Digital Auto Video Plankton Recorder (DAVPR)
User's Manual

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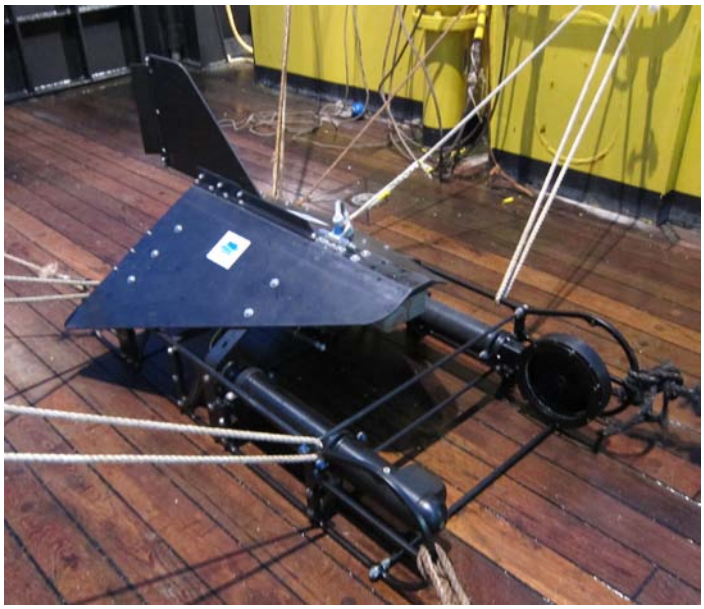

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Purpose of this manual

The purpose of this manual is to provide DAVPR operators with a clear understanding of the proper assembly, operation, maintenance, and safe operating procedures. This manual is a valuable reference tool and should be thoroughly reviewed prior to operating the DAVPR system. I f you feel that any portion of this manual is unclear or if you do not thoroughly understand the operation of the equipment, then please contact Seascan for more information.

Please read this manual prior to operation.

1. INTRODUCTION

1.1. Unpacking the System

The Digital Autonomous Video Plankton Recorder (DAVPR) is typically shipped preassembled on the Tow Frame. All of the underwater cabling between the camera, strobe, instruments and electronics housings has been routed and secured and ready for operational use.

Please take a moment to verify that all of the cabling is secure and all cable connections are properly connected.

The V-Fin depressor will be installed if purchased with the DAVPR system. Please refer to section 7.1 "Installing/Removing the V-Fin " for more information about the V-Fin Depressor.

A NiMH battery pack was installed but not electrically connected in the DAVPR Battery Housing prior to shipping. Please refer to Section 3 "Removing and Installing the Battery Pack" to learn how to reconnect the battery pack.

The shipping box should contain the following items (refer to the photos in section 1.4) :

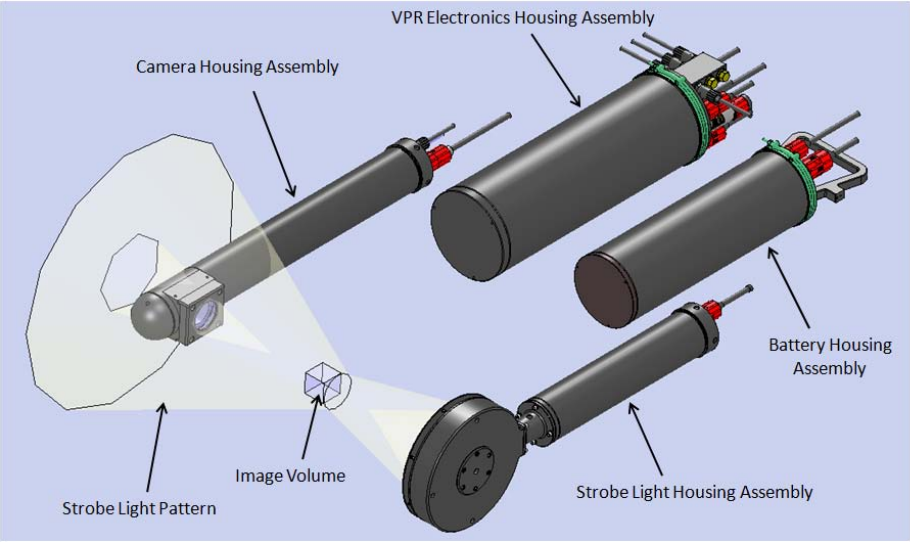
- The DAVPR System assembled to the Tow Frame
- V-Fin Depressor (if purchased)
- DAVPR Guard Assembly (If purchased)
- Pelican Case with two NiMH Battery Packs and one Power Meter
- Pelican Case with Battery Charger
- Laptop Computer with USB License Key
- AC Power Adapter for the DAVPR System
- Gigabit Ethernet Switch
- USB to RS232 Adapter
- Spare Data Cartridge
- User Cables (3)
- Alignment Tools

1.2. Instrument Description

The Digital Auto Video Plankton Recorder (DAVPR) manufactured by Seascan Inc. is an autonomous underwater digital imaging system designed for rapid imaging of plankton taxonomic composition and abundance . The system may be deployed as an additional sensor on an existing towed or vertical profiling platform or towed alone using the Seascan V-Fin Depressor.

Please note: the DAVPR produces digital images and water clarity will affect the quality of the images.

DAVPR Underwater Components:



1.3. Software Description

The DAVPR data processing uses two different software programs. The first program, JpegLS_Adeck (commonly referred to as "AutoDeck"), is pre-installed on the laptop computer that comes with the DAVPR system and support for this software is provided by Seascan Inc. This software takes the full resolution DAVPR image data, separates and decodes the header, decompresses the image and scans it for Regions of Interest (ROIs). The detected ROIs are then saved in a special directory structure that is compatible with the processing done by the second software program, Visual Plankton. The USB license key is required to operate the JpegLS_Adeck software.

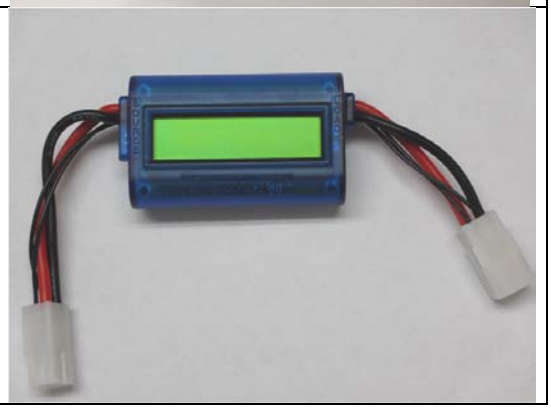
Visual Plankton is a Matlab-based pattern recognition software program developed by the Woods Hole Oceanographic Institution for automated classification of planktonic taxa and particulate matter (Hu & Davis 2005; 2006). Visual Plankton can be downloaded from http://www.whoi.edu/main/vpr. Support for this software is provided by a VPR users group (see Appendix J "VPR User's Group" for more details).

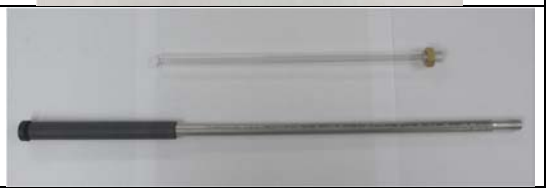
1.4. VPR Components

Item	Description	
1	**VPR Electronics Housing Assembly**	
2	**VPR Camera Housing Assembly**	
3	**VPR Strobe Housing Assembly**	
4	**Camera Power Cable Assembly**: Subconn Micro 8-pin female to 8-pin male cable assembly with black locking sleeves.	
5	**Camera Cable Assembly**: Subconn Ethernet 8-pin female to 8-pin female blue cable assembly with red locking sleeves.	

6	**Strobe Power Cable Assembly**: Subconn 4-pin male to 4-pin female cable assembly with red locking sleeves.	
7	**Input Power Cable Assembly**: Subconn 6-pin female to 6-pin male black cable assembly with red locking sleeves.	
8	**User Interface COMMS (RS232 Communications) Cable Assembly**: Subconn Micro 5 pin female cable assembly with a standard DB9 connector	

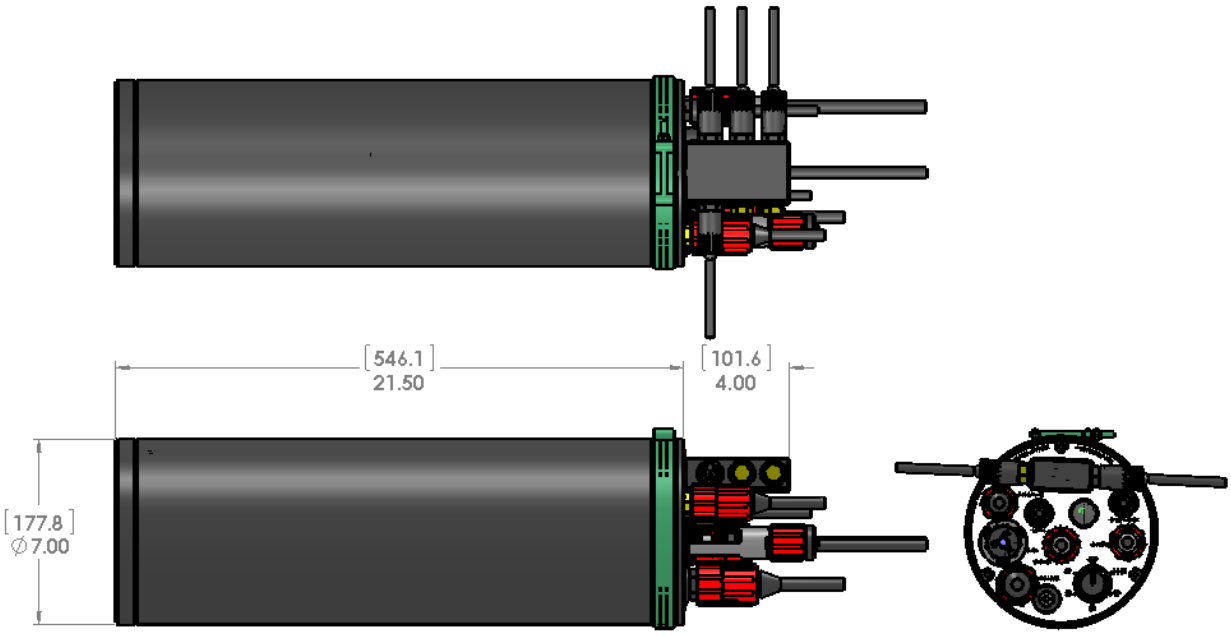
9	**User Interface Ethernet Cable Assembly**: Subconn Ethernet 8-pin male blue cable assembly with a standard Ethernet plug.	
10	**Data Cartridge Drive Cable Assembly**: Subconn 8-pin female connector with a standard USB connector.	
11	**DAVPR Power Supply** for operating the DAVPR system with AC power in the Lab	

12	**Laptop Computer** for processing VPR data	
13	**Gigabit Ethernet Switch**	
14	**USB to RS232 Serial Adapter**	
15	**Power Meter**	

16	**USB Drive** with License Key (Dongle)	
17	**Battery Charger Assembly**	
18	**DAVPR NiMH Battery Pack**	
19	**Data Cartridge**	
20	**Alignment Tools**	

2. DETAILED DESCRIPTION OF DAVPR SUBASSEMBLIES

2.1. DAVPR Electronics Housing Assembly



VPR Electronics Assembly

Air Weight	17.46 kg
Weight in Fresh Water	4.1 kg
Max. Operating Depth in Seawater	1000 m
Operating Temperature	-10 to +45°C
Nominal Input Voltage	28.8 VDC
Operational Current	2.45 A Continuous
Available Internal Hard Drive Space	200 Gb
Maximum Image Transfer Rate	20 images per second

The DAVPR Electronics Housing assembly contains the electronics, computer and software to operate the DAVPR system and any additional science sensors such as the Sea-Bird SBE 49 CTD.

Both the camera and strobe assemblies connect to the Electronics Housing end cap using underwater cable assemblies. Power is supplied to the electronics housing by either the DAVPR Battery assembly or directly by using the DAVPR AC power supply (use only in a dry environment).

The Seascan DAVPR Controller circuit board controls the power to the system, operates the single board computer (SBC) and sends commands to the optics controller board located inside the camera housing.

The microprocessor on the DAVPR Controller Board continuously monitors the Optical Setting Switch (section 2.1.1.1). The system will start capturing images when the switch is moved to one of the four optical settings-S0, S1, S2, or S3.

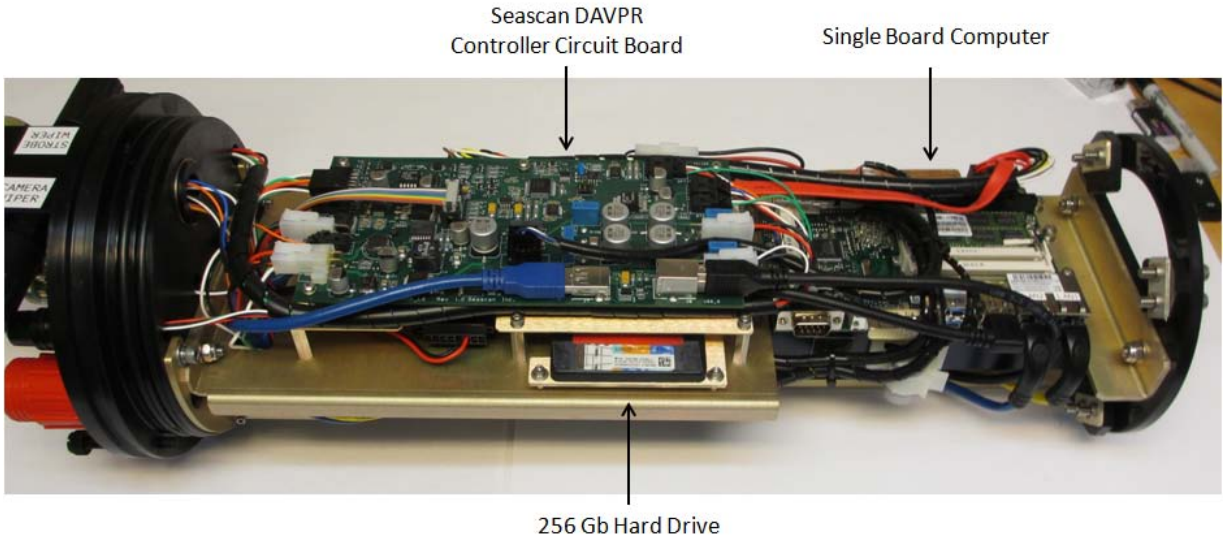
Note: The microprocessor will stop monitoring the Optical Setting Switch if the User Interface Comms cable is plugged into the end cap.

Moving the Optical Setting Switch to "Boot" will turn on the power to the DAVPR system (SBC, camera and strobe) and to any connected instruments, as well as, start the DAVPR application software on the single board computer.

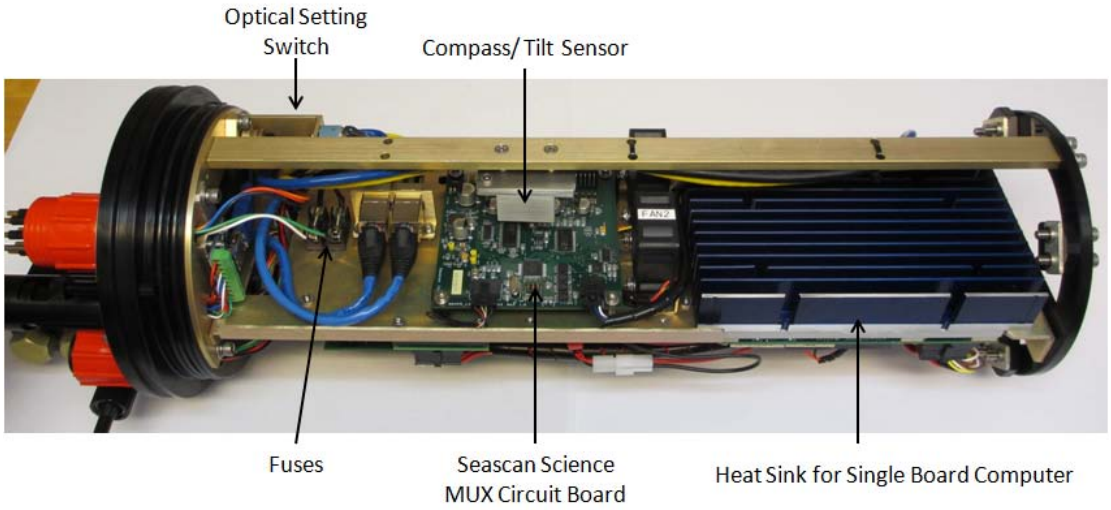
If the battery voltage or supply voltage is below 26.5 VDC then the DAVPR Controller will not start the system or if the power drops below 26.5 VDC then it will shut down the system in a controlled manner.

A dedicated single board computer with Windows 7 Professional operating system manages the image capture and recording. Each image is tied to a header specifying the time, date and any oceanographic instrument data. The data are temporarily stored on the internal hard drive and then automatically transferred to a removable USB drive located on the Electronics Housing end cap.

The 256 GB internal hard drive is partitioned into two drives: C and D. The operating system files are stored on drive C; the data files are stored on drive D. The user can access the hard drives by using the Ethernet connection to the Electronics Housing assembly (section 6.2).



VPR Electronics Chassis-Top View



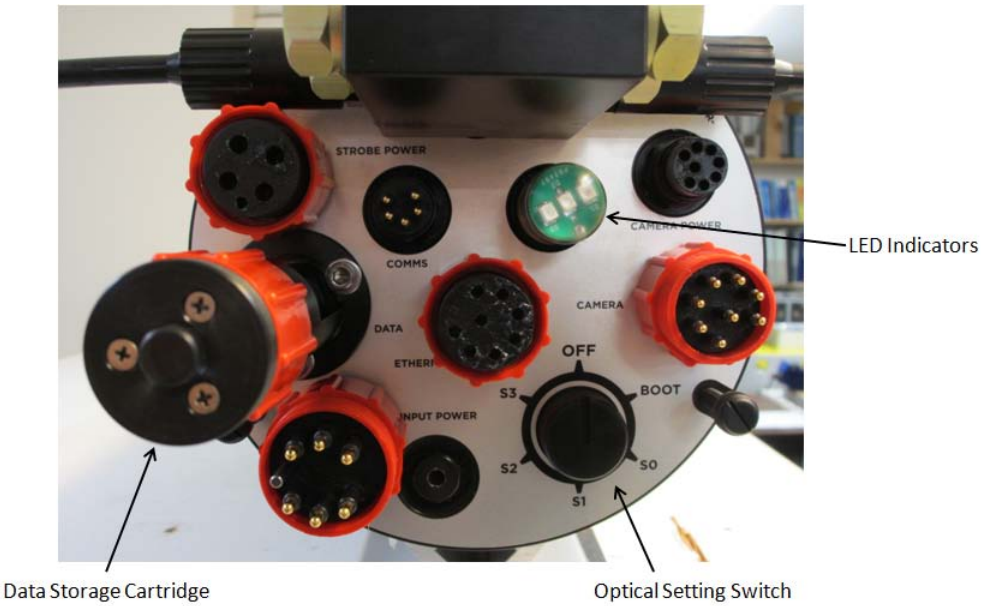
VPR Electronics Chassis-Bottom View

2.1.1. Electronics Housing End Cap

All of the electrical connections from the camera, strobe, and oceanographic equipment, as well as, the user interface connections are made at the Electronics Housing end cap using underwater bulkhead connectors and cable assemblies.

The user controls the system by turning the **Optical Setting Switch** (or by sending commands to the DAVPR controller microprocessor -see Appendix G: RS232 Communication and Control). Data are automatically transferred to and stored on the external **Data Storage Cartridge** located on the end cap. The **LED indicators** display different sequences of red, yellow and green light to indicate the different operating states generated by the DAVPR system.

NOTE: Only make cable connections when the DAVPR system is turned off.



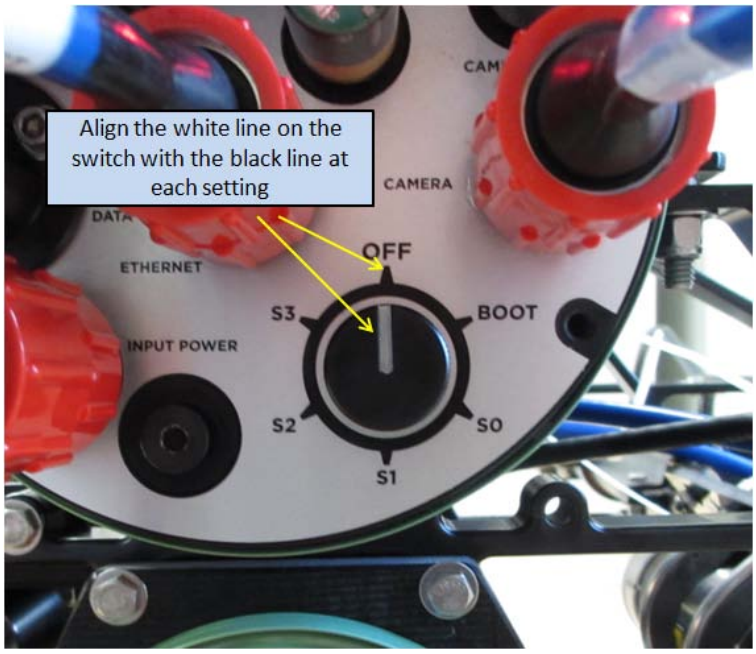
VPR Electronics Housing End Cap

2.1.1.1. The Optical Setting Switch

The single board computer inside the Electronics Housing assembly can be turned on and off by turning the Optical Setting Switch located on the Electronics Housing end cap. There are six positions for the switch: OFF, BOOT, S0, S1, S2 and S3.

- **OFF:** The system is turned off in this position. Power is always applied to the DAVPR Controller when the battery is connected to the Electronics Housing end cap. The red LED will be continuously on indicating the power is connected. There is no power applied to the camera, strobe or any connected instruments.
- **BOOT:** Power is applied to the camera, strobe and any instruments connected to the Electronics Housing end cap. The computer turns on, and the DAVPR application software is started. The system remains in the standby mode. The computer is accessible on a network in this position. If the battery voltage or external power is less than 26.5 VDC then the system may turn on briefly then shut down due low operating voltage.
- **S0:** The camera and zoom lens automatically move to the S0 position settings creating an optical field of view of approximately 9.2 x 6.9 mm. The strobe and camera turn on; images are captured and written to the internal hard drive. If the switch is turned from OFF to S0, then the system will automatically perform the boot process.
- **S1:** The camera and zoom lens automatically move to the S1 position settings creating an optical field of view of approximately 17.1 x 12.8 mm. The strobe and camera turn on; images are captured and written to the internal hard drive. If the switch is turned from OFF to S1, then the system will automatically perform the boot process.
- **S2:** The camera and zoom lens automatically move to the S2 position settings creating an optical field of view of approximately 26.1 x 19.5 mm. The strobe and camera turn on; images are captured and written to the internal hard drive. If the switch is turned from OFF to S2, then the system will automatically perform the boot process.
- **S3:** The camera and zoom lens automatically move to the S3 position settings creating an optical field of view of approximately 41.3 x 30.8 mm. The strobe and camera turn on; images are captured and written to the internal hard drive. If the switch is turned from OFF to S3, then the system will automatically perform the boot process.

Gently rotate the switch between settings until you feel the detent at the switch location or the mechanical stop at the OFF position. The user can feel the detent when the white line on the switch is aligned with the black line at each switch position.

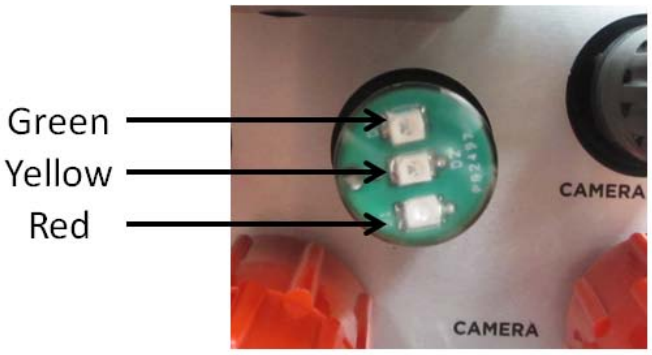


The DAVPR controller looks at the switch position every second. The switch position is acted upon if the switch has not moved in three seconds.

Note: The microprocessor will stop monitoring the Optical Setting Switch if the User Interface Comms cable is plugged into the end cap.

2.1.1.2. LED Indicators

Three different color LED lights potted inside translucent urethane are located on the Electronics Housing end cap. The LED lights will turn on or off depending on the status of the electronics system. The following table lists the LED Indicator sequences for each of the switch positions. ***Please note that the system may take 30 to 90 seconds to reach the desired setting***.



LED Indicator Colors and Location

Switch Position	LED Indicator Sequence and Description	Approx. Time, sec.
OFF	• Red: power is on	n/a
OFF to BOOT	• Red: power is on • Yellow: VPR computer is booting • Green: computer is booted and application software is ready	35
BOOT to S0, S1, S2, or S3	• Green: computer is booted and application software is ready • Green/Yellow: moving optics & camera to chosen "S" setting. • Green: ready; application is running; strobe and camera are on.	40-50
BOOT to Previously Set S0, S1, S2 or S3	• Green: the optic and camera are set in the same position; application is running; the strobe and camera are on.	1
S0, S1, S2 or S3 to BOOT	• Green: ready; application is running; strobe and camera are on. • Green/Yellow: image files are transferred to the Data Storage Cartridge; application is stopping • Green: pc booted and application software is ready	5
OFF to S0, S1, S2 or S3	• Red: power is on • Yellow: VPR computer is booting • Yellow/Green: moving optics and camera to chosen "S" setting • Green: ready; application is running; strobe and camera are on.	70-85
OFF to Previously Set S0, S1, S2 or S3	• Red: power is on • Yellow: VPR computer is booting • Green: ready; application is running; strobe and camera are on.	35
S0, S1, S2 or S3 to OFF	• Green: ready; application is running; strobe and camera are on. • Green/Yellow: image files are transferred to the Data Storage Cartridge; application is stopping • Yellow/Red: shutting down the operating system • Red: power is on	20-30
S Setting to Different S Setting	• Green: application is running; strobe and camera in initial S setting. • Yellow/Green: moving optics and camera to new S setting. • Green: application is running; strobe and camera are on for new S setting	40-50
Low Battery Voltage	• Flashing Green/Yellow/Red	n/a
System Fault	• Green/Yellow/Red	n/a

The system will perform a controlled shut down when the battery voltage reaches 26.5 V. All of the LEDs will flash simultaneously indicating the low battery voltage fault. The user will have to cycle the power to the Electronics Housing in order to clear the LEDs:

- Turn the Optical Switch to the OFF position. Unplug the battery cable from either the Battery or Electronics Housing to clear the LEDs. Plug the battery cable back in after cycling the power. The red LED will be lit indicating that power is applied to the system. The user will need to recharge the batteries to continue operating the system.

The LEDs will indicate a fault condition if the application software does not open correctly. The user will have to remove the power from the Electronics Housing assembly to clear the LED fault indication. Unplug the battery cable assembly from either the Battery or Electronics Housing and then plug the cable back in.

2.1.1.3. Data Storage Cartridge

The DAVPR computer creates two files and starts capturing images after the user selects one of the four optical settings. After 30 minutes of operation, the computer stops the image capture, creates two new files, and resumes capturing images. The previous files are copied to the Data Storage Cartridge and then deleted from the internal hard drive.

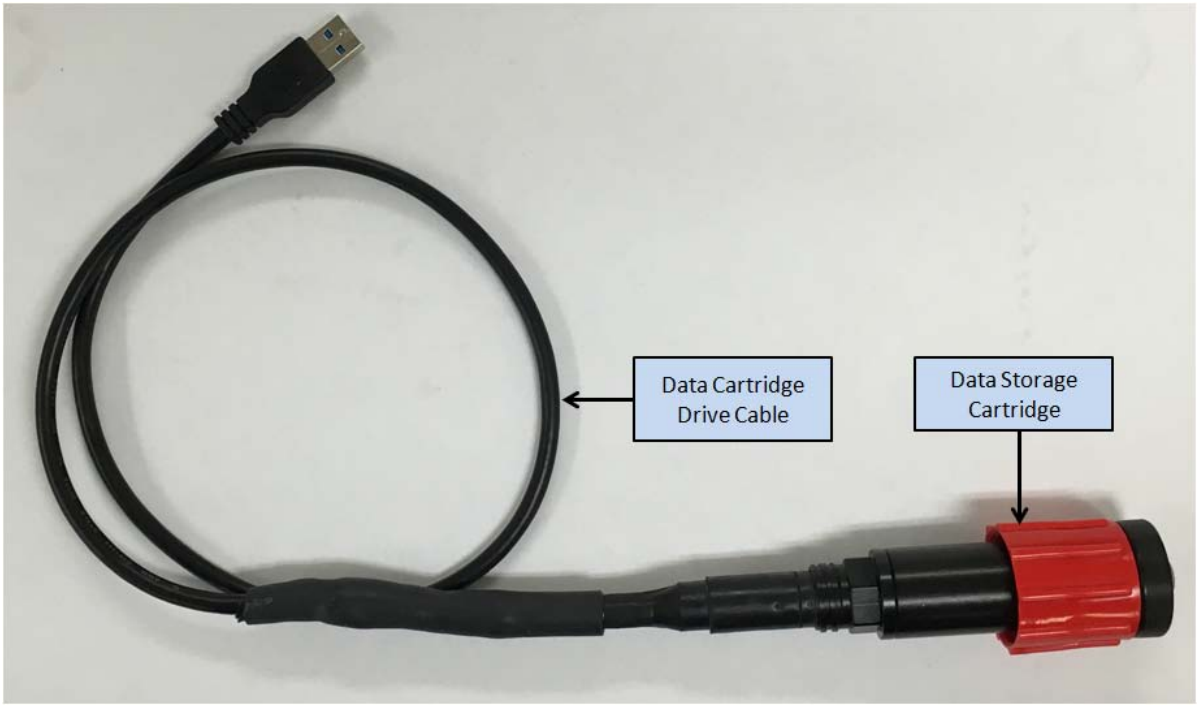
This process continues until the user turns the Optical Setting Switch to either the BOOT or OFF position or if the system has been operating until reaching the low voltage shut off.

When the user turns off the DAVPR by turning the Optical Setting Switch to either the BOOT or OFF position, any remaining data on the internal hard drive will be automatically transferred to the Data Storage Cartridge before the computer powers down the system.

Each image file contains approximately 14 GB of data.

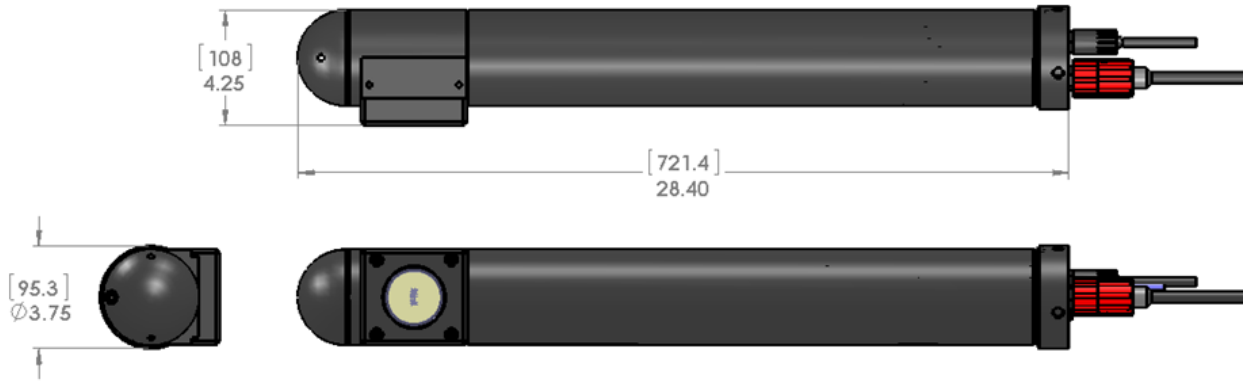
Data Storage Cartridge

The user removes the Data Storage Cartridge (typically after an operational deployment) and transfers the data to the user's computer for post-processing. A custom cable assembly is supplied to connect the eight-pin Subconn connector on the Data Storage Cartridge to a USB port on the computer.



2.2. Camera Housing Assembly

2.2.1. Imaging System Specifications



VPR Camera Assembly

Air Weight	7.25 kg
Weight in Fresh Water	2.95 kg
Maximum Operating Depth in Sea Water	1000 m
Operating Temperature	-10 to +45°C

Camera Specifications	
Manufacturer	SVS Vistek
Model No.	ECO285CVGE
Camera Type	Gigabit Ethernet CCD Color Camera
Image Format	2/3 inch CCD
Camera Resolution	1392 x 1040
Operating Temperature	-10 to +45°C
Operational Frame Rate	20 Hz

Optics Specifications	
Focal Length	12.5 mm to 75 mm manual zoom; fixed at infinity
Iris Range	f/1.8 to f/22
Iris Type	Automatically positioned with stepper motor
Focus Type	Automatically positioned with stepper motor
Operating Temperature Range	-10 to +45°C

Optical Field Of View Settings and Sizes	
VPR Switch Position	Approximate Optical Field of View *
S0	9.2 x 6.9 mm
S1	17.1 x 12.8 mm
S2	26.1 x 19.5 mm
S3	41.3 x 30.8 mm

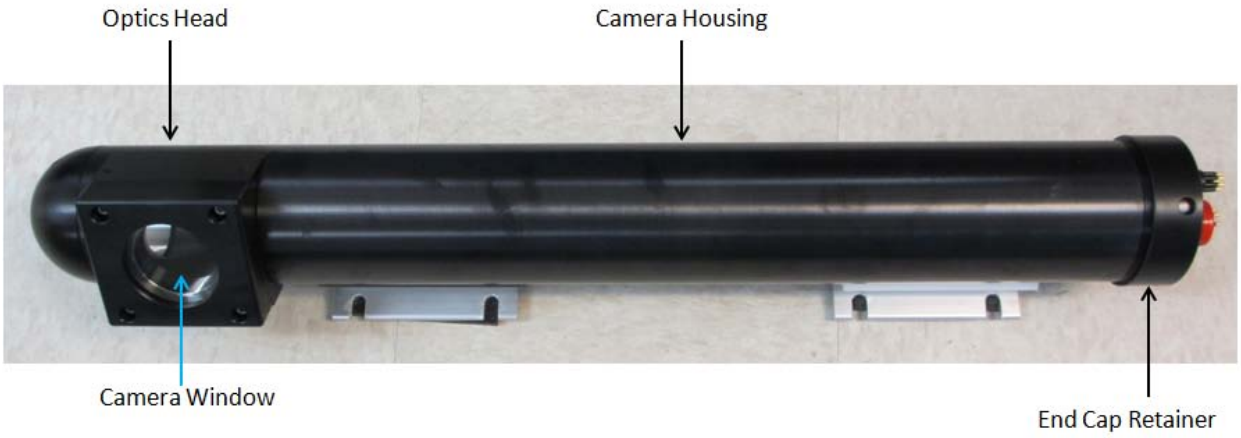
* The optical field of view was measured during the calibration process. The spacing between the camera and strobe housing centerlines is 59 cm.

2.2.2. Optics Controller Board

The Seascan Optics Controller printed circuit board sets the camera and lens position to a memorized set of working parameters. This board is located inside the Camera Housing assembly.

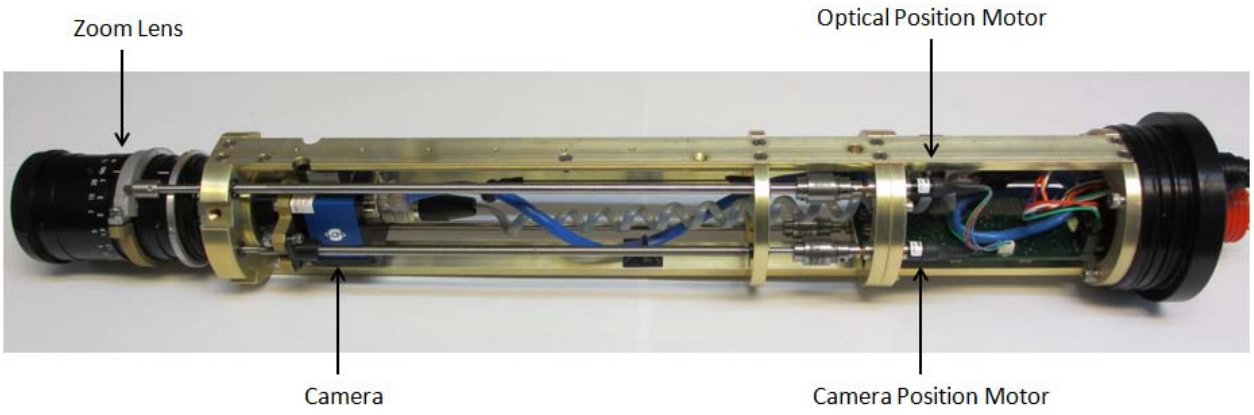
2.2.3. Camera Assembly Description

The camera housing assembly includes the Optic Head, Camera Housing, End Cap and End Cap Retainer. The Optics Head has a 45-degree mirror permanently mounted inside and aligned with the glass window. The Optic Head screws into the Camera Housing and sealed with two rubber o-rings.



The camera chassis assembly is mounted to the camera end cap and slides into the Camera Housing. The End Cap Retainer screws to the outside of the Camera Housing and prevents the end cap and chassis from moving.

The gigabit Ethernet camera is mounted on a linear slide and driven to prefixed axial positions by a small stepper motor. Two additional stepper motors control the position of the iris and focus on the camera lens. The position of the focal length (zoom control) is fixed at infinity.

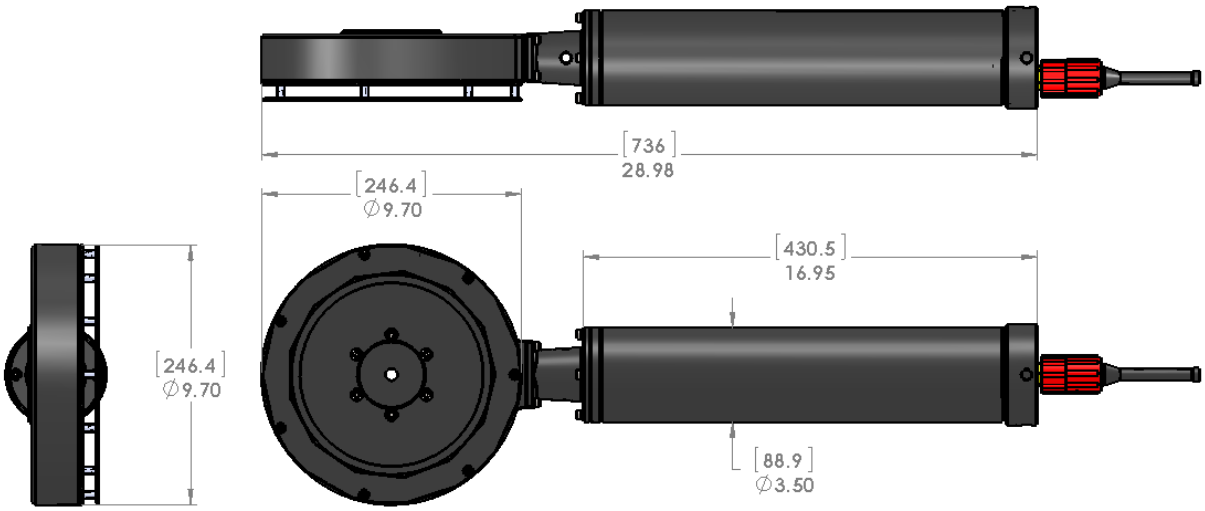


The position of the camera, iris and focus are set for each of the optical switch settings: S0, S1, S2 and S3. The settings correspond to four magnifications within the field of view range and reference an object plane located approximately mid-distance between the camera and strobe housing centerlines.

The depth of field is different for each optical setting and increases with increasing field of view (decreasing magnification). Each of the optical settings was characterized and calibrated at Seascan to define the observed volume.

2.3. Strobe Housing Assembly

2.3.1. Strobe Housing Assembly Specifications



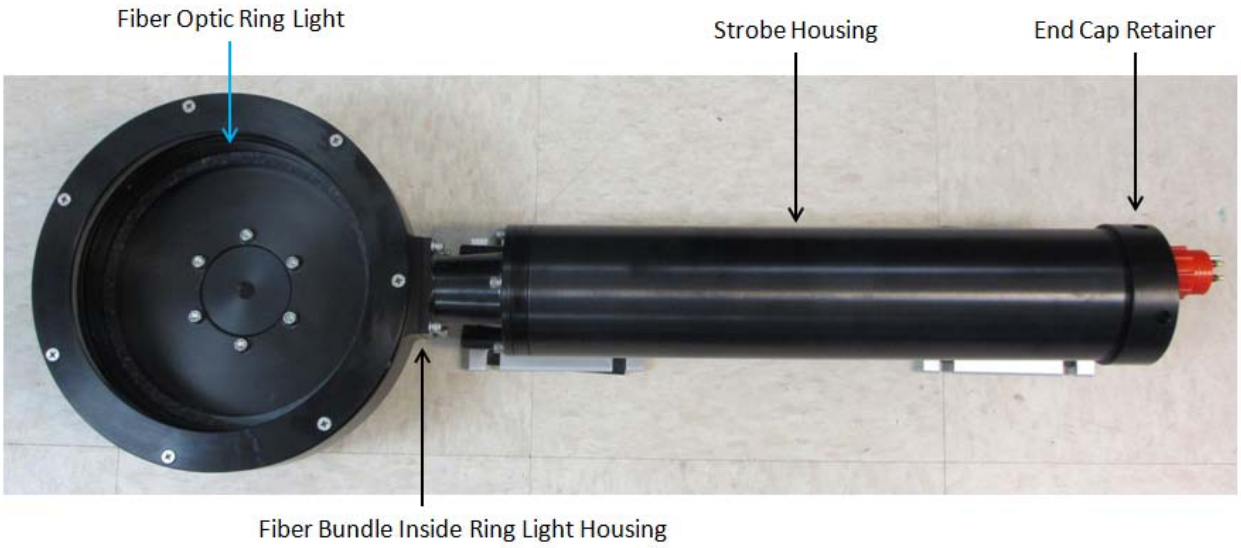
VPR Strobe Light Assembly

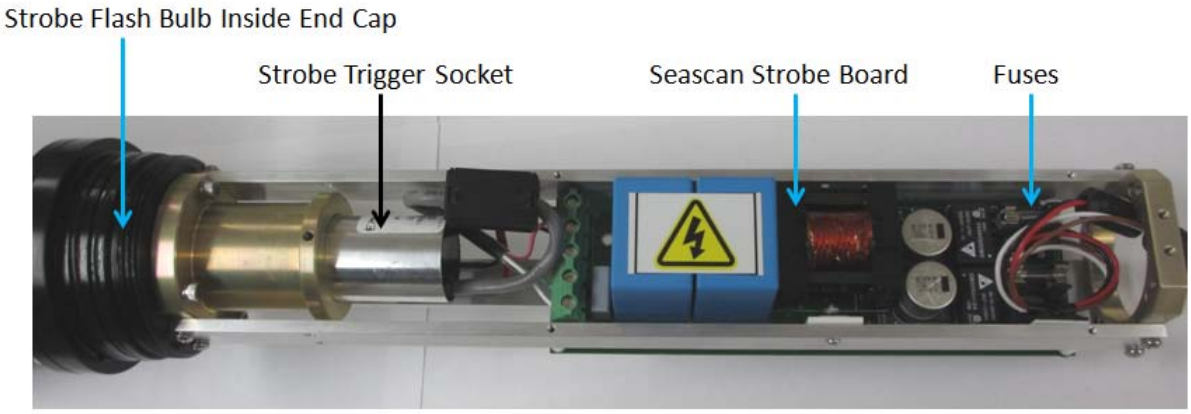
Air Weight	6.58 kg
Weight in Fresh Water	3.18 Kg
Maximum Operating Depth in Sea Water	1000 m
Operating Temperature	-10 to +45°C

Flash Lamp and Trigger Module	
Flash Lamp Manufacturer and Part No.	Excelitas FX-440
Energy per Flash	1.0 J
Average Power	60 W
Voltage, VDC	800 VDC
Trigger Module	Excelitas FYD-4400
Flash Duration	Approx. 3.0 µsec
Operating Flash Rate	20 flashes per second

A bundle of bare fiber optic material is mounted inside the Fiber Optic Ring Light in a thin 8-inch diameter ring. The fibers are mounted on an angle so that the light passing through the optical fiber produces a wide conical light.

