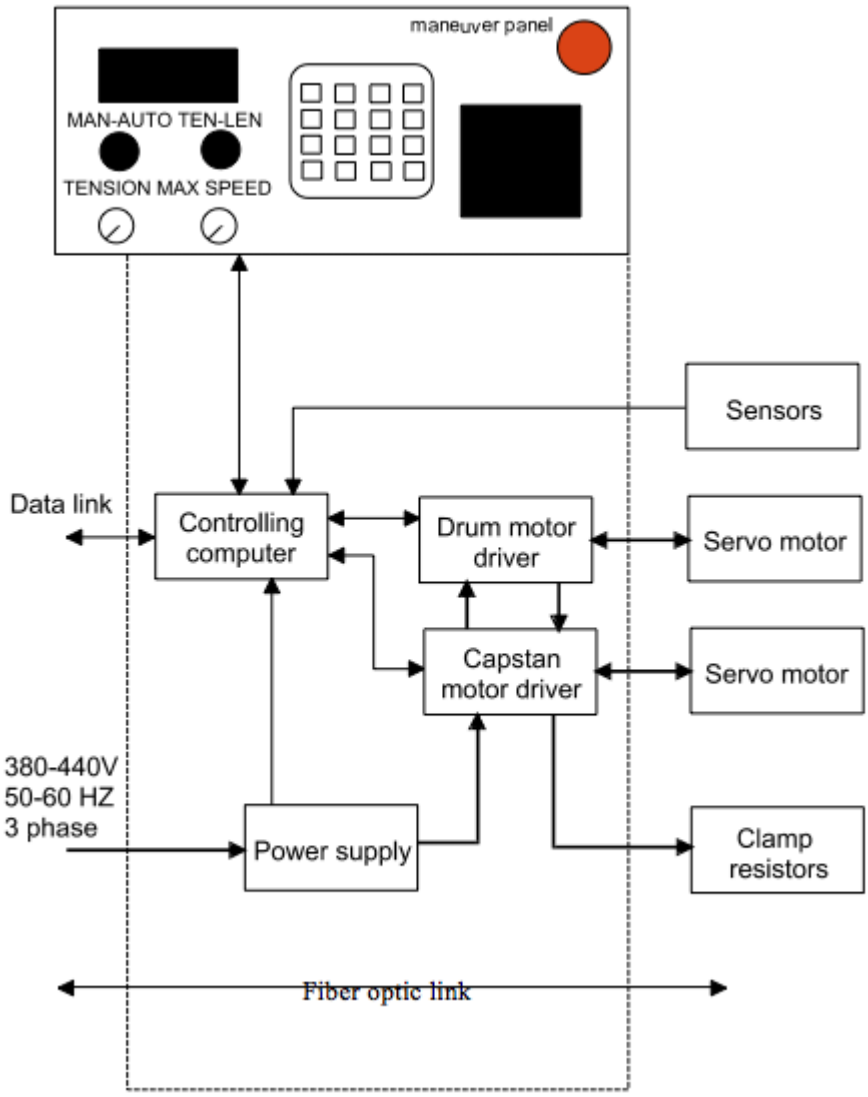

Figure. 5.29 Winch electronics interconnections - block schematic

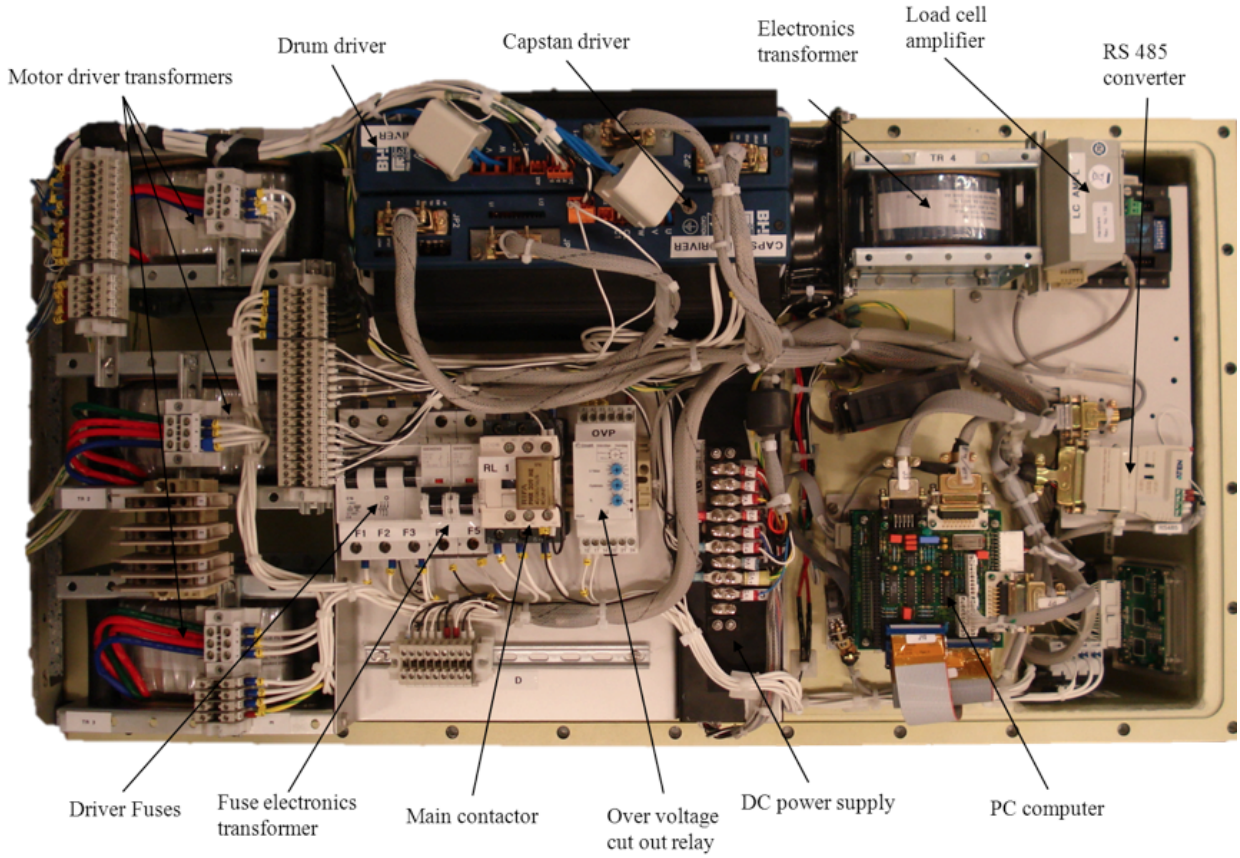

Figure. 5.30 Electronics box major parts

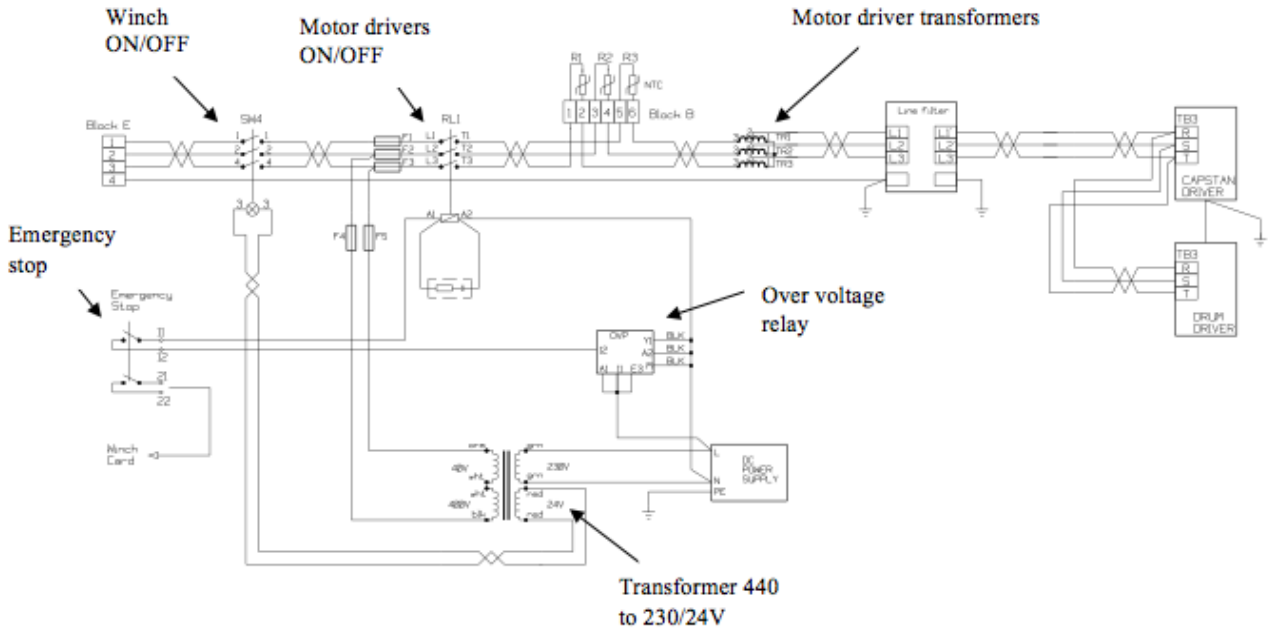

Figure. 5.31 Wiring diagram power supply

CHAPTER 6

CORRECTIVE

MAINTENANCE

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6. CORRECTIVE MAINTENANCE

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

6.1 Introduction

Where access to equipment and lowest replaceable units is straightforward, it is considered unnecessary to give instructions on dismantling and assembling.

6.1.1 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.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the rov system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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. The information on battery handling in chapter 6 shall be thoroughly read and understood before doing any work on the batteries.

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.

Possibility of damage to equipment. Under no circumstances are the vehicle epods to be assembled without anti-extrusion rings.

Danger to personnel and equipment. . 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.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Possibility of damage to equipment. Ensure all vent plugs are securely fitted and shut prior to immersing the vehicle.

Possibility of poor vehicle handling. 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.

Task No	Task Description	When carried out
1	Pre-Dive Check	Pre-flight
2	Post-Dive Check	Post-flight
3	Thruster Motor Oil Level Check and Replenishment	Pre-flight
		Post-flight
		When motor has been drained of oil
		Every 4 months of operational use
4	Thruster Motor Shaft Rotation	Monthly
5	EPOD Vacuum Check	When the EPOD has been opened
6	Fibre Optic Attenuation	No video picture or poor video image
		No communication to vehicle
7	Winch and Tether Check	Monthly and annually
8	Battery Charging	Every 6 months or when needed
9	Tilt Motor Oil Check and Replenishment	Pre- and post-flight

Table. 6.1 Maintenance Tasks

6.1.2 Tools Required

The various maintenance procedures detailed in this handbook call for various standard and specialist tools. Not all tools are required for all procedures and the following list is not exhaustive, however it is strongly recommended that the special to type tools required for the more involved procedures be used. The following tools may be required:

- Flat bladed screwdrivers (common sizes).
- Open ended or ring spanners (common sizes).
- Socket set.
- Pliers, flat nosed.
- Wooden dowel.
- Propeller Puller tool.
- Hex keys (common sizes).
- Two-leg puller tool (150 mm max. spread and reach).
- Torque wrench (to achieve 27 Nm).
- Rubber mallet.
- 4 x Service support stand (Part No 01-4030151)
- 4 x Lid removal screws (Part No 05-1206042)
- Vacuum pump TD81-BUWS (Part No 01-2350045)

6.1.3 Parts Required

It is recommended that a supply of spare parts is always available and ready for use, especially O-rings. The following parts may be required:

- Stainless steel plain M8 nut.
- M8 and M16 Nyloc nuts.
- Loctite 222, 641 and 480.
- Silicone grease (Molycote MS111 or similar).
- Oil container suitable for collecting oil.
- SM4 Thruster V-seal (Part No VSEAL0012)
- SM9 Thruster Motor V-seals (Part No VASEAL0020).
- SM4 Thruster Motor Diaphragm (Part TH066).
- Propeller puller tool (Part No P00602).
- M2 Metal Shell connector O-rings (Part Nos 200-014).
- M3 Metal Shell connector O-rings (Part Nos 200-019).
- Aqualube.

6.2 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 threadforms, 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 silicone 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 silicone grease prior to unit assembly.

The Sabertooth system electronic pod 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.

6.3 Drum exchange

Before any repair or changing of tether is performed, the winch power has to be switched off.

When transporting or storing the winch drum with a mounted tether make sure that the tether end inside the drum is secured with pieces of tape. The vehicle end of the tether must be tied to the drum with a rope or a strap.

When changing the tether on the winch the best way is to exchange the drum.

1. Turn off the winch and disconnect the input power.
2. Disconnect the tether end from the vehicle.
3. Unscrew the two upper shafts of the horse head, turn it pointing towards the drum and take out the tether.
4. Remove the capstan wheel protections and unwind the tether in an eight pattern.
5. Remove the pendulum wheel protection. Now the tether is free.
6. Unscrew the screws holding the slip ring adapter. Remove it and disconnect the tether from the slip ring.
7. Put protection on the tether.
8. Put a sling around the drum and connect the sling to a crane.
9. Stretch the sling and unscrew the screws holding the drum to the shaft.
10. Lift the drum aside and mount a new one in opposite order of above.
11. After drum exchange make sure that total tether length, tether diameter and fed out tether length is correctly entered in the menu system.

12. Make sure that the pendulum arm is in the right position. It can be moved when the handle at the back of the pendulum gear is pulled out. Also make sure that the pendulum gear is in the right position so that the pendulum will follow the direction the tether is wound on the drum.

Possibility of damage to equipment. If the pendulum arm is locked the wrong way it will move in the opposite direction of the tether and the tether may get damaged.

6.4 Termination of Tether

6.4.1 Recommended Fibre Optic Tools

Seaeye supply a Fibre Optic Kit that contains all the necessary tools, connectors and accessories.

Figure. 6.1 Fibre Optic Stripper, Cleave Tool and Scissors

Component	Description	Qty
FOTK-QS	Fibre Optic Toolkit	1
181-7635	ST HOT MELT CONNECTOR	30
FM-L-6-1-PBT-BLK-VO	6 x 1m TUBES&1 Flat Manifold Long	4
FO OVEN KIT	FIBRE OPTIC TERM KIT	1
FOTK-BASE	FIBRE OPTIC BASE TOOL KIT	1
0700-5226	UNIVERSAL FIBRE OPTIC CONNECTOR HOLDER	4

Table. 6.2 Recommended Tools

188-75B	FIBRE OPTIC HOT MELT OVEN 230V	1
PL01689	MAINS LEAD IEC 1M 5A	1
174-167	TORCH F/O KIT	1
181-7635	ST HOT MELT CONNECTOR	6
243-077	STRIPPERS	1
353-3474	F/O STRIPPING TOOL	1
389-1809	FO PATCH CORD ST-ST 1m	2
45162	F/O STRIPPERS 3.2MM	1
45163	F/O STRIPPERS 3.2-5.5MM	1
497-296	ALCOHOL PUMP CONTAINER	1
5037051	SCRIBE TOOL	1
536-329	SIDE FLUSH CUTTERS	1
558-795	WIPES LINT FREE (PACK OF 100)	1
850-079	SCALPAL HANDLE	1
850-091	Replacement scalpel blade,No.10	10
925-C	F/O SHEARS SERRATED	1
ALF3010SA	POLISHING PAPER	50
ALF3030SA	3.0 Micron Polishing Paper (Pink)	50
AW5-ST	ST WASHER ATTENUATOR	5
C124	F/O SHEARS CERAMIC	1
CB-8	CIN BIN	1
EFA6004ASSY	POLISHING PUCK	1
G00201	FIBRE OPTIC MICROSCOPE	1
G999	UNIVERSAL ADAPTOR PRIORSPEC II	1
GPP01	GLASS POLISHING PLATE 180 X 250	1
MLP12ST	F/O Db LOSS METER SET 850/13nm	1
ST-ST-BH	ST-ST Inline Bulkhead Adaptor SM	10
TL07156	TOOL BAG	1

Table. 6.2 Recommended Tools (Continued)

6.4.2 Cable Preparation

1. If using a bend relief boot or cable sleeve, slide the bend relief boot and crimp sleeve onto the cable. It is much easier to do this at the beginning rather than wait until you have stripped the fibre.

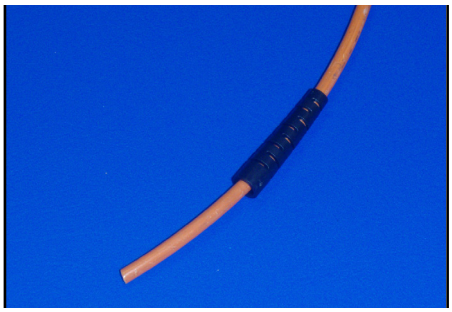

Figure. 6.2 Fibre Optic Bend Relief fitment

2. Strip the cable outer protection jacket. The amount of outer jacket that you strip depends on what fibre you are using and what manufacturer's connectors you are using. Read the manufacturer's instructions that came with your connectors for information on how much to strip back. Cut the inner strands to reveal the inner fibre optic cable.

