Slocum G3S Glider

Maintenance Manual

P/N M313476-NFC, Rev. A

TELEDYNE MARINE
WEBB RESEARCH
Everywhereyoulook™

Teledyne Webb Research
49 Edgerton Drive
North Falmouth, MA 02556
U.S.A.
Tel: (508) 548-2077
Fax: (508) 540-1686

https://www.teledynemarine.com/webb-research

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Revision History

Revision	Description	Author	Approval	Date
A	• Initial Release.	JCC	SQ	7/18/2025

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Preface

This manual provides information required to transport, set up, and maintain the Teledyne Webb Research Slocum G3S Glider. Use this publication in conjunction with the *Slocum G3S Glider Operator Manual* [P/N M311172-NFC].

Conventions Used in This Publication

Where applicable, safety information is presented as follows:

WARNING

Identifies a potential hazard that could result in injury or death to the operator or to other personnel.

CAUTION

Identifies a potential hazard that could result in damage to equipment or loss of data.

Note

Identifies information of particular interest the reader must be aware of.

Tip

Identifies information the reader might find helpful to: achieve better results, be aware of how an action affects the system, or work more efficiently.

Menu Options and Paths

Menu options are in bold type. Rather than writing out "From the **Admin** menu, select **User Administration**, then select **Users**," angle brackets are used to show the next menu level down or menu option:

Select **Admin > User Administration > Users**.

File Types and Extensions

File names are written as `file.typ`, where **`file`** is the descriptor and **`typ`** is the extension.

- When the text mentions a specific file name, it is written as `file.txt` or something similar.
- When the text mentions file types in general, it is written using the extension in all caps without the period before it; for example, `INI` files or `XML` files.

Typographical Conventions

Font	Description
Bold	The name of a folder, node, path, menu option, icon, or command button that acts like a menu option or command (Open, Save, etc.).
Italic	The name of a window, page, tab, dialog box, panel, area, field, button, or drop-down list within the software interface.
[blue square brackets]	A physical key on the computer's keyboard or device's keypad.
`Monospace` `Monospace & yellow`	A system value or text displayed by the screen or computer.
`Monospace Bold` **`Monospace Bold & green`**	A user value or text the user enters.

Manual Revision Notice

This publication could be out-of-date. Always confirm you are working with the latest revision of the guide. To verify this guide is the most current, contact glidersupport@teledyne.com.

Protected Documents

Protected documents are accessible by user account through Glider Support.

Many links and the code mentioned in this manual require access by prior arrangement. Please contact glidersupport@teledyne.com to inquire about access to these protected documents.

Other Manuals

The G3S glider is supported by multiple documents.

- The *G3S Glider Maintenance Guide* (this publication) focuses on the hardware and how to assemble and disassemble the vehicle and Lowest Replaceable Units (LRUs); e.g., a GPS board.
- The *G3S Glider Operator Manual* [`P/N M311172-NFC`] outlines the glider's functionality and piloting.
- The *SFMC User Manual* [`P/N M313476-NFC`] to explain the Dock Server interface and piloting tools.
- The *G3S Glider Training Slides* serves as a reference during Slocum glider training sessions.
- The glider spreadsheets that were explained during training

Note

Before operating a glider, it is recommend that all personnel who pilot or work with the gliders:

- Participate in a TWR-hosted training class
- Become familiar with the material in all these documents

This manual and other materials can be attained by contacting glidersupport@teledyne.com.

Customer Service

We welcome your comments and suggestions for improving our products and documentation as well as developing better ways of serving you. Should you require service or support for a Slocum glider, contact Teledyne Webb Research customer service using any of the following means:

TELEDYNE WEBB RESEARCH
Attention: Customer Service
49 Edgerton Drive
North Falmouth, MA 02556
U.S.A.

Telephone: (508) 548-2077
Fax: (508) 540-1686

E-mail: webbresearch@teledyne.com

https://www.teledynemarine.com/webb-research

E-mail: glidersupport@teledyne.com

https://www.teledynemarine.com/en-us/support/Pages/Webb-Research.aspx

1 Warnings and Precautions

Read through everything in this chapter.

1.1 Electrical Shock

The following always apply:

WARNING

Always shut off the system power before beginning work on equipment.

WARNING

Do not come into contact with electrical connectors. Do not be misled by low voltage. Low potentials can also be dangerous.

WARNING

Do not work alone on electrical equipment. Be sure another person is nearby who can give first aid.

1.2 Heavy Objects

WARNING

Some objects covered in this manual are heavy and need two people to lift them. Muscle strain can occur while loading or unloading the glider and cart.

1.3 Heavy Parts

WARNING

A glider in a crate may pose a crushing hazard.

1.4 Pinch Points

WARNING

When gliders are assembled and disassembled, certain parts may cause a pinch hazard. Be aware of moving parts that may cause a pinch hazard while locking or unlocking the glider and cart and while disassembling and assembling the glider.

1.5 Hazardous Material Warnings and Safety Precautions

Warnings about using and coming into contact with hazardous materials are included throughout this manual. These warnings are designated as shown in the format below. The types of hazardous material warnings that are included in this manual are described below.

WARNING

When working with the following materials, wear the appropriate personal protective equipment (PPE):

- Chemical warnings indicate that the material will cause burns or irritation to human skin or tissue.
- Vapor warnings indicate that vapors from a material can be dangerous to life or health.
- Fire warnings indicate that a material may ignite and cause burns.
- Eye protection warnings indicate that a material will injure the eyes.

For more details, see the specific product(s) you are working with in Table 1-1.

Personnel working with the G3S system may come into contact with hazardous materials. Safety precautions and warnings for these hazardous materials are described in Table 1-1.

Table 1-1: Safety Precautions and Warnings for Hazardous Materials (1 of 3)

Product Name	Safety Precautions and Warnings
Alkaline Batteries	If the glider contains alkaline batteries, there is a small but finite possibility that batteries of alkaline cells will release a combustible gas mixture—especially if the batteries are exposed to water or sea water and/or shorted. This gas release generally is not evident when batteries are exposed to the atmosphere, as the gases are dispersed and diluted to a safe level. When the batteries are confined in a sealed instrument, the gases can accumulate and an explosion is possible. Teledyne Webb Research has added a catalyst inside the glider to recombine hydrogen and oxygen into water, and the glider has been designed to relieve excessive internal pressure buildup by having the hull sections separate under internal pressure. Teledyne Webb Research knows of no way to completely eliminate this hazard. The user is warned, and must accept and deal with this risk in order to use this instrument safely as so provided. Personnel with knowledge and training to deal with this risk should seal or operate the instrument.
AquaShield	• Avoid contact with skin, eyes, and clothing. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors or spray mist. Ensure adequate ventilation. • AquaShield 36 X8 may be harmful if swallowed. • Keep people away from and upwind of the spill and/or leak. • Use personal protective equipment. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.

Table 1-1: Safety Precautions and Warnings for Hazardous Materials (2 of 3)

Product Name	Safety Precautions and Warnings
CSC Lithium Battery	• Remove jewelry before handling lithium batteries. • Avoid contact with skin, eyes, and clothing. Wear the appropriate PPE—eye protection and chemical resistant gloves—while handling lithium batteries. • Do not breathe vapors or spray mist. Ensure adequate ventilation. • Sulfuric acid can form if lithium batteries come in contact with water. • Keep people away from and upwind of the spill and/or leak. • If ingested, drink copious amounts of water (or milk, if available). Do not induce vomiting. • Never give anything by mouth to an unconscious person. Immediately seek medical attention. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when working with batteries. For more information about handling and working safely with lithium batteries, see the following documents: • Electrochem's product data sheet for lithium sulfur chloride cell batteries at http://www.electrochemsolutions.com/pdf/high-rate/csc93/3B0030Datasheet.pdf. • Electrochem's material safety data sheet (MSDS) for lithium sulfuryl chloride cells and batteries at http://www.electrochemsolutions.com/pdf/CSC_PMX_MSDS.pdf. • *Primary Lithium Battery Safety and Handling Guidelines* at http:// www.electrochemsolutions.com/pdf/ Safety_and_Handling_Guide.pdf.
Dielectric Grease	• Avoid contact with skin and eyes. Wear the appropriate PPE— eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors or spray mist. Ingestion may cause slight stomach irritation and discomfort. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvents are used for cleaning.
Drakeol 9 Light Mineral Oil (LT MIN OIL)	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors or spray mist. Ingestion may cause lung inflammation and damage. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvents are used for cleaning.
Loctite 2440	• Avoid contact with skin and eyes. Wear the appropriate PPE— eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors. Loctite 2440 may cause respiratory tract irritation. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.
Loctite 262	• Avoid contact with skin and eyes. Wear the appropriate PPE— eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors. Loctite 262 may cause respiratory tract irritation. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.

Table 1-1: Safety Precautions and Warnings for Hazardous Materials (3 of 3)

Product Name	Safety Precautions and Warnings
Loctite 567 Pipe Sealant	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors. Loctite 567 may cause respiratory tract irritation. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.
NatraSorb S	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Ingestion is unlikely, but if ingested, blockage may occur. Get medical attention.
Parker O-Lube	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • If ingested, immediately drink two glasses of water, induce vomiting, and seek medical attention. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.
Parker Super-O-Lube	• Avoid contact with skin and eyes. Wear the appropriate PPE— eye protection and chemical resistant gloves—while using this product. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.
Royal Purple Hydraulic Oil	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.
Sea-Bird Anti-Foulant Device (AF24173)	• Avoid contact with skin and eyes. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product. • Do not breathe vapors. AF24173 may cause respiratory tract irritation. Ensure adequate ventilation. • Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used for cleaning.

1.6 General Safety and Handling Precautions

General safety and handling precautions that will help avoid personal injury as well as damage to the glider include the following:

- Only trained and authorized personnel should handle the glider.
- Internal maintenance must be performed only by trained and authorized personnel.
- Only trained and authorized personnel should be permitted to operate/deploy the glider.
- Ensure that the glider is powered down properly before removing the green plug.
- Rinse the glider with fresh water after exposure to salt water.
- Never apply greater than 15 volts with a power supply.
- The internal electronics of the glider is sensitive to electrostatic discharge (ESD). Proper precautions must be used at all times when handling any of the glider's electronic components.
- Never connect or disconnect any electrical connections while the system power is on, as damage to electronics could occur.

- Always refer to this publication before and during any maintenance operations.
- Always refer to the Operator Manual for the glider before and during deployment operations.
- When Teledyne Impulse connections are mated, care to the alignment of pins and proper seating of the connector should be taken.
- Carbon fiber hulls should be handled carefully. The O-ring sealing surfaces should be inspected for scratches and defects that could lead to a leak.
- O-rings should be inspected for cleanliness, nicks, and slices. O-ring surfaces should also be inspected for scratches, dents, and cleanliness.

  Parker Fibrous O-Lube 884-4 (Petroleum Naphthenic Oil and Barium Soap) is recommended. Wear the appropriate PPE—eye protection and chemical resistant gloves—while using this product.

- Minor scratches to paint and anodizing should be touched up with automotive paint or nail polish.
- Rinse the pressure transducer thoroughly with fresh water after each saltwater deployment.
- The internal electronics of this equipment are sensitive to electrostatic discharge (ESD) and proper precautions must be adhered to when handling any electrical components of the system.
- Never power a shallow glider without a vacuum.
- Never run a simulation on a glider other than `on_bench`.
- Never deploy a glider in simulation.
- Never deploy a glider in `boot shell`.
- Never exit to `shell` during a deployment.
- Never deploy a glider in `lab_mode`.
- Never perform the top of a yo below 30 meters (with 100- or 200-meter pumps).
- Never secure the glider to the glider cart while the cart is not secure or over the railing or in the water.
- Always observe warnings at all times.
- Always secure the glider properly in crate with all the straps for shipping.
- Significant damage to equipment can occur if it is not properly secured. This is true at all times, in the lab, during transportation and while being deployed.

  Use the glider cart during maintenance. When parts are removed from the cart, take caution to secure the cylindrical pieces because they can roll off surfaces.

- Always use fresh desiccants for each deployment.
- Always monitor internal vacuum before launch (less vacuum indicates a leak; positive pressure may indicate dangerous gas accumulation). The vacuum will fluctuate with temperature.
- Always simulate missions before launch.
- Always test Iridium and Argos telemetry before launch.
- To care for dummy and green plugs, use O-Lube lubrication or silicone spray and keep contact pins clean.
- The ejection weight can come out with moderate force (do not stand behind and activate).

1.7 Storage Conditions

For optimum battery life, the storage temperature range is +10° to +25° C.

When activated, the glider should be equilibrated at a temperature between -2° and +54°C.

1.8 Lifting the Glider

Lifting the glider is a two-man operation. When in the laboratory, it is generally easier to lift the glider while it is strapped to the cart. One person should lift the glider at the forward end and another at the aft end. Please note the glider is heavier at the forward end.

Be sure to follow proper lifting procedures:

- **Plan before you lift** — You and your lifting partner need to know what you are doing and where you are going to prevent any awkward movements. Also make sure your path is clear.
- **Lift the glider close to your body** — You have more strength when you lift close to your body than when you lift at arm's reach. Make sure you have a firm grip on the glider, and keep it balanced close to your body.
- Keep your feet shoulder width apart to improve your support and balance. Take short steps while moving the glider.
- Bend with your knees, and keep your back straight.
- Tighten your stomach muscles while you are lifting the glider. Tight abdominal muscles hold your back in a good lifting position and prevent excessive force on the spine.
- Lift the glider with your legs. Your leg muscles are much stronger than your back muscles.

  Also lower the glider with your legs when you are finished moving it. While you are lifting, keep your eyes focused upward so that your back remains straight.
- Wear a belt or back support to maintain a better lifting posture.

1.9 Science Sensor Handling

Each manufacturer's recommendation for service and care should be followed. Some sensors, especially those protruding, may need special handling during deployment, recovery and shipping to prevent damage.

Individual sensors may have special needs. See manufacturer's recommendations.

1.10 O-ring Maintenance

Following is an excerpt from the *Parker O-Ring Handbook*. This handbook is available for download at:

http://www.parker.com/literature/ORD%205700%20Parker_O-Ring_Handbook.pdf

1.10.1 Cleanliness

Cleanliness is vitally important to ensure proper sealing action and long O-ring life. Every precaution must be taken to ensure that all component parts are clean at time of assembly. Foreign particles—dust, dirt, metal chips, grit, etc.—in the gland may cause leakage and can damage the O-ring, reducing its life.

1.10.2 Assembly

Assembly must be done with great care so that the O-ring is properly placed in the groove and is not damaged as the gland assembly is closed. Some of the more important design features to ensure this are:

1. The inside diameter stretch, as installed in the groove, should not be more than 5%. Excessive stretch will shorten the life of most O-ring materials.
2. The inside diameter expansion needed to reach the groove during assembly ordinarily does not exceed 25–50% and should not exceed 50% of the ultimate elongation of the chosen compound.

   However, for small diameter O-rings, it may be necessary to exceed this rule of thumb. If so, sufficient time should be allowed for the O-ring to return to its normal diameter before closing the gland assembly.
3. The O-ring should not be twisted. Twisting during installation will most readily occur with O-rings having a large ratio of inside diameter to cross-section diameter.

1.10.3 Surface Finishes

All mating surfaces for the O-ring must also be regularly inspected and cared for to maintain the finish and ensure a proper seal.

1.11 External Ballast Adjustment

G3S gliders are equipped with external ballast in four locations: the buoyancy pump, the port and starboard wing rails, and the tail cowling.

All of the external ballast weights are of the same form factor and weigh approximately 13 grams in water.

The aft weight holder can be populated with up to 9 weights, each wing rail,10 weights, and the forward section, 16 weights.

The default configuration is to half populate each section, maximizing the capability to adjust buoyancy in the field. This leaves some ±220 grams of adjustability which equates to ±3.3s density variation in a standard length glider (i.e., ±0.194s/weight).

Due to their small size, the external ballast weights will have negligible effects on vehicle pitch, roll and H-moment (stability).

External ballast weight pockets should be configured to half-populated during ballasting; this maximizes flexibility in the field. Weights may be pressed into desired pockets and removed using a small screw driver, hex key, etc.

To gain access to the:

- **Wing rail weights** — Remove the 5/32-inch socket head cap screws securing the fore and aft of the wing rails.
- **Aft weight holder** — Deflate the air bladder and remove the tail cowling by loosening and removing the socket head cap screws securing the aft cowling.
- **Buoyancy pump weight pockets** — Remove the four 7/64-inch socket head cap screws securing the sonar nose dome (or peek nut for recovery strobe dome models).

External ballast weights should be stored dry and rinsed with fresh water after exposure to salt water.

If possible, plan operations for a vehicle maximizing the use of autoballast and external ballast so as to minimize the number of times that you need to open the vehicle to adjust ballast.

1.12 Main Hull Double O-ring Seals

CAUTION

Debris and damage to sealing surfaces can result in a leak which can incapacitate or cause the loss of the glider. It is critical that sealing surfaces remain clear of debris and that no sharp edges or tools are used.

Damage to the hull sealing surface or the O-ring grooves must be repaired and the glider pressure tested before it is operational ready.

One of the enhancements with the G3S Glider is that all hull sealing surfaces use two O-rings. By increasing the sealing surface area, G3S gliders have a reduced possibility of a leak occurring on a hull sealing surface.

Note

The additional O-ring resulted in the Carbon fiber hulls needing to increase in length by 0.5" from that of the G2 glider.

This change increased the total vehicle displacement for a standard configuration G3S to 57.7 liters. The internal tie rod was lengthened and G2 hulls will not fit on G3S gliders.

The O-ring part number for a double seal application is 304697. The lubricant used is Parker O-Lube 884-2.

The same procedures used for the G2 glider are used for G3S lubrication of the O-rings and hull sealing surfaces (3135-LUBE), available by request from glidersupport@teledyne.com.

The O-rings and their surfaces should be inspected, and the O-rings should be replaced, if necessary, before each glider deployment.

1.13 Comms Port

Note

The shell that screws in and holds the comms connector in place must be present and firmly seated before deployment. This shell needs to be removed to remove or install the aft cowling.

1.14 Power Port

CAUTION

Operators should be aware of the new BMS board and that the G3S glider must be powered down properly. The BMS board requires that the glider be properly commanded to power off, and the operator must wait for the "safe to remove power" message.

Failure to properly shut down will result in the BMS board emitting a tone and ultimately in the emergency circuit becoming active. If powered down incorrectly, the glider should be powered up and then powered down properly.

Note

The shell that screws in and holds the power connector in place must be present and firmly seated before deployment. This shell needs to be removed to remove or install the aft cowling.

The G3S port can be used with a 6-pin green shorting plug (300128 Shorting plug) to activate the batteries and power the glider for deployment. This port can also be used for shore power. When using shore power, do not exceed 16 volts.

Part I: Lab Level Maintenance

WARNING

Do not perform the following procedures in the field. Disassembly and reassembly must be performed in a lab setting.

2 Disassemble the Glider

2.1 Requirements

Tools:	Start-up Kit (P/N ASSY 300652)
Materials and parts:	Glider (200 or 1000 meters)
Personnel required:	2 electronics technicians

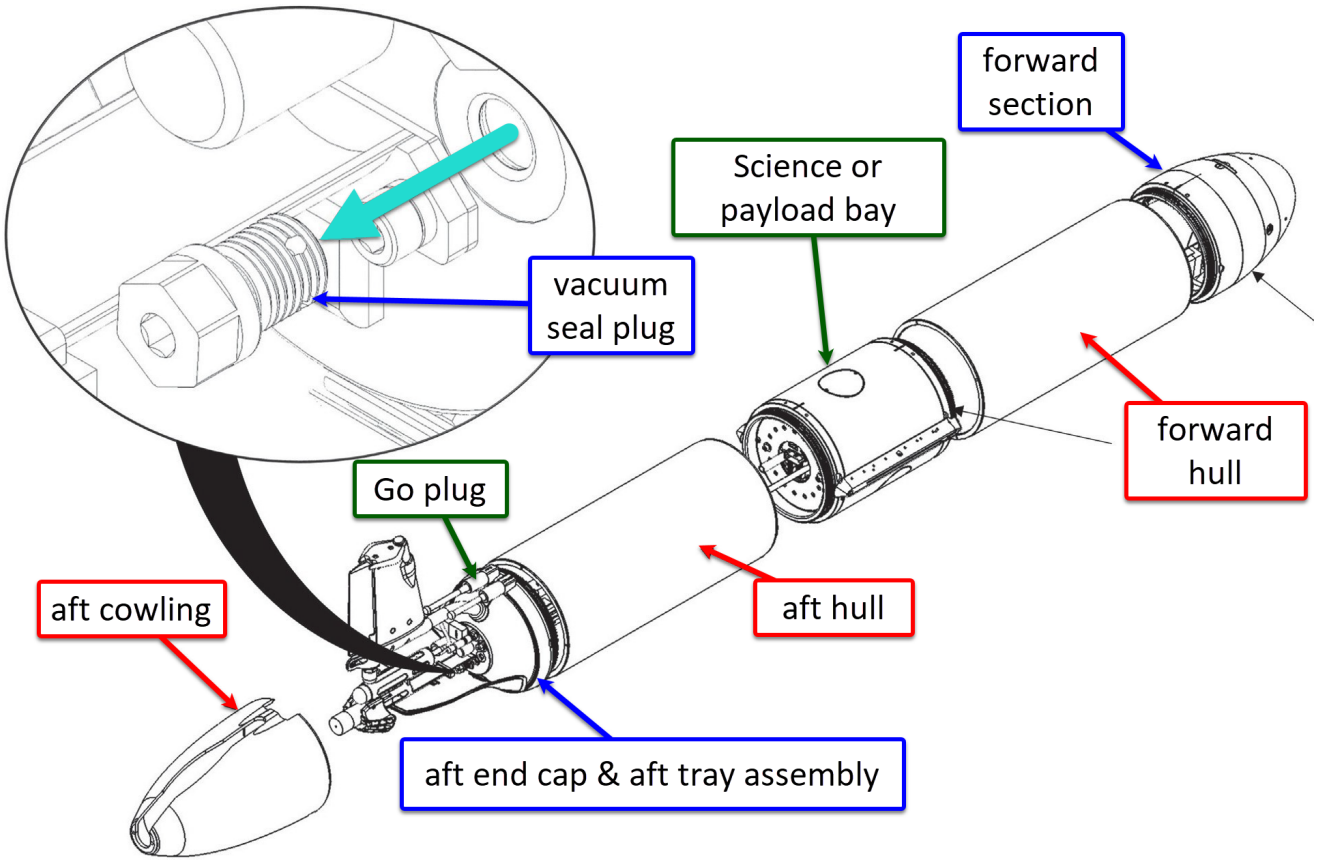

Figure 2-1: G3S Glider disassembly

NOTE: Text references to items called out in Figure 2-1 are surrounded by square brackets and colored to match Figure 2-1.

