

Operator Manual



MISSION SPECIALIST **Defender**

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MISSION SPECIALIST _DEFENDER

Congratulations on flying one of the best designed, supported, and most powerful submersibles in the world. Our team is now part of your team. No matter the challenge, we will do what it takes to ensure your Mission Specialist Defender serves you well each and every mission.

-SCOTT BENTLEY, FOUNDER AND EXECUTIVE CHAIRMAN

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_ABOUT THIS MANUAL

_DOCUMENT SYMBOLS

Several symbols are used throughout this documentation to add emphasis and to assist in relocating important information. The following describes these symbols and their uses.

DANGER

The Danger icon is used to indicate there is a potential risk of personal injury or death. Extra care should be taken to understand the risks, and all personnel should exercise caution. It may also be appropriate to warn others in the immediate vicinity.

CAUTION

The Caution icon is used to indicate there is a potential risk of damage to the equipment or surrounding property. Personnel should receive training in the appropriate procedures before attempting to operate or maintain the equipment.



The Do Not icon is used to indicate that an action or activity should NOT be performed.



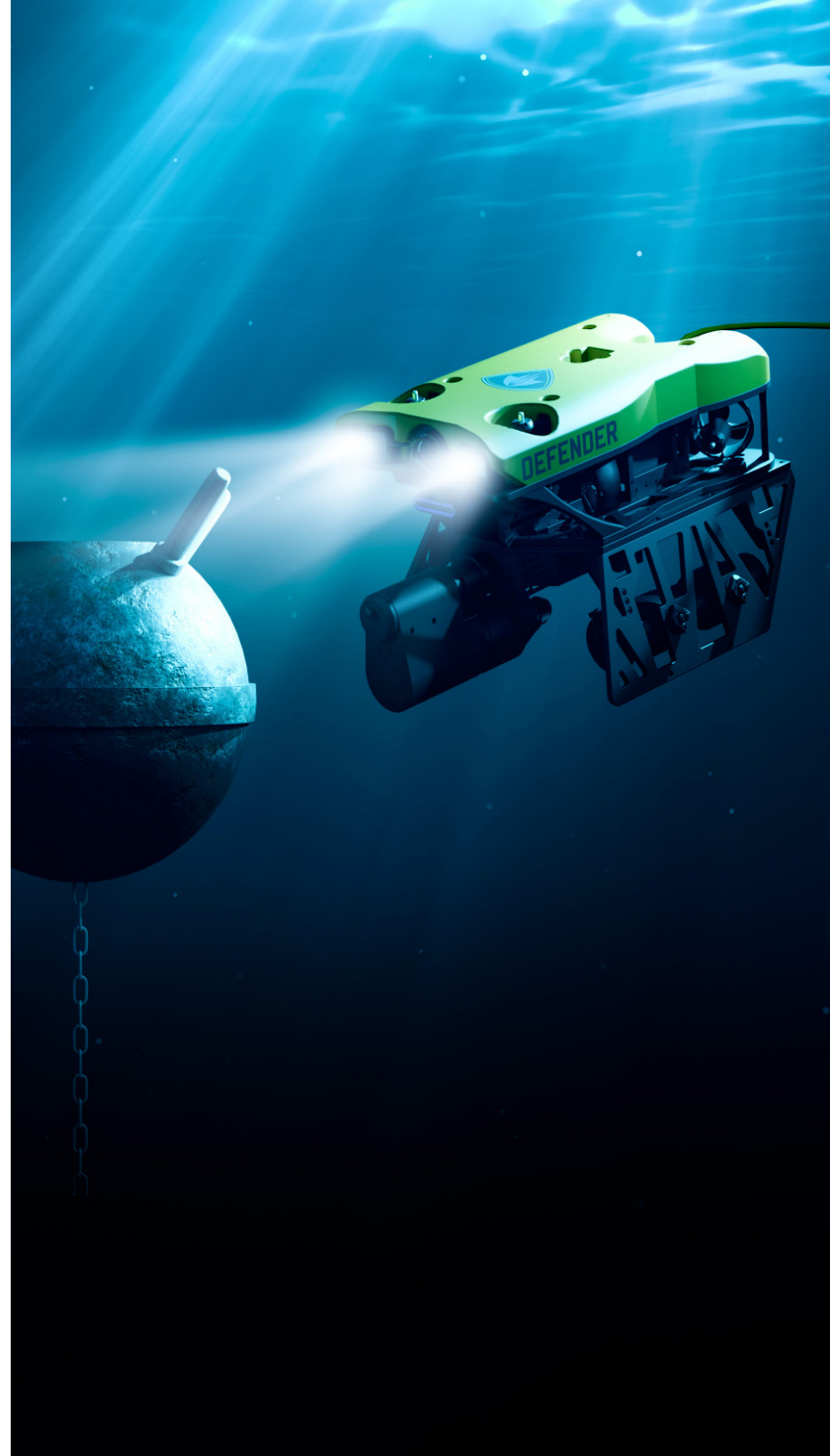
The Note icon is used to highlight an important detail or point of information.



The Tip icon is used to highlight a suggestion or recommendation.

_BEYOND THIS DOCUMENT

There is no substitute for experience and/or training, especially with respect to the real purpose for which you plan to use this equipment. We encourage you to explore options beyond the scope of these materials to expand your knowledge and skills necessary to support your applications. In addition to this documentation, VideoRay offers operator and maintenance training courses and provides comprehensive technical support. Visit our website at videoray.com for more information about resources and support.



_SAFETY FIRST

DANGER

CAUTION

Operating electrical devices in and near the water can be dangerous. There is always a risk of drowning or electrocution in such an environment. Reduce these risks by using common sense and observing safety regulations and recommended safe practice including the following:

- *Never handle power cords while in contact with water or allow power cord connectors or the control panel to enter the water. The only components that can safely be placed in water are the submersible, any onboard accessories and tether, and only after making sure the connections are secure.*
- *Always test the safety components, such as GFCI switches and interlock devices, before beginning operations. Follow the procedures described in this manual for.*
- *Have proper safety equipment, such as PFDs (Personal Flotation Devices), on hand and make sure you know how to use them before you need them.*
- *Keep fingers, hair, loose clothing and other objects away from VideoRay's propellers and other pinch points.*
- *Monitor weather and sea conditions and heed any warnings or alerts.*
- *Be aware of and follow any legal ordinances or regulations in your area regarding operation of vessels and underwater equipment in the water.*



Addressing all aspects of safety while working in a water environment is beyond the scope of this documentation. VideoRay encourages you to participate in safety training appropriate for your industry and applications, including such topics as vessel operations, first aid, survival, and other relevant topics.



Before setting up for or commencing any dive, it is always good practice to make sure there are no hazards to people or the equipment on land or in the water. If there are people in the water nearby, you should advise them that you are going to be operating the submersible. As the pilot/operator, it is your responsibility to ensure the safety of those around you as well as that of the equipment and nearby property.



Do not leave the ROV powered on for more than 10 minutes while not in water, doing so may permanently damage the unit's camera, SONAR, or Power Module and may not be covered under warranty.





SYSTEM OVERVIEW

_SYSTEM COMPONENTS

Unpack the system and familiarize yourself with the components. System components may vary depending on the configuration.



_MISSION SPECIALIST DEFENDER

The Defender submersible carries the cameras, lights and sensors or accessories to the underwater places you need to work.. Thrusters provide mobility and are controlled from the surface via VideoRay tether using the Expeditionary Splashproof Controller or Workhorse Control Console.



_MISSION SPECIALIST CONTROL CONSOLES

The Mission Specialist Workhorse Splashproof Controller and Workhorse Control Console are the power and communications consoles of the system. The Workhorse Splashproof Controller will protect your system from rough seas and poor weather conditions and uses the portable and intuitive Expeditionary Splashproof Controller. The Workhorse Control Console has an integrated computer and touchscreen display and uses an external hand controller.



_MISSION SPECIALIST CONTROLLERS

The Expeditionary Splashproof Controller is a lightweight all-in-one hand-held user interface. The Controller pods can detach from the tablet for integration in the lid of the splashproof console. VideoRay's IP65 Industrial Hand Controller and Xbox Elite Controller can be used with either configuration and are pre-programmed for navigation and accessory control.

_MISSION SPECIALIST TETHER

VideoRay tether connects the ROV to the surface and transmits power and communications to and from the Defender. Several types of tether are available for different system and power configurations.





_MISSION SPECIALIST DEFENDER

VideoRay Mission Specialist systems are the world's first submersibles to deliver custom, purpose-built vehicles using revolutionary production configuration processes. Mission Specialist submersibles are built around the payload using core modules, instead of figuring out how to adapt an existing vehicle platform in order to mount the payload.

The Defender utilizes interchangeable, modular components residing on a single, intelligent network. This topology provides an extremely flexible and customizable platform which can be easily adapted to target specific missions. It is this flexibility which sets the Mission Specialist series apart from current technology in the underwater robot industry.

- Modular Primary Components
- Standard Interfaces
- Rapid Prototyping
- Additive Manufacturing
- Sensor Integration

_SYSTEM

Power Requirements: Universal input 47-440Hz, 85-264VAC

Total System Weight (base Defender & controller): ~33 kg (72 lb)

Cases: 2 Watertight rugged hard cases

_ROV POWER

400 VDC Power Module

12 V/120 W, 24 V/300 W, 48 V/1,500 W

_EXTERNAL POWER REQUIREMENTS

The Workhorse Splashproof Controller and Workhorse Control Console require 100-250 VAC, 50, 60 Hz at a minimum of 3,000 Watts (on 120 VAC supplies, this equates to 20 Amp, and on 240 VAC, 10 Amp).

Power can be supplied to the system by typical shore/grid, generator/inverter, portable power supply, or NiMH & Li-ION subsea batteries. Ensure that a portable power source is clean, consistent, and not in 'eco' mode.

The Expeditionary Splashproof Controller has its own internal battery and an external charger, like most laptops. The external charger requires 100-240 VAC, 50, 60Hz (typically plugged into a conventional 15 Amp, 120 VAC wall outlet in the United States. Other countries that use 240 V may have different amperage ratings).

_BUOYANCY

Float Block: 400 m rated (1,312 ft)

Deep Float Block (optional): 2 km rated (6,561 ft)

Ballast Weights: 50/250 g

_COMMUNICATIONS

(5) 100 Mbps Ethernet ports, (5) RS-485 ports

Power control and monitoring.

_IMU (AHRS)

9 DOF IMU and Magnetic Compass

100 Bar, with 400 Bar optional

0.2° Static Roll/Pitch, 0.5° Dynamic Roll/Pitch, 1.0° Yaw

18°/h Gyro Bias Stability

_LEGACY CAMERA

Up to 1920 × 1080, 25 fps

9-pin Subconn connection

View Angle: 160 deg Tilt (180 degree FOV), 136 deg Horizontal, 91 deg Vertical, Compression: h.264

_ULTRA 4K SMART CAMERA

Digital Pan, Tilt, and Zoom

Real-Time color correction

4056 (V) x 3040 (H) recording on camera

_PROPULSION

Brushless thrusters with integrated controller

4 Vectored Horizontal Thrusters:

Forward: 26.7 kg (59 lbs)

Reverse: 15 kg (33 lbs)

Lateral: 8.6 kg (19 lbs)

3 Vertical Thrusters:

Surface: 23.1 kg (50.9 lbs)

Dive: 12.9 kg (28.4 lbs)

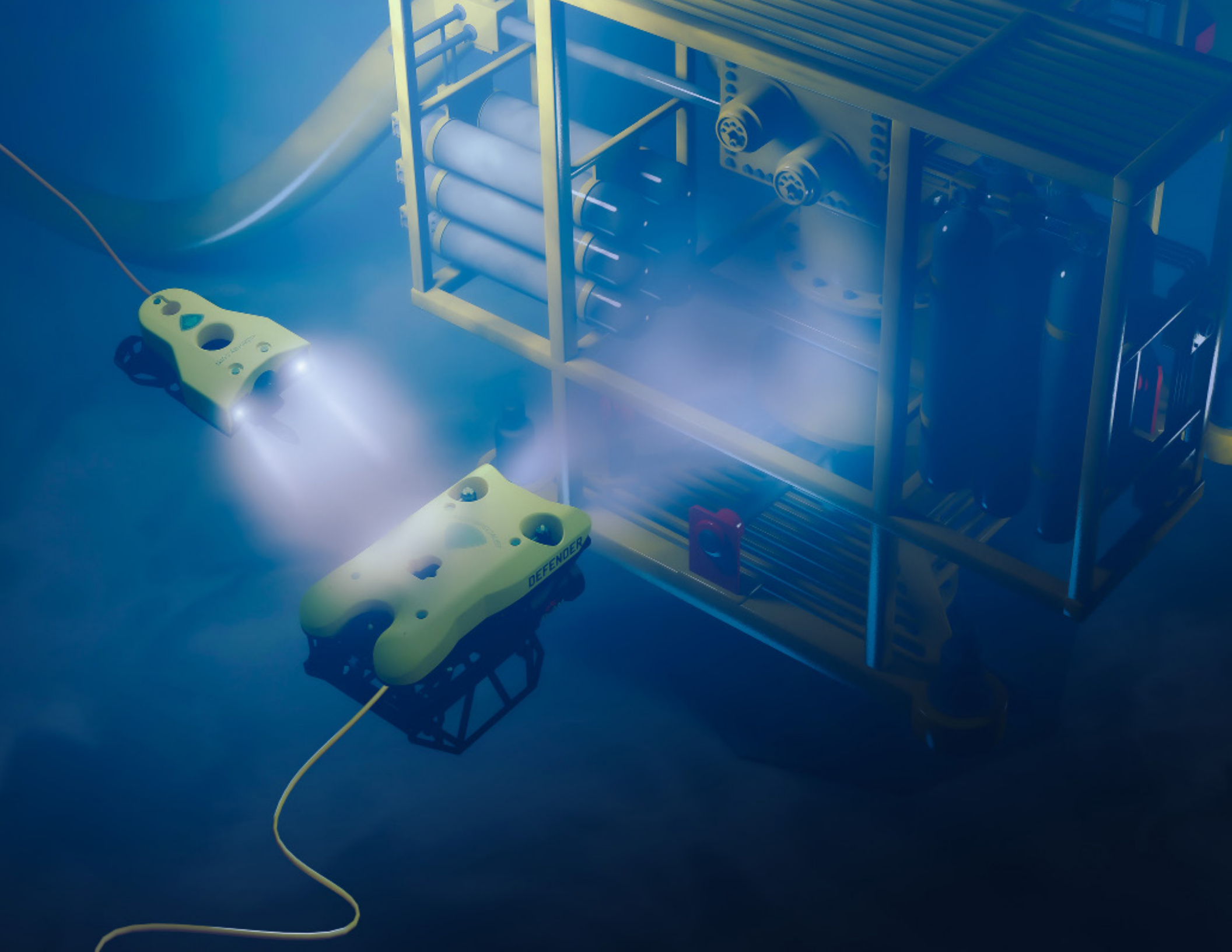
_LIGHTING

2 independent arrays - 60° spot beam, 110° flood beam

Array intensities independently controlled, directionally adjustable

7,600 total lumens per LED module





_MODULES & COMPONENTS

Understanding the features and capabilities of the Mission Specialist Defender is essential to get the most out of using the system. The sections within this system overview provide details about each of the components.

The diagram below outlines the names and functions of the Defender modules and some of the optional accessories not included with the base Defender system. Configurations and accessories may vary.

For detailed specifications and information on Mission Specialist modules, refer to the [Specifications](#) section.

For detailed specifications and information on compatible accessories and sensors, refer to the [Accessories](#) section.



_NOMENCLATURE

_ROV NOMENCLATURE

ROV nomenclature follows the general pattern for seagoing vessels. The descriptions below provides a reference for the directions and attitude relative to the ROV:

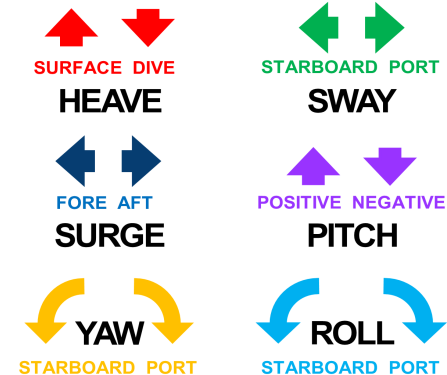
_ROV ORIENTATION

- Bow - The front of the ROV
- Stern - The rear of the ROV
- Port - The left side of the ROV.
- Starboard - The right side of the ROV.
- Fore - Towards the front or the forward direction.
- Aft - Towards the rear or the rearward direction.

_DEGREES OF FREEDOM

The Mission Specialist Defender's seven thrusters provide six Degrees of Freedom (DOF): Surge, Heave, Yaw, Sway, Pitch, and Roll.. The diagram and descriptions below define the Defender's DOF.

1. Surge – Forward and reverse (fore/aft) movement.
2. Heave – Up and down (surface/dive) movement.
3. Sway – Left and right (port/starboard) lateral motion.
4. Yaw – Left and right (port/starboard) pivotal motion.
5. Pitch – Bow Up or Bow Down (positive/negative) motion.
6. Roll – Port Up or Port Down (positive/negative) motion



_CONTROLLERS

_WORKHORSE SPLASHPROOF CONTROLLER

The Workhorse Splashproof Controller (WSC) provides topside power for the Defender for continuous operations and is IP65 rated for all-weather use. It requires topside shore power, generator or power inverter. The WSC is used in conjunction with the Expeditionary Splashproof Controller (shown next section), which is either hand-held or mounted to the open lid of the console.

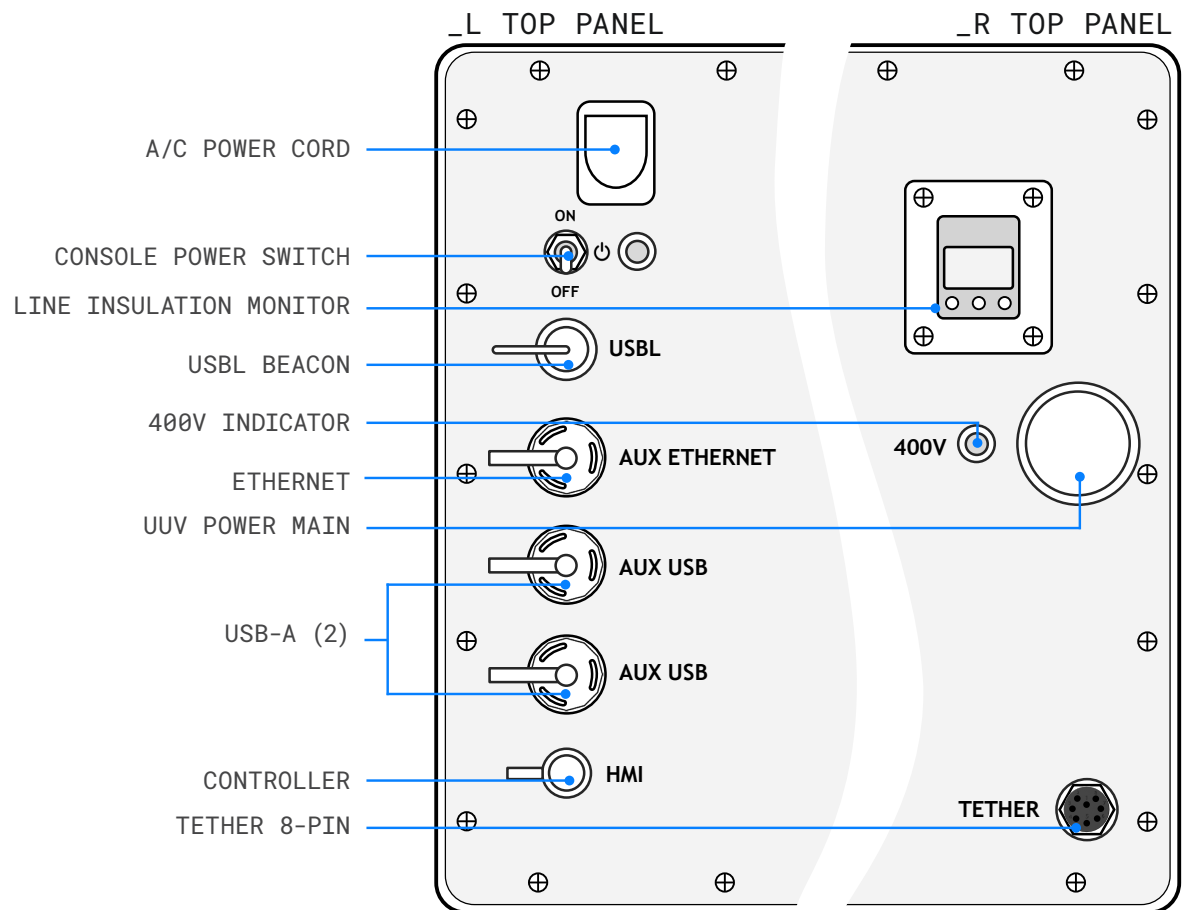
_POWER SPECIFICATIONS

The WSC operates on typical power in the range of 100-240 Volts AC, 50,60 Hz. This can be provided from the land-based grid, a generator, or inverter. The typical power requirements for operating from a generator or inverter are 3,000 Watts continuous.

_SWITCHES AND CONNECTIONS

| SWITCH | FUNCTION |
|--------------------|---|
| POWER SWITCH | Turns the console on and off |
| POWER MAINS BUTTON | Twist the button clockwise to turn ROV power on, push the button down to turn ROV power off |
| LIM MODULE | Test and Reset buttons can be found on the LIM |

| CONNECTION | TYPE | FUNCTION |
|-------------------------------|----------------------|---|
| POWER | Twist-lock Connector | Connects the console to a power source |
| USBL | Teledyne MCBH-5-MP | Provides 12 Volts DC and data connection to the topside USBL beacon |
| AUX ETHERNET | RJ-45 Socket | Connects the console to the computer for Ethernet-based ROV accessories |
| AUX USB PORTS (2) | Type A Socket | Connects USB devices to the computer via the Console |
| HMI (HUMAN MACHINE INTERFACE) | Fischer Multipin | Connects to the console Tablet Computer |
| TETHER | 8 pin Socket | Connects the console to the tether |



_WSC CONSOLE LID TILT ARM

The tilt arm on the left side of the WSC can be used to lock the angle of the console lid and is useful when mounting the Expeditionary Splashproof Controller.

To adjust the angle, loosen the locking collar and adjust the lid to the desired angle, then tighten the locking collar.



CAUTION

Make sure to loosen the display monitor tilt arm and ensure the keyboard is clear of the arm before closing the lid.

ALWAYS use caution when closing the lid to avoid damaging the arm or pinching any cables.

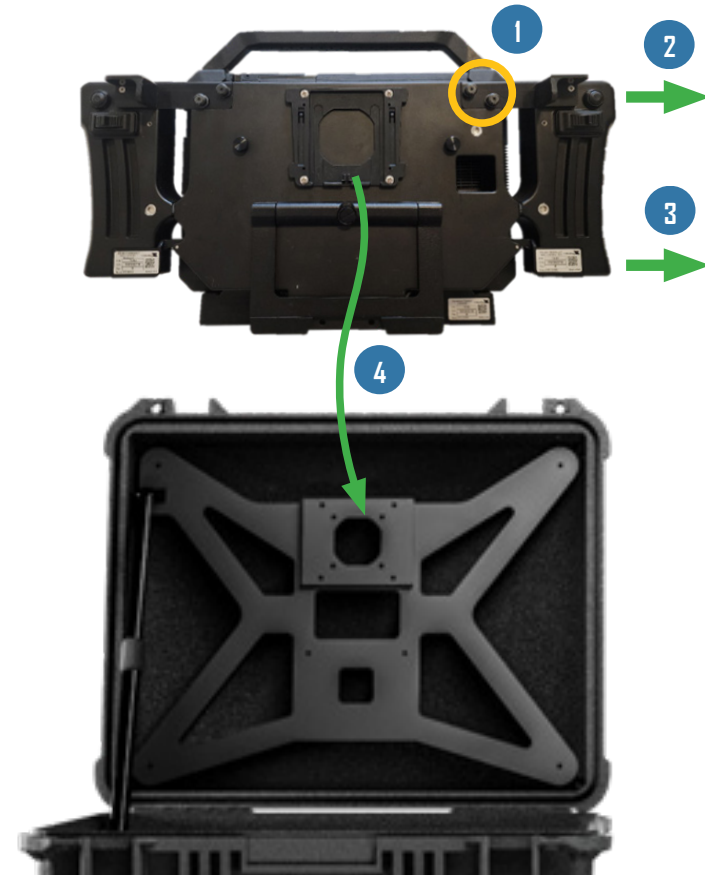
_SPLASHPROOF CONTROLLER MOUNTING

The images below show the mounting plates on the Expeditionary Splashproof Controller and Workhorse Splashproof Controller. To mount the controller:

1. Remove the two thumb screws from each side pod bracket
2. Rotate the top of the pods away from the tablet
3. Release the side pod from the tablet
4. Align the mounts and slide tablet downward until secure



A separate controller will be necessary for operation when mounting the Expeditionary Controller.



_EXPEDITIONARY SPLASHPROOF CONTROLLER

The Expeditionary Splashproof Controller is IP65 rated, lightweight, and has a small footprint for excellent deployment portability. It includes multifunction side pods that serve as the hand controller for the Defender system and is designed to be used as a stand-alone topside controller or with the Workhorse Splashproof Controller (WSC).

_SETTING UP THE CONTROLLER

For general use with topside power, the Expeditionary Splashproof Controller is connected to the WSC using the provided cable with Fischer push-pull connectors. This connection provides power and communications to and from the Defender through the WSC.

When using VideoRay's thin copper tether [Expeditionary Reel](#) and [Mission Specialist Subsea Batteries](#), the controller is used independent of the WSC and the need for topside power.

_CONTROLLER USE

There are several ways to operate the controller:

- Hand-held, with or without the included neck strap,
- Table-top or surface lying flat or using the rear kickstand, or
- Lid-mounted in conjunction with the WSC. When the side pods are removed from the tablet, the system can use VideoRay's IP65 Industrial Hand Controller or the Xbox Elite hand controller.