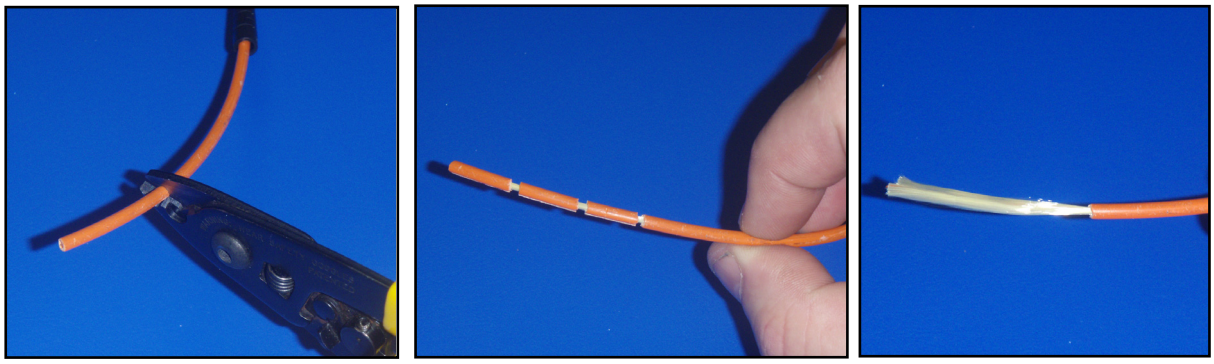

Figure. 6.3 Insulation Removal

3. Trim back the Kevlar (strength member) strands leaving a small tail which acts as a bend restraint within the potted connector.

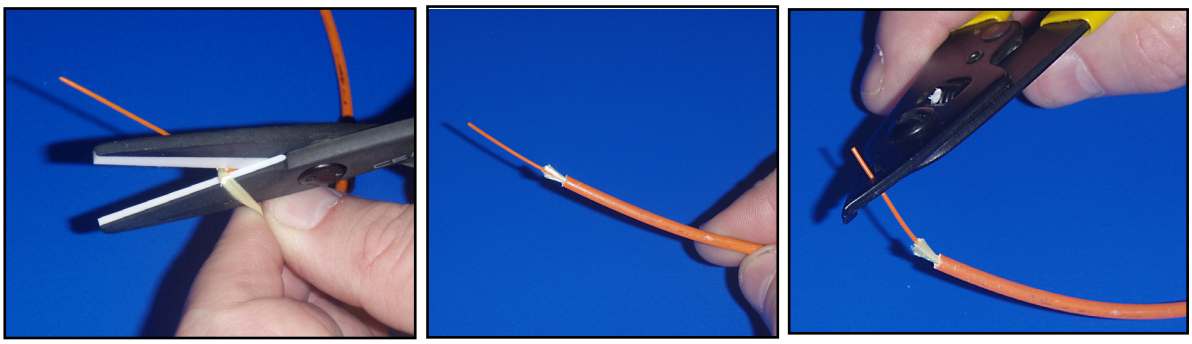

Figure. 6.4 Fibre Preparation

4. Strip back the inner fibre optic jacket to reveal the bare fibre optic element. Once you have stripped your cable back and removed coatings, clean the fibre using IPA (Isopropyl Alcohol) and a wipe; pull the stripped fibre end through the wipe gently to clean.

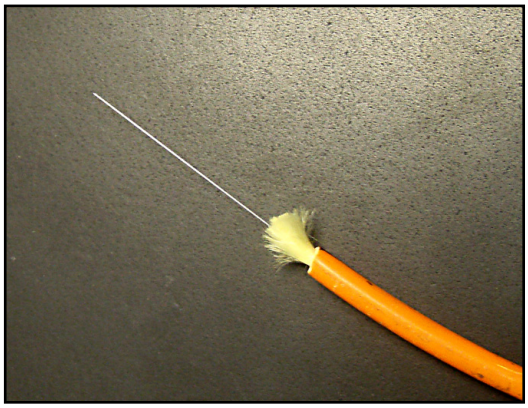

Figure. 6.5 Fibre Preparation

5. Strip back the inner fibre optic jacket to reveal the bare fibre optic element. Once you have stripped your cable back and removed coatings, clean the fibre using IPA (Isopropyl Alcohol) and a wipe; pull the stripped fibre end through the wipe gently to clean.

6.4.3 Assembly

Terminating fibre optic cable using Hot Melt Terminations is a quick, easy and safe method for fibre optic terminations. It has the advantage of using connectors ready loaded with epoxy resin that becomes soft when heated.

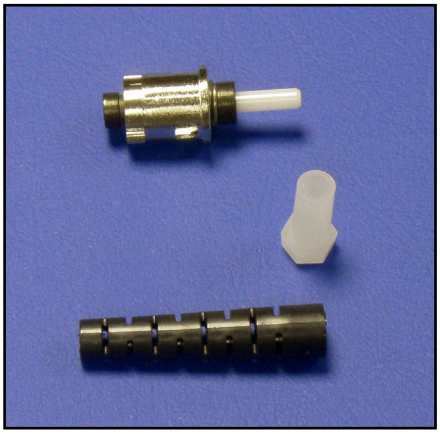

Figure. 6.6 Hot Melt Connector

The procedure for terminating the fibre optic cable using Hot Melt Terminations are:

1. Place the connector into a termination holder. This allows you to place the connector into the curing oven and safely remove it afterwards.
2. Place connector into curing oven; the curing oven must be able to heat the connector to the stated manufacturer's temperature, usually in excess of 200°C. Different manufacturers will require differing times in the oven for their connectors. Ensure you check the instructions carefully.

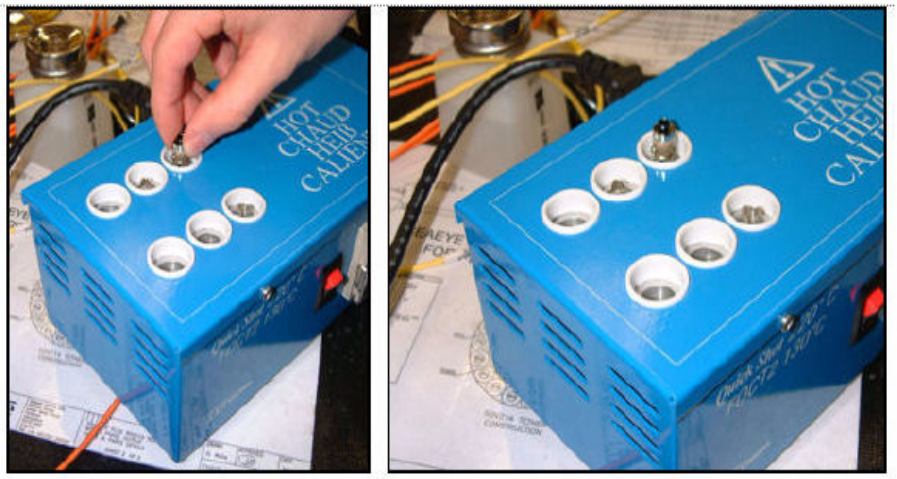

Figure. 6.7 Preparing STP Connector

3. Insert fibre into connector; since the epoxy resin begins to harden as it cools you have a limited amount of time - normally a few seconds - to insert the fibre through the connector and push the cable into the back of the connector until it is firmly seated.

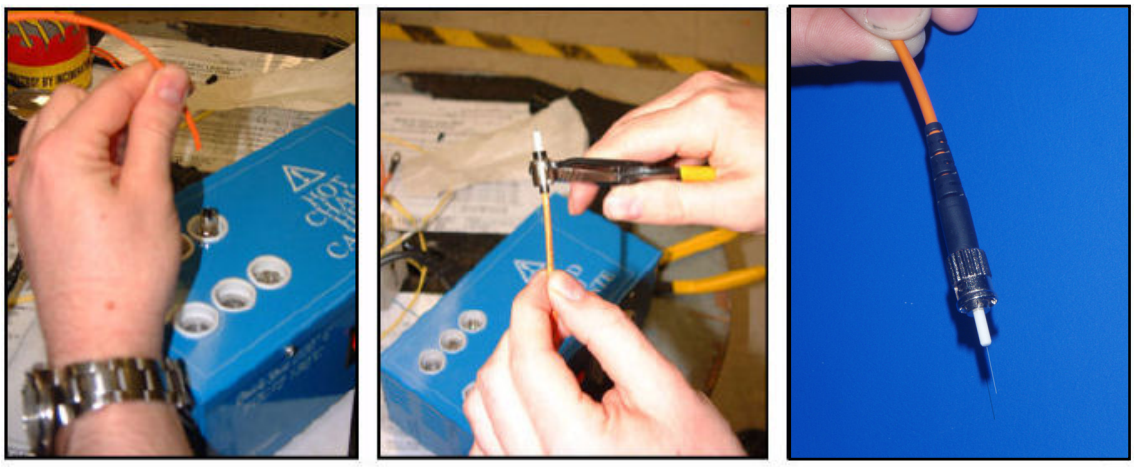

Figure. 6.8 Fitting STP Connector

4. Remove the connector, complete with fibre from the curing oven and allow to cool.

6.4.4 Polishing

The fibre end protruding from the ferrule needs to be cleaved cleanly and as close to the epoxy bead as possible. This is done using a ceramic cleaving tool to score the fibre and then pulling the fibre straight off (away from the ferrule). Scoring the fibre can be tricky and care needs to be taken not to break the fibre end off.

DANGER. Be very careful to dispose of fibre ends properly. The fibres create slivers that can easily puncture skin and cause irritation.

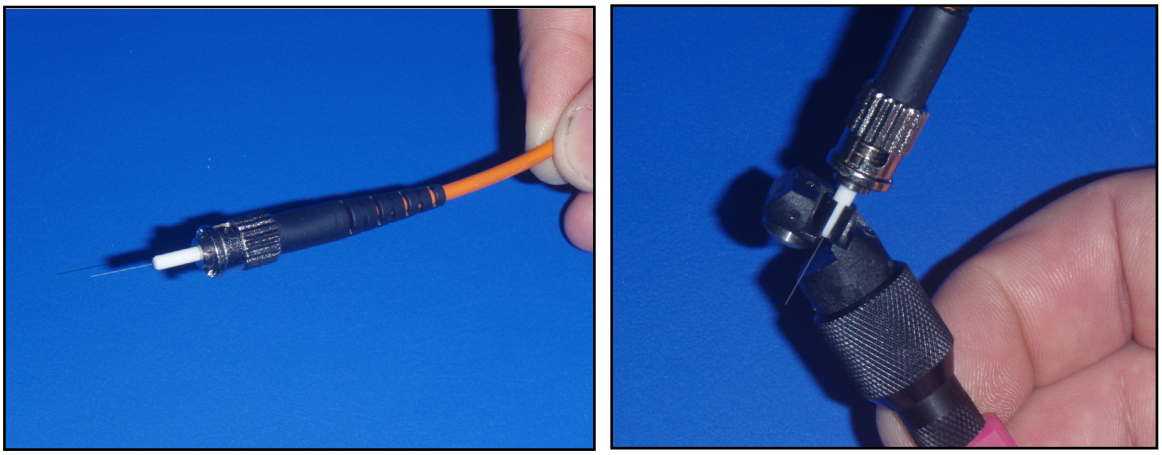

Figure. 6.9 Cutting the Fibre

5. Remove excess fibre, using the special piece of polishing paper supplied with the kit. This is the only paper that should be used for this purpose. Rest the paper on the connector tip and move gently in small circles or a figure of 8 until the protruding stub of the cleaved fibre is flush with the ferrule surface.

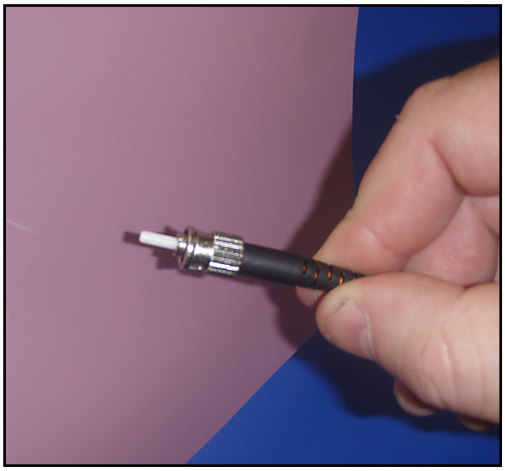

Figure. 6.10 Cleaning Fibre Cable

6. Clean the polishing plate with water or an appropriate window cleaning solution. Dry the plate thoroughly.
7. Place the polishing film onto the polishing pad and secure.
8. Gently insert the connector into the polishing tool.
9. Using a figure of 8 movement, and supporting the weight of the connector for the first three or four turns, gently polish the fibre.
10. During the process the end of the connector can be inspected through a microscope to ensure it is satisfactory.

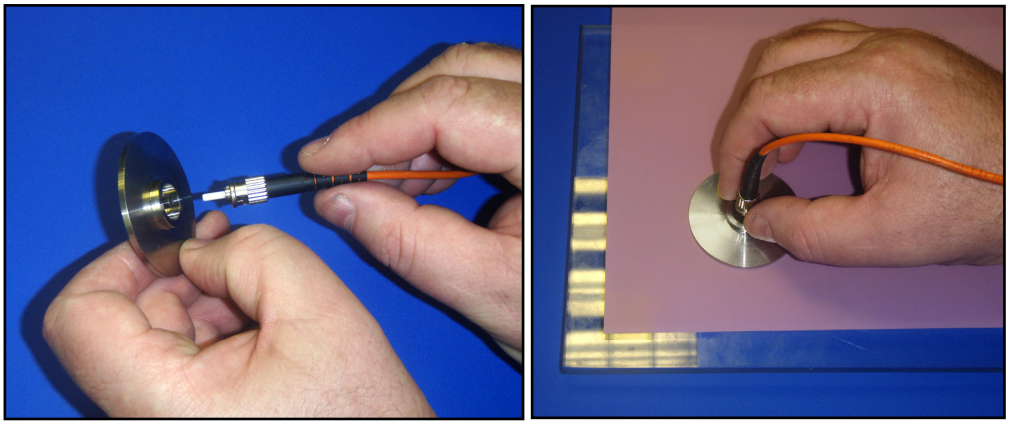

Figure. 6.11 Finishing the Fibre Cable Cleaning

11. Finish polishing with either the Green Fine or White ultra fine paper.

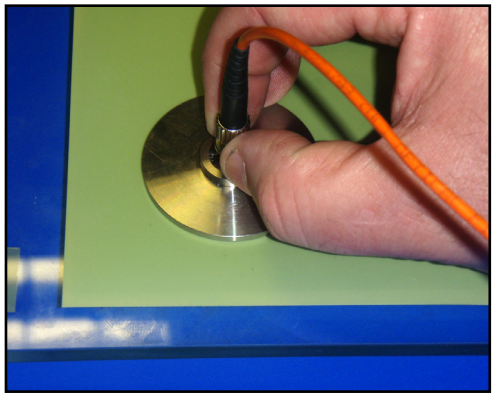

Figure. 6.12 Fine Polishing Paper

12. Remove the connector from the polishing tool and clean the ferrule face with lint free tissue. Inspect the connector with the 100x microscope. If possible place the far end of the fibre near a bright light. Compare the fibre end to the examples below.

Figure. 6.13 Fibre Examples

13. Verify that the fibre is flush with the ferrule surface by moving the microscope focus control. If the fibre and ferrule come into focus together, the fibre is flush. If the fibre comes into focus before the ferrule surface, then the fibre is protruding and additional polishing may be required.

6.5 SM9 Thruster Propeller

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.

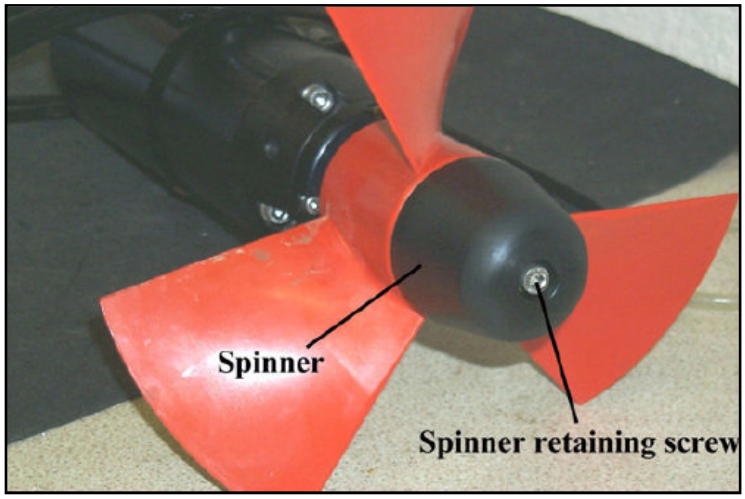

Figure. 6.14 Thruster Boss

3. With the propeller wedged, remove the M16 Nyloc 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.

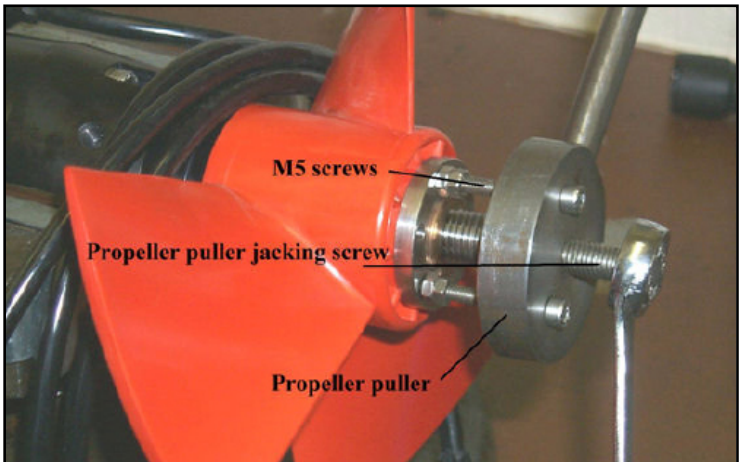

Figure. 6.15 Thruster Propeller Removal

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 initially by 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.

