MSS Defender Operator's Manual

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MSS Operator's Manuals

About this Document

Online Manual

This Quick Start Guide is a subset of the full version of this manual, which is available on the MSS Defender control panel and online in the following formats:

- Installed on the MSS Defender control panel at: Home/VideoRay/documentation/_mss_defender for viewing the HMTL locally.
- http://download.videoray.com/_mss_defender for viewing the HMTL online.
- http://download.videoray.com/documentation/mss/pdf/videoray_doc__mss_defender.pdf for viewing the PDF online.
- http://download.videoray.com/documentation/mss/zip/videoray_doc__mss_defender.exe for downloading the HTML and PDF files.

Document Conventions

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

SYMBOL	DESCRIPTION
	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.
	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 a specific 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 training and technical support and hosts a general user discussion forum and user image gallery.

We also realize that collectively, users of our products spend considerably more time operating our systems than we do ourselves. Users also encounter more diverse operating environments across an extremely broad range of applications. We highly value this vast experience base, and invite and encourage you to share your experiences and suggestions with us. Please feel free to contact us by any of the methods listed below.

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, each page contains a "Help us improve this document" feedback link in the left margin (you must be connected to the Internet to use this link).

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Disclaimer

This document is deemed accurate at the time of its writing, however it is not a legal contract and the information contained herein should not be construed to represent any form of commitment. This document as well as the associated products and services are subject to change without notice.

How to Get Help

Help for your MSS Defender is available through several channels.

All Hours Self-Service / Crowd-Source Tools

Operator's Manuals and Standard Operating Procedures	www.videoray.com/support/manuals.html
Software Downloads	www.videoray.com/support/downloads.html
Frequently Asked Questions	www.rovfaq.com
ROV User Forum	www.rovinfo.com

Global Support

Email	support@videoray.com
Phone	+1 610-458-3000 (*select option* 1)
Skype	videoray.support (*by appointment*)
Remote Sessions	www.videoray.com/support/remote-support.html (*by appointment*)

Regional Support

VideoRay Authorized Dealers and Service Centers	www.videoray.com/dealer.html

Training

Operator Training	www.videoray.com/learn-more/training.html
Advanced Maintenance Training	http://www.videoray.com/learn-more/training/advanced-maintenance-training.html

Operational Strategies and Tactics Support

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

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 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 unusually about the system or operations

In addition, please review VideoRay's Support website for additional information about:

- Principles of Customer Interactions
- Customer Care Philosophy
- Technical Support Policy

- Accessory Support Statement

MSS Defender Overview

The VideoRay Mission Specialist Series is the world's first ROV to deliver custom purpose-built vehicles using a standard production packaging process. Mission Specialist ROVs are literally 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 overall system represents the difference between a pickup truck and purpose-built construction vehicles, with equal differences in performance for specific applications.

Based on modular components and standard interfaces, the development a specific Mission Specialist Series ROV is orders of magnitude faster than designing a vehicle form the ground up or customizing an existing monolithic vehicle.

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

MSS Vehicle Configurations

MSS vehicle configurations include:

the Defender

the Pro 5

Vehicles are shown approximately to scale.

Quick Start Instructions

These Quick Start Instructions are streamlined to cover just the essentials of operating your MSS Defender system. They are provided to get you started as quickly as possible, while keeping you and the equipment safe. They cover the equipment set up and basic operation, but are not intended to result in a comprehensive base of knowledge or set of operational and piloting skills. The remaining sections of this documentation should be referenced for a complete understanding of the features, capabilities, operating procedures and maintenance requirements of your MSS Defender system.

Topics in this Section

- Safety First
- System Components
- Pre-Dive Preparations
- Dive Operations
- Post-Dive Operations

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 practices 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.

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

How Safe Is Safe Enough?

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.

Introduction to the System Components

Unpack the system and familiarize yourself with the components.

ROV

The ROV, or Remotely Operated Vehicle, carries the cameras, lights and sensors or accessories to the underwater places you want to observe. Thrusters provide mobility and these systems are controlled from the surface using the control panel and hand controller.

See the ROV section of the Equipment Guide for more information.

User Control Console

The User Control Console includes the system's power and communications modules, computer and hand controller, and serves as the operator's control interface and video display. Open the User Control Console and familiarize yourself with the components and primary controls on the hand controller. See the User Control Console and Hand Controller sections of the Equipment Guide for a complete description of all of the controls and connections.

See the Control Panel section of the Equipment Guide for more information.

Hand Controller

The hand controller is used to pilot the VideoRay and operate other features like the lights, camera controls and

manipulator. The hand controller is pre-programmed, but can be customized to meet specific user or operational needs.

See the Hand Controller section of the Equipment Guide for more information.

Tether

The tether connects the ROV to the control panel. It delivers power and control signals to the ROV, and returns video and sensor data (optional) from the ROV to the surface. Some systems come with a TDS (Tether Deployment System), that makes the work of managing the tether easier. The tether is also often referred to as the umbilical.

See the Tether section of the Equipment Guide for more information.

Additional Items

Additional items may be supplied with your system including tools, spare parts and other items. If included, these items are described in other sections of this documentation.

Some items shown may be optional and not included with your configuration.

Pre-Dive Preparations

Select a safe and preferably level area to set up the User Control Console. See the On-site Operations section of the Project Management Guide for more information about site selection and set up.

The pre-dive preparations consist of five parts:

1. Visual inspection before setting up the system
2. Setting up the system including making connections
3. Power on tests of the system's safety circuits
4. Primary functions test of the systems features
5. Adjusting the ballast for the desired buoyancy (to be completed in the next phase)

Conduct a Visual Inspection

Assuming this is your first time using the VideoRay, everything should be in proper working order and ready to go, but it is good practice to perform a pre-dive inspection before every dive, even your first. If any problems are noticed, they should be addressed before continuing.

1. Inspect the ROV and other system components to make sure there are no visible signs of damage or loose or worn parts. Also check for water inside any pressure hull modules, such as the camera.

2. Check the horizontal thrusters to make sure that the shafts are not bent and the propellers are free to spin and are not fouled, loose or binding on the thruster guards.

3. Check the vertical thruster(s) to make sure the shaft is not bent and the propeller is not fouled or loose or binding on the float block.

Make the Connections

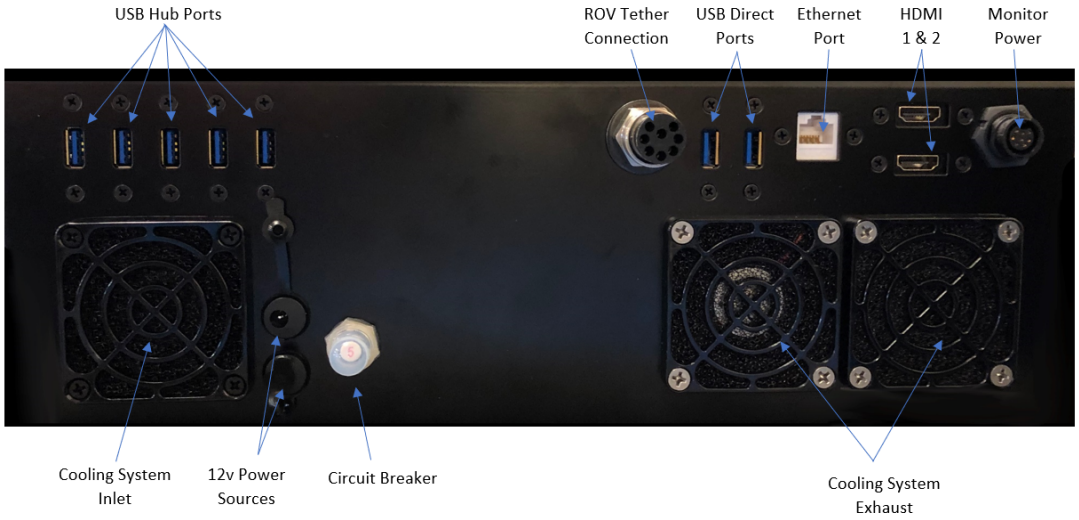
It is best to start making connections at the ROV and working your way to connecting the system to the power source.

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

⚠ Make sure the User Control Console power switch is set to the Off position and make sure the ROV power switch is set to the off position by pressing it.

Top View

Side View



Some of the cables have been connected at the factory. See the appropriate sections of the Equipment Guide for detailed information about each of the connections.

You will typically need to connect only the ROV, tether, strain relief hand controller, and power cord.

1. Connect the female end of the tether connector to the ROV. The connectors have one pin that is offset towards the center of the connector. Make sure the connectors are clean, align the pins, and push the connectors together - do not twist the connectors. Secure the locking collar by screwing the halves together.

2. Connect the braided strain relief from the tether to the rear of the ROV using the retaining screw. See the strain relief section for more information.

3. Connect the male end of the tether to the User Control Console. When not in use, keep the tether connectors clean and protected for the best performance and reliability.

4. Connect the hand controller to one of the USB ports on the User Control Console

5. Plug the User Control Console power cord into a conventional power source (100-240 Volts AC, 50,60 Hz). Power can be supplied through a land-based power outlet, generator or battery and inverter. See the User Control Console section of the Equipment Guide for power source requirements.

Power On Tests

DANGER 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 VideoRay MSS includes two circuit safety components.

- GFCI (Ground Fault Circuit Interrupter)
- LIM (Line Insulation Monitor)

Testing the Circuit Safety Components

Connect the power cord to a suitable power source.

The GFCI can be found inline in the power cord.

1. Press the GFCI Reset button to turn on the GFCI. The green LED should illuminate.

2. Press the test switch on the GFCI. The GFCI should interrupt power and the green LED should go out.

3. 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.

Power On and LIM Tests

Set the Power 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 turned on.

Twist the ROV Power switch to the On position. The green 400 V Power On indicator light should turn on. If the green 400 V Power On indicator light is not on, make sure the system is connected to a working power source and the GFCI and main power switches are turned on.

Test the LIM. The LIM can be found on the right side of the User Control Console. The GFCI switch and the main and 400 V Power switches must both be set to On in order to perform this test.

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.

Starting the VideoRay Control Software

Make sure the system is connected to a working power source and the GFCI / Circuit Breaker and Power switches are turned on.

1. Turn on the User Control Console and wait for the system to complete the boot up process.
2. To start the MSS EOD Workspace control software, double click on the Defender icon EOD Workspace on the desktop.

See the Software Guide for more information about the VideoRay control software.

Testing the System's Functions

The next step is to ensure that the essential features of the ROV are functioning properly. Use the hand controller to perform the following tests. The manipulator functions listed below do not necessarily represent the full capabilities of the system. See the Hand Controller section of the Equipment Guide for the complete list of functions and more information about using the hand controller.

1 Horizontal Control joystick
2 Depth Control knob
3 Camera Tilt Up button
4 Camera Tilt Down button
5 Camera Focus In button
6 Camera Focus Out button
9 Lights Intensity knob

⚠ Additional features and controls may be available depending on the system configuration. These tests represent the minimum set for all configurations.

Test the thrusters

DANGER CAUTION For the next two steps, make sure no one is near the thrusters and do not operate the thrusters out of water for more than 30 seconds to avoid overheating or premature wear of the seals.

1. Gently move the joystick forward and backward and left and right - the horizontal thruster motors should turn the propellers. Release the joystick - it will return to center on its own, and the propellers will stop turning.

2. Rotate the Depth Control knob - the vertical thruster motor should turn the propeller. Return the Depth Control knob to center to cease the vertical propeller rotation.

Test the lights

CAUTION For the next two steps, do not leave the lights on bright for more than 30 seconds while the ROV is out of water to avoid overheating.

1. Rotate the Lights Intensity knob clockwise to increase the intensity of the lights - the lights should get brighter.

2. Rotate the Lights Intensity knob counter clockwise to dim the lights - the lights should dim.

Test the camera functions

1. Press and hold the Camera Tilt Up button - the camera should tilt up smoothly through its entire range.

2. Press and hold the Camera Tilt Down button - the camera should tilt down smoothly through its entire range.

3. Press and hold the Camera Focus In button - the camera should focus in smoothly through its entire range.

4. Press and hold the Camera Focus Out button - the camera should focus out smoothly through its entire range.

⚠ If a manipulator or other accessories are attached, these items should be checked at this time.

Good Advice

The time to catch small problems before they become big problems is during the pre-dive inspection.

Dive Operations

After the previous four pre-dive checks and tests have been completed successfully, you are almost ready to commence the dive. But, there is one more issue to address that could affect the performance of the ROV. The ROV is designed to be operated in a near neutrally buoyant configuration, so the last step before launching your VideoRay is to check the buoyancy, and adjust the ballast if necessary. For most operations, the buoyancy is optimal when the top of the float block is even with the water surface and the ROV is level. If the ROV is too buoyant or too heavy, the vertical position may be hard to maintain or control.

⚠ Buoyancy will need to be adjusted for use in fresh water versus salt water and depending upon whether accessories are used with the ROV.

Buoyancy Check and Adjustment

To determine if the buoyancy is correct, lower the ROV and at least 3 meters (10 feet) of tether into the water. You can lower the ROV by the tether - it will not hurt the tether because there is Kevlar in it. Observe the ROV in the water - it should not be floating too high or sink. It should also be floating level and not tipped to one side or pitched up or down. If the ROV floats too high, you will need to add some ballast weights. If the ROV sinks, you will need to remove some ballast weights. If the ROV is not floating level, you can change the locations of the weights.

The buoyancy can be adjusted by adding or removing the supplied ballast weights to the vehicle. The weights can be added to or removed from the slots by hand. For most operations, the weights should be evenly distributed to provide a balanced attitude of the ROV in water.

Commence the Dive

Once the buoyancy has been adjusted the ROV is ready to launch. Lower it into the water and operate the controls to maneuver it. The ROV can be lowered using the tether.

- Start with the ROV on the surface and push the joystick forward slightly to make the ROV move forward. Move the joystick to the left or right to make it turn left or right. Get a feel for how agile the ROV is.
- Observe the video display as well as the ROV to become acquainted with the camera's wide angle lens and its affect on depth perception underwater.
- Once you feel comfortable with the horizontal maneuverability of the ROV, rotate the depth control knob to dive the ROV. Tilt the camera down as you dive so you can see towards the bottom. Rotate the depth control knob to bring the ROV back to the surface. Tilt the camera up as you surface so you can see towards the surface.
- Change the lights settings, and adjust the camera focus. If you have a manipulator, tilt the camera down so you can see it and open and close the jaws.
- As you get familiar with maneuvering the ROV, you can start to observe some of the on-screen displays including the depth, heading, camera settings and other data.

For your first dives, practice until you are comfortable operating the controls without looking at them and you are able to control the ROV with some precision.

See the Hand Controller section of the Equipment Guide for complete information about using the hand controller and see the Piloting section of the Operations Guide for more advanced tips on piloting the MSS.

Automated Flight Operations

Automated flight operations require additional configuration and tuning to ensure accurate flight dynamics and control. See the Automated Flight Operations section for more details.

Practice Makes Perfect

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

Post-Dive Operations

At the conclusion of your dive, retrieve the VideoRay and power down the system by closing VideoRay Balefire software, turning off the ROV power switch, shutting down the computer and then turning off the main power switch.. Make sure the ROV is secure before disconnecting the tether. After disconnecting the tether, keep the tether connectors clean and do not let them drag on the ground.

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 operation.

⚠ Keeping the ROV clean is one of the most important aspects of good preventative maintenance practices, especially after using it in salt water. If you use your ROV in salt water, or water with contaminants, you should first rinse it, and then soak it in clean fresh water for at least one-half hour. After cleaning the ROV and tether, they should be allowed to air dry before being put away for storage.

CAUTION Failure to properly maintain the ROV by thoroughly cleaning it after use may dramatically reduce its service life.

Debriefing

Congratulations! You are well on your way to becoming an accomplished micro-ROV operator, but there are still many things to learn and skills to master. Continue learning about the system by reviewing the additional sections of this documentation and, most importantly, practice, practice, practice.

If you encountered any difficulties or have any questions, review these Quick Start Instructions and the other documentation that came with your system, including the Equipment Guide. If you still have difficulty or questions, contact VideoRay. Your success is our success, and we are here to help you get the most out of your VideoRay.

VideoRay contact information is available on the About this Documentation page.

Ready to Learn More?

To accelerate your learning and receive recognition for your knowledge and skills, VideoRay offers in-person classes and online training as well as the Micro-ROV User Certificate program. Training can be delivered at your site and customized to your needs. To learn more about these opportunities, click on the training link above to visit the VideoRay Educational Resources website.

ROV System Specifications

Open in New Window

⚠ MSS Defender features and specifications are subject to change without notice.

Specifications for the ROV Modules

Specifications for the VideoRay M5 Modules are provided on the following pages.

Power Module Specifications

Depth Rating

- 2,000 meters (6,500 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 Male Connector (Tether)
- 9-Pin Female Connector (Communications)
- 5-Pin Female 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

⚠ M5 Power Module features and specifications are subject to change without notice.