2.2 Procedure

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

CAUTION

The air bladder must be deflated before the glider can be disassembled. From the GliderDOS prompt, type: **`put c_air_pump 0`** to deflate the air bladder.

CAUTION

The retaining shells, which are new with the G3S glider along with the comms and power port plug on the top end cap, must be removed to remove the tail cone.

CAUTION

The user must issue the **`exit`** command to the glider from a terminal and be instructed by the glider that it is OK to remove power before the Go plug (green) or external power can be removed. Failure to do so may result in corruption of the file system that will render the glider inoperable.

Failure to properly shut down will result in the BMS board emitting a tone and ultimately in the emergency circuit becoming active.

CAUTION

The G2 and G3S O-rings are not interchangeable. G2 O-rings are larger than the G3S O-rings and will not close in a G3S glider. The O-ring part number for:

- **G2** is G-024
- **G3S** is 304697

Referencing Figure 2-1, perform the following steps:

1. When the glider is properly shut down, ensure the power to the glider is OFF:
   a. Remove the GREEN Go plug on the aft end cap.
   b. Replace it with the RED Stop plug.
2. Remove the aft cowling:
   a. Remove the two 10-32 socket head cap screws and washers using the $^{5}/_{32}$" x 12" red T-handle hex wrench.
   b. Remove the two shells from the power and comms connectors at the top of the aft end cap.
   c. Grasp the aft cowling and pull it aft to separate it from the aft end cap.
   d. Gently spread the top of the cowling to allow it to slide off around the fin.

3. Remove the 7/16 x 20 PolyEther Ether Ketone (PEEK) military standard (MS) vacuum seal plug using the:
   - 15 inch-pound torque T-handle
   - 24" extension
   - $^{3}/_{16}$" hex bit

CAUTION

Take care not to damage the seal area or the threads with the side of the tool assembly.

Note

Each hull section can be separated by several inches to access the inside of the vehicle. If you need greater access, disconnect the wiring from and to the payload bay or payload section.

Note

Some legacy gliders may not have the "half moon" cutouts on the aft end cap. If not present, the aft end cap/aft tray assembly may be separated from the aft hull by grasping the tail fin or tail fin tube and gently moving the aft end cap up and down to separate it from the hull.

4. Using the same tool assembly:
   a. Insert the $^{3}/_{16}$" hex bit into the vacuum seal port and engage the tie rod end.
   b. Unscrew the tie rod until tension is felt.
   c. Separate the aft end cap/aft tray assembly from the aft hull using the hull separator tool.
5. Unscrew the tie rod until it disengages from the tie rod receiver in either the:
   - forward section –or–
   - add-on module
6. Using the hull separator tool, separate the aft hull from the payload bay aft stiffener ring.
7. Slide the aft hull and aft end cap/aft tray assembly aft about three inches.

Note

There may be other connectors that are specific to your glider. Disconnect these as appropriate.

8. Disconnect the battery and payload bay wiring from the aft tray assembly.
9. Remove the aft end cap and tray assembly. Set it aside in a cradle or other secure receiver.
10. If lithium batteries are installed:
    a. Remove the two pins securing the battery to the battery mounting bracket on the aft payload by the guard plate.
    b. Carefully remove the aft battery and set it aside in a secure location.
11. If alkaline batteries are installed:
    a. Remove the two $^{1}/_{4}$-20 socket head cap screws and washers that secure the battery to the battery mounting posts on the aft science bay stiffener ring.
    b. Carefully remove the aft battery and set it aside in a secure location.
12. Remove the aft hull and set it aside. Be careful not to damage the hull.

13. Concerning an energy bay or other add-on module:
    - If one is installed, proceed to "2.2.1 If Add-on Module Installed."
    - If not, proceed to "2.2.2 If No Add-on Module Installed" on page 2-4.

2.2.1 If Add-on Module Installed

14. Using the hull separator tool, separate the payload bay from the add-on module.

Note

There may be other connectors that are specific to the glider. Disconnect these as appropriate.

15. Slide the payload bay back about three inches. Disconnect the wiring to separate the payload bay.
16. Remove the payload bay and set it aside.
17. Assemble a tie rod tool:
    - 15 inch-pound torque T-handle
    - $^{5}/_{32}$" hex bit
18. Using the tool, insert the bit into the tie rod receiver of the add-on module.
19. Unscrew the mini tie rod between the add-on module and the forward section.

Note

Some gliders may not have the "half moon" cutouts on the add-on module. If not present, the add-on module may be separated from the forward section by grasping the add-on module hull and gently moving the module up and down to separate it from the hull.

20. Using the hull separator tool, separate the add-on module from the forward section.
21. Slide the add-on module back about three inches.

Note

There may be other connectors that are specific to the glider. Disconnect these as appropriate.

22. If using lithium batteries, disconnect the battery enable connector.
23. Remove the add-on module and set it aside.
24. Proceed to "2.2.3 Final Steps."

2.2.2 If No Add-on Module Installed

25. Using the hull separator tool, separate the payload bay from the forward hull.
26. Slide the payload bay back about three inches.

Note

There may be other connectors that are specific to the glider. Disconnect these as appropriate.

27. If using lithium batteries, disconnect the battery enable connector.
28. Remove the payload bay and set it aside.
29. Proceed to "2.2.3 Final Steps."

2.2.3 Final Steps

30. Insert the $^{5}/_{32}$" x 12" red T-handle hex wrench into the battery mount shoulder screw and unscrew the pitch battery from the forward section.
31. Carefully slide the pitch battery out of the forward section and set it aside.
32. Using the hull separator tool, separate the forward hull from the forward section. Slide the hull aft and carefully remove it and set it aside.
33. The glider sections can now be re-assembled on the glider cart (without the forward and aft hulls and main batteries) for service.

3 Lube the Hull Seams

This chapter explains how to properly lube the hulls of a glider before assembling the glider. This chapter shows:

- The correct amount of lube to apply to the hulls.
- How to spread lube evenly along the hull's O-ring sealing surfaces.
- How to check if the steps were followed correctly.

3.1 Requirements

Tools:	Lint-Free Alcohol Wipes Lint-Free Kimwipes Parker O-ring Lube G-1643
Materials and parts:	Hull sections Hull O-rings
Personnel required:	1 electronics technician

CAUTION

Lubing the hulls must be done just prior to closing the glider for testing or shipment.

A lubed hull should not be left out/unattached for more than a few minutes—the lube traps dust and aerial debris that can cause paths for leaks.

1. Clean the diameter of the hull with a Lint-Free Alcohol Wipes.
   Clean the diameter to approximately 1" deep into the hull, as shown in Figure 3-1:

Figure 3-1: Clean 1" deep into hull

2. Apply an approximately $^{3}/_{8}$" diameter bead of Parker O-ring lube G-1643 on a clean fingertip, as shown in Figure 3-2:

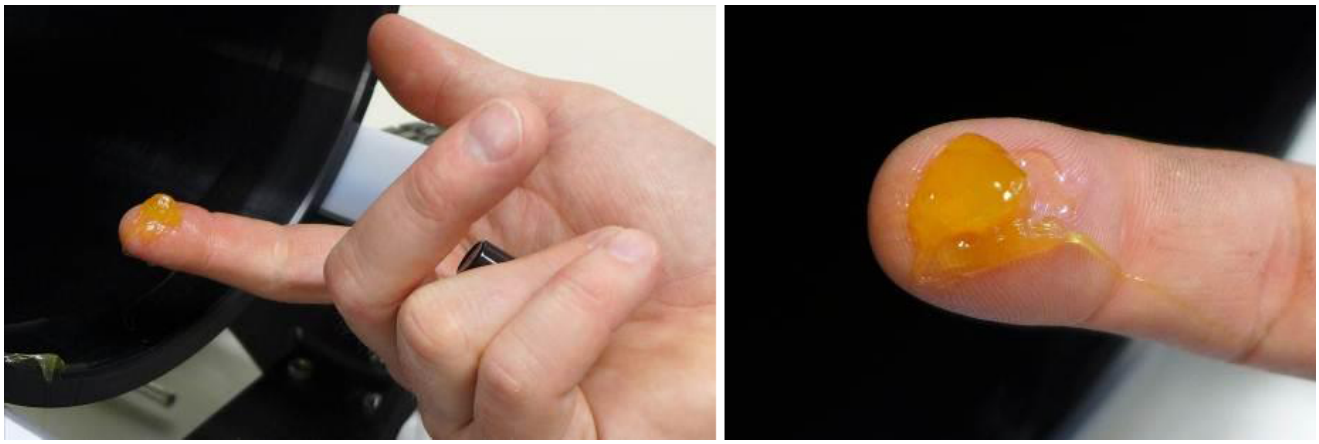

Figure 3-2: Applying lube

3. Spread the bead around the diameter of the hull.
4. Repeat 2 or 3 times as needed to get an even layer onto the hull, as shown in Figure 3-3:

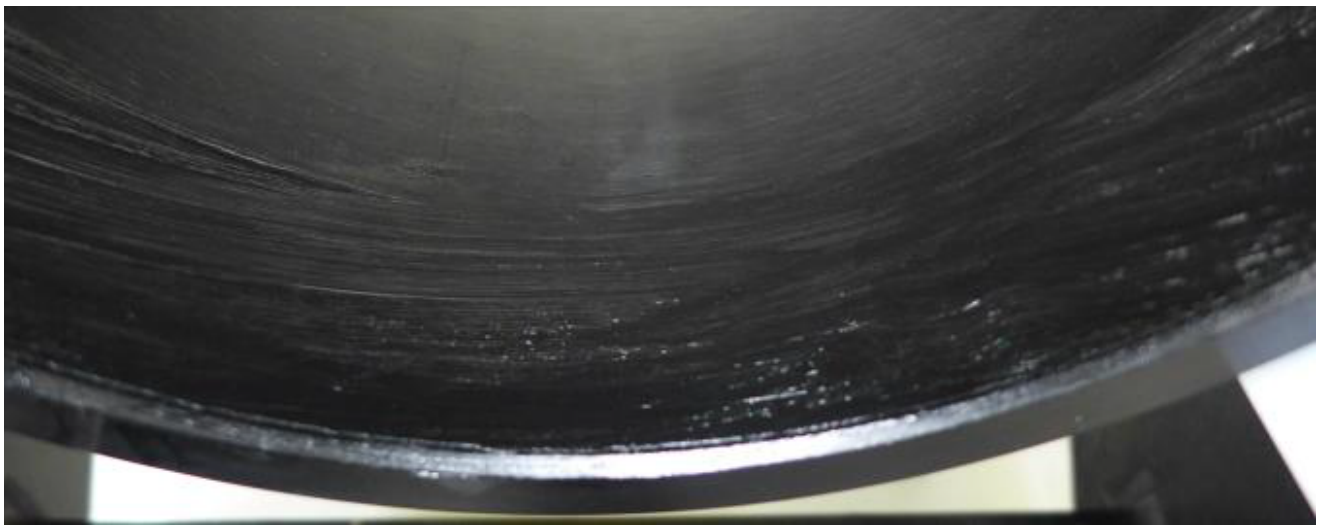

Figure 3-3: Even layer of lube

5. Use a Lint-Free Kimwipe to remove any excess lube from the hull, as shown in Figure 3-4:

Figure 3-4: Remove excess lube

The lube is considered evenly spread when a finger print passes the “Lube Test”: a finger print can be left in the lube without the lube stringing to the finger when the finger is removed.

Figure 3-5 shows an example of a Lube Test failure:

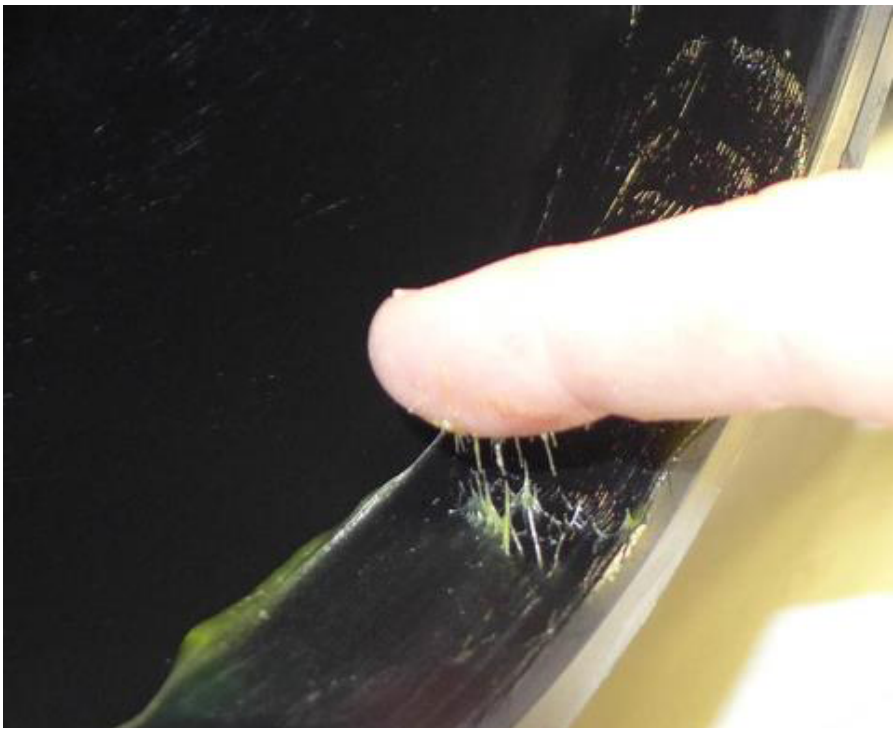

Figure 3-5: Lube Test – Too much lube

6. Spread the lube as needed to pass the finger print test, as shown in Figure 3-6:

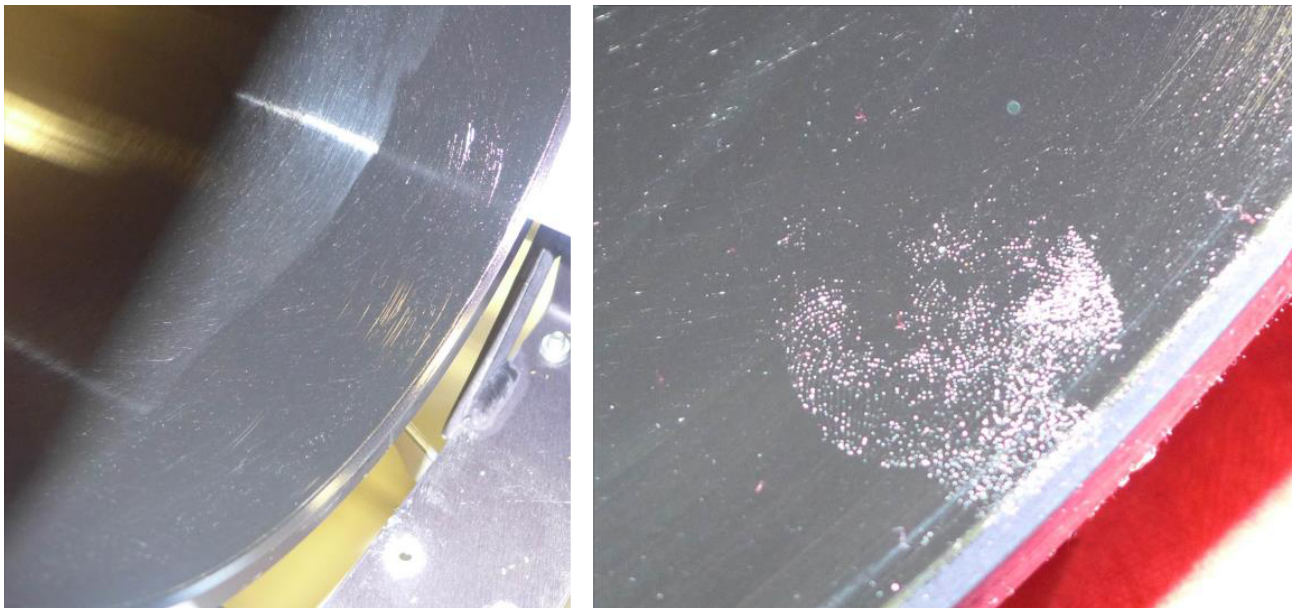

Figure 3-6: Lube Test – Proper amount of lube

4 Re-assemble the Glider

4.1 Requirements

Tools:	Start-up Kit (P/N ASSY 300652)
Materials and parts:	Glider (200 or 1000 meters)
Personnel required:	2 electronics technicians

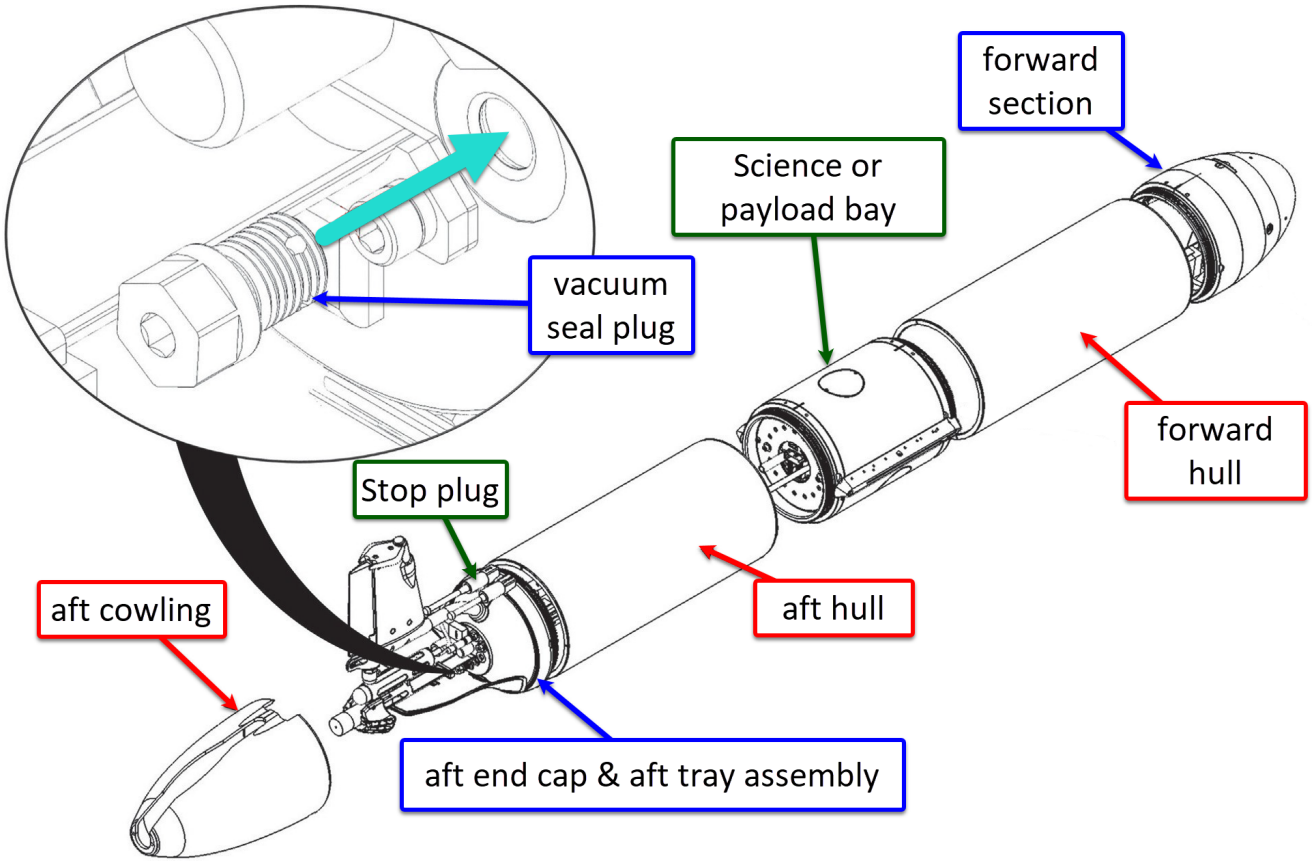

Figure 4-1: G3S Glider re-assembly

NOTE: Text references to items called out in Figure 4-1 are surrounded by square brackets and colored to match Figure 4-1.