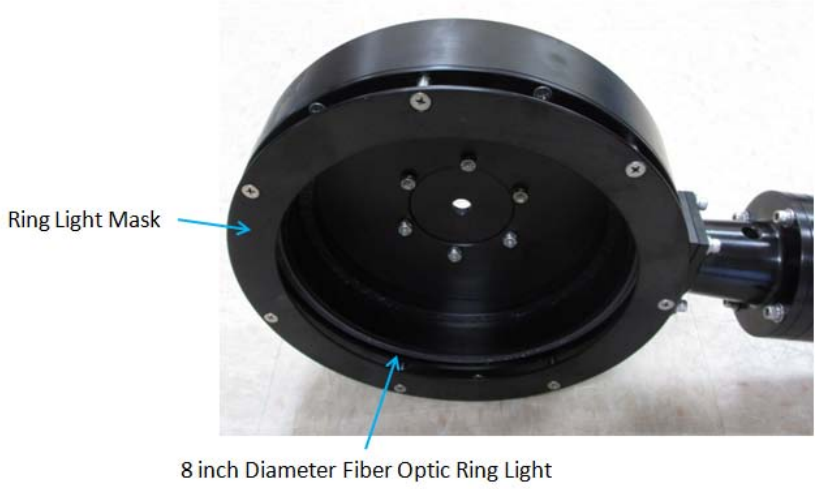
The fiber optic material is bundled together at the end of the Ring Light Housing. The strobe bulb is located inside the Strobe Housing and flashes light into the fiber through a small, sealed glass window.



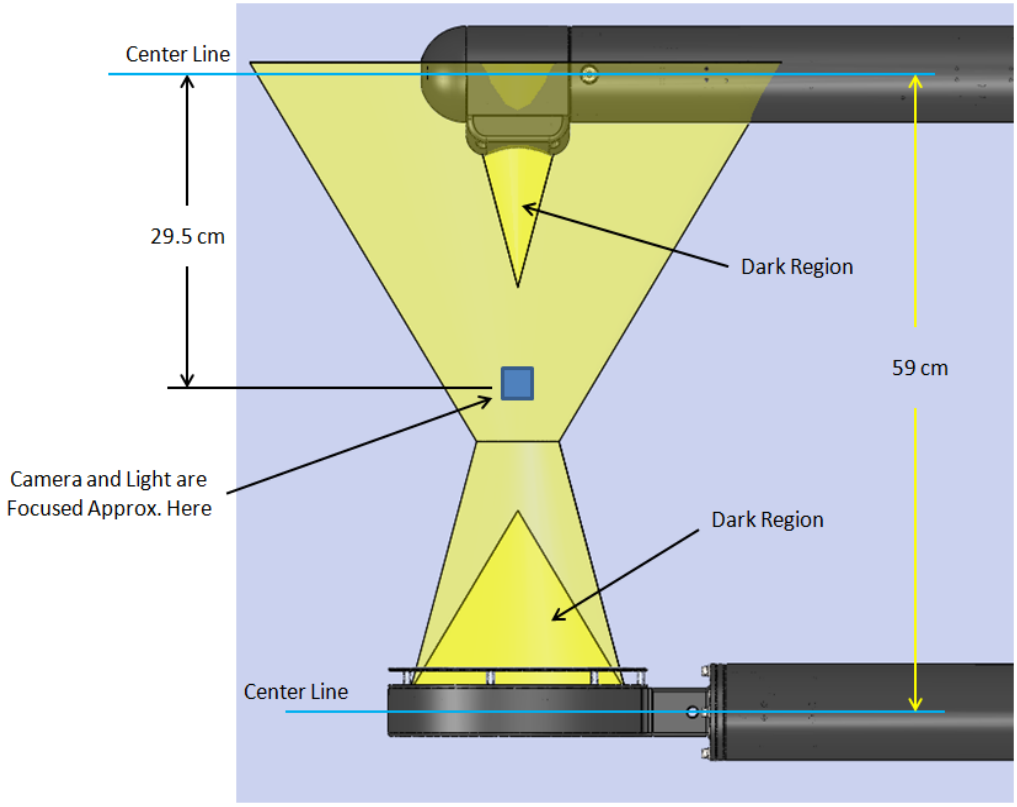


Strobe Electronics Chassis Assembly

A thin aluminum ring called the Ring Light Mask is mounted approximately 12 mm away from the Ring Light Housing. The Ring Light Mask is used to clip the light exiting the Ring Light and prevents light from going into the camera window. **NOTE: The diameter and spacing of the Ring Light Mask were set by Seascan for optimal lighting.**



The separation distance from the centerline of the camera housing assembly to the centerline of the strobe housing assembly is 59 cm. The Strobe Ring Light was designed for this separation distance in sea water and concentrates the strobe light approximately 29 cm from the centerline of the camera assembly. The camera is focused in the brightest region.



2.4. Laptop Computer System Requirements and Software

2.4.1. Operating System

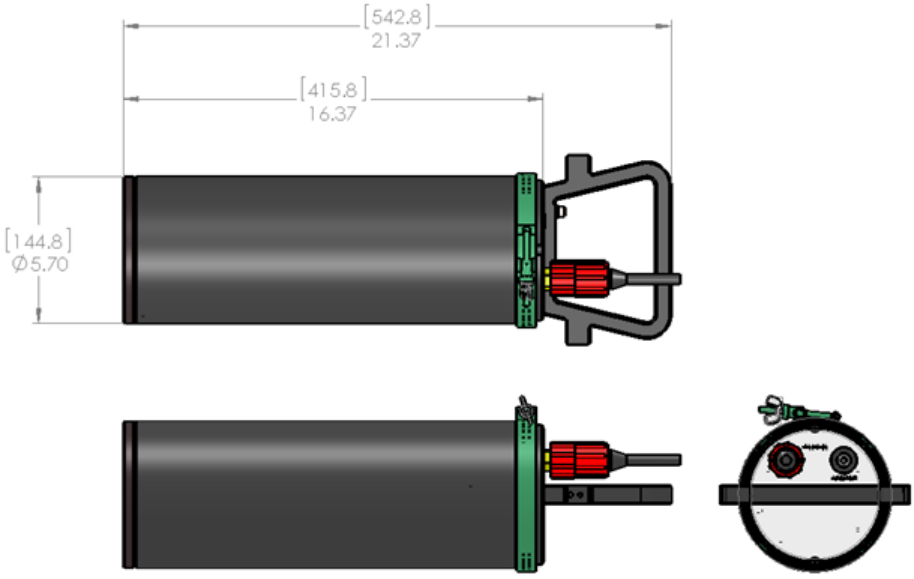
Microsoft Windows 10 Professional, 64-bit Operating System.

2.4.2. Processing Software

JpegLS_ADec (often referred to as "AutoDeck"): The latest version of this software comes pre-installed on the laptop computer. A license key is required to operate this software and was provided with the computer.
CalDeck_DAVPR_Reader: The latest version of this software comes pre-installed on the laptop computer.
Matlab: The Visual Plankton software requires Matlab R2010b 32-bit (version 7.11.0) or earlier (not included).

2.5. Battery Housing Assembly

2.5.1. Battery Housing Specification



Battery Housing Assembly

Air Weight (without battery pack)	7.7 kg
Weight in Fresh Water (without battery pack)	0.31 kg
Max. Operating Depth in Sea Water	1000 m
Operating Temperature	-10 to +45°C
Nominal Output Voltage	28.8 VDC

2.5.2. Battery Housing Description

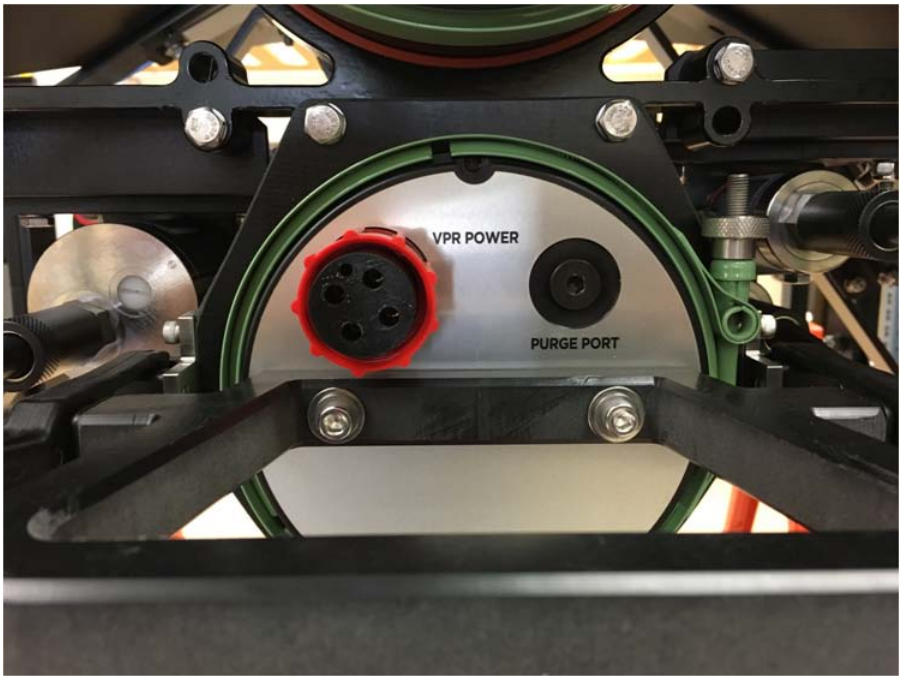
The Battery Housing assembly provides all the power to operate the DAVPR subsystems -the electronics, camera and strobe assembly, as well as any oceanographic instruments connected to the Electronics Housing end cap.

The Battery Housing assembly contains one rechargeable nickel metal hydride battery pack consisting of 24 "F" cells and will provide approximately 430 Wh of power at 28.8 volts. A fully charged battery pack will operate the DAVPR system for approximately 5.5 hours at room temperature (22 ^{o}C) or approximately 5 hours at 0 ^{o}C.

Battery Type	Rechargeable Nickel Metal Hydride (NiMH)
Number and Type of Cells	24 x NiMH F Cells
Nominal Voltage	28.8 Vdc
Nominal Capacity	15 Ah
Overall Length	266.7 mm

Approximate Outside Diameter	114.3 mm
Air Weight	6 kg

The battery housing end cap has one four pin female bulkhead connector labeled "VPR POWER". A four pin male to female rubber cable assembly is used to connect the "VPR POWER" to the bulkhead connector labeled "INPUT POWER" located on the Electronics Housing end cap assembly.



The fitting labeled "PURGE PORT" is used to remove any vacuum in the Battery Housing to facilitate opening and removing the battery chassis or ***to vent any high pressure gases or water in the event that the housing flooded with sea water or the battery pack failed (see section 3 Removing and Installing the Battery Pack)***. The purge port fitting must be installed during operation or the battery housing assembly will fill with seawater and fail.

3. Removing and Installing the Battery Pack

WARNING!

It is possible that a sea water leak at depth could introduce high pressure sea water inside the battery housing and create an unsafe condition for the user. Slowly remove the Purge Port to safely vent the battery housing before removing the V-Band retaining the end cap.

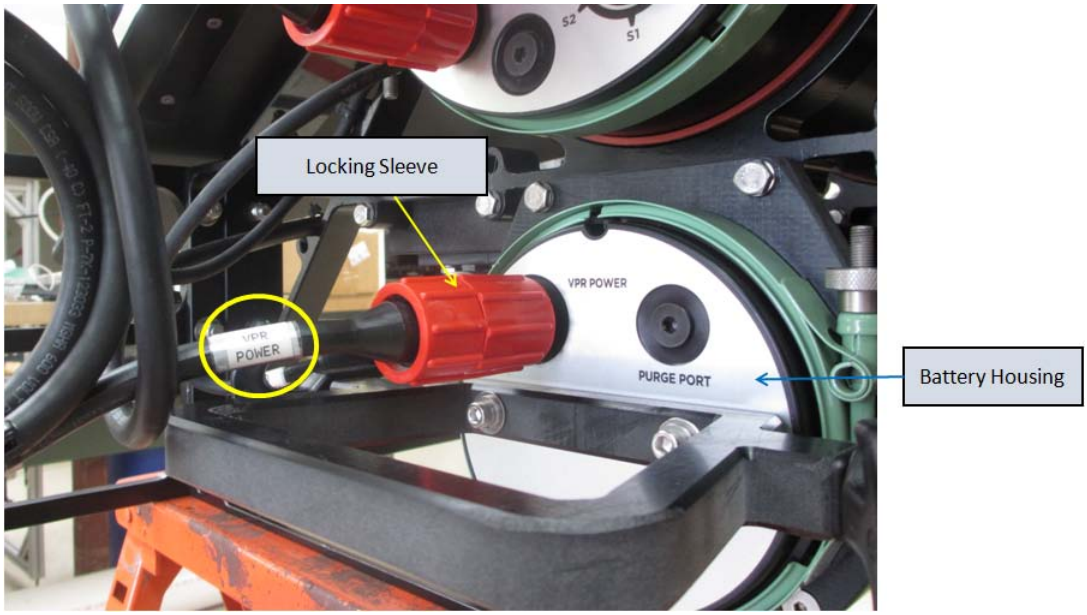
WARNING!

It is possible that a failed battery pack could off gas inside the battery housing increasing the gas pressure inside the battery housing and creating an unsafe condition for the user. Slowly remove the Purge Port to safely vent the battery housing before removing the V-Band retaining the end cap.

Seascan recommends that the user change the battery pack in a dry work space to prevent water from getting into the battery housing or on the battery pack. The Battery Housing is located under the Electronics Housing in the tow frame assembly.

Please note the position of the T-Bolt on the V-Band relative to the Battery Housing end cap. It could be located anywhere around the end cap but it may be preferable to locate it on the side (as shown in the picture below) or the top to protect it.

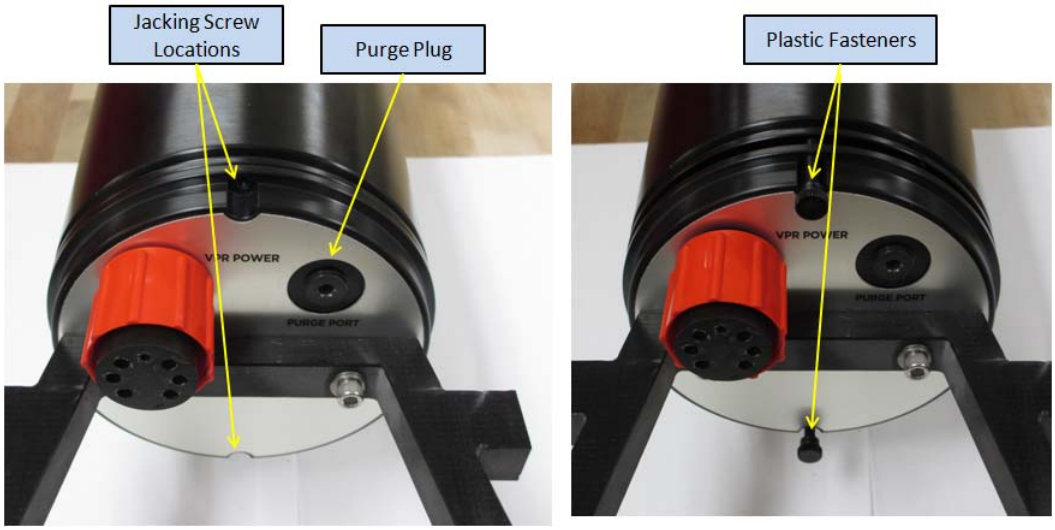
- Locate the bulkhead connector labeled "VPR POWER" on the Battery Housing end cap. You will remove this cable assembly first.



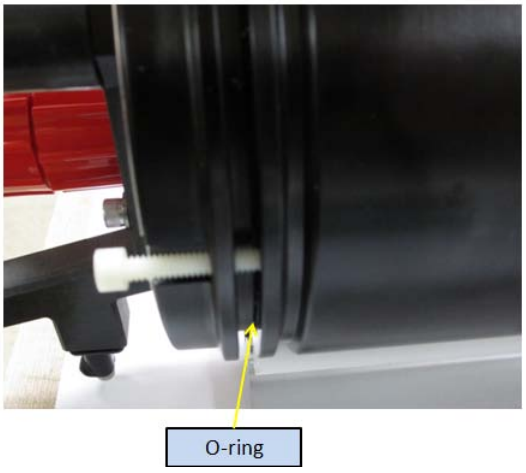
- Unscrew the red plastic locking sleeve retaining the cable assembly to the bulkhead connector and disconnect the 4-pin male cable assembly. This will remove power to the system and allow the user to remove the Battery Housing assembly.
- Unclip the two rubber latches retaining the Battery Housing in the mounting bracket by pulling the rubber latches forward and off of the retainer.

- Slowly remove the Battery Housing out of the mounting brackets by using the plastic handle. Transfer the assembly to a dry work space on the vessel.
- Place the Battery housing horizontally on a work surface.
- Slowly remove the Purge Plug to vent the battery housing. The Purge Plug has a slot along the threads so venting will occur before the plug is fully removed from the end cap.
- **Immediately replace the Purge Plug**. This will ensure that the plug is installed prior to deployment.
- Unscrew the thumb nut located on the V-band clamp retaining the end cap. Remove the V-band and set it aside (temporarily replace the thumb nut to keep the parts together).

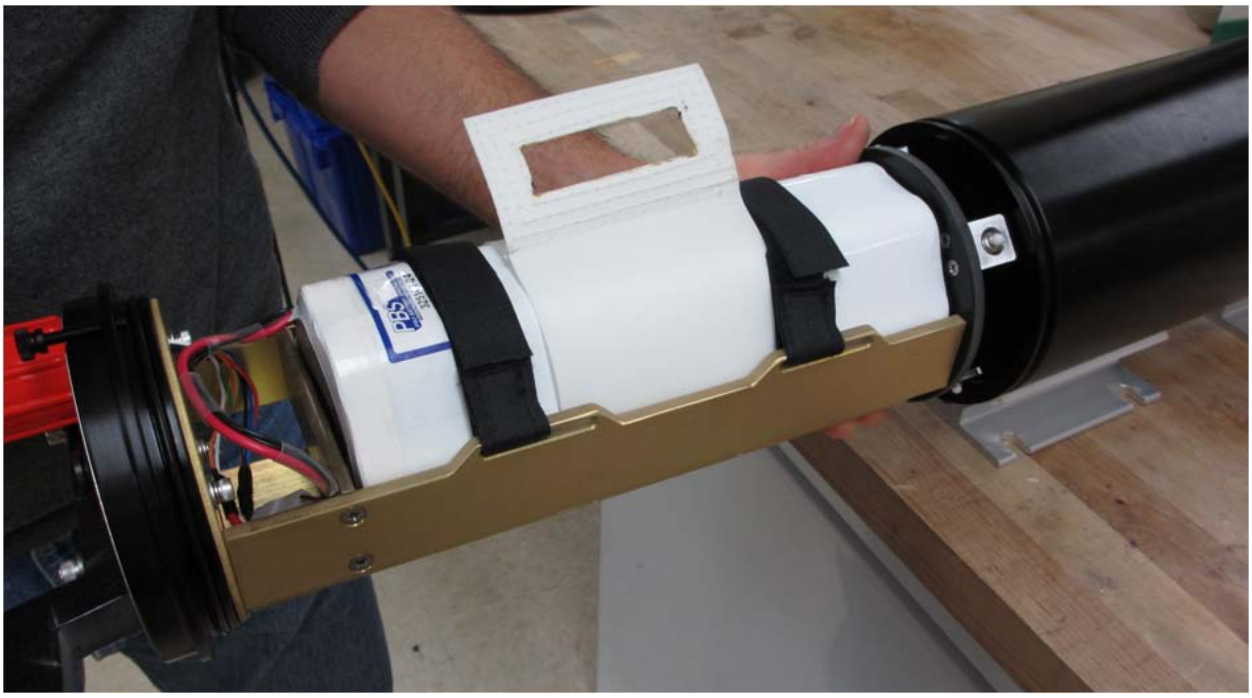
- A rubber o-ring seal located on the Battery End Cap prevents water from leaking into the Battery Housing assembly during operational use. The compressive force on the o-ring seal can make it difficult to remove the end cap. Two threaded holes (Jacking Screw holes) located 180 degrees apart on the edge of the Battery End Cap are provided to easily remove the end cap.



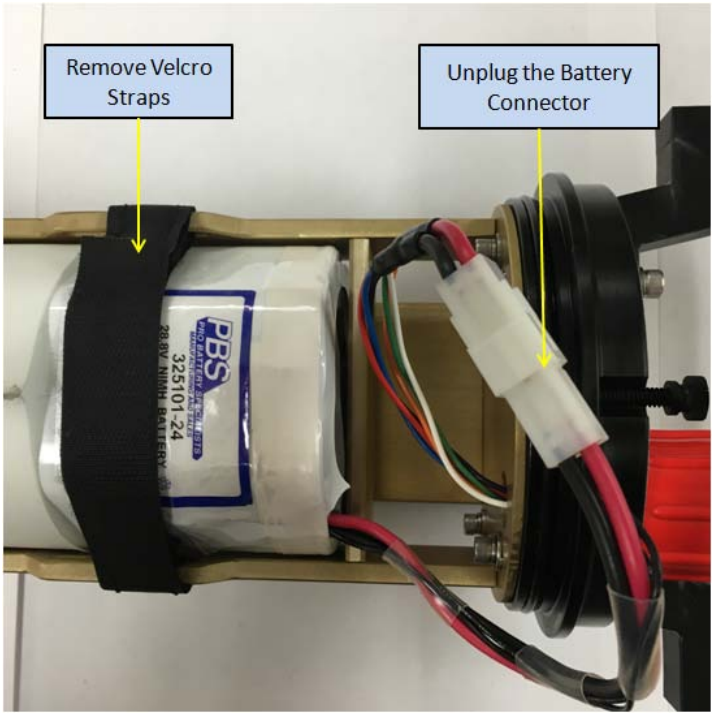
- Install a plastic 10-24 fastener (located in the DAVPR spare parts) in each of the threaded holes. Screw in the fasteners until the screw stops against the end of the Battery housing. Incrementally rotate each screw the same amount to ensure that the end cap pushes evenly away from the Battery Housing. Continue to rotate the screws until you can see the rubber o-ring.

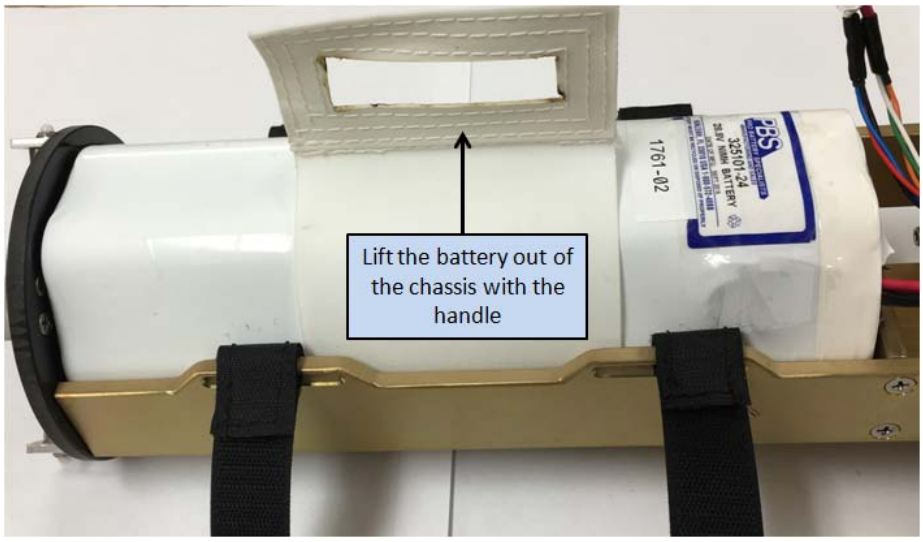


- Slowly pull the Battery Chassis assembly out of the Battery Housing using the plastic handle. Support the bottom of the battery chassis with your other hand. Place the battery chassis assembly horizontally on the workbench to remove the battery pack.



- Pull out the wire bundle and disconnect the battery pack from the end cap. Remove the Velcro straps retaining the battery pack and remove the pack from the chassis by lifting straight up with the handle.





Installing the battery pack is basically the reverse process from removing the pack.

- Gently place the battery pack into the chassis using the handle. Securely replace the Velcro straps over the battery pack .
- Plug in the battery connector to the mating connector on the end cap. The connector housing is keyed and can only connect in one orientation.
- Tuck the wire bundle into the space in front of the battery chassis.

The battery packs may need charging prior to using the DAVPR system. Please refer to section 5 “Charging the Battery Pack” for instructions on checking the battery pack voltage and charging the batteries.

4. INSTALLING THE BATTERY CHASSIS ASSEMBLY

NOTE: It is important to check the o-ring seal and sealing surfaces before installing the Battery Chassis assembly into the Battery Housing. Please refer to section 9 "O-Ring Seals, Inspection and Replacement" for these instructions prior to installing the battery chassis.

Make sure that:

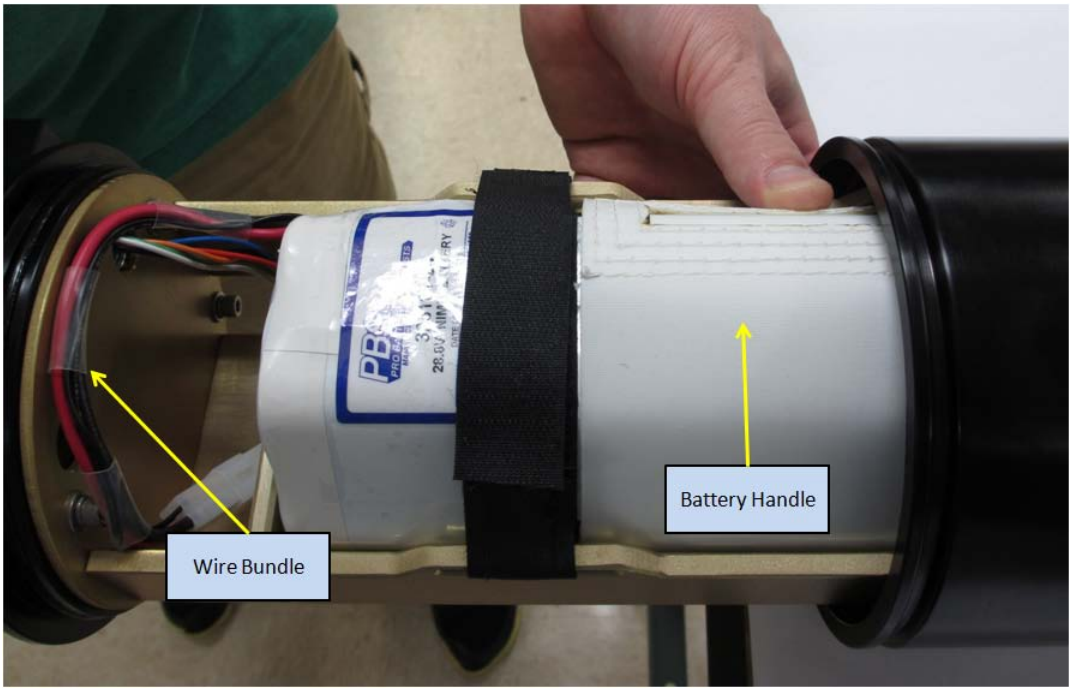
- The velcro straps are tightly secured and no material is sticking up.
- The battery connector is mated and the wire bundle is tucked securely inside the battery chassis.
- The O-ring and sealing surfaces are clean and properly lubricated.
- **The purge plug is fully installed.**

The end of the battery chassis has four spring plungers with plastic balls. The plastic balls will push on the inside of the pressure housing and support the end of the chassis.

- Support the battery chassis assembly with one hand underneath the chassis and one hand on the plastic handle. Carefully and slowly slide the chassis into the pressure

housing. Guide the four spring ball plungers into the pressure housing past the sealing surface.

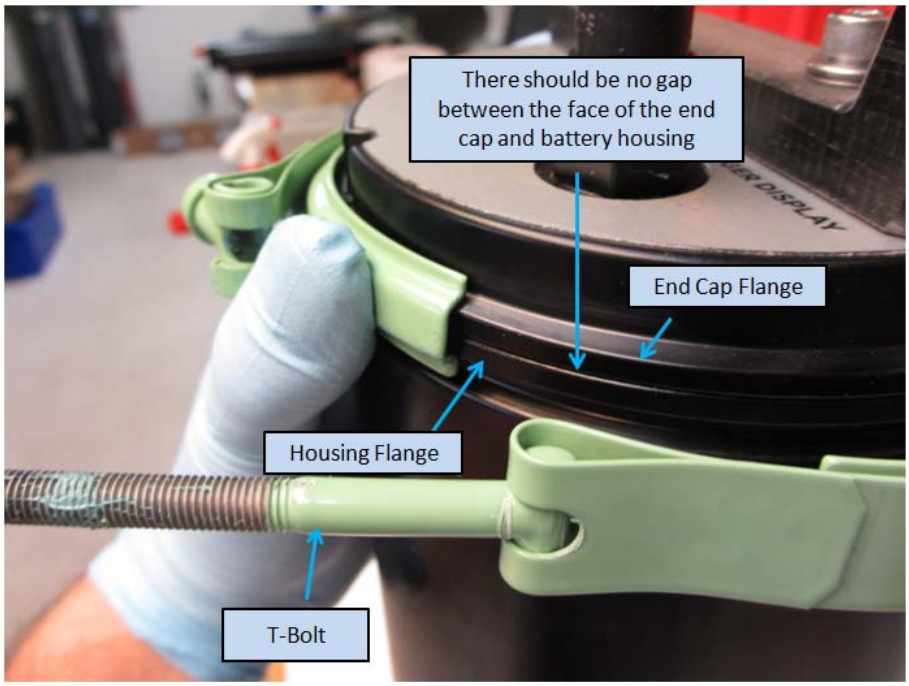
- Fold down and hold the battery handle while sliding the chassis into the pressure housing. Make sure the wire bundle is tucked into the front of the battery chassis during the installation process.



- Slide the chassis in until the O-Ring is just inside the end of the pressure housing.
- Carefully stand the Battery Housing up on end on the work surface. The battery chassis assembly will be supported on the rubber o-ring. Check to ensure that the o-ring was

not pinched out of the groove during installation. The o-ring should be visible all around the top of the battery housing.

- Push down on the plastic handle to seat the o-ring in the pressure housing. There should be no gap between the face of the end cap and battery housing.



Installing the V-Band Retainer

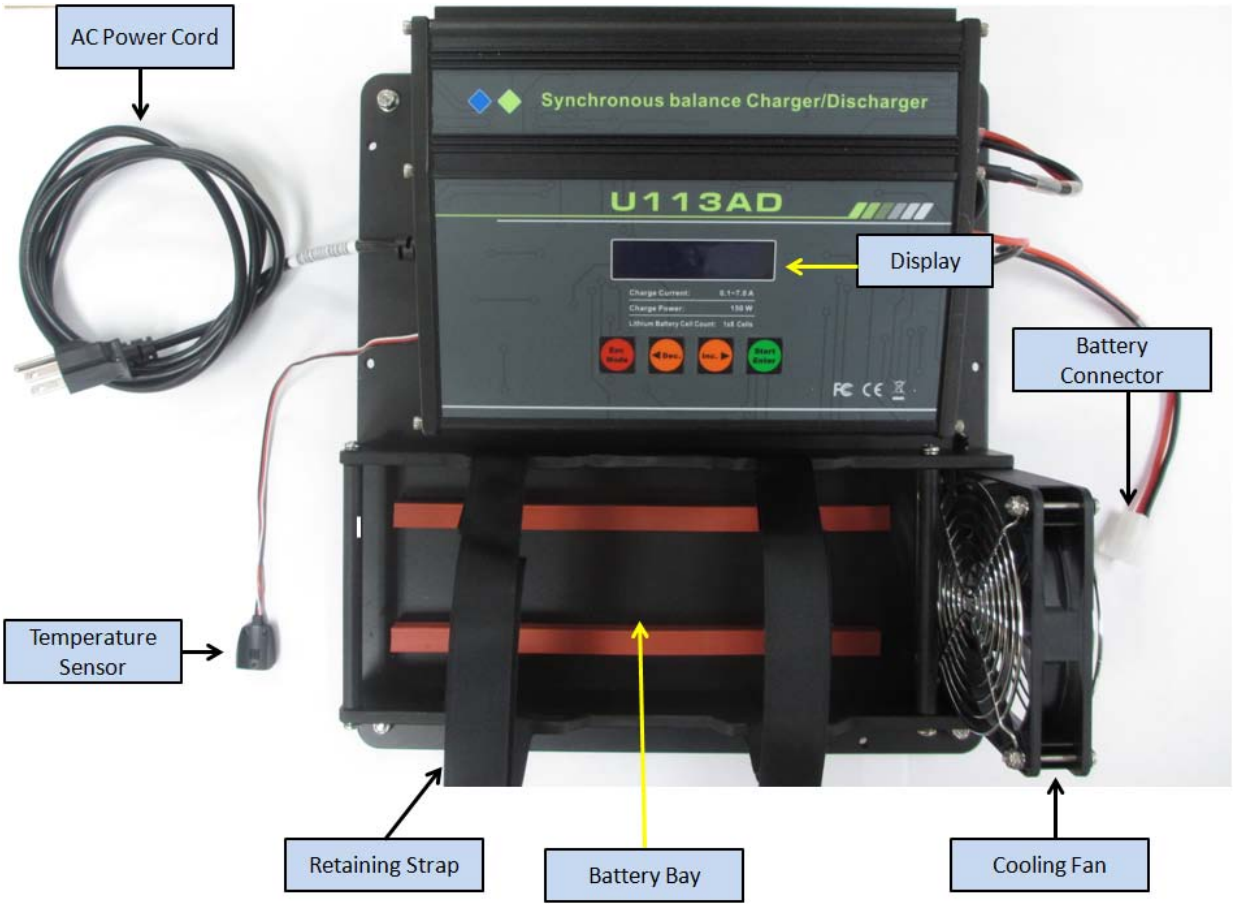
- Carefully wrap the V-Band Retainer around the end cap and housing flange as shown above. Slide the T-Bolt through the mating side on the V-Band and thread on the 1/4-28 thumb nut. **The thumb nut should thread on easily; do not force the nut.**

- Rotate the V-Band so that the T-Bolt is located in the desired position. Tighten the thumb nut firmly so that the V-Band cannot rotate around the housing.
- If the Purge Port Plug was removed, then inspect the o-ring and o-ring surfaces and reinstall the plug.

5. CHARGING THE BATTERIES

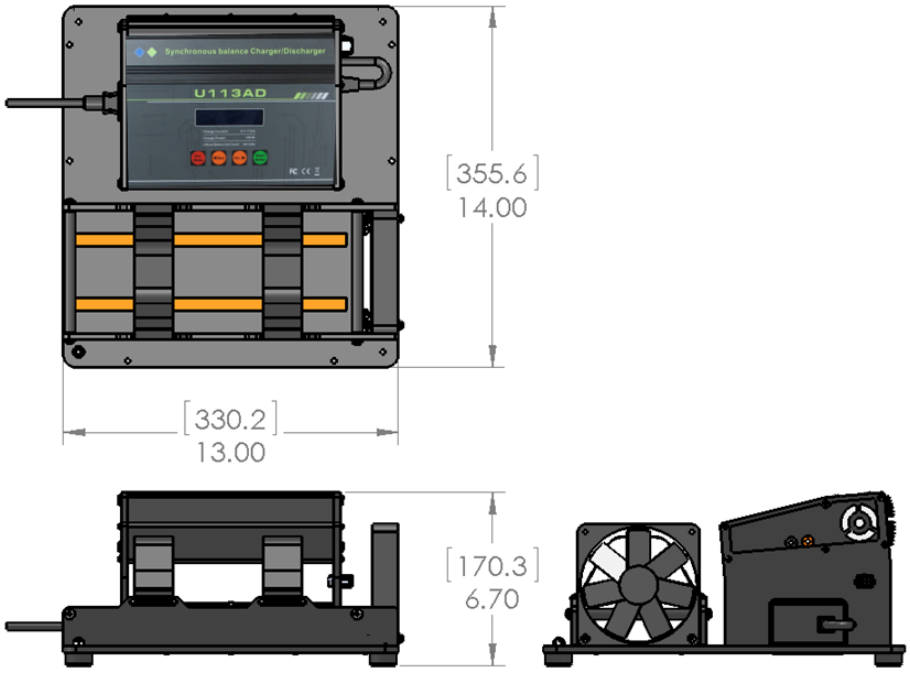
5.1. Battery Charger Overview

A commercially available battery charger is supplied with the DAVPR system. Seascan incorporated the battery charger into a charging workstation that includes a secure location (Battery Bay) for the battery pack and a cooling fan. Space is provided around the battery pack to allow the cooling fan to force air past the battery pack during the charging process. ***It is very important to prevent NiMH batteries from overheating. High temperatures including high storage temperatures will shorten the life of the battery cells.***



Air Weight	4.4 kg
Input Voltage Range	85 to 264 VAC; 100 to 240 VAC Nominal
Input Frequency Range	47 to 63 Hz
Input Current	<3A rms
Inrush Current	<37 A at 230 VAC cold start

Operating Temperature	5 to +50°C
Output Voltage	Automatically Set
Output Current	Maximum Set to 3.5 A
Sensitivity	5 mV/cell
Temperature Cut Off	50° C
Trickle Charge Set To	200 mA
Safety Timer Set To	400 min.
Capacity Cut Off Set To	15.6 A



Battery Charger Assembly

The battery charger can be clamped to a work surface or secured with fasteners. Multiple holes are provided around the base plate for securing with fasteners.

The battery charger is used only to charge the Seascan 24 x F cell rechargeable Nickel Metal Hydride Battery Pack. The battery charger was preset to automatically charge the battery pack at 3.5 A. Typical charging time is approximately 5 hours.

The battery pack has a nominal battery voltage of 28.8 V. During the charging process, the battery voltage will increase to approximately 35 V.

The DAVPR system could operate for approximately 5 to 5.5 hours on a fully charged battery pack depending on the operating temperature.

This charger requires a temperature sensor that must be used during the charging process. The temperature sensor detects when the battery pack is fully charged by monitoring the change in temperature of one of the cells in the battery pack.

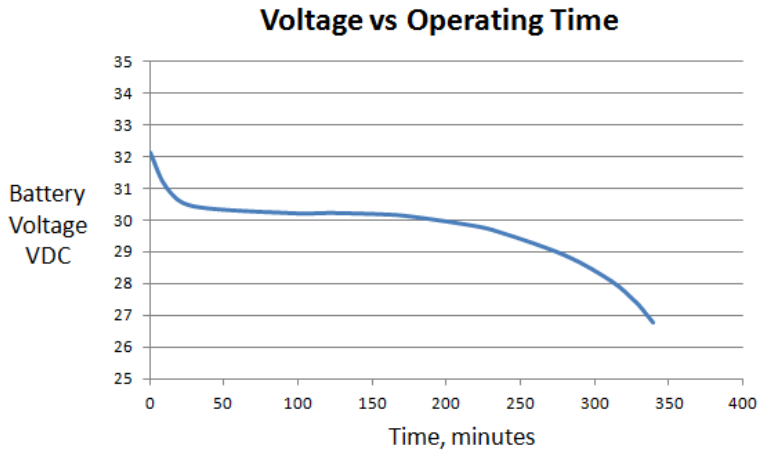
5.2. Safety

The battery charger is designed to minimize the risk of fire and shock hazards. Nevertheless, certain precautions must be observed to ensure safety.

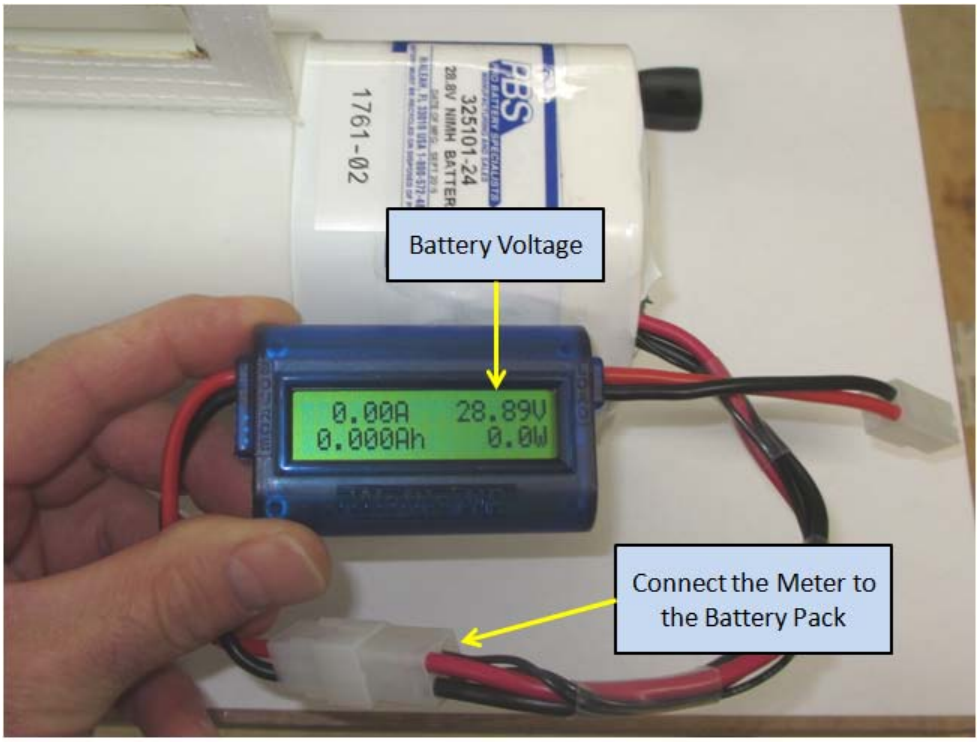
- The battery charger will become warm during the charging process. Please do not cover the charger.
- Do not use the battery charger in an environment below 5 ^{o}C or above 50 ^{o}C.
- Do not use the charger in a wet environment.
- Keep all flammable and volatile materials well away from the operating area.
- Do not damage the charger by dropping, bumping, or striking it, or by placing heavy weights on top of it.
- Do not attempt to use a higher voltage than what is specified in this manual.
- Make sure the battery and the voltage for the battery pack is selected correctly.
- This battery charger can only charge one battery pack at a time. Do not alter the charger to accommodate multiple packs.
- Do not attempt to charger/discharge non-rechargeable or damaged batteries.
- Keep the charger away from children at all times.
- Never leave the charger unsupervised when it is connected to its power supply.