6.5.1 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 Aqualube to the threads, fit a new M16 Nyloc 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 threadforms and O-ring with silicone grease.

6.6 SM4 Propeller and Nozzle

6.6.1 Dismantling

Proceed as follows:

1. Using a wooden dowel wedge the propeller to prevent from turning.
2. Remove and discard the Nyloc nut from the propeller shaft.
3. Fully extend the legs of the puller tool and fit to the propeller with three in number 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.
5. Remove the Propeller Puller tool from the propeller.

NOTE. Should difficulty be experienced when removing the propeller, removal can be facilitated by the careful application of heat to the propeller boss using a heat gun.

6. Loosen but do not remove the screws securing the nozzle to the thruster motor body and withdraw the motor rearwards from nozzle assembly.

NOTE. To avoid damage to the end cap and whip, grip the thruster by the body and lever apart the nozzle if necessary.

6.6.2 Assembling

Proceed as follows:

1. Carefully insert the motor into the nozzle assembly and rotate the motor body to align the electrical whip in the required direction.
2. Tighten the screws to secure the motor body to the nozzle assembly.

3. Apply a liberal coating of Loctite 641 to the taper section of the thruster motor shaft.

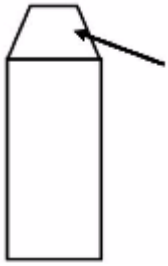

Figure. 6.16 Apply Loctite 641 to the entire surface area of taper

4. Refit propeller to the motor shaft.
5. Wedge propeller to prevent from turning.
6. Fit a plain M8 nut to the motor shaft and tighten until the propeller has located and locked onto the motor shaft.
7. Remove the nut and replace with a new Nyloc nut and torque to 27 Nm.
8. Using a metal rule or other suitable flat surface align the nozzle assembly with the top of the M8 nut by loosening the nozzle assembly screws.

Figure. 6.17 Aligning the nozzle assembly

6.6.3 Refitting

Proceed as follows:

1. Locate the thruster and nozzle assembly in position on the vehicle chassis and secure with two in number hex screws.
2. Reconnect the motor electrical cable to the vehicle EPOD.

NOTE. Dismantling the motor beyond the maintenance described within the handbooks will invalidate the warranty. If in any doubt, consult SAAB SEAEYE prior to any further dismantling of the Thruster Motor.

6.7 SM4 Thruster Motor V-Seal Replacement

WARNINGS.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the ROV system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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.

Danger to personnel and equipment. . The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Proceed as follows:

1. Remove the motor from the ROV.
2. Dismantle the motor.
3. Support the thruster in a vertical attitude shaft uppermost.
4. Gently remove the V-Seal from the nose cone and discard.
5. Lubricate the motor shaft with silicone grease.
6. Fit a new V-seal to motor shaft.

Figure. 6.18 V-seal fitment

7. Assemble the thruster motor.
8. Carry out an oil level check.
9. Refit the motor.

6.8 SM9 Thruster Motor V-Seal Replacement

WARNINGS.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the ROV system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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.

Danger to personnel and equipment. . The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

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 Nyloc 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 silicone 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.

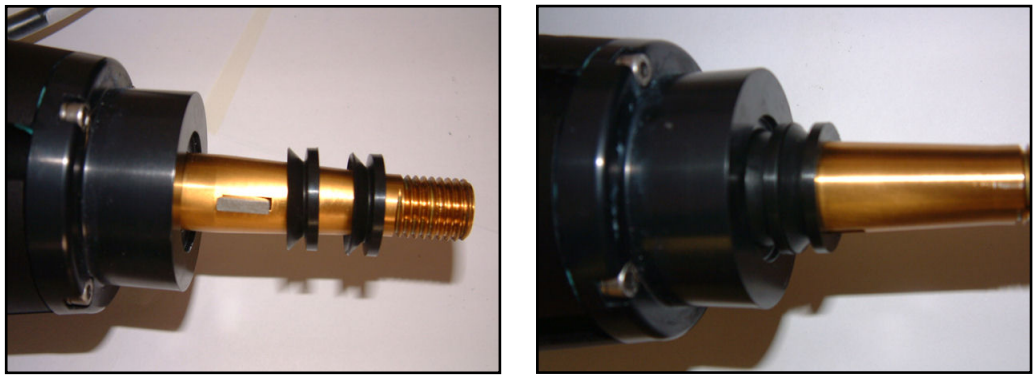

Figure. 6.19 Thruster Shaft V-Seals

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 Nyloc 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.

6.9 SM4 and SM9 Thruster Diaphragm Replacement

tbd

6.10 SM4 Thruster Insulation Testing

WARNINGS.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the ROV system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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.

Danger to personnel and equipment. The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Damage may occur if the thruster insulation test is not carried out correctly.

Proceed as follows:

1. Connect the insulation tester as shown in Figure. 6.20.
2. The thruster can be insulation tested as follows.
   - Earth to DC.
   - Earth to Electronics.
   - Electronics to DC.
3. Reading is to be greater than 200 Mohms.

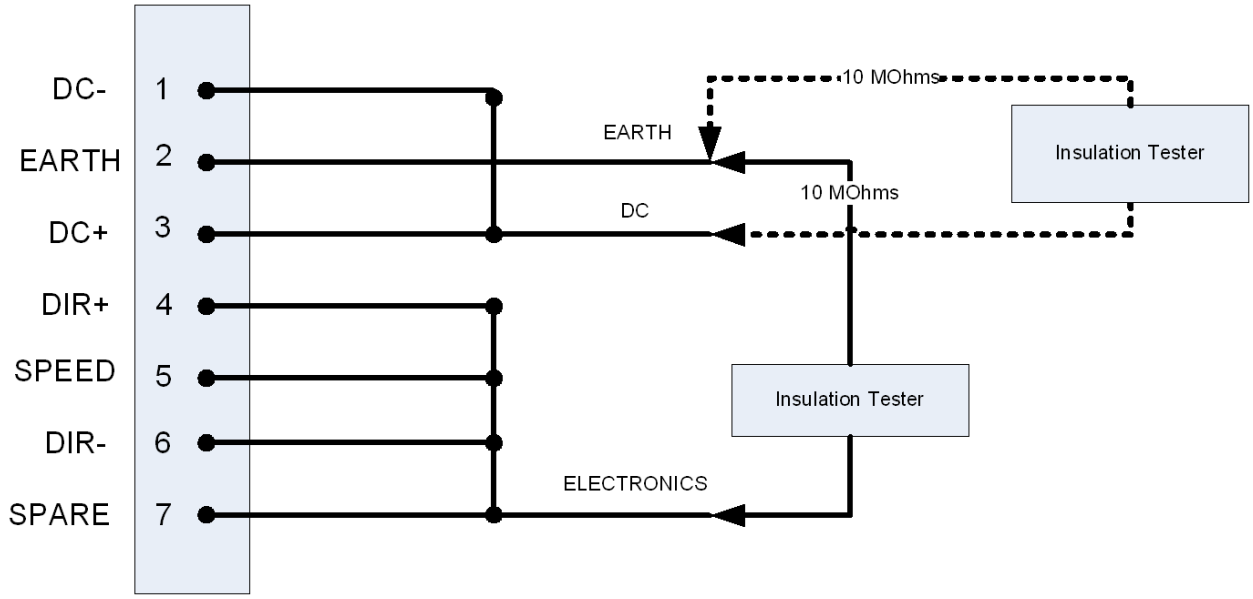

Figure. 6.20 Thruster Insulation Test Setup

NOTE.

Electronic lines must be kept bonded for insulation tests. Damage may occur to electronics if the lines are separated and tested individually.

6.11 Metal Shell Connector O-Ring Replacement

WARNINGS.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the ROV system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

CAUTIONS.

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

Proceed as follows:

1. Using a small screwdriver, open the spiralux washer and slide along the connector body towards the plug moulding.
2. Pull back the nut towards the plug moulding, remove and discard the O-rings.
3. Clean the O-ring grooves, connector body and nut with Amberklene.
4. Lightly lubricate two new O-rings and fit into the connector body O-ring grooves.
5. Slide the nut along the connector body past the spiralux groove.
6. Using a small screwdriver, slide the spiralux washer along the connector body until it locates into its groove.
7. Functionally check all systems.

6.12 Pressure Hull

6.12.1 Removal

Proceed as follows:

1. Remove the screws holding the top lid and remove the lid.
2. Remove the start key compartments.
3. Remove the buoyancy block above and on the sides of the pressure hull.
4. Disconnect all cables from the front and aft lids.
5. Remove the top front buoyancy block to get access to the Doppler log girder.
6. Unscrew the Doppler log girder from the front lid and slip it to the side slightly.

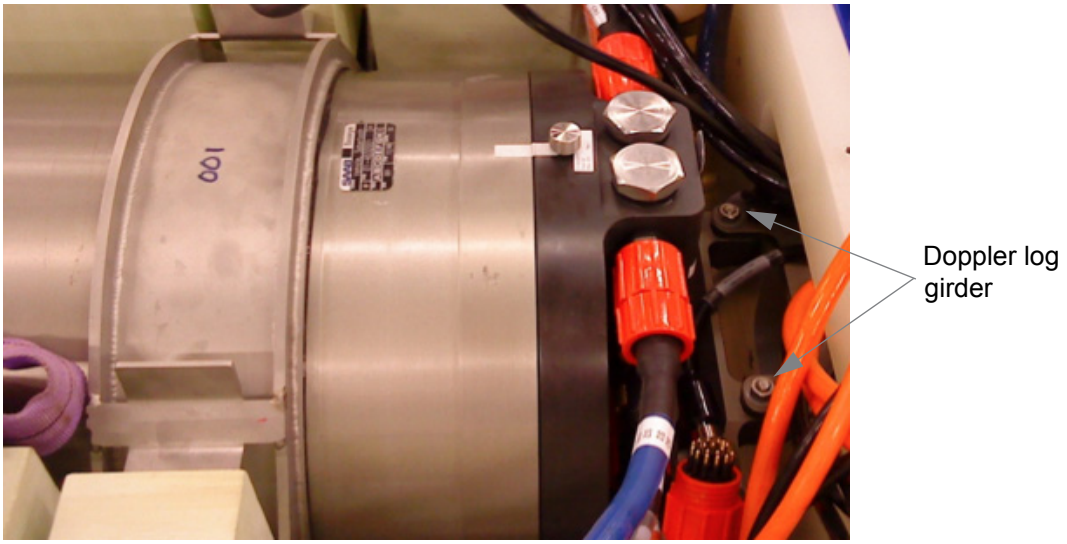

Figure. 6.21 Front lid with Doppler log girder

7. Connect a crane hook to the lifting shackle and lift the hook so that crane is supporting the weight.
8. Unscrew the bolts on the side holders on the outside of the vehicle sides.

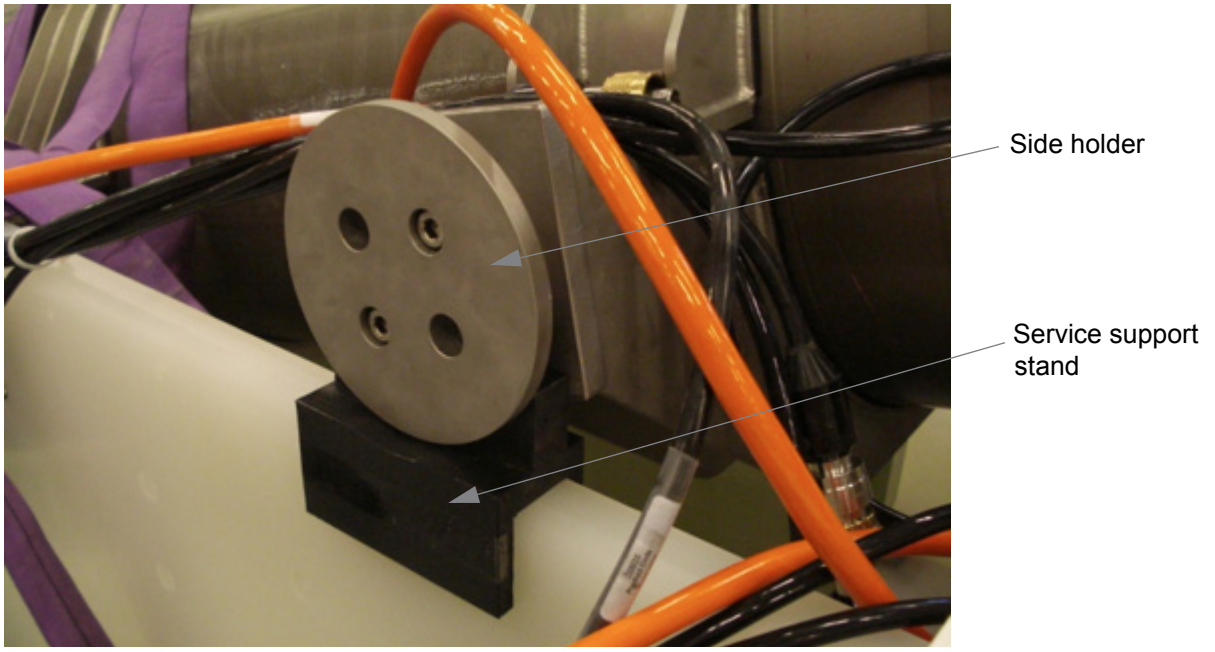

Figure. 6.22 Side holder and service support stand

9. Support the long end of the pressure hull so that the hull carefully can be lifted out horizontally from the vehicle. Be careful so no cables are squeezed. It is especially easy to squeeze cables between the front lid and the Doppler log girder.
10. If desired the pressure hull can be placed on top of the vehicle using the service support stands. To do this the side holders have to be mounted on the pressure hull again.

6.12.2 Dissasembly

Proceed as follows:

1. Unscrew the nuts on the lid anchoring so that the lid clamps can be removed on the end of the pressure hull that shall be opened.

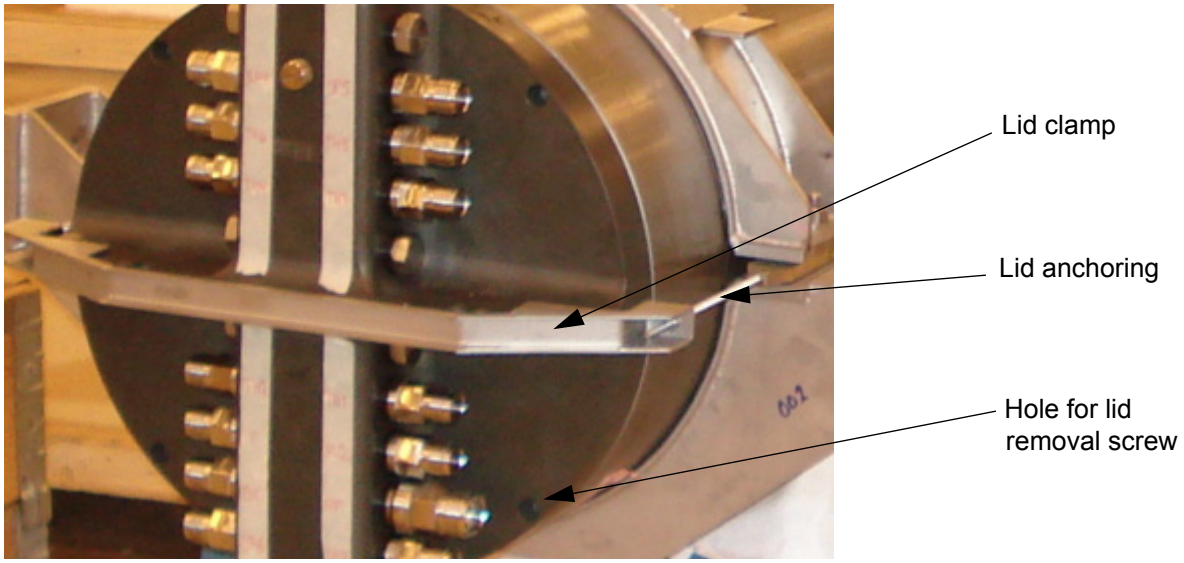

Figure. 6.23 Lid anchoring and lid clamp

2. Loosen the air bleed screw.
3. Insert the lid removal screws in the four holes in the lid.
4. Tighten the four lid removal screw. Alternate between the screws so that each screw is tightened just a little each turn. Continue this until the lid comes loose.
5. Carefully pull the lid out. The connector to the front lid can be removed when the lid has been pulled out just a little. The connectors on the aft lid cannot be removed until the whole lid is out.
6. Disconnect the ground wire from the lid using a spanner.
7. If the battery unit shall be taken out also the other lid shall be removed in the same way.
8. To remove the battery unit the aft locking frame must be removed. Loose the locking frame by rotating the nut with a spanner while holding the tension screw still. The tension screw is held still by inserting a thin screwdriver in the hole in the tension screw.