4.2 Procedure

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

CAUTION

If you also have a G2 glider, be aware that the G2 and G3S O-rings are ***not*** interchangeable.

G2 O-rings [P/N G-024] are larger than the G3S O-rings [P/N 304697] and will not allow a G3S glider to close.

CAUTION

If assembling the glider for the final time before deployment, a careful visual inspection should be performed on all internal components. Inspection check lists can be provided on request.

CAUTION

When the glider is sealed for the final time before a deployment, a full functional test of the glider system must be performed. Contact Glider Support at glidersupport@teledyne.com for a copy of the test procedure.

Note

The hull sections must be aligned parallel and at the same height to allow them to fit together. It is recommended that this work be done on the glider cart.

Referencing Figure 4-1, perform the following steps:

1. Ensure that:
   - Power is not applied to the vehicle.
   - The RED Stop plug is installed on the aft end cap.
2. Place the glider cart on a flat, level surface.
3. Lower or remove the nose ring.
4. Place the forward hull on the cart, ensuring the orientation is correct.

   The SLOCUM G3S labels should be forward on the port and starboard sides.

   Refer to Chapter 3, "Lube the Hull Seams" for lubricating the hull seams.
5. Clean and inspect the double O-ring sealing surfaces of the forward hull, ensuring there are no scratches or other damage that could cause O-ring failure.
6. Clean and inspect the forward section O-ring and O-ring groove.
7. Re-lubricate the O-ring—or replace it, if necessary.
8. Carefully insert the forward section into the forward hull, being careful not to scratch or damage the interior of the hull—particularly the area near the ends where the O-rings seat.
9. Align the index marks on the forward hull and forward section.
10. Press the forward section into the hull, ensuring the O-rings do not get pinched or damaged.
11. Place a drop of Loctite 243 (blue) on the pitch battery mounting screw.
12. Carefully insert the pitch battery into the open end of the forward hull. It is important that you ensure you:
    - Feed the forward cable harness and connectors through the center opening of the battery
    - Do not damage the interior of the hull

13. Secure the pitch battery to the forward section:
    - Tighten the pitch battery mounting screw with the $^{5}/_{32}$" x 12" red T-handle hex wrench.
14. If lithium batteries are installed, connect the battery enable connector JH133 from the LI EM BAT connector on the forward harness (see Figure 9-1 on page 9-2 and Figure 9-3 on page 9-3).

CAUTION

Take care when mating connectors; the pins are delicate.

15. Concerning an energy bay or other add-on module:
    - If one is installed, proceed to "4.2.1 If Another Add-on Module Is Installed."
    - If not, proceed to "4.2.2 If No Add-on Module Is Installed" on page 4-3.

4.2.1 If Another Add-on Module Is Installed

16. Clean and inspect the add-on module O-rings and O-ring grooves and re-lubricate or replace as necessary.
17. Place the add-on module on the glider cart aft of the assembled forward section.

Note

There may be other connectors that are specific to the glider. Connect these as appropriate.

18. Make the connections from the forward section wiring harness and from the pitch battery to mating connectors on the add-on module forward guard plate. Ensure that the battery cable can move freely, as it must flex as the pitch battery moves.

Note

Always visually confirm that no internal wires or other obstructions will prevent glider sections from being drawn together properly while sealing.

19. Align the index marks on the add-on module and the forward hull.
20. Using the 15 inch-pound torque T-handle and $^{5}/_{32}$" hex bit, close the two sections. Make sure the O-rings do not get pinched or damaged.

4.2.2 If No Add-on Module Is Installed

21. Clean and inspect the payload bay forward and aft O-rings and O-ring grooves and re-lubricate or replace them as necessary.
22. Place the payload bay on the glider cart aft of the forward hull and, if present, the add-on module.

Note

If an add-on module is installed, the connectors are labeled.

Note

There may be other connectors that are specific to the glider. Connect these as appropriate.

23. Make the connections from the forward section wiring harness and from the pitch battery to mating connectors on the payload bay forward guard plate.
24. Slide the payload bay and the forward hull or add-on module together, keeping the index marks aligned. If no add-on module is present, ensure that the battery cable can move freely, as it must flex as the pitch battery moves.
25. Place the aft hull on the glider cart, ensuring the orientation is correct.
26. Clean and inspect the O-ring sealing surfaces of the aft hull, ensuring there are no scratches or other damage that could cause the O-rings to fail.
27. Carefully insert the aft battery into the aft hull, with the mounting bracket towards the payload bay.
28. Slide the aft hull and battery to three inches from the payload bay, and then slide the battery out towards the payload bay. Connect the battery mounting bracket to the payload bay:
    - For lithium batteries, mount them with two pull pins.
    - For alkaline batteries, mount them with two $^{1}/_{4}$–20 socket head cap screws and two $^{1}/_{4}$" washers.
29. Move the cables from the payload bay wiring harness and the aft battery aside so as not to impede the tie rod when it is inserted into the payload bay tie rod guide tube.
30. Clean and inspect the aft hull O-rings and O-ring grooves and re-lubricate or replace as necessary.
31. Ensure that all of the connectors on the aft chassis are connected and seated properly.
32. Slide the aft section into the aft hull. Take care that the tie rod runs through the payload bay tie rod guide tube.
33. Press the aft end cap and the aft hull together, ensuring the O-ring does not get pinched or otherwise damaged.
34. Make the connections from the aft battery to the mating connector on the glider aft chassis.
35. If lithium batteries are installed, make the connections from the aft battery to the mating connector hanging from the port side of the main glider board.

Note

There may be other connectors that are specific to the glider. Connect these as appropriate.

36. Make the connections from the payload bay wiring harness to the mating connectors on the main glider board.
37. Slide the aft section and hull together towards the payload bay.

    The tie rod prevents the two sections from closing.
38. Assemble the tie rod tool:
    - 15 inch-pound torque T-handle
    - 24" extension
    - $^{3}/_{16}$" hex bit
39. Insert the tie rod tool into the vacuum seal port on the aft end cap.
40. Screw the tie rod into the forward section (or add-on module) tie rod receiver.

    The glider sections should come together smoothly. They must be tight and square to their mating sections.

41. Ensure the index marks on the hull sections are aligned and that the O-rings are not pinched or damaged.

CAUTION

PEEK parts are delicate. You must use proper tools for PEEK parts and apply the proper torque—otherwise, these parts may be damaged. In general, you can recognize PEEK parts (such as the MS plug) by their light brown color and plastic appearance.

Note

If the hull sections are not tight, flex the glider by lifting or pressing on the tail fin tube to allow for further tightening.

42. Tighten to 15 inch-pounds of torque.
43. Inspect the vacuum seal plug (MS plug) for wear. Replace it if worn.
44. Evacuate the glider ("pull a vacuum"):
    a. Use the following:
       - A vacuum pump with the evacuation tool
       - The $^{3}/_{16}$" torque handle assembly
    b. Evacuate it to at least:
       - Shallow glider — 6 inches Hg
       - Deep glider — 7 inches Hg

       However, it is best to pull a higher vacuum, as you can bleed some air in the when the glider is powered on.
    c. Seal it with the $^{7}/_{16}$ x 20 PEEK MS plug
    d. Tighten the plug to 15 inch-pounds of torque.
45. After the glider is sealed, confirm and adjust the vacuum as needed (*see* "5.2 Check and Set the Vacuum on the Glider" on page 5-1).
46. Install the aft cowling (*see* "20.3 Install the Aft Cowling" on page 20-2).
47. If necessary, re-install the wing rails on the payload bay.

5 Check & Set the Glider Vacuum

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

5.1 Requirements

Tools:	Glider Maintenance Accessory Kit
Materials and parts:	Glider (200 or 1000 meters)
Personnel required:	2 electronics technicians

5.2 Check and Set the Vacuum on the Glider

Before applying power to the glider, verify that the glider is closed and has a proper vacuum. If the glider is not closed and does not have a proper vacuum, then follow these steps:

1. Assemble the glider as described in Chapter 4, “Re-assemble the Glider.”
2. Remove the aft cowling as described in “20.2 Remove the Aft Cowling” on page 20-1.
3. Use a vacuum pump with the evacuation tool and the $^{3}/_{16}$" torque handle assembly to evacuate the glider, sealing with the 7/16 x 20 PEEK MS plug.

   The glider should be evacuated to at least 6 inches Hg for a shallow glider and 7 inches Hg for a deep glider. However, it is best to pull a higher vacuum, as you can bleed some air in the when the glider is powered on. Tighten the plug to 15 inch-pounds of torque.
4. Once there is a proper vacuum and the MS plug is in place, apply the power. The glider then powers on and goes through its normal startup routine. To gain control of the glider, when you see:

```
SEQUENCE: About to run initial.mi on try 0. You have 120 seconds to press control-C to
terminate the sequence. The control-P character immediately starts the mission. All
other characters are ignored.
```

   Press **[Ctrl]**-**[C]** to display the GliderDOS prompt.
5. From the GliderDOS prompt, type callback 30. This hangs up the Iridium phone for 30 minutes. You can enter any value for callback from **1** to **30**.

   Alternatively, you can type:

```
use - iridium
```

   This command takes the Iridium out of service until your testing is complete.

Note

Never deploy a glider in `lab_mode`.

6. Type:

```
lab_mode on
```

This command places the glider in lab mode and prevents the glider from running its default mission.

Note

Never deploy a glider in ballast.

7. Type:

```
ballast
```

This deflates the air bladder, and sets the pitch motor and ballast pump to 0.

8. Wait for the prompt: `Glider ready for ballasting`.
9. Type:

```
report clearall
```

10. Type:

```
report ++ m_vacuum
```

This displays the vacuum inside the glider every time the sensor updates.

If the vacuum is already at 6 inches Hg (7 inches Hg for 1000-meter) Hg, you are done (+/-.2).

If not, you need to adjust the vacuum by allowing air in to decrease the value or pulling more air out to increase the value.

11. Once the vacuum is within 0.2 inches Hg of the target, type:

```
report clearall
```

This stops reporting the vacuum value.

Note

If you are connected via an external power supply, power down by typing **`exit`** before installing the cowling.

12. If not in place already, install the aft cowling on the glider (see "20.3 Install the Aft Cowling" on page 20-2).
13. Install the Stop plug (red) as described in "19.3 Install the Go or Stop Plug" on page 19-2.

6 Forward Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

6.1 Requirements

Tools:	Hull separation tool
Materials and parts:	Forward assembly (shallow or deep)
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

6.2 Removing the Forward Assembly

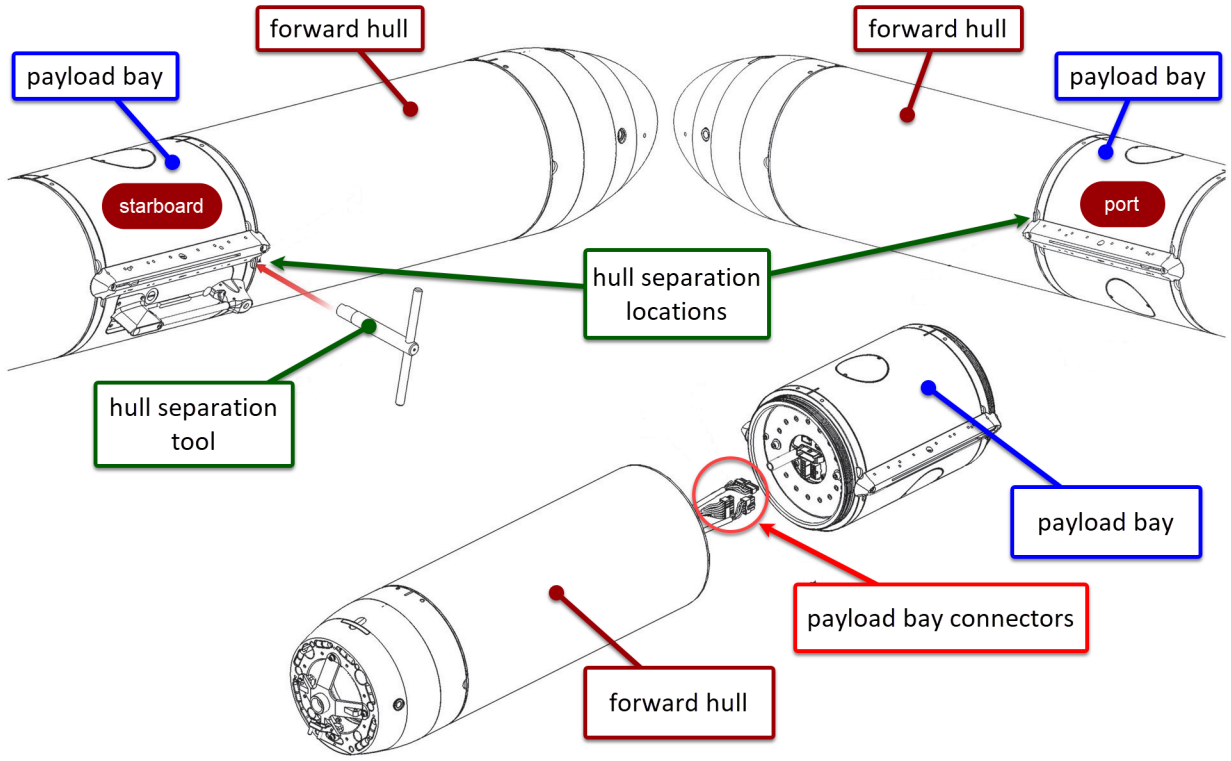

Figure 6-1: Forward assembly, part one (Shallow or Deep)

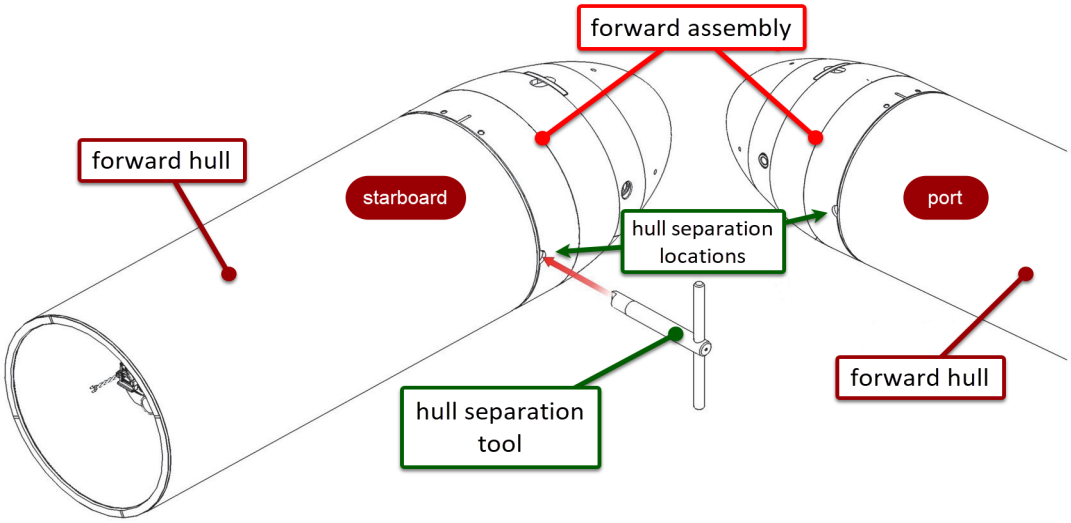

Figure 6-2: Forward assembly, part two (Shallow or Deep)

CAUTION

The forward and aft batteries are heavy and must be supported by the hulls in their respective bays at all times.

If disassembly requires removing hulls or the assembly to which the battery is affixed, remove the batteries from the vehicle first.

Note

Text references to items called out in Figure 6-1 and Figure 6-2 are surrounded by square brackets and colored to match them.

1. As shown in Figure 6-1, use the hull separation tool at the hull separation locations to disengage the forward hull section from the payload bay.
2. As shown in Figure 6-1, disconnect the payload bay connectors from the payload bay.
3. As shown in Figure 6-2, use the hull separation tool at the hull separation locations to disengage the forward hull section from the forward assembly.

6.3 Installing the Forward Assembly

1. As shown in Figure 6-2, align the forward hull section with the forward assembly.
2. As shown in Figure 6-1, connect the payload bay connectors from the forward hull to the payload bay.
3. Align the forward assembly with the payload bay.
4. Reference Chapter 4, "Re-assemble the Glider" for the final installation.

7 Tie Rod Assembly

7.1 Requirements

Tools:	Phillips screwdriver
Materials and parts:	Tie rod assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

7.2 Removing the Tie Rod Assembly

1. As shown in Figure 7-1, remove the six tie rod screws that attach the tie rod assembly to the bottom of the aft electronics tray.
2. Remove the tie rod assembly.

7.3 Installing the Tie Rod Assembly

1. As shown in Figure 7-1, position the tie rod assembly on the standoffs on the bottom of the aft electronics tray.
2. Place a drop of Loctite 243 (blue) on each of the six tie rod screws.
3. Install the six tie rod screws that attach the tie rod assembly to the bottom of the aft electronics tray.

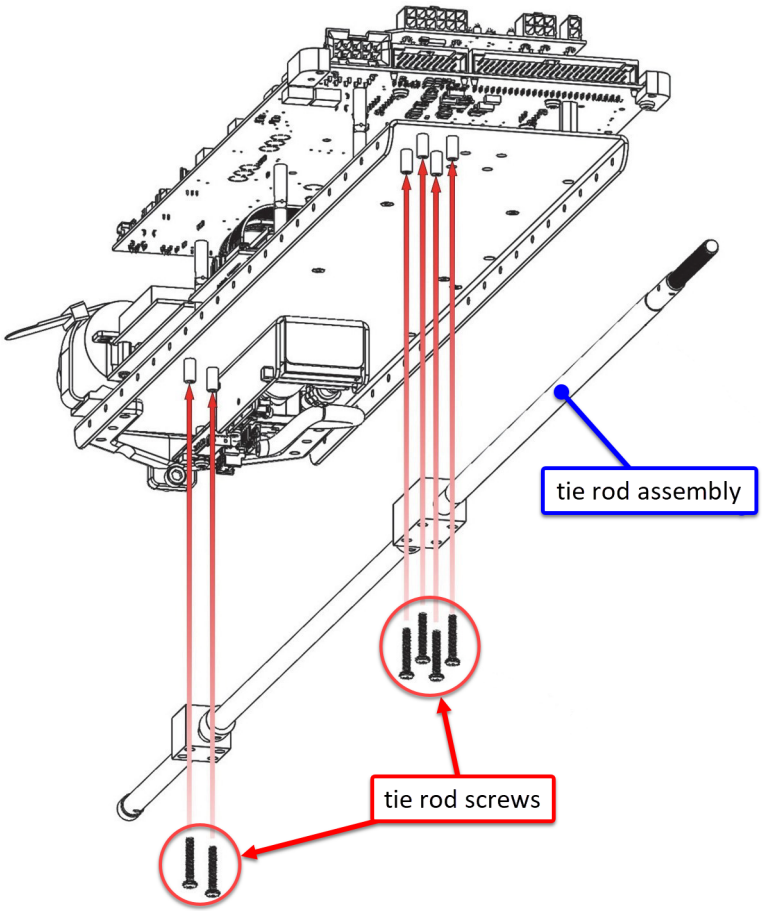

Figure 7-1: Tie Rod assembly

8 Ballast Bottles

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

8.1 Requirements

Tools:	Phillips screwdriver
Materials and parts:	Ballast bottle, 60 ML
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