5.3. Checking the Battery Pack Voltage

A power meter was supplied with the DAVPR system. Use this meter to measure the battery voltage. The battery pack voltage will be approximately 35 V immediately at full charge while on the battery charger. The battery voltage will drop to 32-33 V shortly after charging. The following graph illustrates the battery pack voltage drop during operational use at room temperature. The DAVPR controller will automatically shut down the system when the battery voltage reaches 26.5 V. Charge the battery pack if the voltage is between 27 to 30 Vdc.



- Connect the power meter to the battery pack. The connectors are keyed and can only connect in one orientation. The battery voltage is displayed in the upper right corner of the LCD display.



Use the Power Meter to Measure the Battery Voltage

5.4. Using the Battery Charger

Please read this entire section prior to charging the battery pack for the first time.

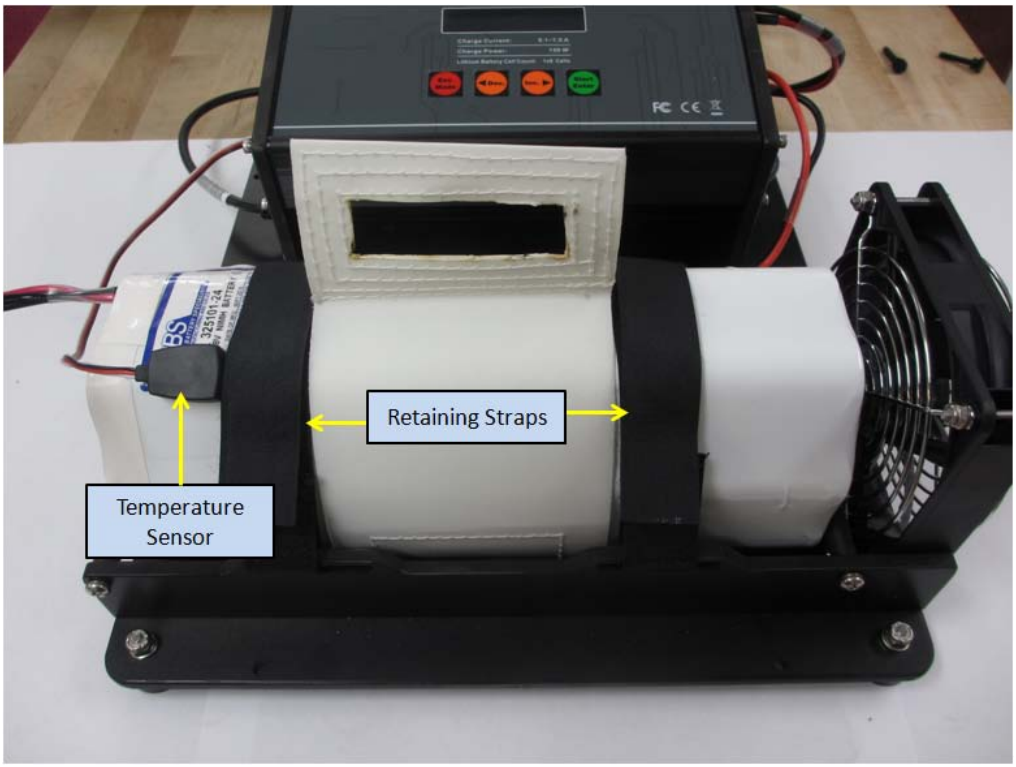
The DAVPR battery charger is preset to automatically charge the battery pack at 3.5 A until:

- The maximum allowable temperature is reached (50^{o} C)
- The charger has been operating for 400 minutes (safety timer)
- The battery capacity is 15.6 A (capacity cut off)

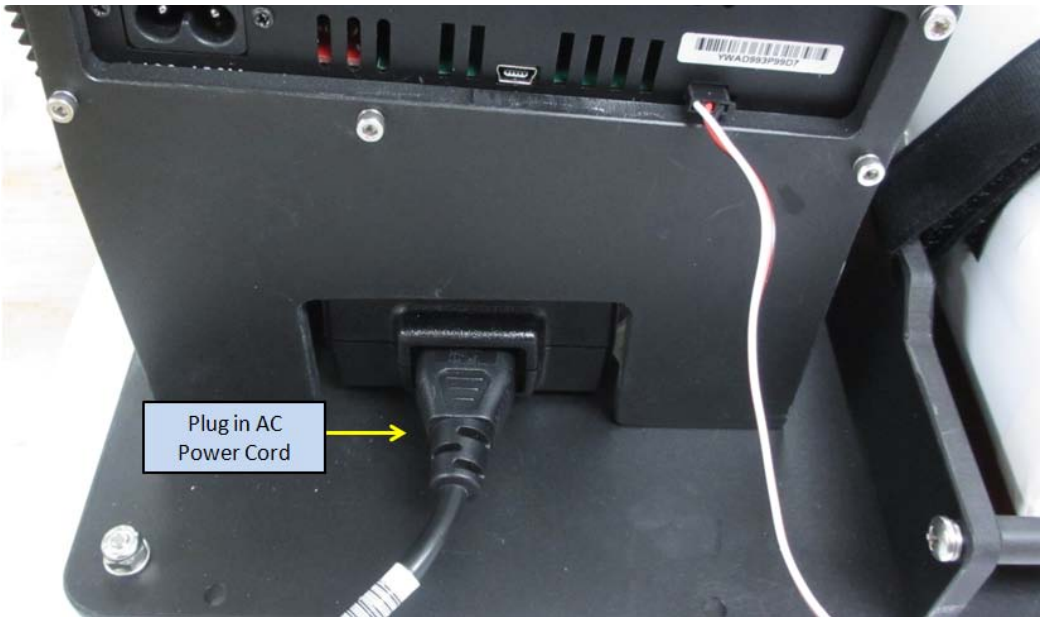
Temperature is typically used in the charging algorithm to detect full charge.

- Remove the battery charger from the Pelican case.
- Securely mount the battery charger to a work surface in a dry work space.
- Center the battery pack in the Battery Bay and secure the pack with the two velcro straps.
- Place the temperature sensor on the battery pack opposite the cooling fan. This part of the battery pack will be the warmest during charging. The temperature sensor is magnetic and will stick to the steel battery cell inside the pack. If the sensor will not remain in place, then secure it in place under the velcro strap.

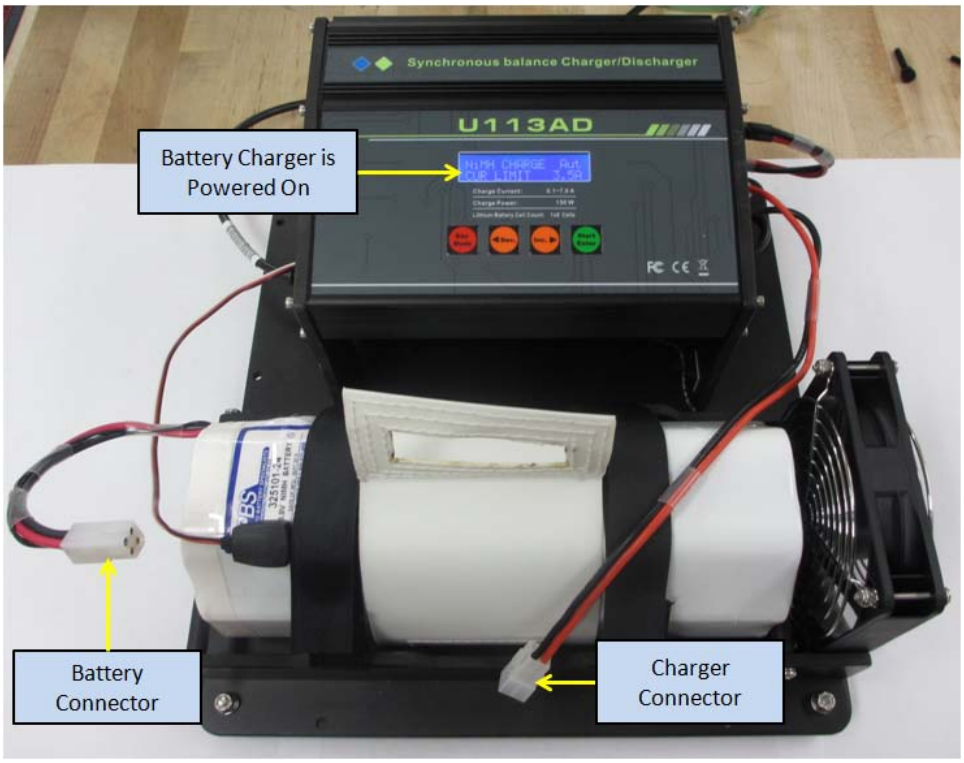
NOTE: It is important to use the temperature sensor during charging. The charging algorithm uses the sensor to determine the end of charge, as well as, prevent the battery cells from overheating. Battery cells will have reduced capacity and life if subjected to high temperatures.



- Plug the end of the AC power cord into the power supply located under the battery charger. Plug the other end of the AC Power cord into an appropriate AC power supply. The battery charger and cooling fan will automatically turn on when connected to a power source.

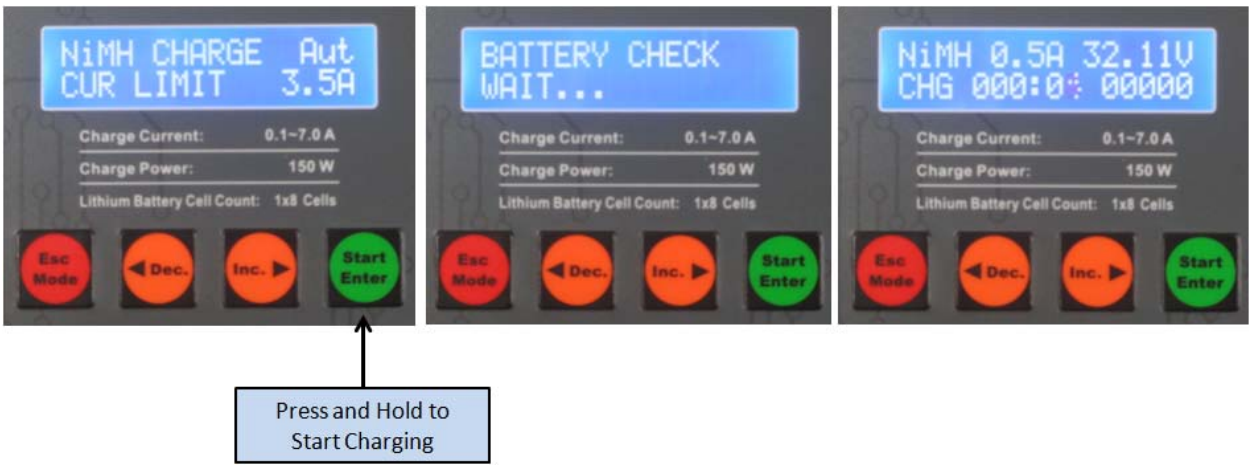


- Plug the battery connector into the charging connector.



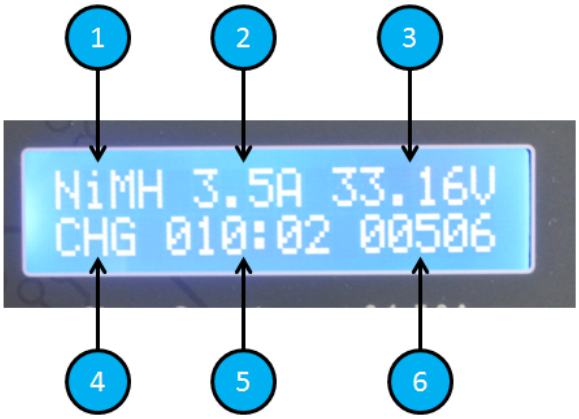
The battery charge is preset to automatically (Aut) charge the DAVPR nickel metal hydride (NiMH) battery pack at 3.5 A until fully charged.

- Press and hold the green "Start Enter" button. The battery charger will beep and the display will change to the following:



The user can monitor the charger display to determine the state of the charging process. Typically the DAVPR battery pack will take approximately 300 minutes to charge, reaching approximately 35 V, and 15,000 mAh.

1. Battery Type
2. Charging Current, A
3. Battery Voltage, V
4. Process
5. Elapsed Time
6. Accumulated Capacity, mAh

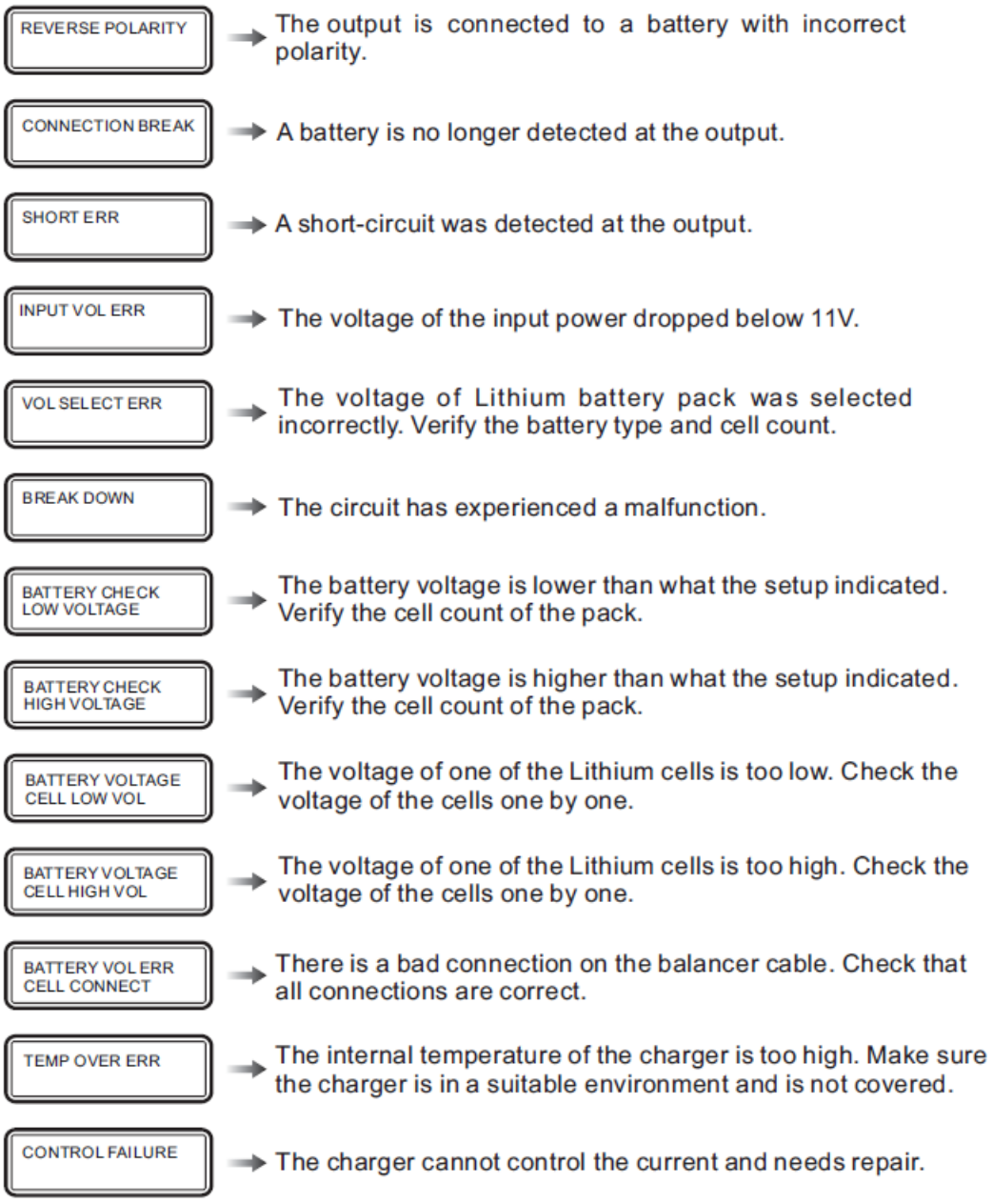


The battery charger will make an audible sound when the battery pack has reached full charge. The display will change indicating that the battery pack is "Full".

- Disconnect the battery pack from the charger and allow the battery pack to cool down for 15 minutes or more.
- Unplug the power cord to turn the charger off.

The user can stop the charging process anytime by pressing the "Esc Mode" button.

5.5. Battery Charger Warnings and Error Messages



6. Operating the DAVPR in the Lab

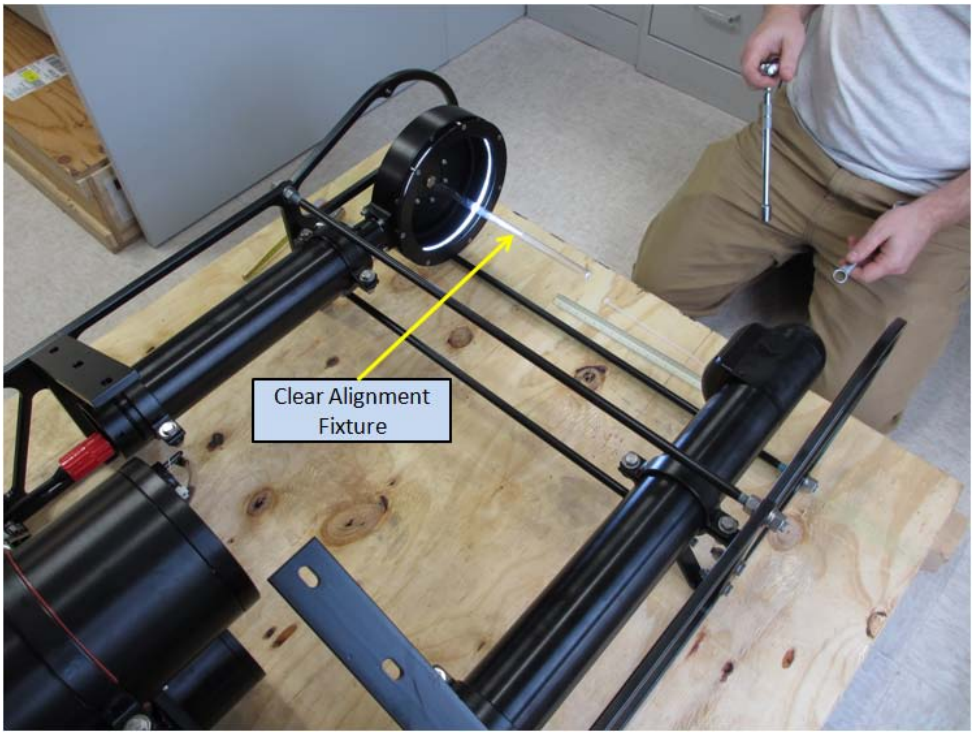
Setting up and using the DAVPR system in the lab allows the user to become familiar with the set up and operation of the DAVPR system. Please review Appendix E "Handling Underwater Connectors" prior to setting the DAVPR system up on the bench.

In this section the user will set up the DAVPR system, access the DAVPR computer, and operate the system in real time while viewing an object in the field of view.

6.1. Setting Up the DAVPR

The DAVPR subassemblies-Electronics, Camera, Strobe, and Battery Housing typically are mounted inside the tow frame prior to shipping from our facility. The Seascan frame maintains the proper separation distance and orientation between the camera and strobe housing centerlines (59 cm).

- Screw in the clear plastic alignment fixture into the center of the strobe ring light. Tighten the brass hex nut to keep the fixture straight. This fixture will extend approximately half the distance between the strobe and camera housings. The end of the fixture will be visible on the laptop screen while operating the DAVPR system.

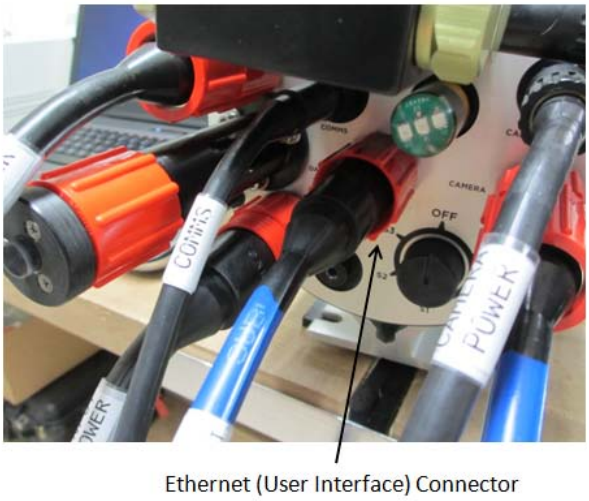


The input power cable is connected last to ensure that there is no power going to the system during the set up. Please follow the set up instructions.

- Next install the User Interface Ethernet cable assembly. Plug the 8-pin male connector into the mating bulkhead connector labeled "ETHERNET" on the Electronics Housing end cap.

Bench Top Ethernet (User Interface) Cable Assembly

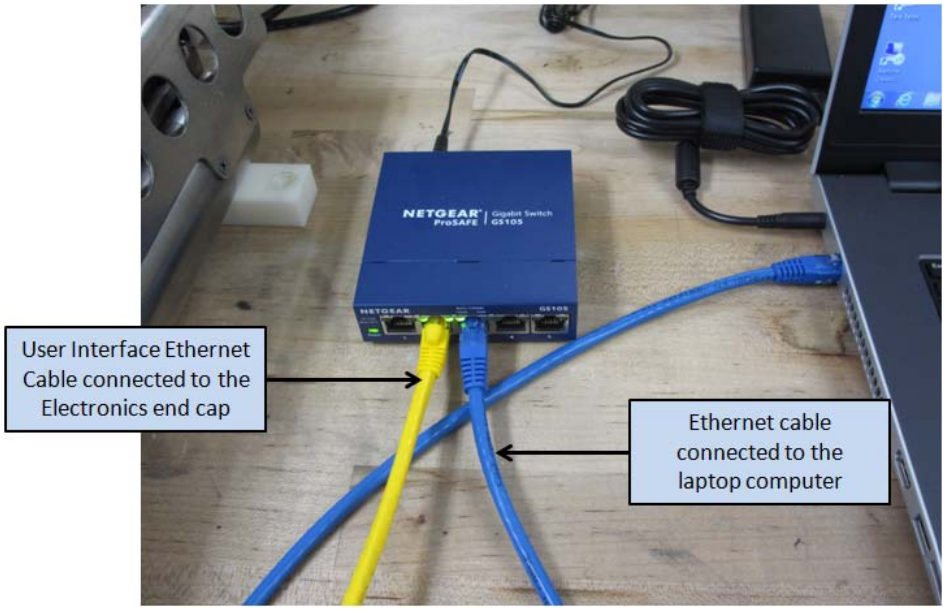
Electronics End Cap



Ethernet (User Interface) Connector

- Plug the standard Ethernet connector on the other end of the cable into the supplied Gigabit Ethernet Switch.
- Connect the laptop computer to the Gigabit Ethernet Switch using an Ethernet cable. The laptop must be on the same network to access the DAVPR computer.

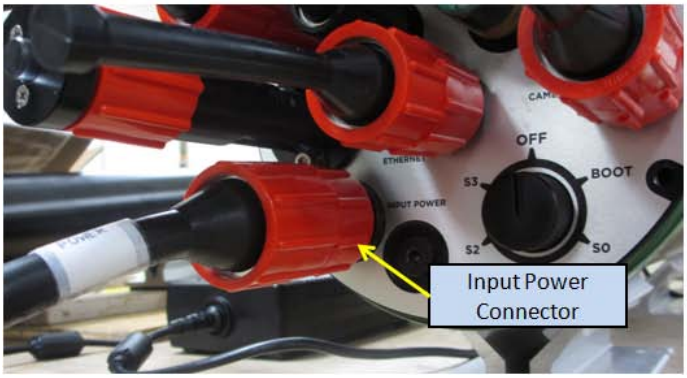
NOTE: The single board computer inside the Electronics Housing assembly is only accessible on a network.



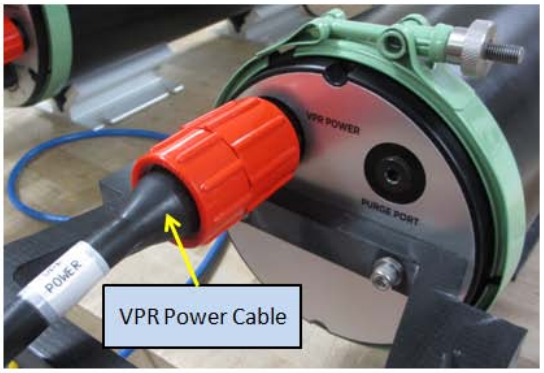
Power is supplied to the DAVPR system either by using the Battery Housing Assembly or by using the DAVPR Power Supply and Adapter Cable. If using the Battery Housing Assembly, then

- Connect the 6-pin female connector labeled "INPUT POWER" to the mating 6-pin male connector located on the Electronics Housing end cap. Connect the other end of the battery cable labeled "VPR POWER" to the mating 6-pin female bulkhead connector located on the Battery Housing end cap. The battery power is now connected to the Electronics Housing assembly and ready to operate. The LED indicator on the Electronics end cap will display a solid red light.

Electronics Housing End Cap



Battery Housing End Cap

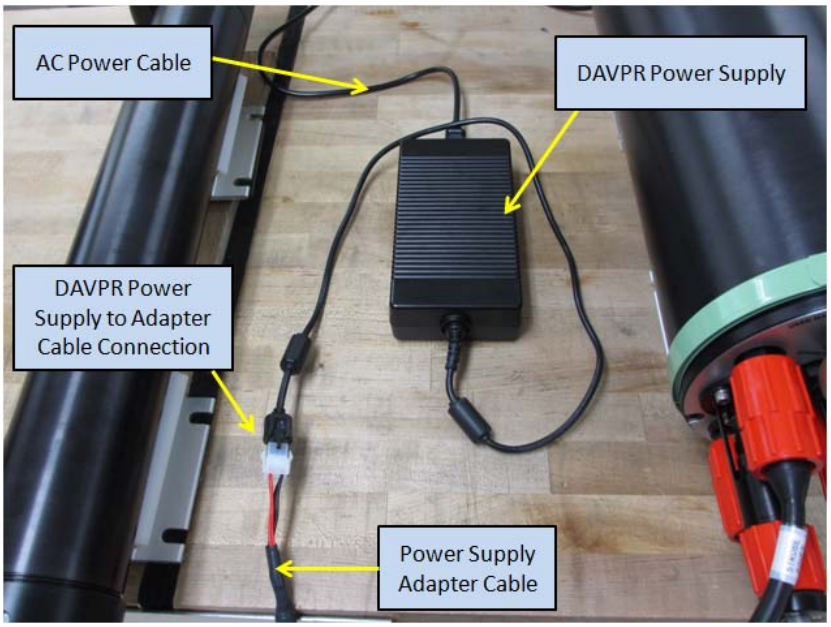


OR if using the DAVPR Power Supply and Adapter Cable, then

DAVPR Power Supply

Power Supply Adapter Cable

- Connect the 6-pin female connector labeled "USER INPUT POWER" on the Power Supply Adapter Cable to the mating 6-pin male connector located on the Electronics Housing end cap labeled "INPUT POWER".
- Plug the DAVPR Power Supply into an appropriate AC power supply.
- Connect together the small plastic 6-pin connectors on the end of the DAVPR Power Supply output cable and the end of the Power Supply Adapter cable. The LED indicator on the Electronics end cap will display a solid red light.



6.2. Accessing the DAVPR Computer

NOTE: The DAVPR computer does not have antivirus software.

Set the Optical Switch on the Electronics housing end cap to "OFF" prior to connecting the system to power. If power is applied to the system and the Optical Switch is not in the "OFF" position, the LED indicator will display a solid red LED indicating that power is applied but the system will not execute the current setting of the Optical Switch.

For example, if the switch is set to S1 and the power is connected, the system will not execute the operations associated with the S1 setting (boot, move optics to S1, and start image capture). The LED indicator will display a solid red light indicating that the power is connected. The system will only execute a ***change*** in the switch position. Moving the switch to S1 to OFF will execute a controlled power down. The LED indicator will display a red/yellow and then a solid red light.

Please note that the Optical Switch will not function if the User Interface COMMS cable is connected to the Electronics end cap and to the laptop computer using the USB/RS232 adapter. The DAVPR system will default to the serial link. Unplug the connection between the USB/RS232 adapter and the COMMS cable.

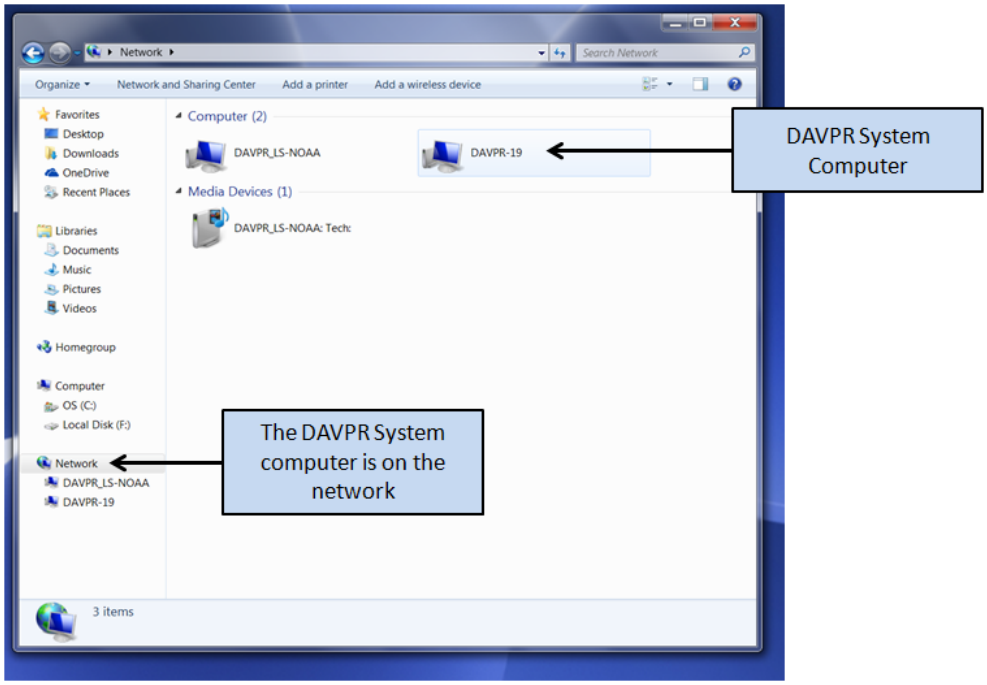
The LED indicator will display a solid red light if power is connected to the Electronics Housing end cap. Turn the Optical Setting Switch from OFF to BOOT. The yellow LED will light while the system initializes and then the green LED will come on indicating that the system is ready.

Power is On
Red LED Light

Optical Switch Set to “Boot”
Yellow LED Light

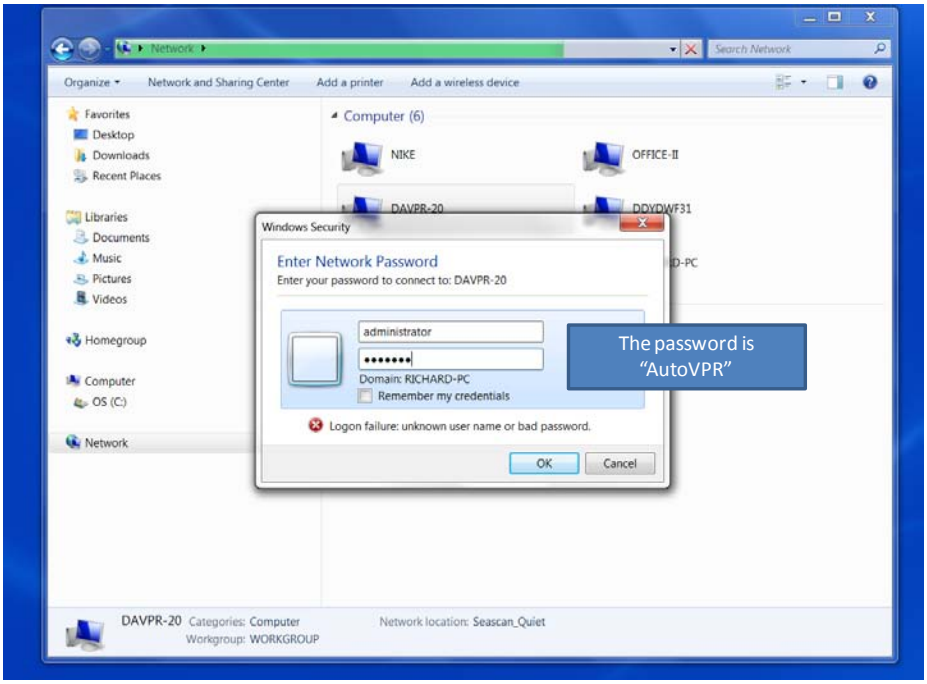
Optical Switch Set to “Boot”
Green LED indicates VPR system is Ready

- Each DAVPR system is numbered and indentified as "DAVPR-##" where "##" is the DAVPR number. The DAVPR number is located on the outside edge of the Electronics end cap. For the following instructions, the DAVPR computer is identified as "DAVPR-19". The user's DAVPR will have a different number.



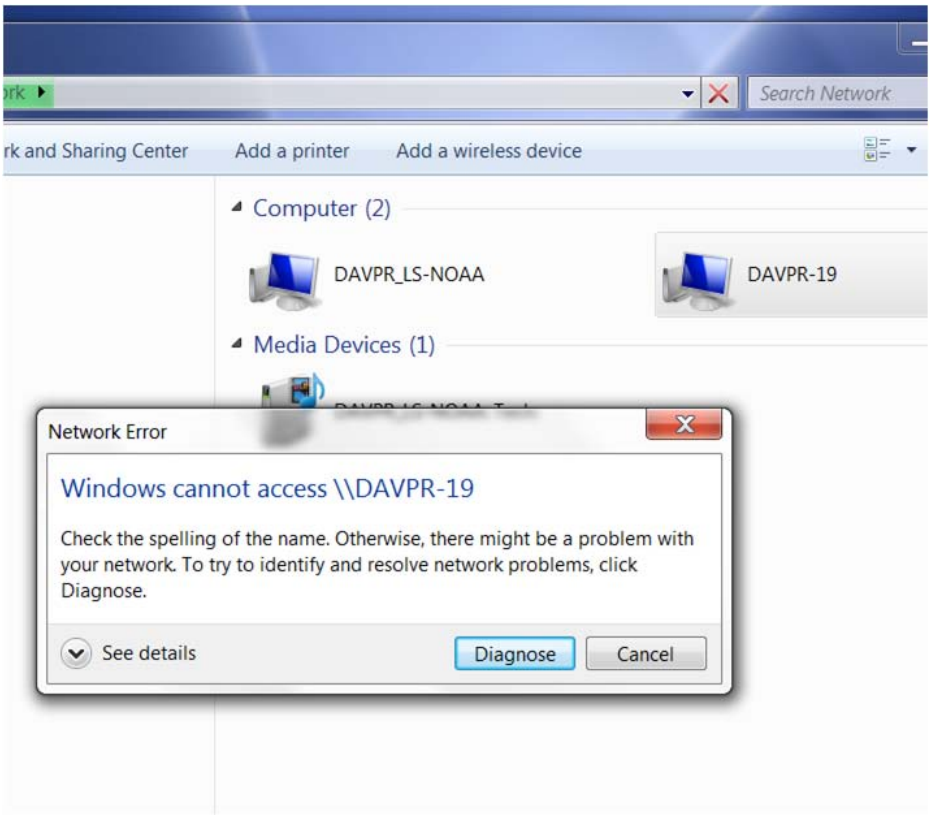
- Double click on the DAVPR-19 icon to access the files on the solid-state hard drive. A security window may pop up and require a user name and password.
    - User name = “administrator”
    - Password = “AutoVPR”

  The user name and password are printed on the outer edge of the Electronics Housing end cap label for reference.

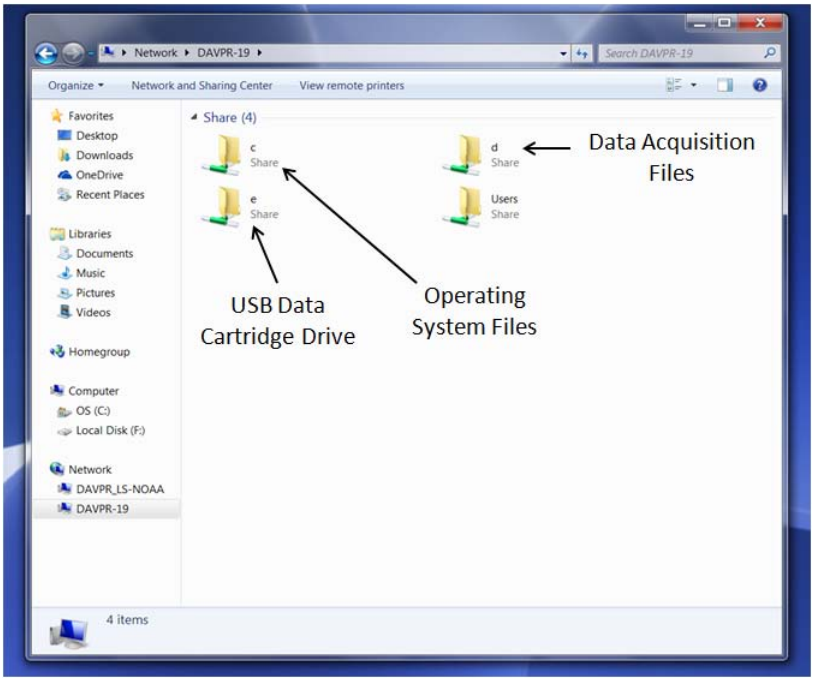


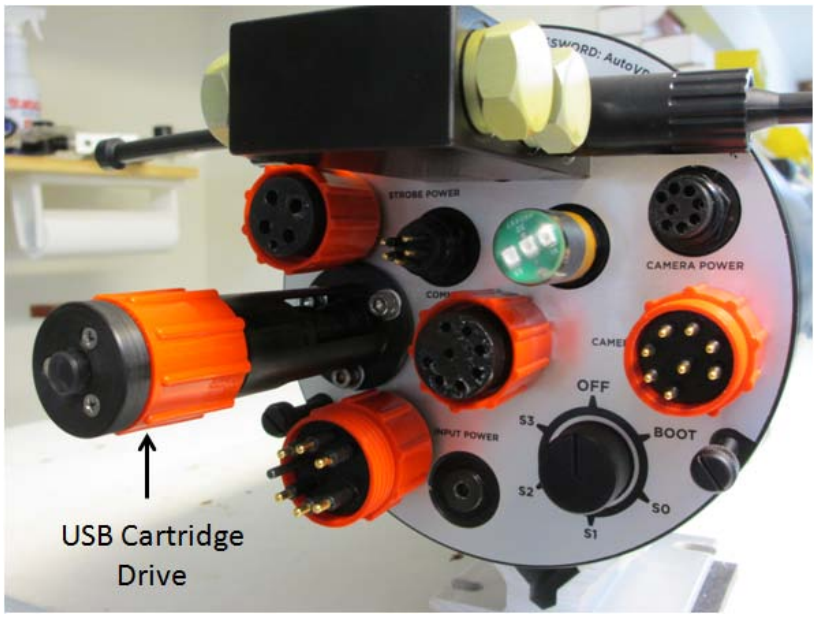
The user name and password is located on the Electronics Housing End Cap

The following error window will appear if the DAVPR system has not booted. Check the Optical Switch position.



The solid state hard drive is partitioned into two drives labeled "C" and "D". Drive C contains the DAVPR operating system files and drive D is for the data acquisition files. Drive E is the USB Data Storage Cartridge drive plugged into the Electronics Housing end cap.



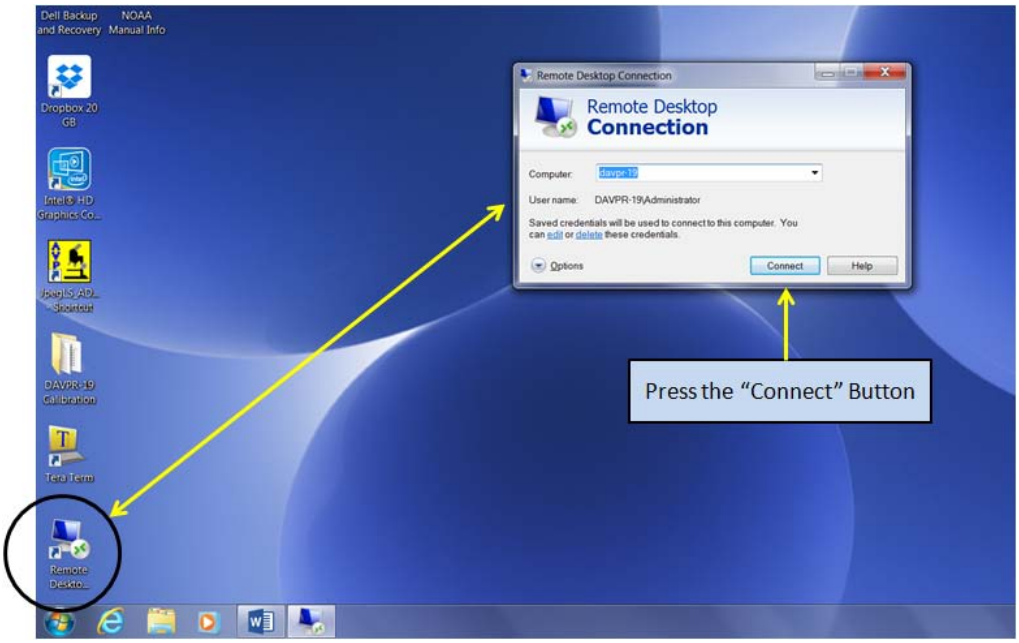


The user can transfer the files located on the Data Storage Cartridge to the desktop computer or another storage device located on the network.

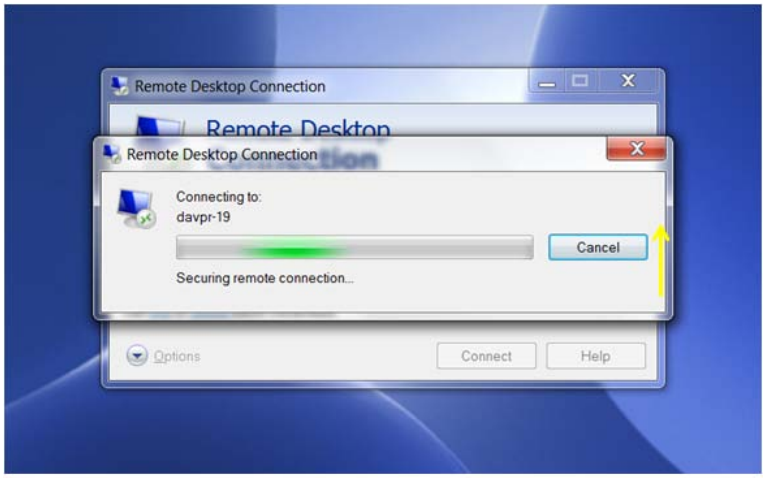
6.3. Real Time Display

Real time images from the camera can be displayed on the user's computer by connecting to the DAVPR computer using Remote Desktop. The Remote Desktop icon is located on the laptop desktop or the application software should be available under "Accessories" located on the "All Programs" menu for Microsoft Windows 10.