! Do not remove the front locking frame, since then the correct position of the battery unit have to be tested out again. It is essential that the front locking frame is correctly mounted so that it has galvanic contact with the pressure hull.

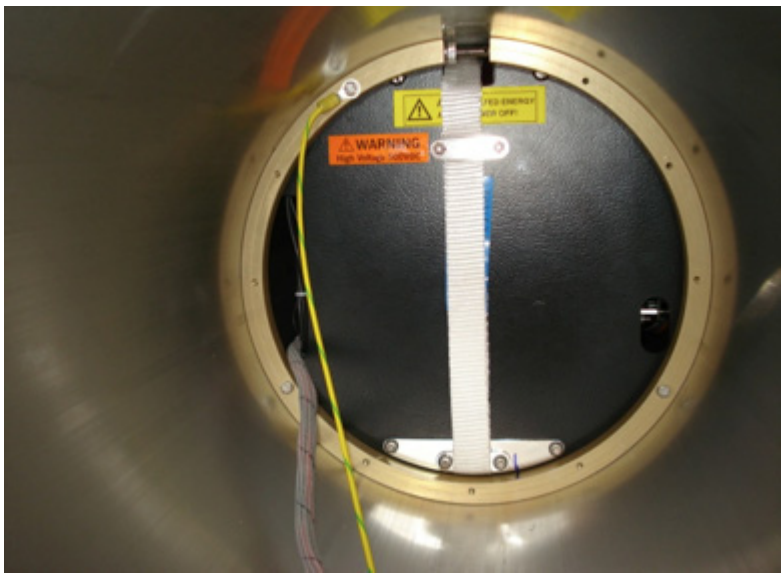

Figure. 6.24 Front locking frame

9. When the aft locking frame has been removed the battery can be pushed out by pushing from the front of the pressure hull.

! Do not perform any work on the battery until the chapter on battery handling has been carefully read.

6.12.3 Assembly

Proceed as follows:

1. The battery unit is pushed in from the aft. Make sure the battery unit is correctly rotated so the threaded bars on the front locking frame fits into the holes of the battery unit. The battery unit shall be in close contact with the front locking frame.
2. Mount the aft locking frame aft of the battery unit.
3. Check that the o-rings on the lids are clean and undamaged. Put some vaseline on if necessary.
4. Connect the connectors and ground wires to the lids and insert both of them as far as possible.
5. Remove the air bleed screw on one of the lids and connect the vacuum pump.
6. Put the lid clamps on and tighten the nuts on the lid anchoring at the same time as lowering the pressure with the vacuum pump. Finally the lids will move into positon.
7. Perform a pressure test on the hull using the vacuum pump.

6.12.4 Installation

Perform the removal procedure in the reverse order.

6.13 Battery Handling

The battery handling instructions shall be read carefully before accessing the battery modules. Even if some information is repeated, for completeness the safety notes from REAP and from Kokam are also included below.

6.13.1 General battery handling rules

- The personnel working on the battery system shall have good knowledge of electricity and of how this battery system is designed.
- Always handle the battery as if it is fully charged.
- Only place the cell modules on a soft material. Especially the corners can easily be damaged.
- If electrolyte should leak out and come in contact with a body part flush with water immediately and seek medical advice.
- The following apply to battery cells:
  - Cells may not be bent.
  - Soldering on cell connections is not allowed.
  - Be careful with the polarity, especially when a cell is reconnected to a cell module.
  - Never pull the cell connections as these easily can come off.
- The following safety equipment shall always be available close to the battery (even when mounted in the vehicle):
  - High voltage insulating gloves
  - Powder extinguisher
- At least two persons shall be present during work on the battery.
- Keep good order around the battery.
- Do not work on the battery if you are tired or stressed.
- When the battery is not mounted inside the vehicle it shall be stored on a small carriage so that it can always be transported away in case of an accident.
- Always measure the voltage in the power connectors before doing any work on the battery to make sure the contactors have opened properly.
- External equipment connected to the battery shall have isolated power supply. For example is preferable to use a laptop when a computer is to be connected to the BMS.
- To minimize the risk for short circuit it is not allowed to wear for example watch, 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 the time. Keep the hands dry.
- Personnel with heart disease shall not work in the battery.

6.13.2 Action plan if an accident occur

The battery is short circuited by an object

If the battery is short circuited by for example 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. This should give enough time so that the stuck tool can be hit with an insulated tool to remove it.

Take the battery outside at least 20 meters from the closest building. Monitor the battery from a distance of at least 15 meters for two hours. If nothing happens during this time the battery can be taken in and disassembled to cell module level (14 cells) and investigated.

The battery is 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.

If a person gets current into the body and gets stuck a second person needs to get the injured person loose from the battery. **Use insulating gloves when doing this!** If necessary perform CPR while waiting for the ambulance.

Internal short circuit inside the battery

When the battery is getting old pure lithium can gather on the electrodes resulting in a short circuit. The only way to detect this is to check if the temperature sensors are detecting a high temperature. Normally the temperature shall never exceed the ambient temperature within the vehicle with more than 20° C. If an internal short circuit is detected follow the procedure for a short circuit caused by an object.

Short circuit caused by water inside the pressure hull

Fresh water for short time (< 3 days of exposure)

When recovering a vehicle that is suspected to contain water recover the vehicle as quickly as possible and open the pressure hull. Equipment that can give sparks is not allowed close to the vehicle since a small amount of oxyhydrogen gas can be generated when the battery is exposed to water.

After recovery take the battery apart down to cell module level (14 cells). Rinse the cell modules with distilled water and let the battery dry in normal room temperature (18-25° C). Keep the cell modules apart (> 1 meter). Visually inspect the cell modules and check for corrosion on cell tabs and that the cells are sealed properly.

If no remarks have been found, the battery can be used again. If the battery has been exposed to water for a longer time follow the procedure below.

Salt water for short time (< 1 hour of exposure)

When recovering a vehicle that is suspected to contain salt water leave the vehicle at the surface for 30 minutes. Large amount of oxyhydrogen gas can have been generated and by keeping the vehicle at the surface the pressure inside the hull can be reduced.

When the vehicle is on deck open the air bleed screw a little to reduce any overpressure. Hold it with pliers so you do not have to hold it directly with your hand. Take measures so that the air bleed screw will not cause harm to people or equipment if it is blown away because of an overpressure. Equipment that can give sparks is not allowed close to the vehicle since oxyhydrogen is explosive. Open the lids so the water can come out.

Self-discharge and corrosion have started so it is important to quickly disassemble the battery down to cell module level (14 cells). Rinse the cell modules thoroughly with distilled water and let the cell modules dry in normal room temperature (18-25° C). Keep the cell modules apart (> 1 meter). Visually inspect the cell modules and check for corrosion on cell tabs and that the cells are sealed properly.

If no remarks have been found, test the battery. If also this works fine the battery can be used again.

6.13.3 Safety note from REAP

Safety Note for Kokam Lithium-Polymer Battery Packs

Kokam Li-Polymer cells are EXTREMELY powerful. A fully charged cell or battery pack stores significant amounts of energy, which can be released at a high power in short time. They can cause severe fires. Do not underestimate their potential danger on the basis of their small size and low weight!

Handle cells and packs with great care. Do not bend, crush, penetrate, shoot, incinerate, heat up or let fall cells or packs. Handle cells in a low state of charge.

Ship cells or packs in appropriate (inspected) containers with sufficient packaging materials. Kokam cells fall under “DANGEROUS GOODS” regulations. Check latest requirements. Ship cells in a low state of charge.

Store cells safely. Make sure that only authorised and trained staff has access to stored cells and packs. Storage should be in dry and cool conditions in order to prevent corrosion and cell degradation. Check cell connections and pack/cell conditions after long storage periods. Store cells and packs in such a way, that they cannot be short-circuited. For example avoid storing them on metal shelves, leave sufficient room to any electrically conducting surfaces or materials and secure them safely.

Store cells with about 50% state of charge (charge to 3.9V per cell) and check state of charge from time to time. Disconnect battery protection devices, battery management systems or any other energy consuming devices from the cells before putting them into storage. Check cell state of charge more frequently if devices cannot be disconnected. Recharge cells or packs before the lowest cell voltage goes below 3.5V.

Pouch cells in general (like for example Kokam cells) have no sturdy case. Cells should be installed and mounted in such a way that there are no substantial forces on their edges and corners. E.g. they should be mounted horizontally instead of vertically (assuming that the main forces are due to the cell weight). This is particularly important in applications with high mechanical shock or vibration (e.g. vehicles). Please use extra support and padding in case cells are mounted vertically.

Make sure that ALL cells are charged and discharged properly and according to manufacturers specifications. Use appropriate settings in chargers, battery protection devices, motor controllers, battery management systems and other devices. Always check the latest requirements with the manufacturer – see www.kokam.com .

Monitor the first charge / discharge cycles of a new system and make sure that it works according to your and the manufacturer’s requirements.

Kokam cell terminals are made of thin copper / aluminium foils. Both materials are subject to corrosion. The thin foils do not allow high tension in the connecting bolts and contact forces may become insufficient. Corrosion and / or low contact forces can increase resistance of cell connections. High contact resistances increase power losses and heat up of cell connections when drawing or charging with high currents. This can cause fire! Check cell connections regularly.

Do not short-circuit cells or packs. Make all efforts to prevent them from being short circuited. Use electrically insulated tools when working on the cells. Best is not to use any electrically conducting materials in conjunction with the battery (housings, desks or shelves). Take great care if you have to. Make sure that isolating materials and cables cannot wear out or that cables can short circuit cells. Use fuses as close to the cells as possible for all cables connected to any of the cells – this includes cables for measurements!

A fully charged cell or pack WILL catch fire with flames several meters long if short-circuited for sustained times. The fire will be caused due to the heat-up of the cells. This can take some time, depending on the cell / pack size, temperature, state of charge, age, type of cooling and type of short-circuit. Hence, it is difficult to give an estimate for this time. Generally, there is sufficient time to remove the short-circuit if realised instantly or to remove the battery from premises. However, make sure that this removal can be achieved safely for your staff.

Any cell or pack fire will generate very hot and long flames up to several meters long depending on several circumstances. However, the cells contain no liquids and the fire will not spread out rapidly. However, it will incinerate flammable materials surrounding the battery. Manufacturing, design and tests with cells or packs or systems comprising these cells should be undertaken in spacious rooms with high ceilings and with space and tidiness around the design / test / manufacturing site. Access for untrained people (cleaners, visitors, security, staff, etc.) must be prevented. One should assure to have fast ways for removing the cells / packs / systems from premises, especially if spacious rooms or high ceilings are not available.

Packs of several cells provide an additional risk: Do not assume that the situation is under control when the fire seemingly calms down. Neighbouring cells WILL catch fire subsequently and this will probably happen with some time-delay. Do not approach the pack until you are sure that the whole pack has cooled down. Wait for several hours.

Read and follow manufacturer's safety datasheet for more information and instructions.

Kokam cells can provide very high current / power. There are various other risks apart from cell fire: High currents can heat up cables, connectors, cells or other devices. Do not burn or hurt yourself by touching hot components, cables or surfaces. Sparks may occur and they can cause eye injuries or other injuries through UV light or through the emission of hot or melted particles. Use appropriate protection such as goggles, etc. Finally, high current can weld! Be careful with watches, fingerings, etc.

Usually, all cables used around the battery system and cells are not rated for full short-circuit currents. Cables WILL catch fire or WILL provide sufficient heat to incinerate surrounding components or materials. The heat can be sufficient to incinerate the cells even if the current was not sufficient to cause any direct harm to the cells (e.g. thin measurement cables may catch fire at less than 10A, which would be fine for the cells, but the fire may heat them up and cause more severe cell fire). Use appropriate fuses for all cables connected to any of the cells and place fuses as close as possible to the cells. Do not assume that a thin cable could be used as a fuse!

Make unfused cable lengths as short as possible and make sure that these unfused cable lengths cannot cause any short circuit. Kokam cell terminals are often protected with thickwall heat-shrink. However, the lower parts of the terminals are usually not covered. These exposed terminals are very thin and hence they provide sharp edges, which could cut into or wear out measurement cables. Make sure that all cables for the cell voltage measurements are routed in such a way that they cannot touch and wear out at these exposed terminals.

The standard configuration in which the cells are shipped is not suitable. Rubber or plastic tubes should be inserted as ducts for these cables.

Watch out for tools, bolts, nuts or other electrically conducting devices that may fall in between or on top of the cells and provide a short-circuit.

Several external components (e.g. chargers, motor controllers, DC/DC converters) contain input capacitor. Pre-charge these capacitors before connecting these devices to the battery. High currents may flow and substantial arcs may occur otherwise.

High voltages can be dangerous! Any battery pack with more than 7 cells can already provide voltages that are potentially dangerous to human beings. Take extreme care when working with systems with more than 14 cells in series! We are unable to provide comprehensive safety information regarding high voltages here. But we will point out a few issues that are special to battery systems. Please consult other sources on safety around high voltage systems.

Allow only trained or certified staff to work with high voltage systems – check local legal requirements and bare in mind that high DC voltages exhibit other risks than high AC voltages. Electricians are not necessarily trained and suitable to work on high voltage battery systems!

Batteries cannot be switched off! The high voltages are always present until the cells are disconnected. Disconnect cells with great care! Make sure that high voltage packs are in enclosed compartments and that voltage supplies and connectors on the interface of these compartments can be electrically disconnected from the battery (e.g. emergency switch). Lock, seal and label high voltage compartments, so that only trained staff can access them.

Bare in mind that some interfaces on BMS (e.g. the RS232 on our BMS) are connected to battery minus of that particular battery pack. Connecting the RS232 to a computer will establish a connection between battery minus and that computer (earth, ground, case). This is particularly dangerous with high voltage systems. Use isolating RS232 converters. Use laptop computers with isolating power supplies instead of desktop computers, which will connect battery minus to earth potential! Do not touch the computer and the battery system at the same time and do not connect the computer with the battery system with electrically conducting materials (e.g. metal desks!).

High DC voltages can be present on certain external components even after disconnecting the battery. Chargers, motor controllers, DC-DC converters and other devices usually use large capacitors on their inputs. These capacitors hold the full battery voltage for some time. Use bleeding resistors and if possible connectors that wouldn't allow you to touch any of the pins. Measure voltages before touching any pins or before opening components.

Make all cell potentials floating – do not establish any potential relationship between any of the cell voltages and ground, earth or system bodies. High humidity may establish such relationships. Use isolating chargers and DC/DC converters.

Do not work in confined spaces with the cells. Use high-impedance but thin gloves. Use only one hand ("put one hand in your pocket"). Don't wear watches, finger rings, necklaces, etc..

Wear safety glasses / goggles.

Make sure that people working with battery cells and packs are "fully switched on", healthy, not over-worked and trained / certified properly.

Make sure that no-one works on his own and that the second person knows what to do in certain cases.

Ensure good working conditions (light, space, cleanliness, tidiness, low humidity, comfortable temperature, etc.)

Obey standards, rules, good-practices, regulations, laws and common sense.

DISCLAIMER: This safety note is supposed to give guidance and help only. We have paid our greatest attention to make it as comprehensive, concise and correct as possible. However, it may not be complete and it is not suitable as a document for training staff or as a safety note for storage or for operators of systems. Customers have to undertake their own risk assessments and they have to derive their own safety documents, notes and warnings. Taking into account their specific circumstances and up-todate local laws / requirements and company / insurance policies. Large Li-Ion cells are a fairly new technology and the experiences gained so far are limited. We cannot be held liable for the completeness, correctness or suitability of the information given here. Customers are advised to undertake their own research and consult other information sources in order to satisfy their own safety standards and minimise any risk. Information is available from many sources and it is updated frequently. Please make sure that the information you hold is up-to-date.

6.13.4 Safety note from Kokam, QA-041001 7.17.4.1

Handling precautions

For use of this battery, must follow as specified below. Other than conditions listed may cause major burst, fire, some smokes and it will cause severe performance failure and unsafe for use. Please be sure to follow instructions carefully.

Protection Circuit Module (PCM)

(A) The Cell(s)/Battery Pack shall be with a PCM which can protect Cell(s)/Battery Pack properly.

PCM shall have functions of (i) overcharging prevention, (ii) over-discharging prevention, and (iii) over-current prevention, to maintain safety and prevent significant deterioration of cell performance. The over current can occur by external short circuit.

(B) Overcharging Prohibition. Overcharging prevention function shall work if any one of the Cells of the battery pack reaches to 4.30V above which charging shall be stopped.

(C) Over-discharge Prohibition. Over-discharging prevention function shall work to minimize a dissipation current to avoid further drop in cell voltage of 2.70V or less per cell in either cells of the battery pack. It is recommended that the dissipation current of PCM shall be designed to be minimized such as 0.5 micro-amperes or less after the over-discharge prevention function works.