_CHARGING

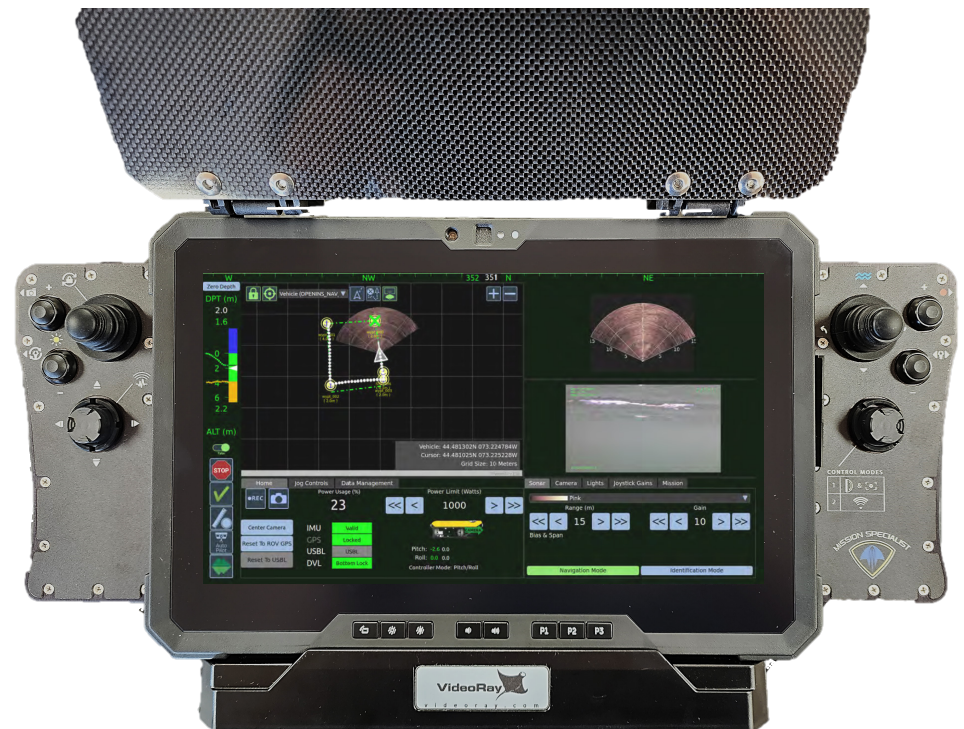
The Expeditionary Splashproof Controller is battery powered. It includes a standard wall DC adapter, but will also receive a charge through the Fischer connection cable to the Expeditionary Reel or WSC during operation.

Shore or grid power is required to charge the tablet computer and the Defender's Subsea Batteries. When possible, it is recommended to use GFCI protected outlets.

_SAFETY CIRCUITS

The WSC includes a standard inline GFCI (Ground Fault Circuit Interrupter) and LIM (Line Insulation Monitor), which detects a voltage leak in 400V conductors. The system also includes a built-in safety interlock that does not allow voltage to enter the WSC's 8-pin tether connection until the tether is mated and completing a circuit with the Defender.

When not connected to topside power and using Subsea Batteries, the Expeditionary Splashproof Controller does not require any safety circuits.



_BUTTONS & CONNECTIONS

The current Expeditionary Splashproof computer is the Dell® Latitude Rugged Extreme 7220/7230 series tablets. For more information about the tablet, consult Dell's specifications found online.

The following features, switches and connections can be found on the Expeditionary Splashproof Controller:

[CONTROLLER FACE]



- | | |
|------------------------|--------------------------|
| 1. Screen Rotate Lock | 8. User Programmable 3 |
| 2. Brightness Decrease | 9. Left Controller Pod |
| 3. Brightness Increase | 10. LED Lens |
| 4. Volume Decrease | 11. Camera |
| 5. Volume Increase | 12. Ambient Light Sensor |
| 6. User Programmable 1 | 13. Right Controller Pod |
| 7. User Programmable 2 | |

[CONTROLLER RIGHT SIDE]



1. DC-in
2. Mini Serial RS-232 port
3. USB 3.0 Type-C port with Display Port Alt Mode/PowerShare
4. USB 3.1 Type-A with Power Delivery
5. Micro SD-card slot
6. Combo mic/headphone Jack
7. Power Switch

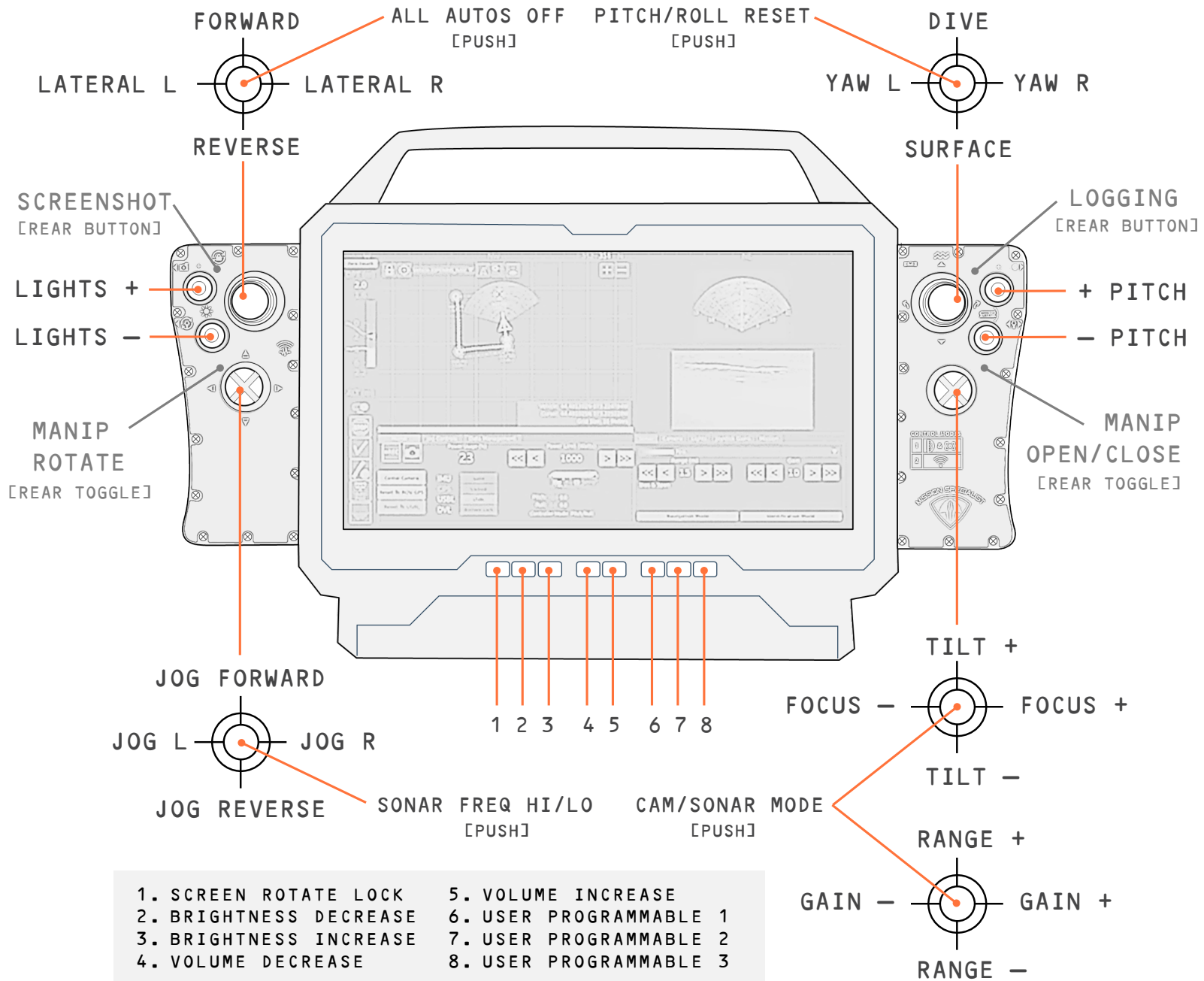
[CONTROLLER BASE]



1. Human Machine Interface (HMI) Fischer push-pull connector
2. USB-A port

Dell is a registered trademark of Dell Incorporated

_EXPEDITIONARY SPLASHPROOF CONTROLLER MAPPING





_WORKHORSE CONTROL CONSOLE

The Workhorse Control Console (WCC) provides power, communications and a video interface between the surface and the Ally through the tether.

The computer, which runs software to control the Ally, is housed in the console along with a touchscreen display monitor. It includes an embedded processor and requires topside power, either shore power, generator, portable power supply, or inverter.

See the next page for details about the ports and connections of the Workhorse Control Console.

_POWER SPECIFICATIONS

The WCC operates on typical power in the range of 100-240 Volts AC, 50,60 Hz. This can be provided from the land-based grid, a generator, or a battery with an inverter (optional). The typical power requirements for operating from a generator or inverter are 3,000 Watts continuous.

Do not block the console side panel intake and exhaust fans. Blocking the fans can lead to overheating and component failure.



The Workhorse Control Console is not rated for all-weather use and requires some protection when used in inclement weather or in an open vessel in rough seas.

_SAFETY CIRCUITS

The WCC includes a standard inline GFCI (Ground Fault Circuit Interrupter) and LIM (Line Insulation Monitor), which detects a voltage leak in 400V conductors. The system also includes a built-in safety interlock that does not allow voltage to enter the WCC's 8-pin tether connection until the tether is mated and completing a circuit with the Ally.

_OPERATOR DISPLAY MONITOR TILT ARM

The Display Monitor Tilt Arm on the left side of the WCC can be used to lock the angle of the console lid and monitor. To adjust the angle, loosen the locking collar and adjust the lid to the desired angle, then tighten the locking collar.



CAUTION

Make sure to loosen the display monitor tilt arm and ensure the keyboard is clear of the arm before closing the WCC lid.

Use caution when closing the lid to avoid damaging the monitor, arm, or pinching any cables.

_SWITCHES AND CONNECTIONS

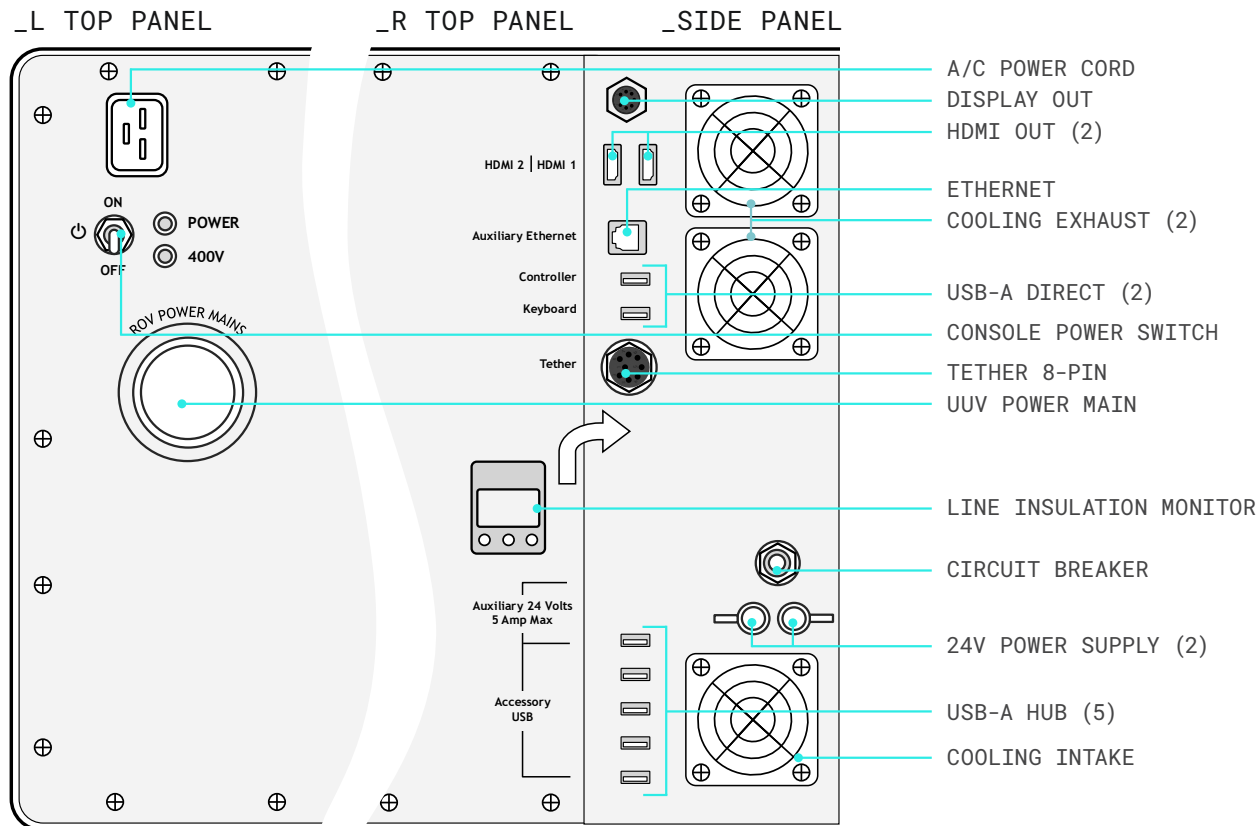
[TOP PANEL]

| SWITCH | LOCATION | FUNCTION |
|------------------|--------------|---|
| POWER SWITCH | Top left | Turns the WCC computer on and off |
| ROV MAINS BUTTON | Center Left | Twist the button clockwise to turn ROV power on, push the button down to turn ROV power off |
| LIM MODULE | Center Right | Test and Reset buttons can be found on the LIM |

| CONNECTION | TYPE | FUNCTION |
|------------|----------|---|
| POWER | IEC Plug | Used to connect the WCC to a power source |

[SIDE PANEL]

| CONNECTION | TYPE | FUNCTION |
|---------------|----------------------|--|
| TETHER | 8-pin Round Socket | Connects the WCC to the tether for ROV power and communications |
| MONITOR | 9-pin Round Socket | Provides power and touch screen function to the monitor |
| MONITOR OUT | HDMI Socket (2) | Provide the video signal to external monitor |
| USB PORTS (7) | Type A Socket | Two dedicated to the keyboard and hand controller; five additional for other devices |
| ETHERNET | RJ-45 Socket | Can be used to connect the WCC to the computer for Ethernet based ROV accessories |
| 24 VDC | DC Type M Socket (2) | Can be used to provide 24 VDC power to topside accessories |



_HAND CONTROLLERS

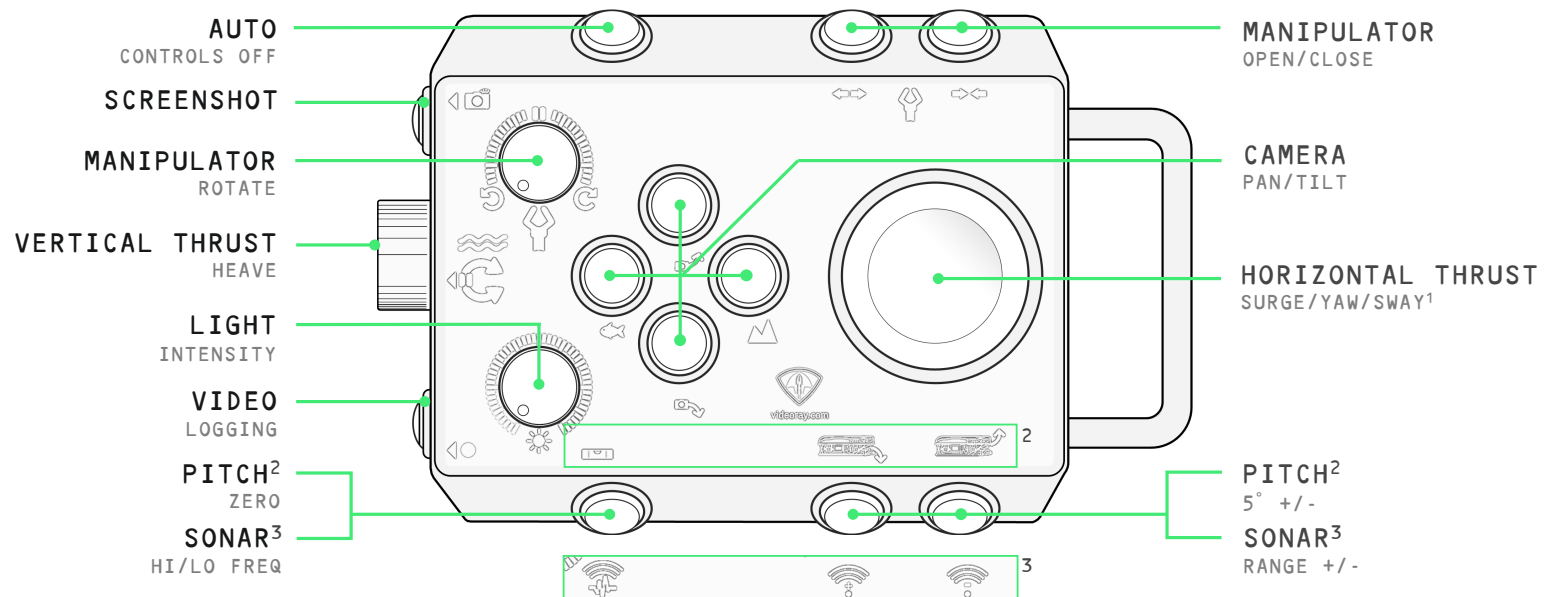
In addition to the Expeditionary Splashproof Controller, other types of hand controllers are standard and supported for use with the Defender system.. Each controller is pre-programmed for ideal recommended use.

The following diagrams show the default mapping settings of each controller.

_IP65 INDUSTRIAL HAND CONTROLLER



The IP65 Industrial Hand Controller allows the operator to navigate the vehicle and control various functions like tilting the camera, operating accessories, or changing the light intensity.



1. Sway (lateral) not applicable to Mission Specialist Pro 5 models.
2. Applicable to Mission Specialist Wraith and Defender models.
3. Applicable to Mission Specialist Ally and Pro 5 models.

_MICROSOFT® XBOX ELITE CONTROLLER

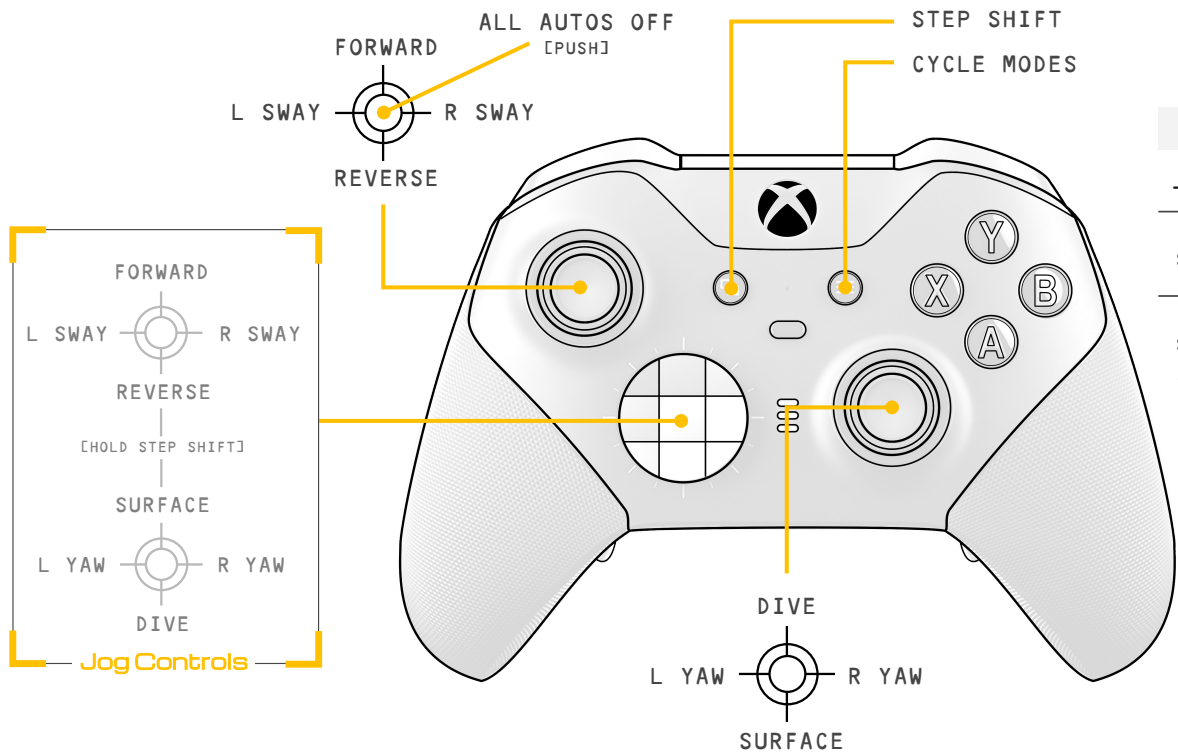


The Microsoft Xbox Elite hand controller is ergonomic and features several modes which allow for numerous functions to be controlled:

- 1. Manipulator
- 2. Sonar
- 3. Pitch/Roll
- 4. Camera/Lights

Press the START button to cycle through the four modes.

Current MODE will be displayed in the GSIQ interface.



| [CONTROLLER MODES] | | | | |
|--------------------|-----------------|-----------------|------------------|--------------|
| _BUTTON | _PITCH/ROLL | _CAMERA | _SONAR | _MANIP |
| LEFT SHOULDER | N/A | LED DIM | N/A | N/A |
| RIGHT SHOULDER | ZERO PITCH/ROLL | LED BRIGHT | N/A | N/A |
| X | ROLL 5° PORT | CAMERA ZOOM IN | SONAR GAIN DOWN | ROTATE LEFT |
| B | ROLL 5° STBD | CAMERA ZOOM OUT | SONAR GAIN UP | ROTATE RIGHT |
| Y | PITCH UP 5° | CAMERA PAN UP | SONAR RANGE HIGH | OPEN |
| A | PITCH DOWN 5° | CAMERA PAN DOWN | SONAR RANGE LOW | CLOSE |

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_VIDEORAY TETHER

_OVERVIEW

Tether connects the Defender to the surface and provides power, communications, video and an APIC (Auxiliary Pair of Independent Conductors) for accessory use. Standard tether consists of conductors, a Kevlar® strength member, flotation (for Neutral and Performance tethers), and an outer jacket. It is available three types: Negative, Neutral and Performance (often called PPT), and is available in standard and custom lengths. Neutral and Performance are neutrally buoyant in fresh water because they have a specially designed foam jacket.

While larger conductors provide the best power transmission capacity, they lead to thicker diameter tethers, which results in higher drag. Negative tether has the largest conductors (best power transmission capacity), followed by Neutral, and then Performance. Negative and Performance tether have the smallest diameter (least drag), while Neutral tether has the largest diameter.

The tether connectors are wet mateable and can be connected while they are wet. One of the pins in the connector is offset. To connect the tether to the Defender, control panel or another tether, align the offset pin of the connectors and press the two connectors together until the base surface of each connector are touching each other. Then, connect the tether locking sleeves by screwing them together to secure the connection.

Multiple tethers can be connected in series like conventional power extension cords. See the 'Tether to Tether Connections' subheading later in this section for recommended tether configurations.

CAUTION

Always secure the tether connectors using the locking sleeves and strain relief system to avoid separation and loss of the ROV.

CAUTION

The tether connectors should be kept clean to avoid abrasion and corrosion on the electrical contacts and damage to the rubber insulation. Tether connectors should not be lubricated with petroleum products or grease. Petroleum will degrade the rubber and grease will attract dirt and lead

to abrasion and corrosion. VideoRay recommends lubricating the connectors with a light coat of pure silicone grease or spray.



The strain relief system between two tether sections includes a small carabineer that should be wrapped with tape to prevent the connection from becoming snagged.

_TETHER BUOYANCY

Performance and Neutral tether include buoyancy- compensating foam that provides near-neutral buoyancy in fresh water. Negative tether contains no foam and will sink. The connectors do not contain any buoyancy compensation and will noticeably sink slightly.

_TETHER STRENGTH

Most VideoRay tether includes Kevlar® rated at 450 kg (1,000 lbs); VideoRay Hybrid Tether has a Vectran™ strength member.

The tether's threaded connectors are rated 80 kg (175 lbs).

CAUTION

These values are breaking strength. Tether should not be regularly subjected to a working strength greater than one-half of the breaking strength. The Defender and tether are equipped with a strain relief cable and connectors, which are rated at 136 kg (300 lbs). The strain relief cable should be used to avoid separation of the tether connectors and loss of the Defender.

The maximum usable tether length is limited by the ability to transmit power and data signals. See the [Tether](#) section for more information.

Kevlar is a registered trademark of E. I. du Pont de Nemours and Company

Vectran is a registered trademark of Kuraray, Incorporated

_DEFENDER TO TETHER STRAIN RELIEF

Use the procedures on the following pages to install and secure the Defender to the tether to prevent a connection failure or submersible loss. The strain relief cable may already be attached to the tether. If so, you can skip steps 1-3.



The procedure on this page demonstrates installation on a Defender with a spring-operated twistlock retaining bolt. The procedure on the following page demonstrates installation on a Defender with the threaded retaining bolt.



Defender to tether strain reliefs may vary depending on model. The installation and connection of either the updated rubber strain relief or original stainless steel strain relief are identical.

CAUTION

Failure to connect the strain relief properly may result in loss of the Defender

1. Insert the loop end of the tether webbing into the elongated loop end of the strain relief.
2. Pass the eye socket end of the strain relief through the loop end of the tether webbing.
3. Pull the eye socket end of the strain relief cable to secure the connection.
4. Apply silicone lubricant as recommended and align the pins of the male Defender whip connector to the female tether connector. Fully mate the connectors and secure the connection with the threaded locking collar.
5. If the Defender's strain relief retaining bolt is locked in the down position, push downward on the top of the bolt against the spring and turn 90 degrees in either direction. Hold the bolt up and insert the strain relief eye socket into the opening in the frame. Align and push the retaining bolt down through the eye socket. Push down and turn the bolt 90 degrees in either direction. The retaining bolt should be locked in the down position..
6. Make sure the strain relief connection is secure. Test to ensure there is no load or tension on the tether connection at any angle.



_DEFENDER TO TETHER STRAIN RELIEF



The procedure on this page demonstrates installation on a Defender with a threaded retaining bolt. The procedure on the preceding page demonstrates installation on a Defender with the spring-operated twistlock retaining bolt.

Defender to tether strain reliefs may vary depending on model. The installation and connection of either the updated rubber strain relief or original stainless steel strain relief are identical.