- Run the Remote Desktop application software. The Remote Desktop Connection window will appear and display the computer name "DAVPR-19".
- Press the "Connect" button.

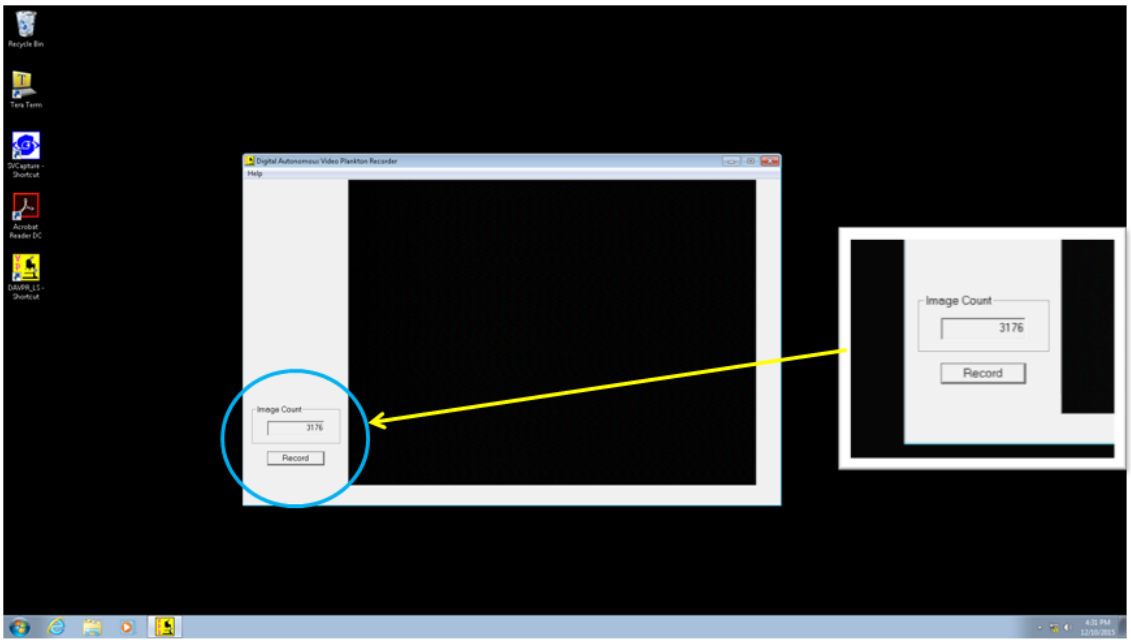


- The Remote Desktop will start connecting to the DAVPR computer. The following screen will appear on the screen. If a window appears requesting a password, enter "AutoVPR".



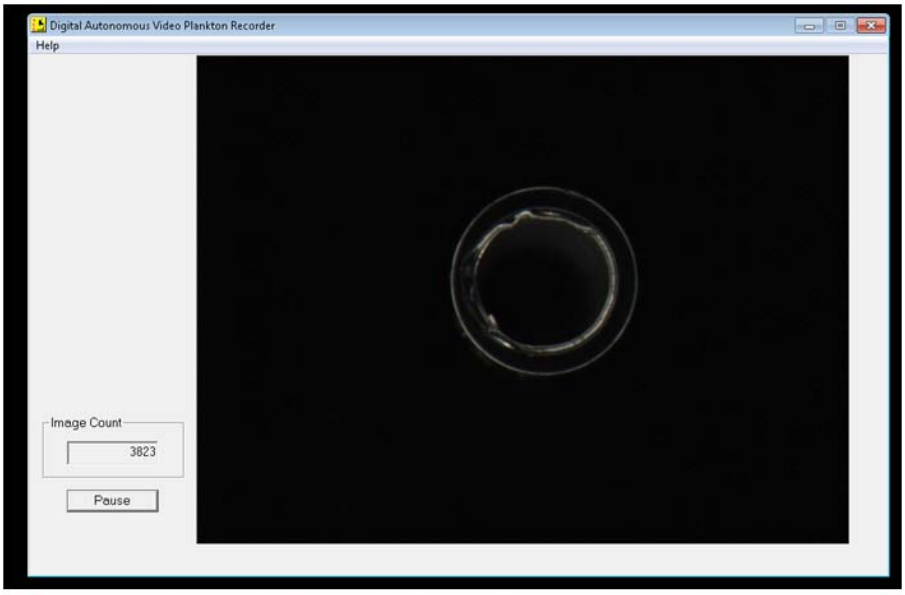
Remote Desktop Connecting to the DAVPR Computer

The DAVPR application software, DAVPR_LS, is always running after booting the computer. The "Digital Autonomous Video Plankton Recorder" application window will appear on the screen after connecting to the DAVPR computer using the Remote Desktop. The "Image Count" is continuously incrementing because the camera is powered on in the "BOOT" position. The "Image Count" represents the accumulated images since power was applied to the system.



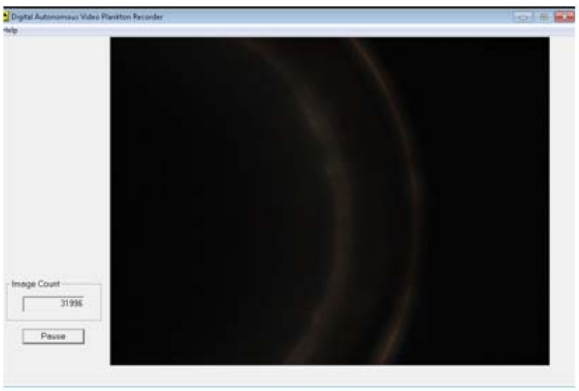
DAVPR Application Software Called DAVPR_LS

- Turn the Optical Switch to S3. The system will set the camera optics and then start the image capture (the strobe light will flash at 20 frames per second). The images will be displayed in on the computer screen within the "Digital Autonomous Video Plankton Recorder" user interface. You should see the end of the plastic alignment fixture. If the image is not centered in the black area on the screen then the position of the camera housing needs adjustment. See section 7.3 Aligning the Camera and Strobe Light.

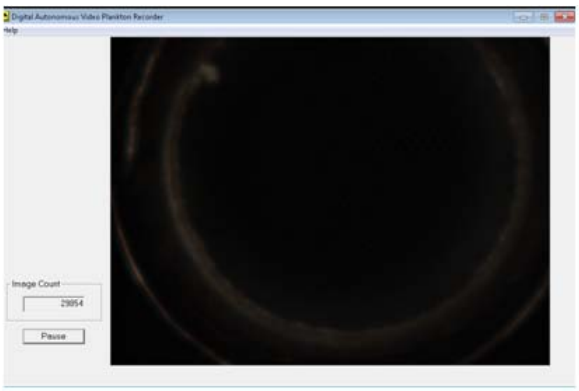


The end of the acrylic tube is shown in the application software for the S3 optical setting

- Press the "Pause" button in the application window. The system will stop the capture process. Press "Record" to restart the capture process.
- Turn the Optical Switch to "Boot" and wait for the solid red light.
- Turn the Optical Switch to "S2". The camera and optics will automatically reposition from S3 to S2 and then start the capture process. The image in the application window will look larger. The image is magnified moving from S3 to S0 and the field of view is decreasing.

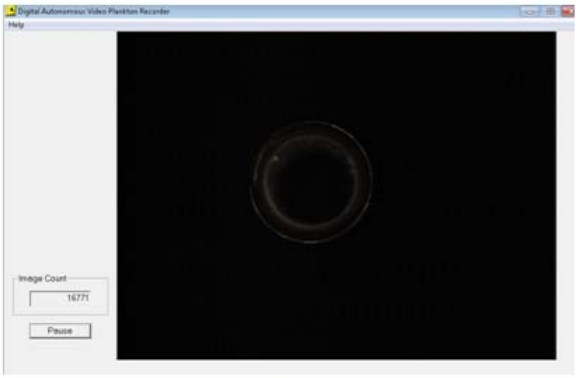


S0



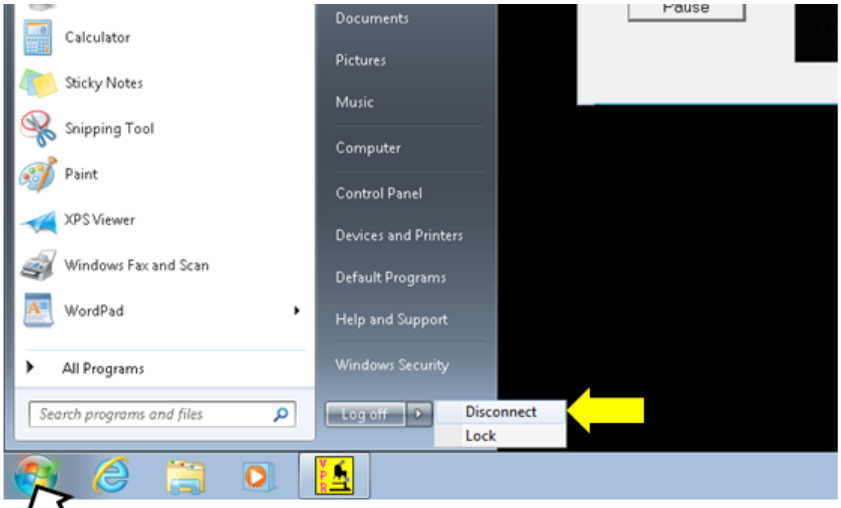
S1

S2



S3

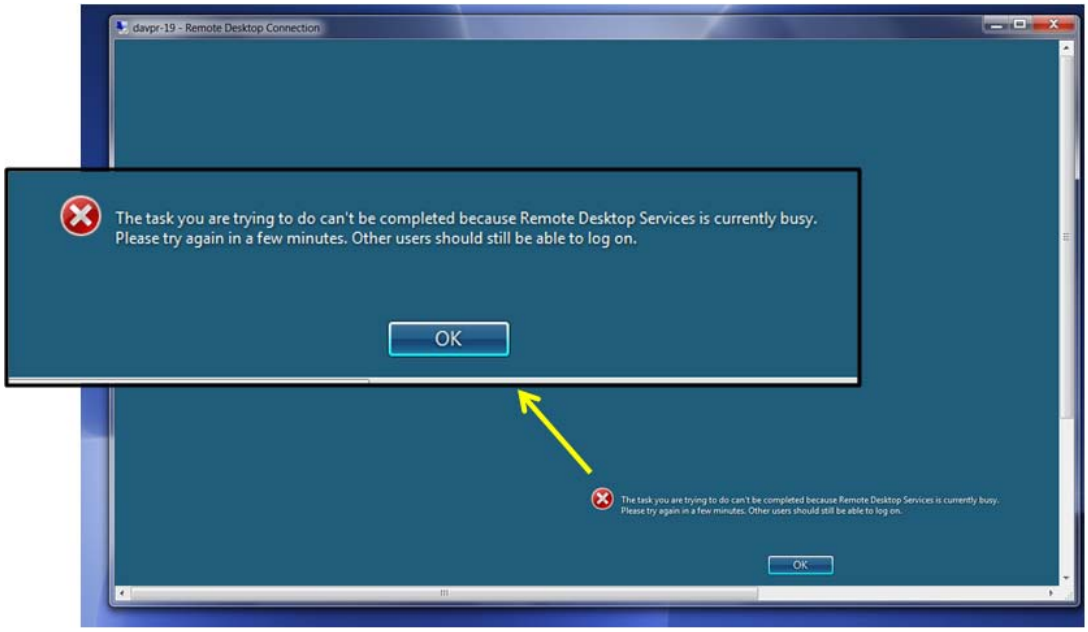
- To properly close the Remote Desktop application software, click the Windows start button to access the program files, click the arrow button next to "Log Off" and then "Disconnect". Do not click the "Log Off" button. This will stop all programs running on the DAVPR system including the DAVPR application program.



Windows Start Button

Press “Disconnect” to close the Remote Desktop application software

Closing the Remote Desktop application by closing the application window will cause a system fault (solid red/yellow/green LEDs) when the user reopens the Remote Desktop application window. The following error message may appear:



Error message when Remote Desktop fails to connect to the DAVPR Computer

The Remote Desktop may fail to connect to the DAVPR computer but the computer is still booted. The DAVPR system will be operational even though the LEDs indicate a system fault. To clear the fault,

- Turn the Optical Setting Switch to "OFF". The system will transfer the files on the hard drive to the Data Storage Cartridge, shut down the application software and power

down. The LED indicator will have a solid red light. The Remote Desktop application will close during shut down if it was previously open.

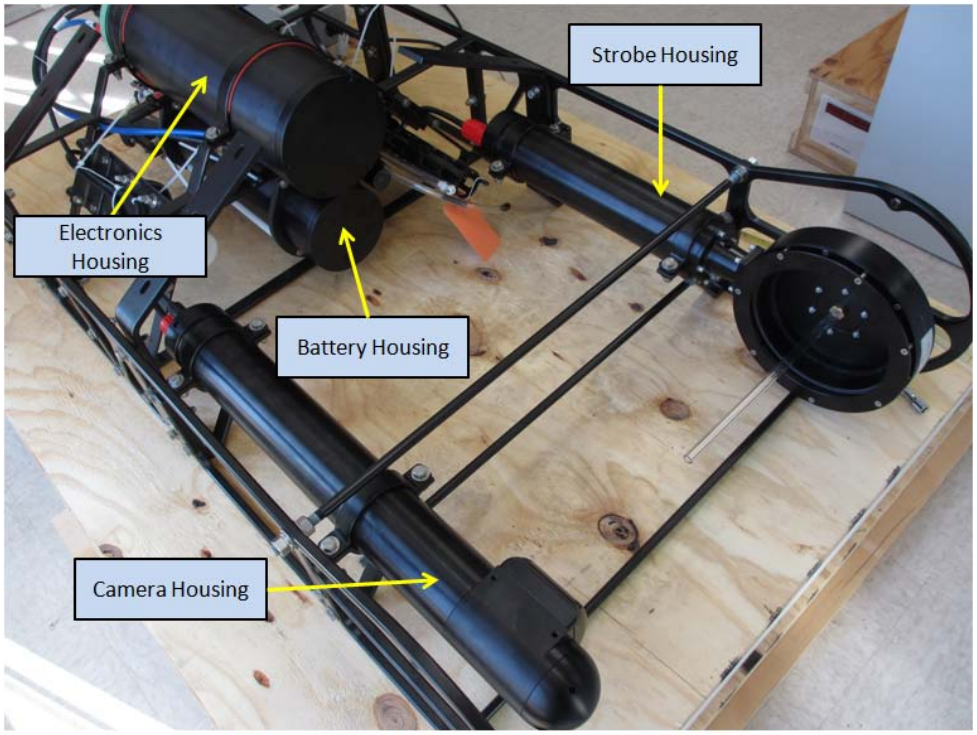
- Turn the Optical Setting Switch back to "S3" (for this example; or any "S" setting). The system will start capturing images.
- Launch Remote Desktop to view the images. If the DAVPR 19 is accessible on the network, then the Remote Desktop will open properly.

Closing the Remote Desktop by pressing the "Log Off" button will shut down both the Remote Desktop application as well as the DAVPR_LS application running on the DAVPR computer. The strobe and camera will stop capturing images. The LED indicator will display the system fault sequence of solid red/yellow/green lights. To clear the fault,

- Turn the Optical Setting Switch to "OFF". The system will transfer the files on the hard drive to the Data Storage Cartridge, shut down the application software and power down. The LED indicator will have a solid red light.
- Turn the Optical Setting Switch back to "S3" or any "S" setting. The system will start capturing images.
- Launch Remote Desktop to view the images.

7. DAVPR Set Up and Operation

The DAVPR subassemblies-Electronics, Camera, Strobe, and Battery Housing typically are mounted inside the Seascan Tow Frame. The Seascan frame maintains the proper separation distance between the camera and strobe housing centerlines (59 cm). The camera window and the strobe lighting are properly aligned prior to shipping the system to the customer.



DAVPR Equipment Mounted in the Seascan Frame

The DAVPR system comes with two rechargeable battery packs and two Data Storage Cartridges allowing the user to quickly redeploy the system. One battery pack should always be fully charged or charging while the system is operating. Typically, the battery pack takes approximately five hours to charge and will operate the system for approximately 5 to 5.5 hours depending on the water temperature.

The DAVPR could be used in a variety of deployment schemes. For example,

- The DAVPR could be mounted to a standard CTD Rosette frame and deployed vertically in the water column (the user would not use the V-Fin for vertical deployments).
- The DAVPR could be used with the V-Fin depressor or mounted on another towed vehicle and towed from a research vessel. The maximum tow speed for the DAVPR System with the V-Fin depressor is 5 knots.
- Some users have mounted the DAVPR system to submersible fixed platforms and operated the system remotely over the serial link. Bio-fouling on the camera window and strobe light must be routinely removed.

7.1. Installing and Removing the V-Fin

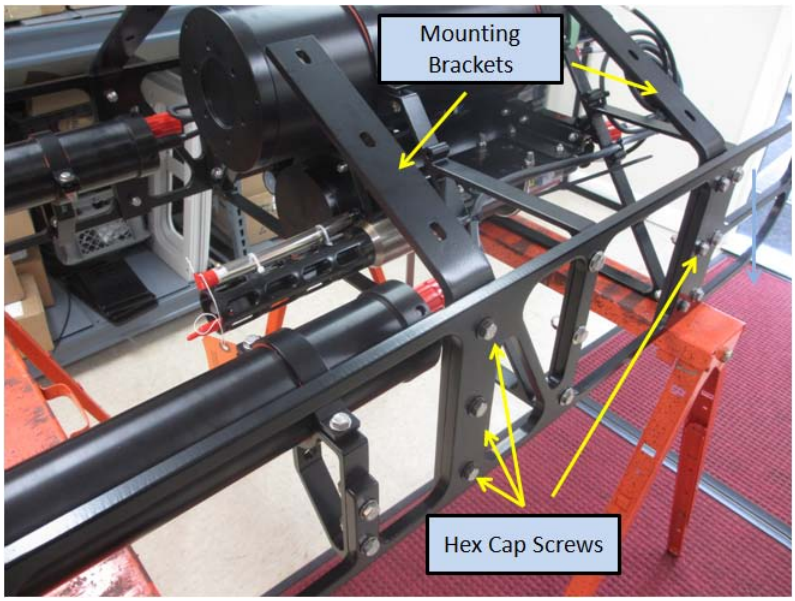
Caution: The V-Fin is heavy and will require at least two people or a suitable mechanical lift to install or remove.

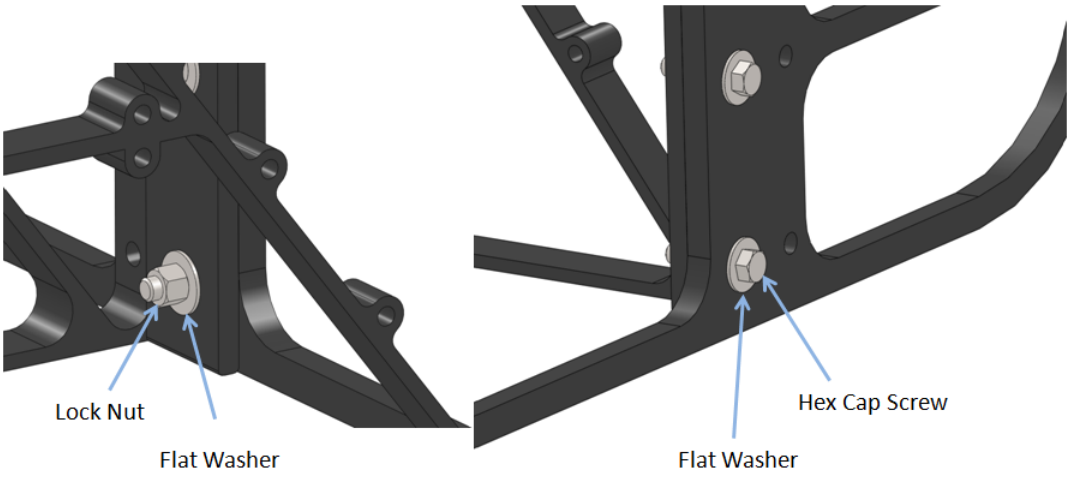
The V-Fin Depressor is required for towing the DAVPR system up to 5 knots (2.5 meters/s).

Please Note: the user will mount the V-Fin using stainless steel hex cap screws and lock nuts. We recommend lightly lubricating the bolt threads to prevent galling (pressure and friction cause the bolt threads to seize with the nut threads). The locks nuts should turn easily when first installed. If not, then stop and remove the nut before galling can occur.

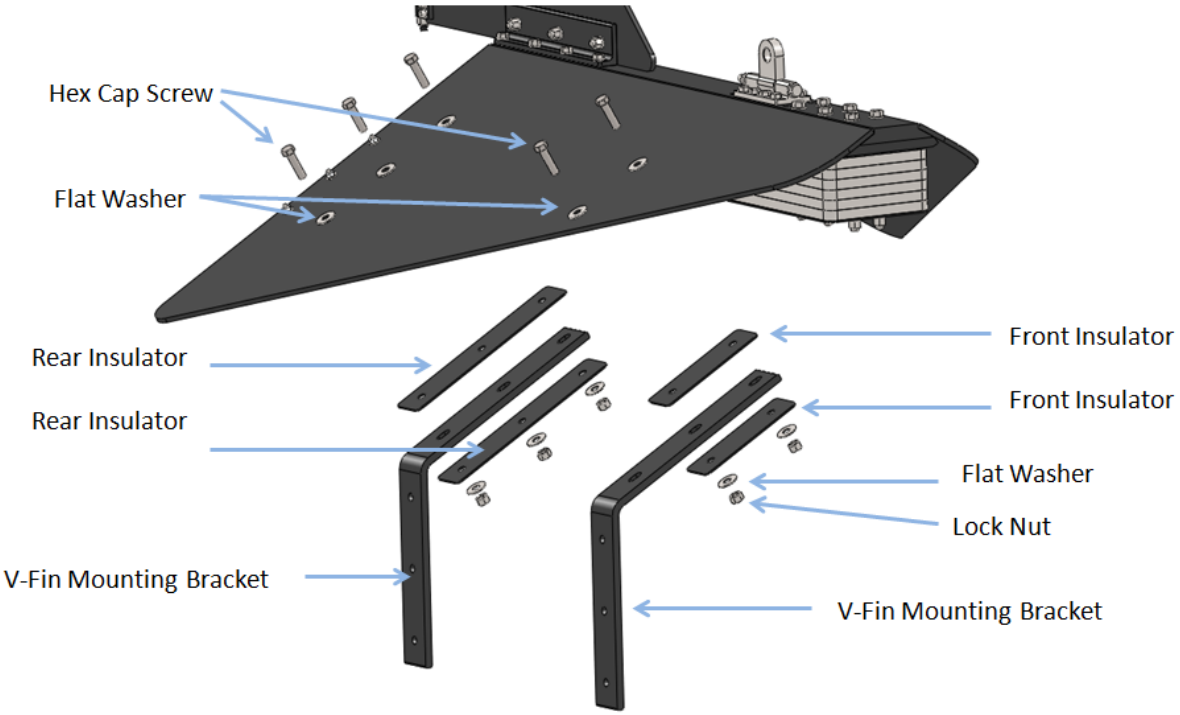
Recommended tools: 3/8 wrench or adjustable wrench and socket wrench with a 3/8 socket.

- Loosely attach the four V-Fin mounting brackets (two on each side) to the Tow Frame using the 3/8-16 x 1-5/8 in. long stainless steel hex cap bolts, washers and lock nuts. Use a washer against the frame and against the mounting bracket.

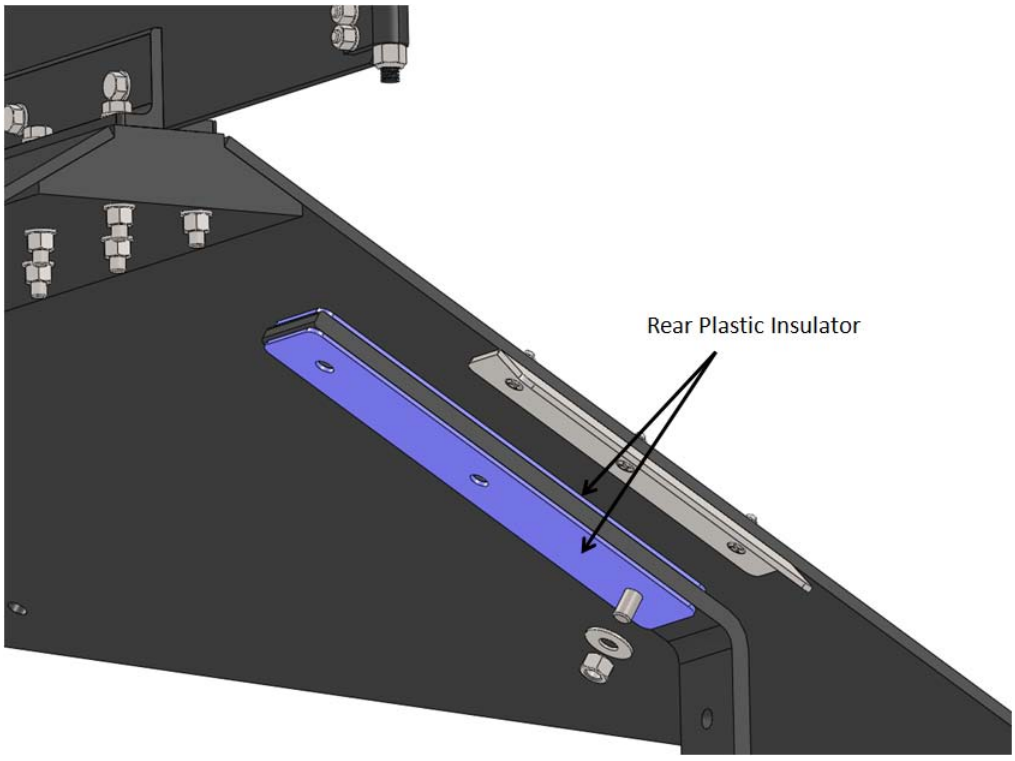




- With two people or using a mechanical lift, place the V-Fin on top of the bracket and align the holes on the V-Fin with the slots in the brackets. While one person holds the V-Fin, the second person should install one 3/8-16 x 1-1/2 in. long stainless steel hex cap bolt and nut to temporarily hold the V-fin in place.
- There are two plastic insulators used with each mounting bracket to isolate the aluminum V-Fin from the stainless steel tow frame. One plastic insulator is required between the V-Fin and the top of the mounting bracket. The other is required on the bottom side of the mounting bracket. Please review the following diagram:



- Starting in the rear, slide a plastic insulator between the V-Fin and the top of the mounting bracket and align the holes with the slot in the mounting bracket and the holes in the V-Fin.
- Push a 3/8-16 x 1-1/2 in. long stainless steel hex cap bolt and washer through the top of the V-Fin, the plastic insulator, and mounting bracket. This will align all the parts.
- Slide a plastic insulator over the hex bolt and hold it against the bottom of the mounting bracket while loosely adding a washer and hex nut as shown below.

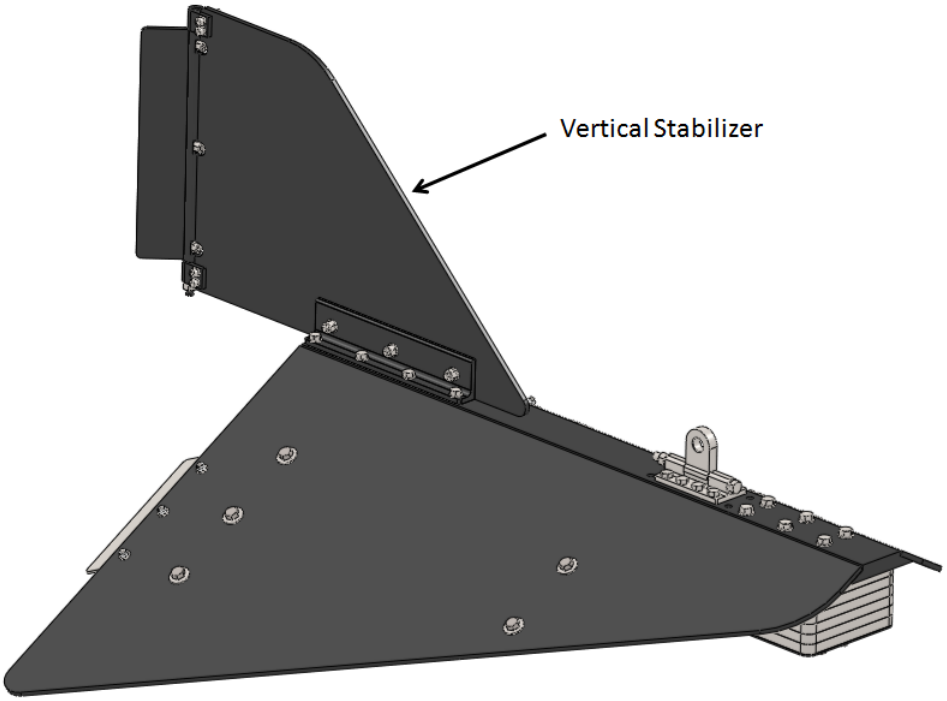


- Loosely install the remaining two hex bolts, flats washers and hex nuts for this mounting bracket.
- Follow the same procedure for the remaining three mounting brackets.
- First tighten the bolts/nuts holding the mounting bracket to the tow frame to 19 ft lb (25.7 Nm) then tighten the bolts retaining the V-Fin to the mounting brackets (same torque requirement).

Removing the V-Fin from the brackets is the reverse procedure.

7.1.1. Vertical Stabilizer

The Vertical Stabilizer is mounted on the rear of the V-Fin and is used to stabilize and align the V-Fin in the direction of towing. An adjustable Trim Tab is located on the back of the Vertical Stabilizer to better align the V-fin (and DAVPR system) in the towing direction.



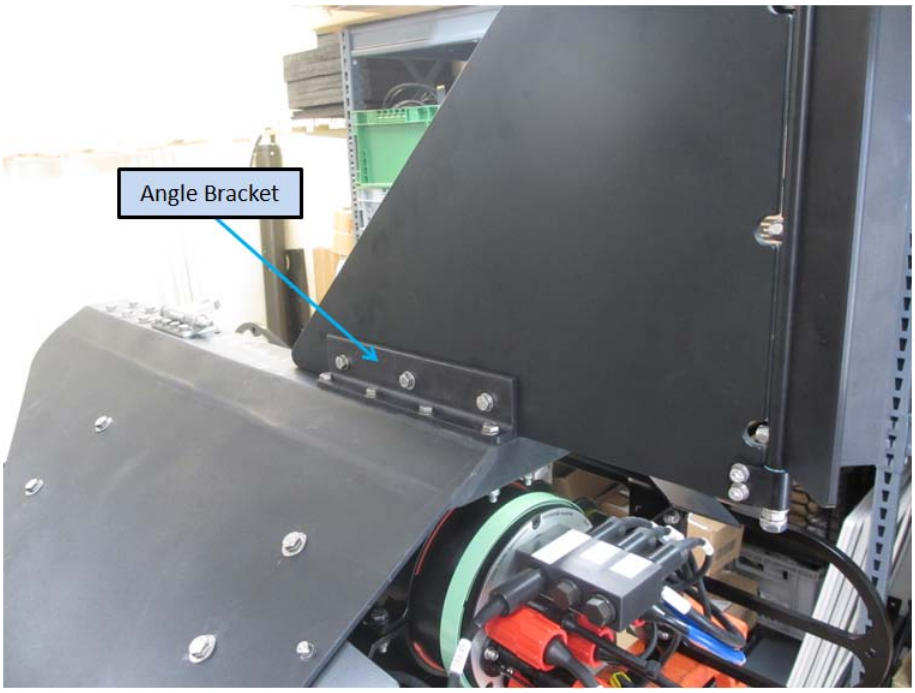
The Vertical Stabilizer is mounted to the V-Fin using 5/16-18 stainless steel hex cap screws with flat washers and lock nuts. The angle mounting brackets were pre-installed at Seascan using 5/16-18 x 2-1/2 in. long stainless steel hex cap screws, washers and lock nuts. The user should not have to remove the two angle mounting brackets from the V-Fin.

7.1.2. Installing the Vertical Stabilizer

Please Note: the user will mount the Vertical Stabilizer using stainless steel hex cap screws and lock nuts. We recommend lightly lubricating the bolt threads to prevent galling (pressure and

friction cause the bolt threads to seize with the nut threads). The locks nuts should turn easily when first installed. If not, then stop and remove the nut before galling can occur.

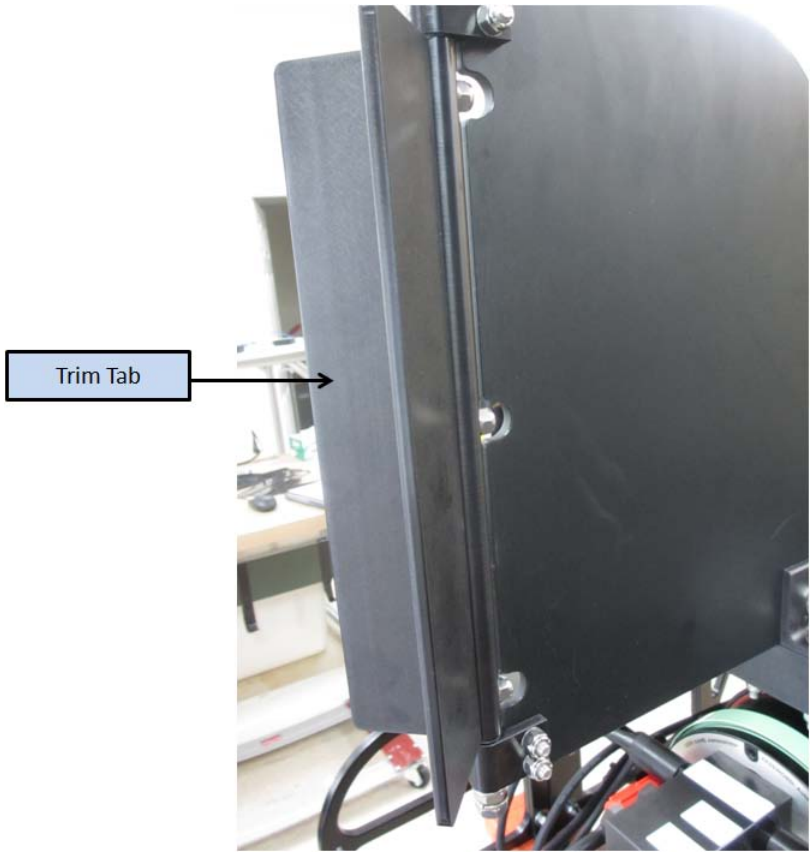
Recommended tools: 1/2 wrench or adjustable wrench and socket wrench with a 1/2 socket.



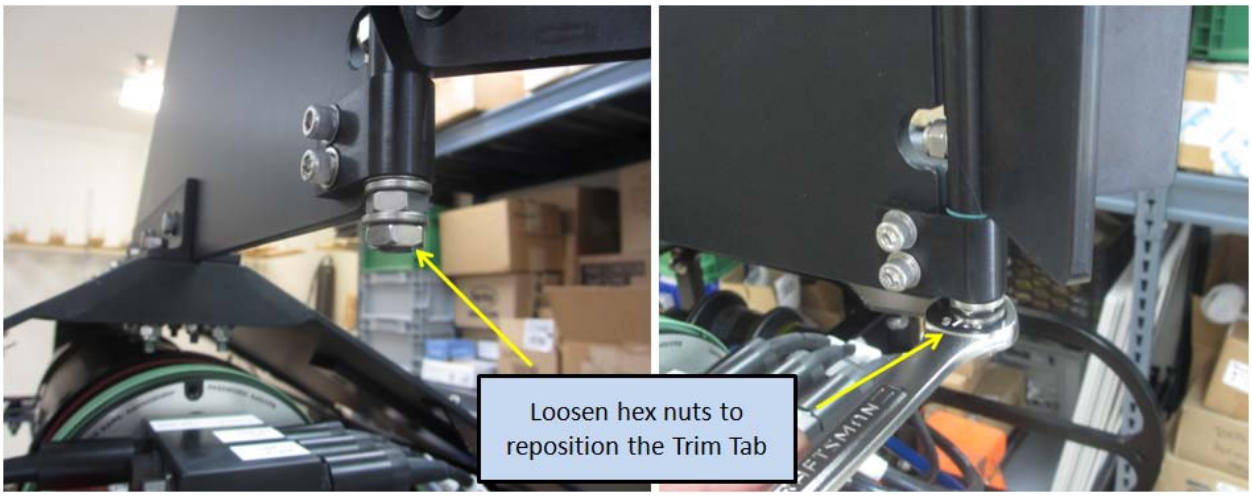
- Pre-assemble the hardware by sliding a flat washer over each of the three hex cap bolts. Lightly lubricate the threads.
- Slide the Vertical Stabilizer between the two angle brackets located on the top of the V-Fin. Align the holes in the brackets with the holes in the Vertical Stabilizer. Slide each of the three hex cap bolts into the holes.
- Add a washer and lock nut on the bolts and tighten the hardware to 11.4 Ft lb (15.5 Nm).

7.1.3. Adjusting the Trim Tab

The Trim Tab is located on the back of the Vertical Stabilizer and can be used to adjust the alignment of the DAVPR system relative to the towing direction. For example, if the DAVPR system is slightly yawed to one side during towing then making a minor adjustment to the Trim Tab will force the DAVPR system into alignment.



- To make adjustments, loosen the bottom 3/8-16 hex nut using a 9/16 wrench or adjustable wrench. This nut is used as a lock nut. Loosen the top hex nut.
- The Trim Tab is free to rotate. Reposition the Trim Tab and then tighten the top nut to hold the position. Tighten the bottom nut to lock the top nut.



7.2. Setting Up the DAVPR System

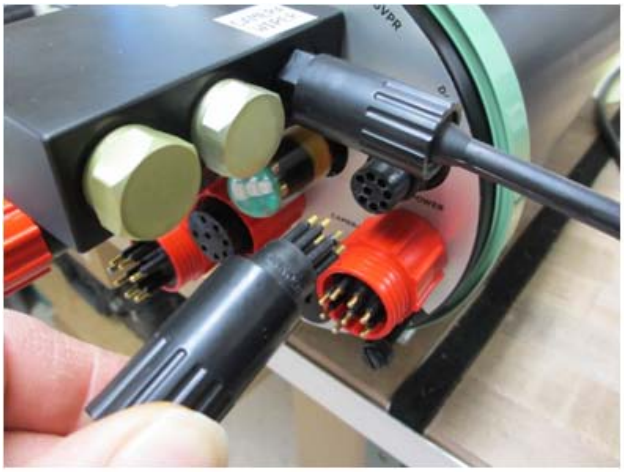
All of the cable assemblies are labeled on both ends. All of the bulkhead connectors on the Electronics housing end cap are also labeled and each will match one of the labels on the cable assemblies.

The input power cable from the Battery Housing is connected last to ensure that there is no power going to the system during the set up. Please follow the set up instructions. If the DAVPR was shipped preinstalled on the tow frame, then all of the cable assemblies should be in place. Please read along and verify that the cables were properly installed.

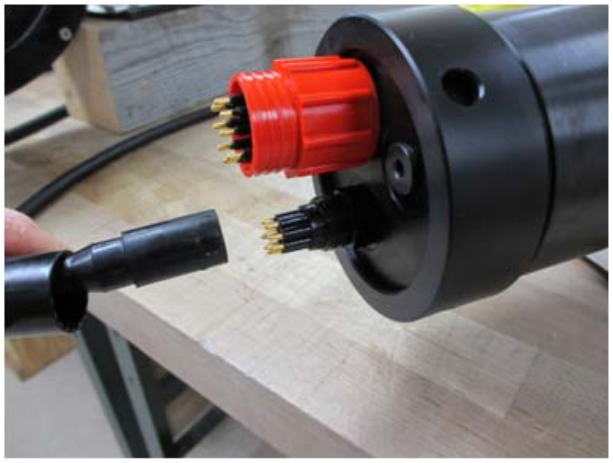
- Set the Optical Switch on the Electronics end cap to "OFF".

- Plug the 8-pin male connector of the camera power cable, labeled “CAMERA POWER”, into the mating female bulkhead connector located on the Electronics Housing end cap. Screw in the plastic locking sleeve to ensure that the cable assembly does not accidentally pull out of the bulkhead connector.

- Plug the 8-pin female end of the cable assembly into the mating 8-pin male bulkhead connector located on the Camera Housing end cap. Screw the plastic locking sleeve in place.



Electronics Housing End Cap



Camera End Cap

- Plug the 8-pin female connector of the camera control cable (blue cable), labeled “CAMERA”, into the mating bulkhead connector located on the Electronics Housing end cap. Screw together the red plastic locking sleeves.
- Plug the other end of the cable assembly into the mating 8-pin male bulkhead connector located on the Camera Housing end cap. Screw together the red plastic locking sleeves.

Electronics Housing End Cap

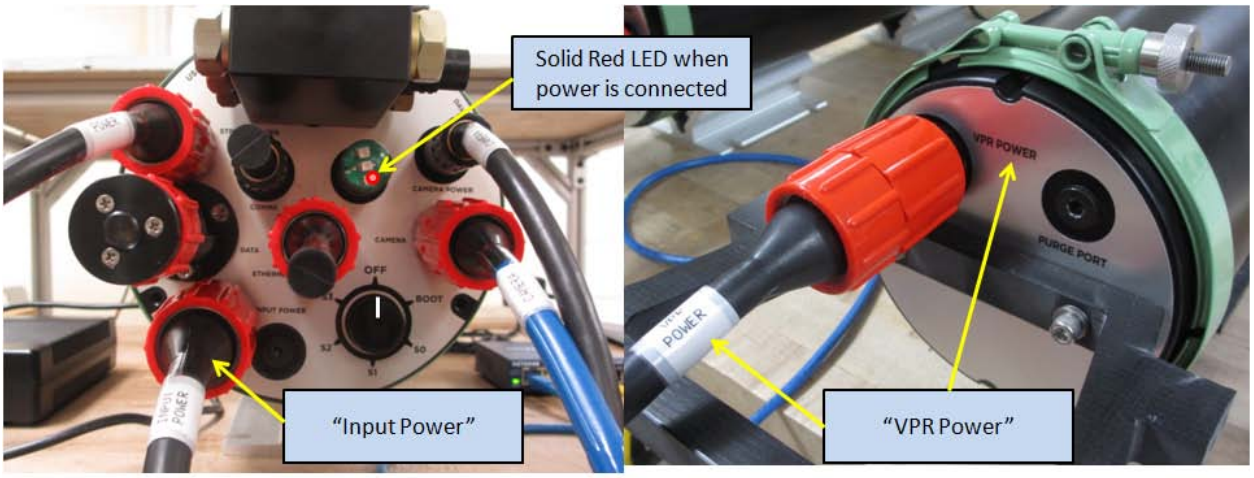
Camera End Cap

- Plug the 4-pin male connector of the strobe power cable, labeled “STROBE POWER”, into the mating female bulkhead connector located on the Electronics Housing end cap. Screw together the red plastic locking sleeves.
- Plug the other end of the cable assembly into the mating 4-pin male bulkhead connector located on the strobe housing end cap. Screw together the red plastic locking sleeves.