Communications Module Specifications

Depth Rating

- 2,000 meters (6,500 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 Male Connector (Upstream, Port 1)
- 9-Pin Female Connectors (Accessories, 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

M5 Communications Module features and specifications are subject to change without notice.

AHRS Module Specifications

Depth Rating

- 2,000 meters (6,500 feet)

Mechanical

- Dimensions: 17.8 cm x 7 cm x 5.4 cm (7.0 inches x 2.75 inches x 2.12 inches) not including cable
- Weight in Air: 0.55 kg (1.2 pounds)
- Weight in Water: 0.21 kg (0.46 pounds)

Connections

- 9-Pin Female Connector

Power Input

- 12 VDC

Communications

- Ethernet
- RS-485

Sensor Feedback

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

IMU Features

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

M5 AHRS Module features and specifications are subject to change without notice.

Thruster Module Specifications

Depth Rating

- 2,000 meters (6,500 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 Male / Female Connector (Stackable)

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

- Direct Drive Brushless Motor
- Several Mounting Options
- 90mm Diameter Propeller
- 3 Blade Propeller with quick connect/release Collet
- Smooth Start at 120 RPM
- Instant Reverse
- No Cogging
- Very Quiet and Smooth Operation

M5 Thruster Module features and specifications are subject to change without notice.

Camera Module Specifications

Depth Rating

- 2,000 meters (6,500 feet)

Mechanical

- Dimensions: 15.4 cm x 8 cm diameter (6.1 inches x 3.1 inches diameter) not including cable
- Weight in Air: 0.66 kg (1.45 pounds)
- Weight in Water: 0.9 kg (0.20 pounds)

Connections

- 9-Pin Female Connector

Power Input

- 12 VDC; Power Consumption: 57w

Communications

- Ethernet
- RS485

Sensor Feedback

- Internal Pressure/Vacuum Integrity
- Internal Humidity
- Internal Temperature
- Tilt Position

Protocols

- Video: Ethernet
- Camera Control: Ethernet
- Servo Control: RS485

Visibility

- Internal Tilt: 85 Degrees
- Horizontal Field of View: 80 Degrees

Features

- Optical BK7 Glass Dome
- Autofocus
- Whitebalance Control
- 16x Digital Zoom
- 13.19 Megapixel Still Capture

M5 HD Camera Module features and specifications are subject to change without notice.

LED Light Module Specifications

Depth Rating

- 2,000 meters (6,500 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 Male / Female Connector (Stackable)

Power Input

- 48 VDC at 76 Watt

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 per light module
- Individually Controlled Arrays (16 emitters per array, 32 total)
    - 60 Degree Spot Beam
    - 110 Degree Flood Beam
- Hard Anodized, Potted Housing

M5 LED Light Module features and specifications are subject to change without notice.

Specifications for the ROV Accessories

Specifications for the VideoRay MSS Defender accessories can be found on the respective information pages of each accessory. See the Optional Accessories section for more information.

Tether Specifications

Tether Diameter

Units \ Type	Negative	Neutral	Performance
mm	8.51 +/- 0.38	11.18 +/- 0.50	8.18 +/- 0.50
inches	0.335 +/- 0.015	0.440 +/- 0.020	0.322 +/- 0.020

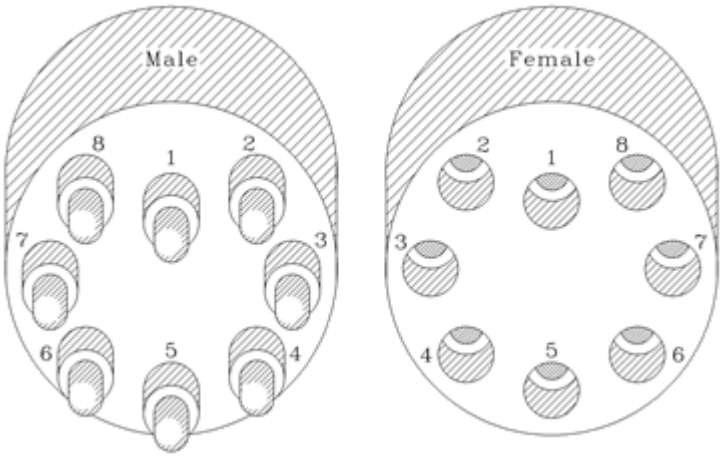
New tether was introduced in 2018. These tethers include a braided Kevlar around the conductors, are slightly different diameter and can be identified by an "FB" code printed on the tether.

Units \ Type	FB Neutral	FB Performance
mm	12.2 +/- 0.25	9.1 +/- 0.25
inches	0.440 +/- 0.010	0.358 +/- 0.010

Minimum Tether Bend Radius

Units \ Type	Negative	Neutral	Performance
mm	88.9	114	82.5
inches	3.5	4.5	3.25

Tether Connector Pin Configuration



Tether pin numbering in the connector is shown above. When looking at the mating surface of the connector, Pin 1 is the offset pin / socket. For male connectors, pins 2-8 proceed in a clockwise direction. For female connectors, sockets 2-8 proceed in a counter-clockwise direction.

Tether Pin Function and Conductor Wire Gauge

Pin	Function	Negative	Neutral	Performance
1	Interlock (GND)	24	24	28
2	Interlock (Sense)	24	24	28
3	400 VDC +	16 (x2)	20 (x2)	24 (x2)
4	M100 EOP+	24	28	28
5	Ground	16 (x2)	20 (x2)	24 (x2)
6	M100 EOP-	24	28	28
7	RS-485 A	24	28	28
8	RS-485 B	24	28	28

⚠ All conductors are straight through, such that pin 1 in the male connector is connected to socket 1 in the female connector, and so on for all eight pins / sockets.

⚠ Conductor pairs 1 & 2, 4 & 6 and 7 & 8 are twisted.

⚠ Pins 3 and 5 use 2 conductors each for maximizing power transmission and tether flexibility.

Tether Buoyancy

Performance and Neutral tether includes 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 sink slightly.

Tether Strength

All tether types include Kevlar that is rated at 450 kg (1,000 pounds), the connectors are rated 80 kg (175 pounds).

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

The maximum usable tether length is limited by the ability of the tether to transmit power and data signals. The maximum usable tether length of MSS systems is about 550 meters (1,800 feet). MSS systems can fiber tether to extend the range. See the Tether Management section of the Operations Guide for more information.

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

System Voltage Advisory

AC Input

Input voltage is universal at 100-240 VAC; 50, 60 Hz. The power requirement for the MSS operating at full power settings is 3,000 Watts. A 2,000 Watt source (i.e. generator) can be used if the system will not be used at full power settings.

ROV DC Power

Historically, the tether voltage to power the ROV has been increasing. Economy models (including the Scout, Explorer and Voyager), Pro 3 variants and the Pro 4 Ultra use 48 V DC for vehicle power. The Pro 4 uses 74 V DC. The MSS (Mission Specialist Series) uses 400 V DC with plans to use higher voltages in the future. Systems with voltages higher than 48 V DC include a LIM (Line Insulation Monitor) protection module in the ROV DC circuit.

CAUTION System components should not be connected to voltage sources higher than their rating.

VideoRay Negative, Neutral and PPT tethers are rated to 600 V DC and are safe to use on any system through the MSS 400 V DC.

CAUTION The standard TDS and Extended TDS are only rated to 300 V DC and should not be used with MSS systems or components.

The new version of the extended TDS is available that includes a 600 V rated slip ring.

If you have any questions about system voltage and compatibility, contact VideoRay Support.

Equipment Guide

Understanding the features and capabilities of the MSS equipment is essential to get the most value out of using the system. The sections within this Equipment Guide provide details about each of the components.

Topics in this Section

- ROV

- User Control Console

- Hand Controller

- Tether

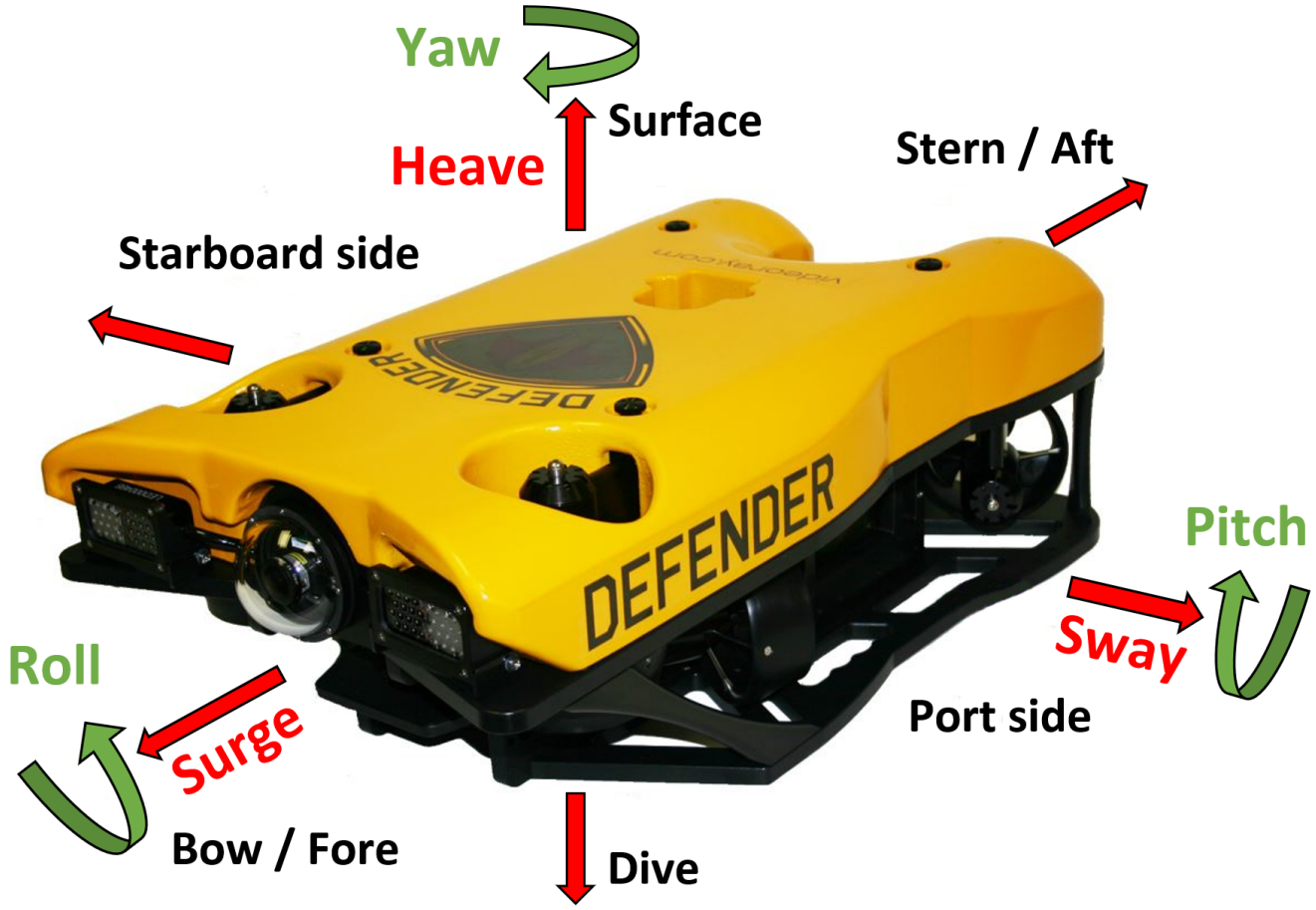
ROV

The MSS ROV consists of modular components (thrusters, lights, cameras, sensors) and a custom frame. Each MSS vehicle is designed to meet the requirements of a specific underwater mission. The frame and sensor payload can be optimized to deliver the vehicle to its intended destination and accomplish the tasks, whether that be recording video, taking measurements of various parameters, or navigation and remote sensing such as sonar or laser imaging.

The sections that follow provide information about the frame and modular components.

ROV Nomenclature

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



ROV Orientation and Directions Reference

Bow - The front of the ROV.

Stern - The rear of the ROV

Port - The left side of the ROV when facing forward.

Starboard - The right side of the ROV when facing forward.

Fore - Towards the front or The forward direction.

Aft - Towards the rear of the rearward direction.

Surface - To ascend or move up in the water column to a shallower depth.

Dive - To descend or move down in the water column to a deeper depth.

ROV Attitude and Motion Reference

Surge - Forward and Reverse motion of the ROV, forward is positive.

Heave - Up and Down motion of the ROV, up is positive.

Sway - Left (to port) and Right (to starboard) lateral motion of the ROV, left is positive.

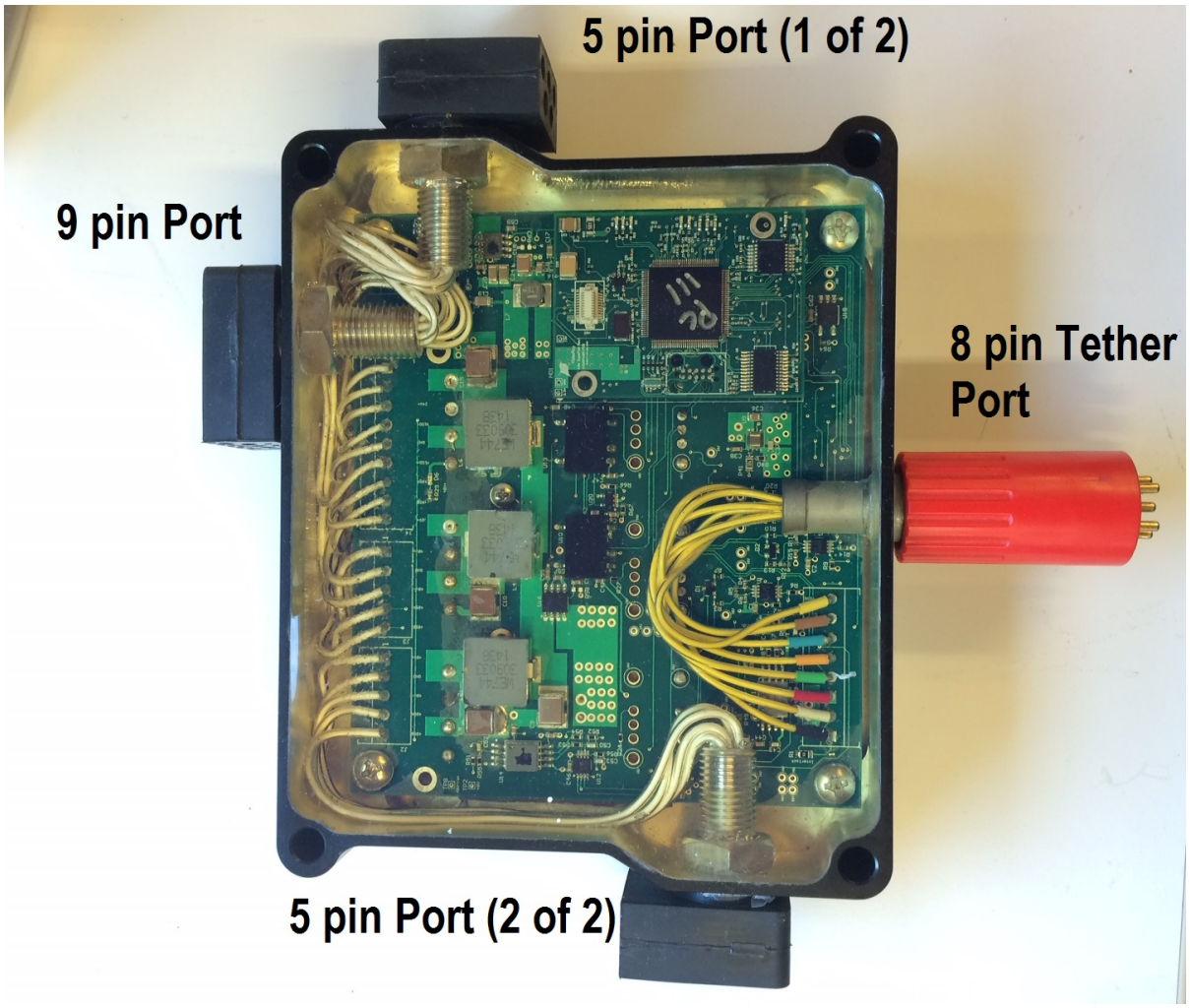
Yaw - Right (to starboard) and Left (to port) rotational motion of the ROV, right (clockwise, viewed from the top) is positive.

Pitch - Bow Up or Bow Down inclination of the ROV, bow up (clockwise, viewed from the port side) is positive.

Roll - Port UP or Port Down relative to Starboard, port up (clockwise, viewed from the rear) is positive.

Power Module

The Power Module receives power from the topside and converts it to power levels required by the various modules, sensors and accessories.



8 Pin Male Tether Connector

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

5 Pin Female High Power (Thruster, Lights) Connector (2)

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

Power is rated at 750 Watts per port for 1,500 Watts total.

9 Pin Female Communications Module Interface Connector

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 +

Power is rated at 300 Watts for the 24 Volt circuit and 120 Watts for the 12 Volt circuit.