CAUTION

Failure to connect the strain relief properly may result in loss of the Defender

1. Insert the loop end of the tether webbing into the loop end of the strain relief cable.
2. Pass the eye socket end of the strain relief cable through the loop end of the tether webbing
3. Pull the eye socket end of the strain relief cable to secure the connection.
4. Apply silicone lubricant as recommended and align the pins of the male Defender whip connector to the female tether connector. Fully mate the connectors and secure the connection with the threaded locking collar.
5. If the Defender's strain relief retaining bolt is threaded in the down position, unscrew the bolt. Hold the bolt up while inserting the strain relief eye socket into the opening in the frame. Guide the bolt down through the eye socket and tighten the bolt to secure the strain relief.
6. Make sure the connection is secure and that all of the load is carried by the strain relief. Test to ensure there is no load or tension on the tether connection at any angle.



_TETHER TO TETHER CONNECTIONS

When connecting two tethers for an operation, do not exceed the recommended maximum range for each type of tether. Exceeding this range will result in inadequate power and data delivery through the tether.

For connecting two tethers, apply silicone lubricant as recommended and carefully align the pins of the male and female connectors. Fully mate the connectors and secure the connection with the threaded locking collar.

_TETHER TO TETHER STRAIN RELIEF

When connecting two tethers together for an operation, the connection shall be secured with a tether to tether strain relief to prevent strain and separation of the connection. Use the following procedures to install and secure the strain relief cord for tether to tether connections.

1. Ensure that you have all parts of the tether to tether strain relief.
2. Ensure that both carabiners are labeled with '600 lb'. Older models of VideoRay ROVs used the 450 lb-rated carabiners and should not be used with Mission Specialist systems.

CAUTION

Using the incorrect carabiners may cause the strain relief to fail under extreme loads

3. Connect one of the carabiners to one loop end of the tether to tether strain relief cord.
4. Connect the carabiner to the tether strain relief webbing and secure the carabiner locking nut.
5. Repeat steps 3 and 4 using the second carabiner and strain relief webbing from the second tether.
6. Make sure the strain relief cable connections are secure so that all of the load is carried by the strain relief and there is no load on the tether connection.



When working in an area where there is a chance the tether can become snagged on an object, the connection can be wrapped with tape to prevent a protruding object from passing through the space between the tether and the strain relief cable.



_EXPEDITIONARY COPPER TETHER

VideoRay's Expeditionary Copper Tether is for use with Mission Specialist Subsea Vehicle Batteries and Expeditionary Reel. The tether provides an extended mission range while significantly decreasing hydrodynamic influence on the tether. Its smaller diameter allows for easier piloting and tether management, especially in current or high winds.

When space is a requirement, the Expeditionary Reel is designed to be used exclusively with the Workhorse Splashproof Controller tablet, which allows for an extremely small system footprint while having an IP65 rating.

The Expeditionary Reel has two power ports for 2590 Li-ion or NiMH rechargeable batteries that deliver power to both the Expeditionary Splashproof Controller (tablet) and topside USBL beacon (if applicable).

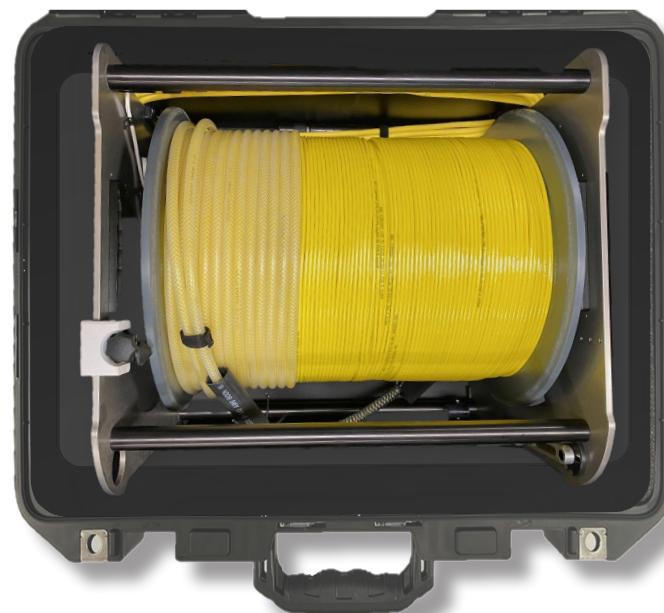
- Up to 500 m range
- Power Input: 2590 Battery; 12V DC
- Ingress protection IP65
- Slip ring, level wind
- Collapsible handle
- Rugged, watertight rolling case



_FIBER OPTIC TETHER

VideoRay's Fiber Optic Tether is for use with Mission Specialist Subsea Batteries and provides superior mission range and data transmission. Hydrodynamic influence on the tether is significantly decreased, resulting in easier piloting and tether management. The 2,000+ m rating allows for maximum mission range.

Fiber Optic Tether is optionally available on the Expeditionary Reel in a 500 m capacity (shown above) or 1,500 m reel as shown to the right. The 1,500 m reel is manual wind and protected inside a rugged, watertight case. Included with the Fiber Optic Tether are Fiber Optic Patch Cables, a Fiber Optic Tool Kit, and Fiber Optic Cleaning Tools.





CONTROL SOFTWARE

_GREENSEA CONTROL SOFTWARE

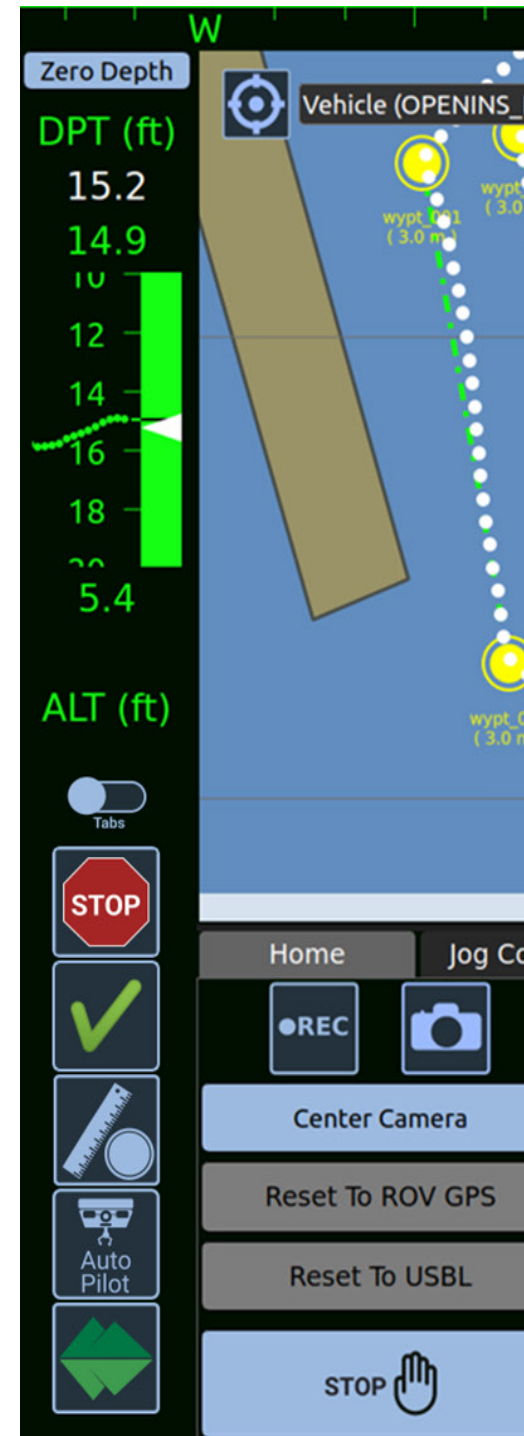
The Mission Specialist control software is provided by Greensea IQ™, a world leader in autonomous vehicle control software. This intuitive software makes it easy for novice pilots to navigate the vehicle to where it needs to be and reduces sensory and task overload for all pilots. Greensea IQ uses the Ubuntu Operating System.

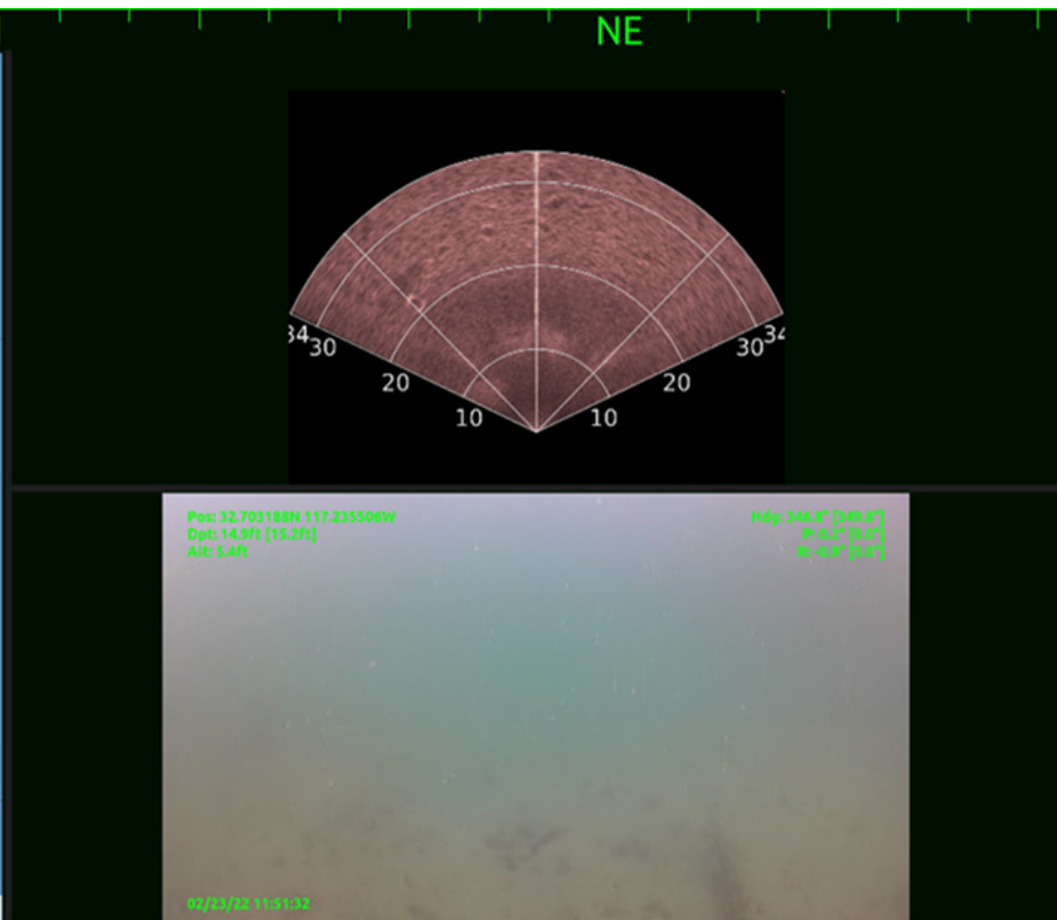
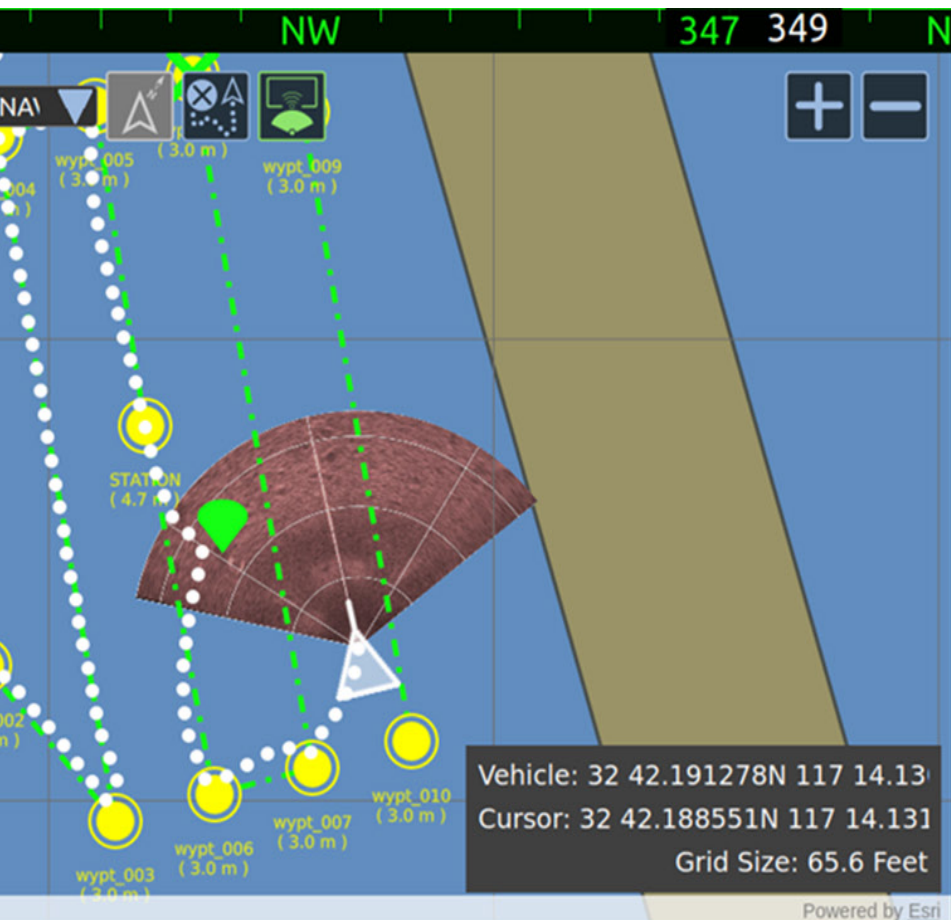
This section of the user manual is a basic guide for operating the Defender. Visit videoray.com/training/ to find information about VideoRay's training courses. For information about specific software versions, visit Greensea's website for resources and user manual downloads.



There are several versions of Greensea IQ control software, thus the interface layout and menus shown here may differ. Advanced operation, navigation, and autonomous flight are not covered in this manual; refer to Greensea user manuals found using the desktop icon or online for information and instructions.

Greensea is a registered trademark of Greensea IQ Intelligent Ocean Solutions





Controls Data Management

Power Usage (%) 7

Power Limit (Watts) 1000

Sensors

| | |
|------|-------------|
| IMU | Valid |
| GPS | Acquiring |
| USBL | USBL |
| DVL | Bottom Lock |

Pitch: 0.2 0.0
Roll: -0.9 0.0
Controller Mode: Sonar

Sonar Camera Lights Joystick Gains Mission

Waypoint Speed

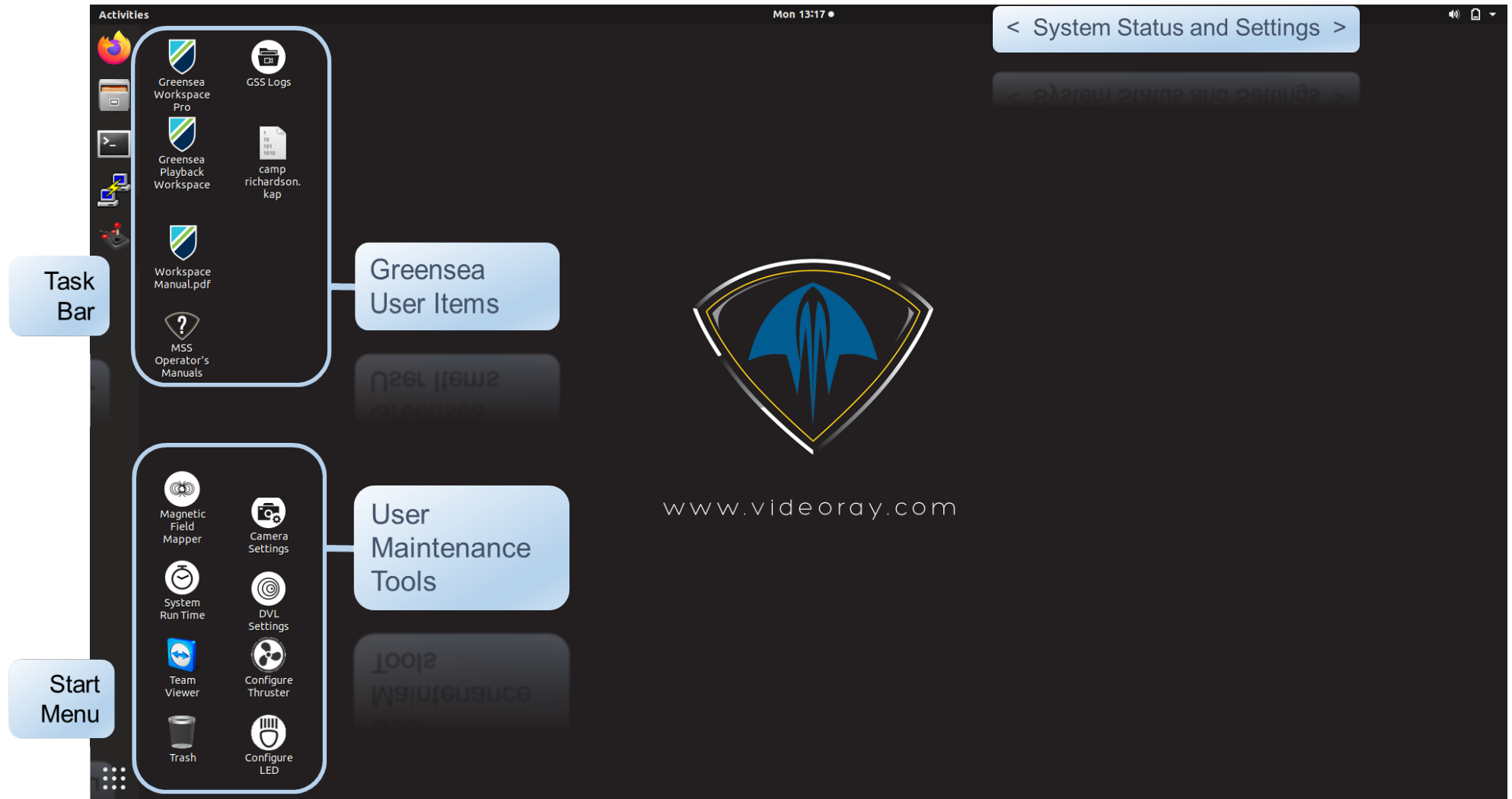
Mission Controls

Waypoint Speed controls: < > buttons, radio buttons for Maximum, Fast, Medium (selected), and Slow.

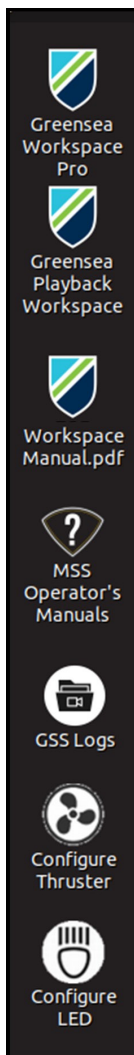
Mission Controls buttons: Stop, Play, Pause, Previous, Next, Home, and a button with a red arrow.

_MISSION SPECIALIST DESKTOP

The Ubuntu desktop for the Mission Specialist system is simplified and categorized by tasks. It is similar to any common user interface and doesn't require software-specific knowledge to navigate. The image below outlines an overview of the icons and general functions.



Commonly used icons on the Ubuntu desktop for Mission Specialist systems are defined below:



Opens the Greensea control software (icon and name may vary depending on version)

Opens the Greensea Playback software to select and play back a recorded mission using telemetry data

Opens the digital Greensea User Manual specific to the installed version

Opens the digital VideoRay Mission Specialist Defender User Manual

Opens the GSS (Greensea Systems) Logs folder where telemetry, camera, and sonar files are stored by default

Opens the Thruster Configuration application for configuring a newly-installed thruster module

Opens the LED Configuration application for configuring a newly-installed LED module



_GREENSEA WORKSPACE

Workspace is Greensea's customizable human/machine interface that uses the OPENSEA underlying modular operating platform. Workspace provides the operator with a simplified, streamlined workflow and enhanced capabilities supporting real-world applications.

The Workspace instruments provide operator inputs and information about the Defender and accessories/sensors. Use Workspace for mission planning, system command and control, and status monitoring.

Workspace instruments also provide information about heading, depth, and attitude (pitch and roll). Auto controls for heading, depth, pitch, and roll are enabled/disabled by the operator. These controls assist in stabilizing the Defender during general navigation by holding depth and heading, as well as holding an attitude, e.g., positive pitch for viewing a ship hull or negative pitch for scanning the bottom.

If a navigation package is included, capabilities for auto altitude (distance from the bottom), dynamic positioning, jog controls, and POI (orbit) mode are also enabled. Refer to the Greensea user manual online for information about these functions.

The Diagnostics View opens the diagnostics menu, which displays critical module and sensor status and information. Refer to the Greensea user manual for information about the diagnostics menu.

CAUTION

Altering settings in the diagnostics menu can result in a failure to operate the Defender as desired. Please contact VideoRay Support before modifying ANY default factory settings.

_FLIGHT VIEW

The Flight View user interface (UI) is customizable. Your specific version may look different from the one shown in this section.

The Flight View is what you will be using for the majority of the time when performing tasks and completing operations. It is made up of a combination of multiple instruments working together to provide you with a heads-up display of vehicle information, mission status, and control tools.

Use the IP65 keyboard hotkeys F1 through F5 to cycle Flight View display layouts as shown on the keyboard label:



F1 - Default 3-View Split (mission, sonar, and video) layout

F2 - Video only layout

F3 - Sonar only layout

F4 - Mission (Map View) only layout

F5 - Sonar/Video split layout

F6 - Display/hide Flight View tabs

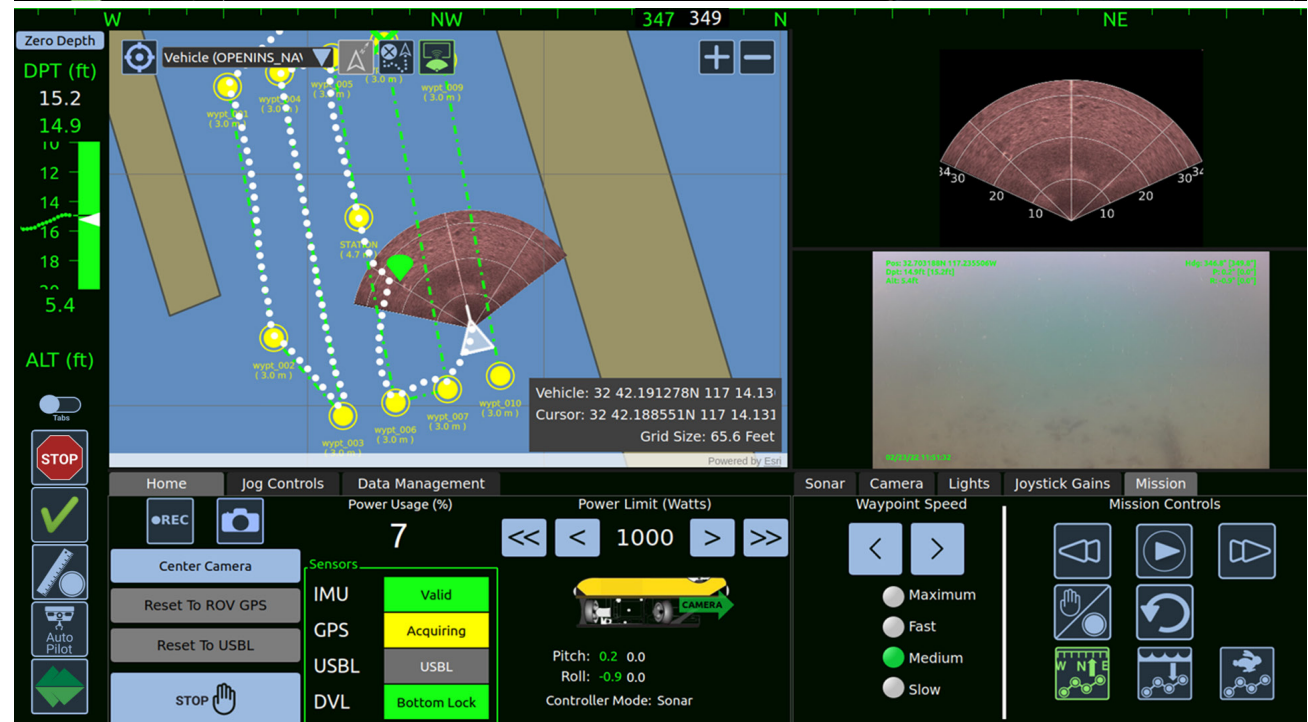


The main operational difference between Greensea versions are the menu appearances and locations. Functionality and features are very much the same.