Electronics Housing End Cap

Strobe End Cap

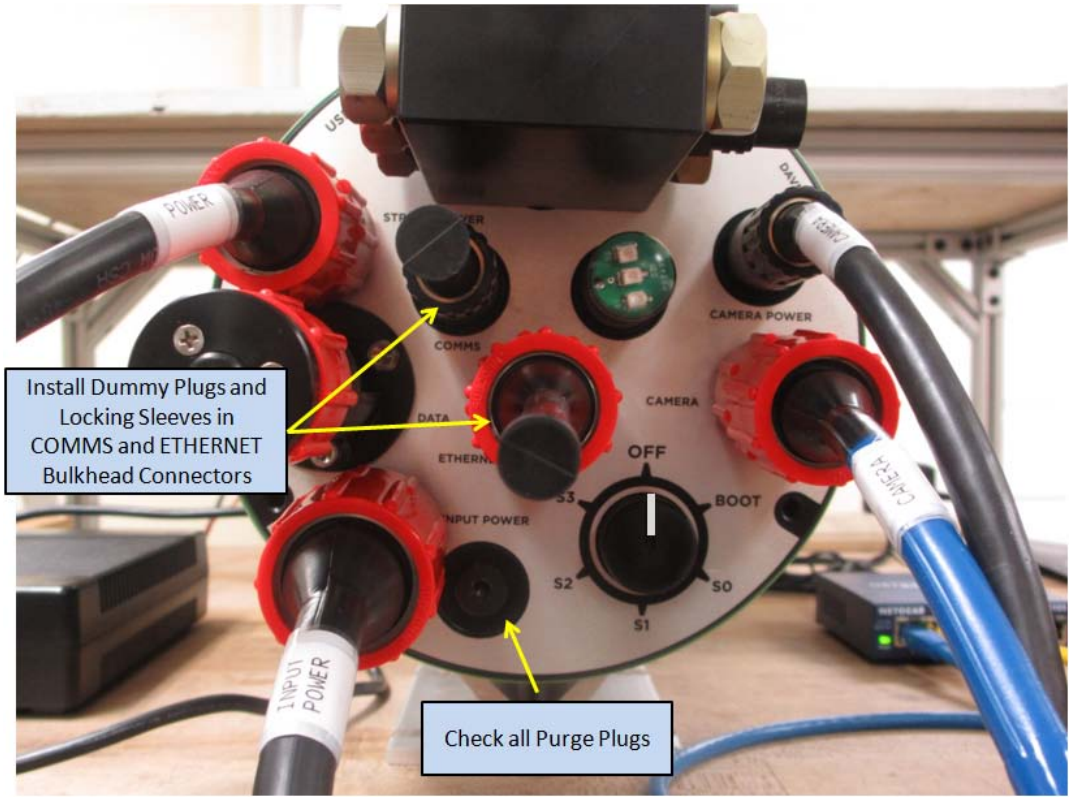
- Set the Optical Switch on the Electronics end cap to "OFF".
- Connect the 6-pin female connector labeled "INPUT POWER" to the mating 6-pin male connector located on the Electronics Housing end cap. Connect the other end of the battery cable labeled "VPR POWER" to the mating 6-pin female bulkhead connector located on the Battery Housing end cap. The battery power is now connected to the Electronics Housing assembly and ready to operate. The LED indicator on the Electronics end cap will display a solid red light.



Electronics End Cap

Battery Housing End Cap

- Connect the cable assemblies from the Sea Bird CTD or install the appropriate rubber dummy plug and locking sleeve.
- Install the rubber dummy plugs and locking sleeves in both the "COMMS" and "ETHERNET" bulkhead connectors.
- Ensure that the Purge Plug on each end cap (electronics, camera, strobe and battery) are fully installed.



The DAVPR computer, and battery charger must be located inside a dry working area on the operating vessel.

- Set up the laptop computer, mouse and data cartridge drive cable.
- Set up the battery charger.
- Remove any files from the spare Data Cartridge assembly.
- Check the spare battery pack voltage and charge if necessary.

7.3. Aligning the Camera and Strobe Light

It is recommended that the user complete the alignment process in a dry workspace; preferably before moving the equipment aboard the research vessel.

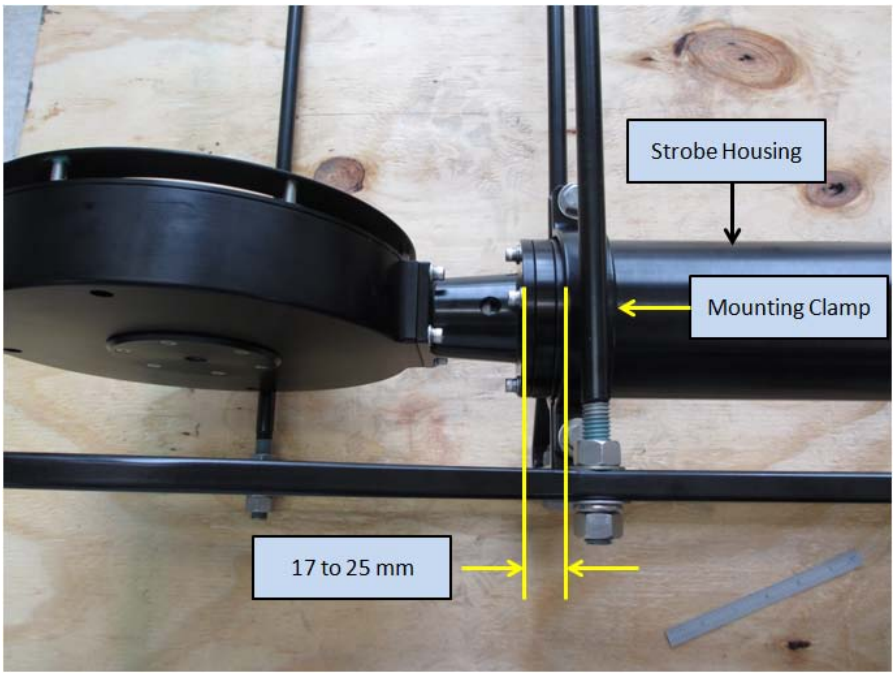
It will be necessary to align the camera optics and strobe light if

- The image is not centered in the screen while viewing with the remote desktop application
- Either the camera or strobe or both were removed from the deployment frame or mounting structure.
- The user is mounting the equipment in a custom frame for the first time.

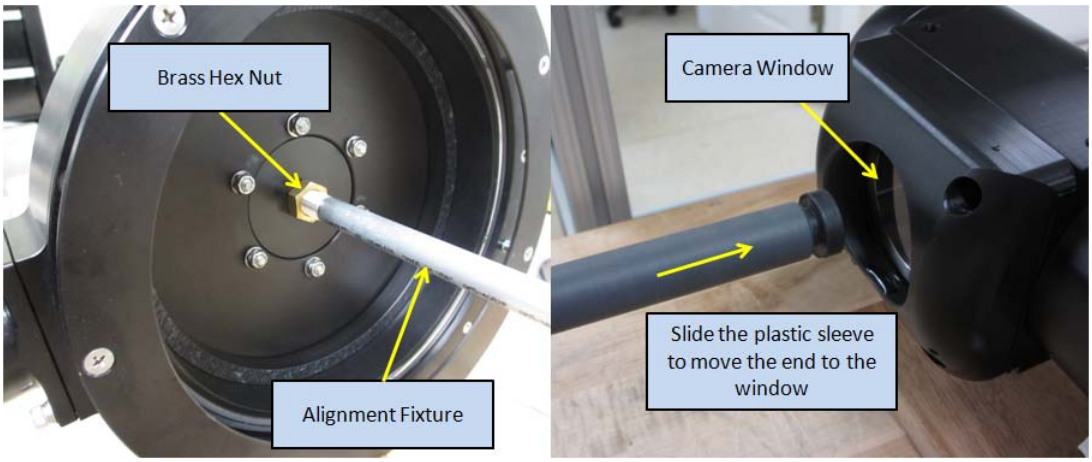
It is best to check the alignment using the two alignment fixtures and viewing the fixture using Remote Desktop on the laptop computer (please refer to section 6.3). The DAVPR computer is only accessible over a network. The user will need to view the laptop screen during the alignment process.

The camera is viewing a volume of water approximately half the distance between the centerline of the camera and the centerline of the strobe housing. The strobe lighting is also maximized at this same location in water. The user can determine if the camera image is located at the brightest location by viewing the test fixture using remote desktop. The image should be centered in the remote desktop window. If not, then make the following adjustments

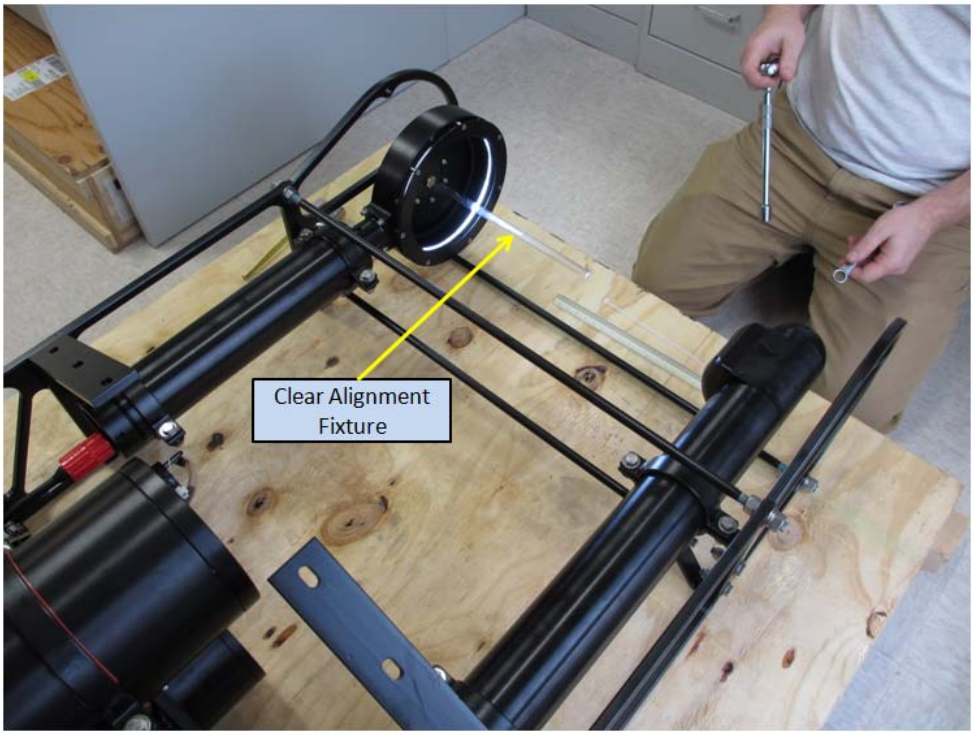
- First, check the orientation of the strobe ring light mounted in the frame. Do not loosen any hardware. Measure the distance between the frame and the back of the strobe ring light at the top and bottom. The measurement should be approximately the same.



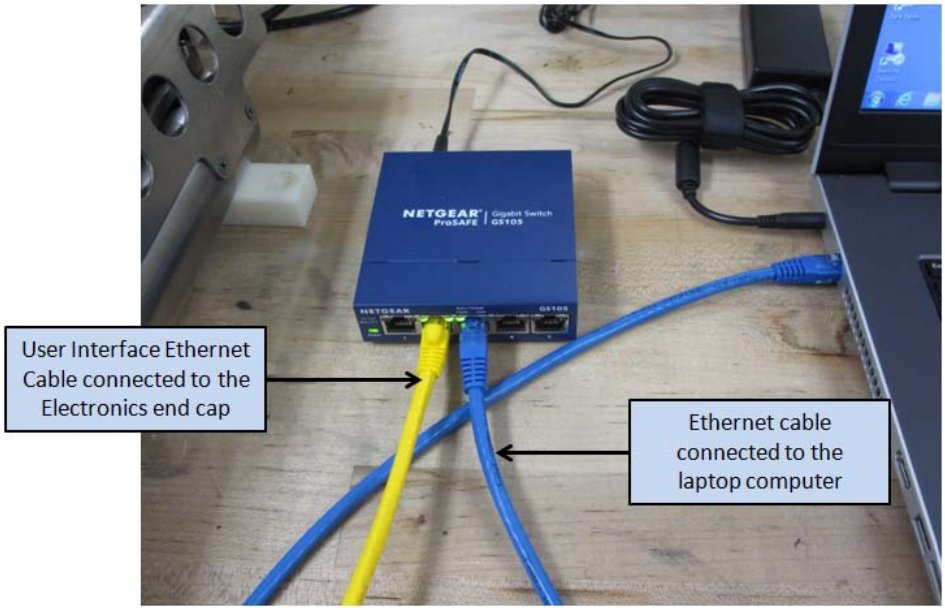
- Loosen the two mounting clamps. Rotate the strobe housing until the distance between the back of the strobe ring light and the top of the frame is equivalent to the distance between the back of the strobe ring light and the bottom of the frame. Clamp the strobe housing in place.
- Loosen the clamps retaining the camera housing.
- Screw in the aluminum alignment fixture into the 1/2-20 threads located at the center of the strobe ring light. Tighten the brass hex nut to keep the alignment fixture perpendicular with the face of the strobe ring light.
- Slide the plastic sleeve on the end of the alignment fixture to the glass window on the camera housing. Adjust the axial position and rotation of the camera housing to center the alignment fixture in the window. Remove the alignment fixture.



- Screw in the clear plastic alignment fixture into the center of the strobe ring light. Tighten the brass hex nut to keep the fixture straight. This fixture will extend approximately half the distance between the strobe and camera housings. The end of the fixture will be visible on the laptop screen while operating the DAVPR system.

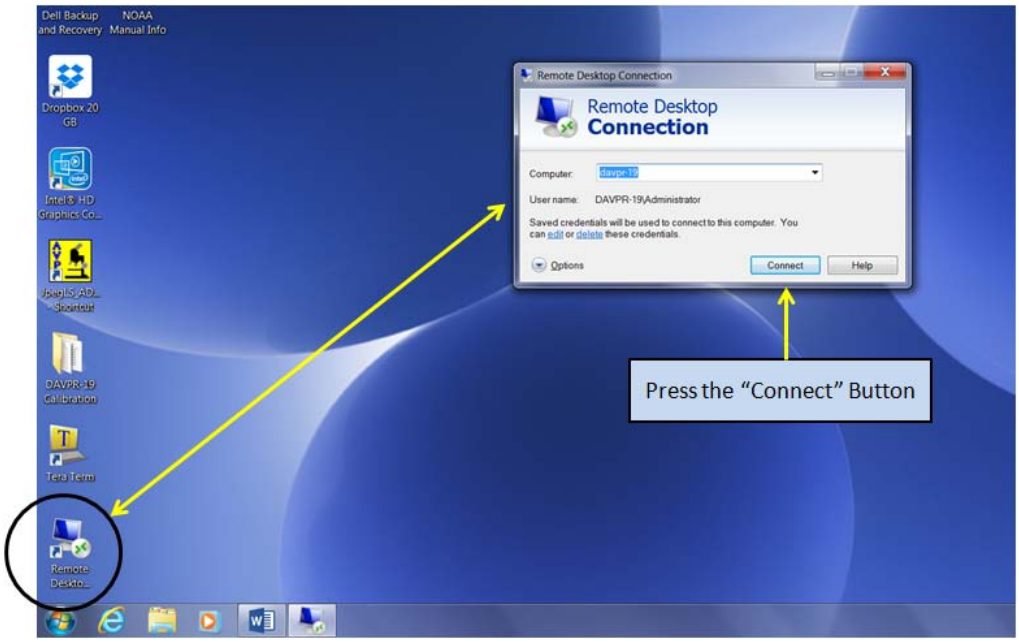


- Next install the User Interface Ethernet cable assembly. Plug the 8-pin male connector into the mating bulkhead connector labeled "ETHERNET" on the Electronics Housing end cap.
- Plug the standard Ethernet connector on the other end of the cable into the supplied Gigabit Ethernet Switch.
- Connect the laptop computer to the Gigabit Ethernet Switch using an Ethernet cable. The laptop must be on the same network to access the DAVPR computer.

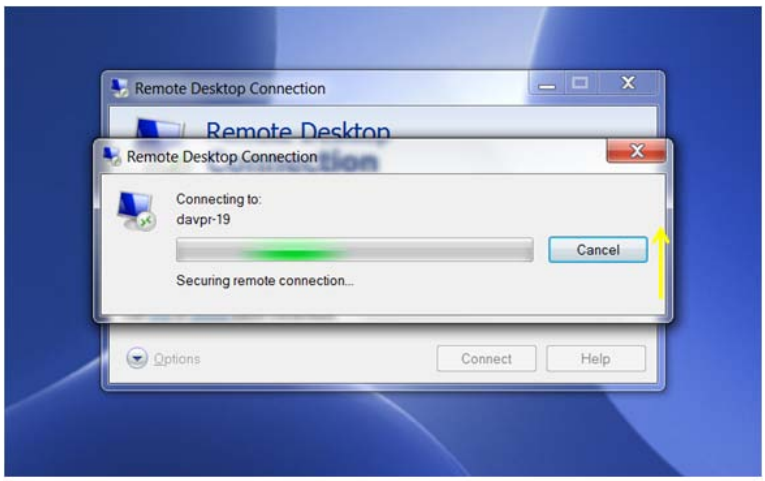


It is assumed that the all the cabling is properly installed as described in section 7.2 and the laptop is powered on.

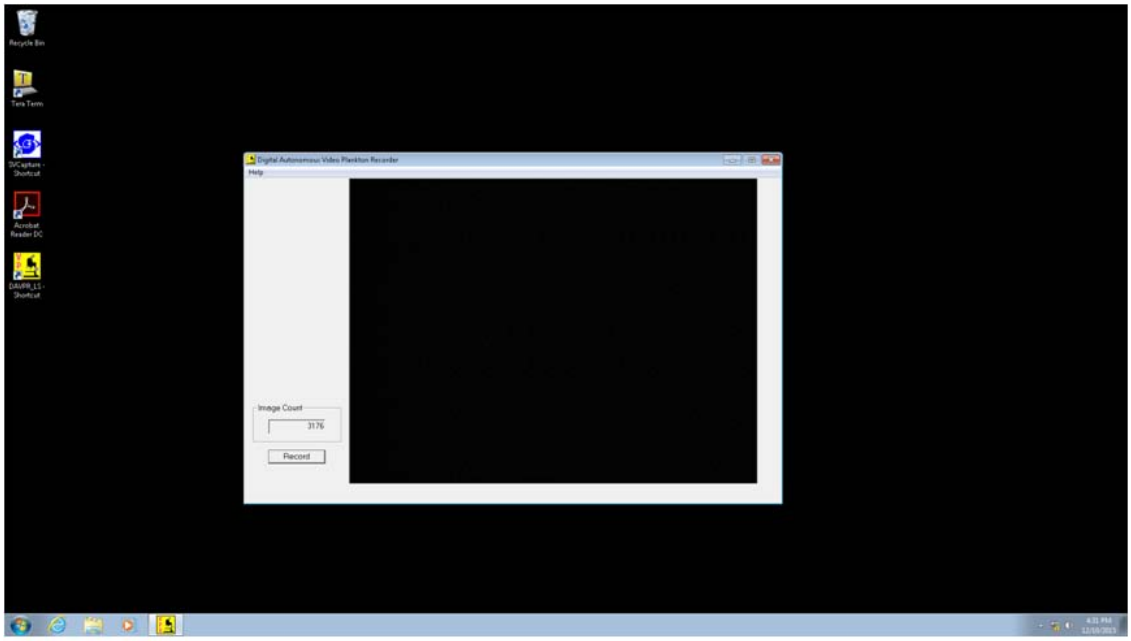
- Rotate the Optical Switch to "BOOT".
- Run the Remote Desktop application software. The Remote Desktop Connection window will appear and display the computer name "DAVPR-##". For these instructions the computer is DAVPR-19.
- Press the "Connect" button.



- The Remote Desktop will start connecting to the DAVPR computer. The following screen will appear on the screen. If a window appears requesting a password, enter "AutoVPR".

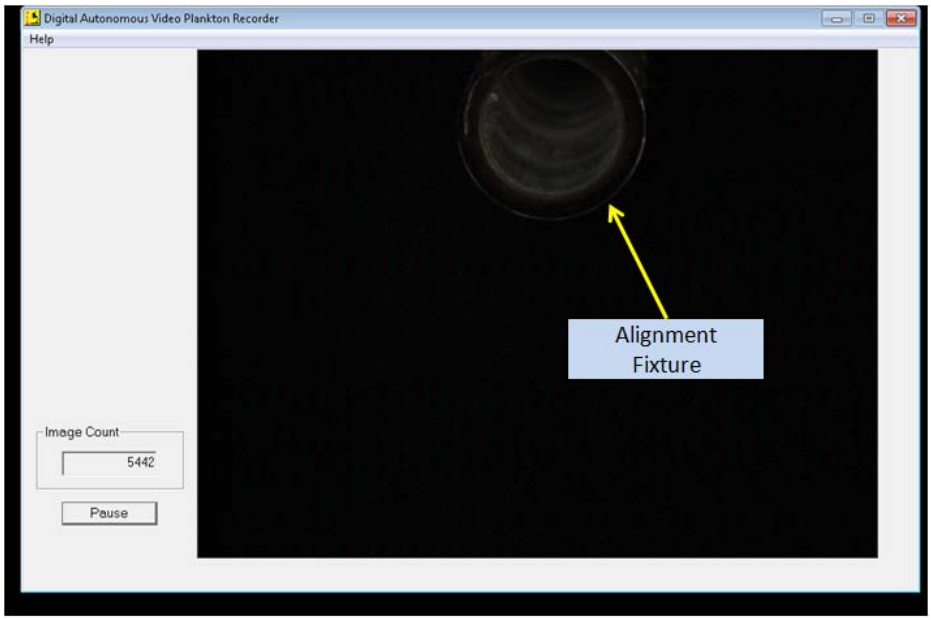


Remote Desktop Connecting to the DAVPR Computer



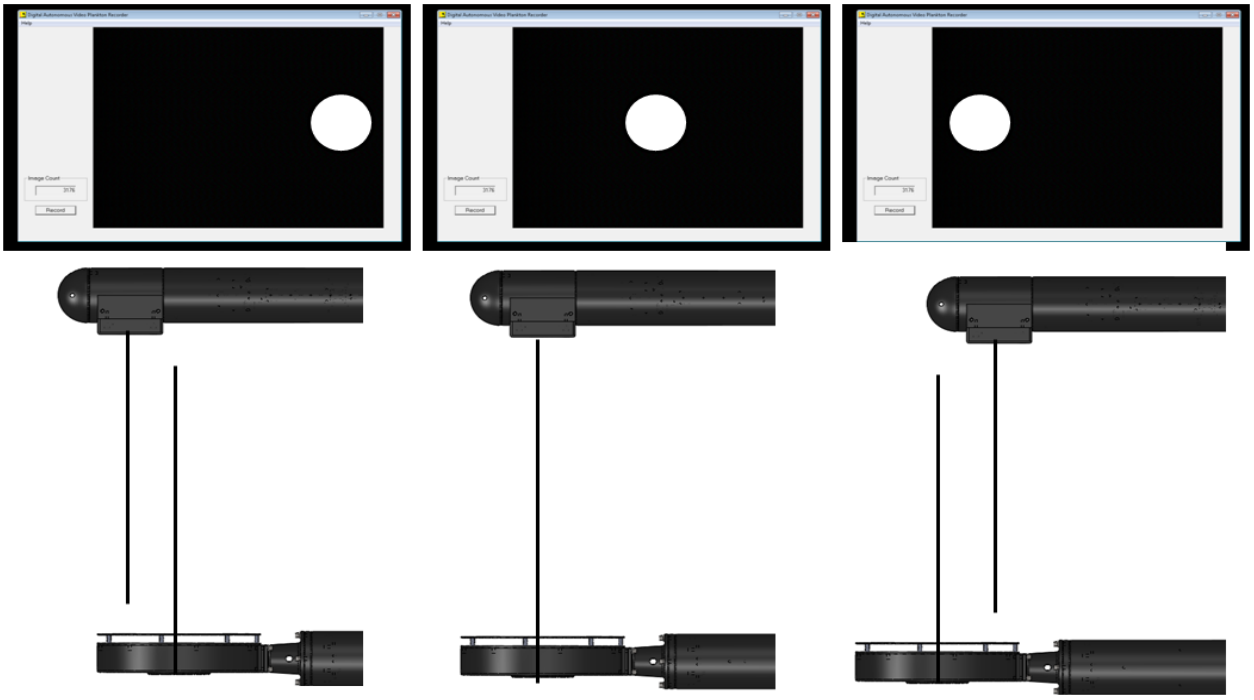
DAVPR Application Software

- Turn the Optical Switch to S3 (lowest magnification). The system will set the camera optics and then start the image capture (the strobe light will flash at 20 frames per second). The images will be displayed in on the computer screen within the "Digital Autonomous Video Plankton Recorder" graphical display. You should see the end of the plastic alignment fixture.



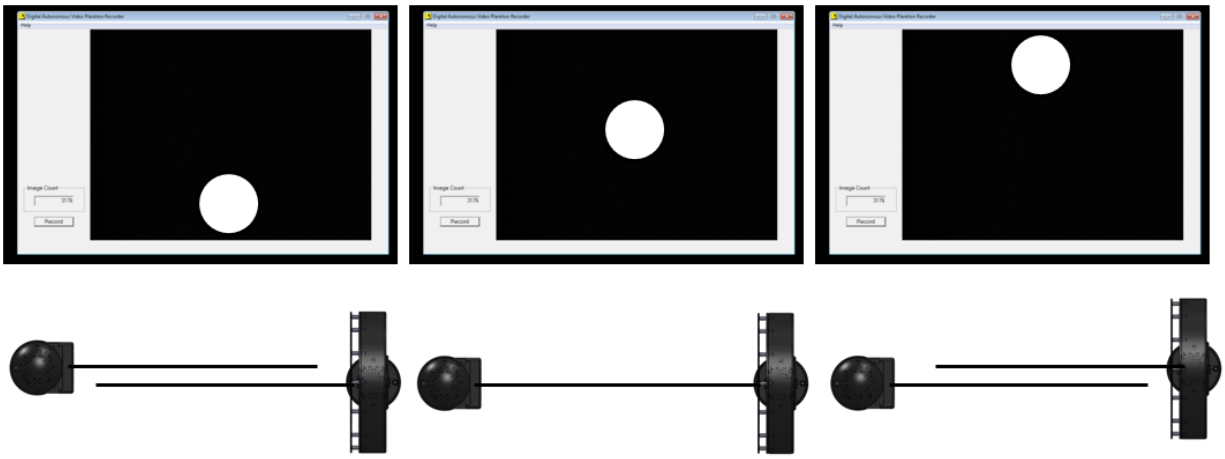
The alignment fixture displayed in real time using Remote Desktop

- Adjust the image in the application software window by moving the camera assembly relative to the strobe position. The following pictures should aid with the adjustment.



Camera in Front of Strobe | Camera Centered with Strobe | Camera Behind Strobe

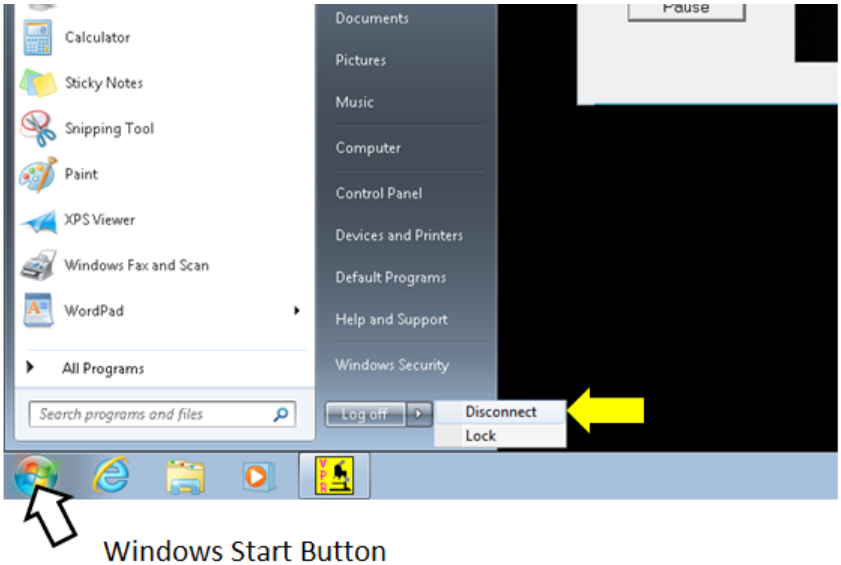
And for rotational adjustment



Camera Above Strobe Camera Centered with Strobe Camera Below Strobe

The end of the acrylic tube is shown in the application software for the S3 optical setting

- Carefully tighten the clamps retaining the camera housing.
- Remove the clear alignment fixture from the strobe housing.
- To properly close the Remote Desktop application software, click the Windows start button to access the program files, click the arrow button next to "Log Off" and then "Disconnect". Do not click the "Log Off" button. This will stop all programs running on the DAVPR system including the DAVPR application program.

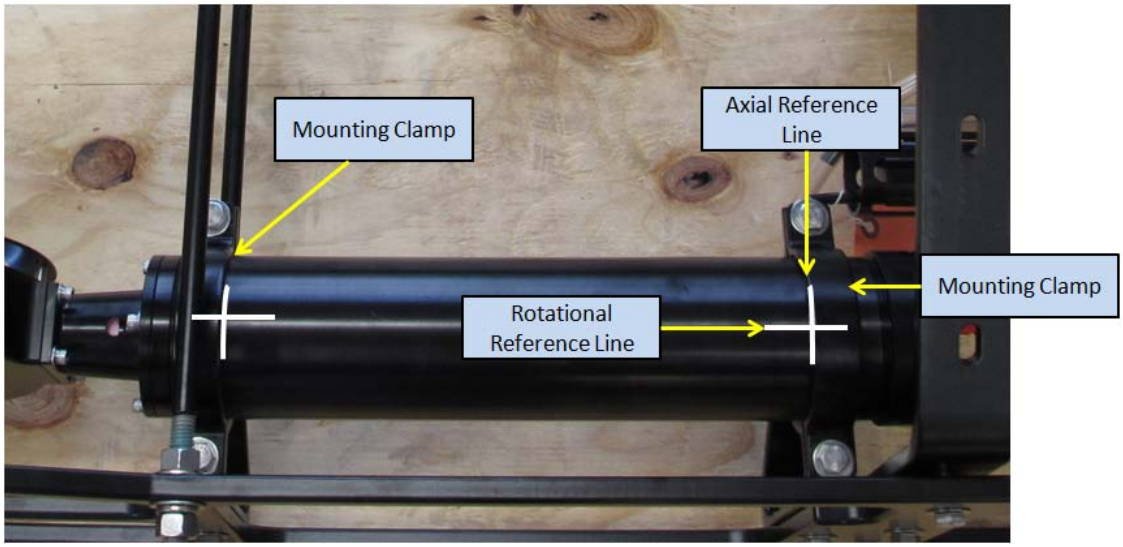


Windows Start Button

Press “Disconnect” to close the Remote Desktop application software

- Turn the Optical Switch to "OFF".
- Turn off the laptop computer.
- Disconnect the User Interface Ethernet cable assembly from the Electronics Housing end cap. Install the rubber dummy plug and locking sleeve.

If the user needs to remove either the camera or strobe housing from the frame, then make a line or place a piece of tape (or both) on the pressure housing next to the mounting clamps. These marks will reference the axial locations of the pressure housing relative to the frame. A mark will also be required for the rotational location.



7.4. Pre-Deployment Checklist

- **Check that the batteries are fully charged prior to deployment**. Use the power meter to check the battery voltage (see section 5.3 Checking the Battery Pack Voltage)

- **Set the DAVPR computer clock** to Greenwich Mean Time (GMT) by accessing the computer using the Ethernet cable and Remote Desktop (see section 6.2 “Accessing the DAVPR Computer”).

- **Set the clock on the desktop computer** to Greenwich Mean Time (GMT).

- Check that all the **files on the Data Storage Cartridge** from the previous deployment have been properly removed and stored on the user's computer. Delete the files prior to the next deployment.

- **Inspect all bulkhead cable connectors** and ensure that the locking sleeves are properly mated and all dummy plugs are in place. Rubber dummy plugs should be installed in the following connectors before deployment:

  Electronics Housing
  - Ethernet
  - COMMS

- Check that the **Data Storage Cartridge** is installed and secured with the red plastic locking sleeve.

- Ensure that the **purge plug** is installed in the Battery Housing, Electronics Housing, Camera and Strobe Housings.

- Turn the **Optical Switch to BOOT** and check for the green LED.

- Check that the system is operating properly. Turn the **Optical Switch to the user's preferred setting (S0, S1, S2 or S3)**. The system will set the camera optics and the start capturing images and the strobe light will flash at 20 frames per second. Turn the Optical Switch to BOOT to stop the image capture.

- Clean the glass window on the camera housing.

*** The DAVPR system is ready for deployment.**

7.5. Deploying the DAVPR

- **Turn the Optical Switch to the preferred setting**. Wait for the system to start capturing images and the strobe flashes continuously.

- **Deploy the DAVPR into the water**. The DAVPR system will operate continuously for approximately 5 hours with a fully charged battery pack. Do not deploy the DAVPR deeper than 1000 meters depth and not faster than 1 m/s for vertical casts and 5 knots when towed by the ship.

- When the DAVPR is returned to the ship, **secure the DAVPR system on deck**.

- **Shut the system off** by turning the Optical Switch counterclockwise to the "OFF" position. **The DAVPR will transfer the remaining data from the internal hard drive to the Data Storage Cartridge before shutting the system down**. The file transfer could take up to 6 minutes. The red light on the end of the Data Storage Cartridge will flash during the file transfer. The red LED on the Electronics Housing end cap will stay on when the file transfer is complete and the system is shut down.

- If the system has been deployed for approximately five hours, then the battery pack will probably be depleted. The three LEDs on the Electronics Housing end cap will be flashing simultaneously indicating a low battery voltage fault. **Remove the Battery Housing and replace the battery pack**.

- **Remove the Data Storage Cartridge** by unscrewing the red plastic locking sleeve and pulling the Cartridge out of the bulkhead connector. Install the second Data Storage Cartridge.

- **Reinstall the Battery Housing** after recharging or replacing the battery packs.

- **Review the "Deployment Check List"** (Appendix K) prior to redeployment.

After redeploying the DAVPR system:

- Plug the Data Storage Cartridge into the Data Cartridge Drive Cable assembly. Plug the USB connector end of the cable into the USB port on the desktop computer. **Transfer the files from the Data Storage Cartridge to the desktop computer** (making a back up file of the data is recommended). Typically, there will be 20 files (10 files with a *.dat extension and 10 files with a *.idx extension) for a five-hour deployment. It will take approximately an hour transfer all the files to the desktop computer.

- **Erase the files from the Data Storage Cartridge after successfully transferring the files**.

Two files are created every 30 minutes while operating the DAVPR. Both files will have the same name but a different extension: *.idx and *.dat. **NOTE: The times associated with the**

files are the time the DAVPR closed the file, not the time the file BEGAN. The user should be aware of this when trying to match up files with a deployment log.

Copy all the files to your selected location, either the desktop computer hard drive or an external USB drive. Create a directory for the cruise on the desktop computer or external drive and then create individual folders (numbered by VPR # or Station #) named vpr### (see section 8 "Data Processing" for more information on directory structure and file naming. Put the two files (*.idx and *.dat) for each deployment into each folder.

NOTE: Every time the system is turned on, a set of files is created. For example, if the system is on ready for deployment but the ship is not in position or ready, and you shut the system off while waiting for the ship to get into position or ready, then a set of files was created. This set of files is not associated with an actual deployment.

8. DATA PROCESSING

8.1. JpegLS_ADeck ("AutoDeck")

The first step of data processing is done with the software program JpegLS_ADeck, which reads in the full resolution DAVPR image data and displays these data on the desktop computer. JpegLS_ADeck separates and decodes the header, decompresses the image and scans it for regions of interest (ROIs).

The basic processing extracts sub-images that are reasonably sharp so as to be able to identify the represented object. To do this, each image is decompressed to full size and a black and white sub-image is extracted by sub-sampling one of every three pixels and scaling the pixel depth to 8 bits. This is the image that will be analyzed for ROIs.

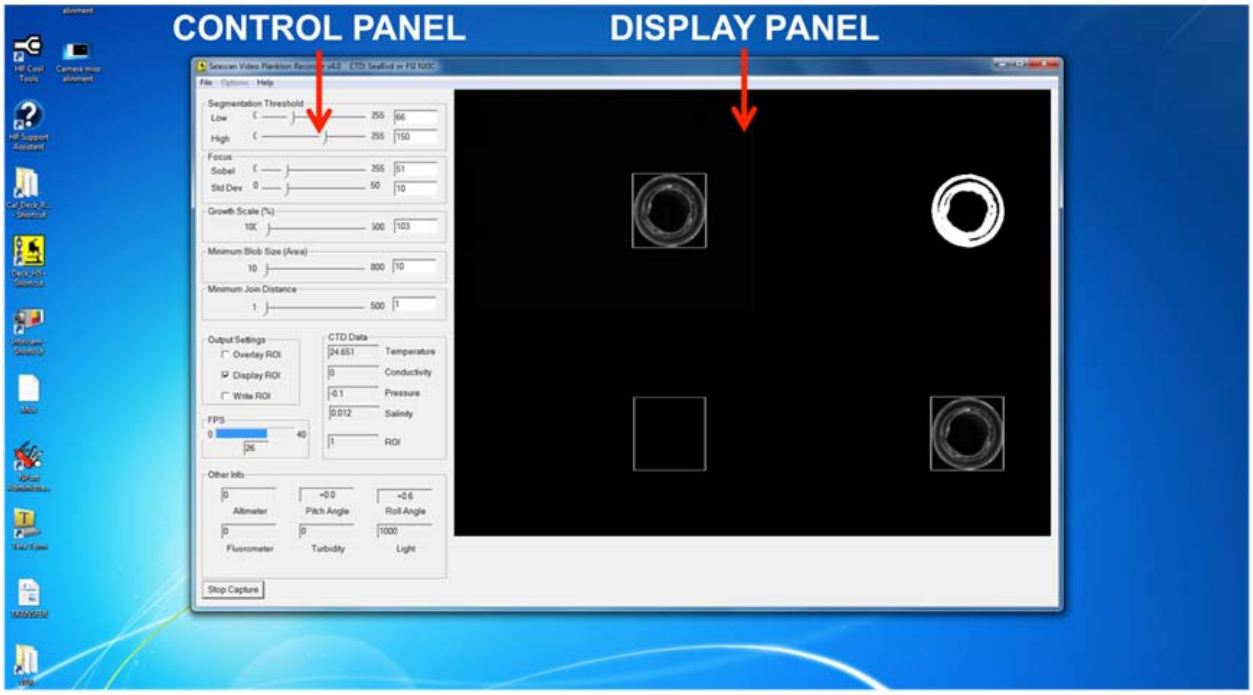
Looking at this analysis image data as a three-dimensional object where z is the luminance of each pixel, this sub-image is sliced at a level z0 called the SEGMENTATION THRESHOLD. A second image is then generated where any luminance value greater than z0 is turned to white and anything less is turned to black. This isolates intersected objects in the image as white patches, which are then boxed into a rectangular area.

Each area in the analysis image that maps into a box is then analyzed for structure (FOCUS) by looking at the light gradient and high frequency content. If the light gradient within the box is over a pre-defined threshold (SOBEL) and the high frequency content exceeds a standard deviation threshold, the box is accepted as containing a ROI and the corresponding sub-image augmented by the GROWTH SCALE is saved as a full resolution ROI. During the image processing, the oceanographic data is saved in a separate file. This is done whether the image contained ROIs or not.

Below is a screen capture of JpegLS_ADeck. The graphic user interface consists of two parts:

- A display panel containing four images related to the image being processed.

- A control panel that sets the working parameters of the application.



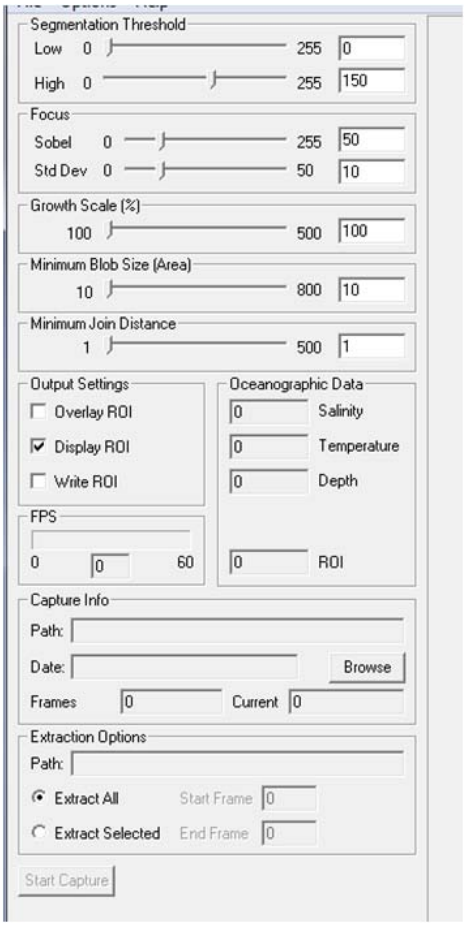
8.1.1. Display Panel

The display panel consists of four images all derived from the original full resolution decompressed image.

- In the upper left corner is the analysis image. It is built from a sub-sampled (one out of three pixels, 8 bit depth) transformation of the full resolution image.
- In the upper right corner is the binary version of the analysis image with potential ROIs (region of interest) appearing as white blobs.
- In the lower left corner each potential ROI that meet the size criteria is boxed into a rectangular area which is then analyzed for light gradient and texture.
- Those boxes that meet the requirements of all user-defined parameter settings are then expanded by the growth scale and qualify as ROIs, which are displayed in the lower right hand corner. Corresponding areas are also shown in the analysis image. The corresponding areas in the original full resolution image are the one saved to disk when ROIs are being written.

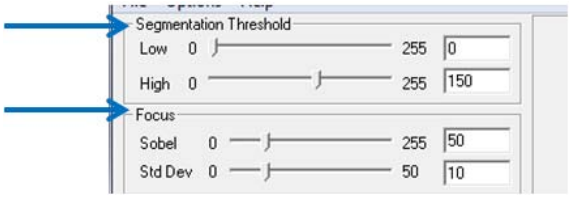
8.1.2. Control Panel

The control panel consists of a number of user-defined parameters that JpegLS_ADeck uses to evaluate whether an image will be saved as a ROI, as well as oceanographic and processing information.



8.1.2.1. Segmentation Threshold

The segmentation threshold has two slider controls: one for the Low Threshold and the other for the High Threshold. The Low Threshold is by default preset at zero and is rarely changed. The High Threshold defines the working level of segmentation with every luminance value above it converted to full white and every value below converted to black. Its default value is set at 150. When the segmentation threshold is set to the right value, the background illumination is barely perceptible as a flickering of tiny dots. The binary transformation applied to the image allows the isolation of white blobs corresponding to objects in the image. These blobs are then boxed and analyzed by the focus detection algorithm.



8.1.2.2. Focus

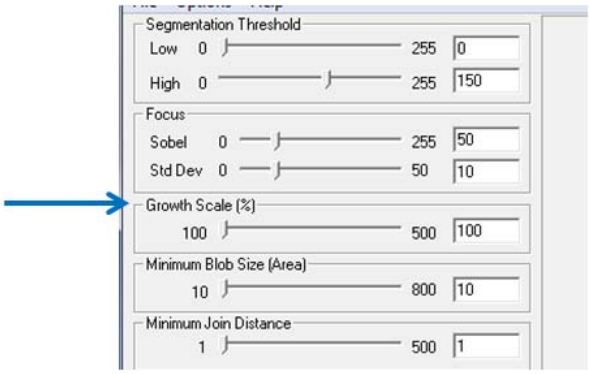
The focus also has two slider controls: one for light gradient analysis (Sobel) the other for

texture (Std Dev). The Sobel control is used by the gradient analysis. This analysis performs a local computation of the light intensity change over the area of the box and is good at detecting edges. It is the primary test. The default value is 50.