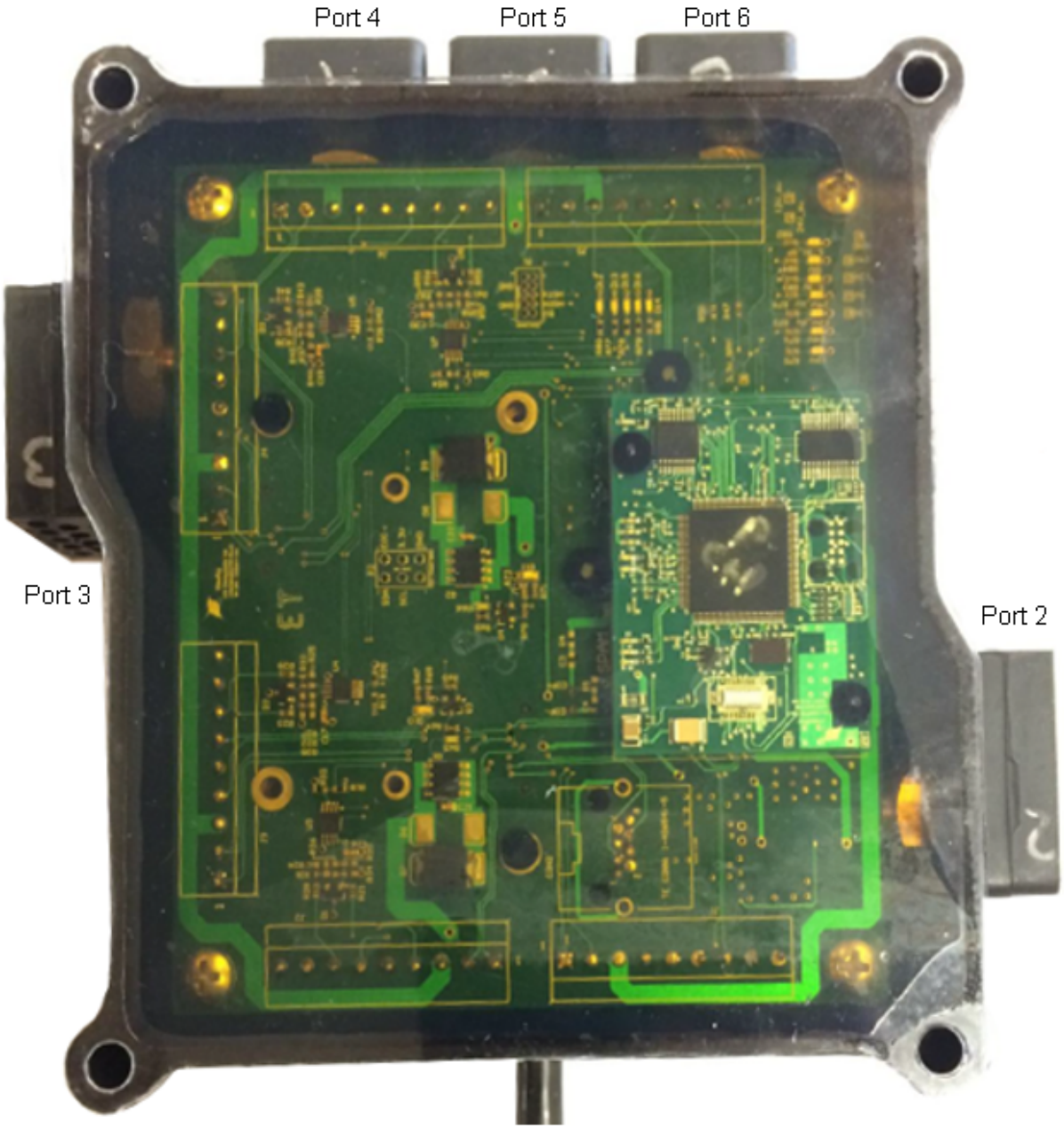
Power Module Arrangement

The Defender vehicle power module is configured as follows:

Power Module Location	Group ID	Node ID	Application ID	TCP/IP Address	TCP/IP Port Number	Notes
Center Starboard	196	1	N/A	192.168.1.65	1 (7446)	

Communications Module

The communications module is the "brains" of the vehicle and coordinates vehicle control systems and provides data paths for sensors and accessories.



9 Pin Interface Connectors

Pin	Male Connector (port 1)	Female 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 +

Power is rated at 300 Watts each for the 24 and 12 Volt circuits.

Communications Module Arrangement

Port	Module/Device	TCP	Baud Rate	Notes

Number	Assignment	Port		
1	Power	7444 (vrport1)	115200	
N/A	Communications Module	7444 (vrport1)	115200	
2	AHRSD	7445		
3	High Definition Camera	7446		
4	Oculus Sonar	7447		
5	Nortek DVL	7448		
6	Rotating Manipulator, GPS	7449	38400	

Defaults: Group ID - 193; Node ID - 2; IP address - 192.168.1.64; RS-485 accessible

AHRS Module

AHRS - **A**ttitude and **H**eading **R**eference **S**ystem

The AHRS 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.

⚠ The AHRS compass may require a Magnetic Field Calibration. See the Compass Calibration page for more information.

Cable Pinout

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 +

AHRS Module Arrangement

The Defender vehicle AHRSD is mounted in the top center of the ROV frame.

AHRSD Location	Group ID	Node ID	Application ID	TCP/IP Address	TCP/IP Port Number	Notes
Top Center	194	3	N/A	192.168.1.65	2 (7446)	Port 7444 IMU, Port 7445 Depth

Thruster Module

MSS 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.

Thruster Propeller

The propellers are designed to be used on counter-rotating thruster arrangements to eliminate torque roll or yaw. Propellers are identified by their pitch orientation using left and right based on their pitch. The convex edge of the propeller blade is the leading edge during motion that is considered forward for that thruster.

- 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-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.

Cable Pinout

The Thruster connector uses a male / female stackable connector allowing the thrusters and LED lights to be connected in series.

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 vehicle is a Defender frame that uses a vectored horizontal thruster arrangement, and three vertical thrusters. The thrusters are configured as shown below:

Thruster Location	Group ID	Node ID	Motor ID	Propeller Orientation	Reverse Option	Maximum Power (Watts)	Notes
Forward Port	129	5	0	Right	Disable	400	
Forward Starboard	129	6	1	Left	Enable	400	
Aft Starboard	129	7	2	Right	Disable	400	
Aft Port	129	8	3	Left	Enable	400	

Vertical Forward Port	129	9	6	Right	Enable	400	
Vertical Forward Starboard	129	10	4	Left	Disable	400	
Vertical Aft	129	20	5	Left	Enable	400	

Camera Module

The camera module provides a live video feed from the vehicle to the surface.

Cable Pinout

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 Arrangement

High Definition Camera

Camera Location	Group ID	Node ID	TCP/IP Address	Notes
Forward Center	196	4	192.168.1.11	

LED Light Module

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

Cable Pinout

The LED Light connector uses a male / female stackable connector allowing the LED lights and thrusters to be connected in series.

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

Lights Arrangement

Light Location	Group ID	Node ID	Application ID	Notes
Forward Top Port	131	11		
Forward Top Starboard	131	12		

ROV Connections

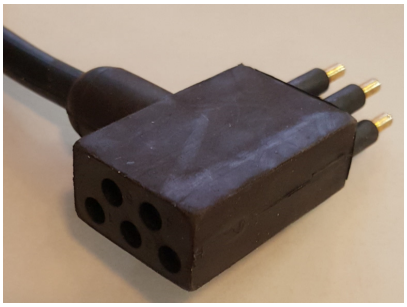
The MSS ROV system uses 3 types of connectors for power and communications between the control panel, vehicle modules and accessories.

8 Pin Tether Connector

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 numbering starts at 1 for the offset pin and is clockwise on the male connector and counter clockwise on the female connector.

5 Pin Thrusters and Lights Connector

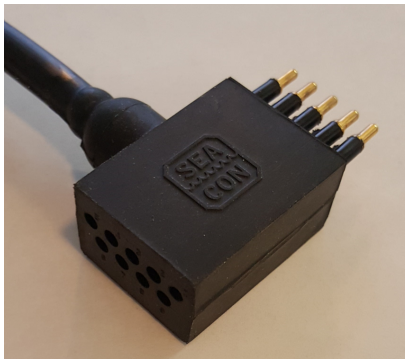


Pin	Function
1	48 V DC +
2	Vehicle Local Ground (12 V, 48 V return)
3	48 V DC return
4	RS-485 A
5	RS-485 B

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

9 Pin Accessory Connector

Pin	Function
1	ETH_RXP-
2	ETH_RXP+
3	24 V DC +



4	ETH_TXP +
5	Ground
6	ETH_TXP -
7	RS-485 A
8	RS-485 B
9	12 V DC +

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

ROV Connections

User Control Console

The User Control Console provides power, communications and a video interface between the surface and the ROV through the tether. The computer, which runs software to control the ROV, is housed in the User Control Console along with a display monitor .

User Control Console Power Specifications

The VideoRay MSS operates on typical residential 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 minimum.

The system includes a GFCI (Ground Fault Circuit Interrupter) / Circuit Breaker to protect the operator.

The power in the tether is 400 Volts DC. This circuit is protected by a LIM (Line Insulation Monitor).

The procedures for testing the circuit safety components can be found in the Pre-Dive Preparations section of the Quick Start Instructions.

CAUTION Do not block the User Control Console fans. Blocking the fans can lead to overheating and component failure.

Display Monitor Tilt Arm

The Display Monitor Tilt Arm on the left side of the User Control Console can be used to adjust the angle of the User Control Console lid and monitor. To adjust the angle of the monitor, loosen the locking collar, adjust the lid to the desired angle and tighten the locking collar.

CAUTION Make sure to loosen the display monitor tilt arm before closing the User Control Console lid, and be careful when closing the lid to avoid damaging the computer or monitor or pinching any cables.

Safety Circuits

The User Control Console includes three safety circuit components.

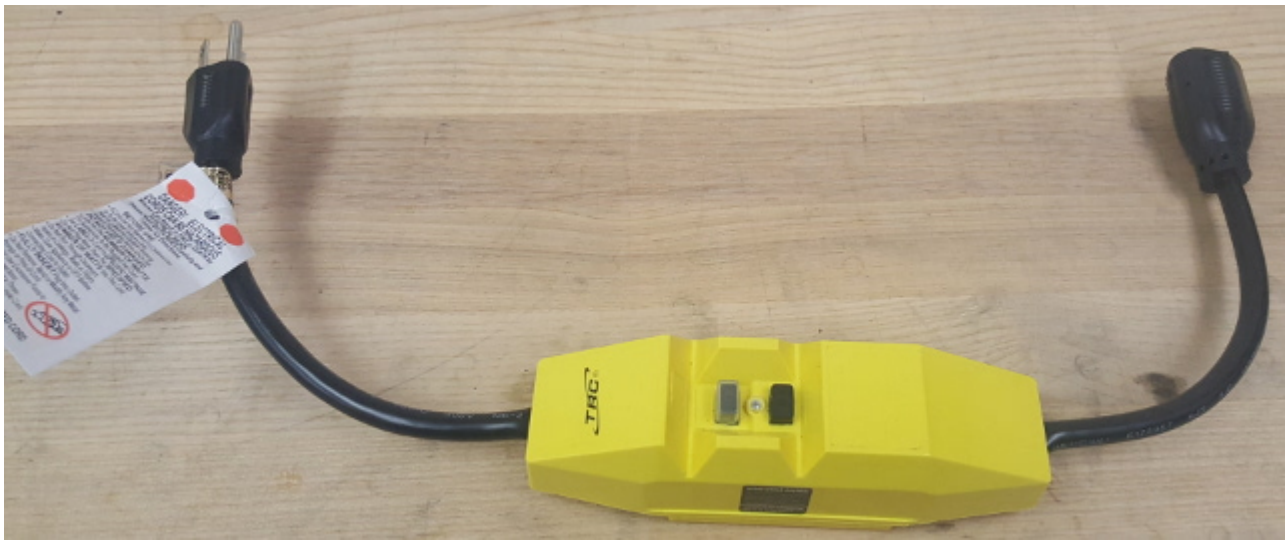
- GFCI (Ground Fault Circuit Interrupter)
- LIM (Line Insulation Monitor)
- ROV Power Safety Interlock

GFCI (Ground Fault Circuit Interrupter)

The GFCI protects the operator from shock from the AC circuit of the power source.

The GFCI is inline with the power cord. When initially connected to a power source, it is in the Off state. You must press the Reset Button to enable it. When enabled, the green LED will be illuminated.

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



LIM (Line Insulation Monitor)

The LIM protects the operator and persons in the water nearby from shock from the DC circuit of the tether. While the GFCI switches are part of the GFCI component and must be turned on to operate the User Control Console, the LIM is automatically enabled when the system is turned on. The LIM operates on a principle similar to the GFCI and monitors the quality of the insulation of the conductors. If the resistance between the conductors drops below the safe threshold, the LIM will trip.

The MSS LIM is two stage. When the LIM detects the resistance between the ROV power conductors falls below 900 kOhms, the yellow LIM Alarm A1 LED will turn on, but the power circuit will remain on. When the LIM detects the resistance falls below 200 kOhms, the yellow LIM Alarm A2 LED will turn on and the ROV power circuit will be disabled. The LIM can be reset by pressing and holding the R button. The yellow LIM Alarm light should turn off. To test the LIM, press and hold the T button. If the LIM continues to trip, the system should be inspected for a fault before being used.

The LIM has additional features that are described in more detail in the LIM Module Manual.

ROV Power Safety Interlock

The ROV Power Safety Interlock prevents the ROV power from being engaged unless an ROV is plugged into the tether. This feature protects users from accidentally contacting the ROV power circuit of an open tether connector.

See the User Control Console Switches and Connections section for more information about these components and their locations, and see the Pre-Dive Preparations section of the Quick Start Instructions for information about testing these components.

Switches and Connections

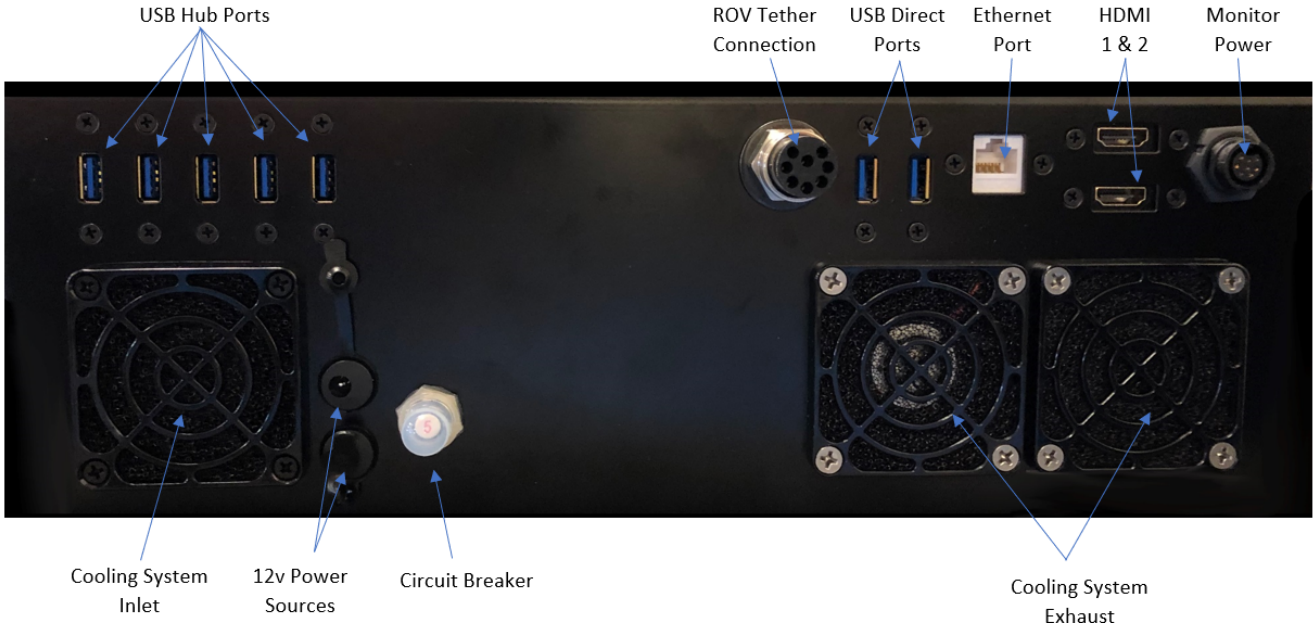
The User Control Console top includes the following switches:

SWITCH	LOCATION	FUNCTION
Main Power	User Control Console top upper	Turns the User Control Console on and off.

Switch	left	
ROV Power Switch	User Control Console top central left	Turns the ROV power on and off. Twist in the direction of the arrows to turn on the ROV power and press the switch to turn it off.
LIM Module	User Control Console top central right	Test and Reset buttons can be found on the LIM.