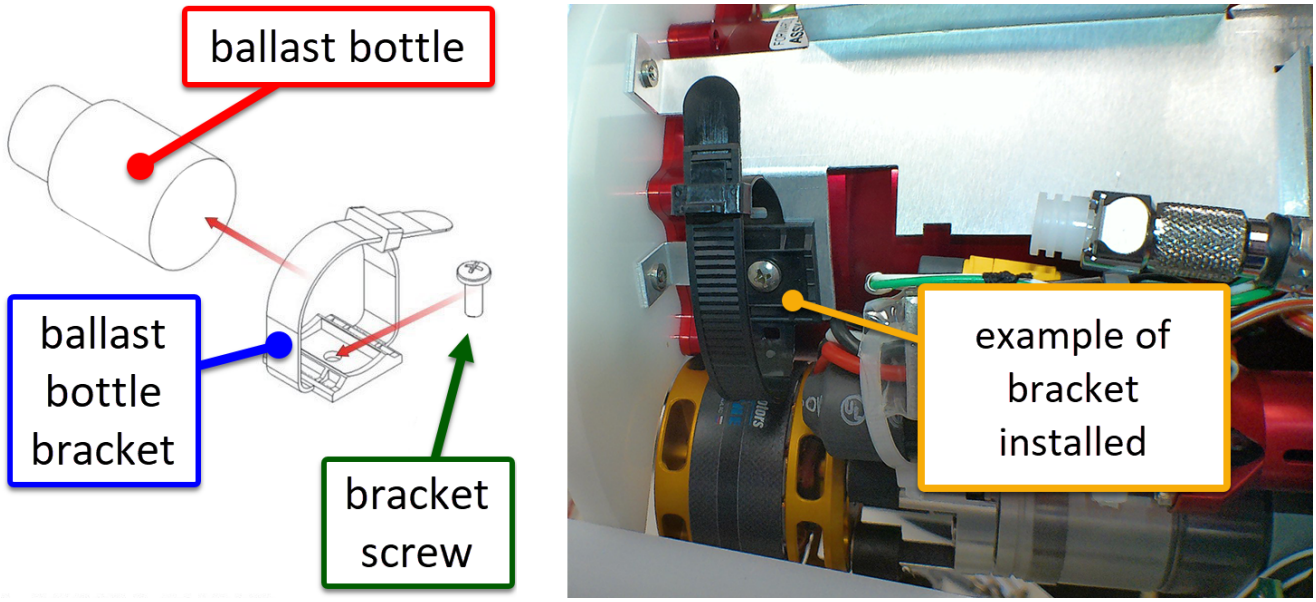

Figure 8-1: Typical assembly & example of Forward Starboard bracket installed

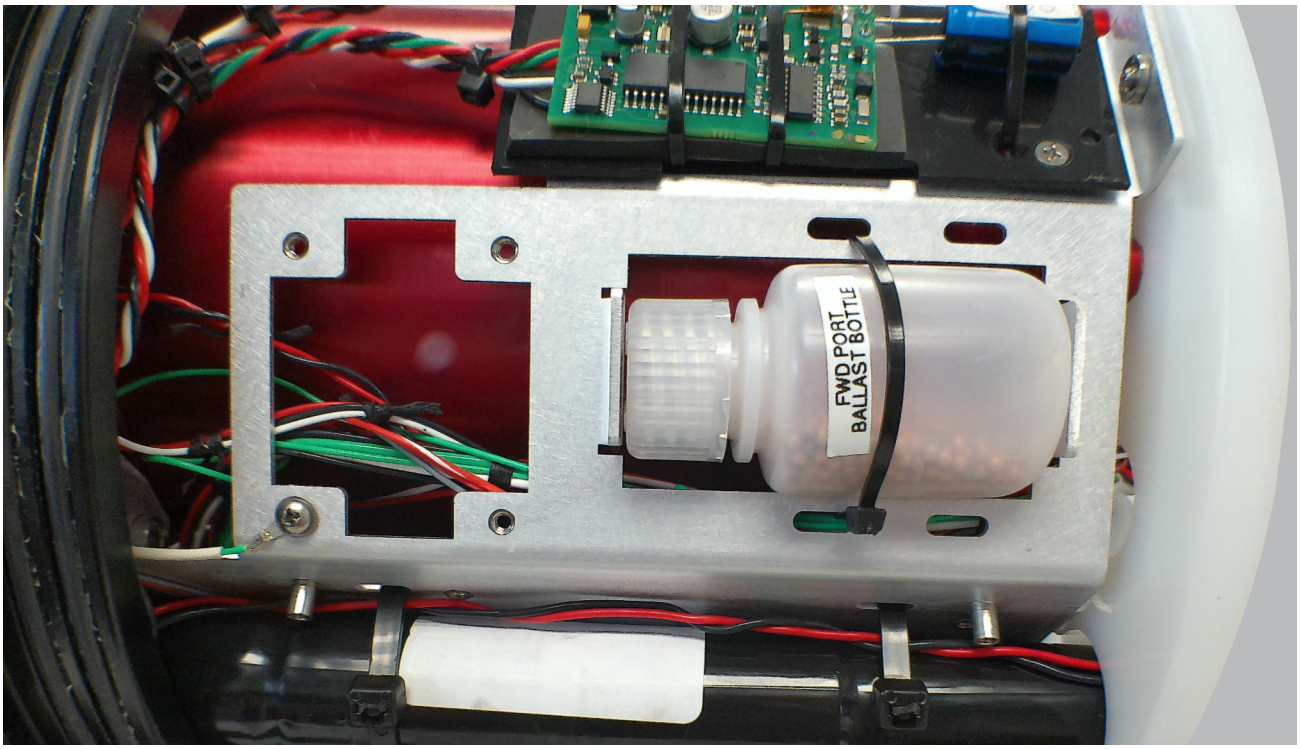

Figure 8-2: The Forward Port ballast bottle (uses zip tie, not bracket)

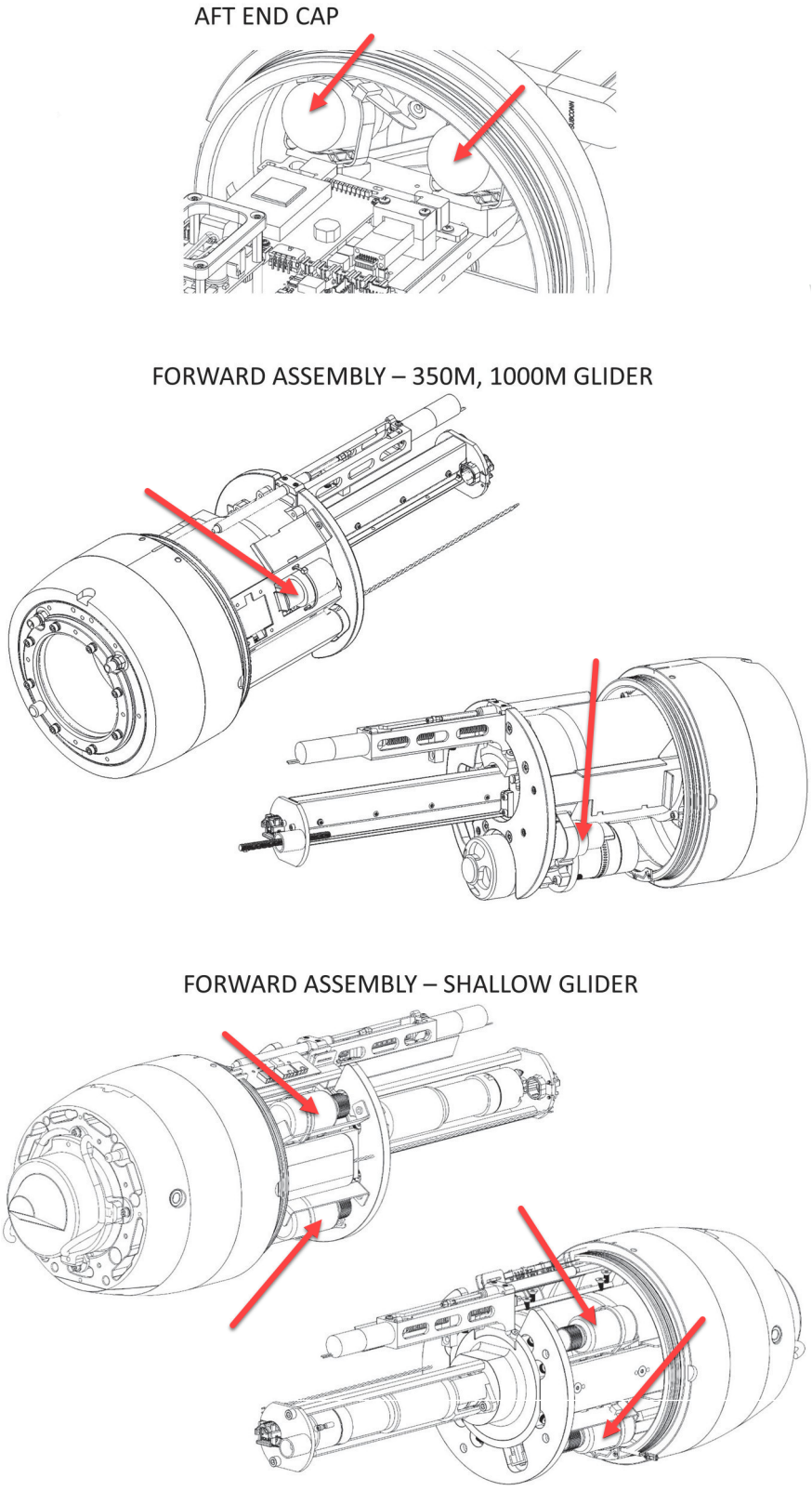

Figure 8-3: Forward and aft ballast bottle locations

8.2 Removing the Ballast Bottles

In reference to Figure 8-3 on page 8-3:

1. Loosen the ballast bottle bracket.
2. Remove the ballast bottle.
3. If necessary due to wear or damage, remove the bracket screw that secures the ballast bottle bracket.

8.3 Installing the Ballast Bottles

In reference to Figure 8-3:

1. If necessary:
   a. Position a new ballast bottle bracket over existing screw hole.
   b. Screw in bracket screw to secure the ballast bottle bracket.
2. Install the ballast bottle.
3. Tighten the ballast bottle bracket.

9 Battery Packs

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

9.1 Requirements

Tools:	$^{5}/_{32}$" x 12" red T-handle hex wrench
Materials and parts:	Glider battery packs
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

Most photographs in these figures show rechargeable lithium battery packs.

WARNING

Lithium batteries pose a significant hazard when stored or handled improperly. The two hazards associated with lithium sulfuryl chloride batteries and their components are fire and explosion, which could occur if the batteries are crushed, punctured, excessively heated, charged, over-discharged, short circuited, or submerged in water in a non-waterproof enclosure.

Lithium sulfuryl chloride cells are safe to handle when all of their components are adequately wrapped and sealed within a stainless steel casing. When that casing is compromised, an immediate danger is present due to exposure of the contents (and byproducts of these contents) with their new environment:

- Lithium metal reacts with water to produce lithium hydroxide, a corrosive liquid and hydrogen gas, which is flammable.
- Sulfuryl chloride (the liquid cathode) is a corrosive liquid that reacts with water to produce hydrogen chloride gas (which is toxic and corrosive) and sulfuric acid, a corrosive liquid.

Remove your jewelry before handling lithium batteries. Wear the appropriate PPE—eye protection and chemical resistant gloves—while handling lithium batteries.

CAUTION

An improperly ballasted glider may not fly well or can cause mission or vehicle failure.

CAUTION

When installing new batteries, the m_coulomb_amphr_total sensor must be set to zero by typing:

```
m_coulomb_amphr_total 0
```

Note

Moving and adjusting the batteries will affect the glider's ballasting and H-moment. This should be done with care to maintain proper ballasting.

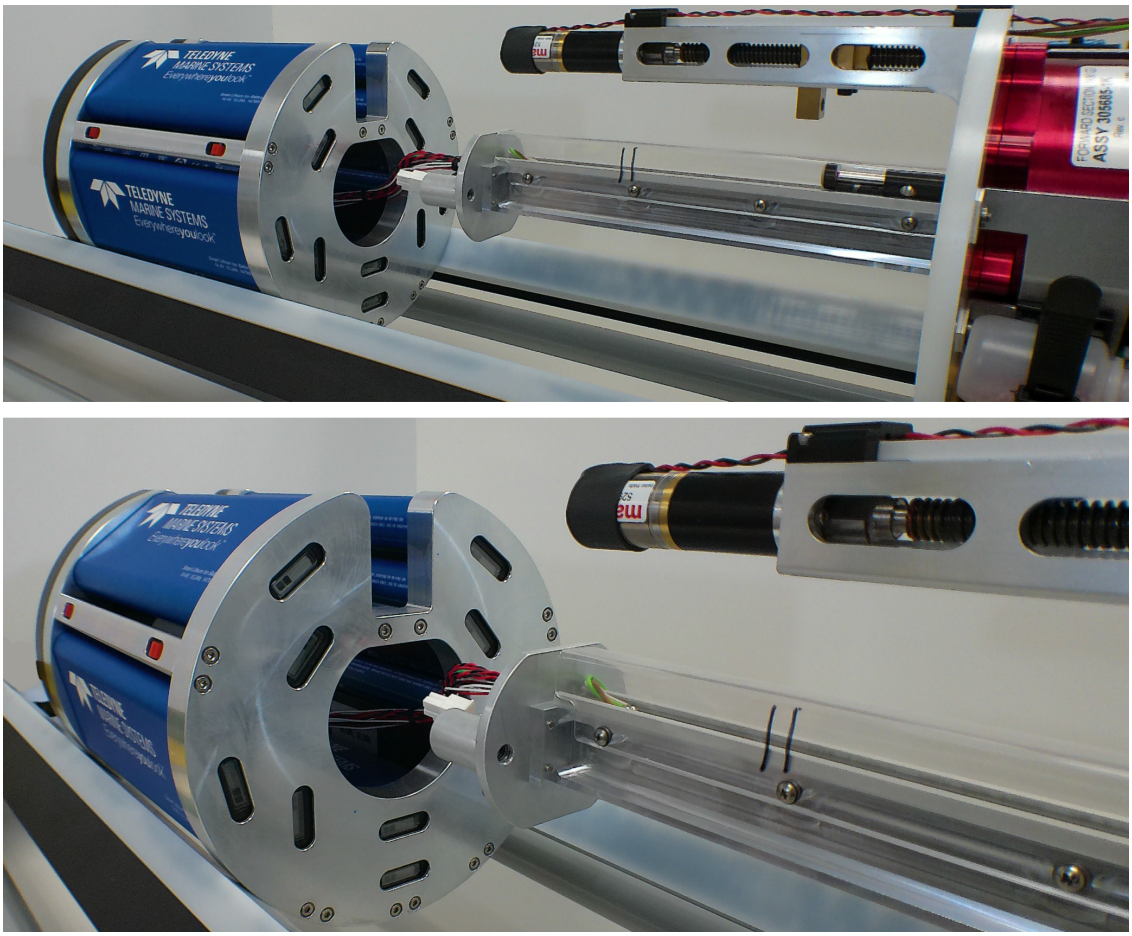

Figure 9-1: Pitch/Forward battery pack

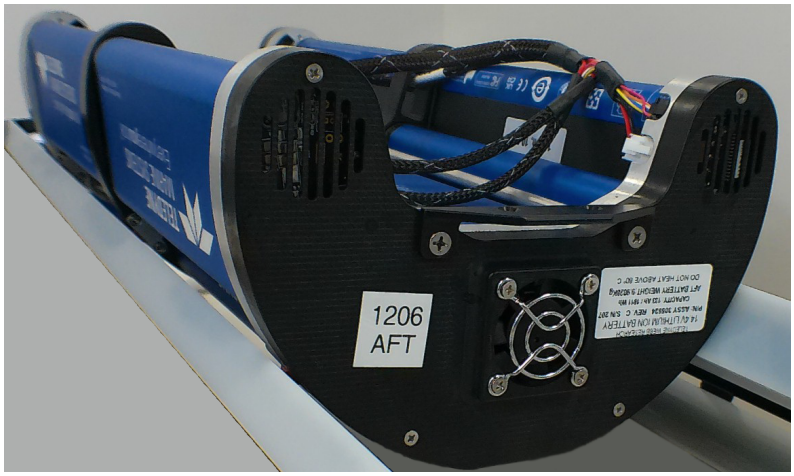

Figure 9-2: Aft battery pack

9.2 Removing the Glider Battery Packs

9.2.1 Pitch Battery

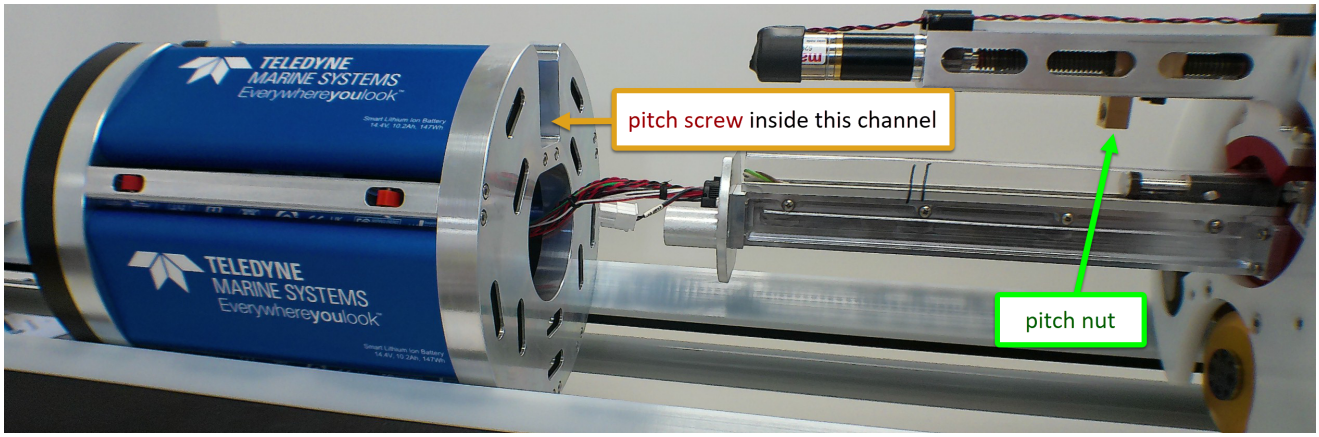

Figure 9-3: Forward/Pitch glider battery pack

1. Unplug the **JH133** connection on the pitch battery from the forward assembly.
2. Unplug the **JH117** connection on the pitch battery from the forward assembly wiring harness.
3. Using the $^{5}/_{32}$" x 12" red T-handle hex wrench, loosen the pitch screw from the pitch nut, as shown in Figure 9-3 above.
4. Remove the pitch battery.

9.2.2 Aft Battery

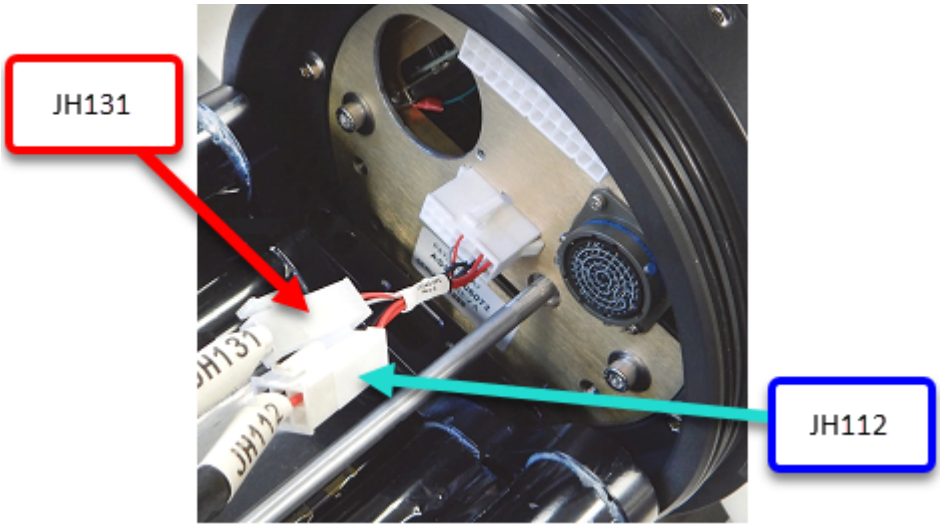

Figure 9-4: Aft battery pack wiring connectors (alkaline battery pack, in this example)

5. Disconnect the **JH112** connection on the aft battery from the aft electronics tray.
6. Disconnect the **JH131** connection on the aft battery from the aft electronics tray.

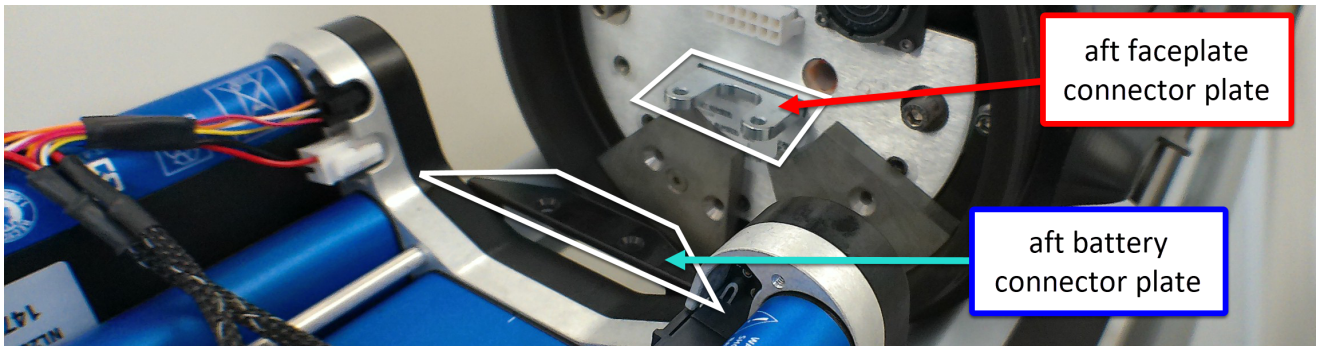

Figure 9-5: Aft battery pack and aft faceplate connectors

7. In reference to Figure 9-5 above, remove the two battery pins that hold the aft battery connector plate to the aft faceplate connector plate.
8. Remove the aft battery.