The standard deviation control (Std Dev) is used by the texture analysis. This analysis is applied to those boxes that pass the Sobel test, and isolate the high frequency content of the image by transforming it though a high pass filter. It then performs a statistical evaluation and assesses variability by computing the standard deviation from the mean over the box area. If this is larger than the set threshold, the box qualifies as a ROI. The default value is 10.

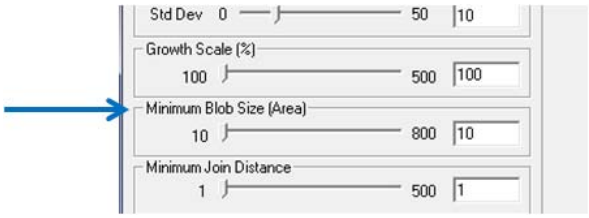
8.1.2.3. Growth Scale

The growth scale allows saving a larger area around the ROI than what was selected around the blob during segmentation. The purpose is to preserve in the saved image some of the finer details surrounding the object like antennas, fins, tentacles, etc. Its default value is 100% but 200-300% is probably a more practical value.



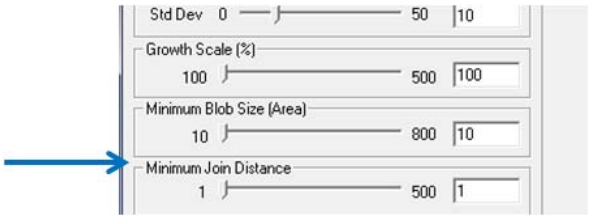
8.1.2.4. Minimum Blob Size

The minimum blob size defines a minimum size for the box passed over by the segmentation. It is expressed in pixels and allows for elimination of smaller boxes without analysis, saving on processing time. Its default value is set to 10.



8.1.2.5. Minimum Join Distance

The minimum join distance feature is used to merge a cluster of smaller boxes that are close together into a single larger box. It is used to properly isolate large translucent objects that can show up as a set of parts rather than a single entity. The distance is expressed in pixels, and any two objects closer than the specified value are merged together. Its default value is one (no merging).



8.1.2.6. Output Settings

This section contains three options:

1. Overlay ROI: If selected, ROIs in the lower right hand corner of the display panel will be superimposed on each other instead of refreshing the image to the currently detected ROIs only. This allows for more time to see the result of the analysis before it is erased for the next image. This option is off by default but it is recommended that you click it on.

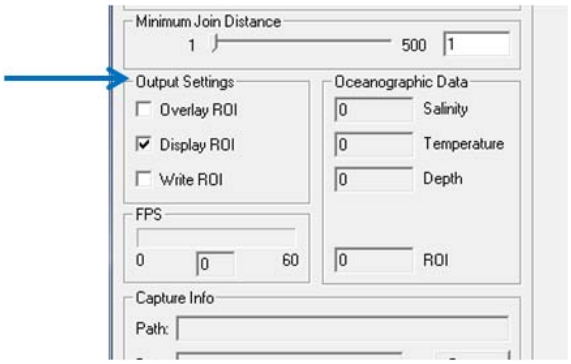
2. Display ROI: If selected, this enables the full display panel (the option is on by default). Suppressing the display allows for a slightly faster processing of images.

3. Write ROI: If selected, this enables the extracted ROIs to be saved to the disk for later analysis by Visual Plankton or any other image analysis software. When selected, JpegLS_ADeck will allow the user to browse for where the ROIs should be saved.

The output path choice is open to the user but if the user is planning to use Visual Plankton (VP) for further processing, VP will expect the data to be stored in the following format:

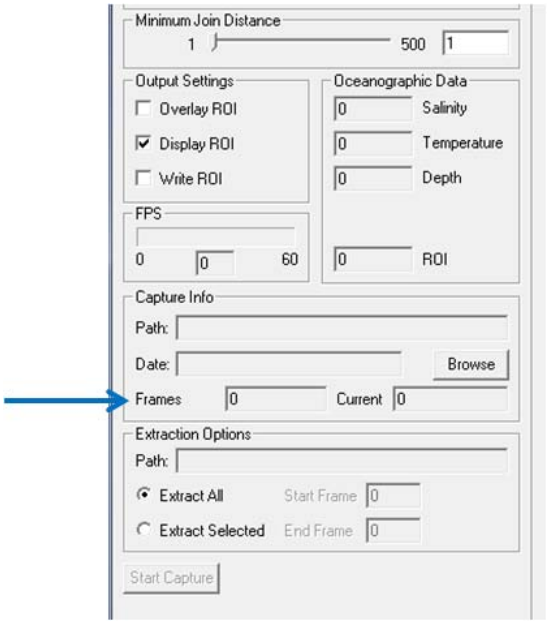
(drive):**data**\cruise**rois****vpr**xxx**d**xxx**h**xx

(drive)	can be any drive available on the computer at hand
\data	should be there, no freedom
\cruise	is the cruise name during which the data was collected, is user specified.
\rois	should be there, no freedom
vprxxx	should be there where xxx is a cast number (no leading zeros)
dxxx**h**xx	are automatically generated in the proper format with dxxx being the day of the year and hxx the hour of the day as computed from the date information contained in the input file name. If you want these day and hour value to be consistent between data collection and data processing, you need to make sure that both the VPR and the processing computer are set to the same time zone, GMT being our preferred setting.



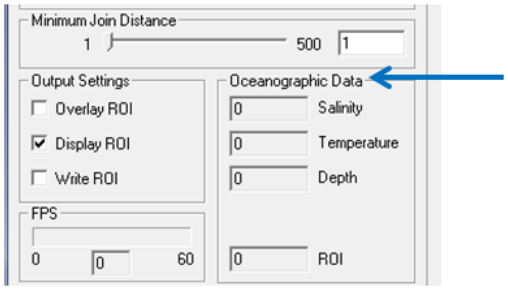
8.1.2.7. Frames per Second

FPS (Frames Per Second) is an indication of how many images are analyzed per second. The camera and strobe are fixed at 20 frames per second.

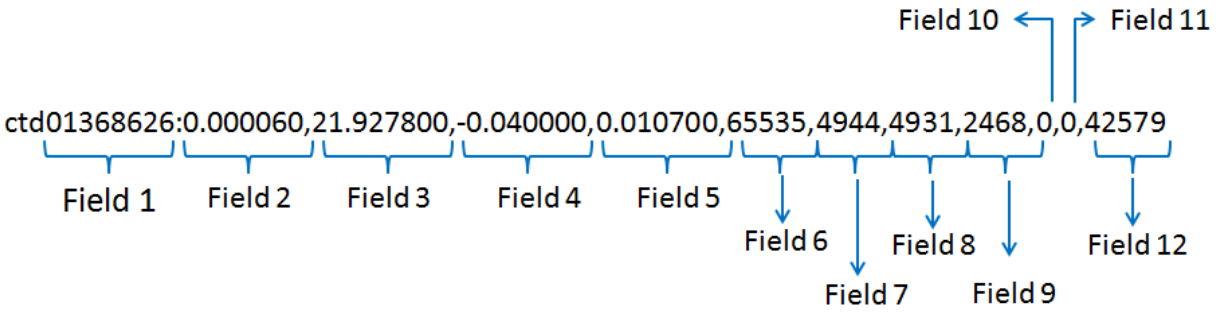


8.1.2.8. Oceanographic Data

Only the CTD information (Temperature in degrees Celsius, Salinity in PSU and Pressure (proxy for depth) in DBars associated with the current image is displayed here.



In the day folder ((drive):**data**\cruise**rois****vpr**xxx**d**xxx), JpegLS_ADeck will also create ctd data files with names hxxctd.dat. There is one of these files for each hour and these files contain the oceanographic data associated with each image in a sequential order. The format is as follows:



Field Number	Description
Field 1	ROI time; time in ms within the day
Field 2	Conductivity from Sea Bird SBE49 FastCAT
Field 3	Temperature, °C, -5 to 35 °C Range, from Sea Bird SBE49 FastCAT
Field 4	Pressure, decibars, 0 to 2000 m depth, from Sea Bird SBE49 FastCAT
Field 5	Calculate Salinity, psu
Field 6	Reserved, mV
Field 7	Wet Labs FLNTU,Fluorometer, mV
Field 8	Wet Labs FLNTU, Turbidity, mV
Field 9	Oxygen, mV, from Sea Bird SBE43 Dissolved Oxygen Sensor
Field 10	Pitch, degrees; positive is pitch up
Field 11	Roll, degrees; positive is roll to the right
Field 12	Total number of images since the system was powered on

The Sea Bird SBE 49 pump will only operate when immersed in sea water.

The Sea Bird submersible pump is used with the Sea Bird SBE43 Dissolved Oxygen Sensor. The pump will only turn on when the pressure is greater than 1 meter depth.

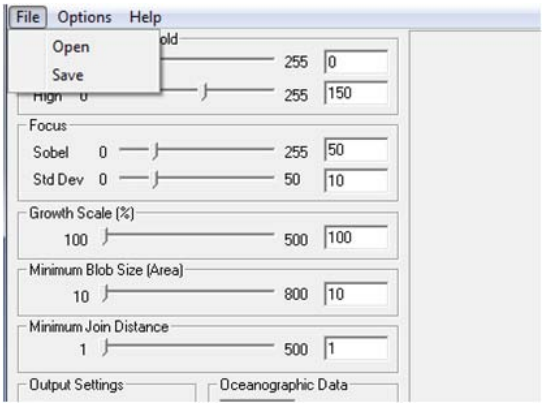
8.1.3. Drop-down Menus

File

Open: Use this menu option to load a config.vpr file (VPR Configuration File) with your saved user-defined parameter settings

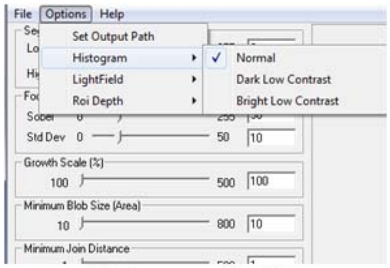
Save: Use this menu option to save your user-defined parameter settings for JPegLS_ADeck into a config.vpr file (VPR Configuration File) so they can be

easily loaded in.

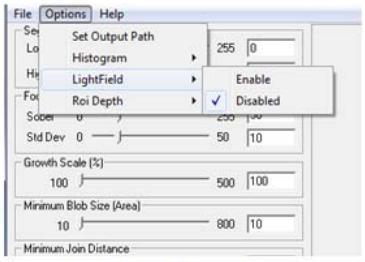


Options

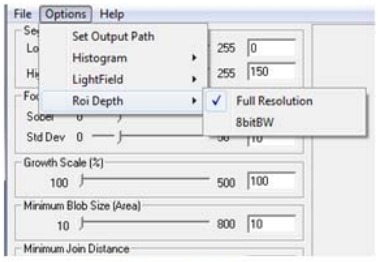
Set Output Path:
Histogram: leave on default “Normal”
LightField: leave on default “Disabled”
ROI Depth: leave on default “Full Resolution”



Histogram Options



LightField Options



ROI Depth Options

Help

About VPR: Brings up window of copyright information for the VPR

8.2. Determining the Best Values for User-Defined Parameters

NOTE: This is just an example of how one user defines the best parameters for their data. Each user should play around with the settings and this methodology to find the way that works best for them. Remember, this step is extremely important but also extremely subjective.

- Carefully read section 8.1.2 Control Panel in order to get a good understanding of each of the user defined parameters.
- Pick a subset of a few thousand frames of one or two casts to use for testing. Make sure the subset you pick is fairly representative of your cruise data (i.e. don’t choose the first 100 frames which are all bubbles).
- Run this subset of ROIs over and over again changing one parameter at a time and keeping the rest constant. Keep track of the total number of ROIs and the total number of identifiable ROIs (i.e. ones that are not blurry).

- Make an excel spreadsheet of this information and review it to find the balance between capturing a lot of blurry images and losing identifiable images. This is extremely subjective based on the user.
- See the example spreadsheet comparing user-defined parameters below. Highlighted fields are the user's choice for parameters for this specific cruise.
- NOTE: The optimal parameters for ROI extraction will change depending on the cruise so this step should be done for each new cruise or field project.

Cast	Frames	Segmentation Threshold		Focus		Growth Scale	Min. Blob Size	# Total ROIs	# Identifiable ROIs
		Low	High	Sobel	Std. Dev.				
vpr01	3000 - 5000	0	130	40	0	300	100	112	12
vpr01	3000 - 5000	0	140	40	0	300	100	18	12
vpr01	3000 - 5000	0	150	40	0	300	100	12	12
vpr01	3000 - 5000	0	160	40	0	300	100	10	10
vpr01	3000 - 5000	0	170	40	0	300	100	8	7
vpr01	3000 - 5000	0	150	20	0	300	100	16	12
vpr01	3000 - 5000	0	150	30	0	300	100	14	12
vpr01	3000 - 5000	0	150	40	0	300	100	12	12
vpr01	3000 - 5000	0	150	50	0	300	100	10	10
vpr01	3000 - 5000	0	150	60	0	300	100	8	8
vpr01	3000 - 5000	0	150	40	0	300	100	12	12
vpr01	3000 - 5000	0	150	40	10	300	100	10	10
vpr01	3000 - 5000	0	150	40	20	300	100	8	8
vpr01	3000 - 5000	0	150	40	0	100	100	12	12
vpr01	3000 - 5000	0	150	40	0	200	100	12	12
vpr01	3000 - 5000	0	150	40	0	300	100	12	12
vpr01	3000 - 5000	0	150	40	0	400	100	12	12
vpr01	5000 - 10000	0	150	40	0	300	10	17	3
vpr01	5000 - 10000	0	150	40	0	300	50	17	3
vpr01	5000 - 10000	0	150	40	0	300	100	13	3
vpr01	5000 - 10000	0	150	40	0	300	150	11	3
vpr01	5000 - 10000	0	150	40	0	300	200	9	3
vpr01	5000 - 10000	0	150	40	0	300	250	8	3
vpr01	5000 - 10000	0	150	40	0	300	300	5	3
vpr06	10000 - 12000	0	140	40	0	300	100	59	25
vpr06	10000 - 12000	0	150	40	0	300	100	47	25
vpr06	10000 - 12000	0	160	40	0	300	100	29	21
vpr06	10000 - 12000	0	150	30	0	300	100	56	25
vpr06	10000 - 12000	0	150	40	0	300	100	47	25
vpr06	10000 - 12000	0	150	50	0	300	100	33	20
vpr06	10000 - 12000	0	150	40	0	300	100	47	25
vpr06	10000 - 12000	0	150	40	10	300	100	35	18
vpr06	10000 - 12000	0	150	40	0	200	100	44	
vpr06	10000 - 12000	0	150	40	0	300	100	47	
vpr06	10000 - 12000	0	150	40	0	400	100	44	
vpr06	10000 - 12000	0	150	40	0	300	10	47	
vpr06	10000 - 12000	0	150	40	0	300	50	47	
vpr06	10000 - 12000	0	150	40	0	300	100	47	
vpr06	10000 - 12000	0	150	40	0	300	150	39	

8.3. Calibration & CalDeck_DAVPR_Reader

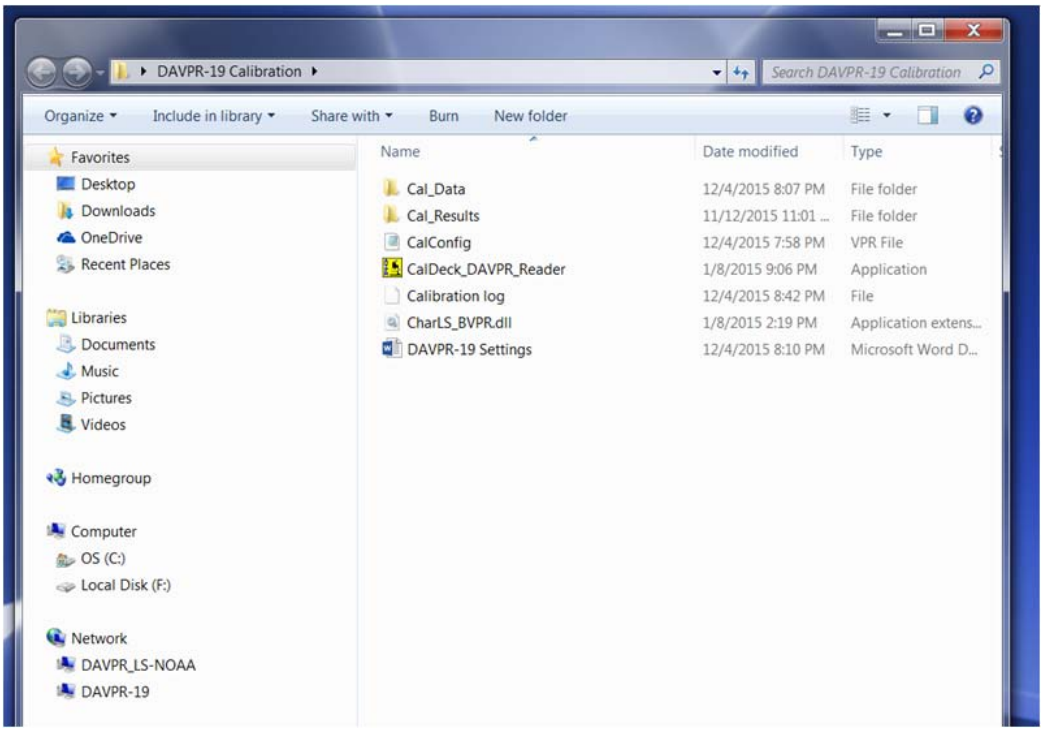
The observed volume of the DAVPR is calibrated at Seascan by moving a target plate with an evenly distributed series of refractive nodes from the camera to the strobe, following the optical axis. A file is recorded while the target plate traverses the field at a constant rate of ~2 mm per second. This process is repeated for each optical setting S0, S1, S2 and S3 (high to low magnification).

The observed volume depends on a number of extraction parameters set by the user in JpegLS_ADeck application software; most important are the high and low segmentation thresholds and the two focus settings (sobel and std dev).

CalDeck_DAVPR_Reader is a hard-coded version of JpegLS_ADeck that imports the most recent factory calibration file and, combined with the values of the user-defined parameters from JpegLS_Adeck, determines the imaged volume at each resolution for the user's settings. **NOTE: The same values the user defines in JpegLS_ADeck to extract ROIs should be used in CalDeck_DAVPR_Reader to determine the correct imaged volume for the user-defined parameters.**

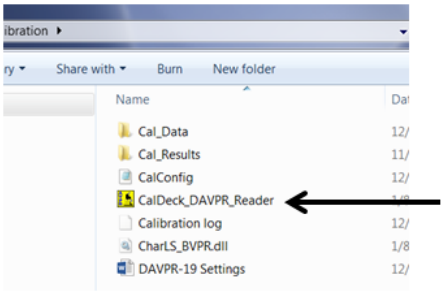
CalDeck_DAVPR_Reader resides in its own directory on the DAVPR desktop computer. Within this directory are the required *.dll's, the specific factory calibration file (CalConfig.vpr), the executable for the CalDeck_DAVPR_Reader software and two sub-directories: Cal_Data and Cal_Results.

'Cal_Data' contains the calibration files for each optical setting, S0 to S3, as well as an information file giving the details of the optical settings. 'Cal_Results' collects the output file for each calibration run executed. If this directory does not exist, it will be created at run time. The output files are named "Analysis_xxxxxxxxxx.dat" where 'xxxxxxxx' is a time stamp.

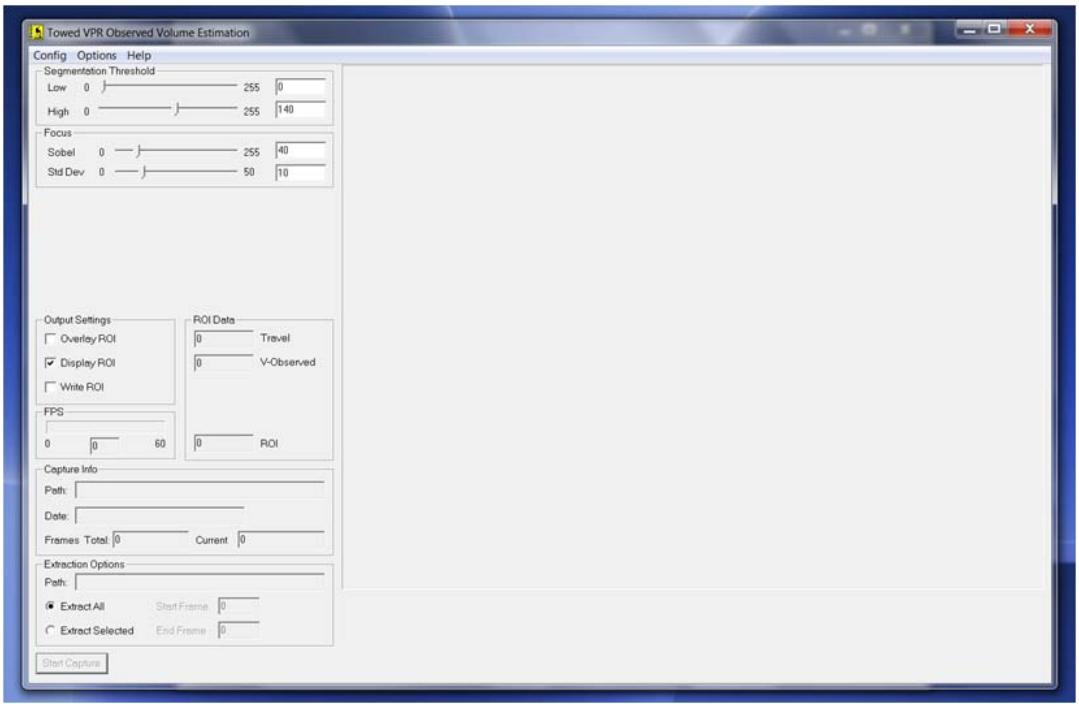


To run CalDeck_DAVPR_Reader to calculate the observed volume:

1. Double-click on the executable 'CalDeck_DAVPR_Reader.exe'



The CalDeck_DAVPR_Reader software will open in a new window. This should look similar to the JpegLS__ADeck graphical display.



2. CalDeck DAVPR_Reader should automatically load its working parameter from the CalConfig.vpr file. If for some reason this is not the case, go to:

Config

Open

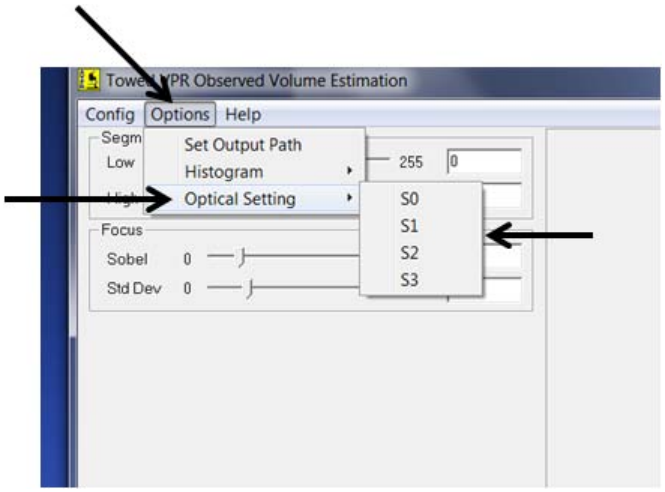
and choose the CalConfig.vpr file in the directory for this calibration

3. Choose the setting used during the ROI extraction by going to:

Options

Optical Settings

and choosing S0, S1, S2 or S3

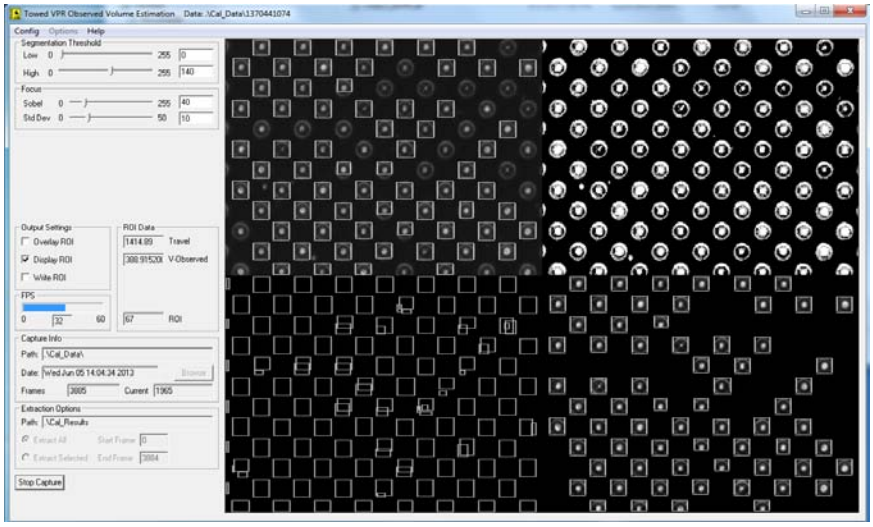


This will tell CalDeck_DAVPR_Reader which calibration file to use.

4. Change the user-defined parameters for segmentation threshold and focus from the default values to the ones used during ROI extraction.

5. Click on 'Write ROI' and save the calibration run to the 'Cal_Results' directory.

6. Click on 'Start Capture'



The factory calibration file will now run in the display panel and the program will display three parameters of interest:

1. The travel distance counted from the start frame position and expressed in 1/10th of a millimeter.
2. The number of ROIs grabbed within an image.
3. The observed volume up to the current frame, expressed in mm^3

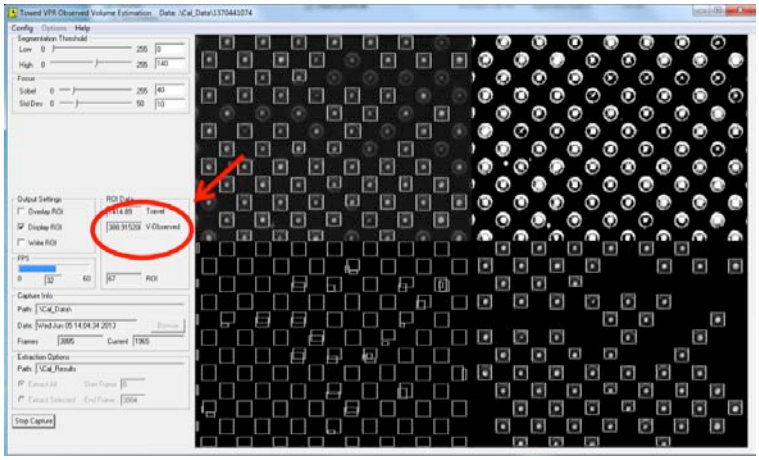
The calibration file consists of pictures of a special target consisting of a grid of refracting dots. The grid pitch is matched to the field of view in order to limit the number of possible ROIs to a 100 or less per image. For each dot on the grid there is a corresponding target surface equal to the square of the pitch. When calibrating, each picture is time-stamped and by knowing the speed of the target, one can calculate the distance between successive frames and then associate a volume with each captured dot. These elementary volumes are summed over the travel of the target and used to calculate the total observed volume for the selected settings. The output data (analysis file) is a text file containing one line per frame analyzed. The line contains 8 parameters separated by commas:

1. Time = elapsed time in miliseconds
2. Dist = travel distance expressed in 1/10th of a millimeter, assuming a uniform travel speed of 1.83 mm per second
3. NRoi = the number of ROIs captured in the current frame
4. Volume = the sum of all elementary volumes captured so far
5. SegH = setting value for high segmentation threshold
6. SegL = setting value for low segmentation threshold

7. Sobel = setting value for sobel
8. Std = setting value for standard deviation

7. Once the calibration file has finished running, the imaged volume information can be found in two places:

1. In CalDeck_DAVPR_Reader, in the box labeled 'VObserved' under 'ROI Data'



2. Open the analysis file and scroll all the way to the end. The number in the fourth column in the last row of the file is the total imaged volume.

NOTE: The imaged volume in both these places is expressed as mm^3. If using Visual Plankton, the user must convert this imaged volume from mm^3 to mL (1 mm^3 = 0.01 mL).

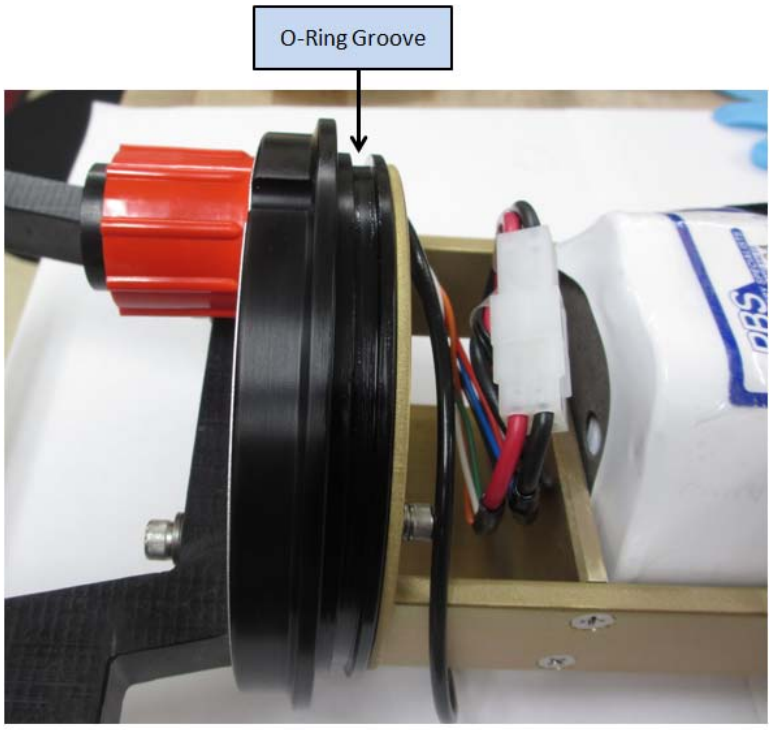
9. O-Ring Seals, Inspection, and Replacement

Each of the DAVPR subassemblies uses one or more rubber o-ring seals to prevent any water from entering into the pressure housings. Therefore, it is important to inspect the o-rings and sealing surfaces on a regular basis. Anytime a seal is opened, such as removing the battery chassis assembly, the user should inspect the o-ring and sealing surface before replacing the components.

The user should be aware that the sealing surfaces on the Electronics, Camera, Strobe, and Battery Housings are located on the inside ends of the cylindrical housings. Care must be taken not to scratch these surfaces while removing the chassis during maintenance or troubleshooting.

Typical Sealing Surface on Pressure Housings

The rubber o-ring seal is typically located in a groove. The surfaces of the groove are sealing surfaces and also require inspection.

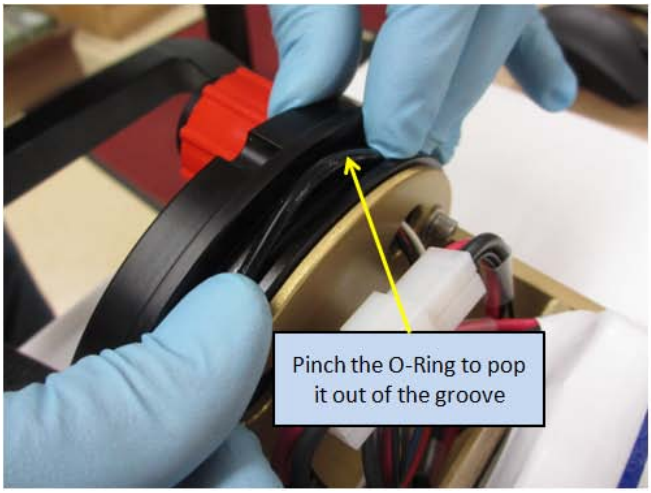


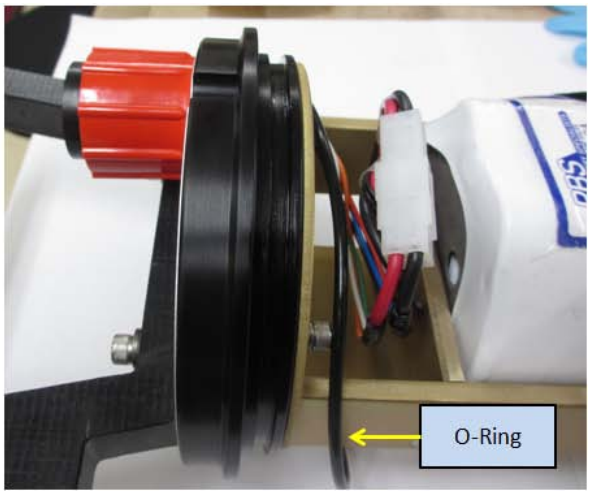
Typical O-Ring Groove

Any o-ring that has been exposed for some time may pick up some debris that sticks to the grease on the o-ring surface. A small amount of debris could potentially cause a water leak and therefore, it is important to inspect all o-rings and sealing surfaces prior to reassembling pressure housings.

Gently squeeze the o-ring between two fingers forcing it to pop up out of the o-ring groove. Grab the exposed o-ring with your other hand and gently peel it out of the groove. Leave the o-ring loosely hanging around the end of the chassis.

Do not use a screwdriver or pointed object to remove the o-ring from the groove. This approach could scratch or damage the o-ring groove surfaces!





Wipe the o-ring groove clean with a lint free paper or cloth wipe and alcohol. Visually inspect the groove for any debris or scratches. Wipe free any debris.

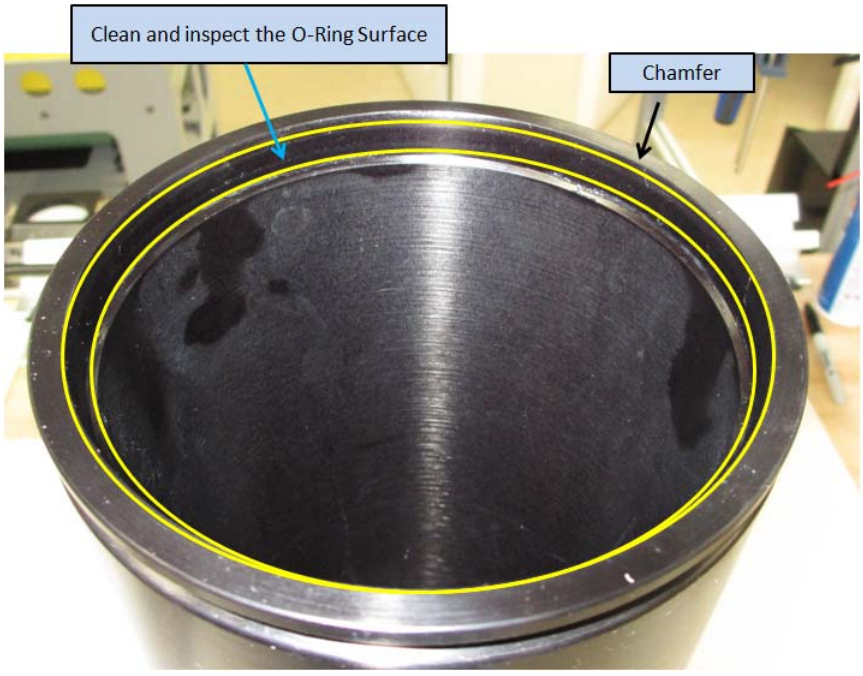
It is difficult to scratch or damage the o-ring groove because it is recessed and protected by the rubber o-ring. Trying to remove an o-ring with a screwdriver or other pointed object could scratch and/or damage the surface.

Gently clean the rubber o-ring by wiping the grease off with a lint free paper or cloth wipe. Inspect the o-ring for any defects such as a nick or cut in the rubber. The user does not have to remove the o-ring from around the chassis for the inspection. Carefully rotate the o-ring around the end of the chassis while inspecting the surface. Roll the o-ring between the fingers to inspect the inside surface.

Replace the o-ring if necessary. It is important to inspect new o-rings in the same manner prior to installation.

Grease the o-ring surface with a small amount of Dow Corning Molykote 111 or equivalent o-ring grease. Use your fingers to spread a thin layer all over the o-ring surface. Rotate the o-ring around the chassis as you spread the grease. Install the o-ring into the o-ring groove.

Clean the mating surface, such as the ends of the cylindrical pressure housing, with a lint free paper or cloth wipe and alcohol. Removing the grease will typically remove any debris stuck in the grease.



Inspect the surface for any debris or scratches. Apply a thin even layer of Dow Corning Molykote 111 or equivalent o-ring grease to the sealing surface. Apply a thin, even layer to the small chamfer leading into the cylindrical surface.

10. MAINTENANCE

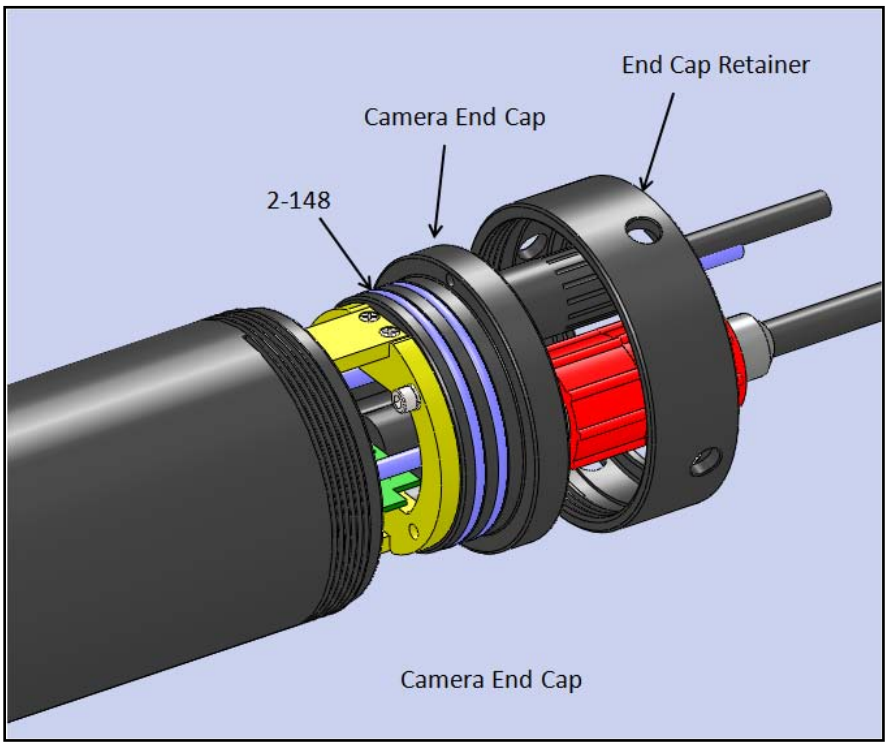
The DAVPR system is constructed of durable materials with protective coatings to withstand harsh environments. Please follow these basic maintenance routines to care for your DAVPR system.

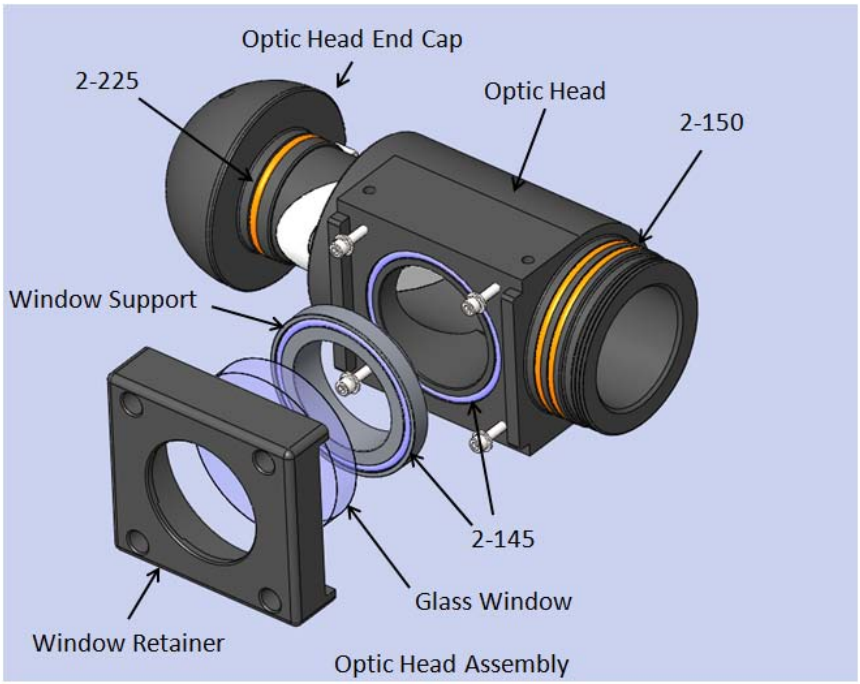
- Thoroughly wash the DAVPR system with fresh water after each use in seawater. Properly install all rubber dummy plugs and/or cable connectors with grease after use (see Appendix E “Handling Underwater Connectors” for details).
- Disconnect and remove the battery pack.
- Discharge the battery pack for long term storage. Discharge the DAVPR battery pack by running the DAVPR system.
- Store the discharged DAVPR battery pack in a cool, dry environment between +5 to 25^{o}C, relative humidity 65+/-5%.
- Lightly grease the threads on the V-Band clamp T-bolt.

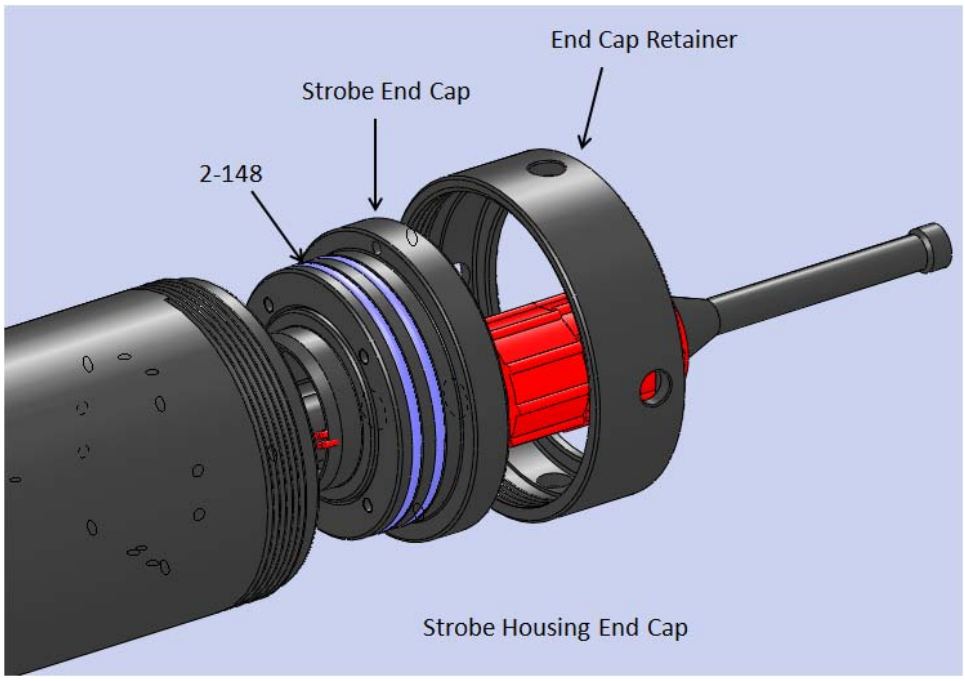
APPENDIX A: O-Ring Diagrams

All o-ring seals are Buna N 70 Durometer material. The o-rings in the following pictures are colored orange or blue for better clarity and do not represent the actual color of the o-ring material; the o-ring material is black.