The User Control Console top includes the following connections:

CONNECTION	LOCATION	FUNCTION
Power (100-240 Volts AC, 50, 60 Hz)	IEC male	Used to connect the User Control Console to a power source.



The User Control Console side includes the following connections:

CONNECTION	TYPE	FUNCTION
Tether Whip (Specifications)	8 pin round female	Used to connect the User Control Console to the tether for power, communications, video and accessory support.
Monitor Power		Provides 12 Volts DC. Used to provide power to the monitor.
Monitor Signal	Display Port Female	Used to provide the video signal to the monitor.
USB Ports (3)	Type A female	Can be used to connect USB devices to the computer via the User Control Console.
Ethernet	RJ-45 female	Can be used to connect the User Control Console to the computer for Ethernet based ROV accessories.

⚠ The Display Port cable uses a locking locking connector. Make sure to press the release button when disconnecting the cable to avoid damaging the connector.

Computer

The computer provides the hardware and operating system platform for VideoRay ROV control software and image and video editing and production. The computer is embedded in the User Control Console.

⚠ For information about using the computer in general, see the instructions that came with it.

⚠ VideoRay does not recommend installing additional hardware or software on the computer unless you are familiar with its operation and confident it will not interfere with the VideoRay control software or the computer's ports. Software that is packaged with VideoRay accessories has been tested and is approved for use.

The computer includes the following connections (which are passed through to connectors on the User Control Console):

CONNECTION	TYPE	FUNCTION
USB (3)	Type A female	Can be used to connect USB devices to the computer.
Ethernet	RJ-45 female	Can be used to connect the computer to a network, or the User Control Console for Ethernet based accessories.
Display Port	Display Port Female	Provides an HD video signal. This can be used to connect the computer to an external monitor.

Additional Specifications

Operating System

- Ubuntu

Temperature

- Operating Temperature: -40 C - 70C
- Storage Temperature: -40 C - 85C

Power Input

- 9 - 48 VDC

Hard Disk Space

- 256 Gb

⚠ Computer specifications are subject to change without notice.

HD Monitor

CAUTION The display port cable has a latching connector. Make sure to press the latch button before trying to remove the connector.

The monitor includes a brightness knob.

The monitor includes the following connections:

CONNECTION	Type	FUNCTION
Power	12 Volt DC	Used to connect the monitor to a power source. The control panel provides a matching 12 Volt DC connector.
Display Port In	Display Port	Used to connect the monitor to the computer.

Additional Specifications

Size

- 18.5" Diagonal

Power Input

- 12 VDC

Native Resolution

- 1920 X 1080

Brightness

- **High Bright ? 1000 nits**

Features

- **Wide Viewing Cone**
- **10 Point PCAP Touch**
- **Front Full Range Diming Pot**

Monitor specifications are subject to change without notice.

Hand Controller

The hand controller is used to operate the VideoRay and its features. Several types of hand controllers are supported. Controllers not included in your configuration are available from VideoRay for purchase. Supported controllers include:

VideoRay IP65 Hand Controller

Microsoft Xbox Elite Gamepad Style Hand Controller

The hand controller functions are described in more detail in the following pages of this guide.

Hand Controller Compatibility

Any Microsoft® Windows® compatible game controller can be used with the MSS, but each controller requires a configuration file to map the joystick, buttons and knobs to the ROV functions.

Microsoft is a registered trademark of Microsoft. Windows is a registered trademark of Microsoft.
Logitech is a registered trademark of Logitech.

Forward / Reverse Control

The joystick is used to control the forward / reverse motion of the ROV.

Location

⚠ The Joystick does not have a label.

Use

Displace the joystick forward (away from you) to move the ROV forward. Displace the joystick rearward (toward you) to move the ROV backward.

The greater the displacement from the center position, the faster the ROV will move or turn in that direction.

The joystick can be moved in any direction to simultaneously move forward or backward while turning or moving laterally.

CAUTION Do not run the horizontal thrusters in air for an extended period of time. Doing so may cause overheating and damage to the components.

Forward / Reverse Control

Lateral Control

The joystick is used to control the lateral motion of the ROV.

Location

⚠ The Joystick does not have a label.

Use

Displace the Joystick to the left to slide the ROV to its left. Displace the Joystick to the right to slide the ROV to its right.

The greater the displacement from the center position, the faster it will move or turn in that direction.

The joystick can be moved in any direction to simultaneously move laterally while moving forward/backward or turning.

CAUTION Do not run the horizontal thrusters in air for an extended period of time. Doing so may cause overheating and damage to the components.

Yaw Control

The joystick is used to control the yaw motion of the ROV.

Location

⚠ The Joystick does not have a label.

Use

Rotate the Joystick to the left to turn (yaw) the ROV to its left. Rotate the Joystick to the right to turn (yaw) the ROV to its right.

Displace the Joystick to the left to slide the ROV to its left. Displace the Joystick to the right to slide the ROV to its right.

The greater the displacement from the center position, the faster it will move or turn in that direction.

The joystick can be moved in any direction to simultaneously turn while moving forward/backward or laterally.

CAUTION Do not run the horizontal thrusters in air for an extended period of time. Doing so may cause overheating and damage to the components.

Yaw Control

Depth Control

The Depth Control knob is used to make the ROV dive or surface by controlling the direction and amount of vertical thrust.

Knob Location and Label

Use

Rotate the Depth Control knob forward (counterclockwise) to dive. The greater the rotation from the center position, the faster it will dive. Rotate the Depth Control knob backward (clockwise) to surface. The greater the rotation from the center position, the faster it will surface.

CAUTION Do not run the vertical thruster in air for an extended period of time. Doing so may cause overheating and damage to the components.

⚠ The Depth Control Knob has a center detent so that, by feel, you can tell when the knob is centered.

Pitch Up

The Pitch Up button increases the vertical angle of the vehicle in the upward direction.

Button Locations and Labels

Pitch Up

Use

Press the Pitch Up button to pitch the nose of the vehicle up in 5 degree increments.

You can press the Pitch Down button to decrease the pitch, or press the Pitch Reset button to return to level.

Pitch Up

Pitch Down

The Pitch Down button increases the vertical angle of the vehicle in the downward direction.

Button Locations and Labels

Pitch Down

Use

Press the Pitch Down button to pitch the nose of the vehicle down in 5 degree increments.

You can press the Pitch Up button to increase the pitch, or press the Pitch Reset button to return to level.

Pitch Down

Pitch / Roll Reset

The Pitch / Roll Reset button restores the vehicle to a level attitude.

Button Locations and Labels

Pitch Reset

Use

Press the Pitch / Roll Reset button to restore the vehicle to a level attitude.

You can press the Pitch Up button to increase the pitch, or press the Pitch Down button to decrease the pitch.

Pitch / Roll Reset

All Autos Off

The All Autos Off button disables any active auto mode and dynamic positioning.

Button Locations and Labels

All Autos Off

Use

Press the All Autos Off button to disable all active auto modes and dynamic positioning.

All Autos OFf

Lights Intensity

The Lights knob controls the intensity of the lights.

Control Location and Labels

Lights Intensity

Use

Rotate the Lights Intensity knob counter clockwise to dim the Lights and clockwise to increase the intensity of the lights.

CAUTION Do not leave the lights on for an extended period of time. Doing so may cause overheating and damage to the components.

Lights Intensity

Camera Tilt Up

The Camera Tilt Up button increases the vertical angle of the front camera in the upward direction.

Button Locations and Labels

Tilt Up

Use

Press and hold the Tilt Up button to tilt the front camera up. Release the button when the camera has tilted to the desired setting or has reached the end of its range.

⚠ You should not continue to hold either tilt button when the camera has reached the end of its tilt range.

Camera Tilt Up

Camera Tilt Down

The Camera Tilt Up button increases the vertical angle of the front camera in the downward direction.

Button Locations and Labels

Tilt Down

Use

Press and hold the Tilt Down button to tilt the front camera down. Release the button when the camera has tilted to the desired setting or has reached the end of its range.

⚠ You should not continue to hold either tilt button when the camera has reached the end of its tilt range.

Camera Tilt Down

Camera Focus In

The Camera Focus In button adjusts the focus of the front camera for near objects.

Button Location and Label

Focus In

Use

Press and hold the Camera Focus In button to adjust the camera focus for near objects. Release the button when the camera has focused to the desired setting or has reached the end of its range.

Camera Focus In

Camera Focus Out

The Camera Focus Out button adjusts the focus of the front camera for far objects.

Button Location and Label

Focus Out

Use

Press and hold the Camera Focus Out button to adjust the camera focus for far objects. Release the button when the camera has focused to the desired setting or has reached the end of its range.

Camera Focus Out

Snapshot

The Snapshot button saves a still image from the active camera.

Button Location and Label

Use

Press the Snapshot button to capture a still image from the active camera.

Snapshots are saved as .JPG formatted files in the gss_logs folder. They are automatically named by date and time. For more information, see the Snapshots section of the Operations Guide.

You can capture a snapshot will recording video.

Video Record

The Video Record button toggles the video record feature for the active camera.

Button Location and Label

Use

Press the Video Record button to start recording a video from the active camera. Press the Video Record button again to stop recording a video from the active camera.

When the recording is active, the record icon button is illuminated green.

Video Recordings are saved as .MP4 formatted files in the gss_logs folder. They are automatically named by date and time. For more information, see the Video Recording section of the Operations Guide

You can capture snapshots while recording video.

Manipulator Open

The Manipulator Open button opens the jaws of the manipulator.

Button Locations and Labels

Manipulator Up

Use

Press and hold the Manipulator Open button to open the jaws of the manipulator. Release the button when the manipulator jaws open the desired amount or have reached the end of their range.

⚠ You should not continue to hold the Manipulator Open button when the jaws have reached the end of their range.

Manipulator Open

Manipulator Close

The Manipulator Close button closes the jaws of the manipulator.

Button Locations and Labels

Manipulator Close

Use

Press and hold the Manipulator Close button to close the jaws of the manipulator. Release the button when the manipulator jaws close the desired amount or have reached the end of their range.

⚠ You should not continue to hold the Manipulator Close button when the jaws have closed on an object or reached the end of their range. You can press and release the button a few times to tighten the jaws.

Manipulator Close

Manipulator Rotate

The Manipulator Rotate knob rotates the jaws of the manipulator.

Button Locations and Labels

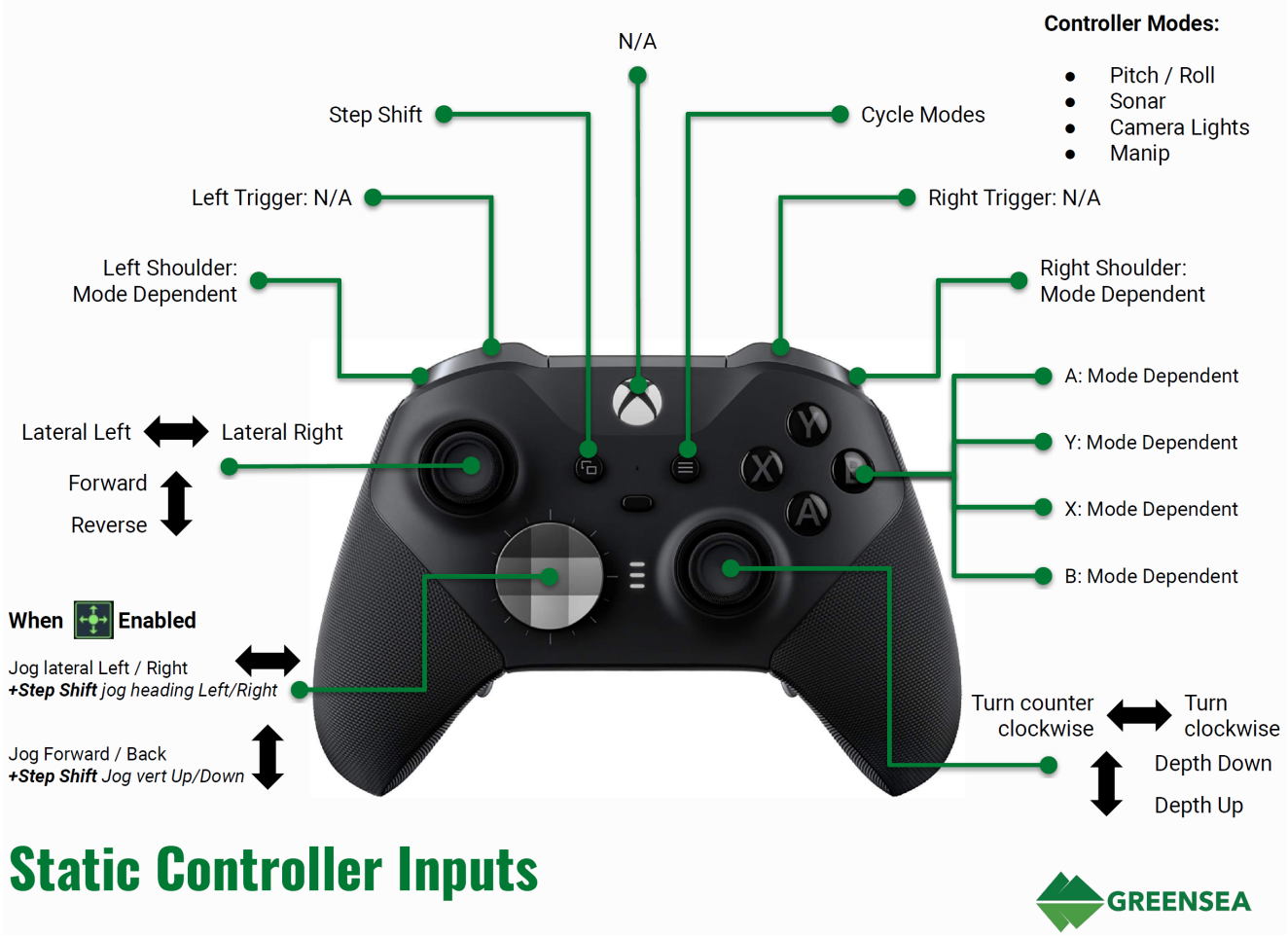
Manipulator Rotate

Use

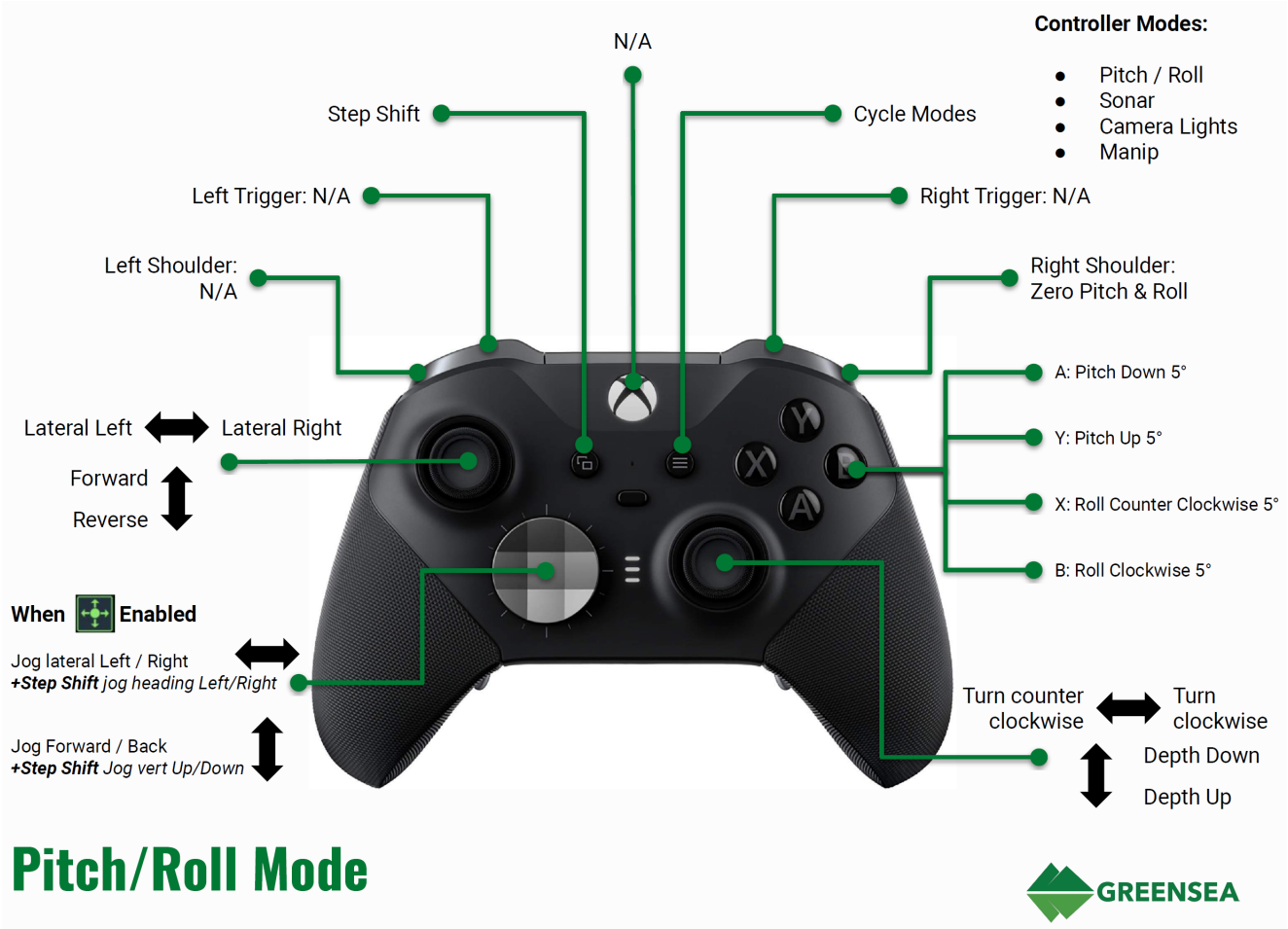
Rotate the Manipulator Rotate knob clockwise to rotate the manipulator jaws clockwise (when viewed from the rear of the manipulator). Rotate the Manipulator Rotate knob counterclockwise to rotate the manipulator jaws counterclockwise (when viewed from the rear of the manipulator). Center the Manipulator Rotate knob to stop the manipulator jaws from rotating.