9.3 Installing the Glider Battery Packs

9.3.1 Aft Battery

1. Position the aft battery and, in reference to Figure 9-5 above, install the two battery pins that hold the aft battery connector plate to the aft faceplate connector plate.
2. Connect **JH131** and **JH112** from the aft battery to the aft electronics tray.
3. Mount the batteries:
   a. For **lithium** batteries — mount with two pull pins
   b. For **alkaline** batteries — mount with:
      - Two $^{1}/_{4}$–20 socket head cap screws, –and–
      - Two $^{1}/_{4}$" washers

9.3.2 Pitch Battery

4. Position the pitch battery.
5. Using the $^{5}/_{32}$" x 12" red T-handle hex wrench, tighten the pitch screw onto the pitch nut, as shown in Figure 9-3 on page 9-3.
6. Connect **JH117** on the pitch battery to the forward assembly wiring harness.
7. Connect **JH133** on the pitch battery to the forward assembly.

10 Leak Detect Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

10.1 Requirements

Tools:	Phillips screwdriver
Materials and parts:	Leak detect assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

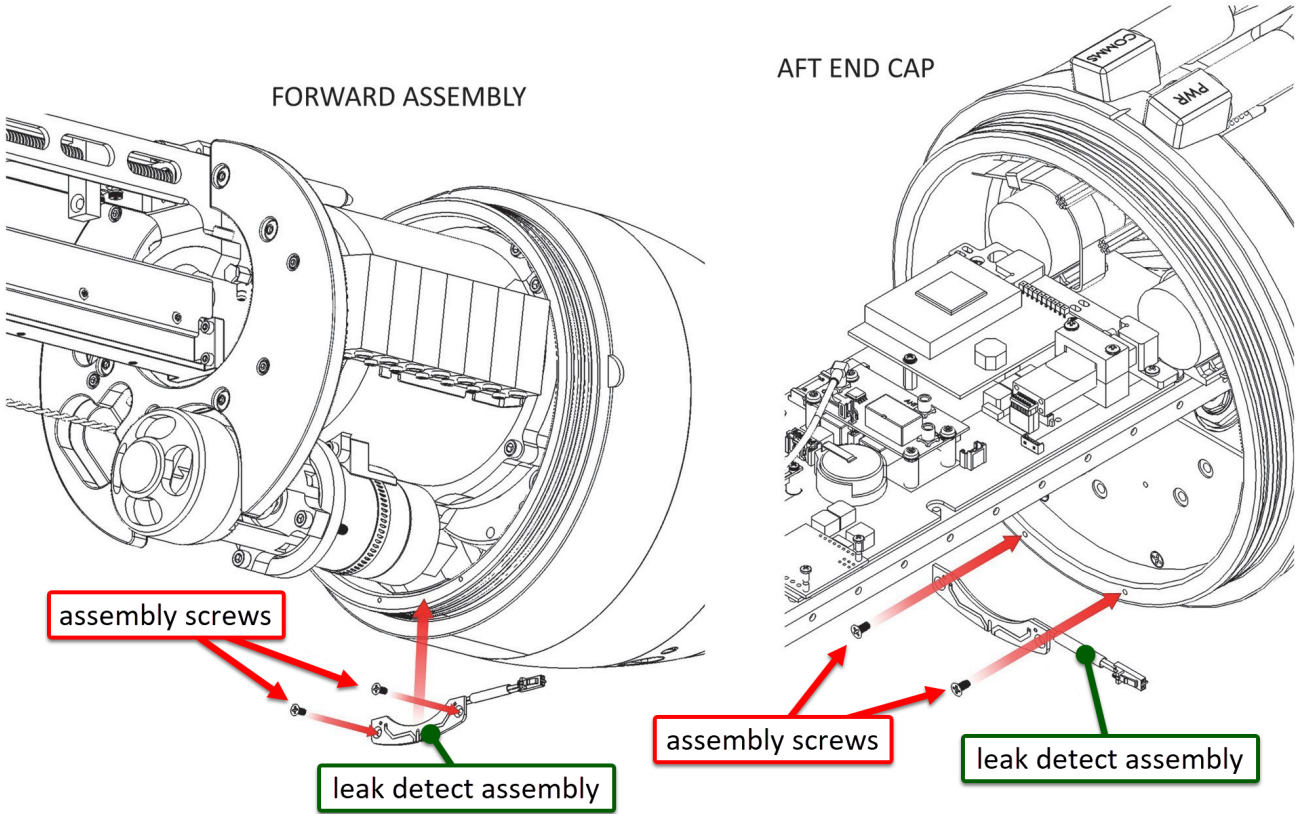

Figure 10-1: Leak detect assembly

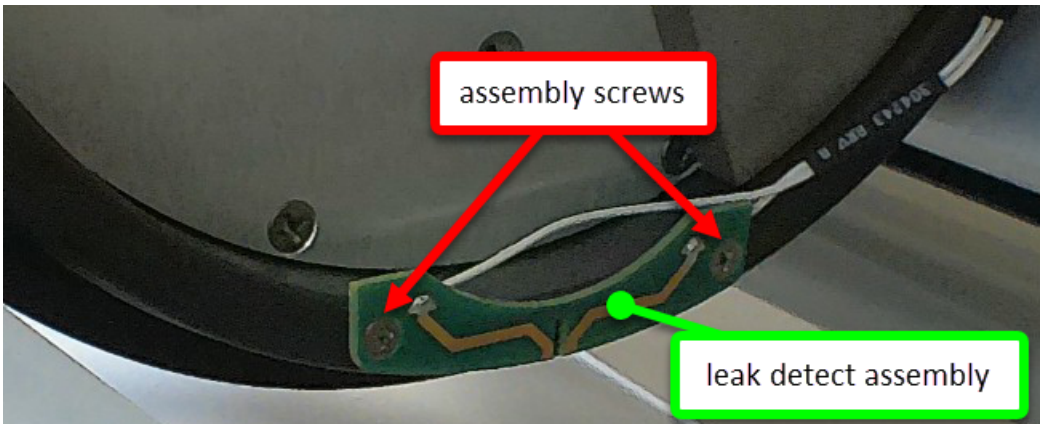

Figure 10-2: Leak detect assembly on the aft end cap

10.2 Removing the Leak Detect Assembly

In reference to Figure 10-1 on page 10-1 and Figure 10-2 above:

1. Unscrew the two assembly screws from either:
   - Forward assembly, –or–
   - Aft end cap
2. Unplug the leak detect assembly from either the:
   - Forward assembly, –or–
   - Aft end cap
3. Remove the leak detect assembly.

10.3 Installing the Leak Detect Assembly

In reference to Figure 10-1 and Figure 10-2:

1. Place the leak detect assembly in position on either the:
   - Forward assembly, –or–
   - Aft end cap
2. Install the two assembly screws to either the:
   - Forward assembly, –or–
   - Aft end cap

11 Forward and Aft Anode Assemblies

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

11.1 Requirements

Tools:	Digital voltage detector with two leads Pliers $^{3}/_{16}$" hex wrench
Materials and parts:	$^{3}/_{4}$" x 1" (large) Aft zinc anode and O-ring $^{1}/_{2}$" x $^{1}/_{2}$" (small) Forward zinc anode and O-ring
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

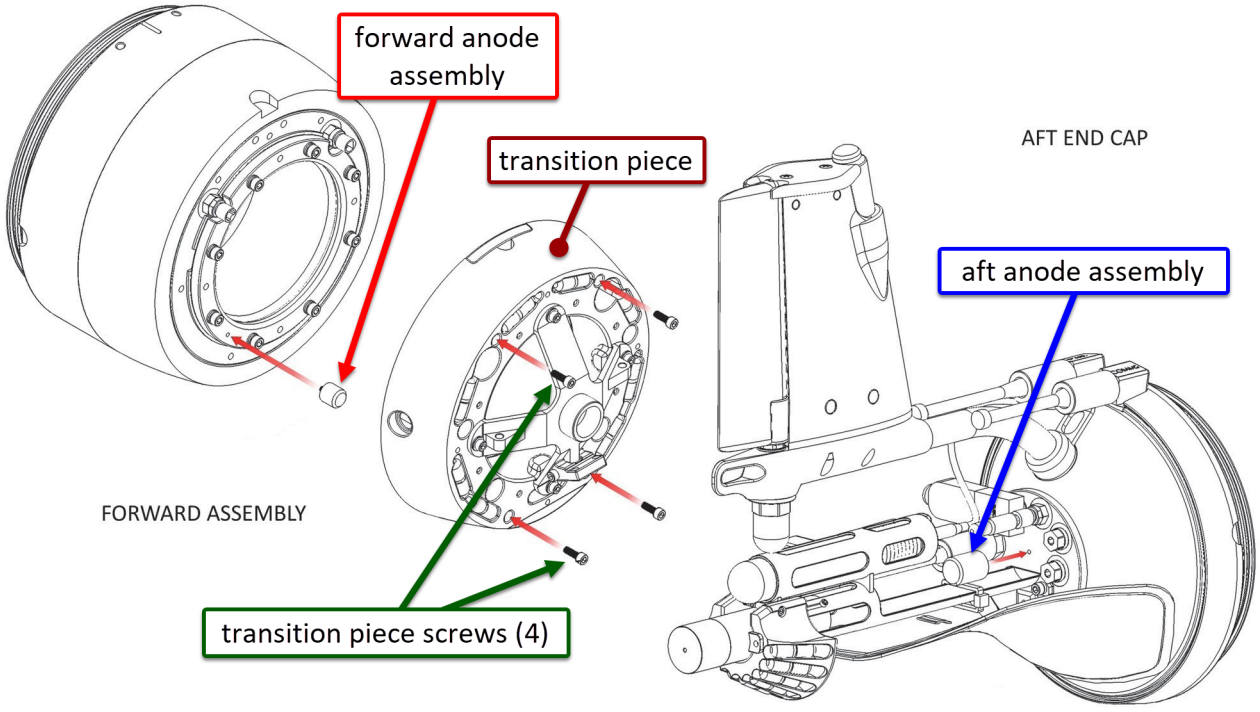

Figure 11-1: Forward anode and Aft anode assemblies

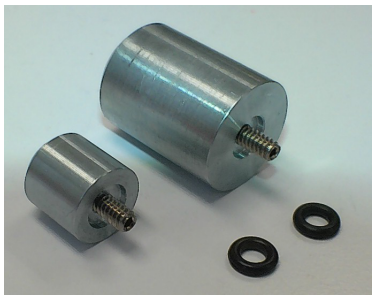

Figure 11-2: Forward anode [*left*] and Aft anode [*right*] and O-rings

11.2 Removing the Aft Anode Assembly

1. Remove the aft cowling (see Figure 2-1 on page 2-1).
2. Grasp the aft anode assembly using a pair of pliers.
3. Unscrew the assembly from the glider.

11.3 Installing the Aft Anode Assembly

CAUTION

Do not apply any thread-lock compound, such as Loctite, to the threads of the anode assembly. The thread-lock compound affects the electrical conductivity, which prevents the anode from operating properly.

CAUTION

Do not overtighten the anode. Doing so may strip the anode's interior threads, rendering it useless.

Note

Three different sizes of anode are available. The appropriate size used should be based on the deployment length and the corrosiveness of the water.

If sacrificial anodes larger than the three available sizes are required, you can:

1. Tap the aft anode assembly.
2. Screw another anode into the back of the tapped aft anode assembly.

1. Create the aft anode assembly:
   a. Screw the 6-32 x $^{1}/_{2}$" set screw into the $^{3}/_{4}$" x 1" zinc anode.
      Leave approximately $^{1}/_{4}$" of the set screw outside of the anode.
   b. Place the O-ring over the set screw at the base of the anode.
      This is your aft anode assembly.
2. Screw the aft anode assembly into the aft end cap by hand.
3. Slip the anode drive socket over the anode and tighten the set screw using the $^{3}/_{16}$" hex wrench.

4. Torque the anode assembly to **10 inch-pounds**.
5. Tighten the anode just beyond finger tight.
6. Using a digital ohmmeter, ensure electrical continuity exists between the center of the anode and either ejection weight tube mounting screw.

11.4 Removing the Forward Anode Assembly

In reference to Figure 11-1 on page 11-1, perform the following:

1. Unscrew the four transition piece screws that holds the transition piece to the forward hull.
2. Separate the transition piece from forward hull using the hull separator tool.
3. Grasp the forward anode assembly using a pair of pliers.
4. Unscrew it from the glider.

11.5 Installing the Forward Anode Assembly

CAUTION

Do not apply any thread-lock compound, such as Loctite, to the threads of the anode assembly. The thread-lock compound affects the electrical conductivity, which prevents the anode from operating properly.

CAUTION

Do not overtighten the anode. Doing so may strip the anode's interior threads, rendering it useless.

1. Screw the 6-32 x $^{1}/_{2}$" set screw into the $^{1}/_{2}$" x $^{1}/_{2}$" zinc anode, leaving approximately $^{1}/_{4}$" of the set screw outside of the anode.
2. Place the O-ring over the set screw at the base of the anode.
3. Screw the anode assembly into the aft end cap by hand.
4. Slip the anode drive socket over the anode and tighten the set screw using the $^{3}/_{16}$" hex wrench.
5. Torque the anode assembly to **10 inch-pounds**.
6. If a torque wrench is not available, tighten the anode just beyond finger tight.
7. Using a digital ohmmeter, ensure electrical continuity exists between the center of the anode and the altimeter bracket screws.
8. Reattach the transition piece by screwing in the four transition piece screws.

12 Altimeter Transducer Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

12.1 Requirements

Tools:	$^{9}/_{64}$" hex wrench $^{5}/_{32}$" hex wrench
Materials and parts:	Altimeter transducer assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to "15.2 Removing the Recovery Assembly" on page 15-2

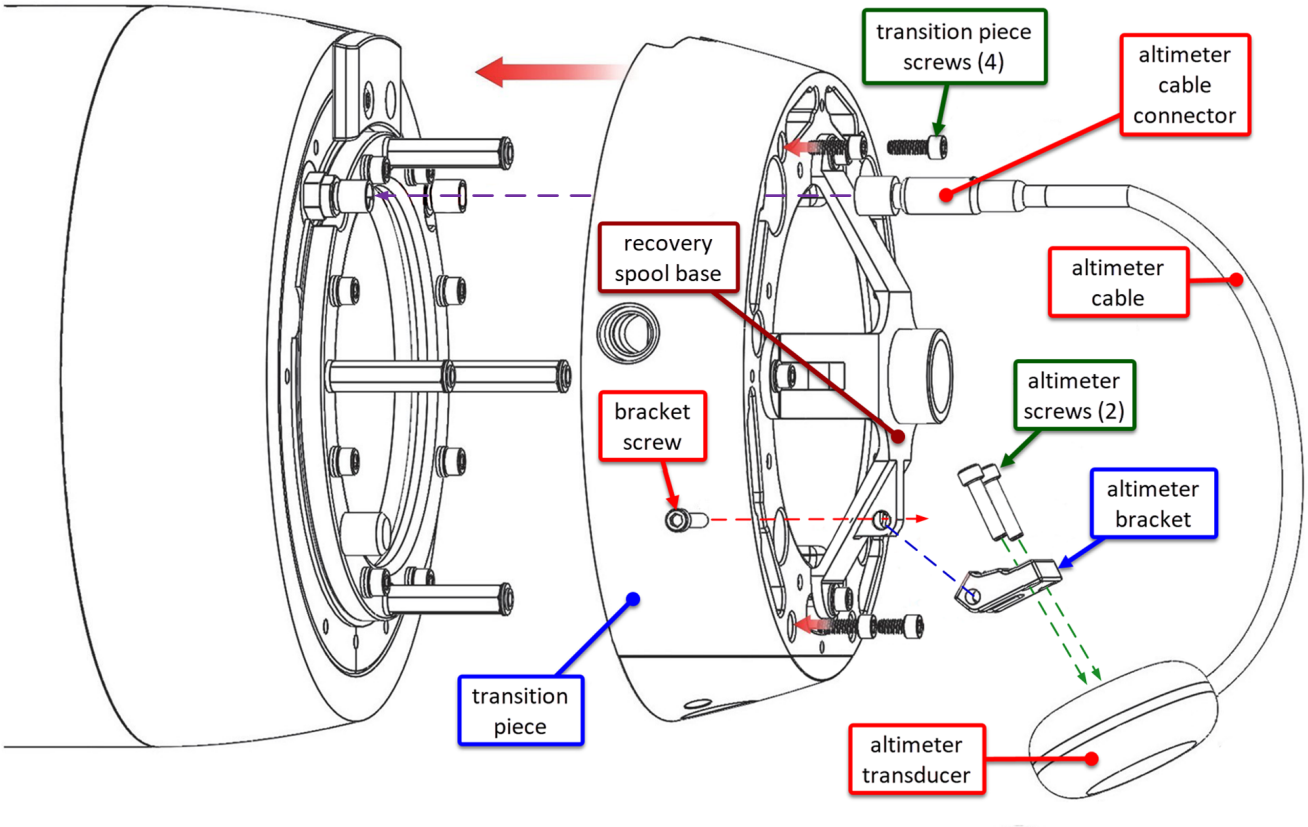

Figure 12-1: Altimeter transducer assembly

12.2 Removing the Altimeter Transducer Assembly

In reference to Figure 12-1 on page 12-1, perform the following:

1. Remove the bracket screw through the recovery spool base from the altimeter bracket.
2. From the altimeter bracket, remove the two altimeter screws from the altimeter transducer.
3. Set the altimeter transducer to the side.
4. Separate the transition piece from the forward hull by removing the four transition piece screws.
5. Disconnect the altimeter cable connector, located at the end of the altimeter cable, from the bulkhead connector.

12.3 Installing the Altimeter Transducer Assembly

In reference to Figure 12-1, perform the following:

1. Screw the altimeter cable connector, located at the end of the altimeter cable, into the bulkhead connector through the transition piece.
2. Reattach the transition piece by screwing in the four transition piece screws.
3. Install the two altimeter screws through the altimeter bracket into the altimeter transducer.
4. Install the bracket screw through the recovery spool base into the altimeter bracket.

13 Recovery Cartridge Assembly

13.1 Requirements

Tools:	Wire cutters
Materials and parts:	Cartridge assembly and monofilament
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

CAUTION

PEEK parts are delicate. Proper tools must be used for PEEK parts and the proper torque applied, otherwise these parts may be damaged.

In general, you can recognize PEEK parts by their light brown color and plastic appearance.