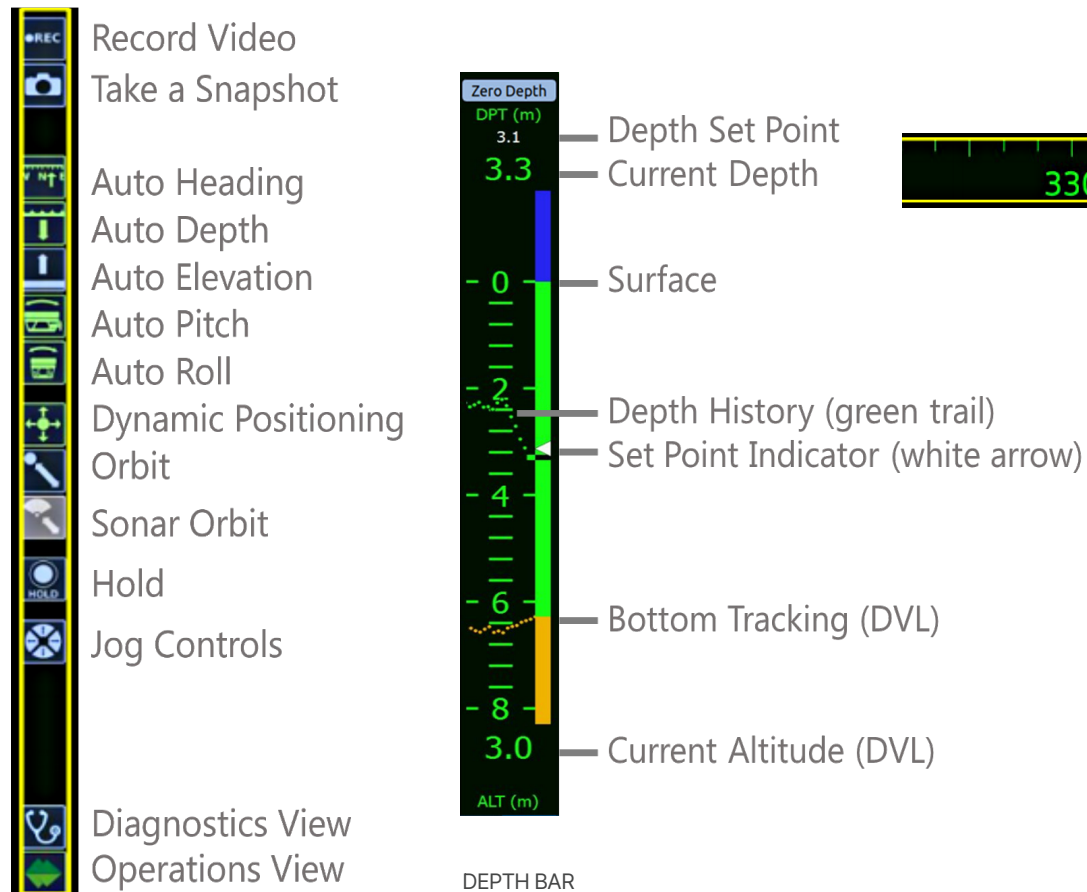
[VERSION 3]



[VERSION 6+]



[GSIQ V. 3]



Heading Set Point Indicator



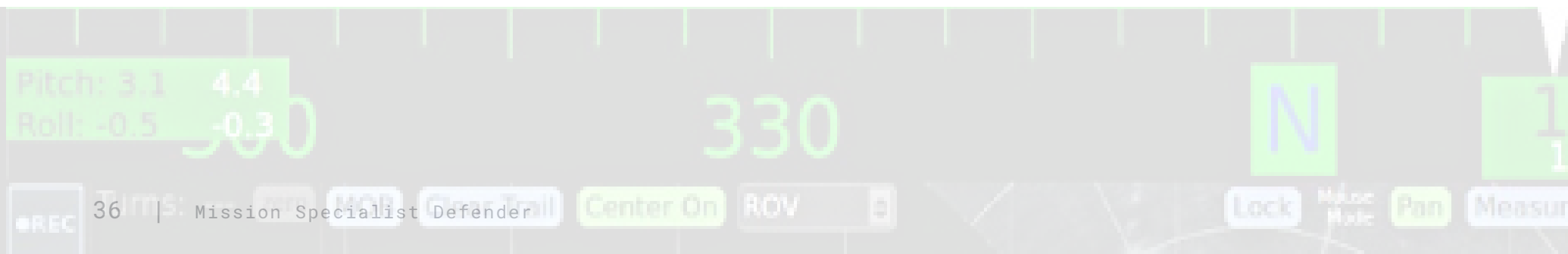
Current Heading (green box)
Heading Set Point (white)

HEADING BAR

When functions are enabled, the buttons change color from blue to green.

CONTROL BAR

DEPTH BAR



[GSIQ V. 6+]

Current Heading (green)



Heading Set Point (white)

HEADING BAR



Depth Set Point

Current Depth

Surface

Depth History (green trail)

Set Point Indicator (white arrow)

Bottom Tracking (DVL)

Current Altitude (DVL)

DEPTH BAR



CONTROL BAR

Displays/hides Flight View menus

Stop Button immediately stops the vehicle, holds that position, and creates an active station-keeping waypoint

Alarm Indicator

Map Tools

Autopilot Controls

View Selector Controls



_GREENSEA VERSION 6+ CONTROL BAR FUNCTIONS



Open the Map Tools flyout:



Measure Tool - Toggle Measure Mode. When enabled, Measure Mode displays on the map. Click or tap the map, and drag to get a distance and bearing measurement.

NOTE: A new measurement is created each time the Map is tapped/ clicked until Measure mode is disabled.



Markers Tool - Toggle Markers mode. When enabled, click or tap the map to add a marker.



Waypoints Tool - Toggle Waypoint Mode. When enabled, click or tap the map to add a new Waypoint to the current mission. This can be used to quickly create missions on the fly.



Region Tool - Toggle Region Mode. When enabled, click or tap the map to add a new point defining a region.

NOTE: When a map view mode is enabled, a new marker, waypoint, or region boundary point is created each time the Map is tapped/ clicked until the corresponding mode is disabled.

When functions are enabled, the buttons change color from **blue** to **green**.



Open the Autopilot flyout:



Toggle Auto-Heading - When enabled, the vehicle maintains and follows the heading setpoint to direct the vehicle, starting with the current heading. Control Inputs move the setpoint.



Toggle Auto-Depth - When enabled, the vehicle maintains and follows the depth setpoint, starting with the current depth. Controller vertical inputs move the setpoint.



Toggle Auto-Altitude - When enabled, the vehicle maintains and follows the depth setpoint, starting with the current altitude. Controller vertical inputs move the setpoint.

Note: Auto-altitude capability requires a DVL with bottom lock.



Toggle Auto-Pitch - The vehicle maintains the Pitch setpoint. Pitch setpoint is 0 degrees when enabled and adjustable in +/- 5 degree increments.



Toggle Auto-Roll - The vehicle maintains the current roll. Roll can be zeroed from the controller. Roll setpoint is 0 degrees when enabled.



Toggle Positioning Mode - When enabled, Positioning creates a waypoint at the vehicle position. While positioning is active, control inputs move the vehicle. When inputs return to null, Workspace creates a waypoint at the vehicle location.



Toggle Point of Interest (POI) Mode - Select an object or position on the Map (generally while using Sonar Overlay) to place a Point of Interest marker and automatically enable POI Mode. When manually enabled, a POI marker is placed in front of the vehicle. Lateral controller inputs will orbit around the POI; forward/reverse inputs will face and decrease/ increase distance from the POI.

Note: Positioning and POI capability require a DVL with bottom lock.



Open the View Selector flyout:



Change Flight View to default 3-View Split (mission, sonar, and video) layout (keyboard shortcut is F1).



Change Flight View to Video only layout (keyboard shortcut F2).



Change Flight View to Sonar only layout (keyboard shortcut F3).



Change Flight View to Mission only layout (keyboard shortcut F4).



Change Flight View to Sonar/Video only layout (keyboard shortcut F5).



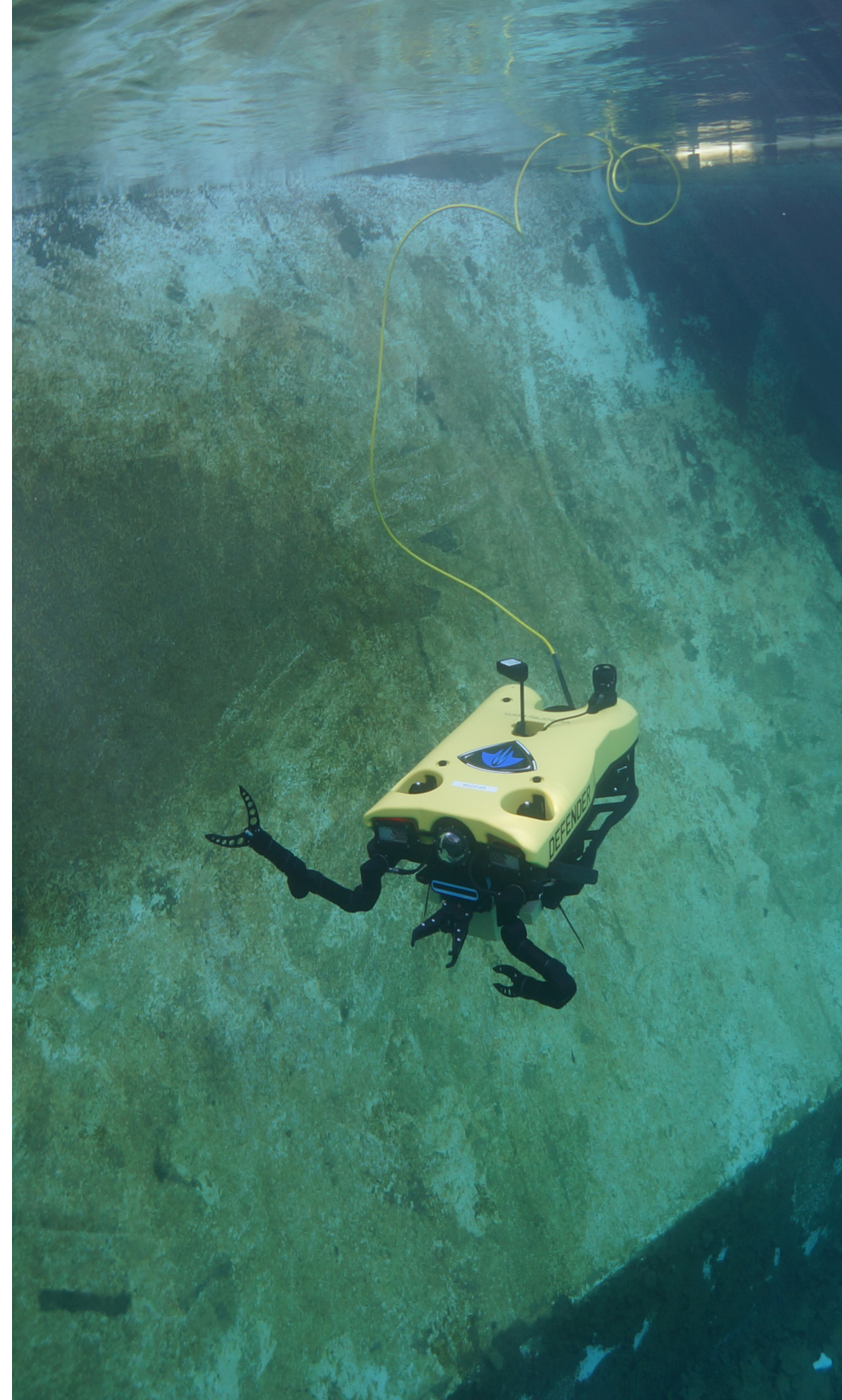
Open User Preferences View. Keyboard shortcut Alt+2.



Open Diagnostics View. Keyboard shortcut Alt+3.



Exit Workspace. Shutdown Workspace application; confirm action.





ORENSEA

videoray.com



**GETTING
STARTED**



_PROJECT MANAGEMENT

While the differences between conducting a recreational dive, an inspection of an offshore well riser or a drowning victim recovery are quite dramatic, each of these dive missions usually consist of the following phases:

- Plan the mission
- Prepare for the mission
- Execute the mission
- Conclude the mission
- Compile and deliver project reports

Of course, how critical a successful outcome is deemed and how much lead time and how many resources are available will dictate how much effort can or will be afforded to each phase.

The essential knowledge and skills required for a consistent ability to “get the job done” go well beyond just being able to set up and pilot an ROV. In this section, the following topics will be discussed to help broaden your understanding of the scope of practical ROV applications:

- Roles and Responsibilities
- Operation Safety
- Tether Management
- Pre and Post-Dive Operations
- Proper Care

_ROLES & RESPONSIBILITIES

_PILOT

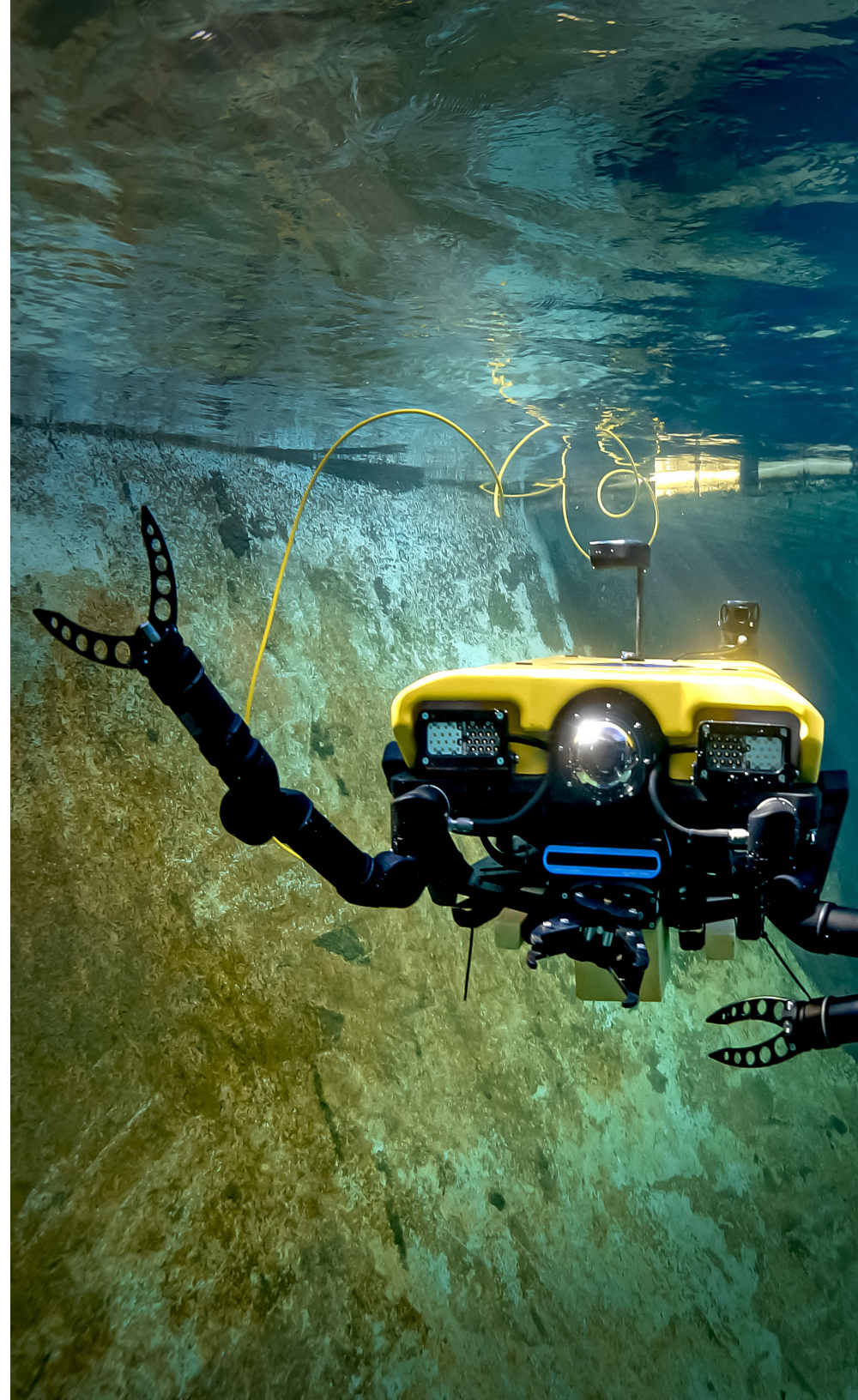
Pilots are responsible for operating the Defender in a safe manner while navigating the ROV to achieve the Operation's objectives. Dark-colored clothing will help to avoid glare in the monitor. Communication with the Tether Handler is key.

_TETHER HANDLER

The tether handler supports the pilot by managing the tether, including making sure the right amount is deployed, keeping it away from surface hazards, keeping loose tether on the surface neat, and communicating with the pilot.

_ACCESSORY OPERATOR/OBSERVER

On most Operations, the pilot will focus intently on navigating the Defender. Having an accessory operator will reduce the burden on the pilot. A good observer will also monitor sonar imagery and accessory readings.



_OPERATION SAFETY

When piloting in confined spaces and areas with underwater hazards, the greatest concern is getting stuck or getting the tether snagged on an obstruction. The best techniques are:

- Ballast the Defender for your operation
- Proceed slowly and plan ahead before entering tight spaces
- Observe the entire surroundings, including above and below, for any obstacles that might entrap the Defender or snag the tether
- Have someone deploy tether as close to the entry point as possible
- Use proper and proven search methods
- Consider deployment locations and techniques that aid in piloting

_TETHER MANAGEMENT

Tether management can have a significant affect on the ability to pilot the Defender and achieve the objectives of the mission

- Make sure tether connections and strain reliefs are secure
- Select a deployment site that aids in piloting and tether management, e.g., a clear path without obstructions
- Only deploy what is needed - too little will affect piloting - too much may result in drag, snags, tangles or propeller cuts
- Do not crush or kink the tether tighter than the minimum bend radius
- Avoid passing the tether over rough surfaces or sharp edges
- Coil loose tether using either an over/under technique or a figure 8 technique to prevent twisting of the tether
- Refer to the [Tether Care](#) section for more information and recommendations





_PRE-DIVE OPERATIONS



Some steps in this section may not apply to all system configurations, e.g., controllers, tether, and accessories. Always refer to Quick Guides and User Manuals for detailed instructions regarding pre-dive mounting, connections, and use specific to each system configuration.

_PRE-DIVE STEPS:

1. Visual inspection before setting up the system
2. Set up the system including making connections
3. Power on tests of the system's safety circuits
4. Primary functions test of the system's components
5. Launch the Defender

1. VISUAL INSPECTION

It is always good practice to perform a pre-dive inspection before every dive. If any problems are noted, they should be addressed before continuing.

1. Ensure all system cases and components are present. Remove the float block and inspect all connections for proper mating and system components to make sure there are no visible signs of damage or loose or worn parts. Also check for water inside the camera dome.
2. Check the horizontal and vertical thrusters to make sure the propellers are free to spin and are not fouled with debris or fishing line, loose, or contacting the thruster guards. Check thruster tell tales for indications of low reservoir levels. A tell tale that has recessed into the thruster housing indicates that the thruster is damaged internally.
3. If equipped, extend the manipulator body by loosening the thumb screws in the frame and set to either 0 degree or 30 degree negative pitch. Attach the preferred jaw to the manipulator body.

4. If equipped, securely mount, lubricate, and connect the Defender's USBL beacon, auxiliary camera, or other accessories.
5. If equipped, extend the Defender's GPS antenna.

2. MAKE THE CONNECTIONS

Systematically make connections at the Defender and work your way toward the power source.



Refer to the [System Overview](#) for a review of ports and connections.



Make sure the console power switch and the ROV power switch are in the off position.

1. Make sure tether connection pins and sockets are clean and free of dirt or debris. Using the provided silicone lubricant, apply a small amount around the circumference of the female sockets and across the mating surface. Align the pins and push the connectors together. Secure the locking collar by screwing the halves together.
2. Connect the strain relief from the tether to the Defender with the retaining bolt and test all angles to prove no tension is on the tether connection. See the [Tether](#) section for further information.
3. Replace the float block.
4. Connect the topside male end of the tether to the console's 8-pin tether whip. When not in use, keep the tether connectors protected with caps for the best reliability.
5. With the Expeditionary Splashproof Controller, connect the Fischer cable to the HMI ports of the tablet and console.
6. Connect the keyboard and controller to the console's USB ports.
7. Make any accessory connections (topside GPS, topside USBL beacon) in the console.
8. Connect and plug the console's power cord into a power source.

3. POWER ON TESTS

CAUTION

If the system does not pass any of the following tests, it should not be used until the problem is identified and corrected.

The Defender system includes two circuit safety components:

GFCI (Ground Fault Circuit Interrupter)

LIM (Line Insulation Monitor)

The system also includes a built-in safety interlock that does not allow voltage to travel through the console's 8-pin connection until the tether is mated to and completes a circuit with the Defender.

_TESTING THE GFCI

- Connect the power cord to a recommended power source.
- The GFCI can be found inline in the power cord.
- Press the GFCI Reset button to turn on the GFCI. The green LED should illuminate.
- Press the test switch on the GFCI. The GFCI should interrupt power and the green LED should go out.
- Press the GFCI Reset button to restore power and continue the pre-dive steps.



When using a power source that includes a GFCI, the VideoRay-supplied GFCI is not needed and can be removed from the power cord.

CAUTION

Connecting or disconnecting cables while the system is powered on is NOT recommended.

_POWER ON AND LIM TESTS

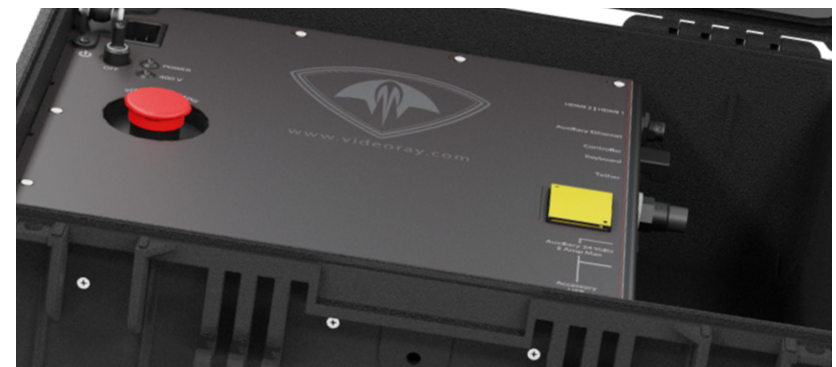
Now that the power source is connected, set the console's power toggle switch to the On position. The green Power On indicator light should turn on. If the green Power On indicator light is not on, make sure the system is connected to a working power source and the GFCI switch is reset.

Next, twist the red Power Mains button clockwise to the On position; the button will pop up and the 400 V Power On indicator light should turn on.

To test the LIM, the Power toggle switch and the Power Mains button must both be on. This test does not have to be conducted before each start, but should be conducted if symptoms of power or communications loss are present. The normal display for the LIM should be '>4 MOhms':

1. The yellow Alarm light should be off. If the yellow light is on, press and hold the Reset button until the yellow Alarm light turns off.
2. To test the LIM, press and hold the Test button until the yellow Alarm light turns on. This may take up to 10 seconds. Release the button when the yellow Alarm light turns on.
3. Press and hold the Reset button to reset the LIM. The yellow Alarm light should turn off. Release the button when the yellow Alarm light turns off.

Confirm power to the Defender by looking for blinking LED indicators on the Power and Communications Modules.



4. FUNCTION TEST

The next step is to ensure that the essential features of the Defender are functioning properly. Use the system controller to perform the following tests. See the [Expeditionary Controller](#) or [Hand Controllers](#) sections for diagrams of functions and more information about using hand controllers.

_OPEN GREENSEA IQ

First, open the system software by clicking on the Greensea icon on the desktop and wait for the software to communicate with the Defender. Video and sonar imagery should be displayed.

_TEST THE THRUSTERS

CAUTION

For the next two steps, make sure people and hands are clear of the thrusters and do not operate the thrusters out of water for more than 30 seconds to avoid overheating and/or premature wear of the seals.

Move the left joystick forward/backward and left/right – the thruster motors should turn the horizontal propellers.

Move the right joystick up/down and left/right - the thruster motors should turn both the horizontal and vertical propellers.



Returning the joysticks/vertical knob to neutral should cease any propeller movement; otherwise ensure all Auto controls are disabled.

_TEST THE LIGHTS

CAUTION

For the next two steps, do not leave the lights on for more than 30 seconds while out of water to avoid overheating. Avoid looking directly into the light beams. Test and confirm both LEDs are functioning properly.

1. Press and hold the Lights On button to increase the intensity of the lights – the lights should get brighter.
2. Press and hold the Lights Off button to dim the lights – the lights should dim.

Turn lights off and confirm off when test is completed.

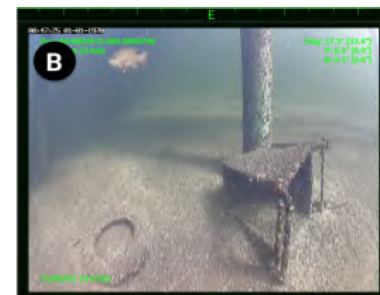
_TEST THE CAMERA

Toggle the Camera Tilt Up and Tilt Down functions, then toggle the Camera Focus In and Focus Out functions. The camera should and tilt smoothly through its entire range and notably focus in and out. These functions only apply to the main camera.

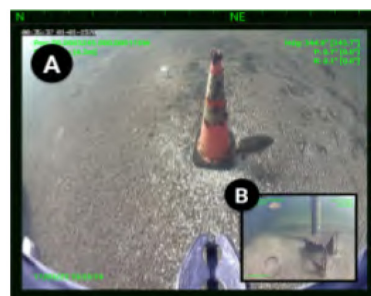
If equipped with an integrated auxiliary camera, tap or right-click on the video display to cycle through video modes. PiP functionality should be viewed during the cycle:



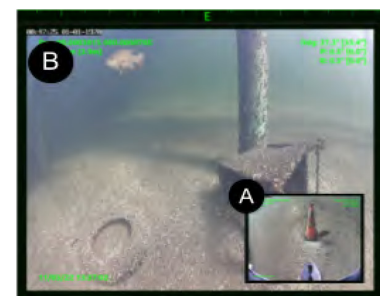
Video A Only



Video B Only



Video A with Video B PiP



Video B with Video A PiP

_TEST THE MANIPULATOR

If equipped, operate the manipulator controls to open/close and rotate its jaw in both directions. The manipulator should operate smoothly through its entire range.



Rotating the manipulator head against/into the ground or other surface will lift up the Defender and may damage the manipulator and/or jaw. Keep the manipulator jaw clear of the ground by turning the Defender on its side or setting it on a platform.

5. LAUNCH THE DEFENDER

The final step is to launch the Defender. Use caution and ensure the deployment is done in a safe and open area of water and accessible as possible. Avoid areas where other people or hazards are in the water. Also ensure that the water depth is sufficient to operate without grounding or thrusting debris through the propellers.

1. Lower the Defender and check the ballast and trim - optimum buoyancy is hovering just at the surface and level trim (pitch/roll). If accessories/sensors have been added or removed from the system, ballast weights will likely have to be added, removed, or moved fore/aft in order to achieve optimum buoyancy.



Buoyancy will need to be adjusted for use in fresh water versus salt water and depending upon whether accessories are added/omitted.

2. Once ballast and trim are adjusted properly, select 'Zero Depth' in the upper left corner above the depth gauge; when a window prompts you, confirm the setting.
3. Enable Auto Controls - Heading, Depth/Altitude (with DVL), Pitch, Roll - to stabilize the Defender and dive slightly under the surface. Return controls to neutral.