Manipulator Rotate

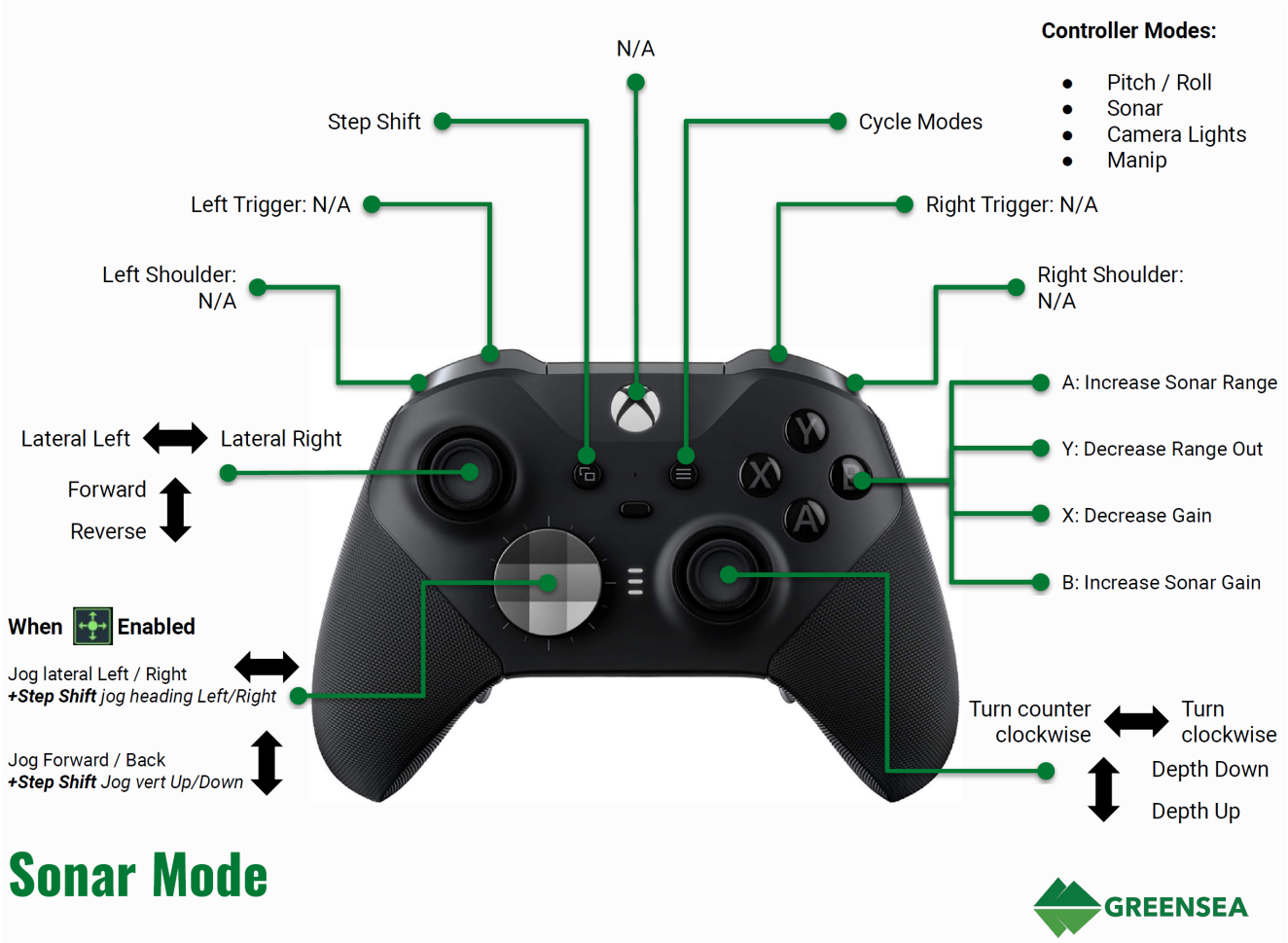
Common Controller Inputs



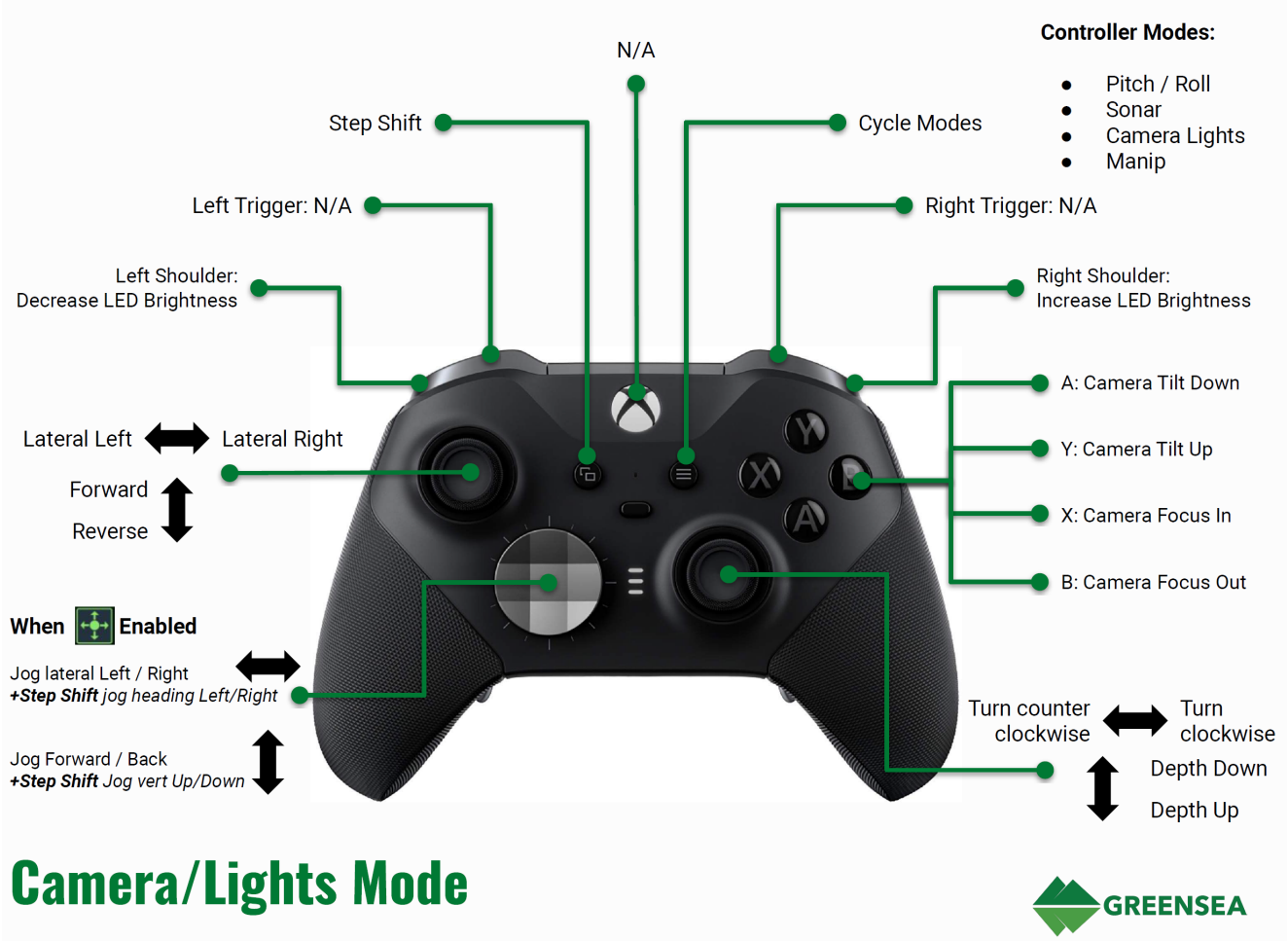
Pitch/Roll Mode


Controller Modes:
Pitch / Roll
Sonar
Camera Lights
Manip
N/A
Step Shift
Cycle Modes
Left Trigger: N/A
Right Trigger: N/A
Left Shoulder: N/A
Right Shoulder: Zero Pitch & Roll
A: Pitch Down 5°
Y: Pitch Up 5°
X: Roll Counter Clockwise 5°
B: Roll Clockwise 5°
Lateral Left
Lateral Right
Forward
Reverse
When Enabled
Jog lateral Left / Right
+Step Shift jog heading Left/Right
Jog Forward / Back
+Step Shift Jog vert Up/Down
Turn counter clockwise
Turn clockwise
Depth Down
Depth Up
Pitch/Roll Mode
GREENSEA

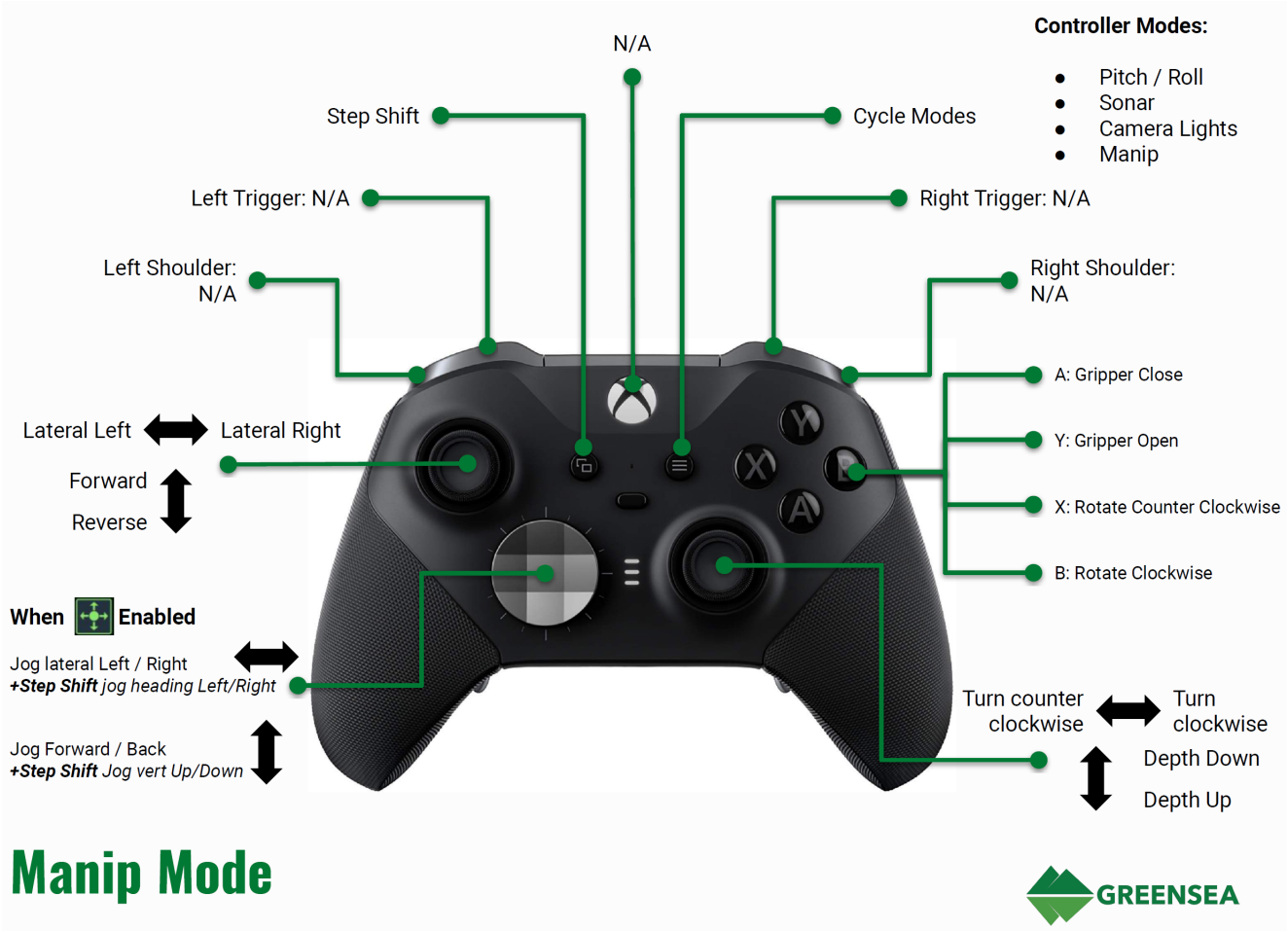
Sonar Mode



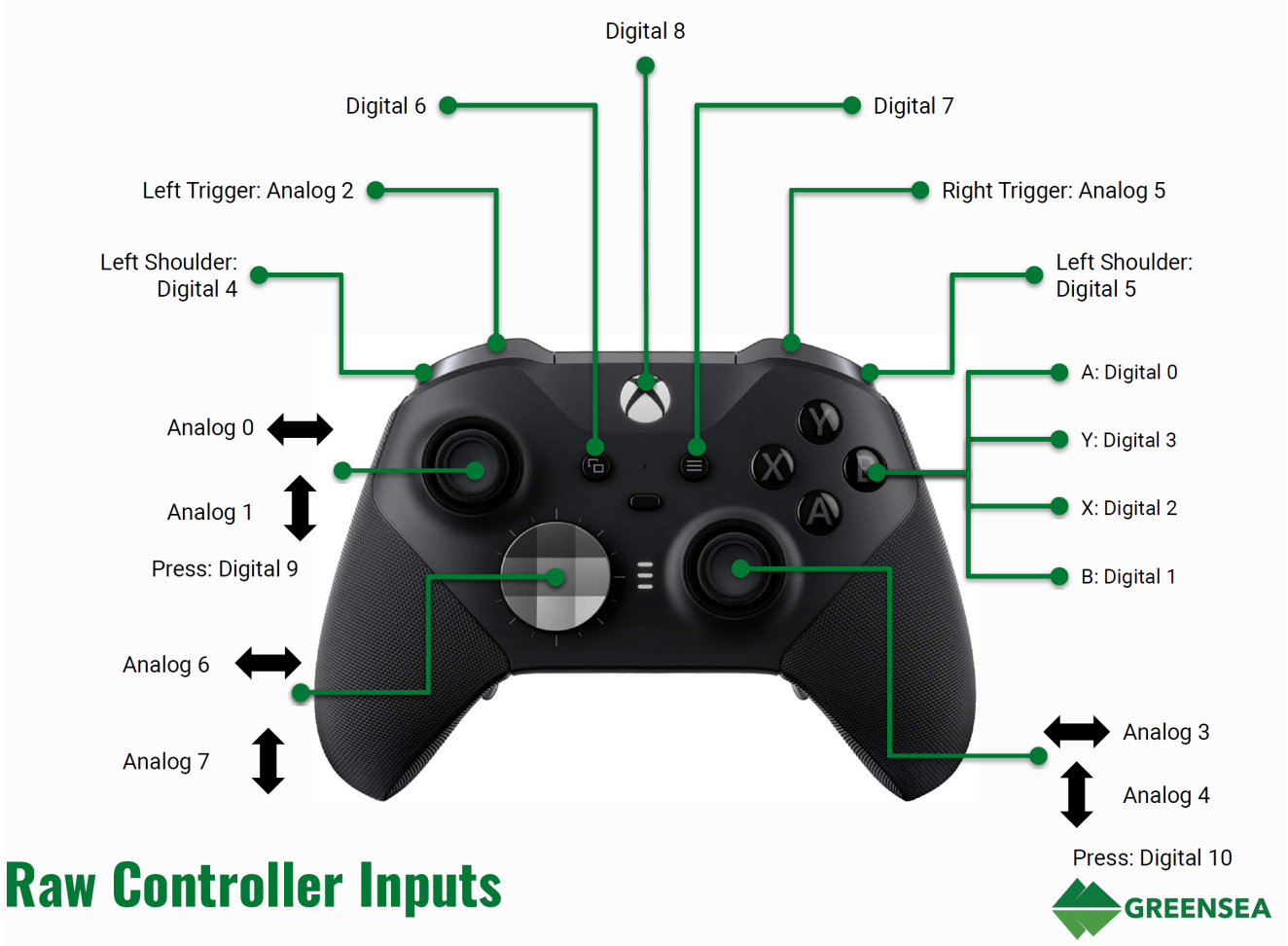
Camera/Lights Mode



Manipulator Mode


Controller Modes:
Pitch / Roll
Sonar
Camera Lights
Manip
N/A
Step Shift
Cycle Modes
Left Trigger: N/A
Right Trigger: N/A
Left Shoulder: N/A
Right Shoulder: N/A
A: Gripper Close
Y: Gripper Open
X: Rotate Counter Clockwise
B: Rotate Clockwise
Lateral Left
Lateral Right
Forward
Reverse
When Enabled
Jog lateral Left / Right
+Step Shift jog heading Left/Right
Jog Forward / Back
+Step Shift Jog vert Up/Down
Turn counter clockwise
Turn clockwise
Depth Down
Depth Up
Manip Mode
GREENSEA

Raw Input



Raw Controller Inputs

GREENSEA

Tether

Tether connects the ROV to the surface and provides power, communications, video and an APIC (Auxiliary Pair of Independent Conductors) for accessory use. The 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 can be purchased 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 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 ROV, 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 Management section of the Operations Guide 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.