Consideration of strength of package film

(A) Aluminum Laminate Film. Easily damaged by sharp edge parts such as Ni-tabs, pins and needles, comparing with metal can case LIB.

B) Film sealed part. May be damaged by heat above approximately 90°C. (Seal break may cause Electrolyte leakage)

Prohibition short part

Never make short circuit the Cells. It makes generation of very high currents which subsidiary cause heating of the Cells, which may cause the electrolyte leakage, gassing or explosion which are very dangerous. The SLPB tabs may be easily short-circuited by putting them on conductive surface. (Such outer short circuit may lead to heat generation and damage of the cell.)

An appropriate circuitry with PCM shall be employed to protect accidental short circuit of the battery pack.

Mechanical Shock

SLPB cells have less mechanical endurance than metal can case LIB. **Falling, hitting, bending, etc. may cause degradation on SLPB characteristics**.

(A) Don't cut, deform, tear or drill the laminate film of battery.

(B) Don't twist or bend the battery. Keep the battery away from excessive pressure especially on the boundary between the body and the sealed part

Handling of tabs

The SLPB tabs are not so stubborn especially for aluminum tabs as positive terminal. **Do not put much force on SLPB tabs**. (Aluminum tab may easily be torn off by shear force.)

Handling warning

Cell connection

(A) Direct soldering of wire leads or devices to the Cell is strictly prohibited.

(B) Lead tabs with pre-soldered wiring shall be spot welded to the Cells. Direct soldering may cause damage of component, such as separator and insulator, by heat generation.

(C) Don't reverse polarity (and terminal). On charging, the battery is reverse-charged and abnormal chemical reaction occurs. And also, there may be case that unexpected large current flows on discharging. There cause the generating, smoke, rupture or flaming

Prohibition of Disassemble the Cells

(A) The disassemble the Cells. The disassembling may cause a chance to generate internal short circuit in the Cell, which may cause gassing, firing, explosion or other troubles.

(B) Electrolyte is harmful. An electrolyte happens to be leaked out from the Cells is harmful to the human bodies. In case if the electrolyte is coming in contact with the skin, eyes or others, the electrolyte shall be flushed immediately with fresh water and seek medical advice by physicians.

Prohibition of Dumping of Cells into Fire

Never incinerate nor dispose the Cells in fire. These may cause explosion of the Cells, which is very dangerous and is prohibited.

Prohibition of Cells immersion into liquid such as water

The cells shall never be soaked with liquids such water, sea water, drinks such as soft drinks, juices, coffee or others.

Keep the battery away from babies

Keep the little battery out of the reach of babies in order to avoid troubles by swallowing. In case of swallowing the battery, see a doctor immediately.

Prohibition of getting into a microwave or a high pressure container

It causes the generating, smoke, rupture or flaming because of sudden heat or damage of sealing condition of battery

Battery Cells Replacement

The battery replacement shall be done only by either Cells supplier or device supplier and never be done by the user.

Prohibition of User of Damaged Cells

The Cells happens to have a chance to be damaged during shipping by any shocks. If any abnormal features of the Cells are found such as damaged in a packaging film of the Cell, deformation of the Cell, smelling of an electrolyte, an electrolyte leakage and others, the Cells shall never be used any more.

6.14 SM9 Thruster Tilt Adjustment

If the vehicle has a tendency to roll or to change depth when going forwards quickly the X-motor pitch angles can be adjusted. Remove the top aft buoyancy block to access the turnbuckles. Also the pitch of the wing can be used to compensate for problems to stay at the same depth.

Check the thrust of the YZ-motors in the MMI when going fast forwards to see how well trimmed the X-motors are. If the X-motors are well trimmed less power will be used by the YZ-motors and the endurance of the vehicle will increase.

Figure. 6.25 Thruster Tilt Adjustment. The arrow points at a turnbuckle.

6.15 Fuse Exchange

6.15.1 Vehicle Battery Fuse

Item	Current Rating	Type
Battery fuse	56A high speed	HRC high speed (Part no 03-0814056)

Table 6.3 Vehicle battery fuse

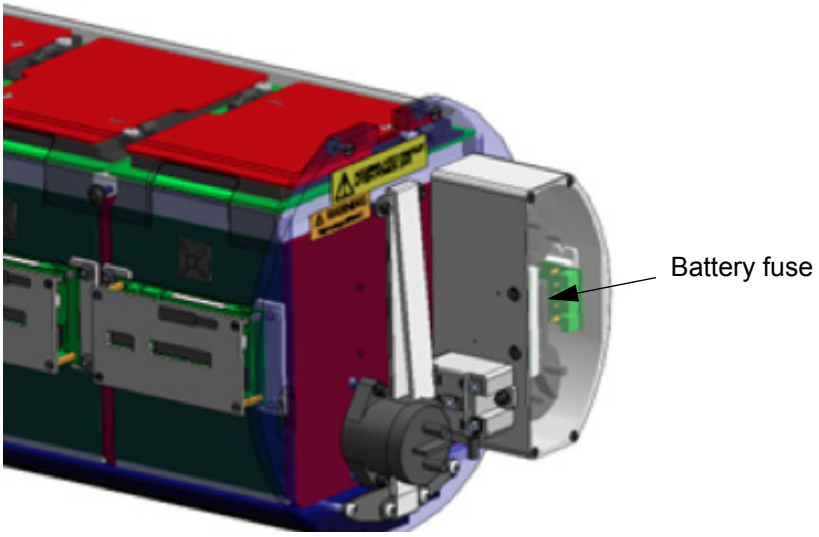

Figure. 6.26 Battery fuse

! Disconnect the battery at the cell modules before exchanging a 56A fuse. Carefully read the chapter on battery handling in chapter Disassembly and Repair before opening the battery modules.

To replace the battery fuse proceed as follows:

1. Remove the battery unit from the pressure hull.
2. Remove the screws so that the plastic lid over the battery cells can be lifted.
3. Disconnect the cable to the + terminal on battery cell module 4 (named 4+). If this is not done there will be voltage on the fuse even if it is blown. Be very careful when working on live terminals!
4. Remove the cover over the junction box to access the fuse.
5. Replace the fuse.
6. Install the junction box cover.
7. Connect the cable to 4+ again.
8. Put the plastic lid on the battery on again.
9. Install the battery unit in the vehicle again.

6.15.2 Vehicle Front Lid Fuses

Item	Current Rating	Type
F1-1 Power supply fuse	5AT	5AT 415VAC 6.3x32mm (Part no 1175146)
F1-2 Power supply fuse	5AT	5AT 415VAC 6.3x32mm (Part no 1175146)

Table 6.4 Vehicle front lid fuses

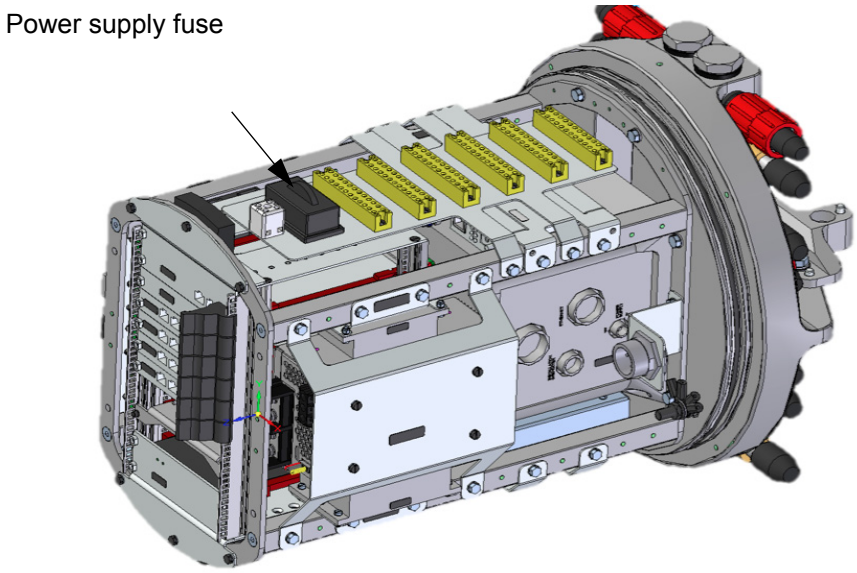

Figure. 6.27 Fuses on front lid

6.15.3 Vehicle Aft Lid Fuses

Item	Current Rating	Type
FB1-1 Tools connector	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)
FB1-2 Tools connector	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)
FB2-1 Starboard X-motor	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)
FB2-2 Starboard X-motor	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)
FB3-1 Port X-motor	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)

Table 6.5 Vehicle aft lid fuses

Item	Current Rating	Type
FB3-2 Port X-motor	12.5 AT	12.5A FF 500VAC 6.3x32mm (Part no 117-5110)
FB4-1 Starboard YZ-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB4-2 Starboard YZ-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB5-1 Port YZ-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB5-2 Port YZ-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB6-1 Y-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB6-2 Y-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB7-1 Z-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)
FB7-2 Z-motor	5 AT	5AT 415VAC 6.3x32mm (Part no 1175146)

Table 6.5 Vehicle aft lid fuses

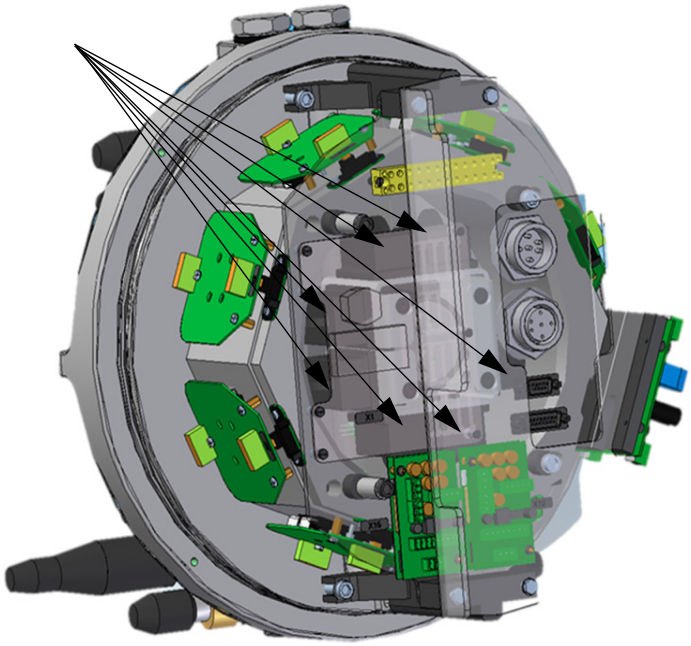

Figure. 6.28 Fuses on aft lid

6.15.4 Winch Fuses/Circuit Breakers

Item	Current Rating	Type
F1-F3 Motor drivers supply circuit breaker	16AT	3-pole circuit breaker
Capstan motor driver (internal)	2 x 20A	High speed
Drum motor driver (internal)	2 x 20A	High speed
F4-F5 DC power supply input circuit breaker	2AT	2 x 1-pole circuit breaker
DC power supply fuse (internal)	4AT	6.3x32mm

Table 6.6 Winch fuses/circuit breakers

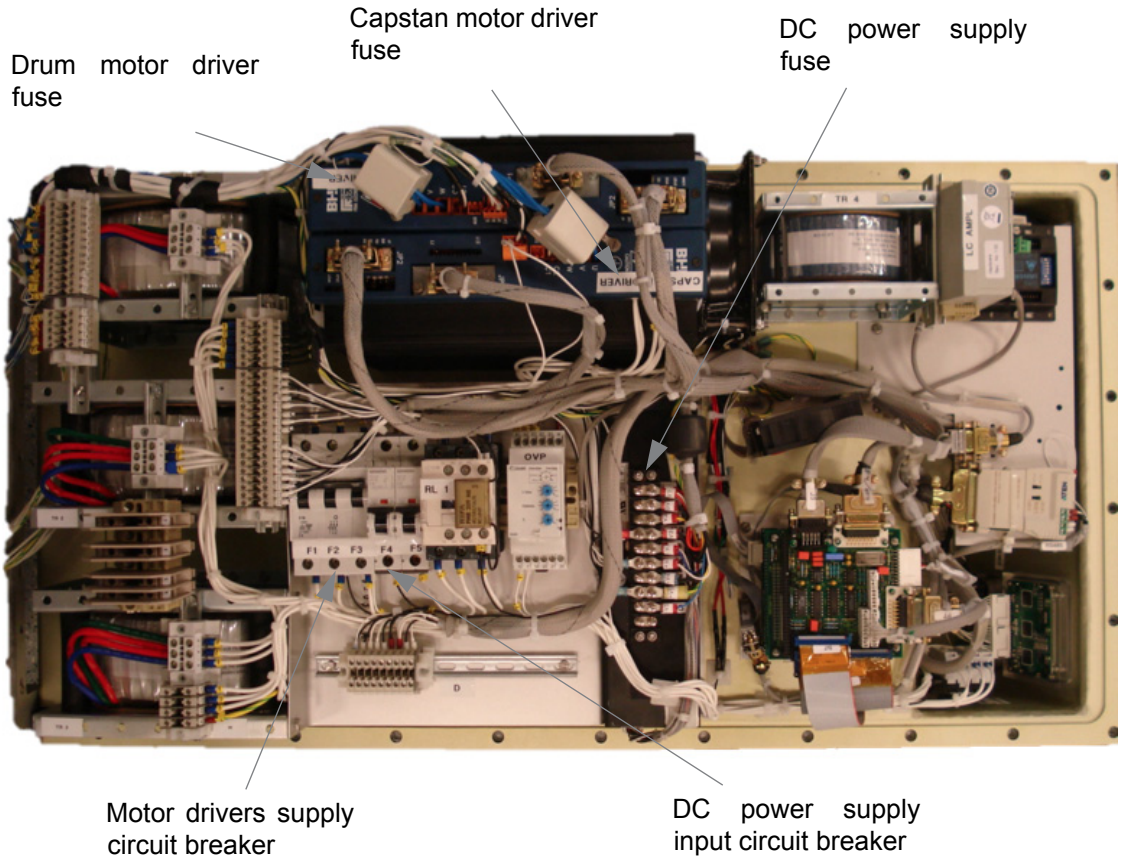

Figure. 6.29 Winch fuses and circuit breakers

6.16 Configuring the Castle Gateway3 6252 PCB

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 opto-isolation of RS-485 interface and works within a wide temperature range (from: -40°C+85°C). Jumper settings have been added to allow future connectivity options and features.

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.

Configuration

Before the can be used on the system, it's 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. 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 ROV 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.

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 the conflicting gateways from the network, leaving one gateway connected, and then changing function on the connected gateway to the free location.

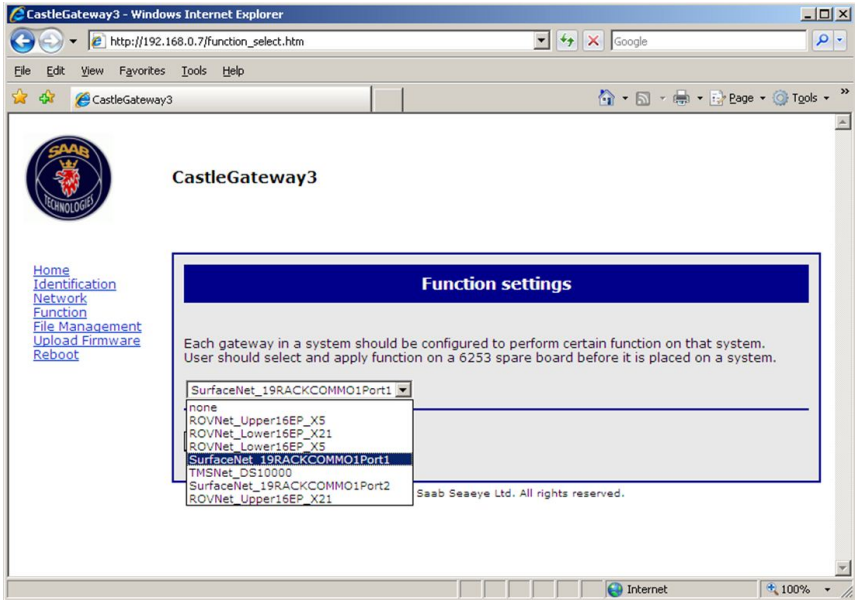

Figure. 6.30 Function Selection

Identification

There is an option implemented to help the pilot/user 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.