You are now ready to start your mission. For your first dives, practice until you are comfortable operating the controls without looking at them and you are able to have control with some precision. While unfamiliar with the Greensea control software, it is recommended to conduct operations in a closed pool or calm area of open water until the operation of the controller and Workspace tools are more familiar.

Developing the skills to operate your Mission Specialist Defender like an expert may take some time. Practicing on a regular basis is highly recommended.



Enabling Auto controls and/or Dynamic Positioning commands the Defender to hold its position in the water. Moving the Defender from this position by either grabbing it or pulling the tether will result in unintended and likely forceful thruster propulsion. Disable all Auto controls and Dynamic Positioning before handling or recovering the Defender.

_POST-DIVE OPERATIONS



At the conclusion of your dive, communication between the pilot and other personnel is critical. Make sure thruster controls are in the neutral position prior to reaching in or around the water near the Defender. Also make sure Auto Controls and Dynamic Positioning have been disabled, or the Defender will attempt to hold a position, depth/altitude, attitude, and/or heading during the recovery, resulting in unexpected propulsion.

1. Disable Auto Pilot controls and Dynamic Positioning (with DVL).
2. When safe to do so, recover the Defender from the water by tether pull method or with a firm grip on the Defender frame.
3. Secure the Defender on a level area where it can't slip or be damaged.
4. If equipped with a quick-release jaw, open the manipulator approximately halfway to allow for jaw removal.
5. Push down on the red Power Mains to power off the Defender.
6. Stop mission video logging and exit Greensea software.
7. Power off the console via the toggle switch.
8. For the Splashproof Controller, power off the tablet.
9. Undo all system connections, inspect, and replace protective caps/covers.
10. Thoroughly rinse and soak the Defender, deployed tether, and subsea accessories using fresh water.



See detailed recommendations for post-dive cleaning and care in the next section.

11. Conduct a thorough post-dive inspection of the system and allow to dry completely before storage.
12. Remember to export or delete telemetry and log files from the 'GSS logs' folder shortcut on the desktop.

_PROPER CARE

Proper maintenance of your VideoRay system ensures a long service life and that it will be ready to operate when you are. After each dive, you should visually inspect the system for damage that might have occurred during your mission.

The most common system post-dive inspection failures are thrusters and propellers. Check thruster tell tales for proper levels and check propellers for extensive wear. Take extra care to thoroughly inspect these components before and after each deployment to ensure the system is capable of performing as expected for the next mission.

Keeping the Defender clean is one of the most important aspects of good preventative maintenance practices, especially after using it in salt water.



Do not rinse system components using a high-pressure water supply or nozzles; typical volume from a hose without a nozzle is sufficient and recommended.

In addition to general soaking/rinsing of the Defender, conduct the following specific tasks to prevent debris, crystallizing, and corrosion from occurring.:

- Remove and rinse the entire float block and underfloat connections/components.
- Rinse and inspect thrusters and propeller/propeller shafts, checking for damage, debris, sea grass, fishing line. Check tell tales for oil depletion and remove propellers to clear debris when necessary.
- Rinse and flush system accessories (DVL/sonar/manipulator).
- Rinse and inspect deployed section of tether.

After completing the above steps, submerge and soak the system in clean fresh water for at least one-half hour. During this time, wipe down the console's inside top panel with a slightly damp cloth and inspect/clean connection ports. Allow to dry before replacing port covers and storing the console.

After thoroughly cleaning and inspecting the system, it should be allowed to air dry thoroughly before storage.

CAUTION

Failure to properly maintain the Defender will dramatically reduce its service life and may void any current warranty.



ACCESSORIES

_OVERVIEW

Numerous accessories can be used with the Defender to extend its capabilities and range of performance. These accessories allow the Mission Specialist systems to support a wide variety of mission profiles.

This section provides an overview of what accessory equipment is available. For up-to-date information, including new accessories and updates, visit <http://www.videoray.com>. For information about installing and using accessories, including operational recommendations, please see the guides provided with each accessory.

_ACCESSORY TYPES

Submerged – devices mounted on the ROV or tether. The level of integration varies from none to tightly coupled use of power, data and control.

Topside – topside components of ROV mounted accessories (such as a computer, software and interface electronics).

Mission Support – for logistics support of operations, such as a generator, tables, awning for shade, etc.

_ACCESSORY CATEGORIES:

- Platform Integration / Autonomy
- Imagery Support and Enhancement
- Intervention
- Propulsion
- Sonar Systems
- Positioning Tracking Systems
- Sensors
- Adapter Modules
- Topside Support
- Tactical Operations Support

_ACCESSORY USE

Multiple accessories can be connected in parallel by the use of a stackable connector. For example, the manipulator and cutter do not use a stackable connector, but can be used with other accessories by plugging in their connector as the last one in sequence.

CAUTION

Accessory ports must be sealed with a terminated connector or an accessory port terminator dummy plug. Failure to seal the accessory port may lead to loss of control of the Defender or damage to components.

_INCLUDED ACCESSORIES

Several topside accessories are included with all Mission Specialist system configurations:

_SUN SHADE

The sun shade can be attached directly to the control panel lid and provides shade for the computer and monitor to make it easier to see the display when working in bright light. See the label on the sun shade for installation instructions.

_TOOL KIT

A basic tool kit is provided in order to perform routine maintenance and field repairs. The tool kit also contains spare parts including ballast weights, propellers and other items.

_MISSION SUPPORT ACCESSORIES

In addition to components that are included with each Defender configuration and commercially available accessories, VideoRay recommends users procure a variety of mission support items. The list of recommended items will vary depending on the typical mission requirements, although it will be obvious that some of these items have general applicability to all mission profiles.

These brief lists are intended to provide a sample of what you may want to add to your operations kit:

_GENERAL LOGISTICAL SUPPORT

Basic operations support items including shade/weather protection, table and chairs, foul weather gear, water, and snacks

Power sources including alternate or backup generators and batteries/inverters

Supplemental video display devices for large group viewing (this can help prevent people from hovering over and distracting the pilot)

Supplemental tools, such as a flashlight, knife, tape, cable ties

Supplemental spare parts for field repairs

_TACTICAL OPERATIONS SUPPORT

Tether weights and davit

Retrieval devices or baskets

Body recovery bag

_SYSTEM ACCESSORIES

The following pages provide specific information about typical accessories that are supported and factory-integrated on the Mission Specialist Defender. Your configuration may or may not include these accessories.

Many other accessories are available for mounting on and integrating with the Defender, to include:

- Mission Specialist Subsea Batteries
- Multifunction Manipulator
- Forward-Looking SONAR
- Scanning SONAR
- Side-Scan SONAR
- Auxiliary Cameras
- GoPro Camera
- CP Probe
- Laser Scaler
- UT Gauge
- Flooded Member Detector
- Cavitation Cleaner
- Water Quality Sonde
- MCM/UXO Disruptors

Visit videoray.com or email sales@videoray.com for more information about available and compatible accessories.

_MANIPULATOR

The manipulator allows the operator to interact with and retrieve objects. The Defender has a retractable manipulator and two tracks that allow it to be extended straight forward or downward at a 30 degree angle. The vehicle pitch control can be used to orient the manipulator at additional angles for optimal ability to grasp an object.



_EDDYFI INUKTUN ROTATING MANIPULATOR

The Mission Specialist Rotating Manipulator has full 360° head rotation and five interchangeable jaws for multiple tasks – anything from untangling tether snags to collecting samples to recovering objects up to 22.6 kg (50 lb). Using the hand controller, you can retrieve items in confined or hazardous locations. The Defender's camera can be tilted down to focus on the jaw to provide a close view of the operation; some models include quick-release removal for easy jaw selection. Refer to the [Manipulator Maintenance](#) section for further information.

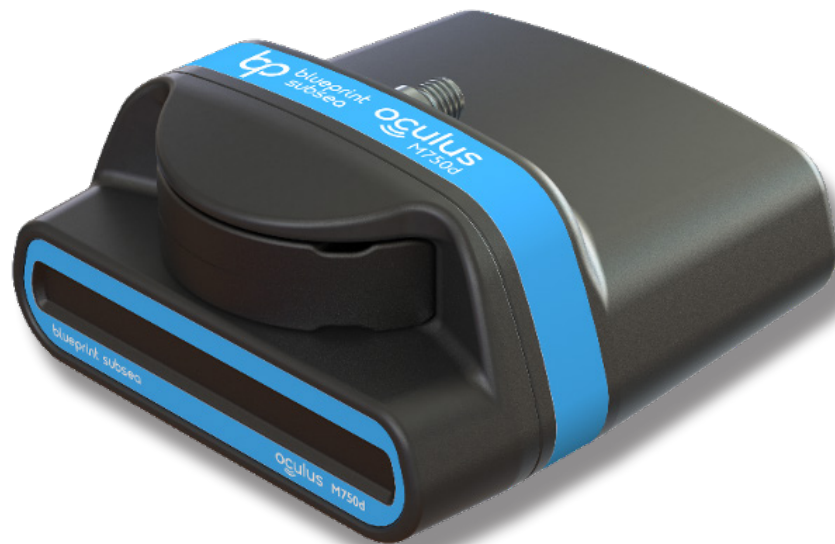


_SONAR

The sonar provides the operator with a forward-looking image of the Defender's surrounding environment even when water visibility is limited. The Defender's auto pitch can be enabled to adjust the sonar viewing angle down or up to improve the sonar imaging quality whether looking for targets on the bottom or the underside of a ship's hull.

_BLUEPRINT SUBSEA OCULUS M750D

The Blueprint Oculus Sonar M750d is a general purpose dual-frequency forward-looking sonar used for navigation and high resolution for near field target identification.



_DVL/GPS NAVIGATION PACKAGE

The DVL (Doppler Velocity Log) is an acoustic device that calculates the vehicle velocity vector by measuring the Doppler shift of its array of four transducers. When combined with the compass, the ROV's direction and position can be calculated.

VideoRay ROV GPS is located on the Defender to determine its position while on the surface.

_NORTEK DVL 500-300M

The Nortek DVL 500-300m DVL provides acoustic tracking of the Defender's velocity vector which can be used as part of a mathematical navigation solution to track its location. This also allows for autonomous dynamic positioning (station keeping and course following).

_ROV GNSS/GPS

The VideoRay ROV GNSS/GPS Receiver is mounted on the Defender and is used to establish the location when it is on the surface. This can be used to "seed" the navigation system with coordinates.



_USBL

The USBL system uses acoustic beacons on the surface and Defender to provide a relative location of the Defender with respect to the surface beacon. This location is described by bearing and distance. GPS can be used to convert this relative location into a precise latitude and longitude.

_SEATRAC

Piloting the Defender to waypoints, tracking the progress and monitoring divers is made simple through Greensea and also through the interactive and customizable displays of the SeaTrac PinPoint software application.



_4K CAMERA

An upgraded primary camera will greatly enhance search, inspection, and identification tasks.

_ULTRA 4K SMART CAMERA

VideoRay's latest release in camera technology combines best-in-class image sensing with NVIDIA's intelligent Orin NX processor. With 12 Megapixel resolution and a 200-degree field of view, customers can see more of their surroundings at a higher resolution than ever before. By providing customers with access to both vehicle telemetry and imaging data through our on-board API we are enabling the next generation of autonomy in a form factor that works across all VideoRay Mission Specialist systems.



The Ultra 4k Smart Camera now comes standard on most Mission Specialist models.



_AUXILIARY CAMERA

An auxiliary camera can be mounted in different locations on the Defender and allows for alternate views of the environment and surroundings.

_ATLANTAS STORM IP

The Storm IP by Atlantis Marine is a fixed-focus underwater HD camera designed to be used on an Ethernet-based ROV with either fiber optic or DSL-type Ethernet link.

The camera outputs an H.264 or MJPEG network video stream at 1080p or 720p. The video stream can then be decoded and viewed using the GreenSea IQ interface.



_SUBSEA BATTERIES

Subsea batteries allow for remote deployments where power isn't available. Power at the submersible also allows for extended mission ranges without concern for voltage loss or large diameter tether.

_MISSION SPECIALIST SUBSEA BATTERIES

Mission Specialist Subsea Batteries deliver power to Defender submersibles without the need for a topside power source. When combined with the lightweight Expeditionary Splashproof Controller and thin copper tether on the Expeditionary Reel, the mission is no longer bound by the location of power outlets.

Mission Specialist Subsea Batteries are the perfect accessory for missions that require a small topside footprint or where topside power is not available.

Depth ratings to 300m or 1km, available in Nickel Metal Hydride or Lithium-Ion.





MAINTENANCE

_MAINTENANCE GUIDE

This section will describe the maintenance requirements and procedures for periodic or common maintenance requirements. It will not be detailed enough to be considered a component level repair manual, but will address component replacement of modular components.

_USER MAINTENANCE POLICY

Users are ultimately responsible for the safe operation and longevity of their VideoRay equipment by minimally following best practices outlined in the Operator's / Maintenance Manual, recognized industry standards and using common sense.

VideoRay strongly recommends that all service and repair of VideoRay equipment owned by users be carried out by VideoRay Certified Technicians at VideoRay Authorized Service Centers. Equipment leased from VideoRay **MUST** be returned to a VideoRay Authorized Service Center for service and repair.

VideoRay also understands that logistics and other issues may make it difficult and costly to return the equipment to a Factory Authorized Service Center for completion of some of the simpler procedures. The following procedures are considered acceptable for the owners and lessees to complete without impact on the warranty. Note that cleaning components is a required condition for continued warranty protection and that failure to exercise reasonable care during these procedures may result in warranty claims being denied.

- Cleaning components
- Lubricating connectors
- Removing and replacing:
 1. Float Block
 2. Skid
 3. Propellers
 4. Thruster Nozzle
 5. Modules in their entirety
 6. Externally Mounted Accessories

Instructions for performing these procedures are generally included in this manual. Users who do not feel comfortable completing these procedures are invited to contact VideoRay Support for assistance.

Opening modules or the control panel may void the warranty.

For users who want to complete service and repair procedures beyond the scope of the above list on their own, VideoRay offers Advanced Maintenance courses and Factory Service manuals for additional fees. These may be valuable for situations where the equipment will be used for mission critical applications or in remote locations. However, the best advice in these situations is to maintain spare equipment on-site for instant resumption of operations in the event of failure.



_PERIODIC MAINTENANCE

Most maintenance tasks and/or repairs are discovered during thorough pre and post-dive inspections.

The following table provides information for periodic inspection and maintenance. All users should follow these guidelines, however, some repair/replacement procedures require advanced training.

| TASK | FREQUENCY | SKILL LEVEL | NOTES |
|-----------------------------|--|----------------------------|--|
| VISUAL INSPECTION | Before and after every dive | All Users | See Pre-Dive Preparations |
| FRESH WATER RINSE | After every dive | All Users | See Proper Care |
| PROPELLER REPLACEMENT | When the propeller blade is cracked, chipped or excessively worn | All Users | See Propeller Replacement |
| FLOAT BLOCK REPLACEMENT | Replace if the outer shell is significantly worn and before the outer shell is worn through to the core material | All Users | Contact VideoRay |
| CAMERA DOME REPLACEMENT | When the dome is scratched or marred within the camera's view or has deep scratches or cracks | Advanced Training Required | Camera dome is factory vacuum sealed, contact VideoRay |
| FRAME COMPONENT REPLACEMENT | If you notice cracks or other signs of damage, you may need to replace that component | Advanced Training Required | Contact VideoRay |

_CONNECTOR CARE

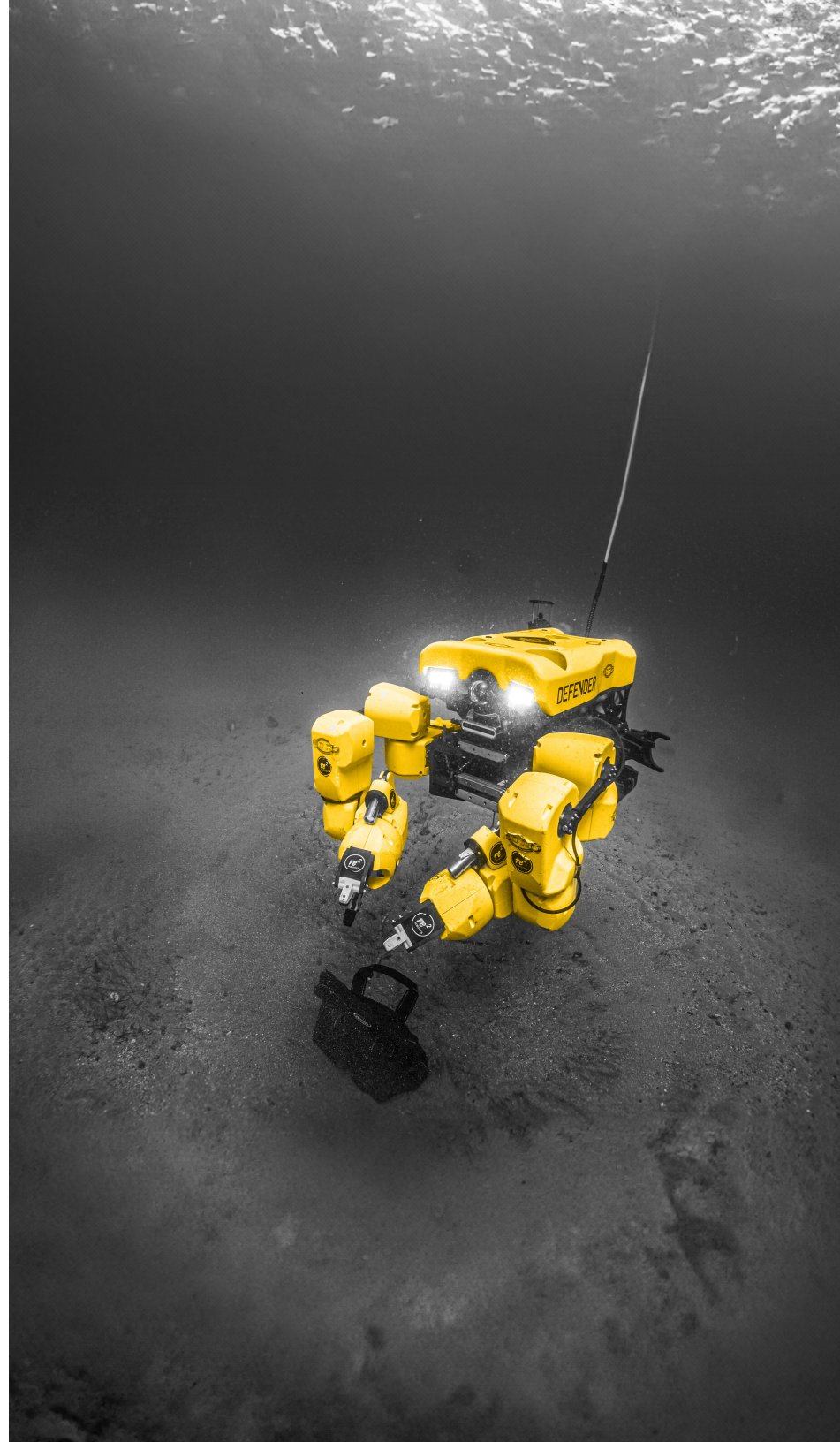
Connectors should be handled with care and inspected and cleaned regularly. Always follow any specific instructions provided by an outside manufacturer for connector care. The following general guidelines are provided to ensure power/communications and help extend the life of the connectors.

- Apply a light coating of silicone lubricant around the sockets and a thin coating on mating surfaces on all subsea connections.
- If too much lubricant has been applied and connection backs away, disconnect/reconnect until fully mated.
- Do not allow dirt or debris to get into the sockets.
- Do not allow the pins to suffer from abrasion.
- Ensure the connector is clean before mating. Do not use an abrasive cleaner.
- Make sure to align pins with sockets carefully to prevent damage while mating.
- Ensure the connection is completely sealed when connected.
- Use connector locking devices when they are supplied for the connector.
- Use the appropriate strain relief if applicable for the connection and make sure the strain relief is connected properly to ensure there is no strain on the connector.
- For subsea connectors, rinse the connector in fresh water any time it has been disconnected from its mate.
- Periodically, disconnect the connectors and inspect each side for corrosion or damage and inspect the sealing surfaces or O-rings.

_TETHER CARE

Tethers should be handled with care and inspected regularly. The following general guidelines are provided to help extend the life of the tethers:

- Do not allow dirt or debris to get into the sockets.
- Do not allow the pins to contact surfaces causing abrasion.
- Make sure the connector is clean before mating. Do not use an abrasive cleaner.
- Apply a light coating of silicone lubricant around the circumference of the sockets and mating surface before connecting to its mate.
- Make sure to align the pins with sockets carefully to prevent damage while mating.
- Make sure the connection is completely sealed when connected.
- Use the connector locking devices.
- Use the appropriate strain relief and make sure the strain relief is connected properly to ensure there is no strain on the connector.
- Rinse the tether connectors in fresh water any time it has been disconnected from its mate.
- Use the tether connector caps to protect the tether connectors when the tether is not in use.
- Inspect tether connectors Periodically for corrosion or damage and inspect the sealing surfaces.
- Do not exceed the maximum tether strength ratings:
 - Performance (PPT) = 635 kg (1,400 lbs)
 - Expeditionary Copper = 170 kg (375 lbs)
 - Hybrid Fiber Optic Tether = 730 kg (1,600 lbs)
 - Fiber Optic Tether = 300 kg (660 lbs)
 - Tether strain relief = 136 kg (300 lbs)
 - Tether connector locking collars = 35 kg (75 lbs)



_MANIPULATOR

When changing manipulator jaw sets or removing the jaw for storing the Defender, have the manipulator near the halfway open point and not in a tightly closed position. If necessary, power up the system to open the manipulator near the halfway open point.

Follow these basic instructions for removing and replacing the manipulator jaw:
For more detailed instructions, refer to the Eddyfi User Manual provided in the jaw set case.

_STEP-BY-STEP PROCEDURES

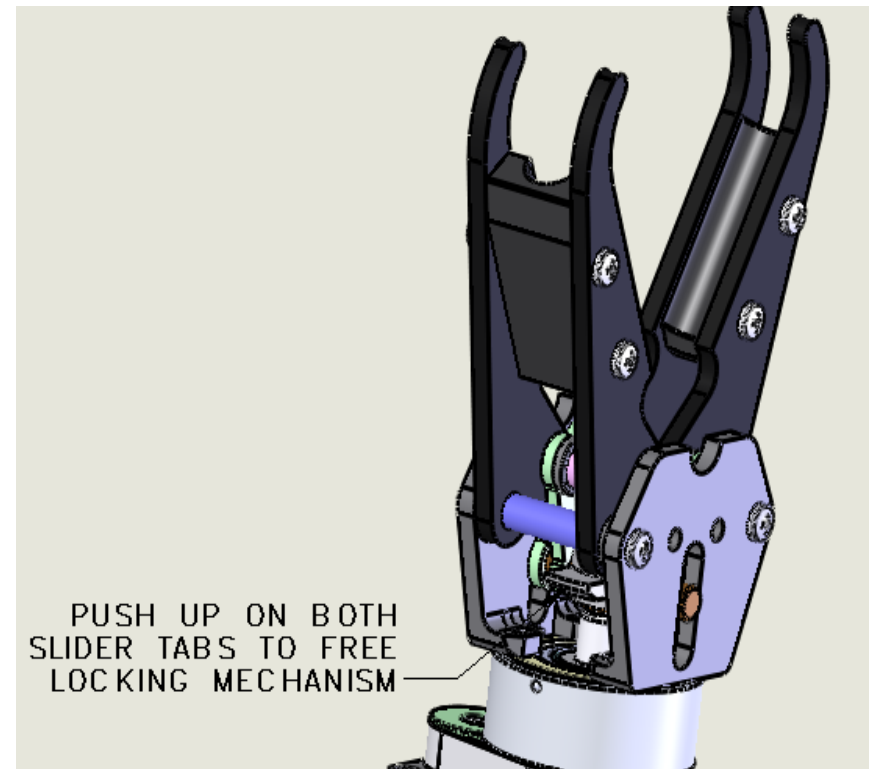
1. With the system powered off and/or persons clear of the controller, place the Defender on a smooth and stable surface either on its side or upside down.
2. Push up all the way on both slider tabs to release quick connect mechanism and open the jaws completely.
3. When looking toward the jaw, lights, and front of the Defender, the knurled nut turns clockwise to loosen. Unscrew until nut is free.
4. Lightly pull up on the jaw until it lifts off the drive unit. Remove the jaw assembly from the drive unit by gently sliding it off the actuator shaft.
5. Perform the steps in reverse order attach a jaw. Make sure to align the slots in the base with the dogs in the jaw's inner sleeve..



Do not lubricate the o-ring or drive belt.

_CLEANING

In order to ensure the Manipulator functions well, it should always be thoroughly cleaned after every use. Always use fresh water at standard line pressure (700kPa/100psi max). Always make sure to drain any water from the bellows port (small hole) on the front of the housing. Failure to clean properly could result in premature corrosion of components.



2.



3.



4.

_COMPASS CALIBRATION

Most times, holding and 'flying' the Defender in figure-8 and spherical patterns while the system is powered on will calibrate and correct compass error.

For the best navigation performance, the compass should be calibrated in the following situations:

- When the system is first received if the compass does not appear to be accurate.
- When using the system in a remote location where it has not been used before if the compass does not appear to be accurate.
- Whenever the compass does not appear to be accurate.



The compass will be affected by iron or magnetic sources, such as ship's hulls or sheet piling or other natural deposits. Calibrating the compass will not correct for these anomalies.

_STEP-BY-STEP PROCEDURES

Magnetic Field Mapper software must be installed on the Workhorse Control Console or tablet. If the Magnetic Field Mapper software is not installed, It can be downloaded at:

https://videoray.exavault.com/files/quarterdeck/xsens/mag_mapper.tgz

The user name is quarterdeck and the password is quarterdeck (use all lower case). After logging in, navigate to the xsens/folder and download mag_mapper.tgz

The AHRS firmware must be updated to attitude_sensor-1.4.4.hex or higher. If the firmware is not up-to-date, see: Command: vr_refresh and its following page for more information about updating the firmware.

1. Connect the system as normal and power on Console toggle switch, tablet, and the ROV mains.
2. If Greensea Workspace has been started since turning on the Console or tablet:

- a. Open a terminal window.
 - b. Enter the following command: killall_vr.sh
 - c. Press the Enter key
 - d. Close the terminal window.
3. Unplug all USB devices from the console except the keyboard / mouse.
 4. Make sure vehicle has been powered on for at least 10 seconds.
 5. Move the vehicle to a magnetically "clean" area at least 20 feet from any car or truck, not near concrete (which may contain rebar), away from steel structures etc.