13.2 Install the Recovery Cartridge Assembly

1. Align the burn-wire bushing assembly with the metal release housing, as shown in Figure 13-1:

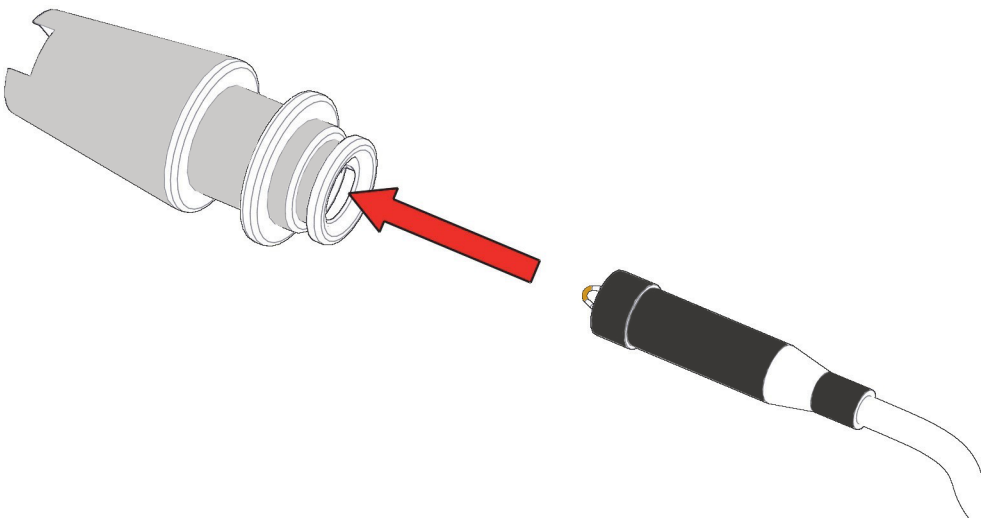

Figure 13-1: Aligning the burn wire assembly with the metal release housing

2. Feed the burn-wire bushing assembly into the metal release housing until it resembles Figure 13-2:

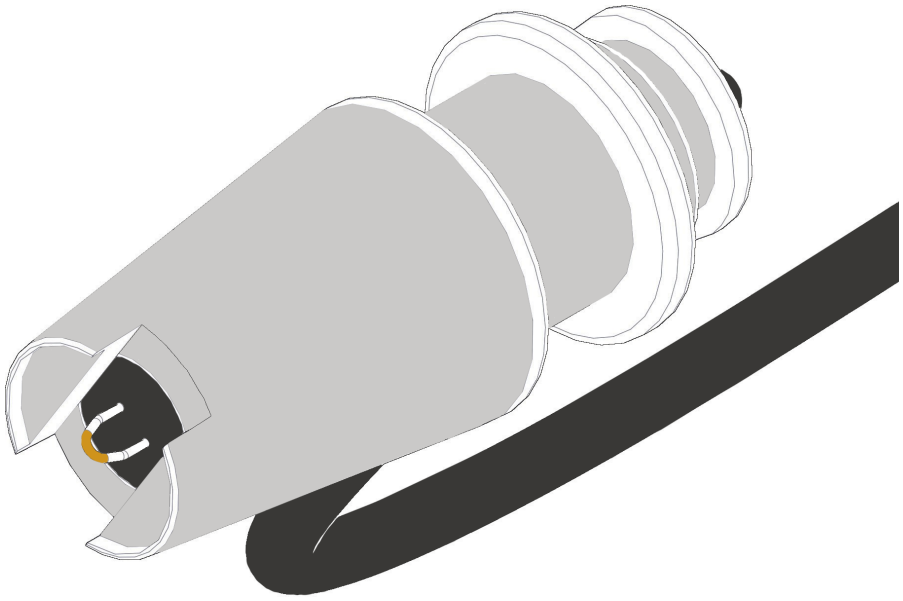

Figure 13-2: Burn wire assembly fed into the release housing

3. Slide the threaded PEEK stud over the wire loop and into the release housing, as shown in Figure 13-3:

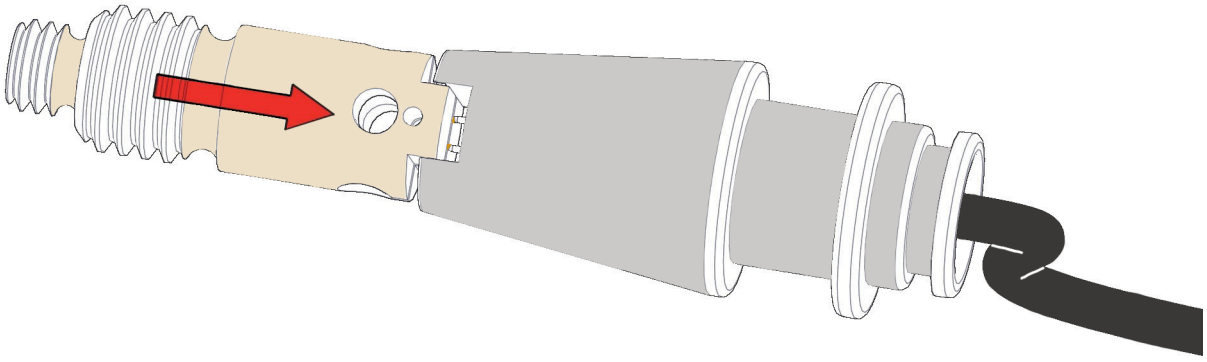

Figure 13-3: Sliding the threaded PEEK stud into the release housing

4. Sharpen on end of a long piece of monofilament.
5. Feed the monofilament:
   a. Through the small hole in the threaded stud,
   b. Under the wire loop,
   c. Out of the other side of the threaded stud, as shown in Figure 13-4:

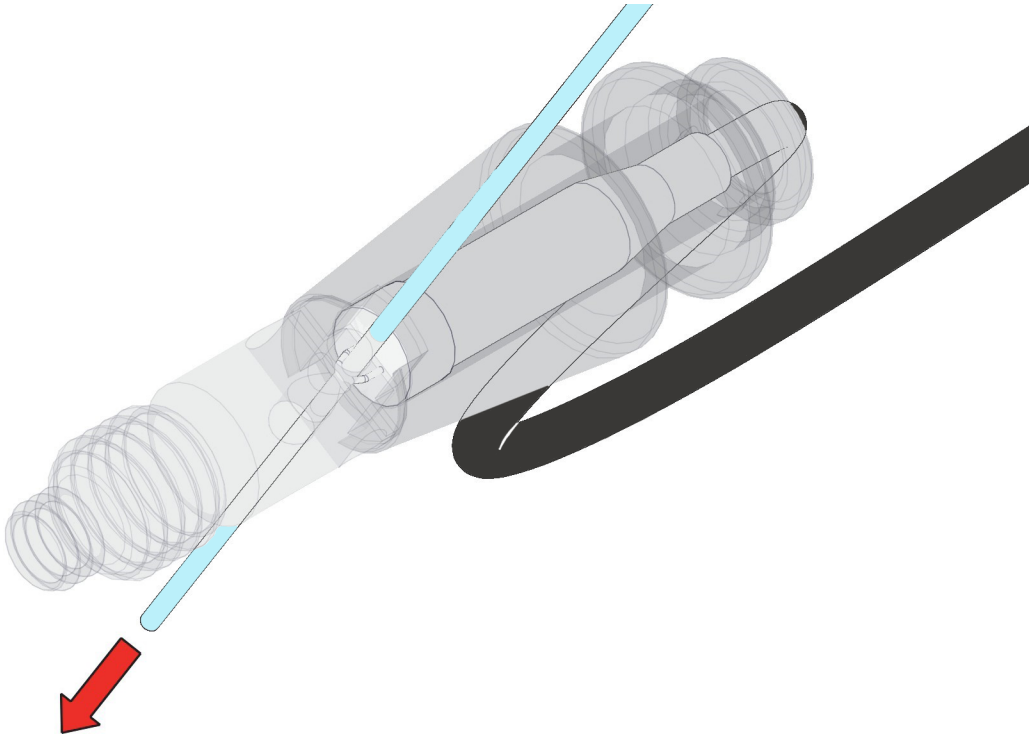

Figure 13-4: Feeding the monofilament through the threaded stud

6. Pull the monofilament through until the cut end almost at the hole in the stud.
7. Trim each end of the monofilament flush to the release housing, as shown in Figure 13-5:

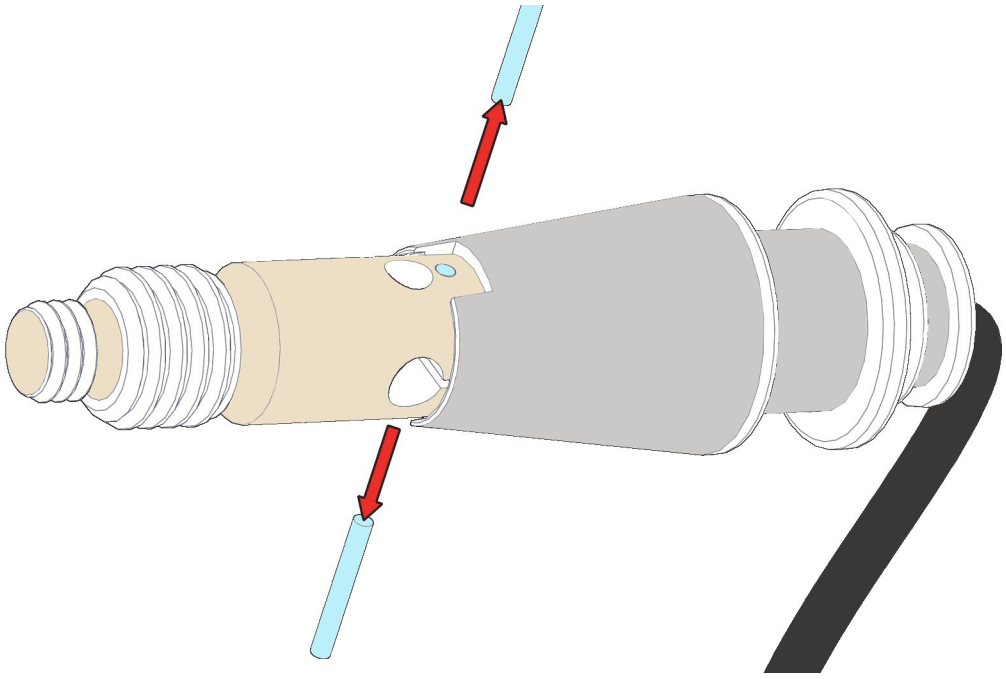

Figure 13-5: Trimming the monofilament

8. Ensure the release housing and the threaded stud are securely fastened by attempting to pull them apart, as shown in Figure 13-6:

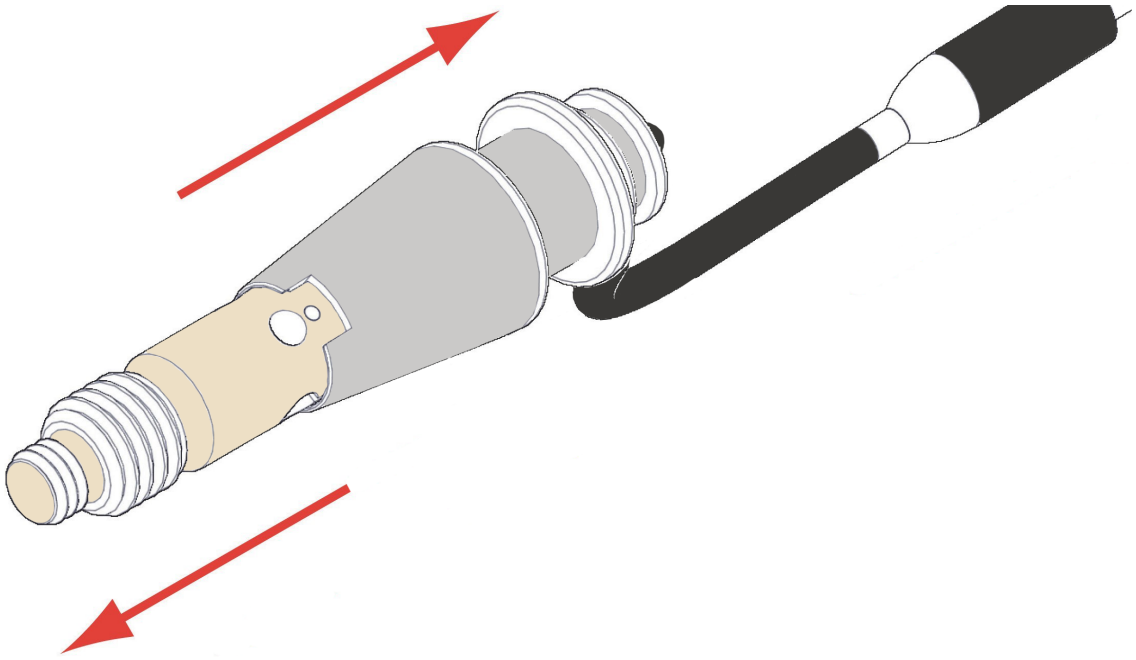

Figure 13-6: Attempt to pull release housing and threaded stud apart

The housing and stud should be attached firmly and not come free.

14 Recovery Spool Base

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

14.1 Requirements

Tools:	$^{9}/_{64}$" hex wrench $^{3}/_{32}$" hex wrench
Materials and parts:	Recovery spool base (shallow or deep)
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to: • Chapter 2, "Disassemble the Glider" • "15.2 Removing the Recovery Assembly" on page 15-2 • "12.2 Removing the Altimeter Transducer Assembly" on page 12-2

Referring to Figure 14-1 on the next page:

Tip

Because all these pieces are loose, it is recommended you provide a tray or shallow bin of some sort. Set it underneath this assembly so that it catches all the pieces that will fall as you remove each screw.

- The recovery spool base is an X-shaped attachment that mounts onto the transition piece.
- Attaching each leg of the base involves:
  - A spacer on either side of the leg
  - A washer on either side of each spacer
  - A screw that holds all those pieces together and secures the base onto the transition piece

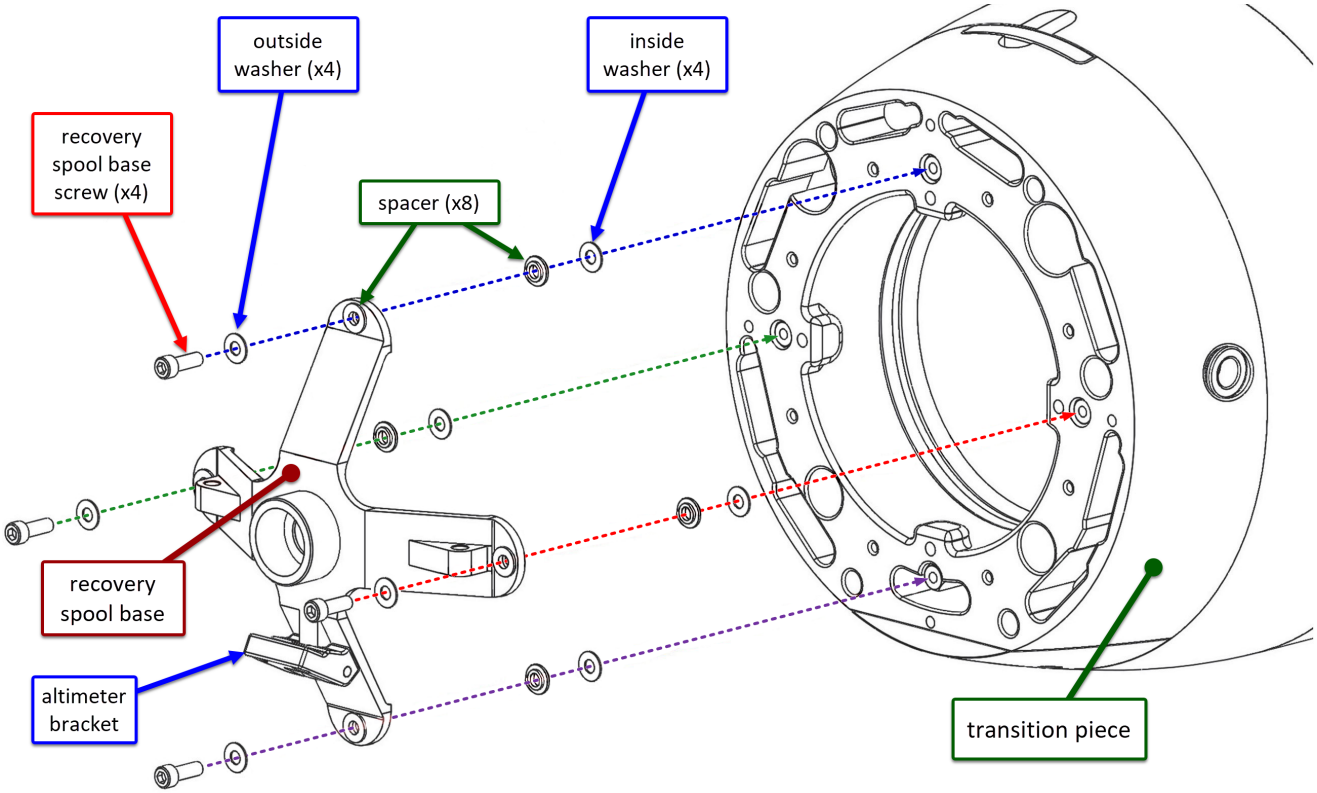

Figure 14-1: Recovery spool base

14.2 Removing the Recovery Spool Base

1. For each leg of the recovery spool base:
   a. Remove the recovery spool base screw.
   b. Allow the inside washer, outside washer, and spacers to fall into a tray.
2. Allow the additional cable mount at the top leg (Figure 14-2) to remain on the cable and dangle off to one side.

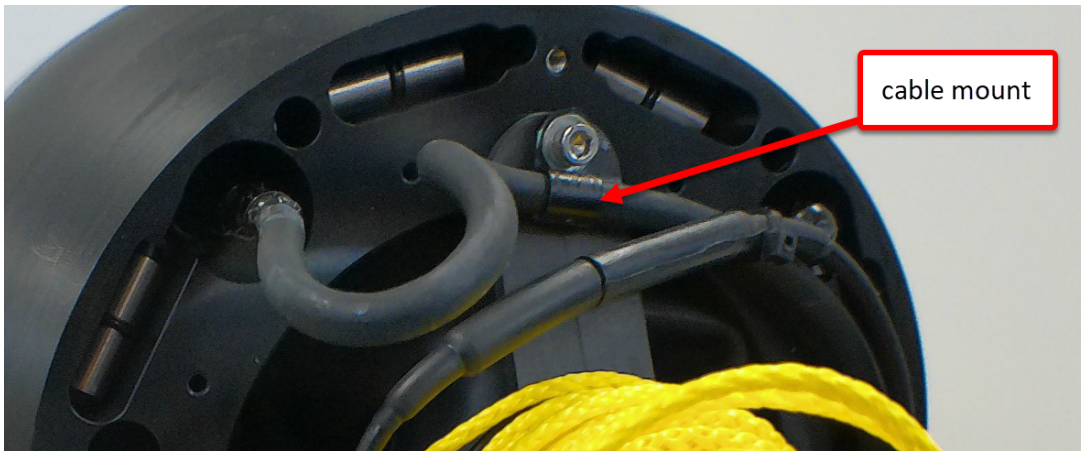

Figure 14-2: Cable mount piece on top screw

3. Remove the recovery spool base from the transition piece.
4. Allow the altimeter bracket to remain attached to the recovery spool base, if desired.

14.3 Installing the Recovery Spool Base

1. Beginning with the top leg:
   a. Slip the cable mount, the outside washer, and a spacer onto a screw.
   b. Slip the pieces above through the top leg of the recovery spool base.
   c. Slip a spacer then an inside washer onto the transition piece side of the screw.
   d. Attach the screw onto the transition piece loosely, allowing some movement of the base for attaching the remaining legs.
2. For each remaining leg of the recovery spool base, perform steps a–d above (without the cable mount).
3. Once all legs are attached, screw all recovery spool base screws until they are hand-tight.

15 Recovery System Assembly

The recovery system assembly is also shortened to the "recovery assembly."

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

15.1 Requirements

Tools: Phillips screwdriver
Snap-ring pliers

Materials and parts: Recovery assembly

Personnel required: 1 electronics technician

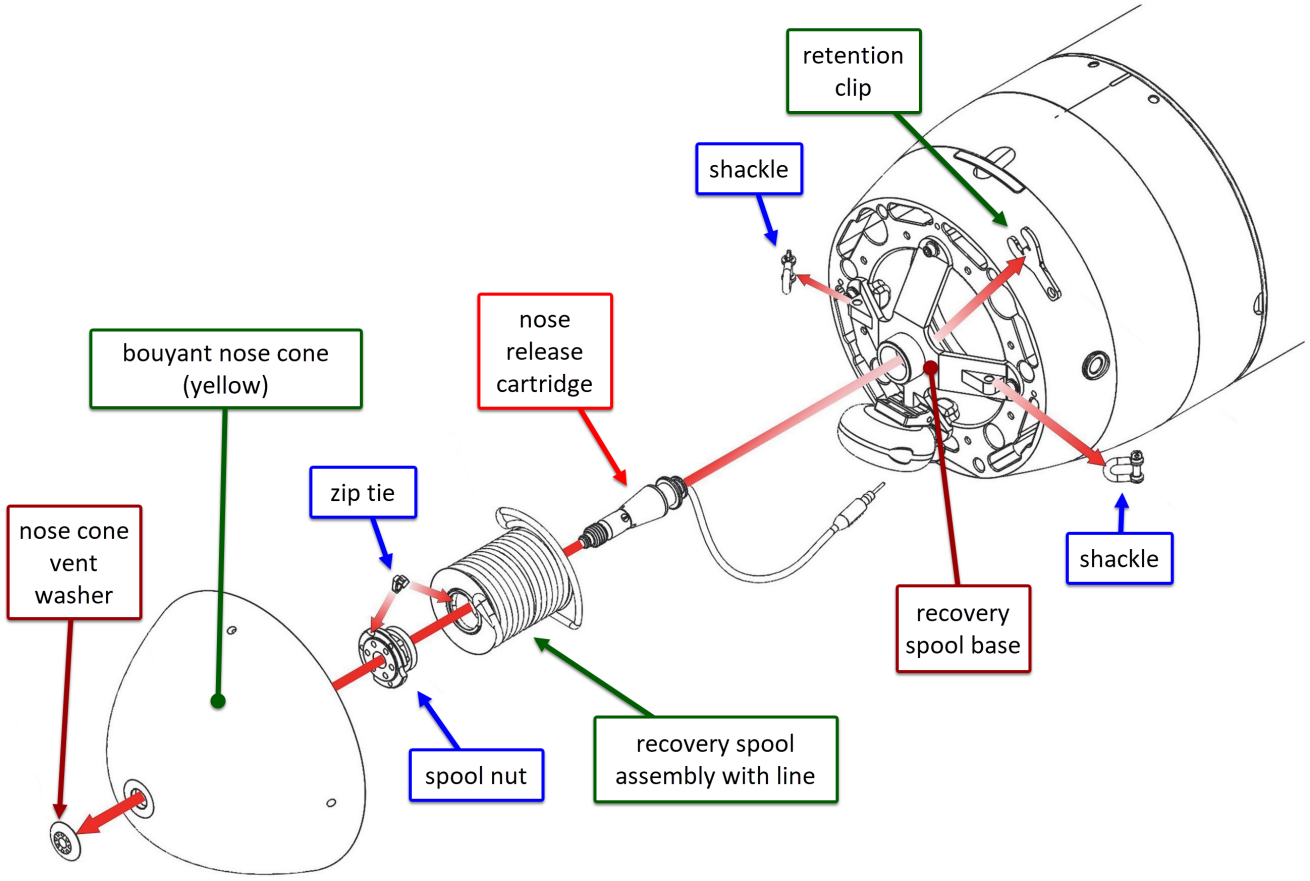

Figure 15-1: Recovery system assembly

15.2 Removing the Recovery Assembly

1. Ensure the RED plug is installed.
2. As shown in Figure 15-1, remove the nose cone vent washer.
3. Remove the buoyant nose cone.
4. Remove the zip tie.
5. Unscrew the spool nut.
6. Remove the shackles from the recovery spool base.
7. Remove the recovery spool assembly with line.
8. Remove the retention clip.
9. Disconnect the nose release cartridge connector from the altimeter.