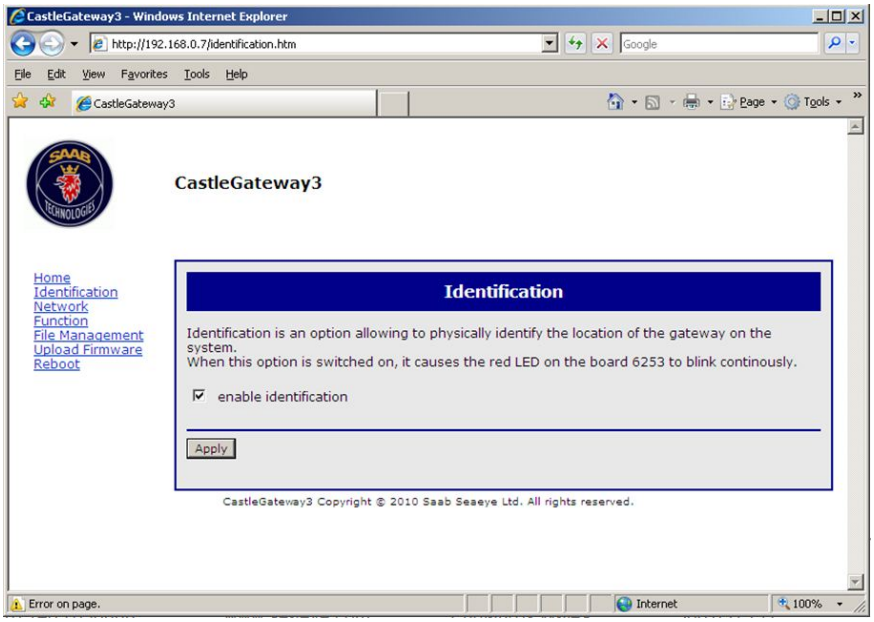

Figure. 6.31 Identification

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 from 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.

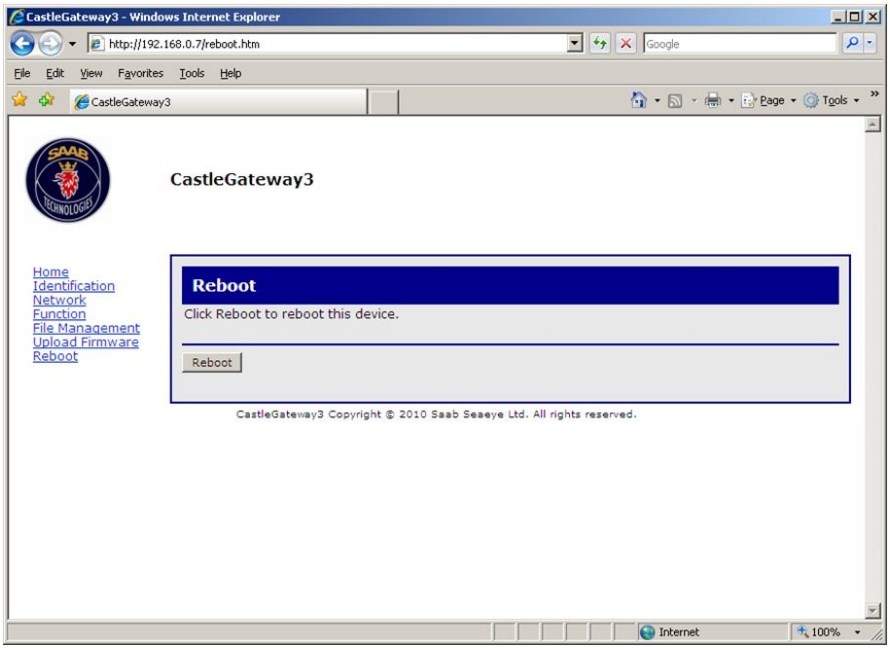

Figure. 6.32 Reboot

CHAPTER 7

MAINTENANCE TASKS

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7. MAINTENANCE TASKS

This Chapter contains the approved methods by which the maintenance tasks listed in Table 7.1 are carried out.

7.1 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 6.

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 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.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the rov system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

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. The information on battery handling in chapter 6 shall be thoroughly read and understood before doing any work on the batteries.

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.

Possibility of damage to equipment. Under no circumstances are the vehicle epods to be assembled without anti-extrusion rings.

Danger to personnel and equipment. . 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.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Possibility of damage to equipment. Ensure all vent plugs are securely fitted and shut prior to immersing the vehicle.

Possibility of poor vehicle handling. 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.

Task No	Task Description	When carried out
1	Pre-Dive Check	Pre-flight
2	Post-Dive Check	Post-flight
3	Thruster Motor Oil Level Check and Replenishment	Pre-flight
		Post-flight
		When motor has been drained of oil
		Every 4 months of operational use
4	Thruster Motor Shaft Rotation	Monthly
5	EPOD Vacuum Check	When the EPOD has been opened
6	Fibre Optic Attenuation	No video picture or poor video image
		No communication to vehicle
7	Winch and Tether Check	Monthly and annually
8	Battery Charging	Every 6 months or when needed
9	Tilt Motor Oil Check and Replenishment	Pre- and post-flight

Table. 7.1 Maintenance Tasks

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:

- Torque wrench (to achieve 27 Nm; 20 ft/lbf; 2.8 kg/m).
- Hex key set.
- A non metallic wedge for wedging propellers.
- Diaphragm puller tool (Part No TH110).

Parts Required

No parts required.

Procedure

Proceed in accordance with Pre-Operational checklist.

Pre-dive check	
⚠ Make sure that the vehicle is turned off, i.e. the start key is not inserted.	
Vehicle checks	
Check SM9 thruster propeller torque settings are 27 Nm (wedge props with dowel to prevent from turning). To do this the thruster propeller dome needs to be removed.	
Check SM4 thruster propeller torque settings are 27 Nm (wedge props with dowel to prevent from turning).	
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.	
Remove all camera lens caps and clean lens with soapy water if necessary.	
Check that the air bleed screws on the X-thrusters are tightened.	
If the EPOD have been opened or the top cover have been removed confirm that the two air bleed screws on the EPOD and the air bleed screw on the antenna are tightened.	
If the top cover has been removed confirm that all unused bulkhead connectors on the EPODS have dummy connectors correctly fitted.	

Table. 7.2 Pre-Operational Checks

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.	
If the vehicle have not been used for a month or longer all the propellers needs to be rotated several turns before switching ON the vehicle.	
Start the SAC and the MMI	
Turn ON the SCU with the power ON/OFF switch on the SCU front panel. When Windows has started start the CARUS and MMI applications using the icons on the desktop.	
Select the following settings in the MMI: **Overview tab** Joystick sensitivity:100% Control Mode: Deck Global functions-Cruse: OFF Global functions-Roll lock: OFF Auto functions: Depth **Control tab** Doppler: ON Lamps: Fully OFF Control winch: UN-pressed	
Press the button Take Control to be able to control the vehicle from the MMI	
Starting up the winch	
Check the following on the control panel: MAN/AUTO switch: MAN position TENSION/LENGTH switch: TENSION position TENSION potentiometer: Fully CCW (Min tension)	
Check that no foreign objects have fallen into the horse head, capstan mechanism, pendulum mechanism, belt transmission or onto the drum.	
Check that the tether is properly reeled on the capstan.	
Switch ON the winch by pressing the POWER button, it is lit up when pressed. After approximately 10 sec. the LCD screen will be lit. TENSION: 0N LENGTH: 0M TENSION: 0N LENGTH: 0M *Remote mode info/show data info*	
Check that Winch Link error not is shown on the MMI and that the text Tension and Deployed are not shown in red.	

Table. 7.2 Pre-Operational Checks (Continued)

Push the joystick forward and check that it is possible to pull out the tether. Pull the joystick backwards and check that it is possible to spool in the tether.	
Starting up the vehicle	
Turn the vehicle on by inserting the Start Key in the OF connector. Check that the ROV Link error disappears.	
Check that a camera picture can be displayed on the MMI (if running in tethered mode).	
Check that all LINK warning messages have disappeared from the MMI.	
Check that the message INS Alignment is replaced with INS Fine Align within five minutes.	
Check that all thrusters are working by giving thrust in all directions and that the thrusters respond the right way in all directions. · Forward/backwards · Sideways (STB/Port) · Rotate (STB/Port) · Up/down · Pitch · 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.	
Check in the MMI that the battery charge is enough for the planned operation.	

Table. 7.2 Pre-Operational Checks (Continued)

Pilot/Operator (sign and print)---------- Date----------

Authorised to dive? YES/NO

Supervisor (sign and print)---------- Date----------

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:

- Torque wrench (to achieve 27 Nm; 20 ft/lbf; 2.8 kg/m).
- Hex key set.
- A non-metallic wedge for wedging propellers.
- Diaphragm puller tool (Part No TH110).

Parts Required

No parts required.

Procedure

Proceed in accordance with Post-dive checklist.

Post-dive check	
The vehicle should be powered on with Thrust Mode set to DM in the MMI when starting the following checks.	
Vehicle checks	
Check that 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. · Forward/backwards · Sideways (STB/Port) · Rotate (STB/Port) · Up/down · Pitch · 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	
Turn OFF the vehicle by removing the key from connector OF. Mount the protective cover on the OF connector.	
Turn OFF the winch with the power ON/OFF switch on the winch maneuver panel.	

Table. 7.3 Post-Operational Checks

Turn OFF the SAC by shutting down the Windows.	
Turn OFF the SCU with the power ON/OFF switch on the SCU front panel.	
Vehicle checks	
Rinse the vehicle with fresh water.	
Check SM9 thruster propeller torque settings are 27 Nm (wedge props with dowel to prevent from turning). To do this the thruster propeller dome need to be removed.	
Check SM4 thruster propeller torque settings are 27Nm (wedge props with dowel to prevent from turning).	
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 X-thrusters are tightened.	
Remove any debris from the vehicle.	
Inspect all propellers and nozzles, looking for any possible damages.	
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.	
Winch check	
Check that no parts have loosened during the mission.	
Check that the tether is properly reeled on the capstan.	
Flush the winch and tether with fresh water to prevent corrosion.	
Visually inspect the tether closest to the vehicle for damages.	
Battery charging	
Charge the vehicle battery if necessary.	

Table. 7.3 Post-Operational Checks (Continued)

Pilot/Operator (sign and print)---------- Date----------

Authorised to Stow? YES/NO

Supervisor (sign and print)---------- Date----------

TASK 3a
SM4 and SM9 THRUSTER MOTOR OIL LEVEL CHECK AND REPLENISHMENT

Frequency of Task

Pre and Post-flight.

Replenishment every 4 months of operational use.

Introduction

The purpose of this check is to ensure that the thruster motor oil level is correct prior to operational use and details the procedure on how to replenish the oil if required. The thruster motor uses Mobilect39 oil, under **NO** circumstances are any other oils to be used.

Tools Required

The following tools may be required:

- Hex key set.
- A non metallic wedge for wedging propellers.
- Diaphragm puller tool (Part no TH110).
- Seaeye Fillkit (Part No P00514-110).

Parts Required

The following parts may be required:

- Mobilect39 oil (5 litre can has part no TH-OIL-LTR(5L)).
- Clean container for collecting oil.

Oil Level Check Procedure

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.

Danger to personnel and equipment. The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTION.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Proceed as follows:

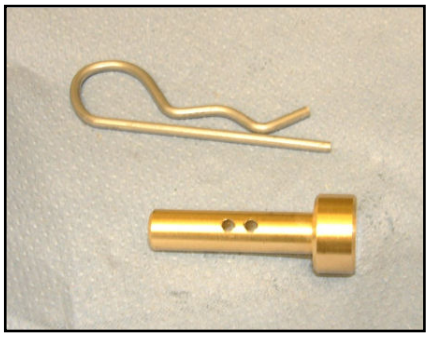

Figure. 7.1 Diaphragm Puller Tool

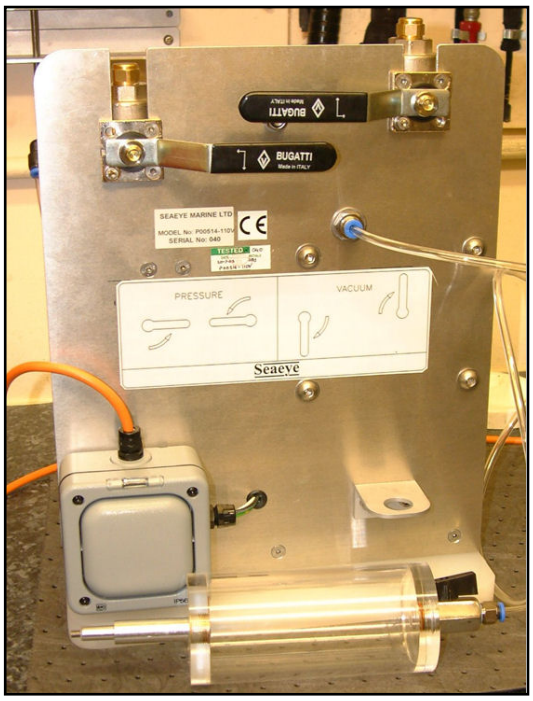

Figure. 7.2 Oil Fill Kit P00514

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 at least one of the two holes are fully visible.
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.

Oil replenishment procedure

NOTE.

It is recommended that the oil is replenished every 4 months of operational use.

Proceed as follows:

1. Remove the required motor from the ROV.
2. Position the motor horizontally on a clean bench.
3. Insert the Diaphragm puller tool into the motor end cap and screw onto diaphragm-threaded stud.
4. Holding the motor securely, pull on the diaphragm puller tool until the second locking pin hole is visible above the end cap and insert locking pin. If necessary, loosen the motor fill screw to release the pressure taking care that the oil pressure does not cause the oil to be released through the fill screw hole. Release the puller tool.
5. Carefully, remove the motor fill screw and retain. Replace the O-ring.

Figure. 7.3 Bleed Screw

6. Ensure the Fillkit reservoir is clean and empty and the power switch is set to OFF.
7. Confirm that the reservoir valve is open (vertical position) and that the control valves have one in the horizontal position and one in the vertical position (no pressure or vacuum operational position).

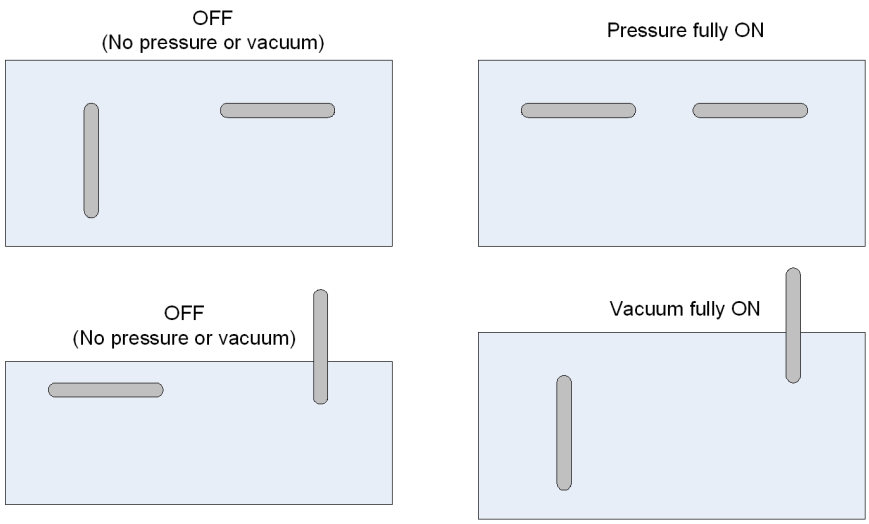

Figure. 7.4 Filler Kit Valve Positions

8. Place the reservoir end in the container of the motor oil.
9. Switch on the Fillkit.
10. Slowly move the control valve towards the VACUUM position and confirm oil is being drawn from the reservoir.
11. When the reservoir is three quarters full, return the control valve to the OFF position.
12. Move the reservoir valve to the horizontal position and switch off the Fillkit.
13. Connect the reservoir to the motor fill screw orifice. Position the motor so that it is at a slight angle with the motor fill screw orifice at the 'upper' position.
14. Move the reservoir valve to the vertical position.
15. Remove the diaphragm puller tool locking pin.
16. Switch on the Fillkit. Slowly move the control valve to the PRESSURE position and observe that the diaphragm puller tool rises as the oil is pumped into the motor. Ensure that the diaphragm puller tool does not reach the fully upper position. Move the control valve to the OFF position valve and then slowly move the control valve to the VACUUM position to remove the air from the motor. Ensure that the diaphragm puller tool does not reach the fully lower position while carrying out the 'cycling' operation.
17. Slowly continue to 'cycle' the control valves to the PRESSURE and VACUUM positions and observe that the diaphragm puller tool rises and falls. Ensure that the diaphragm puller tool does not reach the fully lower position while carrying out the 'cycling' operation.
18. Observe that the air is expelled from the motor diaphragm through the oil reservoir.
19. When all air has been expelled, position the control valves in the OFF position.
20. Hold the motor assembly in the vertical position with the diaphragm puller tool upper most.
21. Continue to operate both the control valves and observe that the diaphragm puller tool rises as the oil is pumped into the motor and falls when the air is expelled from the motor.
22. Slowly continue to 'cycle' the control valves up and down and observe that the diaphragm puller tool rises and falls. Ensure that the diaphragm puller tool does not reach the fully lower position while carrying out the 'cycling' operation.
23. Observe that the air is expelled from the motor through the oil reservoir.
24. When all air has been expelled, position the control valves in the OFF position.
25. Hold the motor assembly in the vertical position with the diaphragm puller tool facing downwards.
26. Continue to slowly operate both the control valves and observe that the diaphragm puller tool rises as the oil is pumped into the motor and falls when air is expelled from the motor.
27. Slowly continue to 'cycle' the control valves up and down and observe that the diaphragm puller tool rises and falls. Ensure that the diaphragm puller tool does not reach the fully upper lower position while carrying out the 'cycling' operation.
28. Observe that the air is expelled from the motor through the oil reservoir and that there is enough oil in the motor to ensure that the diaphragm puller tool is showing two holes.