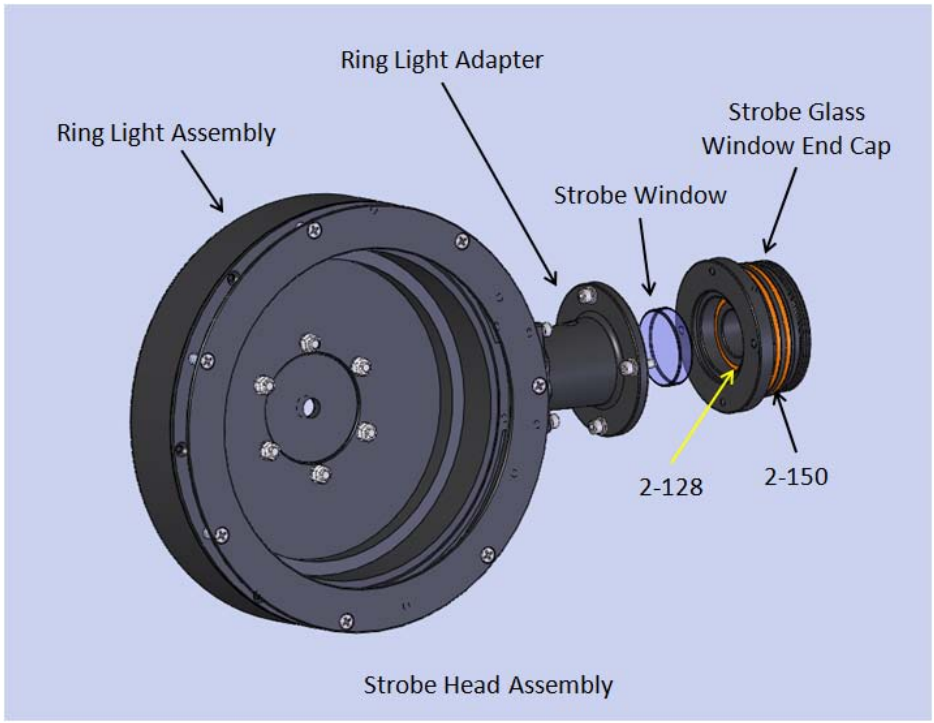
Location	O-Ring Size Number
Camera End Cap	2-148
Optic Head	2-150
Window Support by the Camera Glass Window	2-145
Window Support (bottom)	2-145
Optic Head End Cap	2-225
Purge Plug	3-904
All Bulkhead Connectors	
Strobe End Cap	2-148
Light Ring Adapter (the o-ring used here is not for sealing; used to push on glass window)	2-028
Glass Window End Cap	2-150
Under the Strobe Glass Window	2-128
Electronics Housing End Cap	2-257
Electronics Housing Aft End Cap	2-257
Connector Tree	2-212
Connector Adapter	2-018
Optical Switch	2-014 2-012
Battery Housing End Cap	2-249
Battery Housing Aft End Cap	2-249
Subconn 4 and 8 Pin Bulkhead Connectors	2-014
Subconn 8 Pin Ethernet Bulkhead Connector	2-014


End Cap Retainer
Camera End Cap
2-148
Camera End Cap

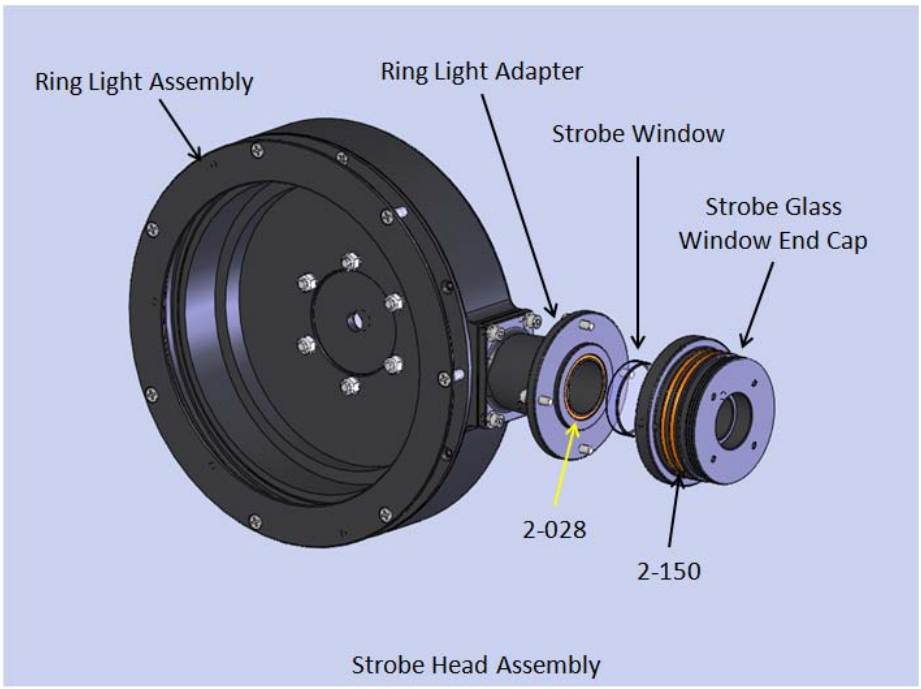

Optic Head End Cap
2-225
Optic Head
2-150
Window Support
2-145
Glass Window
Window Retainer
Optic Head Assembly



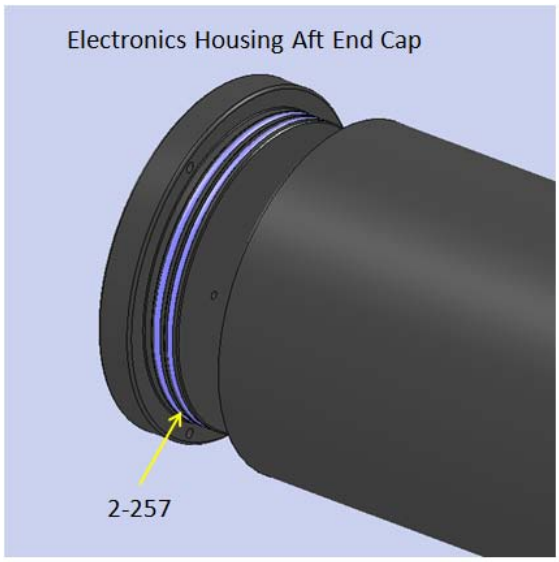
Strobe Housing End Cap

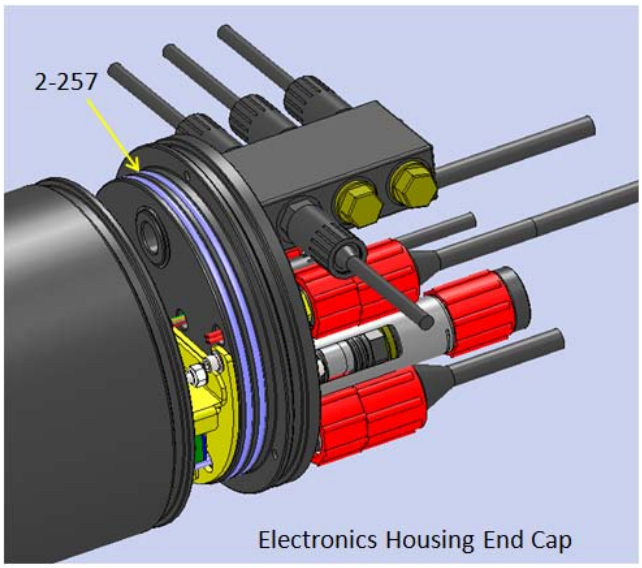


Strobe Head Assembly

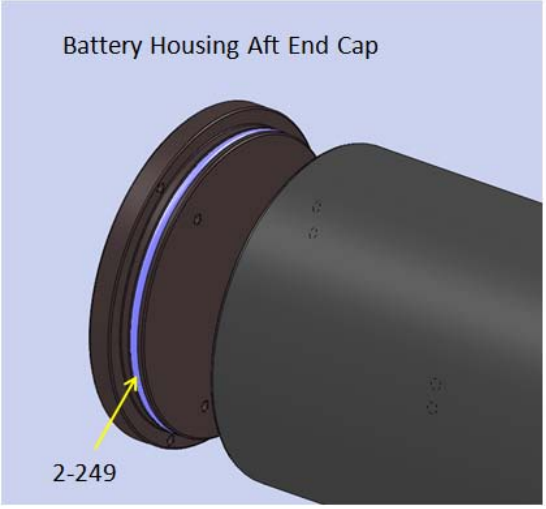


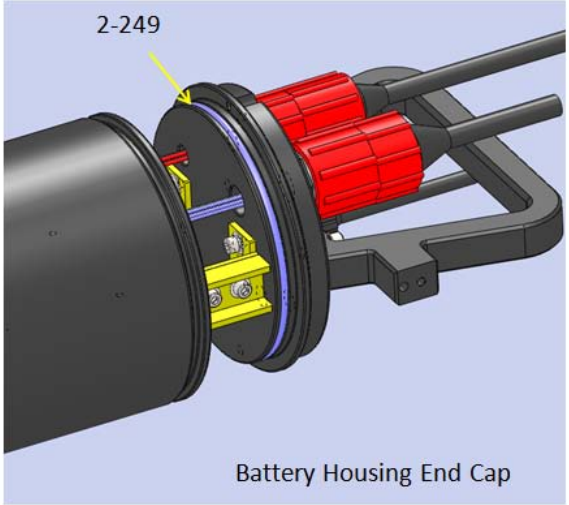
Strobe Head Assembly



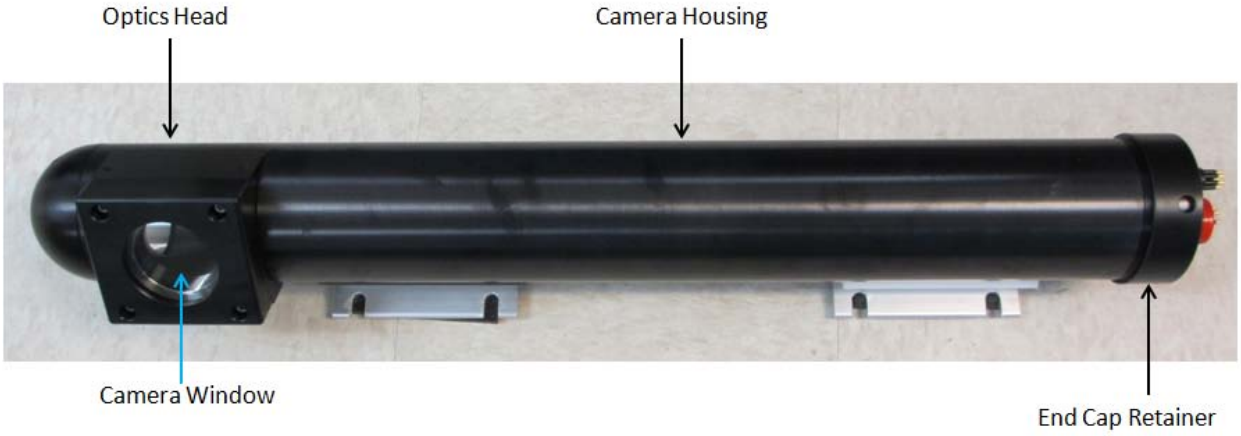


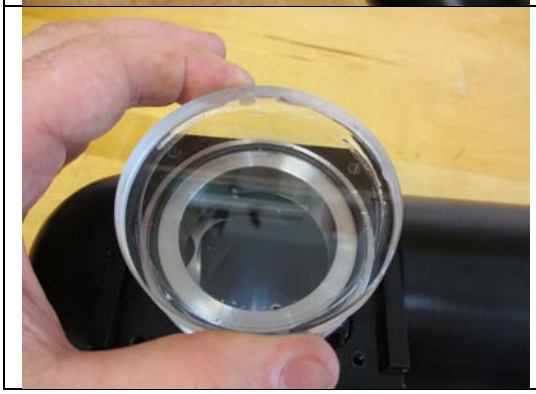
Electronics Housing End Cap

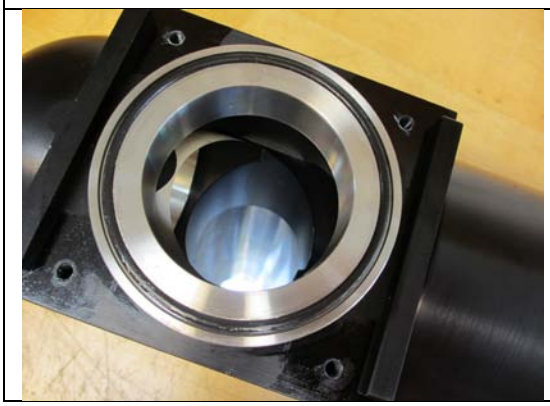

Battery Housing Aft End Cap
2-249

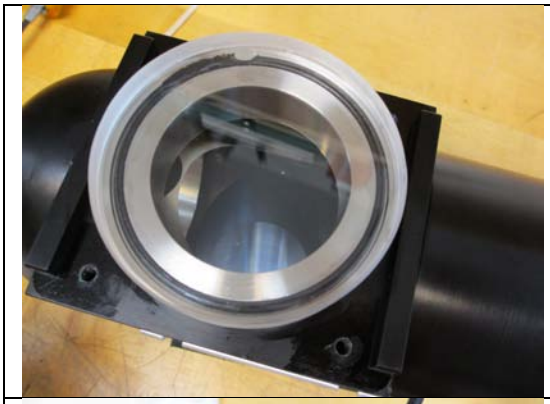
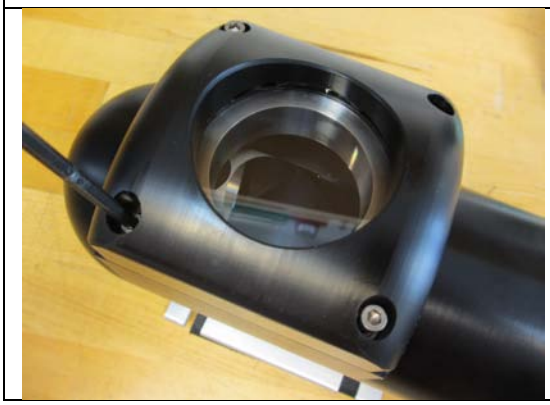

2-249
Battery Housing End Cap

APPENDIX B: Cleaning and Inspecting the Optic Head



	**STEP 1** Remove the four 10-32 socket head cap screws holding the Window Retainer to the Optic Head.
	**STEP 2** Carefully remove the Window Retainer by lifting straight up. The glass window is freely resting on the Window Support under the Window Retainer.
	**STEP 3** Carefully remove the glass window and place it on a soft lint free cloth.

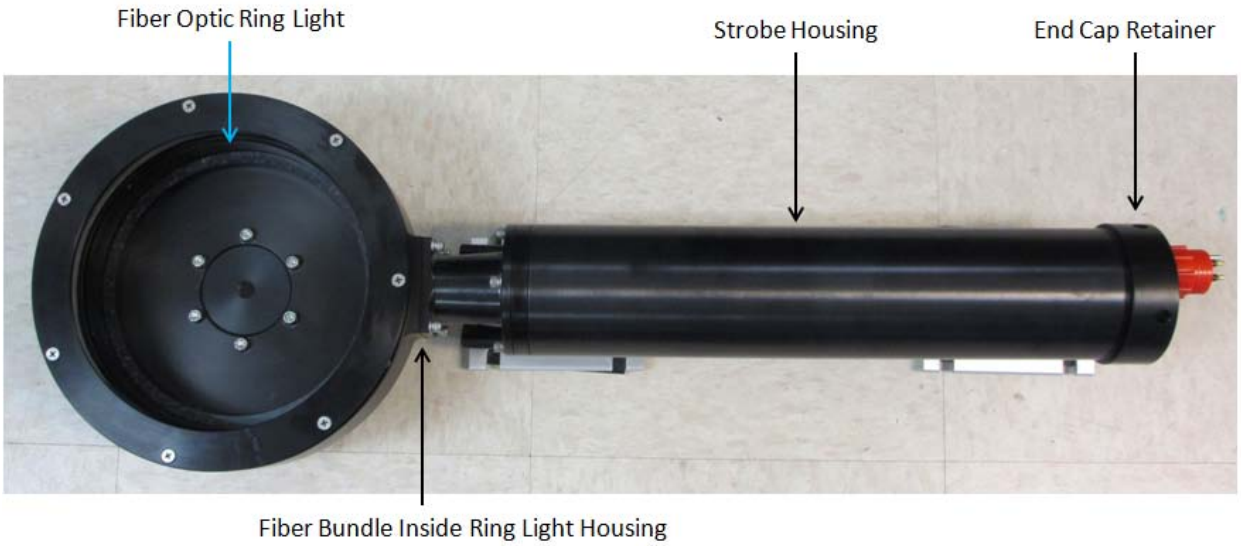
	**STEP 4** Remove the rubber o-ring from the stainless steel Window Support. Clean and inspect the o-ring for any nicks or defects. Replace the o-ring if necessary.
	**STEP 5** Remove the stainless steel Window Support. Clean and inspect the surfaces that come in contact with the rubber o-rings. Look for any signs of corrosion that may cause a water leak. Replace the part if necessary.
	STEP 6 Remove the rubber o-ring located on the face of the Optic Head (under the Window Support). Clean and inspect the o-ring. Replace if necessary. Clean and inspect the o-ring groove prior to installing the o-ring.
	**STEP 7** Install the stainless steel Window Support into the Optic Head. Make sure there is an o-ring in the face of the Optic Head prior to installation. Install the o-ring in the face of the Window Support.

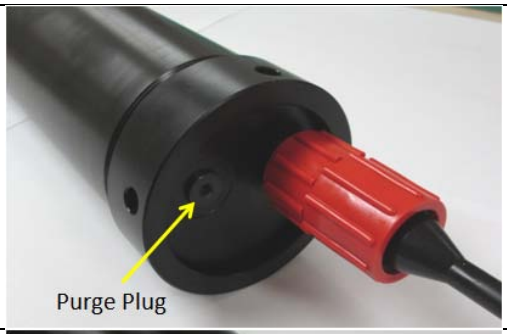
	**STEP 8** Clean the glass window with lint free lens paper prior to installing the glass on the Window Support. Place the glass window on the Window Support
	**STEP 9** Carefully place the Window Retainer on the glass window and align the mounting holes with the threaded holes in the Optic Head. Coat the threads of each screw with waterproof grease such as Aquashield. Install the hardware into each hole in the Window Retainer.
	**STEP 10** Partially tighten each socket head cap screw starting in one corner and moving across to the opposite corner. Continue to tighten each screw until the Window Retainer is firmly seated. Tighten the screws to 16.8 in lb torque (1.9 Nm).

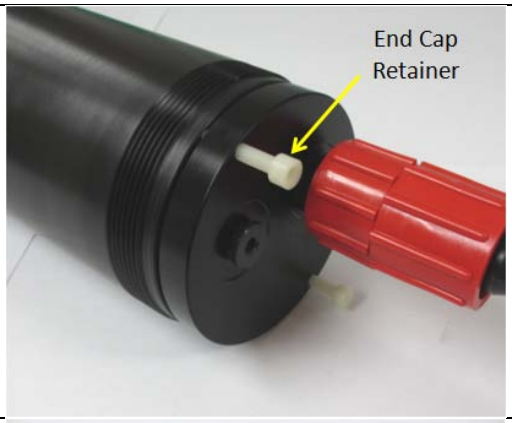
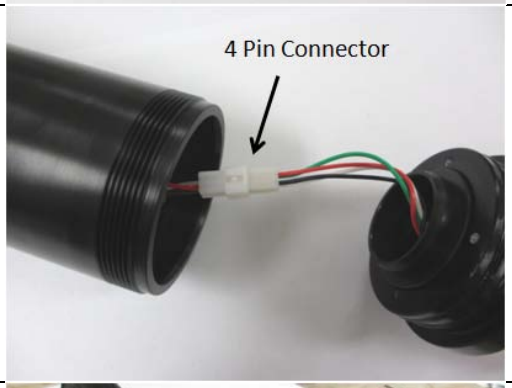
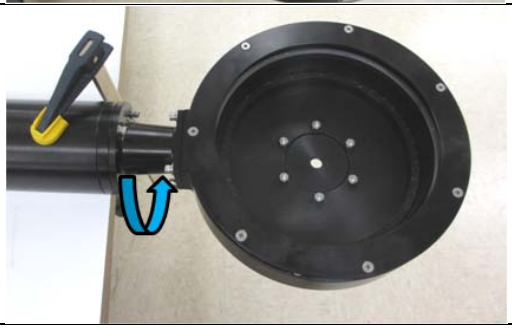
APPENDIX C: Replacing the Strobe Bulb

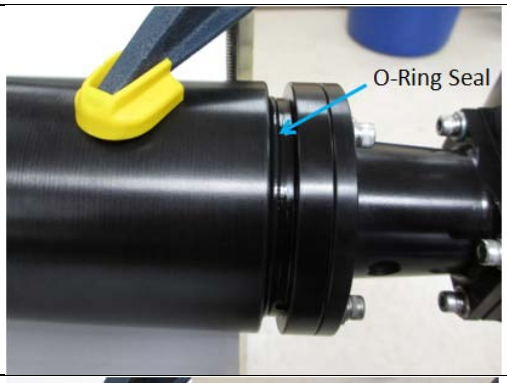
WARNING!

The DAVPR Strobe electronics has high voltages. The two large capacitors may be charged to 800 VDC. Ensure that input power is disconnected before disassembly. Handle the electronics carefully.



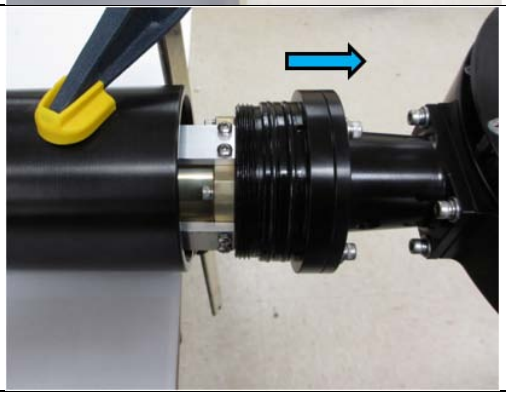
	**STEP 1** Loosen the purge plug located on the end cap using a 3/16 hex key. This will allow the housing to vent and remove any vacuum inside.
	**STEP 2** Unscrew and remove the plastic End Cap Retainer

	**STEP 3** Install a plastic socket head cap screw into the two threaded holes on the end cap. Screw in each socket head cap screw equally. The screws will push against the end of the strobe housing and force the end cap out.
	**STEP 4** Gently pull the end cap away from the end of the housing. Disconnect the 4 pin electrical connector.
	**STEP 5** Carefully and securely clamp the strobe housing to the workbench with the end of the housing extending past the edge of the workbench.
	**STEP 6** Place your hands on the Fiber Optic Ring Light assembly and slowly turn counter clockwise. The turning should be easy and smooth; do not force it. At first you will have to overcome the friction of the o-ring seals.



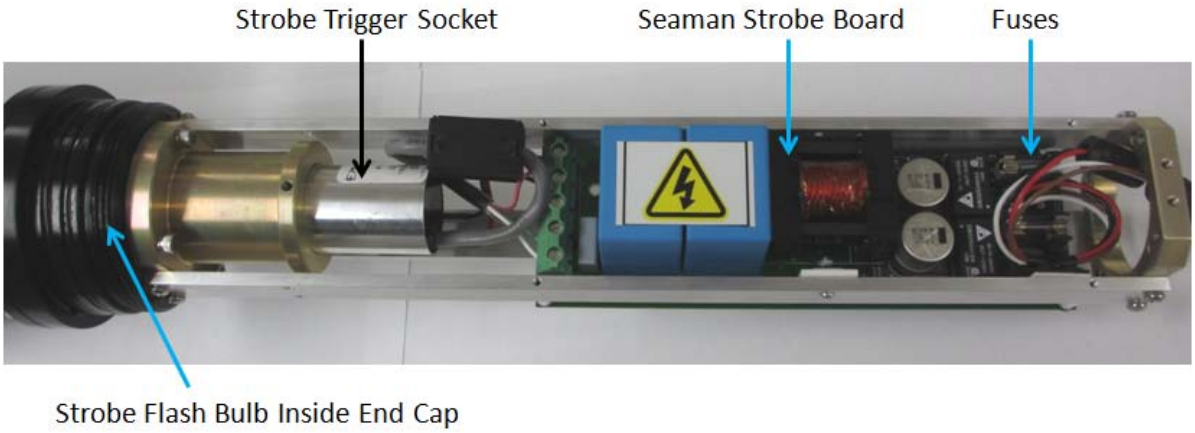
STEP 7

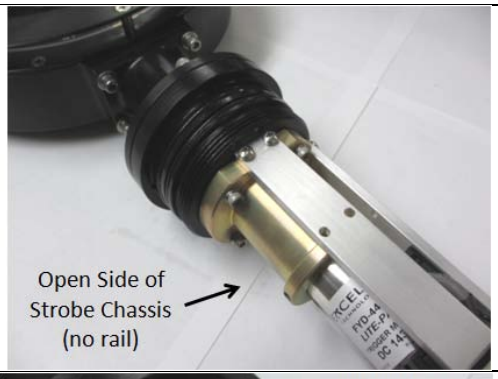
Stop turning when you can see the first o-ring seal.



STEP 8

Slowly pull the strobe chassis out of the housing.

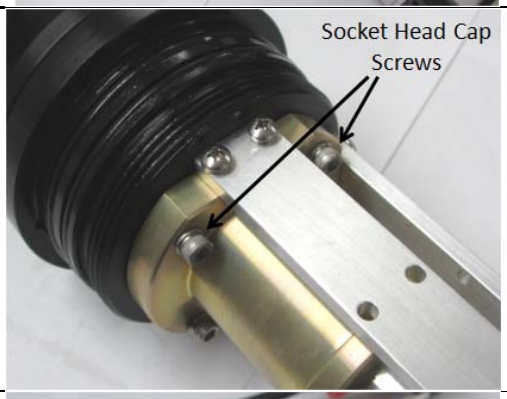




STEP 9

Note the orientation of the strobe chassis to the Fiber Optic Ring Light assembly so you can reassemble the chassis to the Ring Light in the same orientation.

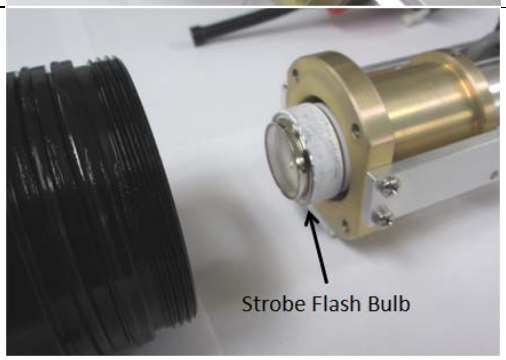
Note how the Trigger Socket wiring is tucked into the chassis and secured with a cable tie. You will need to replace this cable tie.



STEP 10

Caution: The strobe flash bulb extends into the end cap. The end cap is used as a heat sink for the bulb. Do not allow the bulb to support the weight of the chassis when the four screws are removed.

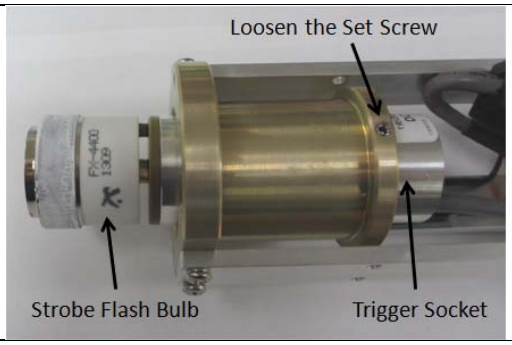
While supporting the chassis with one hand, remove the four socket head cap screws.



STEP 11

Gently slide the flash bulb out of the end cap. White thermal grease is used to transfer the heat from the bulb to the end cap during operation.

Do not touch the glass face of the bulb with your fingers unless you are replacing the bulb.



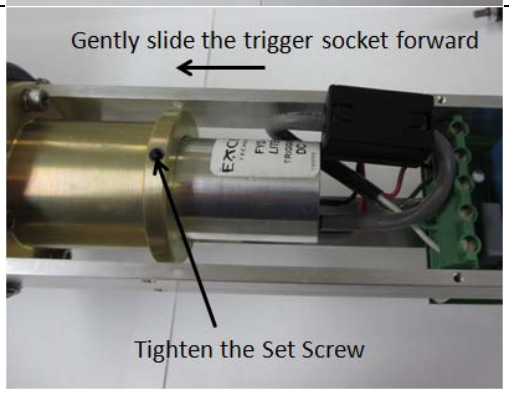
STEP 12

Loosen the set screw. The trigger socket is now free to slide in the chassis. Gently slide the trigger socket forward until the flash bulb extends beyond the chassis as shown. Tighten the set screw to hold the socket in place while removing the flash bulb.

STEP 13

Properly orient the strobe chassis with the Ring Light assembly (as shown and refer to STEP 1 for the orientation). Place one or more of the socket head cap screws through the end of the chassis in preparation of mounting the chassis to the end cap.

While supporting the chassis with your hand, carefully slide the flash bulb into the end cap and tighten the socket head cap screws.



STEP 14

The Trigger Socket is free to move since the set screw is loose. Gently slide the Trigger Socket forward to ensure that the flash bulb is inside the Strobe Glass Window End Cap.

Tighten the set screw.

Tuck the wiring inside the chassis and secure with a plastic cable tie.

STEP 15

Inspect the two rubber o-rings. Clean and grease the o-rings if necessary or replace if necessary. Refer to appendix A and B.

STEP 16

Clean and inspect the sealing surface on the inside of the strobe housing.

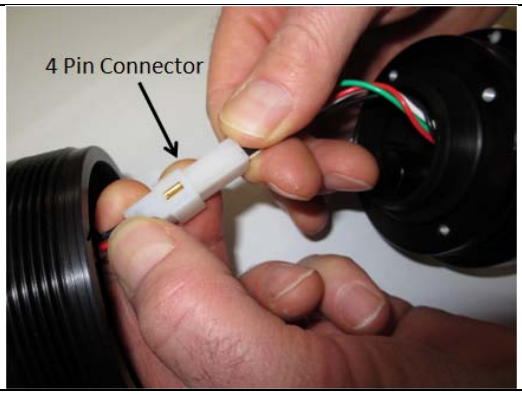
STEP 17

Carefully slide the strobe housing over the chassis assembly and up to the Strobe Window End Cap.

Carefully stand the assembly up resting on the Fiber Optic Ring Light as shown in the picture. This orientation will make it easier to start threading the strobe housing on to the Strobe Window End Cap.

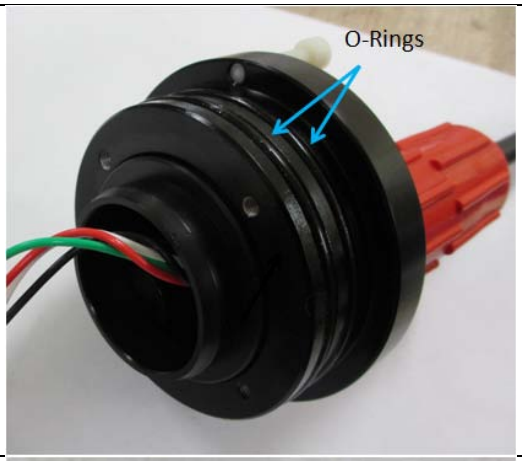
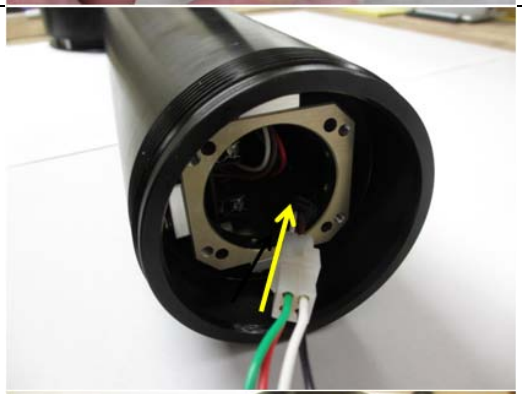
Slowly thread the strobe housing on to the Strobe Window End Cap. There will be more resistance as the housing rubs on the two O-rings but it should be easy to turn. If not, stop! Unthread the parts and begin again.

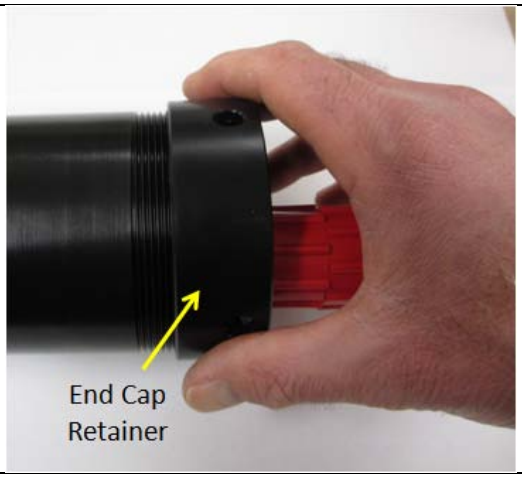
Turn the strobe housing until the end butts against the Strobe Window End Cap.



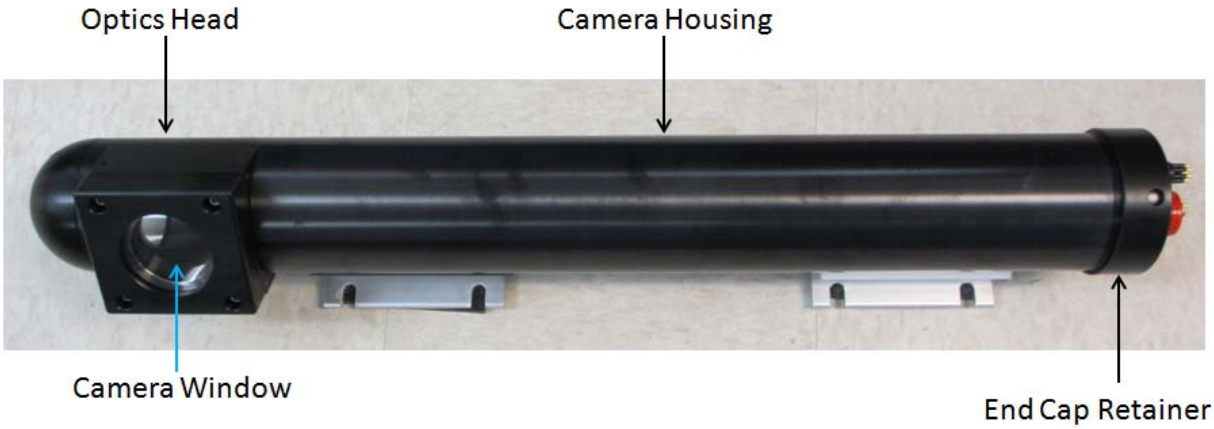
STEP 18

Plug in the 4 pin connector from the Strobe End Cap to the mating connector on the Strobe Chassis.

	**STEP 19** Inspect the two O-rings on the Strobe End cap prior to installing the end cap into the Strobe Housing. Refer to section 12 in the manual.
	**STEP 20** Note the orientation of the connector and purge plug on the Strobe End Cap relative to the face of the Ring Light prior to inserting the end cap into the Strobe Housing.
 	**STEP 21** Carefully slide the connector into the Strobe Chassis while inserting the end cap into the Strobe Housing. Carefully coil the wires inside the Strobe End Cap while inserting the end cap into the Strobe Housing.

	**STEP 22** Slide the end cap in to the housing with the connector and purge properly oriented with the face of the Ring Light. Stand the Strobe Housing up resting on the Ring Light and slowly push down on the end cap. The O-rings should go smoothly into the housing. The face of the end cap should butt against the face of the housing.
	**STEP 23** Screw on the plastic End Cap Retainer hand tight to hold the end cap firmly in position. Tighten the purge plug. If the purge plug was removed, inspect the o-ring and reinstall it.

APPENDIX D: Removing and Installing the Camera Chassis Assembly



	**STEP 1** Unscrew and remove the plastic End Cap Retainer
	**STEP 2** Loosen the purge plug located on the end cap using a 3/16 hex key. This will allow the housing to vent and remove any vacuum inside.

STEP 3

The Camera Chassis assembly is not keyed to the camera housing and orientation is important.

Note the orientation of the tapped holes and connectors relative to the Optic Head.

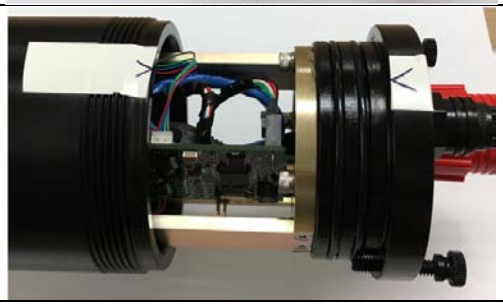
Place a piece tape on both the Camera Housing and End Cap. Mark the tape to reference the orientation of the End Cap relative to the Camera Housing.

STEP 4

Install a plastic 10-32 threaded screw into the two threaded holes on the end cap.

Turn each screw equally. The screws will push against the end of the Camera Housing and force the end cap out.

Note: do not use metal screws. The metal will scratch the anodize coating on the Camera Housing.

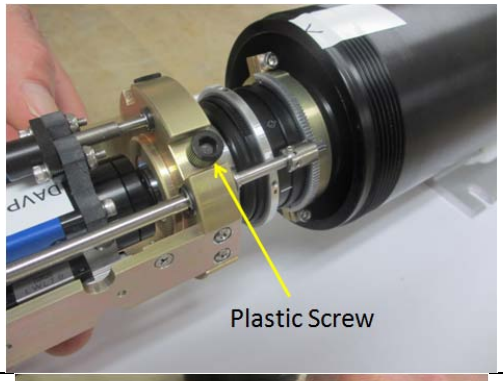


STEP 5

Carefully slide the Camera Chassis out of the Camera Housing.

Installing the Camera Chassis Assembly

Installing the Camera Chassis is basically the reverse procedure from removing the Camera Chassis.



STEP 1

Inspect and clean if necessary the O-ring surfaces on the Camera Housing and the O-ring and O-ring grooves on the Camera End Cap. Refer to section 12. O-Ring Seals, Inspection and Replacement

Carefully slide the Camera Chassis into the Camera Housing. Avoid scratching the O-ring surface on the Camera Housing with the chassis assembly.

There are four plastics screws located on the end of the chassis. These are used to slide along the inside of the Camera Housing and support the chassis in the housing.

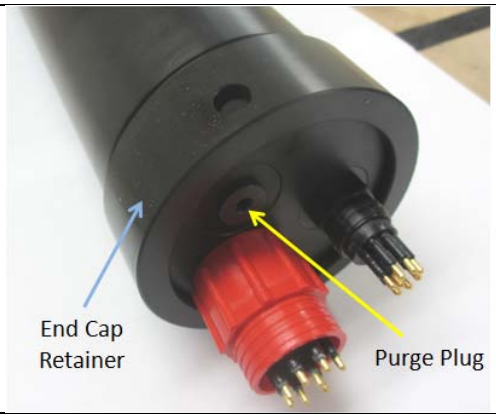
Slide the chassis into the housing until the first O-ring is near the end of the Camera Housing.

STEP 2

Align the reference marks on the Camera End Cap and Camera Housing.

STEP 3

Slowly push the Camera End Cap into the Camera Housing. Some force will be required to squeeze the O-rings into the Camera Housing.

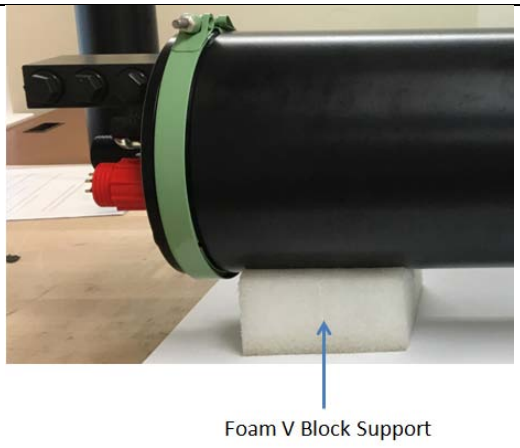


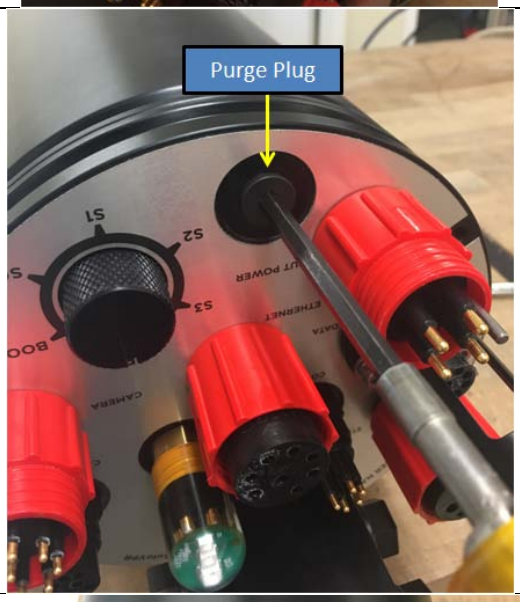
STEP 4

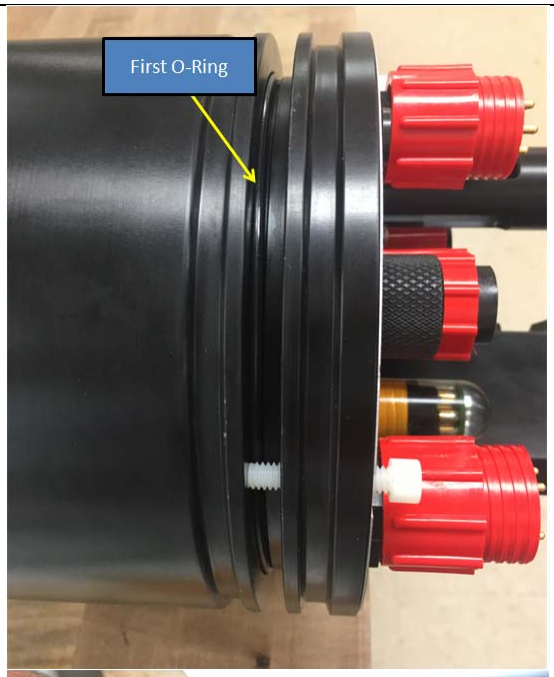
Remove the reference marks and install the plastic End Cap Retainer.

Screw in the Purge Plug.

APPENDIX E: Removing and Installing the Electronics Chassis Assembly

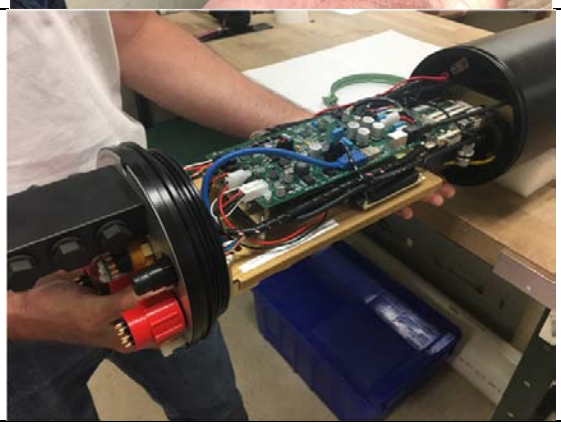
Removing the Electronics Chassis Assembly	
	**STEP 1** Place the Electronics Housing on a flat surface and prevent it from rolling. We typically use V- Blocks fabricated from foam or wood.