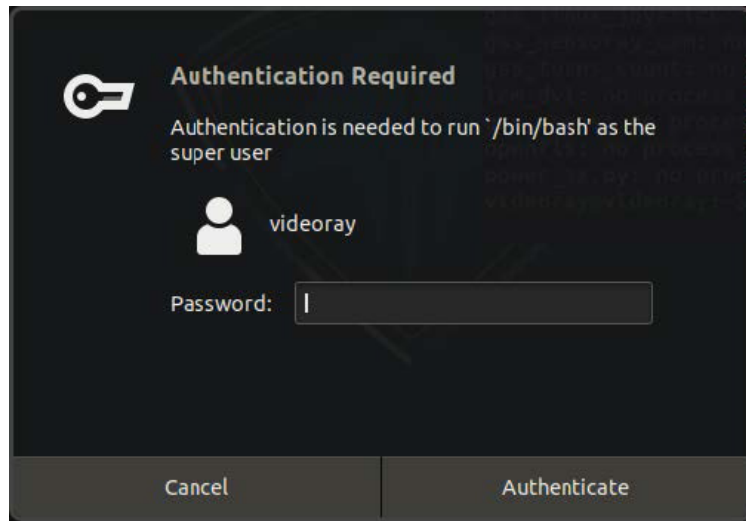
The ROV must be separated as far as possible from iron or magnetic sources during the calibration process for best results.

6. Start the Magnetic Field Mapper software by double clicking on the Magnetic Field Mapper icon on the desktop.

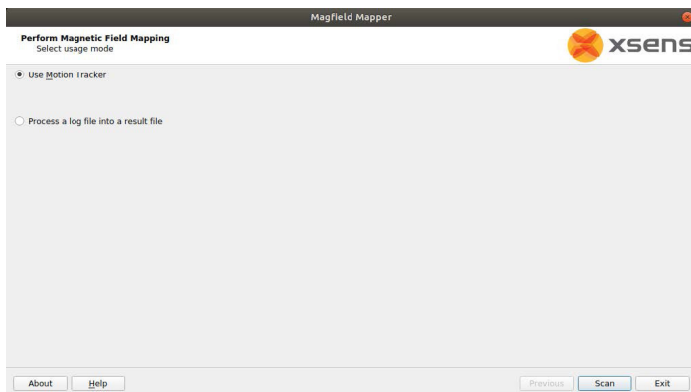


7. When asked if you trust this application and want to Launch it, click on the Yes button.

8. When asked for the password, enter videoray and click on the Authenticate button (use all lower case).



9. When the Magnetic Field Mapper software starts, make sure the Use Motion Tracker option selected and click on the Next and then the Scan buttons.



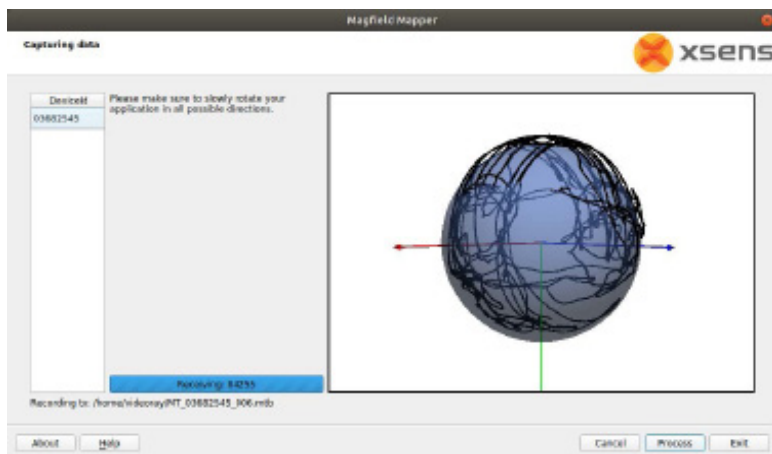
10. Wait up to 30 seconds for the Magnetic Field Mapper software to find the AHRS Module. If the software reports that it does not find any devices, close the software and restart it and repeat these steps.
11. When the Magnetic Field Mapper software finds the AHRS, which will be listed by a unique ID number, ensure the checkbox in front of the number is checked and click on the Next button.



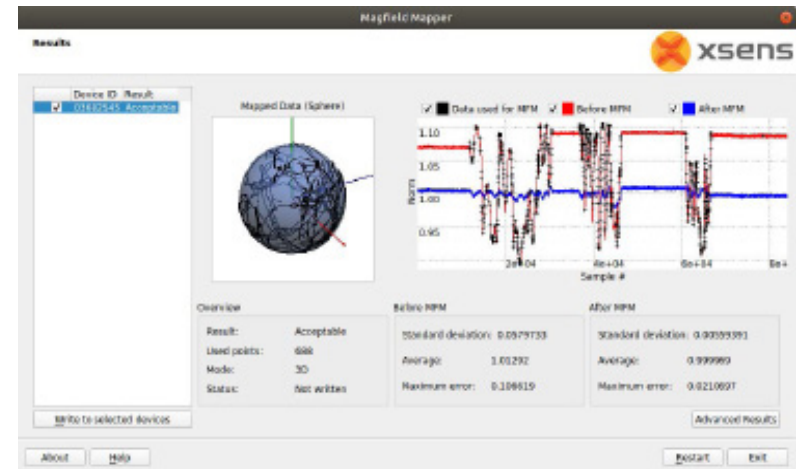
12. The Capturing Data screen will appear with a graphic display of three axes and a sphere.
13. The vehicle must be rotated slowly 360 degrees about all axes. As you rotate, the sphere will update with areas that are mapped. The goal is to cover as much of the sphere as possible.
 - a. Start by holding the ROV flat and spin around in a circle to rotate about the ROV's vertical axis.
 - b. Hold the ROV upside down and spin around in a circle to rotate about the ROV's inverted vertical axis.
 - c. Hold the ROV with its port (left) side up and spin around in a circle to rotate about the ROV's pitch axis.
 - d. Hold the ROV with its starboard (right) side up and spin around in a circle to rotate about the ROV's inverted pitch axis.

- e. Hold the ROV nose up and spin around in a circle to rotate about the ROV's roll axis.
- f. Hold the ROV nose down and spin around in a circle to rotate about the ROV's inverted roll axis.
- g. The sphere should show six circles, one on each side roughly centered about each axis.
- h. Repeat the above steps, but angle the ROV 45 degrees relative to two axes in each case. An example would be holding the ROV flat, and then tipping the front down 45 degrees and at the same time the left down 45 degrees for the rotation.
- i. This should result in additional circles which should more completely cover the sphere. The sphere does not have to be completely covered, but there should not be any large gaps in the coverage.

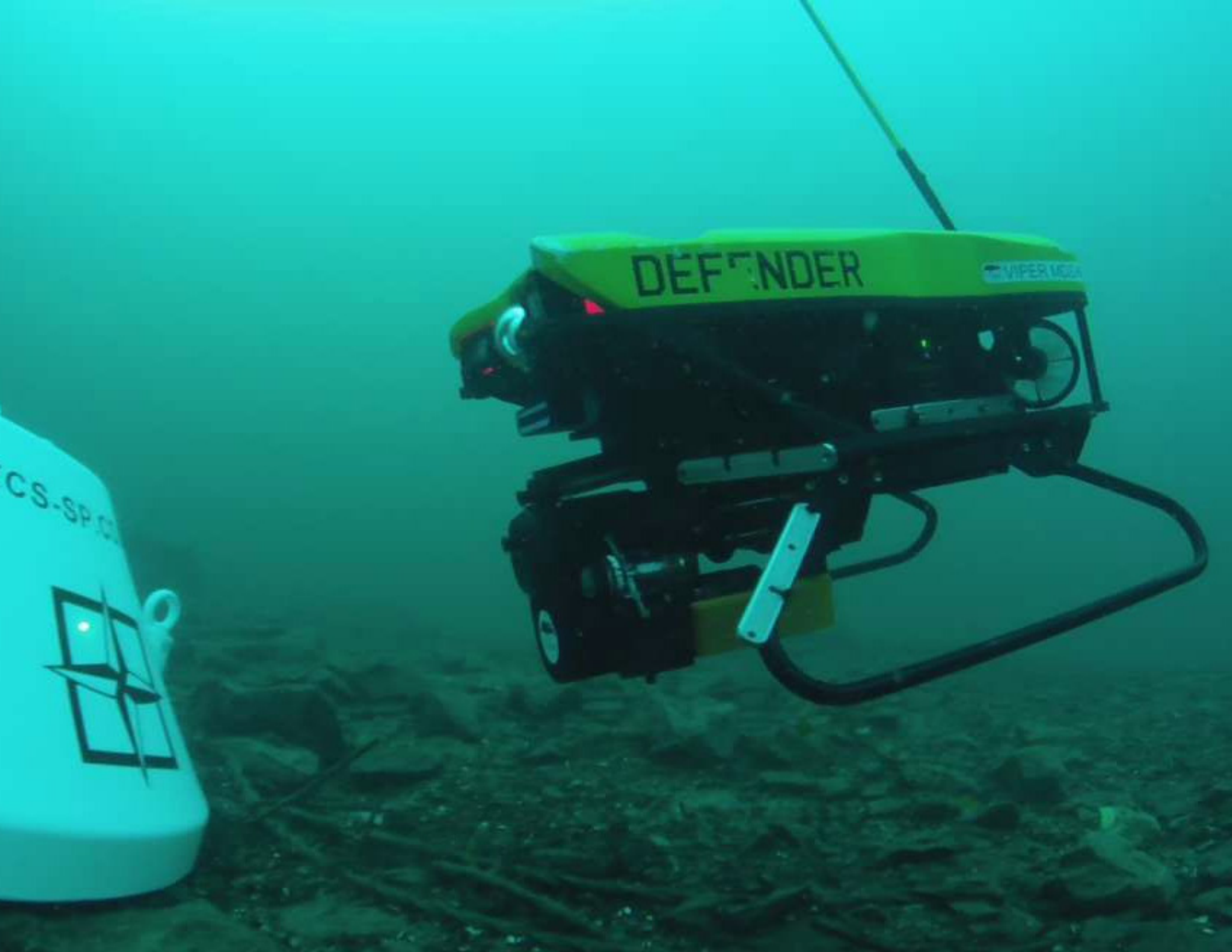
14. After completing the rotations to cover as much of the sphere as possible click on the Process button.



15. The display will update with a before (red) and after (blue) graph. The red graph will likely have sections with a lot of variation and be offset from 1.0. The blue graph should have much less variation and average value close to 1.0.



16. Click the Write to selected devices button.
17. Click the Exit button to close the Magnetic Field Mapper software.
18. Turn off the ROV power, wait 10 seconds and then turn the ROV power on again.
19. The compass calibration is complete and the ROV is ready to use.



_MODULE REPLACEMENT & CONFIGURATION

_POWER MODULE REPLACEMENT

Replacing a Power Module requires hardware replacement. The Power Module will be pre-configured when delivered, so there is no need for software configuration procedures.

_HARDWARE REPLACEMENT

To remove and replace a Power Module, follow these steps:

1. Power down and disconnect the system.
2. Remove the top float block by removing the four screws holding the float block to the frame.
3. The DVL will need to be removed in order to remove the Power Module.
4. For the Power Module to be replaced, disconnect the thruster and LED light connector stack from the top of the Power Module.
5. Using a Phillips head screwdriver, remove the 4 screws that hold the Power Module to the frame.
6. Remove the damaged Power Module from the vehicle, being careful to thread the remaining connected cables through the frame.
7. Remove the cables from the old Power Module and install them in the same locations on the replacement Power Module.
8. Thread the cables through the frame the way they were routed on the old Power Module.
9. Mount the replacement Power Module in the frame and secure it using the Phillips head screws removed earlier. Do not over tighten these screws.
10. Reinstall the thruster and LED light connector stack into the top connector on the Power Module.
11. Replace the DVL.
12. Replace the float block using the screws removed earlier.

_COMMUNICATIONS MODULE REPLACEMENT

Replacing a Communications Module requires hardware replacement. The Communications Module will be pre-configured when delivered, so there is no need for software configuration procedures.

_HARDWARE REPLACEMENT

To remove and replace a Communications Module, follow these steps:

1. Power down and disconnect the system.
2. Remove the float block from the frame.
3. The DVL will need to be removed in order to remove the Communications Module.
4. Remove the Communications Module male connector cable from the front of the Power Module.
5. For the Communications Module to be replaced, note the modules connected and order of the module cables connected to the top of the Communications Module and remove these cables.
6. Using a Phillips head screwdriver, remove the 4 screws that hold the Communications Module to the frame.
7. Remove the damaged Communications Module from the vehicle, being careful to thread the remaining connected cables through the frame. You may need to remove one or both of the Module cables. If so, note the modules connected and locations where the cables are connected to the Communications Module.
8. Thread the cable for the Power Module through the frame the way it was routed on the old Communications Module and connect it to the Power Module.
9. Mount the replacement Communications Module in the frame and secure it using the Phillips head screws removed earlier. Do not over-tighten these screws.
10. Reinstall the module cables on the Communications Module using the same port locations as the cables were originally installed.
11. Replace the DVL.
12. Replace the float block using the screws removed earlier.

_AHRS REPLACEMENT

Replacing an AHRS requires hardware replacement. The AHRS will be pre-configured when delivered, so there is no need for software configuration procedures.

_HARDWARE REPLACEMENT

To remove and replace an AHRS Module, follow these steps:

1. Power down and disconnect the system.
2. Remove the top float block by removing the four screws holding the float block to the frame.
3. For the AHRS to be replaced, follow the AHRS cable to the Communications Module and remove it, noting its location.
4. Carefully thread the disconnected cable and connector back through the frame until it is clear.
5. Using a Phillips head screw driver, remove the 2 screws that hold the AHRS to the frame.
6. Remove the damaged AHRS from the vehicle.
7. Mount the replacement AHRS on the frame and secure it using the Phillips head screws removed earlier.
8. Thread the cable and connector through the same routing as the old AHRS. Connect the cable to the same location on the Communications Module as before.
9. Replace the float block using the screws removed earlier.

_CAMERA REPLACEMENT

Replacing a Camera requires hardware replacement. The Camera will be pre-configured when delivered, so there is no need for software configuration procedures.

_HARDWARE REPLACEMENT

To remove and replace a Camera Module, follow these steps:

1. Power down and disconnect the system.
2. Remove the top float block by removing the four screws holding the float block to the frame.
3. For the Camera to be replaced, follow the Camera cable to the Communications Module and remove it, noting its location.
4. Carefully thread the disconnected cable and connector back through the frame until it is clear.
5. Using a Phillips head screw driver, loosen the 4 screws (2 in each bracket) that hold the Camera to the frame.
6. Slide the camera out of the brackets from the front of the vehicle.
7. Slide the replacement Camera cable and then the replacement camera into the brackets and make sure it is level with the tilt gear on the right (when viewed from the front of the camera) and secure it using the Phillips head screws loosened earlier. Tighten the screws evenly and do not over tighten the screws.
8. Thread the cable and connector through the same routing as the old Camera. Connect the cable to the same location on the Communications Module as before.
9. Replace the float block using the screws removed earlier.

_THRUSTER REPLACEMENT

Replacing a thruster requires both hardware replacement and software configuration procedures. Each thruster must be configured for its specific location on the vehicle.

_HARDWARE REPLACEMENT

To remove and replace a thruster, follow these steps:

1. Power down the system.
2. Remove the top float block by removing the four screws holding the float block to the frame.
3. Note the position of the thruster being replaced in the vehicle frame. The position of the thruster being replaced will determine the propeller orientation and configuration parameters to be programmed into the replacement.
4. For the thruster to be replaced, follow the thruster cable to the main thruster/LED connector stack (located under the main float block) and disconnect the damaged thruster from the stack.
5. Carefully thread the disconnected cable and connector back through the frame until it is clear.
6. Using the 5mm hex driver, remove the two (2) M6 plastic thruster bolts securing the thruster to the frame.
7. Remove the damaged thruster from the vehicle. If the propeller is still in good condition, remove it from the damaged thruster using the prop tool and the 7/16" nut driver.
8. Install a new correct orientation propeller (or the recovered propeller) on the replacement thruster.
9. Note the serial number for the replacement thruster. This number will be used to identify and program the replacement thruster once installed in the vehicle.
10. Install the replacement thruster in the same location as the one being replaced, and thread the cable and connector through the same routing as the old thruster. Connect the cable to the same location in the connector stack as before.
11. Mount the thruster to the frame using the M6 nylon bolts, and the 5mm hex driver.

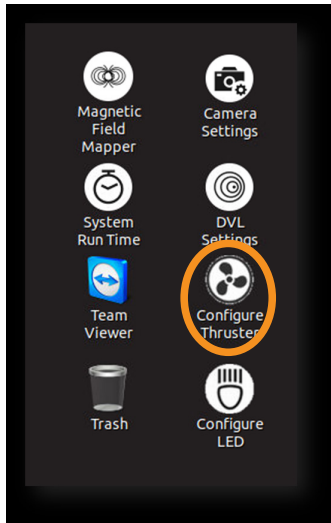


To avoid shearing the nylon bolts; do NOT over-tighten. Apply moderate torque using your fingertips on the driver handle until snug.

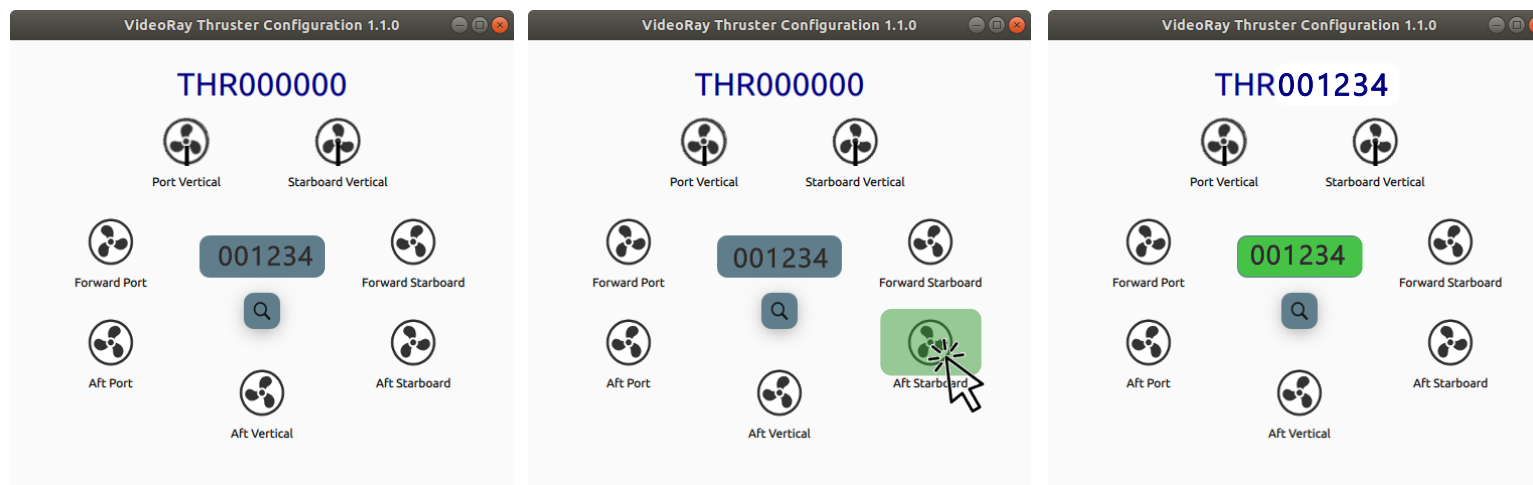
12. Replace the float block using the screws removed earlier.

_THRUSTER CONFIGURATION

To program a newly-installed thruster module using the desktop tool, locate the Configure Thruster icon on the Desktop.



Double-click to open the program. In the central input field, enter the Serial Number (exclude 'THR') of the new thruster. Next, select the icon that specifies the new thruster's location. The central input field will then turn green, indicating that the programming was successful.



_PROPELLER REPLACEMENT

Propellers are considered wear items and should be inspected before every dive during the Pre-Dive Setup procedures. Failed propellers can cause control and navigation issues, including total loss of the Defender, and should be evaluated during the Pre-Dive Setup or whenever control issues are noted. Operators should learn to recognize the symptoms of a fouled or ineffective propeller, including the inability to navigate straight forward or dive/surface as expected.

_PROPELLER REPLACEMENT GUIDELINES

Propeller replacement can be based on a rigid pass/fail criteria, such as when a propeller blade breaks off and is missing, in which case the propeller should be replaced immediately, or based on a risk assessment when the propeller has mild to moderate wear. Such a risk assessment should consider the importance and urgency of the mission. If the mission is critical, deep, or difficult to retrieve the Defender in the event of a control failure due to the loss of a propeller, such as operating in a confined space, a propeller that exhibits even mild wear should be replaced. If the mission is brief, shallow, or there is no risk or difficulty in retrieving the Defender by its tether, then even moderately worn propellers can remain in service.

Propellers should be replaced if any of the following conditions are observed:

1. Any propeller that results in poor vehicle performance or control.
2. Any propeller that is missing one or more blades.
3. Any propeller that has a crack along the axis of its hub.



This type of failure may not be as obvious as others, but it can significantly impact vehicle control. You may need to apply light pressure the propeller blades to expand the crack to make it more visible.

4. Any propeller with a crack that exceeds $\frac{1}{3}$ of the dimension of the blade in the direction of the crack.
5. Any propeller with a chip or chips when the total width of the chip(s) exceeds $\frac{1}{3}$ of the dimension of the blade in depth into the blade or length along the blade's edge.

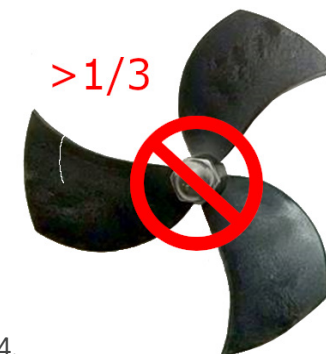
_GENERALLY ACCEPTABLE PROPELLER WEAR

Generally, any propeller that has a ragged edge can be used as long as it does not affect vehicle performance or control. Loose pieces or pieces bent out of the plane of the propeller should be removed using sandpaper or a file.

2.



3.



4.



5.

_PROPELLER REPLACEMENT PROCEDURES

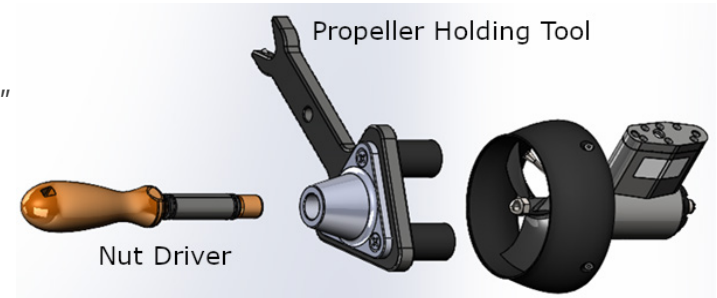
Propellers are connected to the thruster shaft using a drill chuck-like collet that has a fluted tapered core that compresses on the shaft when the propeller nut is tightened. Propeller shafts can be bent or broken if lateral force is applied to the propeller while removing it. Using the propeller holding tool can prevent accidental lateral force from being applied to the shaft during the removal and replacement procedures.

_PROPELLER REMOVAL

To remove a propeller, loosen, but do not remove the nut using the propeller holding tool and 7/16" nut driver. The collet should then be free to slip out of the hub, open and release from the shaft. The propeller can then be pulled off the shaft.

In some cases, the collect can remain stuck in the hub, which prevents the collet from releasing from the shaft. If the collet is stuck on the shaft, these methods might help to free it:

- Loosen, but do not remove the nut. Pull the propeller toward you while repeatedly applying a sharp quick rap to the tip of the nut using a hard tool. This should pop the hub off the collet and free it from the shaft.
- If the above method does not work, use the collet removal tool provided in the tool kit. Remove the propeller nut completely and thread the collar onto the collet. Use a 5mm Allen driver to turn the collet puller screw clockwise, which should pull the propeller off the collet.



_PROPELLER REPLACEMENT

Some thrusters are counter-rotating and the correct propeller pitch for that thruster's location must be installed. See the Thruster Arrangement configuration table in the [Specifications](#) section for the correct propeller type selection for each thruster.

Left-hand propellers can be identified as follows:

- The top blade has the leading edge on the left when viewed from the end with the nut.
- The blades appear to curve clockwise when viewed from the end with the nut.
- Left hand propellers have hub that is all plastic.

Right-hand propellers can be identified as follows:

- The top blade has the leading edge on the right when viewed from the end with the nut.
- The blades appear to curve counterclockwise when viewed from the end with the nut.
- Right hand propellers have a stainless steel collar on the hub at the shaft end.



LEFT

RIGHT

After selecting the correct propeller pitch for its installed location, loosen but do not remove the propeller nut and install the propeller on the thruster shaft until it is seated completely. Using the propeller holding tool and 7/16" nut driver, tighten the propeller nut. The nut should be tightened firmly to prevent it from slipping off during operations.

_LED REPLACEMENT

Replacing an LED requires both hardware replacement and software configuration procedures. Each LED must be configured for its specific location on the vehicle.