29. When all air has been expelled, position the control valves in the OFF position.
30. Fit the locking pin through the diaphragm lower locating pin hole.
31. Switch off the Fillkit.
32. Move the reservoir valve to the horizontal position.
33. The diaphragm puller tool will fall to the locking pin level.
34. Remove the Fillkit reservoir from the motor.
35. Refit the motor fill screw.
36. Clean the motor of any oil spillage.
37. Remove the locking pin and observe the puller tool pinholes and ensure that at least one of the holes remain visible. This indicates that the motor is completely filled with oil and purged of air. Should the tool “sink” into the motor end cap repeat the fill procedure.
38. Remove the diaphragm puller tool.
39. Visually examine the thruster for signs of oil leaks.
40. Sparingly lubricate the motor connector threadforms with silicone grease.
41. Refit the motor to the ROV.

TASK 4
SM9 AND SM4 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 and equipment. . The thruster motors may operate without warning when the vehicle is energised. Ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTION.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Proceed as follows:

- Rotate all motor shafts through several revolutions.

TASK 5
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 with the communication unit.

Tools Required

Vacuum pump TD801-BUWS (part no. 01-2350045).

Parts Required

No parts are required.

Procedure

Proceed as follows:

1. Unscrew the air bleed screw 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.

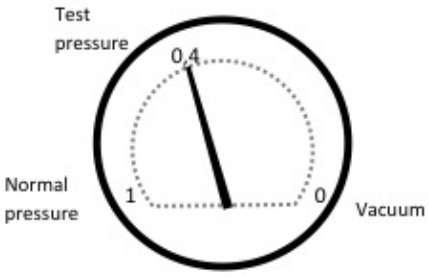

Figure. 7.5 Pressure measuring

3. Close the valve and turn off the vacuum pump.
4. Wait approximately 10 minutes to let the temperature stabilize inside the EPOD before taking a reading. The temperature will drop inside the EPOD when pumping out the air. And the pressure will change when the air get warmer.
5. Take a reading and wait approximately 30 minutes. The pressure should not change.

Depending of what and how much work that 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 is changed it could take longer time to detect a leakage. Extend the time if it is not absolutely sure that the EPOD not is 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 on the air bleed screw before putting it back on the EPOD. Replace the O-ring if needed

TASK 6
FIBRE OPTIC ATTENUATION ADJUSTMENT

Frequency of Task

Fiber-optic attenuation measurement is to be carried out on loss of video picture, poor picture quality or poor/bad data communication.

Introduction

The purpose of this measurement is to ensure that the amount of attenuation in the fiber-optic system is as low as possible below the optical power budget. Losses can occur at many points in the system e.g. connector loss, splice loss, fiber loss, the total of which is to be less than optical power budget specification. Poorly made splices and connections will greatly increase the amount of attenuation. As losses approach the optical budget, the picture starts to “sparkle” with eventual loss of video picture, similarly the fiber-optic system can be overdriven resulting in the same symptoms as an over attenuated system. In overdriven systems, special attenuators are used to attenuate the fiber-optic signal.

Tools required

- Fibre-optic test source and receiver
- Single mode test leads
- Attenuation table.

Optical power budget	Focal: >24 dB, AMG: >29 dB
Type of loss	Attenuation
Pair of CWDM muxes	< 4.3 dB
Tether cable	1310 nm: 0.4 dB/km, 1550 nm: 0.25 dB/km
Slip ring	<3.5 dB
Connectors	<0.2 dB/connector

Table. 7.4 Fibre Optic Loss Calculation

Parts Required

No parts are required.

Fibre optic attenuation measurement procedure

1. Check all fibre-optic connections are correctly mated.
2. Calculate the theoretical amount of system signal loss using the above table.
3. Calibrate the source and receiver.
4. Connect the source and receiver over the fibre-optic link and compare the result with the optical budget.
5. If the attenuation is higher than expected is possible to localize the point of attenuation by splitting the system down and connecting the fiber optic source and receiver at each section end.

TASK 7
WINCH AND TETHER CHECK

Frequency of Task

Monthly (task 7.1), annually (task 7.2)

Tools Required

Grease gun

Parts Required

Grease LGMT 20/0.2 (part no. 93-0060021)

Omala oil 220 (part no. 93-0060004)

Silica gel bag (part no. 93-0090150)

Procedure

Task 7.1. Monthly

1. Check the winch and make sure that everything is rigidly mounted.
2. Flush the winch and the tether with fresh water to prevent corrosion.
3. Lubricate the bearings on the horse head with a grease gun in the lubrication nipples.
4. Grease eccentric plate on rocker gear.

Task 7.2. Annually

1. Check the drive and the slave wheels of the capstan to see if any abnormal wear or crack has appeared.
2. Check the drive belts to see if any abnormal wear or crack has appeared.
3. Check the functions of all guide reels on the winch. If any doubt disassemble the reels, clean the reel and its shaft and replace the reels if necessary.
4. Loosen the covers of the drum bearings and check the bearings. Lubricate the drum bearings with proper grease and put the covers back.
5. Check the clamp resistor's back end to see if there is an oil leakage from the unit. If any doubts occur, disassemble the resistors, check the over pressure valve and the O-rings.
6. Check the pendulum mechanism to see if any abnormal wear has occurred. Clean the moving parts and lubricate them with a proper grease.
7. Check the pendulum and the capstan gear boxes to see if there is an oil leakage. Change the oil if it seems to be worn out.
8. Open the electronic box and check the inside to make sure that no corrosion has occurred. Check the O-ring and replace it if any doubts occur. Replace the silica gel bag.
9. Check the winch frame to make sure that no scratches have occurred. If there are any scratches through the paint, clean the scratches and fill them with paint.

TASK 8
BATTERY CHARGING

Frequency of Task

Whenever needed.

If not used, at least every 6 months.

Introduction

This task ensures that the battery is fully functional and in good condition prior to each operational use.

! 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

Charger Description

Figure. 7.6 Battery charger

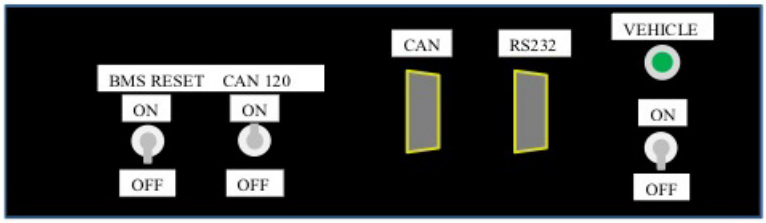

Figure. 7.7 Battery charger front panel

Control/indicator/connection	Function
BMS Reset on/off	Reset of the BMS in the vehicle.
CAN 120 ohm on/off	Termination resistance on the CAN bus. The default value is ON. Set to OFF if something, for example a computer, with a termination is connected to the CAN connector.
CAN	CAN bus connector used to connect to the CAN bus.
RS232	RS232 interface used for configuration of the Brusa battery charger.
Vehicle on indicator	Lit when the vehicle is connected to the charger and it is powered ON.
Vehicle on/off	Used for switching on the vehicle when connected to the charger.

LED indicators on the Brusa charger

Charger connected to mains power

Charger malfunction. Lit because of one of the following reasons

- Main switch OFF
- Over-temperature
- Mains over-voltage
- Battery not connected
- Internal charger fault
- PRO-signal used when updating firmware is high

There are three more (two yellow and one green) LED indicators that cannot be used when running in CAN mode.

Procedure

Proceed as follows:

1. Check that the Main power switch on the battery charger is switched OFF.
2. Check that the switch CAN 120 is switched ON if nothing is connected to the CAN connector on the front of the charger.
3. Connect the battery charge and the CAN bus cables to the vehicle.

Figure. 7.8 Battery charger connection

4. Check that the 230 VAC main power is connected to the charger.
5. Switch ON the charger and check that the red LED on the charger is not lit. It is possible to know that the battery is charged from the sound of the fans in the charger. The charging time is up to approximately 3 hours depending on how much charge there was in the battery when starting.
6. When the battery is fully charged the fan on the charger will stop. Switch OFF the Main power switch on the charger.
7. Disconnect the battery charge and the CAN bus cables from the vehicle.

TASK 9
PAN/TILT MOTOR OIL CHECK AND REPLENISHMENT

Frequency of Task

Pre- and Post-flight.

Introduction

This procedure checks that the oil level in a Tilt Unit as well as in a Pan and Tilt Unit is correct prior to, and on completion of, each vehicle operation. Carry of this procedure on each Pre- and Post-flight.

WARNING.

Damage to pan and tilt unit. If frequent topping up is required an investigation is required to ascertain the possibility of damage to the pan and tilt unit.

Tools Required

The following tools may be required:

- Hex keys (common sizes).
- Flat bladed screwdrivers (common sizes).

Parts Required

The following parts may be required:

- Diaphragm compressor tool (Part No TH110).
- Fill Kit (Part No P00514).
- Fill Kit Adaptor.
- Mobilect39 Oil.

Oil Level Check Procedure

Proceed as follows:

1. Inspect the Pan and Tilt Unit for evidence of damage or oil leaks.
2. Using the diaphragm compressor tool ensure that the top of the Pan and Tilt Unit diaphragm stud is between 25 mm and 10 mm.
3. If the diaphragm threaded stud is more than 25mm below the top of the diaphragm cover, carry out the oil topping up procedure. If the stud is less than 10 mm below the cover, examine unit for water ingress and damage.

Oil Level Replenishment Procedure

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. Position the unit vertically, with the sight glass upper most.
4. Remove the sight glass taking care not to damage the seal.

5. Fill the unit with oil through the motor cap opening.
6. Refit the sight glass and seal.
7. Position the unit with vent screw uppermost.
8. Insert diaphragm puller tool into diaphragm cover and screw onto diaphragm threaded nut.
9. Pull on the tool to release the pressure and remove vent screw.
10. Ensure the Refill Kit is set to off and the reservoir is clean and dry.
11. Fill a clean container with fresh oil.

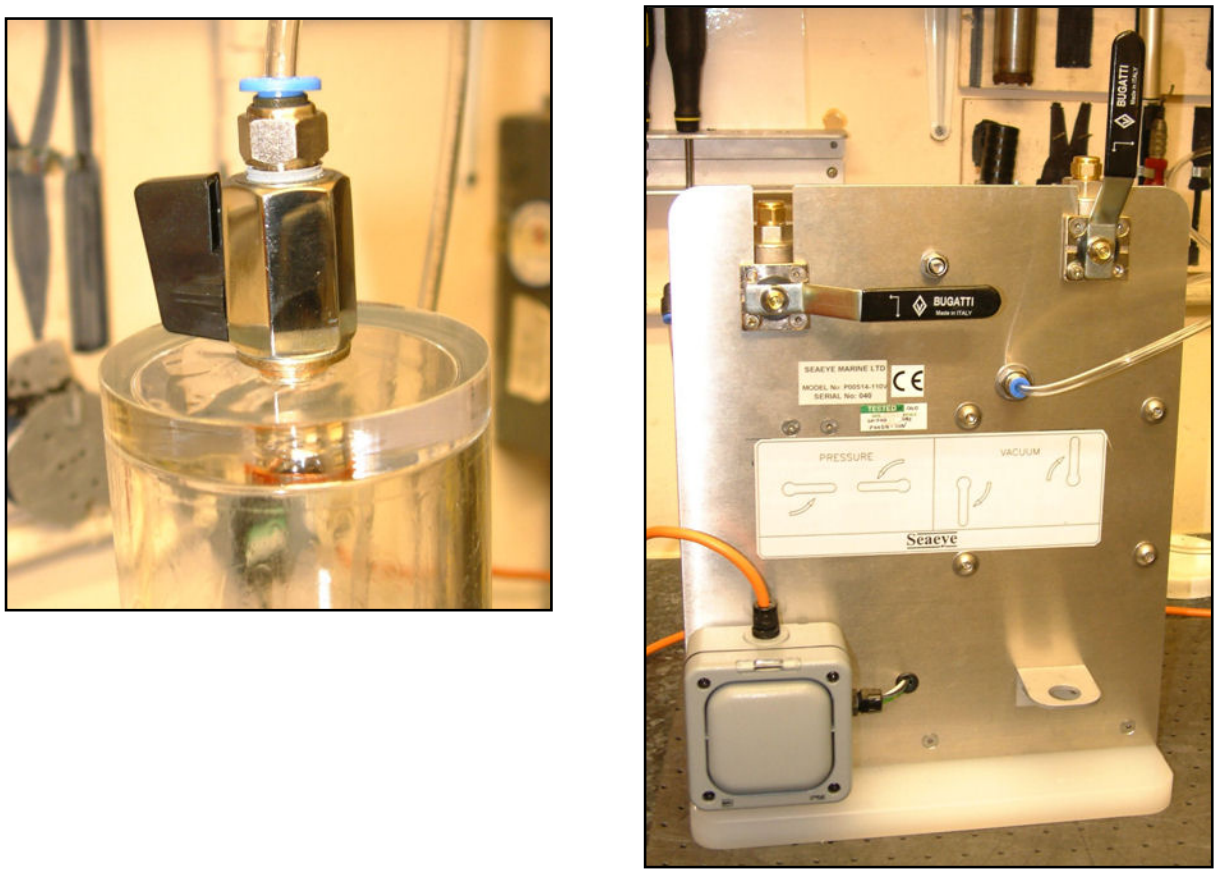

Figure. 7.9 Fill Kit Controls

12. Confirm the following:
    - Vacuum Valve – vertical position (OFF).
    - Pressure Valve – horizontal position (OFF).
    - Reservoir Valve – vertical position (OPEN)

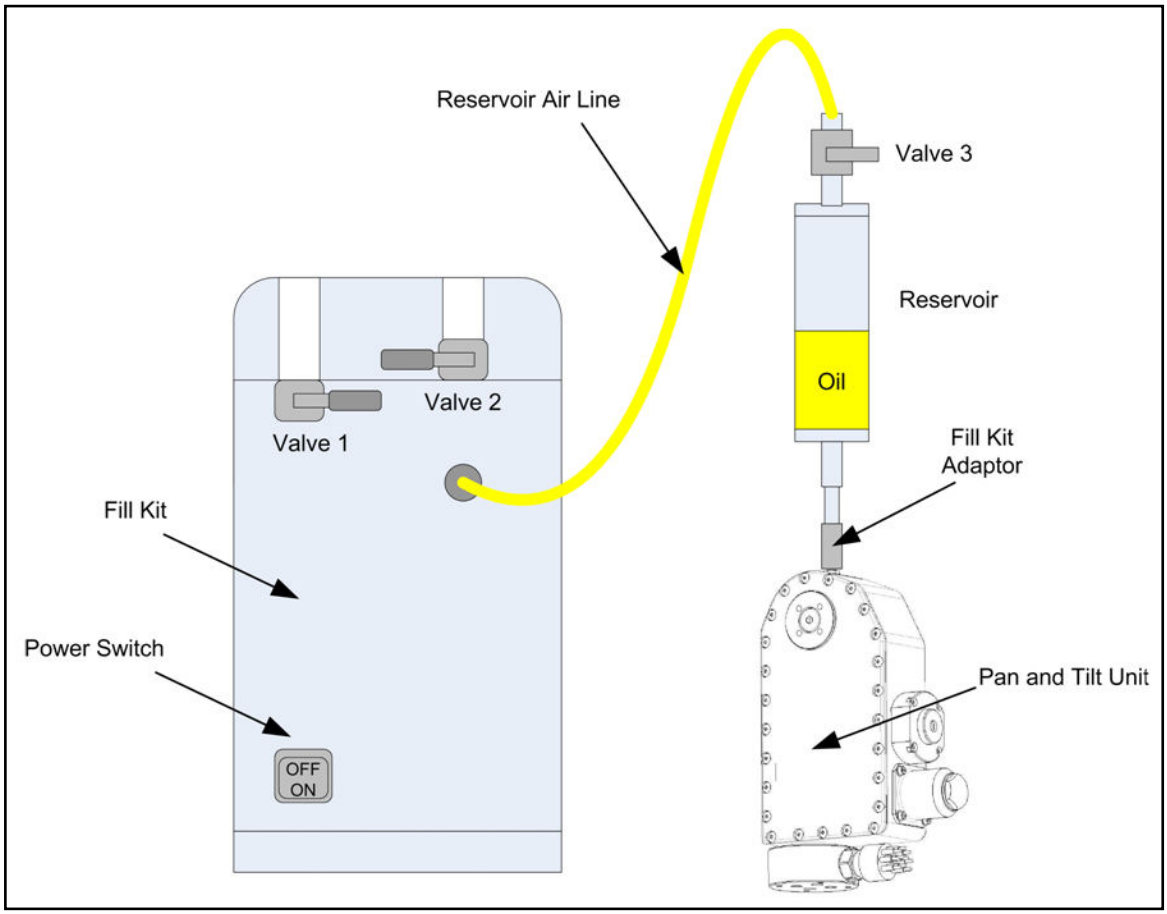

Figure. 7.10 Pan and Tilt Oil Fill Kit

13. Place the reservoir end in the container of the motor oil.
14. Switch on the Fillkit.
15. Slowly move the vacuum valve towards the horizontal position and confirm oil is being drawn from the reservoir.
16. When the reservoir is three quarters full, return the vacuum valve to the vertical position.
17. Move the reservoir valve to the horizontal position and switch off the Fillkit.
18. Connect the reservoir to the unit fill screw orifice. Position the unit so that it is at a slight angle with the unit fill screw orifice at the 'upper' position.
19. Move the reservoir valve to the vertical position.
20. Remove the diaphragm puller tool locking pin.
21. Switch on the Fillkit. Slowly move the vacuum valve and observe that the diaphragm puller tool rises as the oil is pumped into the motor. Ensure that the diaphragm puller tool does not reach the fully upper position. Close the vacuum valve and slowly open the pressure valve to remove the air from the motor. Ensure that the diaphragm puller tool does not reach the fully lower position while carrying out the 'cycling' operation.
22. Slowly continue to 'cycle' the pressure and vacuum valves up and down and observe that the diaphragm puller tool rises and falls. Ensure that the diaphragm puller tool does not reach the fully lower position while carrying out the 'cycling' operation.