	**STEP 2** The V-Band retains the Electronics End Cap to the Electronics Housing. Use 7/16 wrench or socket to remove the hex nut on the V-Band T-Bolt. Remove the V-Band from the End Cap and replace the hex nut on the threads for safe keeping.
	**STEP 3** Loosen the purge plug located on the end cap using a 3/16 hex key. This will allow the housing to vent and remove any vacuum inside.
	**STEP 4** There are three 1/4-20 tapped holes equally spaced on the outside edge of the Electronics End Cap. Install a plastic socket head cap screw into two or three of the threaded holes. Screw in each socket head cap screw equally. The screws will push against the end of the Electronics housing and force the end cap out. Note: do not use metal screws. The metal will scratch the anodizing on the electronics housing.



STEP 5

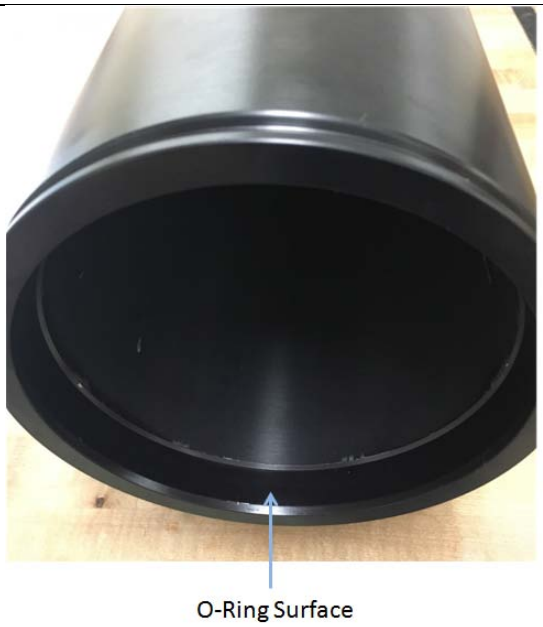
After pushing the end cap past the first O-ring, use both hands, one on each side, to slowly push/pull the End Cap out of the housing.



STEP 6

Slowly slide the Electronics Chassis out of the housing while supporting the bottom of the chassis with one hand.

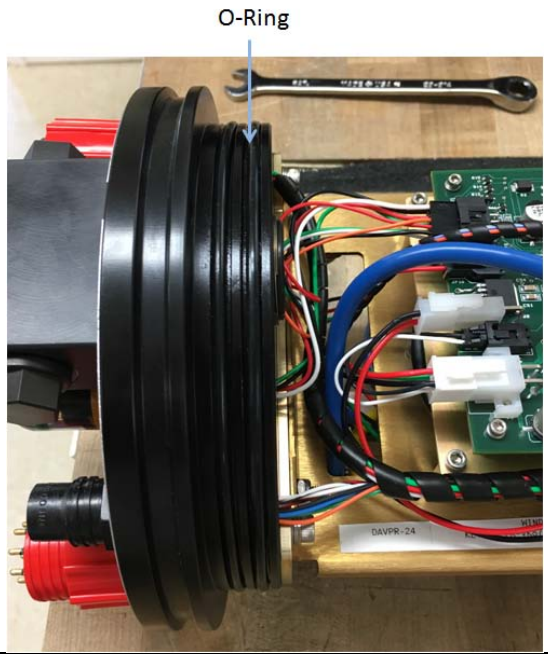
Installing the Electronics Chassis Assembly



STEP 1

Inspect the O-ring surface on the Electronics Housing. Clean and lightly grease the surface if necessary.

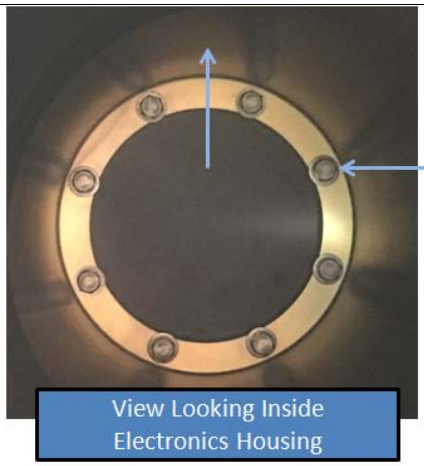
Please refer to section 12 O-Ring Seals, Inspection and Replacement

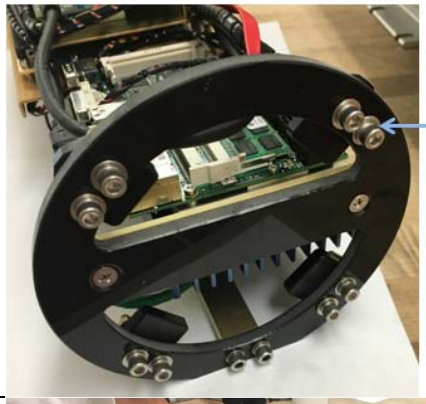


STEP 2

Inspect the two O-rings and O-ring grooves on the Electronics End Cap. Clean and lightly grease if necessary.

Please refer to section 12.1 Cleaning and Inspecting O-Ring Grooves and Mating Surfaces.

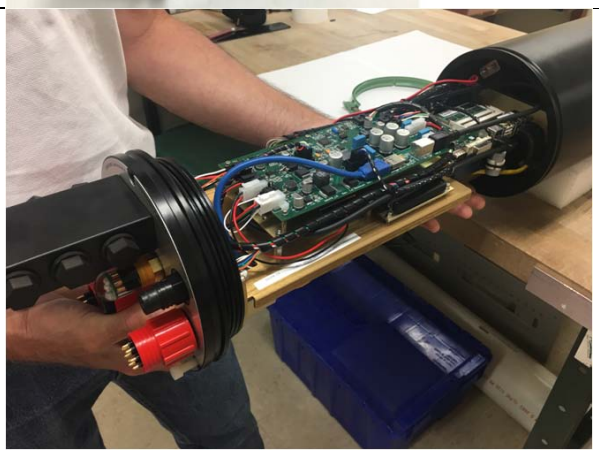




STEP 3

The Aft End Cap is held in place with 8 equally spaced hex cap bolts located on the inside of the Electronics Housing. Position the Electronics Housing so that the hex bolts are oriented as shown in the picture.

This will prevent the fasteners on the end of the Electronics Chassis from interfering with the hex bolts during installation of the Electronics Chassis.



STEP 4

Slowly slide the Electronics Chassis into the Electronics Housing while supporting the bottom of the chassis with one hand.

Ensure that none of the wiring gets pinched between the chassis and the Electronics Housing or End Cap.

	**STEP 5** Push the End Cap into the Electronics Housing up to the first O-ring. Then stand the Electronics Housing assembly up vertically on the work surface. Verify that the first O-ring is inside the Electronics Housing and not pinched between the End Cap and Electronics Housing.
	**STEP 6** Using both hands, push down uniformly on the end cap to squeeze the second O-ring into the Electronics Housing. The End Cap should be sitting flush on the end of the Electronics Housing.

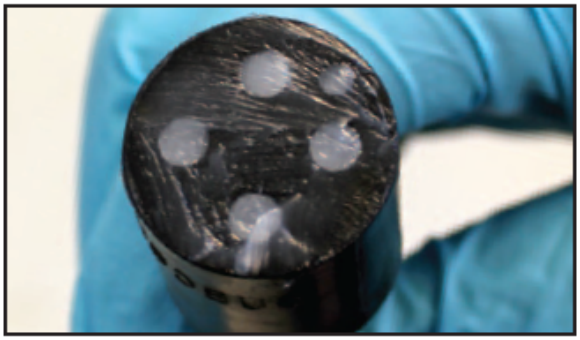
	**STEP 7** Replace the V-Band and tighten the hex nut using a 7/16 hex wrench or socket. Tighten the nut approximately 1.2 Nm (10 in lb).
Purge Plug 	**STEP 8** Inspect and clean the Purge Plug O-ring and surfaces if necessary and screw the Purge Plug in place.

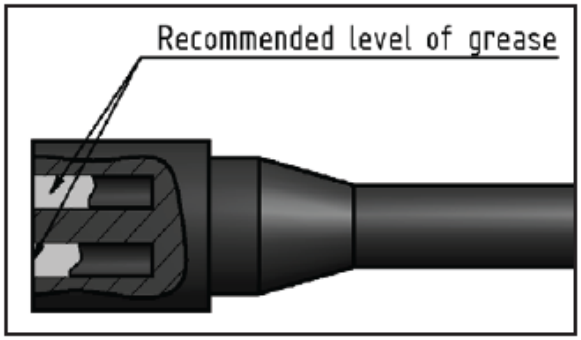
APPENDIX F: Handling Underwater Connectors

Handling Connectors

- Always apply grease before mating connectors
- Disconnect cables from bulkhead connectors by pulling straight and not at an angle.
- Do not pull on the cable and avoid sharp bends at the bulkhead connection.
- Do not over-tighten the bulkhead connector

Greasing and Mating Connectors





- Grease connectors with Molykote 44 Medium before every mating.
- Press grease into the female connector approximately 1/3 the socket depth.
- All the sockets should be completely sealed and a transparent layer of grease should be visible on the face of the connector.
- After greasing, fully mate the male and female connector and remove any excess grease from the connector joint.
- Assemble the plastic locking sleeves.

Cleaning

- Use a spray base contact cleaner such as isopropyl alcohol to clean the connectors.
- New grease must be applied again prior to mating connectors.

Tightening Force for Bulkhead Connectors

The DAVPR system uses all anodized aluminum bulkhead connectors. The recommended torque for bulkhead connectors with 7/16-20 threads is 10.0 Nm and for 5/8-18 threads is 29.0 Nm.

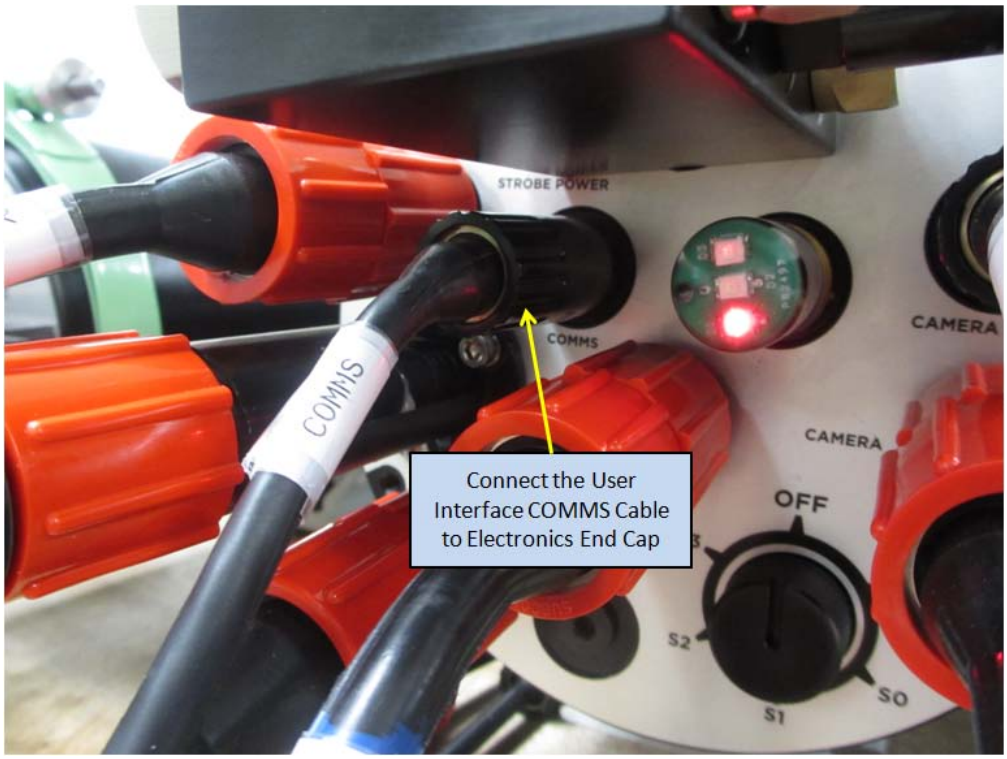
APPENDIX G: RS232 Communications and Control

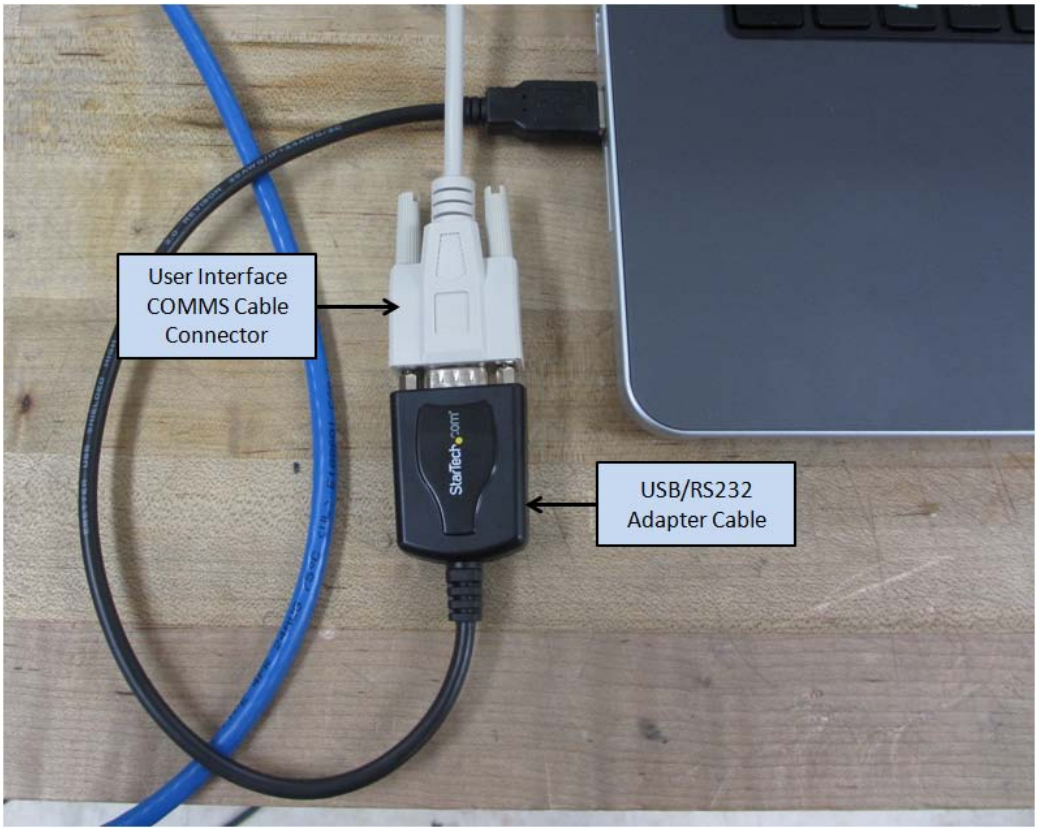
The operator can control the DAVPR by sending commands over the serial connection to the DAVPR Controller microprocessor. The operator can control all the functions of the DAVPR over the serial link:

- Booting the single board computer
- Changing the camera field of view to one of four preset positions.
- Turning on or off the image capture
- Shutting down the system in a controlled manner

The user can remotely operate the DAVPR system by sending commands to the DAVPR computer over the RS232 communications link. The user will need a terminal emulator program in order to operate the DAVPR system through the RS232 communications link. The descriptions in the following sections use Tera Term. Tera Term has been installed on the user's laptop computer.

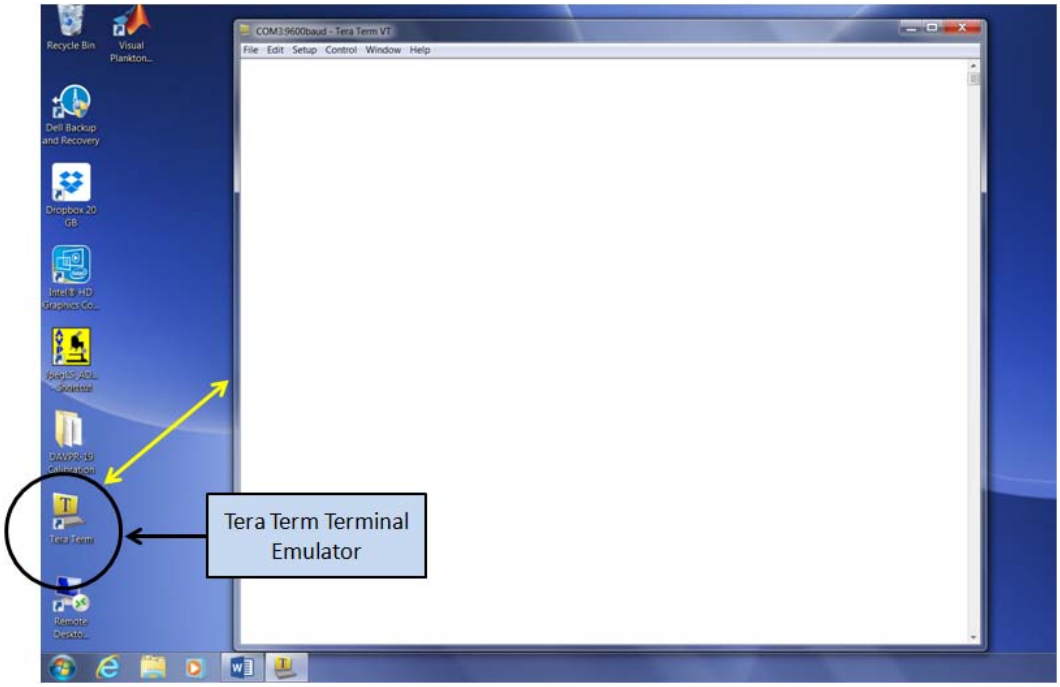
- Connect the User Interface COMMS cable assembly to the user's computer either directly or through a commercially available serial adapter. **Note:** the Optical Switch will not function when the RS232 COMMS cable is connected to a computer and should be set in the OFF position.


STROBE POWER
COMMS
CAMERA
COMMS
CAMERA
OFF
S2
S1
SO
Connect the User Interface COMMS Cable to Electronics End Cap


User Interface COMMS Cable Connector
USB/RS232 Adapter Cable

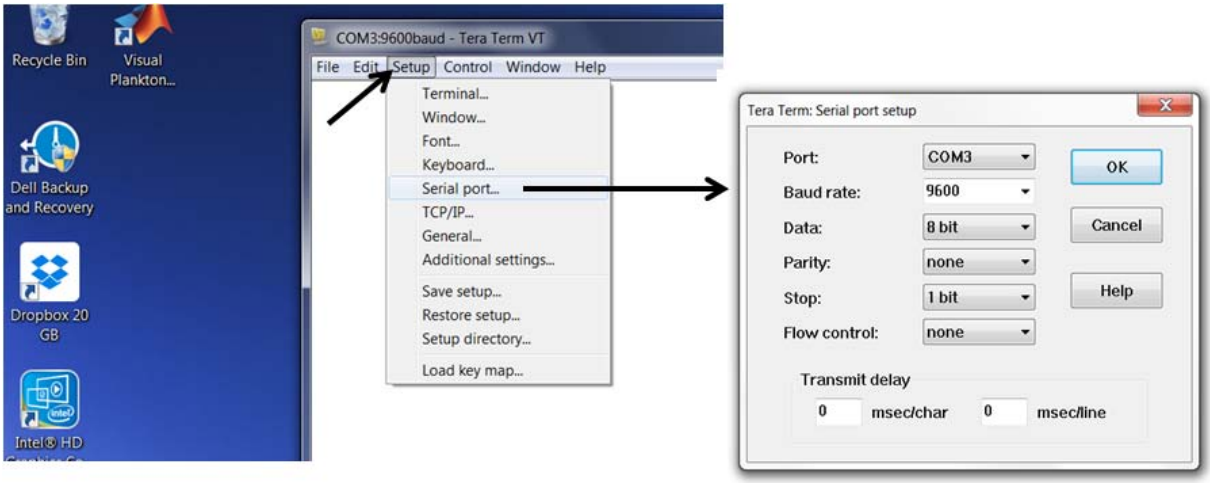
- Apply power to the DAVPR system by either connecting the Electronics to the DAVPR Battery or using the DAVPR Power Supply and Adapter Cable (see section 7. Operating the DAVPR in the LAB) . Leave the Optical Setting Switch in the OFF position.

- Run the terminal emulator program.



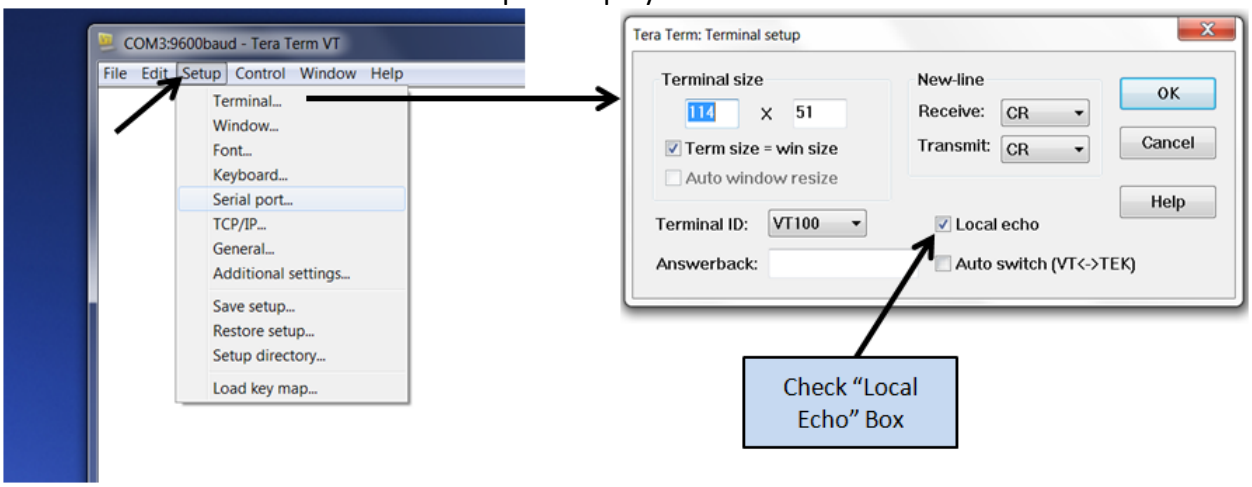
Go to: Setup_
Serial Port Setup_

- Change the baud rate for the COMM port to 9600
- Click 'OK'



Go to: Setup_
Terminal Setup_

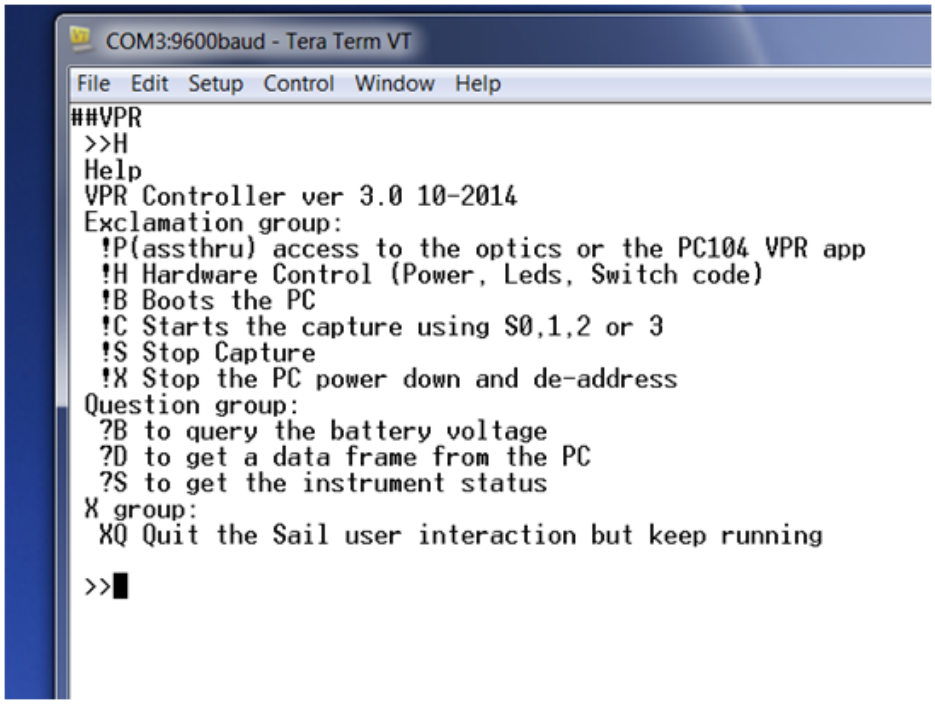
- Check on the "Local Echo" setting so that the character inputs display in the terminal emulator window



NOTE: (cr) = carriage return
(sb) = space bar

##VPR(sb) gets the attention of the DAVPR computer.
The ">>" prompt will appear on the screen.

>> H(cr) will open the help menu



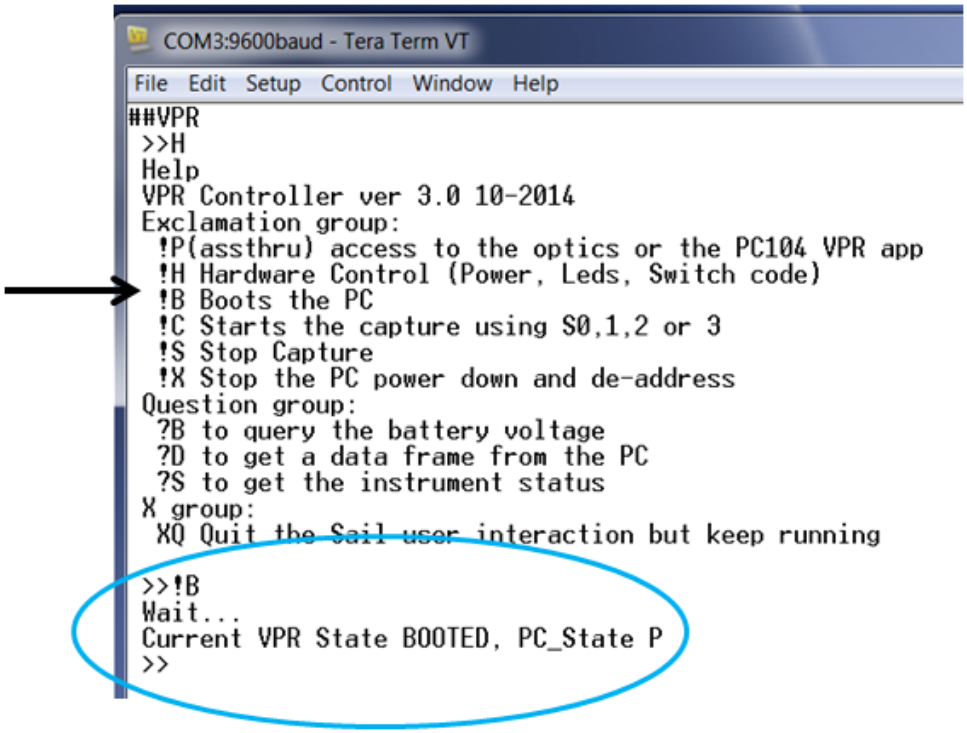
Enter the commands as shown in the help menu and then hit 'enter'. For example:
>> !B (cr) will boot the PC

>> ?B (cr) will query the battery voltage

The DAVPR computer may disconnect if a command is improperly entered or after more than two minutes passes between commands. The ">>" indicates that the DAVPR computer is still accessible by the user. Enter the ##VPR and press the space bar to get back the command prompt.

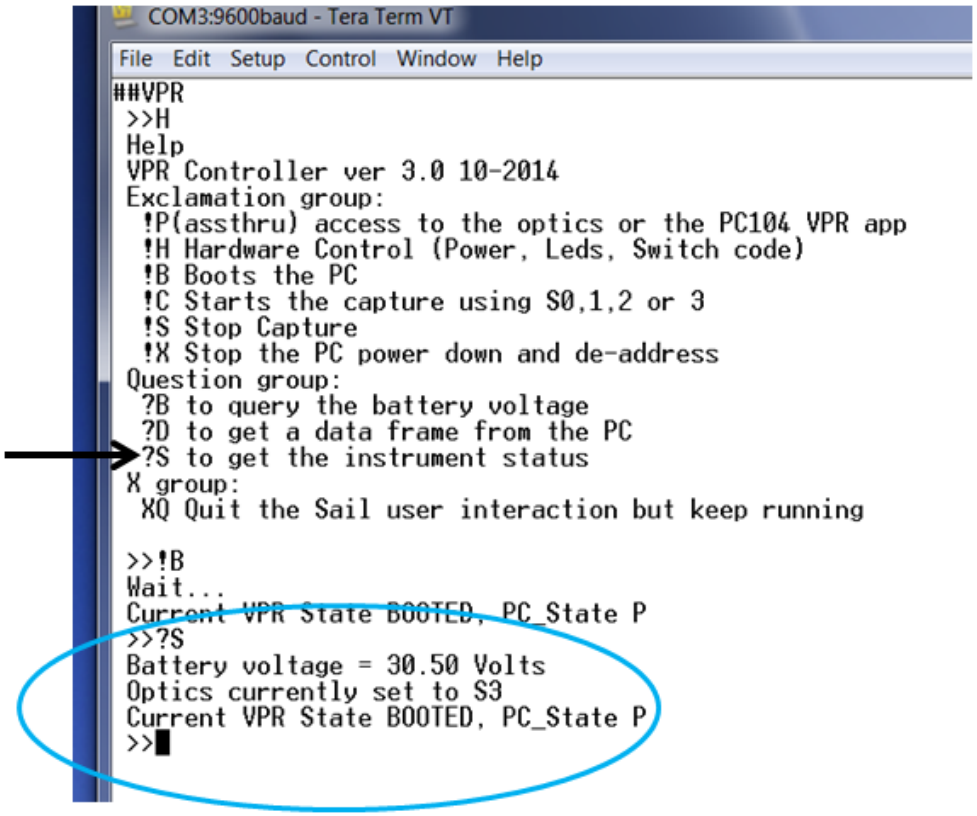
You must "Boot" the DAVPR computer in order to operate the system.

>> !B (cr) will boot the PC in the DAVPR system. The following screen will appear:



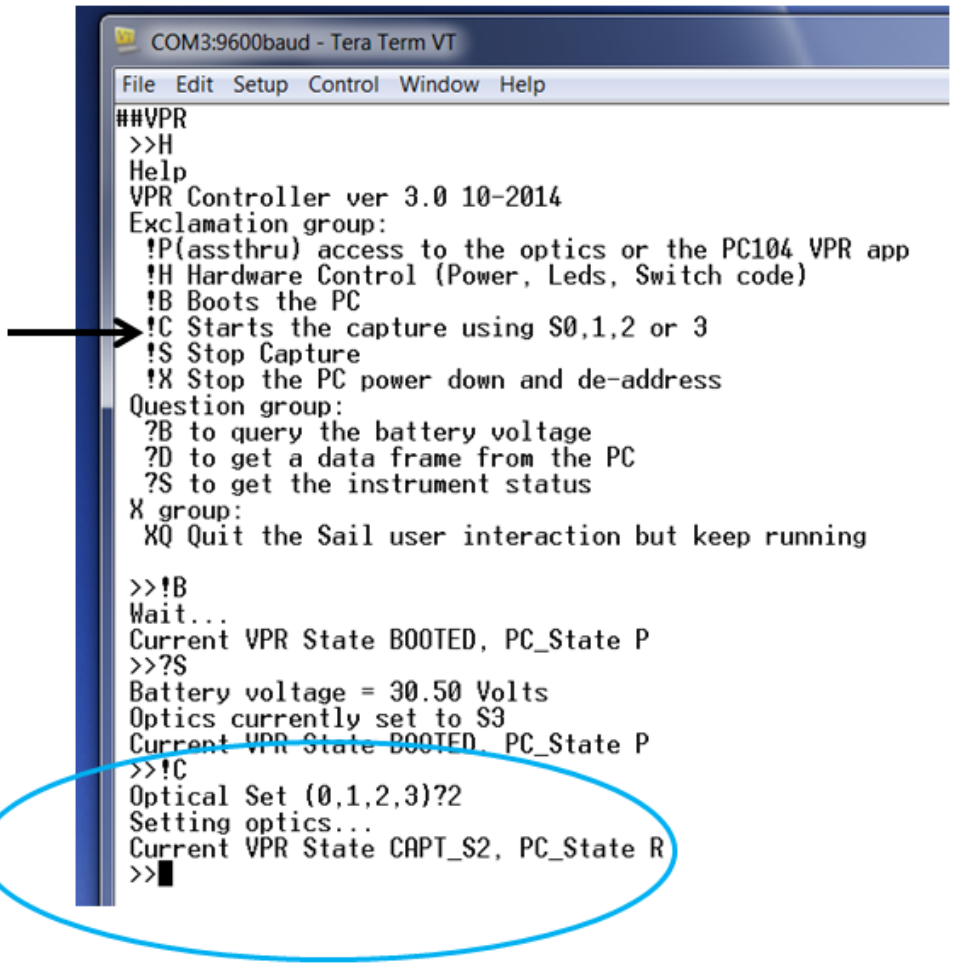
Query the instrument status by typing,

>> ?S (cr) The following screen will appear:



Set the optics and start capturing images by typing,

>>!C(cr) Set the optics to S0, S1, S2 or S3 by entering a 0 for S0, 1 for S1, 2 for S2 or 3 for S3.

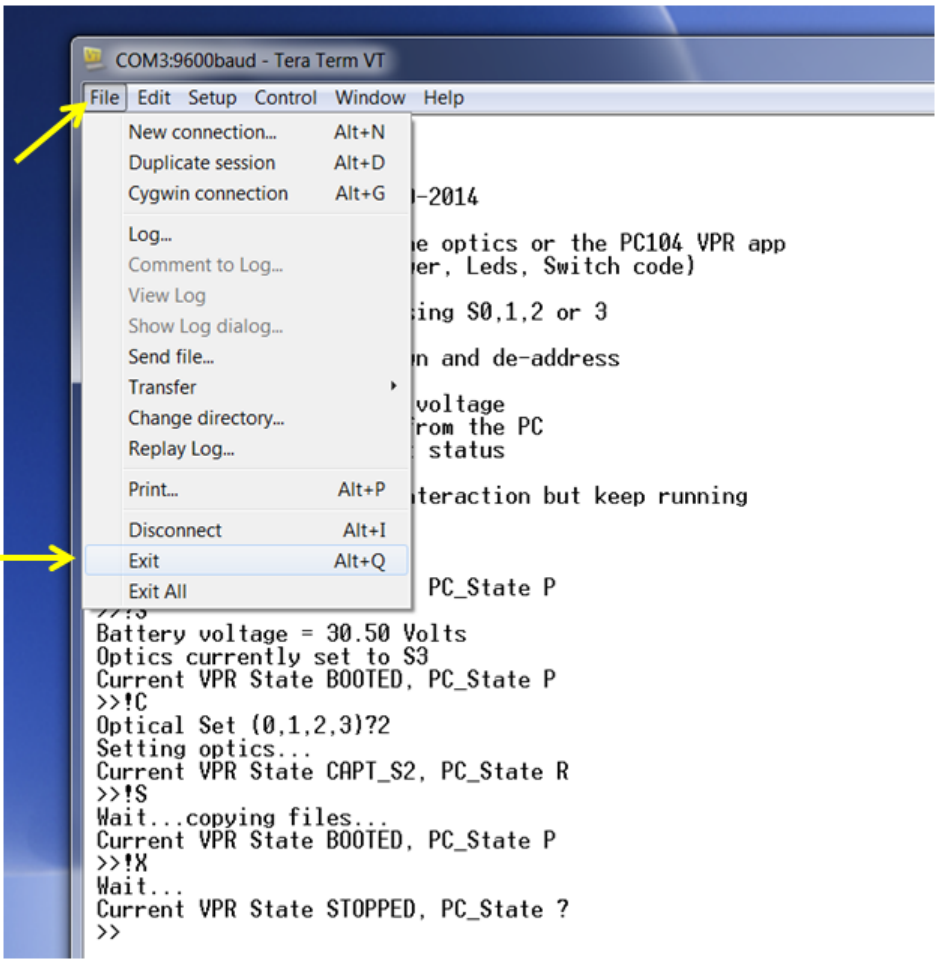


After choosing an optical setting, the system will move the camera, the iris and the focus to the predetermined position for that setting and field of view. This process may take up to a minute. Immediately after reaching the optical setting, the DAVPR system will start capturing images (the strobe light will start flickering). The real time images can be seen on the Remote Desktop.

>>!S(cr) will stop the image capture process

The user can then either change the optical setting:
>>!C(cr) will start the capture again
or:
>>!X(cr) will turn the DAVPR system off

Close the terminal emulator application by clicking on the File button and then the Exit button.



The Help Menu:

!P = **Passthru**: This command allows the user to access to the optical settings and the option to change these settings. These settings were set at Seascan and used for calibrating the DAVPR system. Changing these settings will affect the calibration.

!H = **Hardware Control**: This menu is used by Seascan for testing.

!B = **Boot**: This command boots the DAVPR computer. The computer must be booted in order to run the system using the terminal emulator commands or to use Remote Desktop.

!C = **Change Optical Setting**: This command allows the user to select the optical setting 0 for S0, 1 for S1, 2 for S2 and 3 for S3 and then automatically start the image capture process. The strobe ring light will turn on indicating that the process has started.

!S = **Stop Capture**: This command stops the image capture process. The strobe ring light will stop operating. Power is still applied to the camera, strobe, and DAVPR computer.

!X = **Quit**: This command turns off the DAVPR application software and powers down the system computer.

?B = **Battery Query**: This command returns the battery voltage. The DAVPR computer will shut down when the battery voltage is less than 26.5 VDC.

?D = **Data**: This command returns one data set from the MUX board in the DAVPR Electronics Housing. The user can use this command to query data remotely.

?S = **Status**: This command returns the battery voltage, the current optical setting, and state of the DAVPR computer.

APPENDIX H: DAVPR Literature

ASHJIAN, C. J., S. L. SMITH, C. N. FLAGG and N. IDRISI. 2002. Distribution, annual cycle, and vertical migration of acoustically derived biomass in the Arabian Sea during 1994-1995. *Deep Sea Research II* **49:** 2377-2402.

BENFIELD, M. C., C. S. DAVIS and S. M. GALLAGER. 2000. Estimating the in-situ orientation of *Calanus finmarchicus* on Georges Bank using the Video Plankton Recorder. *Plankton Biology and Ecology* **47:** 69-72.

CASSIE, R. M. 1959a. An experimentl study of factors inducing aggregation in marine plankton. *New Zealand Journal of Science* **2:** 339-365.

CASSIE, R. M. 1959b. Some correlations in replicate plankton samples. *New Zealand Journal of Science* **2:** 473-484.

CASSIE, R. 1960. Factors influencing the distribution pattern of plankton in the mixing zone between oceanic and harbour waters. *New Zealand Journal of Science* **3:** 26-50.

DAVIS, C. S., S. M. GALLAGER, M. S. BERMAN, L. R. HAURY and J. R. STRICKLER. 1992a. The Video Plankton Recorder (VPR): Design and initial results. *Archiv fur Hydrobiologie, Beihefte, Ergebnisse der Limnologie* **36:** 67-81.

DAVIS, C. S., S. M. GALLAGER, M. MARRA and W. K. STEWART. 1996. Rapid visualization of plankton abundance and taxonomic composition using the Video Plankton Recorder. *Deep-Sea Research II* **43:** 1947-1970.

DAVIS, C. S., S. M. GALLAGER and A. R. SOLOW. 1992b. Microaggregations of oceanic plankton observed by towed video microscopy. *Science* **257:** 230-232.

DAVIS, C. S., Q. HU, S. M. GALLAGER, X. TANG and C. J. ASHJIAN. 2004. Real-time observation of taxa-specific plankton distributions; an optical sampling method. *Marine Ecology Progress Series* **284:** 77-96.

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APPENDIX I: Licensing Terms

Jpeg-LS Library Licensing Terms

The image compression used in the DAVPR software calls a set of routines from the CharLS JPEG_LS library. This is an open source library with the following licensing terms:

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APPENDIX J: VPR User's Group

A Video Plankton Recorder user group exists of all the current owners of any version of the Digital Autonomous VPR or the Real Time VPR. This purpose of this open list serve is to provide a place for users to discuss issues or troubleshooting of both hardware and software with other VPR users.

To be added to the Video Plankton Recorder user support group, please contact Melissa Patrician (mpatrician@whoi.edu).

APPENDIX K: DAVPR Deployment Check List

Item	Description	
1	Is the clevis or shackle properly secured to the V-Fin tow point?	
2	Inspect the tow frame for any loose hardware; tighten if necessary	
3	Inspect the V-Fin for any loose hardware; tighten if necessary	
4	Are the batteries fully charged?	
5	Are the connectors on the Camera Housing end cap properly connected and are the locking sleeves secured?	
6	Is the purge plug on the Camera Housing properly secured?	
7	Are the connectors on the Strobe Housing end cap properly connected and are the locking sleeves secured?	
8	Is the purge plug on the Strobe Housing properly secured?	
9	Is the VPR Power Cable properly connected to the Battery Housing and are the locking sleeves secured?	
10	Is the connector on the Battery Housing end cap properly connected and is the plastic locking sleeves secured?	
11	Is the purge plug on the Battery Housing properly secured?	
12	Are the connectors on the Electronics Housing end cap properly connected and are locking sleeves secured?	
13	Are the rubber dummy plugs installed in the "COMMS" and "ETHERNET" connectors on the Electronics Housing end cap and are the plastic locking sleeves secured?	
14	Is the purge plug on the Electronics Housing properly secured?	
15	Are the connectors on any oceanographic instrument end cap(s) properly connected and are the locking sleeves secured?	
16	Are the connectors from the oceanographic instruments on the Electronics Housing end cap properly connected and are locking sleeves secured?	
17	Have the data on the Data Storage Cartridge been downloaded, backed up and deleted before this deployment?	
18	Is the Data Storage Cartridge properly installed and is the locking sleeve secured?	
19	Is all the cabling between housings and along the frame properly secured with cable ties?	
20	Is the cabling leaving the bulkhead connector have a generous bend radius and not stressed? Adjust if necessary.	
21	If the Battery Housing is connected, then the red LED should be continuously on indicating that the system has power - Is this true?	
22	Turn the Optical Setting Switch to BOOT. The green LED should be continuously on indicating that the system properly booted - Is this true? Turn the system OFF after verifying the "Boot".	
23	Are the clocks inside the DAVPR electronics and the desktop computer synchronized to Greenwich Mean Time (GMT)?	
24	Are the desktop computer, monitor & accessories securely tied down?	

25	Do you have the User Interface Ethernet Cable Assembly?	
26	Do you have the User Interface Comms Cable Assembly?	
27	Do you have the Data Cartridge Drive Cable Assembly?	
28	Do you have the Battery Charger and its power cord?	
29	Do you have the spare battery pack?	
30	Do you have a spare Data Storage Cartridge?	
31	Do you have an Ethernet hub?	
32	Do you have a RS232 to USB adapter?	
33	Do you have the USB Dongle with the JpegLS_Adeck License for the desktop computer?	
34	Did you set up the desktop computer and run the JpegLS_Adeck program?	
35	Do you have a spare(s) USB hard drive for data storage?	