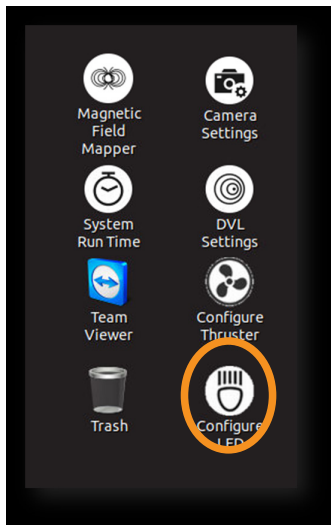
_HARDWARE REPLACEMENT

To remove and replace an LED Light, follow these steps:

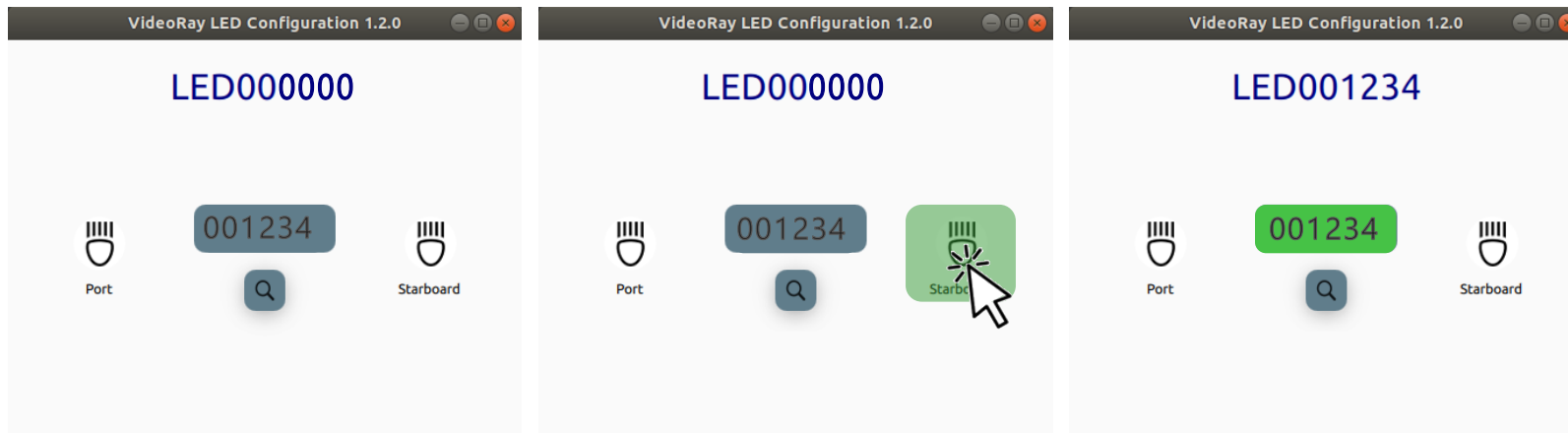
1. Power down the system.
2. Remove the top float block by removing the four screws holding the float block to the frame.
3. Note the position of the LED being replaced in the vehicle frame. The position of the LED being replaced will determine the configuration parameters to be programmed into the replacement.
4. For the LED to be replaced, follow the LED cable to the main thruster / LED connector stack (located under the main float block) and disconnect the damaged LED from the stack.
5. Carefully thread the disconnected cable and connector back through the frame until it is clear.
6. Using a Phillips head screw driver, remove the 4 screws that hold the LED module to the tilting / pivoting bracket.
7. Remove the damaged LED from the vehicle.
8. Note the serial number for the replacement LED. This number will be used to identify and program the replacement LED once installed in the vehicle.
9. Mount the LED in the tilting / pivoting bracket and secure it using the Phillips head screws removed earlier.
10. Thread the cable and connector through the same routing as the old LED. Connect the cable to the same location in the connector stack as before.
11. Replace the float block using the screws removed earlier.

_LED CONFIGURATION

To program a newly-installed LED module using the desktop tool, locate the Configure LED icon on the Desktop.



Double-click to open the program. In the central input field, enter the Serial Number (exclude 'LED') of the new LED. Next, select the icon that specifies the new LED's location. The central input field will then turn green, indicating that the programming was successful.







SPECIFICATIONS

_POWER MODULE

The VideoRay Mission Specialist Ally Power Module receives power from the topside or subsea batteries and converts it to power levels required by the various modules, sensors and accessories.

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 18 cm x 13 cm x 4 cm (7.1 inches x 5.1 inches x 1.6 inches)

Weight in Air: 1.14 kg (2.5 pounds)

Weight in Water: 0.55 kg (1.2 pounds)

[CONNECTIONS]

8-Pin Connector (Tether)

9-Pin Socket Connector (Communications)

5-Pin Socket Connectors (Thrusters and LEDs) 2X

[POWER INPUT]

Input Voltage Range: 200 – 420 V DC

[POWER OUTPUT]

48V: 1500 W

24V: 300 W

12V: 120 W

| PIN | FUNCTION | WIRE | AWG | COLOR |
|-----|-----------|------|-----|-------|
| 1 | 48 V DC + | 20 | | Red |
| 2 | GND | 22 | | Green |
| 3 | 48 V DC - | 20 | | Black |
| 4 | RS-485 A | 24 | | Gray |
| 5 | RS-485 B | 24 | | White |



| PIN | FUNCTION |
|-----|-------------------|
| 1 | Interlock (GND) |
| 2 | Interlock (Sense) |
| 3 | Tether V+ |
| 4 | M100 EOP+ |
| 5 | Tether V- |
| 6 | M100 EOP- |
| 7 | RS-485 A |
| 8 | RS-485 B |

| PIN | FUNCTION |
|-----|-----------|
| 1 | NC |
| 2 | NC |
| 3 | 24 V DC + |
| 4 | M100 EOP+ |
| 5 | GND |
| 6 | M100 EOP- |
| 7 | RS-485 A |
| 8 | RS-485 B |
| 9 | 12 V DC + |

_COMMUNICATIONS MODULE

The communications module is the “brains” of the vehicle and coordinates vehicle control systems and provides data paths for sensors and accessories. Power is rated at 300 Watts for the 24 Volt circuit and 120 Watts for the 12 Volt circuit. This is the total output of the internal DC/DC converters and is divided across all connections as demanded by each externally connected device. Each connector pin is rated to 5 Amps, which should not be exceeded.

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 25.5 cm x 15.2 cm x 5.3 cm
(6.12 inches x 6.0 inches x 2.1 inches) not including cable

Weight in Air: 1.19 kg (2.6 pounds), Weight in Water: 0.55 kg (1.2 pounds)

[CONNECTIONS]

9-Pin Connector (Upstream, Port 1)

9-Pin Socket Connectors (Ports 2 – 6) 5X

[POWER INPUT]

24V: 300 W, 12V: 120 W

[POWER OUTPUT]

24V: 300 W, 12V: 120 W

[COMMUNICATIONS]

Ethernet, RS-485

[SENSOR FEEDBACK]

Current Monitoring, Voltage Monitoring



| PORT | MODULE/DEVICE ASSIGNMENT | TCP PORT | BAUD RATE NOTE |
|------|--------------------------|----------------|----------------|
| 1 | Power | 7444 (vrport1) | 115200 |
| N/A | Communications Module | 7444 (vrport1) | 115200 |
| 2 | AHRS | 7445 | |
| 3 | Camera | 7446 | |
| 4 | Oculus Sonar | 7447 | |
| 5 | Nortek DVL | 7448 | |
| 6 | Manipulator, GPS | 7449 | 38400 |

| PIN | PLUG CONNECTOR (PORT 1) | SOCKET CONNECTORS (PORTS 2-6) |
|-----|-------------------------|-------------------------------|
| 1 | NC | ETH_RXP + |
| 2 | NC | ETH_RXP - |
| 3 | 24 V DC + | 24 V DC + |
| 4 | M100 EOP+ | ETH_TXP + |
| 5 | GND | GND |
| 6 | M100 EOP- | ETH_TXP - |
| 7 | RS-485 A | RS-485 A |
| 8 | RS-485 B | RS-485 B |
| 9 | 12 V DC + | 12 V DC + |

_AHRS MODULE

AHRS - Attitude & Heading Reference System, is also sometimes referred to as an Inertial Measurement Unit, or IMU. It provides feedback on the vehicle's orientation. Measurements include magnetic heading, attitude and rates of change. The AHRS also includes a pressure sensor to determine the depth of the vehicle.

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 17.8 cm x 7 cm x 5.4 cm (7.0 inches x 2.75 inches x 2.12 inches)
Weight in Air: 0.55 kg (1.2 pounds), Weight in Water: 0.21 kg (0.46 pounds)

[CONNECTIONS]

9-Pin Connector

[POWER INPUT]

12 VDC

[POWER OUTPUT]

24V: 300 W, 12V: 120 W

[COMMUNICATIONS]

Ethernet, RS-485

[SENSOR FEEDBACK]

9 DOF IMU
Magnetic compass
Pressure-Based Depth Sensor (100 Bar, with 400 Bar optional)

[INCREMENTAL DOF]

0.2 degree Static Roll/Pitch
0.5 degree Dynamic Roll/Pitch
1.0 degree Yaw
18 degree/h Gyro Bias Stability



The AHRS compass may require a Magnetic Field Calibration. See the [Compass Calibration](#) section for more information and instructions on calibration.

| PIN | FUNCTION |
|-----|-----------|
| 1 | ETH_RXP + |
| 2 | ETH_RXP - |
| 3 | 24 V DC + |
| 4 | ETH_TXP + |
| 5 | GND |
| 6 | ETH_TXP - |
| 7 | RS-485 A |
| 8 | RS-485 B |
| 9 | 12 V DC + |

_ULTRA 4K SMART CAMERA

[DEPTH RATING]

2,000 meters (6,562 feet)

[MECHANICAL]

Dimensions: 15.4 × 7.6 cm OD (6.1 × 3.0 in)

Weight in Air: 0.885 kg (1.9 lbs)

Weight in Water: 0.523 kg (1.2 lbs)

[CONNECTIONS]

9-Pin Subconn

[POWER INPUT]

35-12 VDC; power consumption: 15 W

[COMMUNICATIONS]

RTSP over Ethernet

[SENSOR FEEDBACK]

Displays in Greensea UI at 1620 × 1080 @ 25fps

Real-Time color correction

Internal pressure/temperature readouts

Zoom window/pan position

[OPTICAL]

12.33mp, 4056 (V) × 3040 (H) pixels (max)

Field of View: 180 Degrees H, 150 Degrees V

Digital Pan/Tilt/Zoom

[FEATURES]

Manual video balance adjustments

4056 × 3040 snapshot support through Greensea UI

4056 × 3040 video stream topside

Gray Level Grouping image enhancement

Displays in Greensea UI at 1620 × 1080 @ 25fps



| PIN | FUNCTION |
|-----|-----------|
| 1 | ETH_RXP + |
| 2 | ETH_RXP - |
| 3 | 24 V DC + |
| 4 | ETH_TXP + |
| 5 | GND |
| 6 | ETH_TXP - |
| 7 | RS-485 A |
| 8 | RS-485 B |
| 9 | 12 V DC + |

_CAMERA MODULE (LEGACY)

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 15.4 × 8 cm OD (6.1 × 3.1 in)

Weight in air: 0.66 kg (1.45 lbs)

Weight in water: 0.9 kg (2.0 lbs)

[CONNECTIONS]

9-Pin Subconn

[POWER INPUT]

12 VDC; power consumption: 57 W

[COMMUNICATIONS]

Ethernet, RS485

[SENSOR FEEDBACK]

Internal pressure/vacuum integrity

Internal humidity

Internal temperature

Tilt position

[OPTICAL]

Mechanical internal tilt: 85 degrees

Horizontal Field of View: 80 degrees

[FEATURES]

Optical BK7 glass dome

Auto focus

White balance control

16x digital zoom

13.19 megapixel still capture

_THRUSTER MODULE

Mission Specialist vehicles use a modular thruster configuration that allows vehicle designs to be optimized for water conditions and payload delivery requirements. Modular thrusters are also easy to replace in the field.

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 13.2 cm x 12.2 cm x 11.8 cm
(5.19 inches x 4.80 inches x 4.64 inches) not including cable

Weight in air: 0.65 kg (1.4 pounds), Weight in water: 0.33 kg (0.73 pounds)

[CONNECTIONS]

5-Pin Pin/Socket stackable connector

[POWER INPUT]

48 VDC at 750-Watt max input

[COMMUNICATIONS]

RS-485 galvanically isolated control

[SENSOR FEEDBACK]

Input Current Total

Input Voltage

RPM

Internal temperature

[FEATURES]

Oil-filled, direct-drive brushless motor

90mm diameter 3-blade propeller

Quick connect/release collet

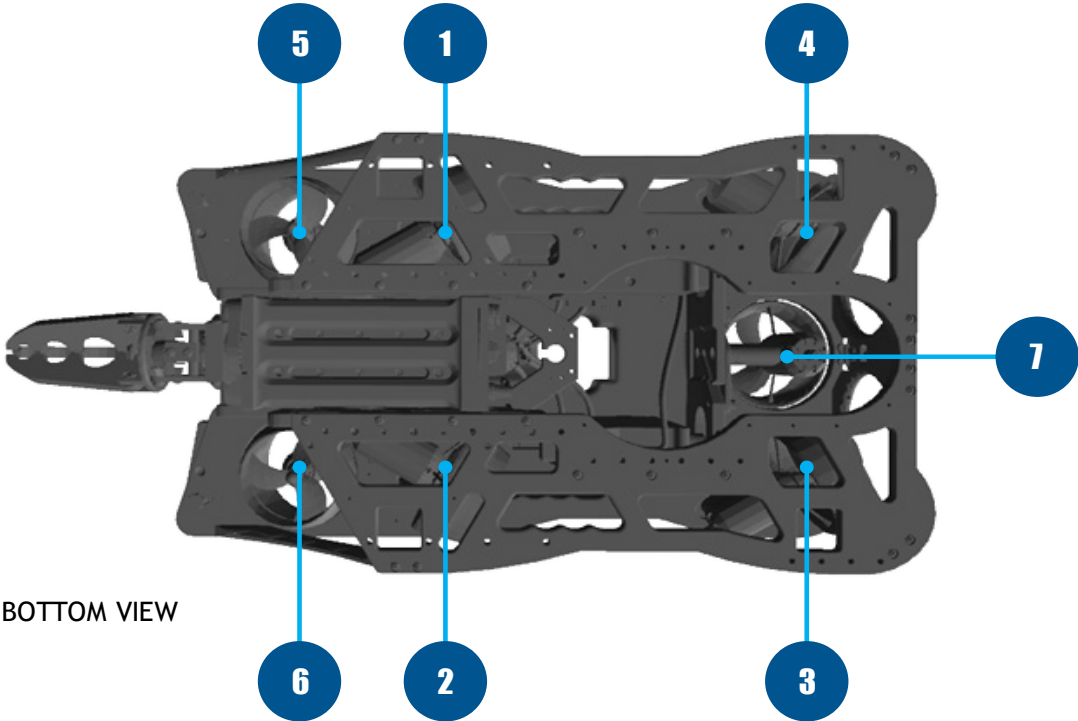


| PIN | FUNCTION | WIRE | AWG | COLOR |
|-----|-----------|------|-----|-------|
| 1 | 48 V DC + | 20 | | Red |
| 2 | GND | 22 | | Green |
| 3 | 48 V DC - | 20 | | Black |
| 4 | RS-485 A | 24 | | Gray |
| 5 | RS-485 B | 24 | | White |

[THRUSTER ARRANGEMENT]

The Defender ROV uses a vectored horizontal four-thruster arrangement and three vertical thrusters. The thrusters are configured as shown below:

| | THRUSTER LOCATION | GROUP ID | NODE ID | MOTOR ID | PROP ORIENTATION | REVERSE OPTION | POWER (WATTS) |
|---|----------------------------|----------|---------|----------|------------------|----------------|---------------|
| 1 | FORWARD PORT | 129 | 5 | 0 | Right | Disable | 400 |
| 2 | FORWARD STARBOARD | 129 | 6 | 1 | Left | Enable | 400 |
| 3 | AFT STARBOARD | 129 | 7 | 2 | Right | Disable | 400 |
| 4 | AFT PORT | 129 | 8 | 3 | Left | Enable | 400 |
| 5 | VERTICAL FORWARD PORT | 129 | 9 | 6 | Right | Enable | 400 |
| 6 | VERTICAL FORWARD STARBOARD | 129 | 10 | 4 | Left | Disable | 400 |
| 7 | VERTICAL AFT | 129 | 20 | 5 | Left | Enable | 400 |



_LED MODULE

The LED Module provides variable levels of illumination and beam control.

[DEPTH RATING]

1,000 meters (3,280 feet)

[MECHANICAL]

Dimensions: 7.6 cm x 7 cm x 2.8 cm
(3.0 inches x 2.75 inches x 1.12 inches) not including cable

Weight in Air: 0.14 kg (0.31 pounds)

Weight in Water: 0.09 kg (0.10 pounds)

[CONNECTIONS]

5-Pin Pin/Socket stackable connector

[COMMUNICATIONS]

RS-485 Galvanically Isolated Control

[SENSOR FEEDBACK]

Input voltage

Input current total

Internal temperature

[FEATURES]

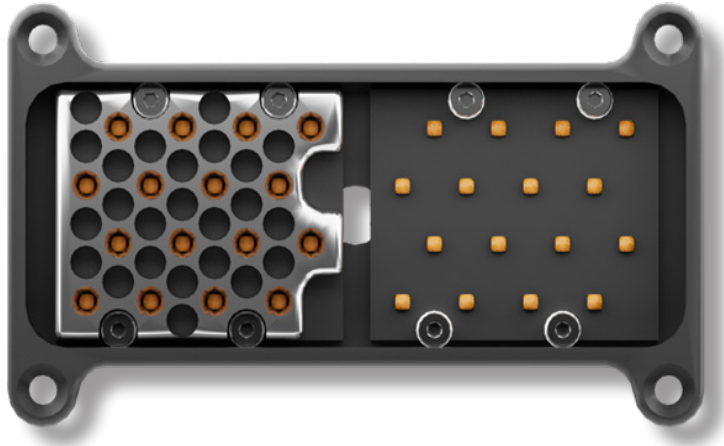
3,000 K CCT, 80 CRI White

2,880 Calculated minimum flux (lm) per array, 5,760 total lm each

Individually controlled arrays (16 emitters per array, 32 total)

60 degree spot beam, 110 degree flood beam

Hard Anodized, Potted Housing



| LIGHT LOCATION | GROUP ID | NODE ID |
|-----------------------|----------|---------|
| FORWARD TOP PORT | 131 | 11 |
| FORWARD TOP STARBOARD | 131 | 12 |
| REAR/AUX (OPTIONAL) | 131 | 31 |

| PIN | FUNCTION | WIRE AWG | COLOR |
|-----|-----------|----------|-------|
| 1 | 48 V DC + | 20 | Red |
| 2 | GND | 22 | Green |
| 3 | 48 V DC - | 20 | Black |
| 4 | RS-485 A | 24 | Gray |
| 5 | RS-485 B | 24 | White |

_CONNECTORS

Mission Specialist systems use 3 types of connectors for power and communications between the control panel, modules, and accessories:

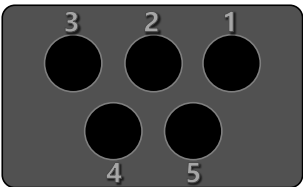
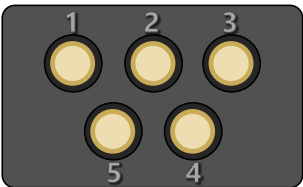
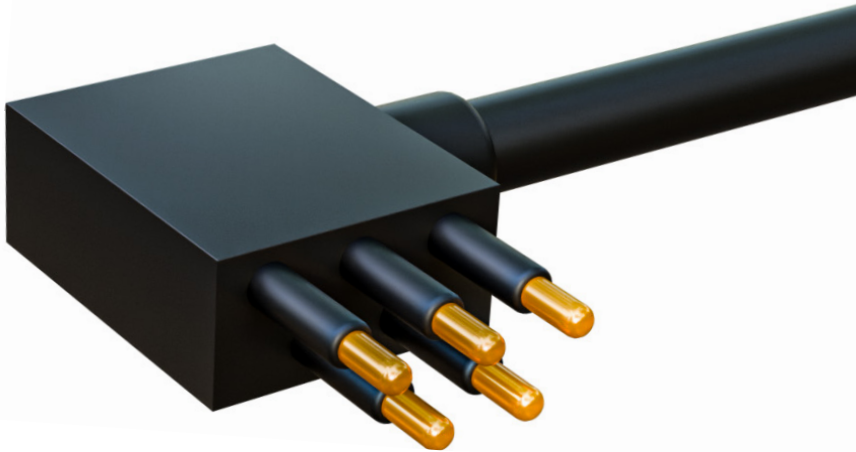
5 Pin Thruster/LED Connector

9 Pin Accessory Connector

8-Pin Tether Connector (next section)

_5 PIN THRUSTER/LED CONNECTOR

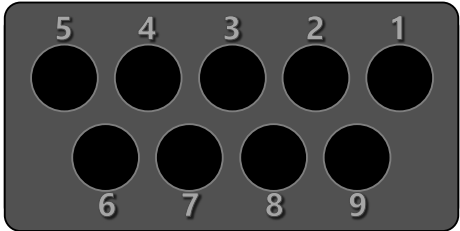
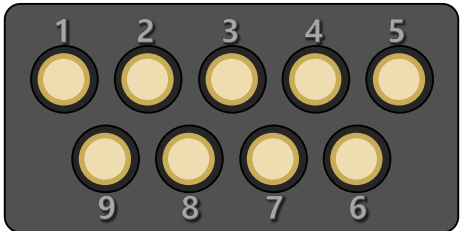
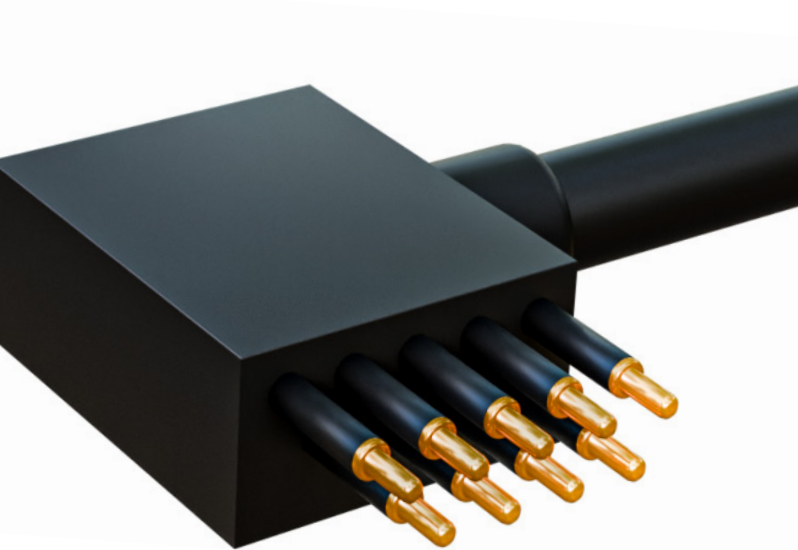
Pin numbering is clockwise starting at 1 in the upper left when looking at the face of the connector pins with the row of 3 pins on top.



| PIN | FUNCTION |
|-----|---|
| 1 | 48 V DC + |
| 2 | Vehicle Local Ground (12 V, 48 V return) |
| 3 | 48 V DC return |
| 4 | RS-485 A |
| 5 | RS-485 B |

_9 PIN ACCESSORY CONNECTOR

Pin numbering is clockwise starting at 1 in the upper left when looking at the face of the connector pins with the row of 5 pins on top.



| PIN | FUNCTION |
|-----|-----------|
| 1 | ETH_RXP + |
| 2 | ETH_RXP - |
| 3 | 24 V DC + |
| 4 | ETH_TXP + |
| 5 | GND |
| 6 | ETH_TXP - |
| 7 | RS-485 A |
| 8 | RS-485 B |
| 9 | 12 V DC + |

_TETHER

The chart below provides current product specifications on Mission Specialist tether types available at the time of this publication.