23. Observe that the air is expelled from the unit diaphragm through the oil reservoir.
24. When all air has been expelled, position the pressure and vacuum valves in the off position.
25. Fit the locking pin through the diaphragm lower locating pin hole.
26. Remove reservoir from Pan and Tilt Unit.
27. Refit the Pan and Tilt vent screw.
28. Remove the locking pin.
29. Inspect the Diaphragm puller tool “fill hole” which should remain visible. If the “fill hole” is below the end cap, repeat the fill procedure.
30. Remove the diaphragm puller tool.
31. Examine the unit for leaks.
32. Clean any oil contaminated parts.
33. Lubricate the Pan and Tilt connector with silicone grease.
34. Refit the Pan and Tilt Unit.

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CHAPTER 8

DIAGNOSTIC

MAINTENANCE

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8. DIAGNOSTIC MAINTENANCE

8.1 Introduction

This chapter is used as an aid for faultfinding. Firstly, all possible error messages are presented, followed by other type of possible symptoms.

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. Before any diagnostic 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.

Danger of fatal electric shock. Before removing or obtaining internal access to the equipment, isolate all the units power supplies.

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 have taken adequate precautions.

Possibility of fatal electric shock and danger to personnel and equipment. Before switching on the ROV system, ensure that the system is fully assembled and operable and no maintenance activity is in operation.

Possibility of fatal electric shock and danger to personnel and equipment. 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. the information on battery handling in chapter 6 shall be thoroughly read and understood before doing any work on the batteries.

Possibility of damage to equipment. Under no circumstances are the vehicle epods to be assembled without anti-extrusion rings.

Danger to personnel and equipment. . The thruster motors may operate without warning when the vehicle is energised. ensure that the vehicle is clear of any obstruction and personnel prior to energising the vehicle.

CAUTIONS.

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.

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

Danger of damage to equipment. When using an insulation meter, ensure that the cable under test is disconnected at both ends.

Danger of damage to Thruster Motor. Do not operate the Thruster Motor in air for longer than one minute.

Possibility of damage to equipment. Ensure all vent plugs are securely fitted and shut prior to immersing the vehicle.

Possibility of poor vehicle handling. 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.

8.3 Error messages

The following error messages can appear at the MMI:

Bad DVL Data	The data from the doppler velocity log is not valid.
Bad Line Isolation	The line isolation of the high voltage is below 500 kOhm.
Battery Charge Current Too High	The Battery Management System reports that the battery is charged with too high current. Possible reasons and actions: **Faulty current measurement**: Check configuration of BMS card 0. Check current sensor. **Faulty battery charger**: Exchange battery charger.
Battery Charge Temperature Too High	The Battery Management System reports that the battery is too warm to be charged. Possible reason and action: The battery is too warm: Cool vehicle down before charging.
Battery Discharge Current Too High	The Battery Management System reports that too much current is consumed from the battery. Possible reasons and actions: **Faulty current measurement**: Check configuration of BMS card 0. Check current sensor.
Battery Discharge Temperature Too High	The Battery Management System reports that the battery is too warm to discharge. Possible reason and action: The battery is too warm: Cool vehicle down before turning on.
Battery Hardware Overvoltage	The Battery Management System reports an over voltage problem in the battery. Consult REAP.
Battery Hardware Undervoltage	The Battery Management System reports an under voltage problem in the battery. Consult REAP.
Battery Overvoltage	The Battery Management System reports an over voltage problem in the battery. Possible reason and action: Faulty BMS configuration: Check BMS configuration.

Battery Undervoltage	The Battery Management System reports an under voltage problem in the battery. Possible reason and action: Battery fully discharged: Charge battery.
BMS Can Receive Overflow	The Battery Management System reports problems with the CAN communication. Consult REAP.
BMS CAN Response Failure	The Battery Management System reports problems with the CAN communication. Consult REAP.
BMS Link	There is no communication from the Battery Management System cards to the RAC. Possible reasons and actions: **The batteries do not wake up**: **The BMS cards may need a hardware reset**: Connect the battery charger and use the BMS hardware reset on the battery charger. **The batteries are working: Faulty CANview Ethernet converter**: Replace CANview Ethernet converter. **The batteries are working: Faulty CAN wiring**.: Check CAN wiring.
Castle2 Link	No error status data can be received from the Castle2 network.
Command Link Error	Light Command Link Error. The light is specified by ID.
Comms Lost	Light Communications Lost. The light is specified by ID.
Component Group Restart	A software error has caused a whole group of software components to restart. If this message appears contact Saab Seaeye.
Component Restart	A software error has caused a software component in SAC or RAC to restart. If this message appears contact Saab Seaeye.
Controller Link	There is no controller connected to the active MMI, or no MMI is active.
Current Divergence	Light LED Current Divergence. The light is specified by ID.
DC Out of Range	Light 24V DC Out of Range. The light is specified by ID.
Deleting oldest log files	Deleting the oldest log files. The log files allocates more than the maximum allowed disk space. The computer is identified by the ID. Download and delete log and video files to fix this problem.
Depth Link Error	There is no data coming from the depth sensor.
DVL Link Error	There is no data coming from the doppler velocity log sensor.
Gain Error	Light Gain error - 5V rail is out of range. The light is specified by ID.
Gateway Link	There is no Ethernet connection with the Castle2 gateway specified by ID.
INS Acc Anomaly	There is a problem with the an accelerometer in the INS.
INS Alignment	The INS is in alignment state. This state lasts five minutes after the INS receives the start-up position. During this state there shall be no excessive acceleration of the vehicle.
INS Altitude Saturation	The altitude is higher than 4000m.

INS CPU Overload	The system has not enough calculation power in the current configuration. INS Interface board CPU overload (too much output protocols with too high output rates).
INS Degraded Mode	This message is triggered when a fixed number (varying between 1 and 100, depending on the type) of successive occurrences of the same error happen.
INS Dynamic Exceeded	Acceleration greater than maximal accepted value or rotation rate greater than maximal accepted value.
INS Failure Mode	This message is triggered when a fixed number (varying between 3 and 1000, depending on the type) of successive occurrences of the same error happen.
INS Fine Align	The INS is in fine align state. The vehicle can be used but full position accuracy has still not been achieved. To get good accuracy DVL data and GPS data shall be provided to the INS. It is recommended to move in stair case shaped tracks or on figures of eight tracks to get good observability of the sensor errors. This state lasts until the INS heading accuracy is below 0.1 degree.
INS FOG Anomaly	There is a problem with a FOG sensor in the INS.
INS HRP Invalid	Heading, roll and pitch angles are not valid from the INS. This flag is set during the Alignment state or if there is a problem with the inertial sensors (FOG Anomaly, Acc Anomaly) or the speed has been saturated.
INS Link	There is no data coming from the INS. After startup there is always a short moment of INS Link since the unit is starting up.
INS Speed Saturation	The speed is higher than 80 knots. The algorithm is frozen. The INS must be restarted.
INS Temperature Error	Temperature acquisition error (Optical source, ACC and FOG temperatures on sensor board) or temperature measurement out of normal range or temperature variation measurement out of normal range.

Leak	A leak sensor indicates a leak. Which leak sensor is indicated by the text Front, Aft or Communication Unit. Possible reasons and actions: **Water intrusion**: Retrieve the vehicle as fast as possible. Turn off the vehicle to avoid getting short circuit in the electronics of the vehicle. Remove front and back sections of the vehicle. Search for possible leakage spots such as air bleed screw and O-rings. If the leakage is large and the electronic components are soaked with salt water, rinse the components with fresh water. Dry electronics and vehicle with heating fan. **Short-circuit in a leak sensor**: Check if there is a metal piece or something that causes the short-circuit. **Faulty leak sensor**: Check the function of the leak sensor by loosening the connectors one by one until indication of leakage disappears. Exchange leak sensor (and the indication of leakage disappears).
Leak Link	There is no data coming from the aft leak sensor since there is no data coming from the relevant 6134P board.
Leak Sensor Broken	A leak sensor is broken or disconnected. Which leak sensor is indicated by the text Front, Aft or Communication Unit
Line Isolation Monitor Link	There is no data coming from the Line Isolation Monitor since there is no data coming from the relevant 6134P board.
Logging stopped	The logging of data files and recording of video has stopped. This is due to not enough free disk space or some other problem with writing to the disk. The computer is identified by the ID. Try to download and delete log files to fix this problem.
No depth data to the INS	There is no depth sensor data received by the INS or the depth sensor data is not valid and therefore not used by the INS.
No DVL data to the INS	There is no DVL data received by the INS or the DVL data is not valid and therefore not used by the INS.
No GPS data to the INS	There is no GPS data received by the INS or the GPS data is not valid and therefore not used by the INS.
No Pilot	There is no active MMI. Click the button Take Control on the MMI.
Overtemperature Shutdown	Light Over temperature Shutdown. The light is specified by ID.

Profiler Link	There is no data from the profiler sonar coming to the RAC. Possible reasons and actions: **No power to profiling sonar**: Check the 24V power supply in the UW-connector to the profiling sonar. **Faulty communication wiring**: Check the LEDs on the Ethernet switch in the vehicle to see if there is connection to the profiling sonar. **Faulty profiling sonar**: Exchange or check configuration of profiling sonar.
PWM Failure	Light PWM Output Failure. The light is specified by ID.
PWM Output Drive Divergence	Light PWM output drive divergence > 200. The light is specified by ID.
ROV Link Error	There is no communication with the ROV application computer (RAC).
Servo comm lost:	Servo communications lost. The servo is specified by ID.
Servo supply undervoltage	Servo supply undervoltage. The servo is specified by ID.
Servo supply overvoltage	Servo supply overvoltage. The servo is specified by ID.
Servo overcurrent tripped	Servo overcurrent tripped. The servo is specified by ID.
Servo mechanical failure	Servo mechanical failure. The servo is specified by ID.
Servo oil level low	Servo oil level low. The servo is specified by ID.
Supply Overvoltage	Light Supply Voltage over 375V. The light is specified by ID.
Supply Underoltage	Light Supply Voltage under 100V. The light is specified by ID.
Temperature Divergence	Light LED Temperature Divergence. The light is specified by ID.
Thruster All Halls High	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster All Halls Low	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Comms Lost	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Comms Lost	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Critical Electronic Failure	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Critical Overcurrent	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Dangerous Overcurrent	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.

Thruster Drive Module Failed	This error requires a reset on the thruster specified by IDID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Halls Out of Sequence	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Link Error	There is no communication with thruster specified by ID.
Thruster Motor Oil Level Low	The Oil level in thruster specified by ID is low. This should be fixed before next launch of vehicle.
Thruster Motor Overtemperature	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Supply Overvoltage	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Thruster Supply Undervoltage	This error requires a reset on the thruster specified by ID. If error reappears frequently, the thruster needs to be serviced or replaced.
Trigger event	An event has been triggered by the vehicle in autonomous mode. The type of event is specified in the description field.
Winch Bad Length Value	The length value from the winch can not be trusted. Not relevant for this system
Winch Bad Tension Value	The tension value from the winch can not be trusted. Not relevant for this system
Winch Link	There is no link between the winch and the SAC. Possible reasons and actions: **The serial link in the winch menu system is set to Send Mode**: Change to Normal Mode for the serial link in the winch menu system. **The link wiring from the winch to the SAC is faulty**: Check the wiring. **The RS485 converter in the winch or in the SAC is faulty**: Replace RS 485 converter in winch or in SAC.
Winch Malfunction	There is a general error in the winch. Not relevant for this system
Winch remote mode not allowed	The winch is set to not allow to be remotely operated.
Winch Tether End Stop	The calculated remaining tether is less than 100 m. Not relevant for this system
Winch/Vehicle Speed Difference	There is a difference in speed between the winch and the vehicle. This message is disabled, but can be enabled in the file sabertooth_system.xml in the SAC.
Voltage Reference Failure	Light Voltage Reference Failure. The light is specified by ID.

8.4 Winch Errors

8.4.1 Winch is not working - on/off switch does not lit up

POSSIBLE REASON	SOLUTION/ACTION
No power to the winch (mains missing).	Make sure that the winch is properly connected to mains. Make sure fuses before winch are not blown. Make sure that the on/off switch is set in on position.
Internal mains fault in electronics box.	Check the power cord supplying the winch with electrical power. There should be three phase approximately 400 V at block B at the on/off switch, and at the three phase fuse input (Y).
Internal fuses have blown.	Check the two 220 V power circuit breakers. If any of the circuit breakers have tripped, the contactor will not start the motor drivers, neither will the computer start.

Table. 8.1 Winch is not working - on/off switch does not lit up

8.4.2 Winch motor does not move

The winch computer starts and the LED is working but the winch motors do not move.

POSSIBLE REASON	SOLUTION/ACTION
The emergency button is pressed.	Release the button.
The 3 phase circuit breaker F1 - F3 has tripped.	Reset the circuit breaker and try once again. If it still trips, check the drivers.
The Z and/or W fuses inside the drivers are blown.	The driver(s) is (are) faulty (short circuited). Send to Saab Seaeye for repair.
The NTC-resistors has burnt.	Usually a visual investigation can detect faulty, burned NTC-resistors. These are normally aged. Replace worn out items.

POSSIBLE REASON	SOLUTION/ACTION
Internal faults in the drivers generating a FAULT signal to the computer. (Red LEDs are lit up at the driver)	Check the LEDs on the motor drivers. Possible fault are described in the driver manual.

Table. 8.2 Winch motor does not move

8.4.3 220 V circuit breakers trip when turning on the winch

POSSIBLE REASON	SOLUTION/ACTION
Internal damage in the DC power supply (PS).	Check by disconnecting the PS at the 220 V input. If the circuit breaker does not trip when winch is turned on and the PS is disconnected, the PS is faulty and should be replaced.
Transformer TR4 faulty.	If the circuit breaker trips when winch is turned on and the PS is disconnected, the transformer TR4 is faulty and should be replaced.

Table. 8.3 220 V circuit breakers trip when turning on the winch

8.4.4 Three-phases circuit breaker trips when turning on the winch

POSSIBLE REASON	SOLUTION/ACTION
One or both motor drivers are damaged.	Check which one(s) by disconnecting one at a time and try to switch on the winch. Exchange the faulty driver(s) and send it to Saab Seaeye for repair.

Warning: Carefully test winch functionality in manual mode.

Table. 8.4 Three-phases circuit breaker trips when turning on the winch

8.4.5 Tension differs/the winch is shaking or behaves unstable

The tension differs a lot depending on the emergency stop button position or the winch is shaking or behaves unstable when running in an automatic mode.

POSSIBLE REASON	SOLUTION/ACTION
Grounding between frame and electronics box is poor.	Fasten screws to the earth or exchange parts that are too oxidized.

Table. 8.5 Tension differs/the winch is shaking or behaves unstable

8.4.6 Winch sends no data on link

POSSIBLE REASON	SOLUTION/ACTION
The serial mode is set to “normal” and no request for winch info reaches the winch.	Check if the requesting device is sending properly. Check if the incoming request gets through the RS485-RS232 adapter. If not, exchange the adapter.
Serial mode set to SEND and link adapter is not sending anything.	If data is sent to the adapter, exchange it.

Table. 8.6 Winch sends no data on link

8.4.7 Winch motor operates very poorly/behaves very shaky

POSSIBLE REASON	SOLUTION/ACTION
The load sensor or its amplifier is faulty.	Check all connections from the sensor to the winch card. Test the load sensor system by pressing the load sensor by hand while the emergency button is down. The load should be presented on the LCD with a low noise level if working properly.

Table. 8.7 Winch motor operates very poorly/behaves very shaky

8.4.8 LCD lights up but there is no text/motors are broken

POSSIBLE REASON	SOLUTION/ACTION
Major problems with the controlling computer.	Replace the winch computer.

Table. 8.8 LCD lights up but there is no text/motors are broken

8.4.9 Motor stops during operation/program is still running

POSSIBLE REASON	SOLUTION/ACTION
Internal faults inside the drivers generates a FAULT signal to the computer.	Check the LEDs on the motor drivers.

Table. 8.9 Motor stops during operation/program is still running