The strain relief system includes a carabineer that could get hooked on something underwater and cause the ROV to become trapped. To avoid this possibility, tape over the carabineer with electrical or duct tape.

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 tether connectors with pure silicone spray.

Tether Specifications

Tether Diameter

Units \ Type	Negative	Neutral	Performance
mm	8.51 +/- 0.38	11.18 +/- 0.50	8.18 +/- 0.50
inches	0.335 +/- 0.015	0.440 +/- 0.020	0.322 +/- 0.020

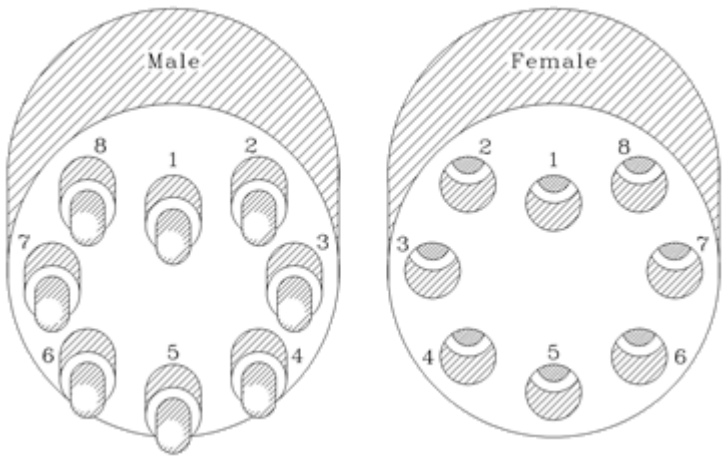
New tether was introduced in 2018. These tethers include a braided Kevlar around the conductors, are slightly different diameter and can be identified by an "FB" code printed on the tether.

Units \ Type	FB Neutral	FB Performance
mm	12.2 +/- 0.25	9.1 +/- 0.25
inches	0.440 +/- 0.010	0.358 +/- 0.010

Minimum Tether Bend Radius

Units \ Type	Negative	Neutral	Performance
mm	88.9	114	82.5
inches	3.5	4.5	3.25

Tether Connector Pin Configuration



Tether pin numbering in the connector is shown above. When looking at the mating surface of the connector, Pin 1 is the offset pin / socket. For male connectors, pins 2-8 proceed in a clockwise direction. For female connectors, sockets 2-8 proceed in a counter-clockwise direction.

Tether Pin Function and Conductor Wire Gauge

Pin	Function	Negative	Neutral	Performance
1	Interlock (GND)	24	24	28

2	Interlock (Sense)	24	24	28
3	400 VDC +	16 (x2)	20 (x2)	24 (x2)
4	M100 EOP+	24	28	28
5	Ground	16 (x2)	20 (x2)	24 (x2)
6	M100 EOP-	24	28	28
7	RS-485 A	24	28	28
8	RS-485 B	24	28	28

⚠ All conductors are straight through, such that pin 1 in the male connector is connected to socket 1 in the female connector, and so on for all eight pins / sockets.

⚠ Conductor pairs 1 & 2, 4 & 6 and 7 & 8 are twisted.

⚠ Pins 3 and 5 use 2 conductors each for maximizing power transmission and tether flexibility.

Tether Buoyancy

Performance and Neutral tether includes 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 sink slightly.

Tether Strength

All tether types include Kevlar that is rated at 450 kg (1,000 pounds), the connectors are rated 80 kg (175 pounds).

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

The maximum usable tether length is limited by the ability of the tether to transmit power and data signals. The maximum usable tether length of MSS systems is about 550 meters (1,800 feet). MSS systems can fiber tether to extend the range. See the Tether Management section of the Operations Guide for more information.

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

Tether Strain Relief

The Defender strain relief is used to secure the ROV to the tether to prevent separation and loss of the vehicle if the tether connection becomes separated. The strain relief also minimized the load on the tether connector.

There are two different strain relief systems. One is for use between the ROV and tether and the second is for use when connecting two tethers together. There is not a strain relief system for the topside connection.

Instructions for using these strain relief systems is found on the following pages.

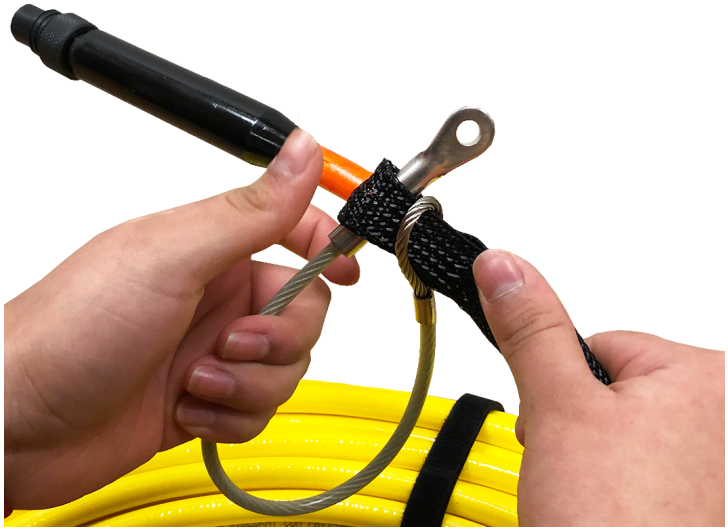
ROV to Tether Strain Relief

Use the following procedures to install and secure the vehicle to the tether to prevent loss of the vehicle due to a connection failure. The strain relief cable may already be attached to the tether. If so, you can skip steps 1 to 3.

CAUTION Failure to connect the strain relief properly may result in loss of the vehicle.

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. Align the pins and insert the male ROV whip connector to the female tether connector until the faces mate. Secure the connection with the locking collar.

5. Insert the strain relief eye socket into the hole in the frame and secure it with the retaining screw.

6. Make sure the connection is secure and 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 a protruding 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.

Tether to Tether Strain Relief

When connecting multiple tethers for an operation, each connection should be secured with a tether to tether strain relief to prevent separation of the connection. Use the following procedures to install and secure the strain relief cord for tether to tether connections. The ROV strain relief cable may already be attached to the tether. If so, it should be removed.

CAUTION Failure to connect the strain relief properly may result in loss of the vehicle.

1. Ensure that you have all three parts of the tether to tether strain relief as shown below.

2. Ensure that both carabiners are labeled with '600lbs'. Older models of VideoRay ROVs used the '450lbs' rated carabiners and these should not be used with MSS systems.

CAUTION Using the incorrect carabiners may cause the strain relief to fail under loading.

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 a protruding 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.

Connections Summary

The following connections are required:

1. Connect the female end of the tether to the ROV.
2. Secure the tether strain relief to the ROV.
3. Connect the male end of the tether to the User Control Console.
4. Connect the keyboard to a USB port on the User Control Console.
5. Connect the hand controller to a USB port on the User Control Console.
6. Connect the power cord to a suitable power source.

Accessories

Numerous accessories can be used with the MSS to extend its capabilities and range of performance. These accessories allow the MSS

Multiple accessories can be connected in parallel by the use of a stackable connector. 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 The accessory port must be sealed with a terminated accessory connector or the accessory port terminator dummy plug. Failure to seal the accessory port may lead to loss of control of the ROV or damage to the components.

Included Accessories

Several topside accessories are included with all MSS 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 displays 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 some spare parts including ballast weights, propellers and other items.

Additional Sensors and Tooling

This configuration includes the following sensors and tooling:

- Multibeam Sonar
- DVL (Doppler Velocity Log
- Rotating Manipulator
- GPS

Optional Accessories

The following pages provide information about the various accessories that are supported on the VideoRay Defender. Your configuration may or may not include all of these accessories.

Sonar

The sonar provides the operator with a forward-looking image of the ROV's surrounding environment even when visibility is limited. The vehicle auto pitch can be used 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

BluePrint Subsea

Blueprint Subsea Oculus M750d

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

Reference Documents

- Blueprint Subsea Oculus M750d Data Sheet
- Blueprint Subsea Oculus M750d User Manual

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.

Inuktun

Eddyfi Inuktun

Inuktun Rotating Manipulator

The MSS 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 VideoRay ROV's camera can be tilted down to focus on the jaw to provide a close view of the operation.

Reference Documents

- Inuktun Rotating Manipulator Jaws Specifications
- Videoray Rotating Manipulator Operator's Manual
- Manufacturer's User Manual

DVL

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 also calculated. The position update rate is much faster than with USBL acoustic systems, and can be used to provide feedback for autonomous flight operations.

Nortek

Nortek

Nortek DVL 500-300m

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

Reference Documents

- Nortek DVL 500-300m Data Sheet
- Nortek DVL 500-300m Quick Start Guide
- Nortek DVL 500-300m Operations Manual

GPS

GPS (Global Positioning System) is used to locate the latitude and longitude of the ROV and the deployment location (vessel or dock).

Topside GPS is used to identify the location of the the vessel or area where the pilot is working.

VideoRay ROV GPS is located on the vehicle to determine the position of the ROV while on the surface of the water.

VideoRay

VideoRay

ROV GPS

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

⚠ The GPS will not acquire a signal while it is underwater. For tracking underwater, a DVL or USBL is required.

Reference Documents

- VideoRay GPS Antenna Manual
- VideoRay GPS Receiver Manual

GlobalSat

GlobalSat

GlobalSat USB 5 Hz

BU-353-S4-5Hz is a WAAS enabled USB GPS receiver that features a highly sensitive, low power consumption chipset in a ultra compact form factor. The BU-353-S4-5Hz is powered by a SiRF Star IV GPS chipset, and will provide you with superior performance in urban canyons, and in dense foliage. With the SiRF CGEE (Client Generated Extended Ephemeris) technology, has the capability of predicting satellite positions for up to 3 days in advance, and will deliver a CGEE-start time of less than 15 seconds under most conditions without any network assistance. The BU-353-S4-5Hz's Micro Power mode allows the receiver to stay in a hot start-like condition almost continuously while consuming very little power. Supports NMEA 0183 V3.0 (GGA, GSA, GSV, RMC) The BU-353-S4-5Hz outputs NMEA data 5 times a second (5Hz). The baud rate is 115200. Compatible with Windows XP, Vista, 7, 8, 8.1, 10, Mac OSX, Linux & Android.

Reference Documents

- GlobalSat USB 5 Hz Data Sheet

Lowrance

Lowrance

Lowrance Point 1

The Lowrance Point-1 is the ideal position and heading device. The Point-1 provides extremely accurate and rapid boat position and speed updates. In addition - unlike other position-only antennas - the Point-1 provides heading for accurate boat direction at any speed and for radar/chart overlay. The Point-1 easily connects to any HDS Gen2, HDS Gen2 Touch or Elite-7 display or any NMEA 2000 network. It is fully waterproof and can be pole or surface mounted.

USBL

The USBL system uses acoustic beacons on the surface and ROV to provide a relative location of the ROV 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.

Blueprint Subsea

BluePrint Subsea

SeaTrac

Piloting ROV's to waypoints, tracking the progress of AUV's and monitoring Divers is made simple the interactive and customisable displays of the SeaTrac PinPoint software application.

Topside Beacon

Submersible Beacon

Reference Documents

- BluePrint Subsea Seatrac Data Sheet
- BluePrint Subsea Seatrac User Manual
- BluePrint Subsea PinPoint User Manual
- BluePrint Subsea NavPoint User Manual

Mission Support Accessories

In addition to the equipment that is included with each MSS configuration and the 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 and stimulate thinking about what you might want to add to your "operations kit:"

General Logistical Support

- Basic operations support items including tables and chairs, foul weather gear, food, water, etc.
- Power sources including 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, etc.
- Supplemental spare parts for field repairs (Basic spares are included for some items)

Tactical Operations Support

- Tether weights and davit
- Retrieval devices or baskets

In general, VideoRay does not supply these items, and users must procure them on their own.

Software Guide

MSS software consists of three main components:

1. Topside User Interface, installed on the User Control Console and used to control the ROV.
2. Configuration and diagnostic software installed on the User Control Console used to configure and test each ROV module.
3. Module Firmware installed on each module to allow the module to perform its functions.

The topside user interface software is available in several versions:

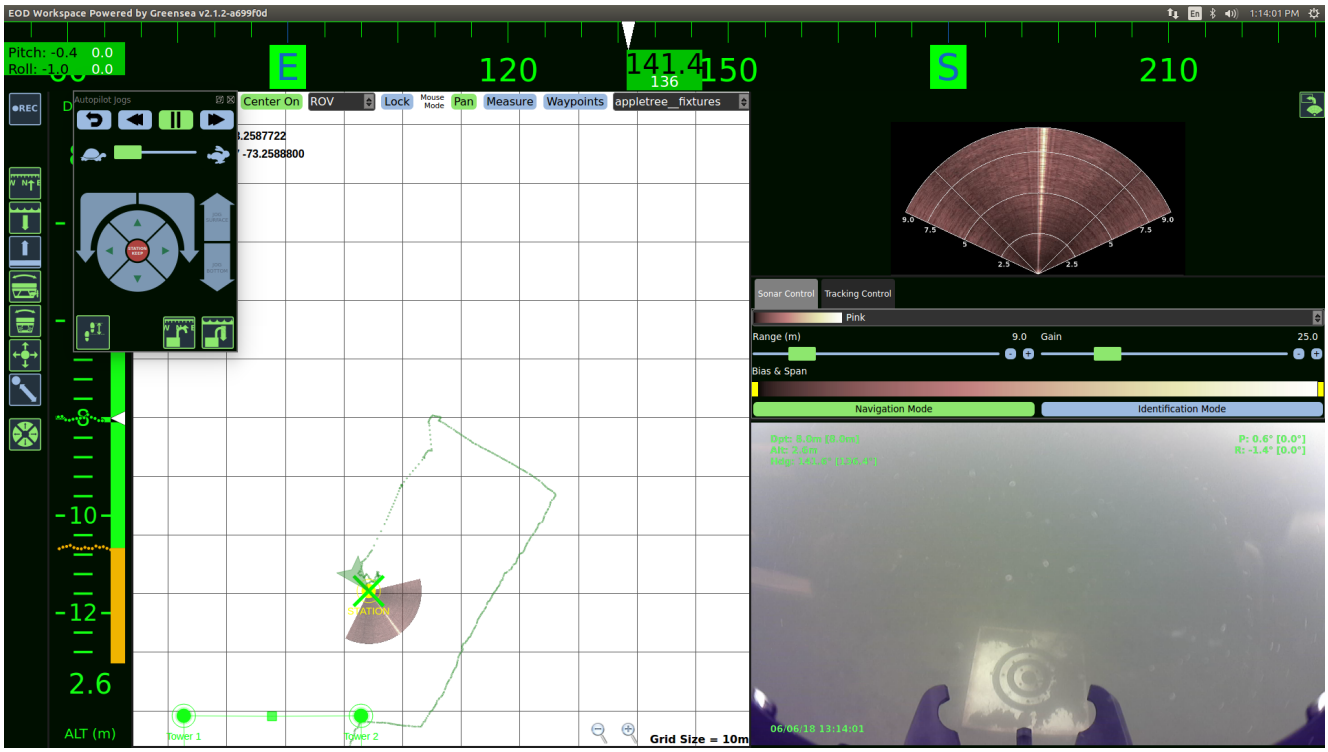
1. Greensea Systems Inc., with fully autonomous capabilities
2. VideoRay basic interface
3. User developed software

Greensea Systems Interface Overview

Greensea's EOD Workspace is the topside control software for the MSS.

To start VideoRay EOD Workspace, double click on the Defender icon

on the desktop.