Please refer to videoray.com/products/accessories/tether/ or contact Support for the most up-to-date specifications and product information.



| PIN | FUNCTION |
|-----|-------------------|
| 1 | Interlock (GND) |
| 2 | Interlock (Sense) |
| 3 | Tether V+ |
| 4 | M100 EOP+ |
| 5 | Tether V- |
| 6 | M100 EOP- |
| 7 | RS-485 A |
| 8 | RS-485 B |

Topside & Subsea Battery Power Compatibility

| | | |
|---------------------------|---|--|
| PERFORMANCE (PPT) | <ul style="list-style-type: none"> OUR MOST VERSATILE TETHER STANDARD LENGTHS: 40m, 100m, 300m CUSTOM LENGTHS AVAILABLE | Neutral Buoyancy - 1,400lb/635kg Breaking Strength Range: 400m ETDS Reel Capacity or 450m Loose 60 Mbps O.D.: 9.1mm STATIC/DYNAMIC MIN RADIUS: 10/20 x O.D. WEIGHT IN WATER: ~ Neutral |
| NEUTRAL | <ul style="list-style-type: none"> LARGER POWER CONDUCTORS THAN PPT MULTIPLE STOCK & CUSTOM LENGTHS | Neutral Buoyancy - 1,000lb/450kg Breaking Strength Range: 300m ETDS Reel Capacity or 400m Loose 60 Mbps O.D.: 12.2mm STATIC/DYNAMIC MIN RADIUS: 10/20 x O.D. WEIGHT IN WATER: ~ Neutral |
| NEGATIVE | <ul style="list-style-type: none"> SMALLEST DIAMETER FOR TOPSIDE POWER MULTIPLE STOCK & CUSTOM LENGTHS | Negative Buoyancy - 1,000lb/450kg Breaking Strength Range: 400m ETDS Reel Capacity or 400m Loose 60 Mbps O.D.: 8.5mm STATIC/DYNAMIC MIN RADIUS: 10/20 x O.D. WEIGHT IN WATER: ~ -10 Kg/Km |
| HYBRID FIBER OPTIC | <ul style="list-style-type: none"> LONGEST RANGE TOPSIDE POWER TETHER SM 9/125 2 CORE OPTICAL FIBER CUSTOM LENGTHS AVAILABLE | Negative Buoyancy - 1,600lb/725kg Breaking Strength Range: 500m VR Hybrid Reel Capacity or up to 1.25km Loose or Custom Reel 1 Gbps/100 Mbps O.D.: 12mm STATIC/DYNAMIC MIN RADIUS: 5/12 x O.D. WEIGHT IN WATER: ~ -8 Kg/Km |

Subsea Battery Power Compatibility

| | | |
|-----------------------------|--|---|
| EXPEDITIONARY COPPER | <ul style="list-style-type: none"> SMALL OPERATIONAL FOOTPRINT THINNEST TETHER FOR MINIMUM DRAG STANDARD LENGTH: 500m | ~ Neutral Buoyancy - 375lb/170kg Breaking Strength Range: 500m Expeditionary Reel Capacity 60 Mbps O.D.: 4.4mm STATIC/DYNAMIC MIN RADIUS: 4/10 x O.D. WEIGHT IN WATER: ~ -2 Kg/Km |
| FIBER OPTIC | <ul style="list-style-type: none"> MAXIMUM BANDWIDTH SM 9/125 4 CORE OPTICAL FIBER CUSTOM LENGTHS AVAILABLE | ~ Neutral Buoyancy - 660lb/300kg Breaking Strength Range: 500m Expeditionary Reel Capacity, 1.5km Fiber Reel Capacity, 2km+ Loose/Bag 1 Gbps/100 Mbps O.D.: 4.5mm STATIC/DYNAMIC MIN RADIUS: 10/20 x O.D. WEIGHT IN WATER: ~ -2 Kg/Km |



TROUBLESHOOTING

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|----------|---|--|---|--|
| Power | No power to the topside control box | Bad power cord, power source, power supply, GFCI tripping. | Green power on indicator should be illuminated. Check power source, ensure system power cables are fully inserted into the console, and the GFCI is not tripped. | Plug power cords in firmly and test/reset the GFCI. Turn system on following powering on procedures (console toggle switch, ROV power mains, Greensea software). |
| | No power to the ROV. | ROV power switch. | Light for '400V' indicator on top panel should be illuminated. | Turn the red power mains button clockwise; the button should pop up. |
| | | Poor or faulty tether connection. | Turn ROV power off, disconnect tether at ROV and console, inspect, clean and lubricate connections. | Reconnect tether, turn ROV power on, check power/communication. |
| | | | Turn power to ROV off, remove tether from the system and connect ROV tether whip directly to console tether whip. | Turn power to ROV on, check power/communication and functions. Use another tether if available. |
| | | Faulty ROV or console whip. | Turn power to ROV off, remove 8-pin whips from the system and connect ROV directly to console using the tether. Repeat this test isolating each whip. | Inspect and clean tether whip connections and re-test or replace as needed. |
| | | Miscellaneous software glitch. | Software glitch will not affect power supply to ROV, but symptoms may appear as though ROV is not receiving power. | Perform other diagnostics and recommendations in this section; power system on following powering on procedures (console toggle switch, ROV power mains, Greensea software). |
| | | Voltage leak in the tether to the ROV. | Line Insulation Monitor (LIM) on top panel has measured a leak across the cable result in the reading dropping below 4.00 Mohms | Power system down, disconnect tether from console and power on the console, observe the LIM reading. *Make sure rubber connectors are greased before deployment* |
| | | | | Power system down, use a different tether if available, power on the system and observe the LIM reading. Remove the tether from the TDS if further troubleshooting is required |
| | Underpowered or experiencing brownouts while operating. | Insufficient power to system. | If using generator/inverter, ensure power is 3000W minimum, pure or true sine wave and ECO mode is off. | Provide sufficient or alternate power source and follow system powering on procedures (console toggle switch, ROV power mains, Greensea software). |
| | | | Check condition/rating of extension cord, recommended is rated for 400V and of sufficient gauge (>16GAW). | Use an extension cord in good condition and recommended rating. |
| | | Insufficient power through tether to ROV. | Turn power to ROV off, inspect tether and connections for damage and debris. | Clean and lubricate tether connections and reconnect. Turn system on following powering on procedures (console toggle switch, ROV power mains, Greensea software) and check functions. |
| | | | Check ROV power limit settings in Greensea menu (v.3.2 Control Tools or v.6.10 Home Tab) Turn power to ROV off, remove tether from the system and connect ROV tether whip directly to console tether whip. | Set power limit to 1,000 watts (default), may be set higher for demanding environments (current, payload). Turn system on following powering on procedures (console toggle switch, ROV power mains, Greensea software) and check functions. |
| | | | Excessive tether range (length) resulting in insufficient power transmission for ROV power demands. | Avoid exceeding maximum tether range; refer to the system user manual for tether specifications. Adjust power limit settings in the Greensea menu (v.3.2 Control Tools or v.6.10 Home Tab); default setting is 1000W, reducing the setting will demand less power to the ROV. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|----------|---|---|---|--|
| Thruster | Thruster motor not working. | Thruster connection not mated properly. | Remove float block and ensure all 5-pin connectors are fully seated without gaps between them. | Power down system, clean, lubricate and mate connectors so that no gaps exist between them. |
| | | | Remove float block and inspect port side 5-pin extension connection. Inspect 5-pin thruster connections. | Power down system, clean, lubricate and ensure it is fully connected at the Power Module. Remove float block, inspect, clean, and apply a light coat of silicone grease to 5-pin connectors in the BUS network, then reconnect. |
| | | Thruster not programmed correctly. | Identify thruster position on the ROV. | Refer to VideoRay user manual for thruster configuration steps. |
| | | Thruster damaged. | Power off ROV and inspect thruster telltale, housing, and propeller shaft for oil loss or damage. | Replace thruster. |
| | | Power Module BUS reading under 48 V. | Check for loose 5 pin connectors at the Power Module. If any connectors are loose, replace the module. The 5-pin connector pins 1 and 3 at the Power Module should read 48V DC. If lower, not enough power is being supplied. Ensure the 400V ROV switch power is on (up). | Replace Power Module. Ensure 5-pin connectors are properly lubricated with silicone and the connectors do not move by hand. Isolate a bad thruster (or LED) in the chain. If lower than 48V, the power module needs to be replaced. |
| | Thruster RS-485 board no longer communicating | | Power on the ROV, open the terminal window and execute vr_enum . This will list all thrusters and other RS-485 components. | If an expected thruster is not listed, try changing the BUS connection on the Power Module, also try to connect the thruster by itself, if the thruster is still not listed, it may need to be replaced, after replacing ensure to program the new thruster. |
| | ROV not moving as expected with control inputs. | Incorrect propeller orientation for the specific programmed thruster position. | Identify thruster position on the ROV | Refer to VideoRay user manual for propeller orientation for each thruster position. |
| | | Incorrect reverse orientation set in the debug configuration for thruster position. | Identify thruster position on the ROV | Refer to VideoRay user manual for thruster configuration steps. |
| | | Improper thruster configuration. | Slowly apply joystick input and observe the direction of rotation for each propeller. | Use Thruster Configuration Tool (if installed) to program thruster's serial number and location. Refer to VideoRay user manual for thruster configuration steps. |
| | Not enough power. | Power source output is under 3000W from topside | Check power supply; if using a generator, ensure proper continuous wattage and run with ECO mode off. If using an inverter, ensure proper wattage and is a pure-sinewave model. | Supply sufficient power using an alternate source, follow system powering on procedures and function test thrusters. |
| | | Power lowered on the power manager/joystick inputs in Greensea. | View the power settings and joystick gains in the appropriate Greensea menus. | Adjust settings; default settings are 1,000W for power settings and 75/50/50% (GSS v.3) or 50/30/30% (GSS v.6). |
| | | Damaged thruster, propeller wear, propeller obstructed. | Inspect thruster and propeller for damage to blades and along hub, obstruction, unusual wear. | Remove propeller and clear any debris (grass, fishing line) Replace thruster and/or propeller. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|----------|----------------------------|--|---|--|
| Thruster | | | Inspect propeller for hairline crack along hub (shaft) by pulling propeller blades apart and observing the propeller hub between them. | Replace propeller, ensuring to note the propeller type (left or right). |
| | No communications. | Bad connection. | Inspect 5-pin thruster connections. Ensure there is silicone grease and no gaps or damage to the connector. Ensure there is no corrosion on pins. | Slight corrosion can be corrected by gently using a metal brush ONLY on the affected areas. Ensure not to damage the rubber of the connector with the wire brush. Silicone grease should then be applied to any subsea connector. |
| | | Bad thruster whip. | Inspect connector pins for damage or corrosion. | Power on the ROV, open the terminal window and execute vr_enum This will list all thrusters and other RS-485 components. If not listed, replace and configure thruster. |
| | | Oil leaked into whip. | Confirm thruster telltale condition. | Power on the ROV, open the terminal window and execute vr_enum This will list all thrusters and other RS-485 components. If not listed, replace and configure thruster. |
| | | Flooded thruster. | Check for signs/means of water entry (housing physically penetrated, internal corrosion, water exiting thruster housing, sunken/recessed telltale) | Power on the ROV, open the terminal window and execute vr_enum This will list all thrusters and other RS-485 components. If not listed, replace and configure thruster. |
| Camera | No video feed displayed. | Poor tether connection. | Check tether connections. | Turn power to ROV off, clean, inspect, and lubricate tether connections. |
| | | Faulty tether. | Remove tether from system. | Turn power to ROV off, remove tether connections and connect ROV tether whip directly to Console tether whip. |
| | | Loose connection. | Check camera connections. | Remove float block, check all connections. |
| | | Miscellaneous software glitch. | All connections have been checked, no other causes identified. | Close Greensea software, turn off power to ROV and Console and follow system powering on procedures. |
| | | Bad Ethernet pin on camera connector, port, or tether. | Check to see if the camera tilt function is operational. | If the tilt is operating, but the video feed is not, attempt to connect the camera module to a different 9-pin port on the communications module and connect to it through Sensoray. |
| | Tilt function not working. | Greensea software issue. | Connect and power on the system. Do not open Greensea and open a browser (Firefox) Type 192.168.1.11 in the address bar. | If there is communication with the camera, you will see camera details in the Sensoray server. If the camera is not tilting, check all other 485 modules to ensure they are communicating properly (see below). |
| | | Comms Module RS485 issue. | Check to see if all other RS485 modules are communicating properly | Check the Greensea diagnostics screen to see if all thruster and LED modules are appearing without a fault or run a 'vr_enum' command in the terminal window to see if all RS485 modules appear. |
| | | Two versions of Greensea software are running. | Minimize the Greensea workspace window and check if there is another version running. | Close all Greensea windows and open the appropriate version from the desktop. |
| Sonar | No sonar feed displayed. | Miscellaneous software glitch. | All connections have been checked, no other causes identified. | Close Greensea software, turn off power to ROV and Console and follow system powering on procedures. |
| | | Process is turned off. | Often occurs when running sonar through native software on external computer. Check the Greensea Diagnostics Menu Process View tab for a running process. | Open the Alt+3 diagnostics menu, and open Process View tab. Find the Oculus Sonar process and ensure the status is set to 'keep_alive' and not 'stop' or 'start'. To change status, click on 'Enable Editing', select 'keep_alive', click on 'Apply Changes', and disable editing. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|----------|---------------------------------|--|--|---|
| Sonar | | Bad cable or connection. | Disconnect sonar cable, clean and inspect, lubricate and reconnect. | Power on the unit for about 10-15 mins in ambient temperature. If the sonar does not heat up, it is not getting power. |
| | | | | |
| DVL | No or intermittent DVL lock. | Altitude outside operational range of DVL. | Adjust altitude to between 0.2-75 m (~7"-246') from sea floor. | Confirm DVL lock and Dynamic Positioning/Auto Altitude functions. |
| | | Cables interfering with the beams. | Inspect bottom of ROV for DVL obstructions. | Carefully route and secure any cables to the outside of the cylindrical collar of the DVL. |
| | | Air bubbles or debris interfering with beams. | Dive to 1-2 feet of depth and aggressively turn the ROV back and forth. | Confirm DVL lock and Dynamic Positioning/Auto Altitude functions. |
| | | Sea floor composition. | Acoustic beams not receiving signals due to grassy or non-reflective bottom | Navigate to a location with a solid bottom; confirm DVL lock and Dynamic Positioning/Auto Altitude functions. |
| | | Miscellaneous software glitch. | DVL lock intermittent or not functioning with other causes eliminated. | Close Greensea software, turn off power to ROV and Console and follow system powering on procedures. |
| | Position inaccurate. | Inconsistent bottom lock, extended period of navigation. | DVL lock present and tracking but positioning error is noted. | Reset position to USBL (if equipped) or return to surface and reset position to GPS. |
| | | Geographical conditions. | DVL affected by noise from nearby acoustic sources or reverberation from vertical structures. | Try to navigate away from other acoustic sources and clear of large structures. Also be cognizant of positional error and when necessary, reset position to USBL if equipped) or return to surface and reset position to GPS. |
| | | | | |
| USBL | No positioning data. | No communication between beacons. | No power to beacon/s. | Check and properly lubricate connections with silicone. Confirm power by checking flashing LED indicators of each beacon (topside: 1 blink/1 flash, ROV: 1 blink/2 flashes). |
| | | | Beacons aren't visible to each other or not in hemispherical range. | Dive ROV in line-of-sight and lower in the water than the topside USBL beacon. |
| | | | Ensure there are no air bubbles encompassing the topside USBL beacon. | Move the topside USBL beacon around swiftly underwater, stabilize and check communication/positioning data. |
| | Poor connections. | Inspect, clean, and reconnect all topside and ROV USBL beacon connections. | | Dive ROV in line-of-sight and lower in the water than the topside USBL beacon and check communication/positioning data. |
| | | | | |
| | | | | |
| | System not configured properly. | | Check that the topside USBL beacon LED shows 1 blink/1 flash, indicating that it is Beacon ID #1. The ROV beacon should show 1 blink/2 flashes as Beacon ID #2. | Refer to SeaTrac user manual configuration instructions. <i>With Greensea integration, the topside X150 beacon will need to have ID #1, not the SeaTrac default of #15.</i> |
| | System boot error. | | Close the Greensea software if safe to do so, shut down the system and restart using the following sequence: 1. Boot up – wait until the boot up is complete, 2. Plug in the GPS USB, 3. Plug in the USBL USB, 4. Start Greensea control software. | Dive ROV in line-of-sight and lower in the water than the topside USBL beacon and check communication/positioning data. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|------------------|--------------------------|---|---|---|
| USBL | Position inaccurate. | Environmental factors. | Communication affected by water temperature, dissolved oxygen content, marine plant life, acoustic noise from vessels, reposition topside beacon. | Navigate in another location with no obstructions and improved environmental conditions. |
| | | Geographical conditions. | Communication affected by bottom shape, depth of a channel, acoustic noise/reverberation from nearby structures. | Try different topside USBL beacon locations clear of structures or other acoustic sources. |
| | | Topside X150 beacon orientation. | Communication affected by the beacon's mounting method, position in the water, surrounding structure. | Suspend the topside USBL beacon ~1 m underwater and away from vessel hull or structures. |
| | | Beacon offset settings in software configuration. | Check Greensea GPS Antenna and Launch & Recovery configuration (v.3.2 'Ship Config' or v.6.10 'Vessel Config') settings. | Reset settings to 0.00 and confirm position of topside USBL beacon in the Map View. |
| Subsea Batteries | No power to the ROV. | Batteries not charged. | Batteries do not turn on when power wand inserted, no audible tones. | Ensure batteries are powered off and connect to chargers provided by VideoRay, follow recommended charging procedures. |
| | | Low state of charge. | Batteries turn on briefly, then shut off. | Batteries will automatically will shut down the battery output on a low-voltage condition (36 V). Ensure batteries are off and connect to chargers provided by VideoRay, follow recommended charging procedures. |
| | | | Greensea workspace battery meters (if equipped) indicate low levels. | Batteries will automatically will shut down the battery output on a low-voltage condition (36 V). Ensure batteries are off and connect to chargers provided by VideoRay, follow recommended charging procedures. |
| | | Improper/poor connection. | Both batteries don't turn on when inserting power wand in one battery. | Lubricate and fully mate the 5-pin FM/M connector of the power supply cables inline with one of the ROV's 5-pin chain of connections. Lubricate and fully mate the other end to the battery on the same side. Repeat these steps for each battery. Inspect all 5-pin connections and fully mate. Check Power Module and ensure proper mating of connectors. |
| | | | Batteries turn on but don't provide power to the ROV. | Lubricate and fully mate the 5-pin FM/M connector of the power supply cables inline with one of the ROV's 5-pin chain of connections. Lubricate and fully mate the other end to the battery on the same side. Repeat these steps for each battery. Inspect all 5-pin connections and fully mate. Check Power Module and ensure proper mating of connectors. |
| | Batteries not turned on. | | Check for status lights blinking on the Power and Communications modules. | Powering up one battery will automatically power up the other battery. Insert the included power wand into the circular opening in the center forward-facing end of only one of the batteries. Fully insert the wand for approximately one second and remove, after which two audible tones should be heard from each battery. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|------------------|--|--|---|--|
| Subsea Batteries | | One battery is not turned on. | Battery inadvertently turned off during improper power up sequence. | Powering up one battery will automatically power up the other battery. Insert the included power wand into the circular opening in the center forward-facing end of only one of the batteries. Fully insert the wand for approximately one second and remove, after which two audible tones should be heard from each battery. |
| | | | LED light modules red rear status lights blink momentarily, status lights not blinking on the Power and Communications modules. | Powering up one battery will automatically power up the other battery. Insert the included power wand into the circular opening in the center forward-facing end of only one of the batteries. Fully insert the wand for approximately one second and remove, after which two audible tones should be heard from each battery. |
| | | Batteries were mixed with another set. | Check battery labels for Node ID numbers. | Ensure batteries have different Node IDs (32 and 33) and proceed with startup. |
| | | Batteries exceeding temperature limits | Battery Management System detected extreme temperatures and shut off battery output (> 55° C or < -5° C). | Protect batteries from exceeding temperature limits, usually accomplished by deploying the ROV in water. |
| | Greensea Workspace experiencing brownouts while operating. | Low state of charge. | Video and sonar imagery going dark or freezing, compass ribbon freezing, display going dark. | Disable all Auto controls and lights, decrease ROV power setting to 500 W, and make recovery of the ROV the mission priority. |
| | Battery power not lasting as expected/ needed. | High power demands from ROV related to navigation. | Navigation in water current, auto controls maintaining ROV attitude/position, excessive thruster use. | With NiMH batteries, decrease Greensea power setting to 700 W (default setting is 1,000 W). Pilot heading into or with current, requiring less lateral thrust. Decrease joystick gains for less thruster demands. Pilot more efficiently and with less thrust. Manage tether to avoid excessive hydrodynamic drag. |
| | | High power demands from ROV related to accessories. | High usage of lighting or other accessories/sensors. | With NiMH, decrease ROV power setting to 700 W (default is 1,000 W). Turn off or dim ROV LEDs when not needed. Only connect/use accessories and sensors when needed for a mission. |
| | | Additional or alternative battery set needed. | Mission needs exceed expected/listed battery endurance. | Consider Li-ion batteries as an alternative to NiMH or have another battery set available. |
| | | Batteries will automatically power on during charge cycle. | ROV powers up when connecting batteries immediately following a charge cycle. | The batteries will turn on while charging and automatically shut off after 5 minutes once charging is complete. The batteries may each be turned off manually during this time period. |
| | Batteries making humming noise. | Battery internals | The battery pod's internal electronic stack includes a battery control electronic module. | Use system with batteries as normal. |

| CATEGORY | PROBLEM/SYMPTOM | POSSIBLE CAUSE | DIAGNOSTICS | RECOMMENDATIONS |
|--------------------|---|--------------------------------|--|---|
| Fiber Optic Tether | Nothing displayed or functioning in Greensea Workspace. | ROV Power Mains not turned on. | Fiber Optic module requires a topside power source. | Turn the red power mains button clockwise; the button will pop up and the software will begin communicating with the ROV. |
| | | Improper/poor connection. | Tether from Fiber Optic module or reel not connected/poor connection. Poor connection with Fiber Optic patch cable. | Make or test tether connection to console 8-Pin tether whip. Note twist lock coupling and the locating sleeve of the type ST patch cable connector. Use provided Fiber Optic lubricant and connect patch cable properly between the ROV module and Channel 1 of the tether termination block. |
| | | | Connectors have been submerged in salt water and not cleaned. | Clean Fiber Optic terminations and connections with provided cleaning kit. |
| | Tether termination block won't mount to ROV frame. | Tight bend in tether. | Tether bend interferes with mounting tether termination block. | Insert thumb screw through the tether termination block. Lay block flat in the channel of the termination mount on the ROV frame. Slide block rearward in the channel until the thumb screw drops slightly into the threaded mounting hole. Turn thumb screw clockwise, using caution to prevent damage to threads, and tighten securely. |



SUPPORT RESOURCES

_HOW TO GET HELP

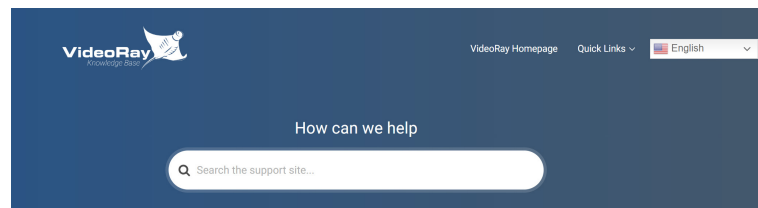
Help for your Mission Specialist Defender is available through several channels.

_ALL HOURS SELF-SERVICE SUPPORT

VideoRay's Online Knowledge Base is the one-stop location for almost any support need. Simply enter your keyword to find detailed information about:

| | |
|--------------------|-------------------------------|
| Operator's Manuals | Standard Operating Procedures |
| System Modules | System Controls |
| Specifications | Maintenance |
| Live Support | Software Downloads |

<https://kb.videoray.com/>



_GLOBAL SUPPORT

Email support@videoray.com
Phone +1 610-458-3000 (option 1)

Remote sessions via TeamViewer are available by appointment, as well as video calls. Contact us using one of the above methods for options.

_REGIONAL SUPPORT

VideoRay Authorized Dealers and Service Centers

<https://videoray.com/contact-us/locate-dealer-or-service-center/>

_BEFORE CONTACTING SUPPORT

Please make sure to consider the following information before contacting VideoRay's Technical Support to report a problem.

The following information should be available:

- User name and contact information
- Name of the owner if not the same as the user
- System model
- Serial Number of the affected component(s)
- Accessories in use
- Detailed information about the issue:
 - Symptoms
 - Operating conditions that create the symptoms
 - Anything new or unusual about the system or operations

Once you have collected the recommended information, contact VideoRay Support.

_OPERATIONAL STRATEGIES & SUPPORT

If you need help understanding how to apply your system to a specific project, contact VideoRay or your local VideoRay dealer. We can provide guidance or help you find a certified consultant.

_TRAINING

The Training team at VideoRay offers operator and maintenance courses around the globe with personalized courses and instruction.

Email training@videoray.com

Phone +1 610-458-3000 (option 2)

Training Opportunities videoray.com/training/

_QUALITY COMMITMENT

VideoRay strives to design, manufacture, deliver and support the highest quality products and services, including this documentation. We have made every effort to ensure that this documentation is accurate and provides you with the most up-to-date information.

If you find any errors in this documentation or have suggestions for improvements, please contact VideoRay's Product Department.

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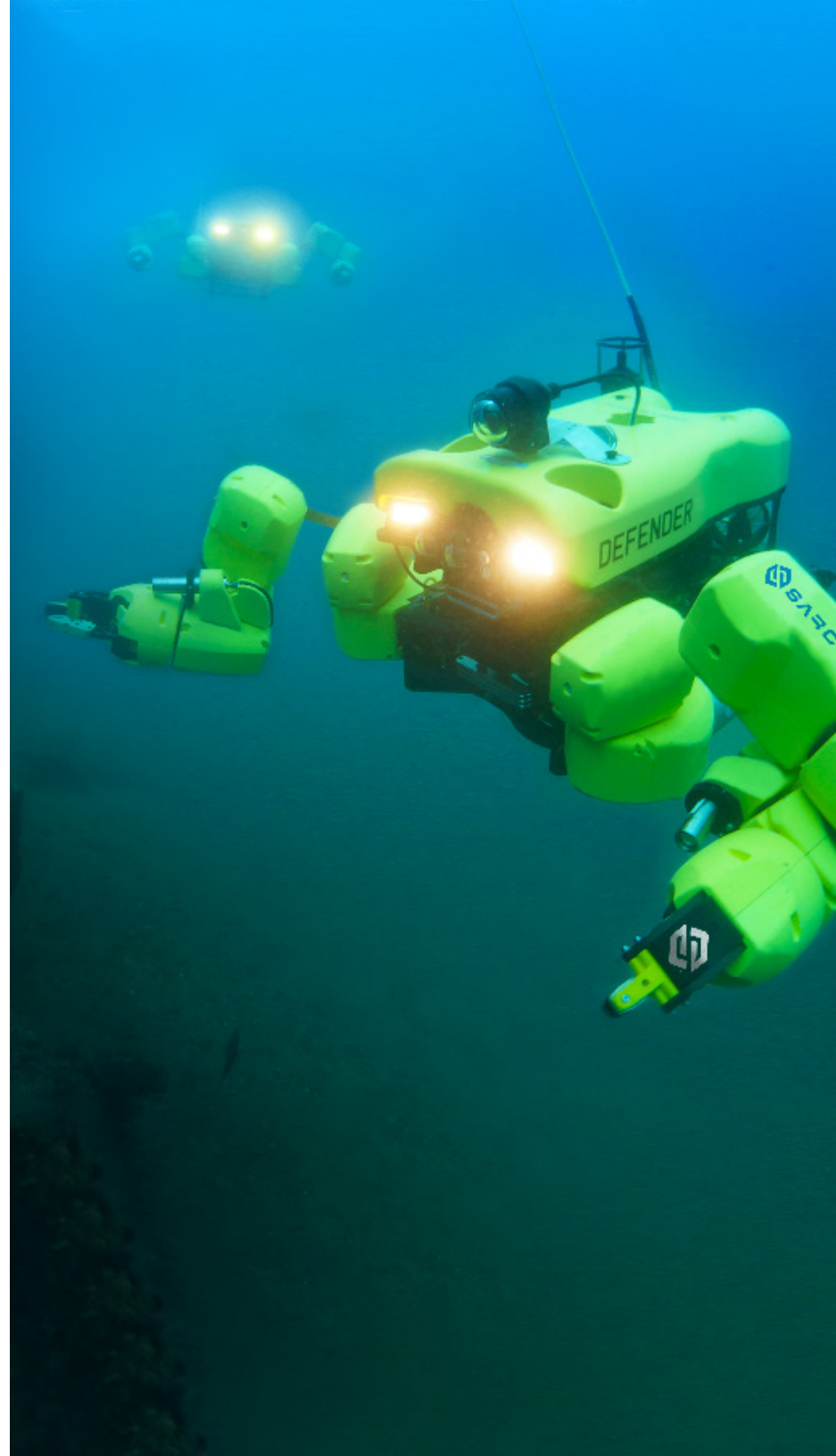
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