15.3 Installing the Recovery Assembly

1. In reference to Figure 15-2, feed the nose release cartridge wire though the center of the recovery spool base, and feed the connector back out at the 4 o'clock position.

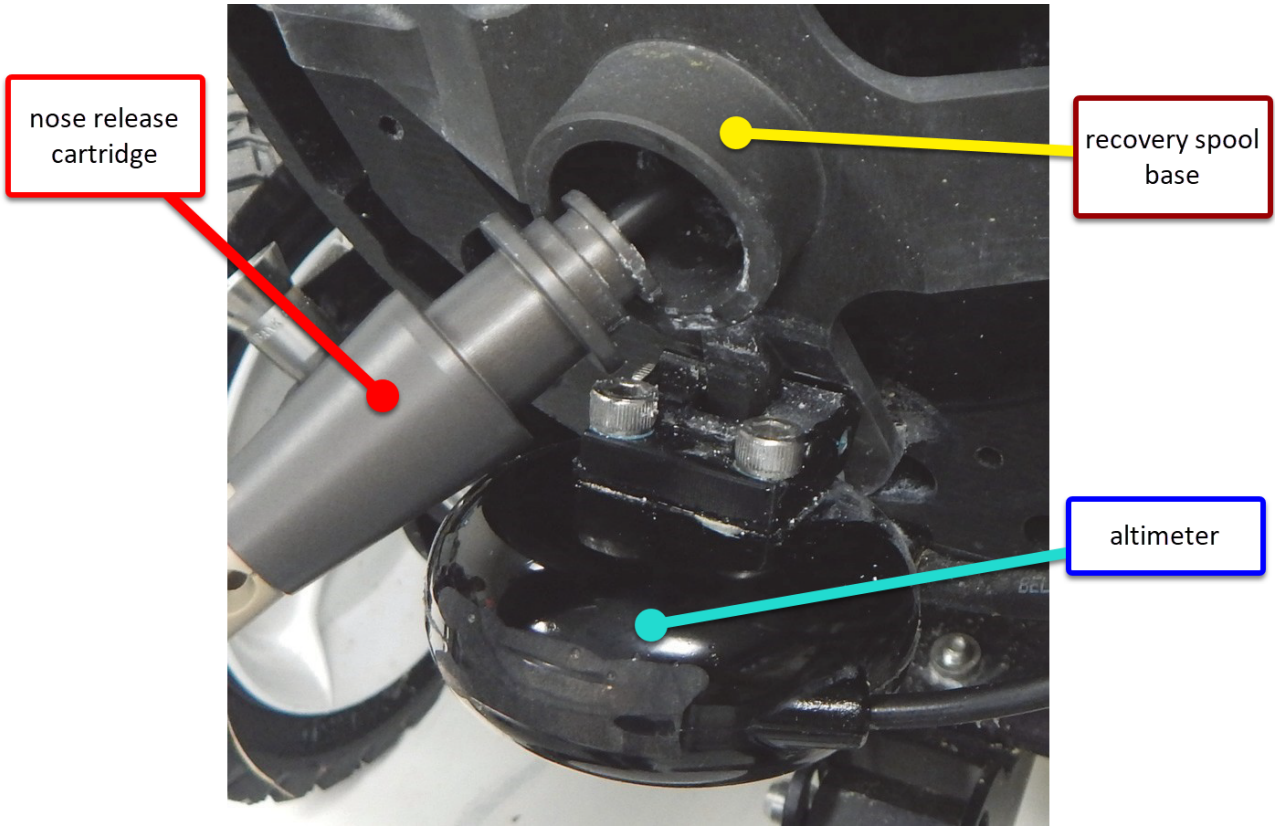

Figure 15-2: Nose release cartridge wire fed through recovery spool base

2. As shown in Figure 15-3, install the retention clip onto the nose release cartridge under the recovery spool base at the 4 o'clock position.

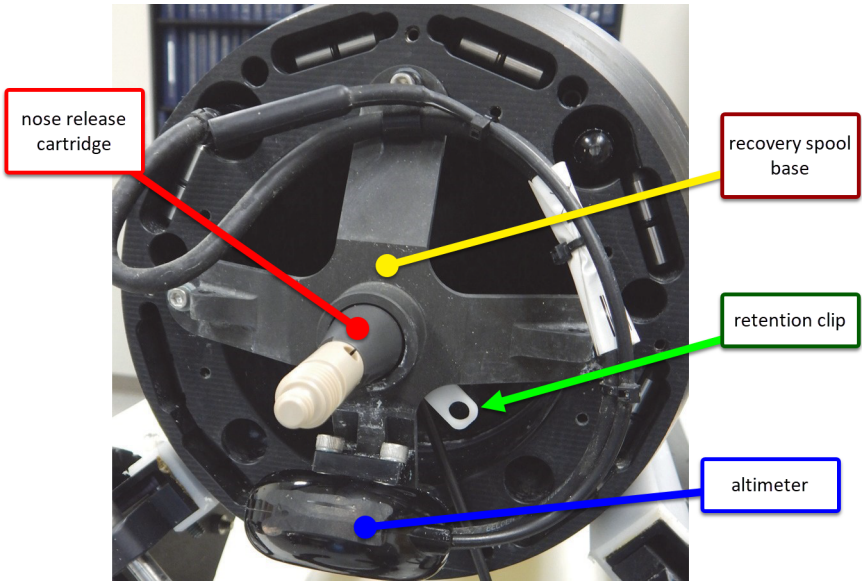

Figure 15-3: Nose release cartridge in recovery spool base, clip at the 4 o'clock position

3. Rotate the nose release cartridge so that the center tab on the retention clip aligns with and inserts into the slot on the cartridge base.

Note

Ensure the cut (sharp) end of the cable tie faces ***away*** from the ballast pump. Otherwise, the sharp end of the cable ties can puncture the ballast pump's bladder.

4. Connect the nose release cartridge connector to the altimeter and secure the wire with nylon cable ties.
5. Secure the wire to the hole on the end of the retention clip tab with a cable tie.
6. Slide the recovery spool assembly with line (*see* Figure 15-1 on page 15-1) over the nose release cartridge, as shown in Figure 15-4:

Figure 15-4: Recovery spool over the nose release cartridge

7. Tighten the spool nut (*see* Figure 15-5) to the nose release cartridge until it is flush with the end of the large threads, as shown in Figure 15-5:

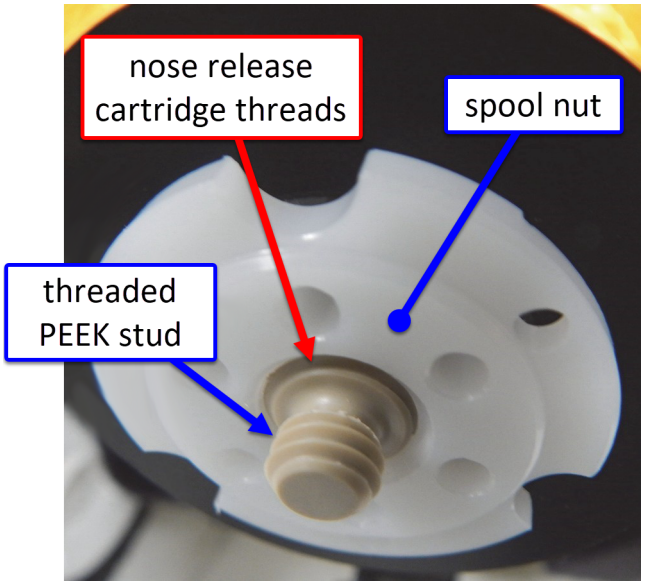

Figure 15-5: Spool nut goes onto the nose release cartridge threads

The spool should rotate easily.

8. Install the end loop of the line closest to the base through both shackles (*see* Figure 15-1 on page 15-1), as shown in Figure 15-6:

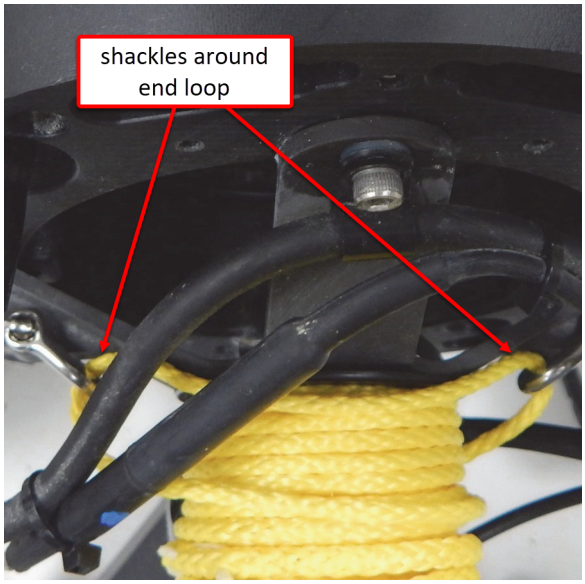

Figure 15-6: Line's end loop through both shackles

9. Attach the shackles to the recovery spool base.
10. Attach a cable tie to the spool nut and the forward loop on the recovery spool assembly, as shown in Figure 15-7:

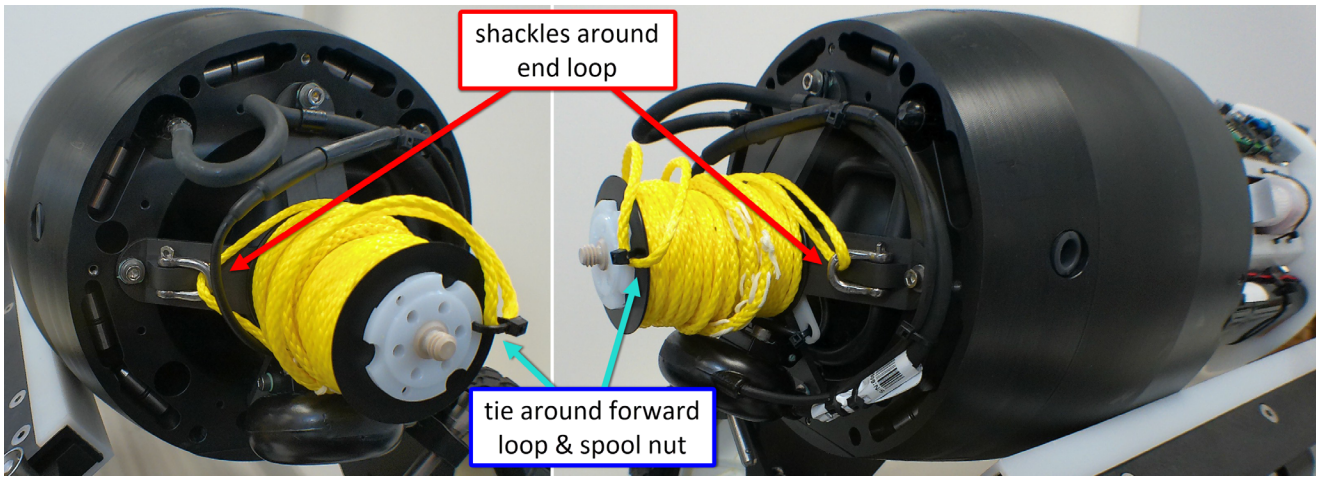

Figure 15-7: Cable tie through spool nut and forward loop

11. Tighten the zip tie to secure the line to the spool nut (*see* Figure 15-1 on page 15-1).
12. Hold the spool nut, and rotate the spool to take up any excess slack in the recovery line.

CAUTION

Failure to remove the rubber band or other device securing the line could result in the line recovery system's failure.

13. Remove the rubber band or other device securing the line during shipping.

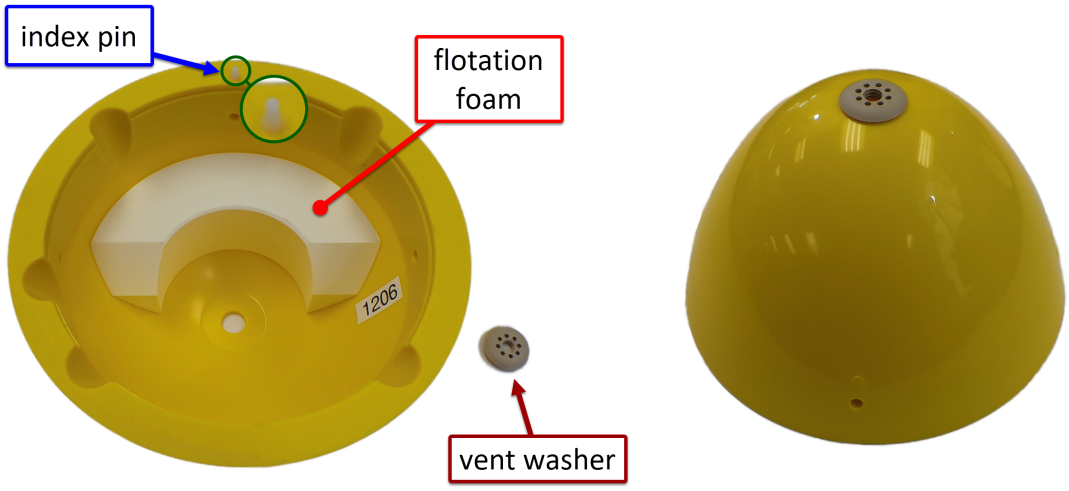

Figure 15-8: The buoyant nose cone and vent washer, [*inside*] and [*outside*]

14. In reference to Figure 15-8 on page 15-5, line up the buoyant nose cone such that the flotation foam and index pin are on the top side of the glider.

Note

If the buoyant sonar dome assembly will not move into the proper position, reposition the zip ties that are securing the wire harness.

15. In reference to Figure 15-5 on page 15-4 and Figure 15-8 on page 15-5:
    a. Slip the buoyant nose cone over the threaded PEEK stud of the nose release cartridge.
    b. Lightly finger screw the nose cone vent washer onto the threaded PEEK stud so it stays.
    c. Place the ends of a pair of long-nose pliers into opposite holes in the nose cone vent washer.
16. Tighten the vent washer hand-tight.
    The result should resemble Figure 15-9:

Figure 15-9: The buoyant nose cone assembly attached

16 Payload (Science) Bay Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

16.1 Requirements

Tools:	Phillips screwdriver
Materials and parts:	Payload bay assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

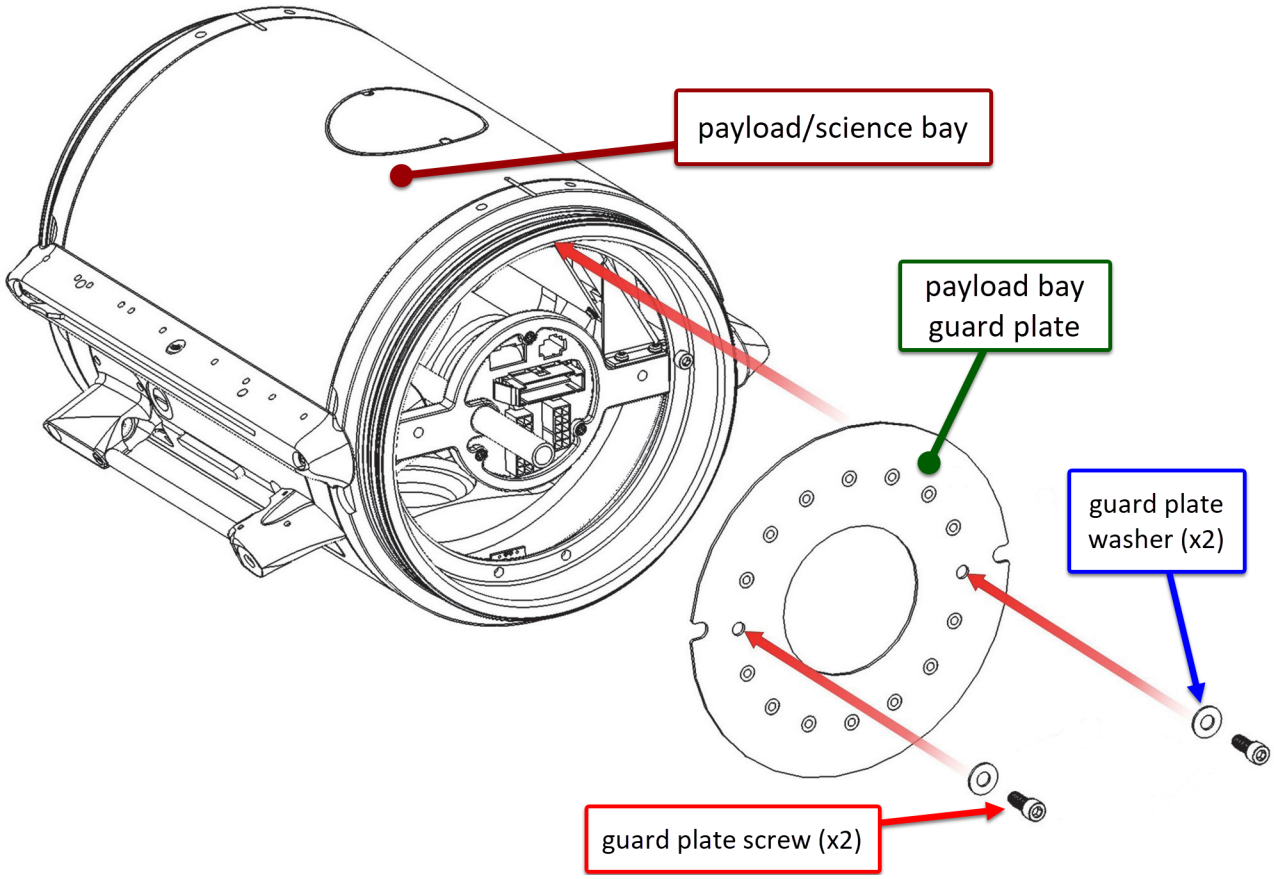

Figure 16-1: Payload bay assembly

16.2 Removing the Payload Bay Guard Plate

CAUTION

If the roll weights are repositioned or replaced, ballasting should be validated.

1. Remove the two guard plate screws and the two guard plate washers from the payload bay guard plate.
2. Remove the payload bay guard plate from the payload bay.

16.3 Installing the Payload Bay Guard Plate

1. Insert the payload bay guard plate into the forward opening of the payload bay.
2. Secure the payload bay guard plate by installing the two guard plate washers and the two guard plate screws into the payload bay guard plate.

17 Wings

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

17.1 Requirements

Tools:	Philips head screwdriver
Materials and parts:	2 Wings
Personnel required:	1 electronics technician

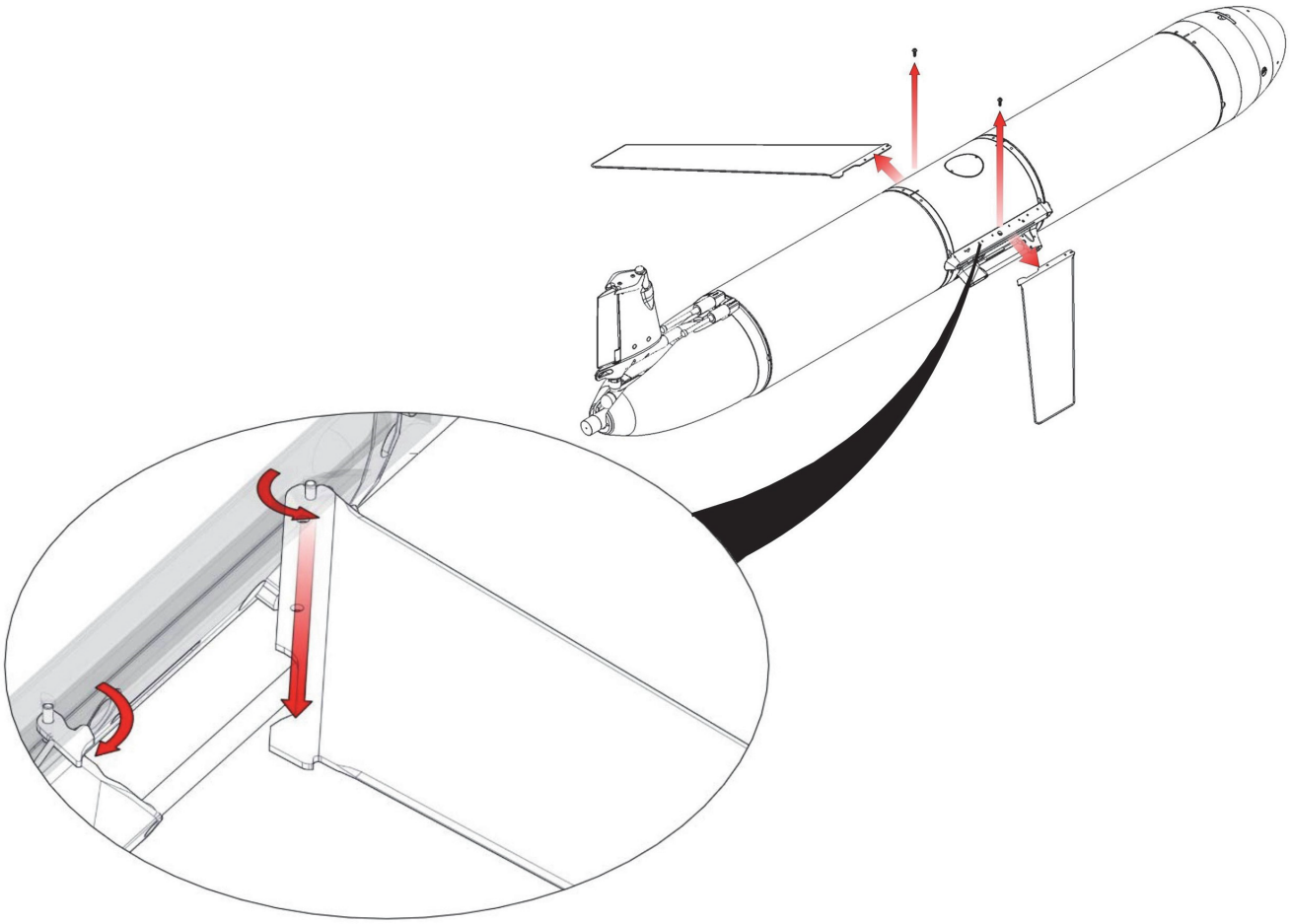

Figure 17-1: Wings

17.2 Removing the Wings

CAUTION

Take care when removing the wings, as they are not buoyant and will sink if dropped in water.