For more information about Greensea's VideoRay EOD Workspace software, see the Greensea Section of the MSS Manuals Compilation.

VideoRay Interface Overview

There are four applications that are required to operate the VideoRay vehicle control software. These are stored in the ~/Flighthack folder.

- Start the thruster controls using vr_engage.py
- Start the camera controls using vr_engage_camera.py
- Start the video window

  ⚠ Video is automatically in record mode when the video window is started.

  ⚠ When stopping video, you must enter CTRL-C in the text window to close the file properly.
- Start the manipulator controls (optional) using vr_engage_manip_rotating.py

Each application may be started in any sequence, but following a consistent sequence such as above is recommended.

Software Management

This section provides information about the software environment and managing the software.

Folder Structure

Home/ - User Root Folder

charts/ - Recommended location for charts

firmware/ - Module Firmware

flighthack/ - MSS Utilities

gss_config/ - Configuration Files

gss_logs/ - Recordings

gss_mission/ - Mission Definition Files

Software Updates

Software updates can be downloaded from https://videoray.exavault.com/

Username: quarterdeck
Password: quarterdeck

⚠ In the instructions below, replace <<name>> with the appropriate name for the most recent version. This name will be provided on any release notice you might receive. If do not know the name, it will be named using the following format: <<date>>_videoray_topside_<<ubuntu reference>>.run.

⚠ In the instructions below, <<configName>> is "defender" and "pro5" (use only one at a time and do not use the quotes).

1. Log in to the download site
2. Navigate to the greensea folder
3. Download the latest <<name>>.run to the Downloads folder
4. Open a Terminal Window and enter the following commands:
    a. rm gss_configs (*(If this reports an error, use:* rm -r gss_configs *)*
    b. rm -r gss_configs-<<configName>> *(repeat for each vehicle model config file)*
    c. cd Downloads
    d. chmod +x <<name>>.run
    e. sudo ./<<name>>.run oculus *(or use the desired sonar)*
    f. When prompted enter the password, use: videoray
5. Start the workspace using the desktop icon
6. Exit the workspace
7. In the Terminal Window, enter the following commands
    a. cd .config/greensea_systems
    b. rm workspace.ini
    (Do not delete any other files, specifically gss.key)
8. Close the Terminal Windows

The new version should be installed and ready to run. Contact VideoRay support if you need assistance.

Module Configuration

The modular concept requires that modules be configured prior to installation or replacement in a specific vehicle arrangement.

⚠ Configuration information is specific to each vehicle. Information about the configuration for a specific vehicle can be found in the Submersible section of the Equipment Guide.

Conceptual Overview

Thrusters and other modules can be thought of as employees, and the vehicle as the jobsite. Each employee (Module) has a unique name (Serial Number stamped or printed on the module and coded in the firmware). When the employee goes to work at the jobsite (is installed on the vehicle), it is assigned an employee number (Node ID) by the person doing the configuration. The jobsite supervisor (control software) communicates with the employees using their employee number, so the employee number for each module on a jobsite must be unique. Work instructions are announced to all employees at the same time, so each employee must listen for their specific instructions and ignore the instructions for other employees. When there are multiple employees of the same type on a jobsite, these employees may be assigned specific work tasks (Application ID or Motor ID). The employee will only listen for instructions related to their work task. For example a starboard thruster will only respond to horizontal control inputs, while a vertical thruster will only respond to vertical control inputs. This approach allows vehicles to be configured with great flexibility. Examples include:

- A vehicle can be configured with one LED light, or with multiple LED lights. Multiple LED lights can be controlled in unison, or divided into banks that operate independently.
- A vehicle can be configured with a single vertical thruster, or additional vertical thrusters can be added to create a heavy lift vehicle, or to enable pitch and roll control.

General Requirements

1. Each employee (Module) must have a unique name (Serial Number).
2. Each employee (Module) must have a unique employee number (Node ID) on a jobsite (vehicle), but different vehicles may use repeated Node IDs.
3. Some employees (Modules) may be assigned specific work tasks (Application ID or Motor ID).
4. At a specific jobsite (Vehicle) more than one employee (Module) may be assigned the same work task (Application ID or Motor ID).
5. Modules may have additional parameters that can be configured that can affect their operation or performance, such as temperature cut-off, RPM limit or calibration values.

The following sections provide information about module replacement.

Configuration Commands

The following configuration commands are available for updating firmware and configuring M5 modules for MSS vehicle systems:

- **vr_refresh** - Refresh the firmware for a module
- **vr_enum** - Enumerate (list) the connected modules
- **vr_setid** - Set the Node ID and Group ID for a module
- **vr_debug_putty.py** - Debug and/or configure a module
- **vr_create_virtport_all.sh** - Create virtual ports for modules not connected directly to the RS-485 bus

More information about using these commands can be found in the following section of this guide.

Command: vr_refresh

The vr_refresh command is used to update the firmware on a module.

Use

vr_Refresh [OPTIONS] [SINGLE_HEX_FILE_NAME]

- [Options] - See the table below
- [SINGLE_HEX_FILE_NAME] - The file name of the firmware update, including its path.

OPTION	Alternate	Argument(s)	Description	Default
-?	--help		Display this help information	
--version			Display the Version Number	
-c	--com	Com_Port_Name	Com port to use	dev/ttyUSB0
-i	--id	Node_ID	Node ID of the Module to update, use 255 for broadcast to all nodes	255
--sn		Serial_Number	The Serial Number	any
--block_size		Block_Size	The block size of the firmware	1024
--timeout		Timeout	Set the connection Timeout in mS	1500
--skip_bootcheck			Skip sending a bootcheck command	
--skip_initial_reset			Skip sending an initial reset command	
-v	--verbose		Output verbose diagnostics	
-r	--reset		Reset device upon completion	
--UNLOCK			Allow programming of the bootloader	
---input_file		Filename	The file name of the firmware update file, including its path	

⚠ Some of the options use two dashes "--," not a long dash

Updating Firmware

⚠ To use vr_refresh on modules connected to the communications module, you need to open a virtual port and specify the port to use. See vr_create_virtport_all.sh for more information.

Example firmware update commands for different modules (in each case, X.Y.Z should be replaced by the actual version number):

Power Module

- vr_refresh -i 1 ~/firmware/power_converter-X.Y.Z.hex --block_size 16384

Communications Module

- vr_refresh -i 2 ~/firmware/comms_hub-X.Y.Z.hex --block_size 16384

AHRS Module

- vr_refresh -c vrport2 -i 3 ~/firmware/attitude_sensor-X.Y.Z.hex --block_size 16384

Thruster Module (Use the correct Node ID)

- vr_refresh -i 5 ~/firmware/motor_controller-X.Y.Z.hex

Camera Module

- vr_refresh -c vrport3 -i 4 ~/firmware/camera_adapter-X.Y.Z.hex --block_size 16384

LED Module (Use the correct Node ID)

- vr_refresh -i 11 ~/firmware/led_controller-X.Y.Z.hex

Firmware Block Sizes

Module	Block Size	Comms Path
Power Module	16384	Direct
Communications Module	16384	Direct
AHRS Module	16384	vport2
Power Module	Default	Direct
Camera Module	16384	vport3
LED Module	Default	Direct

Command: vr_enum

The vr_enum command is used to enumerate (list) the modules that are connected to the vehicle.

Use

vr_enum [OPTIONS] [min explcit id] [max explicit id]

- [Options] - See the table below
- [min explicit id] - The minimum Node ID to include the list
- [max explicit id] - The maximum Node ID to include in the list

OPTION	Alternate	Argument(s)	Description	Default
-?	--help		Display this help information	
--version			Display the Version Number	
-c	--com	Com_Port_Name	Com Port to use	dev/ttyUSB0
-p	--pretty		Use nicer human readable device type display	
-v	--verbose		Output verbose diagnostics	
--timeout		Timeout	Connection timeout in mS	1,000
-	--retry_count	Retry_Count	Set retry count for broadcast enumeration	5
--explicit		either max_node_id or min_node_id max_node_id	Explicit nodes to search,	

Examples

⚠ To use vr_enum on modules connected to the communications module, you need to open a virtual port and specify the port to use. See vr_create_virtport_all.sh for more information.

For Power, Communications, Thrusters and LEDs

- vr_enum

For the AHRS and camera modules, you need to include the virtual port.

AHRS Module

- vr_enum -c vrport2

Camera Module

- vr_enum -c vrport3

⚠ Some of the options use two dashes "--," not a long dash

Command: vr_setid

The vr_setid command is used to set the Node_ID and Group_ID of a module.

Use

vr_setid [OPTIONS] SN Node_ID Group_ID

- SN - See the table below
- Node_ID - The Node ID to program into the module (1 - 255)
- Group_ID - The Group ID to program into the module (1 - 255)

OPTION	Alternate	Argument(s)	Description	Default
-?	--help		Display this help information	
--version			Display the Version Number	
-c	--com	Com_Port_Name	Com port to use	dev/ttyUSB0
--arguments		Node_ID Group_ID	The Node_ID (1 - 254) and the Group_ID (1 - 254) to program into the module	

Examples

⚠ To use vr_enum on modules connected to the communications module, you need to open a virtual port and specify the port to use. See vr_create_virtport_all.sh for more information.

For the examples below, replace "S.N" with the actual serial number. The serial number is case sensitive.

Power Module

- vr_setid S/N 1 196

Communications Module

- vr_setid S/N 2 193

AHRS Module

- vr_setid S/N -c vrport2 3 194

Thruster Module (Use the correct Serial Number and Node ID)

- vr_setid S/N 5 129

Camera Module

- vr_setid SN -c vrport3 4 196

LED Module (Use the correct Serial Number and Node ID)

- vr_setid S/N 11 131

⚠ Some of the options use two dashes "--," not a long dash

Command: vr_debug_putty.py

The vr_debug_putty.py command is used to configure or test a module.

Use

./vr_debug_putty.py [OPTIONS] [N [N...]]

- [Options] - See the table below
- N - The Node ID of the module to reset and enter debug mode.

⚠ This command must be executed from the flighthack folder and requires the preceding "./"

OPTION	Alternate	Argument(s)	Description	Default
-?	--help		Display this help information	
-c	--com		Com port to use	dev/ttyUSB0

Power Module

- vr_debug_putty.py 1

Communications Module

- vr_debug_putty.py 2

AHRS Module

- vr_debug_putty.py -c vrport2 3

Thruster Module (Use the correct Node ID)

- vr_debug_putty.py 5

Camera Module

- vr_setid SN -c vrport3 4

LED Module (Use the correct Node ID)

- vr_debug_putty.py 11

⚠ Some of the options use two dashes "--," not a long dash

Command: vr_create_virtport_all.sh

The vr_create_virtport_all.sh command is used to create virtual ports that allow the Ethernet protocol to be used to communication with modules connected to the communications module.

Virtual Ports

MSS communications are supported using Ethernet and RS-485 protocols. Modules may use one protocol or the other, or both. The configuration commands described on the previous page, including vr_enum, vr_setid, vr_refresh and vr_debug_putty.py use only the RS-485 protocol. For modules that only support Ethernet, a virtual port must be set up to bridge the RS-485 to Ethernet for the Communications Module port to which the device is attached. The vr_create_virtport_all.sh can be used to create the required virtual ports.

Use

./vr_create_virtport_all.sh &

There are no arguments for this command.

⚠ This command must be executed from the flighthack directory and requires the preceding "./"

⚠ The trailing "&" allows this command to run in the background, otherwise you would need to open a new terminal window to use commands that access the virtual ports. When finished using the virtual ports, they should be removed using the following command: killall socat.

Example Using Virtual Ports to Communicate with a Camera

This example assumes that a Camera Module with serial number CAMADP000123 is plugged into port 2 of the Communications Module.

1. Connect and power up the system, but do not start the control software.
2. Launch the terminal program and use the following commands to access the camera.
3. Navigate to the working folder, type: cd flighthack
4. Enumerate the modules on the system, type: vr_enum You will notice that the camera does not show up in the list of enumerated modules.
5. To create the virtual ports, type ./vr_create_virtport_all.sh &
6. Now, when you enumerate the modules using vr_enum, the camera and any other non-RS-485 devices should show up in the list. You can also see the virtual ports using the standard directory listing command, ls
7. To send a commands to the camera, you need to include the -c portNumber option, where the portNumber to use is the one to which the device is attached on the Communications Module (in this case port 2, so vrport2).
    - To set the Node_ID and Group ID:
      vr_setid -c vrport2 CAMADP000123 4 196
    - To enter Debug mode:
      ./vr_debug_putty.py -c vrport2 4

ROV Materials List

The following is a list of materials used in the exterior portions of the vehicle and tether:

1. Stainless Steel
    1. 18-8
    2. 304
    3. 316
    4. PH17-4
    5. 302 (GPS Mast Spring)
2. High-density polyethylene (HDPE)
3. Neoprene Rubber
4. Nitrile Rubber
5. Polyurethane (PU)
    1.
    2. Foam
6. Aluminum 6061 Anodized Type III
7. Aluminum 6061 Micralox
8. Polycarbonate (PC)
9. Polypropylene (PP)
10. Polyvinyl chloride (PVC)
11. Nylon 6/6
12. RENY (50% glass fiber reinforced Super Nylon (Polyamide MXD6))
13. Potting
    1. 3M Scotchcast 2123 (Polybutadiene Rubber)
    2. 20-2621 Urethane potting compound (Poly urethane)

3. Loctite E-05CL (Epoxy)
14. Brass
15. Acetal Copolymer (POM)
16. Glass BK7
17. Polyethylene terephthalate (PETG)
18. Cyanoacrylate Adhesive (CA)
19. Polytetrafluoroethylene (PTFE)
20. Ceramic Zirconia
21. Carbon PEEK
22. Copper (Motor Windings)
23. Titanium Grade 2 (GPS Mast)

Users may check this list against chemical compatibility charts available from several sources.

This information is provided for convenience. Providing this information does not explicitly or implicitly extend the warranty to cover the use of VideoRay products in solutions that are not specifically listed in the Environmental Compatibility section. VideoRay is not responsible for errors or omissions in any of the presented information.

VideoRay can provide engineering services for a fee to determine chemical compatibility. Contact VideoRay for more information.

Project Management

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

1. Establish the need, objectives and acceptable outcomes of the mission
2. Plan the mission
3. Prepare for the mission
4. Execute the mission
5. Conclude the mission
6. 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.

- Mission Planning
- General Logistics
- On-site Operations
- Project Completion

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

User's 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:
    - Float Block
    - Skid
    - Propellers
    - Thruster Nozzle
    - Modules in their entirety
    - Externally Mounted Accessories

Instructions for performing these procedures are included in the Operator's / Maintenance Manual. Users who do not feel comfortable completing these procedures are invited to contact VideoRay 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.

Configuration / Calibration

Configuration and or calibration is required for several devices. For module configuration see the pages in the Submersible section.

Device Calibration

Compass Calibration.

Compass Calibration

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 Operator Control Console. 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.

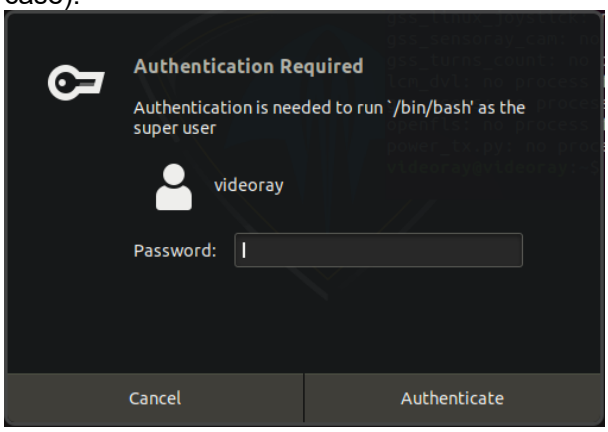
⚠ The AHRS firmware must be updated to attitude_sensor-1.4.4.hex or higher. If the firmware is not up-to-date, see: Command: vr_refresh and its following page for more information about updating the firmware.

1. Connect the system as normal and power on Operator Control Console and the ROV.
2. If EOD Workspace has been started since turning on the Operator Control Console.
    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 Operator Control 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.

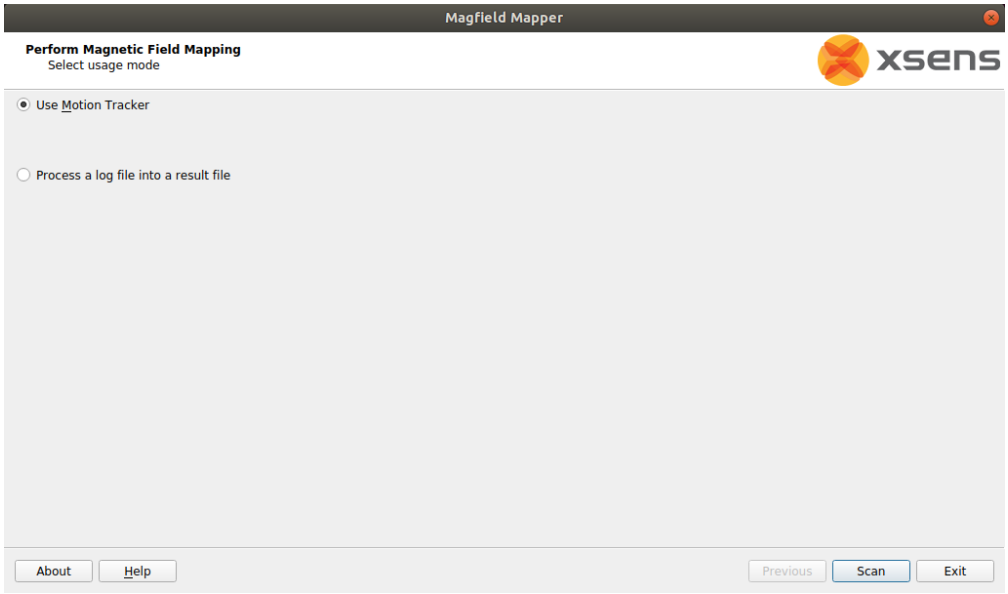
   ⚠ The ROV must be separated as far as possible from iron or magnetic sources during the calibration process for best results.

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

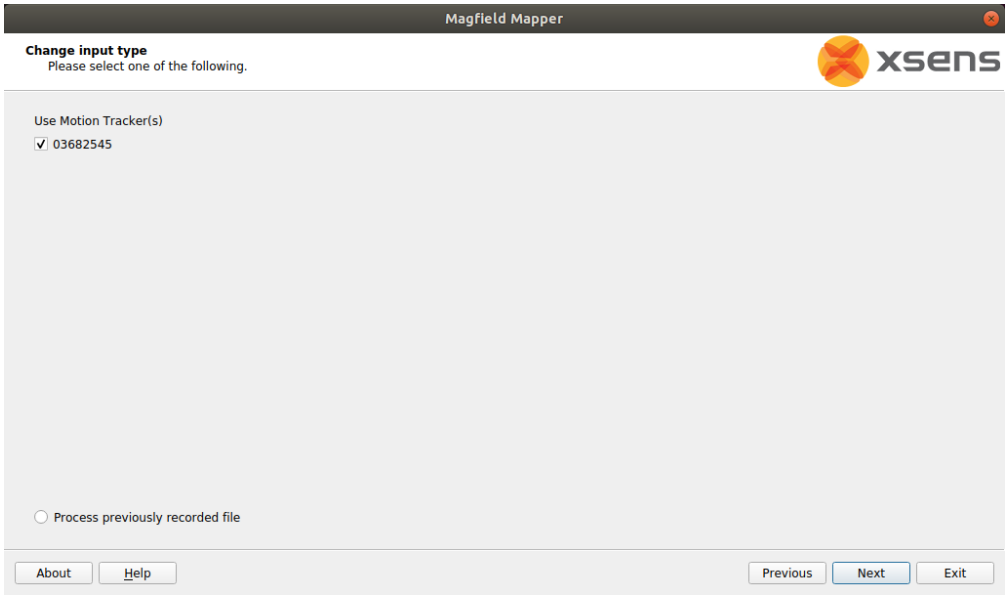
7. When asked if you trust this application and want to Launch it, click on the Yes button.
8. When asked for the password, enter videoray and click on the Authenticate button (use all lower case).



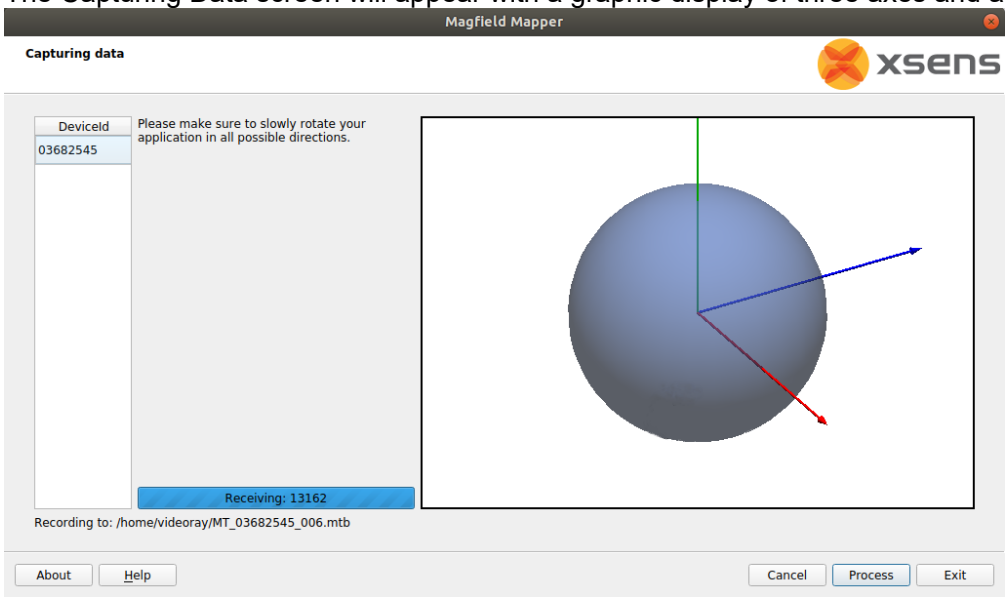
9. When the Magnetic Field Mapper software starts, make sure the Use Motion Tracker option selected and click on the Next and then the Scan buttons.



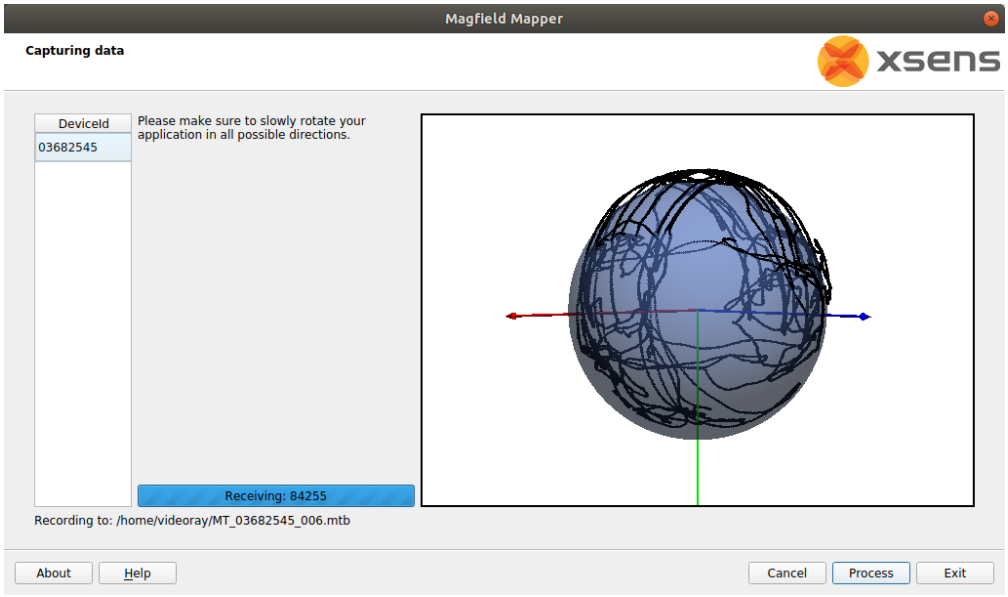
10. Wait up to 30 seconds for the Magnetic Field Mapper software to find the AHRS Module. If the software reports that it does not find any devices, close the software and restart it and repeat these steps.
11. When the Magnetic Field Mapper software finds the AHRS, which will be listed by a unique ID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



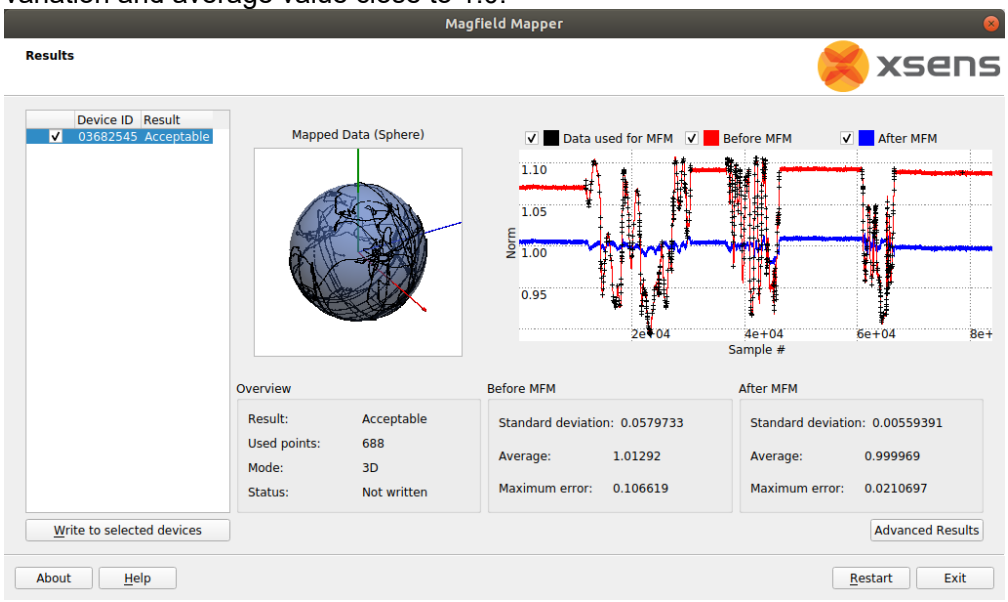
12. The Capturing Data screen will appear with a graphic display of three axes and a sphere.



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 Configuration and Replacement

Power Module Replacement

Replacing a Power Module requires hardware replacement. Currently, 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 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 screw driver, 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.

Power Module and Control Software Configuration

This section is reserved for future use.

Communications Module Replacement

Replacing a Communications Module requires hardware replacement. Currently, 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 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 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 screw driver, 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.

Communications Module and Control Software Configuration

Refer to the configuration parameter table in the Communications Module section of the Equipment Guide.:

⚠ These steps are only required if a manipulator is being used on the vehicle.

⚠ Commands below are case sensitive.

1. Connect and power up the system, but do not start the control software.

2. Launch the terminal program and use the following commands to program the Communications Module.

3. Navigate to the working folder, type:
    - cd flighthack followed by the Enter key

4. Enumerate the modules on the system, type:
    - vr_enum followed by the Enter key

5. The replacement Communications Module serial number should appear in the list of enumerated devices, such as COMHB000356 (COMHB will be present, but the number may be different).

6. Enter diagnostic mode of the new Communications Module, type:
    - ./vr_debug_putty.py 2 followed by the Enter key

    where *2* is the default Node ID of the new Communications Module. This will open a new diagnostic window.

7. To access the configuration menu in the diagnostic window, type:
    - c

You do not need to type the Enter key. In configuration mode you are now able to configure the baud rate for the rotating manipulator port.

8. Using the values from the Communications Module configuration table change the parameters on the Communications Module to match the baud rate for the manipulator port from the table.

   To change the baud rate value for the manipulator port, follow these steps:
   1. Identify the port where the manipulator is connected and note the option number for the baud rate parameter.
   2. Type the *Option Number* followed by Enter, then type the *Desired Baud Rate Value (38400)* followed by Enter.

9. Press the s key followed by Enter to save the configuration.
10. Press the x key followed by Enter to exit the configuration menu.
11. Press the x key again to exit diagnostic mode. You do not need to press Enter.
12. Close the diagnostic window.
13. Close the terminal window.

AHRS Replacement

Replacing an AHRS requires hardware replacement. Currently, 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, 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. 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.

AHRS and Control Software Configuration

This section is reserved for future use.

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. Configuration parameters are identified in the Thruster section of the Equipment Guide.

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 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 shape, remove it from the damaged thruster using a 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. Do not overtighten the bolts.
12. Replace the float block using the screws removed earlier.

Thruster and Control Software Configuration

Refer to the configuration parameter table in the Thruster section of the Equipment Guide.:

⚠ Commands below are case sensitive.

1. Connect and power up the system, but do not start the control software.
2. Launch the terminal program and use the following commands to program the thruster.
3. Navigate to the working folder, type:
    - cd flighthack followed by the Enter key
4. Enumerate the modules on the system, type:
    - vr_enum followed by the Enter key
5. The replacement thruster serial number should appear in the list of enumerated devices. Note that the serial number on the thruster strut is only the ending significant digits. The serial number found in the output from vr_enum uses the complete format, such as THRxxxxxx, where xxxxxx is the sequential number.
6. Register the replacement thruster, type:
    - vr_setid *SN NodeID GroupID* followed by the Enter key

where *SN* is the serial number of the replacement thruster (case sensitive value as found in the vr_enum output), and the *NodeID* and *GroupID* are from the thruster configuration table This step ensures that each thruster has a unique Node ID on this vehicle.

7. Type:
    - vr_enum followed by the Enter key

   again to verify the replacement thruster is registered with its Node ID.

8. Enter diagnostic mode of the replacement thruster, type:
    - ./vr_debug_putty.py *NodeID* followed by the Enter key

   where *[Node ID]* is the Node ID of the replacement thruster. This will open a new diagnostic window.

9. To access the configuration menu in the diagnostic window, type:
    - c

   You do not need to type the Enter key. In configuration mode you are now able to define the thruster's position on the vehicle (Motor or Application ID) and other operating parameters.

10. Using the values from the thruster configuration table change the parameters on the thruster to match those from the table. Minimally, the following settings should be entered or confirmed:
    1. Whether reverse is Enabled or Disabled (configuration parameter 2)
    2. Maximum Thruster Power (configuration parameter 17)
    3. Motor or Application ID (configuration parameter 31)

    To change the values, follow these steps:
    1. For most parameters, type the *Option Number* followed by Enter, then type the *Desired Value* followed by Enter.
    2. For the Reverse command (configuration parameter 2), simple type 2 followed by Enter to toggle the value from Disabled to Enabled or back again.
11. Press the s key followed by Enter to save the configuration.
12. Press the x key followed by Enter to exit the configuration menu.
13. Press the x key again to exit diagnostic mode. You do not need to press Enter.
14. Close the diagnostic window.
15. Close the terminal window.

Camera Replacement

Replacing a Camera requires hardware replacement. Currently, 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, 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. 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.

Camera and Control Software Configuration

This section is reserved for future use.

LED Light Replacement

Replacing an LED Light requires both hardware replacement and software configuration procedures. Each LED Light must be configured for its specific location on the vehicle. Configuration parameters are identified in the LED Light section of the Equipment Guide.

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 Light being replaced in the vehicle frame. The position of the LED light being replaced will determine the configuration parameters to be programmed into the replacement.
4. For the LED Light to be replaced, follow the LED Light cable to the main thruster / Light connector stack (located under the main float block) and disconnect the damaged LED Light 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 Light from the vehicle.
8. Note the serial number for the replacement LED Light. This number will be used to identify and program the replacement LED Light once installed in the vehicle.
9. Mount the LED Light 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 Light. Connect the cable to the same location in the connector stack as before.
11. Replace the float block using the screws removed earlier.

LED Light and Control Software Configuration

Refer to the configuration parameter table in the LED Light section of the Equipment Guide.:

⚠ Commands below are case sensitive.

1. Connect and power up the system, but do not start the control software.
2. Launch the terminal program and use the following commands to program the LED Light.
3. Navigate to the working folder, type:
   - cd flighthack followed by the Enter key
4. Enumerate the modules on the system, type:
   - vr_enum followed by the Enter key
5. The replacement LED Light serial number should appear in the list of enumerated devices, such as LED000356 (LED will be present, but the number may be different)
6. Register the replacement LED Light, type:
   - vr_setid *SN NodeID GroupID* followed by the Enter key

   where *SN* is the serial number of the replacement LED Light (case sensitive value as found in the vr_enum output), and the *NodeID* and *GroupID* are from the LED Light configuration table This step ensures that each LED Light has a unique Node ID on the this vehicle.
7. Type:
   - vr_enum followed by the Enter key

   again to verify the replacement LED Light is registered with its Node ID.
8. Enter diagnostic mode of the replacement LED Light, type:
   - ./vr_debug_putty.py *NodeID* followed by the Enter key

   where *[Node ID]* is the Node ID of the replacement LED Light. This will open a new diagnostic window.
9. To access the configuration menu in the diagnostic window, type:
   - c

   You do not need to type the Enter key. In configuration mode you are now able to define the LED Light's position on the vehicle (Application ID) and other operating parameters.
10. Using the values from the LED Light configuration table change the parameters on the LED Light to match those from the table. Minimally, the following settings should be entered or confirmed:
    1. Application ID (configuration parameter 21)

    To change the values, follow these steps:
    1. Type the *Option Number* followed by Enter, then type the *Desired Value* followed by Enter.
11. Press the s key followed by Enter to save the configuration.
12. Press the x key followed by Enter to exit the configuration menu.
13. Press the x key again to exit diagnostic mode. You do not need to press Enter.
14. Close the diagnostic window.
15. Close the terminal window.