1. Use a Philips head screwdriver to loosen the wing retaining screw on each wing rail, if present.
2. Release the snap-in retaining lever located at the rear of each wing rail.
3. Pivot the wing forward and pull it out of the wing rail slot.

17.3 Installing the Wings

1. Position the slot in the forward end of the wing in the wing rail slot where it will slide around the retaining post.
2. Pivot the wing aft until it snaps into the retaining lever on the aft end of the wing rail.
3. Use a Philips head screwdriver to tighten the wing retaining screw, if present.

18 Aft Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

18.1 Requirements

Tools:	Phillips screwdriver Hull separation tool
Materials and parts:	Aft assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

WARNING

Lithium batteries pose a significant hazard when stored or handled improperly. The two main hazards associated with lithium sulfuryl chloride batteries and their components are fire and explosion, which could occur if the batteries are crushed, punctured, excessively heated, charged, over-discharged, short circuited, or submerged in water in a non-waterproof enclosure.

Lithium sulfuryl chloride cells are safe to handle when all of their components are adequately wrapped and sealed within a stainless steel casing. When that casing is compromised, an immediate danger is present due to exposure of the contents (and byproducts of these contents) with their new environment.

- Lithium metal reacts with water to produce lithium hydroxide, a corrosive liquid and hydrogen gas, which is flammable.
- Sulfuryl chloride (the liquid cathode) is a corrosive liquid that reacts with water to produce hydrogen chloride gas (which is toxic and corrosive) and sulfuric acid, a corrosive liquid.

Remove your jewelry before handling lithium batteries. Wear the appropriate PPE—eye protection and chemical resistant gloves—and while handling lithium batteries.

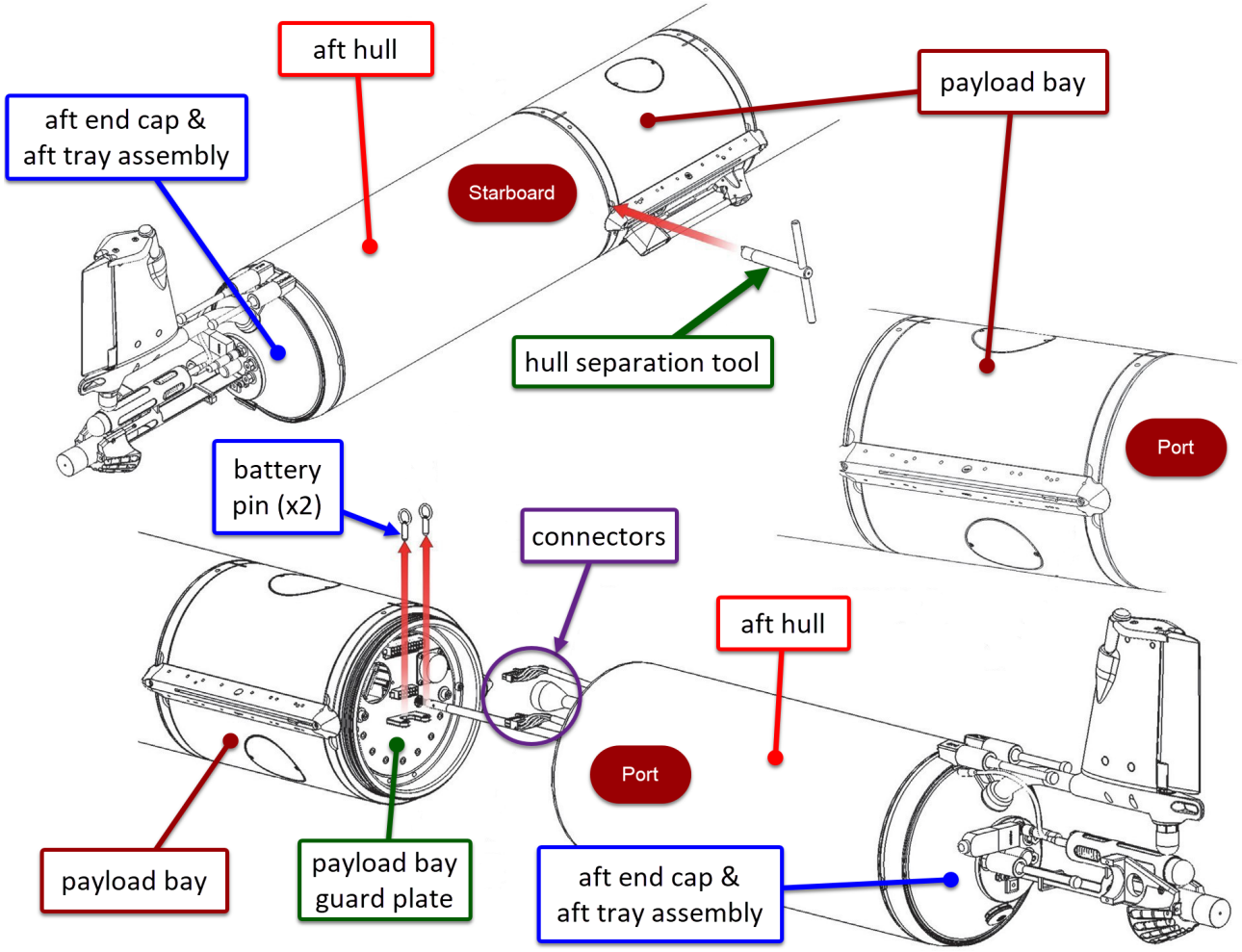

Figure 18-1: Aft assembly

Aft assembly = (aft hull) + (aft end cap & aft tray assembly)

18.2 Removing the Aft Assembly

CAUTION

The aft batteries are heavy and must be supported by the hulls in their respective bays at all times.

If disassembly requires removing hulls or the assembly to which the battery is affixed, the batteries should be removed from the vehicle first, or conversely disconnected and left inside in the hulls while the assembly is removed and worked on.

Perform the following:

1. Separate the aft hull section from the payload bay using the hull separation tool at the location indicated in Figure 18-1 on page 18-2.
2. Disconnect all connectors from the payload bay to the aft hull.

3. If the glider uses lithium batteries, free the aft battery pack from the payload bay by pulling the two battery pins from the battery bracket on the payload bay guard plate.
4. Separate the aft hull section from the aft end cap assembly.

18.3 Installing the Aft Assembly

Note

Refer to "1.10 O-ring Maintenance" on page 1-6.

Referring to Figure 18-1, perform the following:

1. Align the aft hull section with the aft end cap assembly.
2. If the glider uses lithium batteries, secure the aft battery pack to the battery bracket on the payload bay guard plate on the payload bay with the two battery pins.
3. Reconnect all connectors from the payload bay to the aft hull.
4. For final installation, see Chapter 4, "Re-assemble the Glider."

19 Power and Communications Plugs

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

19.1 Requirements

Tools:	None
Materials and parts:	Stop plug (RED) Go plug (GREEN)
Personnel required:	1 electronics technician

19.2 Remove the Stop or Go Plug

WARNING

The glider operator must command the glider to exit, then be instructed by the glider that it is okay to remove the power before the plug can be removed.

If not handled properly, the file system may become corrupt, rendering the glider inoperable.

Before exiting, the operator must instruct the glider to deflate the air bladder.

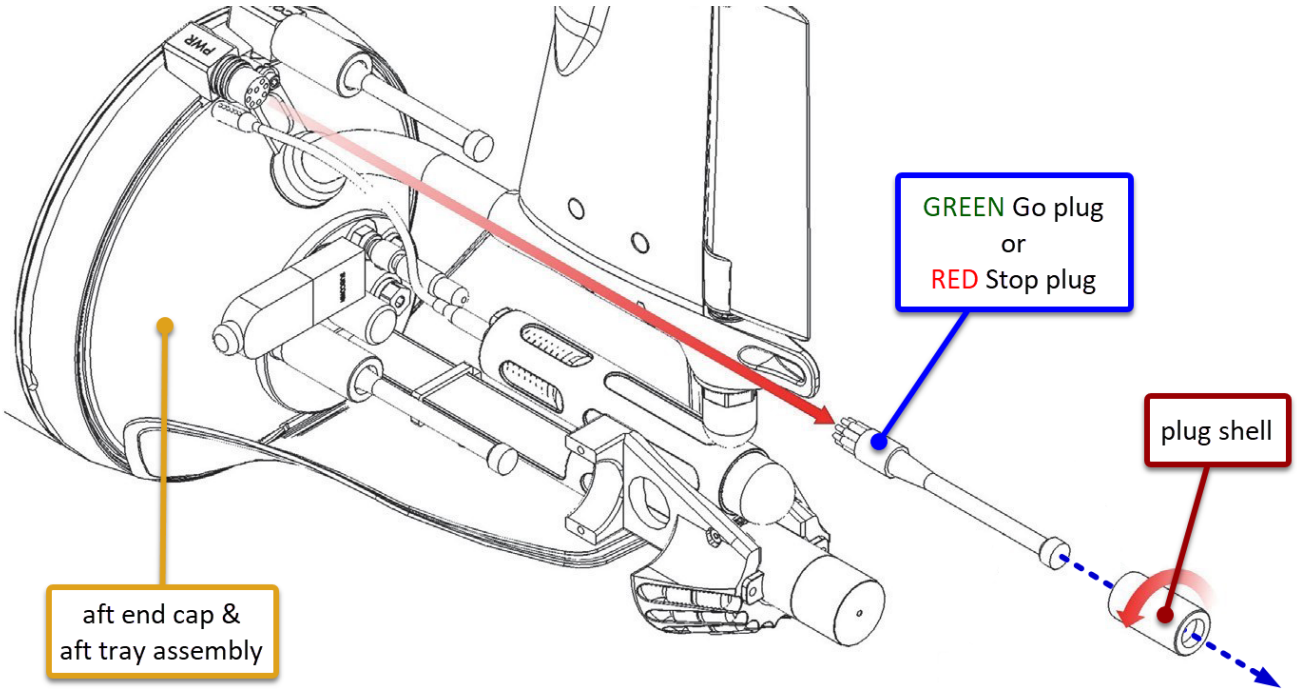

Figure 19-1: The PWR (Power) plugs

Referring to Figure 19-1, perform the following:

1. Unscrew the plug shell that holds in the RED Stop plug or the GREEN Go plug.
2. Pull firmly on the RED Stop plug or the GREEN Go plug to remove it.

19.3 Install the Go or Stop Plug

Note

Once powered ON, the Slocum glider assumes it is deployed. It runs the mission **`initial.mi`** unless communication is established and an operator intervenes.

Before powering the glider, operators must confirm the preferred communications method is both configured and functioning properly. If you are using Dockserver, refer to the *SFMC Users Guide* for more information.

For instructions for configuring FreeWave and a terminal, refer to the *Slocum G3S Glider Operator Manual*.

1. Before installing the RED Stop plug or the GREEN Go plug, ensure that the pins are not bent.
2. Install the RED Stop plug or the GREEN Go plug by pushing firmly until it is seated properly.
3. Screw in the plug shell that holds in the RED Stop plug or the GREEN Go plug.

19.4 Remove the Direct Comms or Dummy Plug

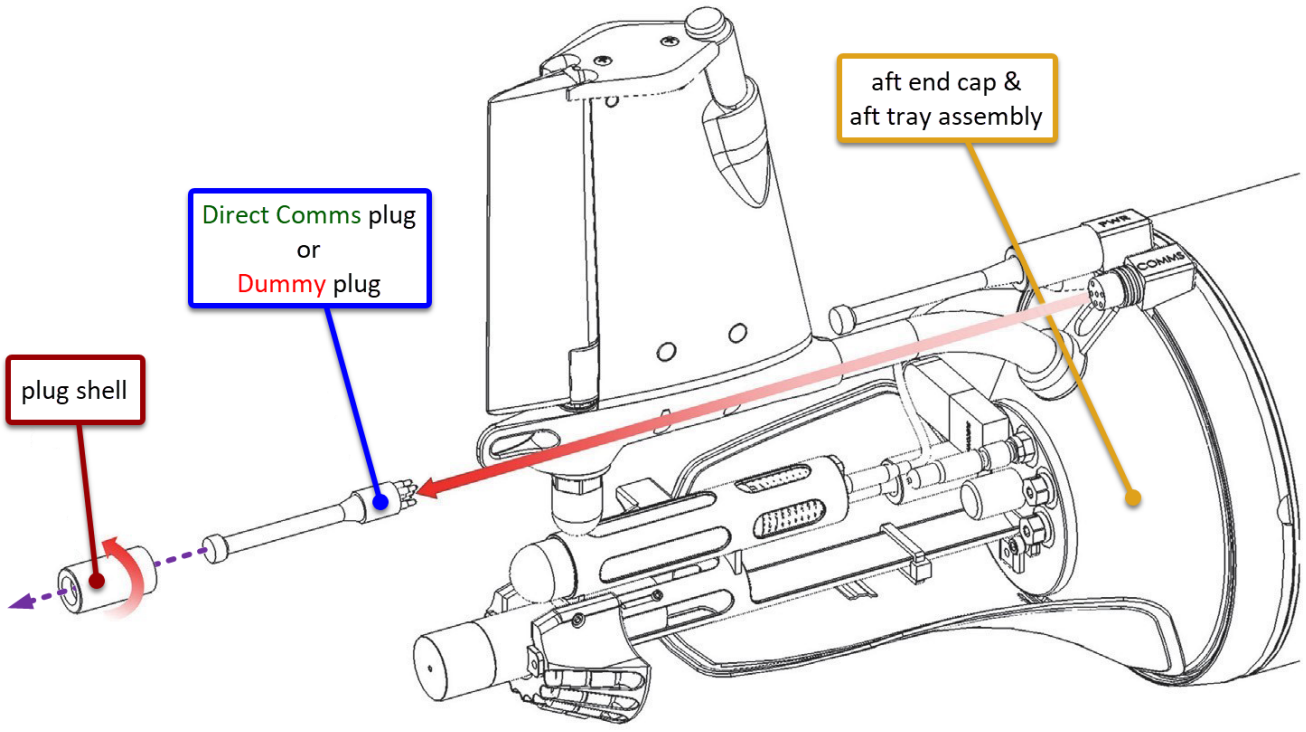

Figure 19-2: The COMMS (Communications) plugs

Referring to Figure 19-2, perform the following:

1. Unscrew the plug shell that holds in the Direct Comms plug or Dummy plug.
2. Pull firmly on the Direct Comms plug or Dummy plug to remove it.

19.5 Install the Dummy or Direct Comms Plug

1. Before installing the Dummy plug or Direct Comms plug, ensure that the pins are not bent.
2. Install the Dummy plug or Direct Comms plug by pushing firmly until it is seated properly.
3. Screw in the plug shell that holds in the Dummy plug or Direct Comms plug.

20 Aft Cowling

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

20.1 Requirements

Tools:	$^{5}/_{32}$" hex wrench
Materials and parts:	Aft cowling
Personnel required:	1 electronics technician

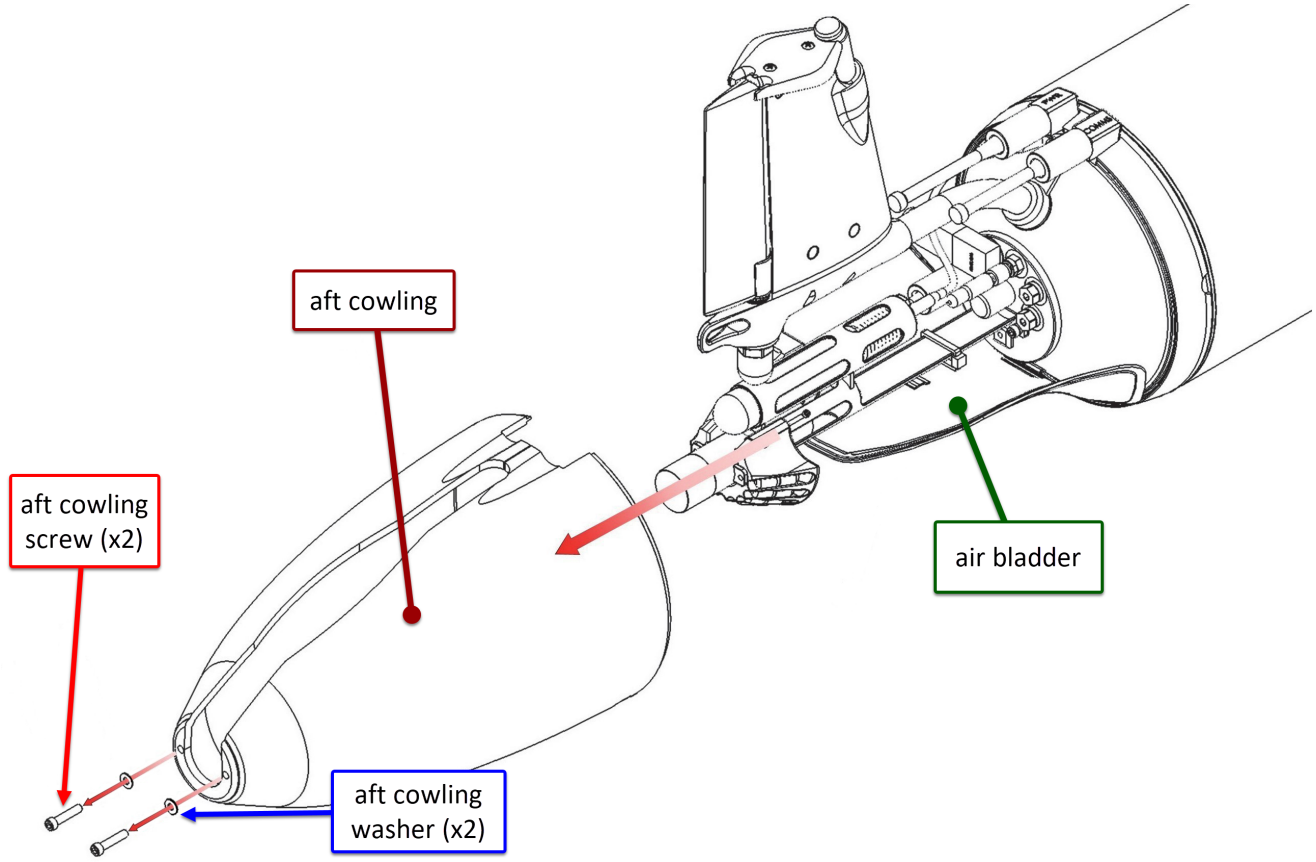

Figure 20-1: Aft cowling

20.2 Remove the Aft Cowling

1. The air bladder must be deflated in order to remove the aft cowling.
   To deflate the air bladder, type the following from `lab_mode` or GliderDOS:

```
put c_air_pump 0
```

2. The glider must be powered down before removing the aft cowling.
3. Turn OFF the power to glider:
   a. Remove the GREEN Go plug or external power cable.
   b. Replace with the RED Stop plug.
4. Remove the two 10-32 socket head aft cowling cap screws and aft cowling washers that hold the aft cowling in place using the $^{5}/_{32}$" x 12" red T-handle hex wrench.
5. Pull the aft cowling back, gently separating it at the top to allow it to slide over the antenna tail fin.

20.3 Install the Aft Cowling

1. Slide the aft cowling forward, gently separating it at the top to allow it to slide over the antenna tail fin.
2. Insert the two 10-32 socket head aft cowling cap screws and aft cowling washers that hold the aft cowling in place.
3. Screw the socket head aft cowling cap screws snugly.

21 Iridium SIM Card

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

21.1 Requirements

When Iridium SIM cards are delivered from the manufacturer, they are configured to work only when the user inputs a personal identification number (PIN, which is set by the manufacturer to 1111).

However, the glider is not equipped to work with PINs and must be reconfigured so that Iridium communications do not require a PIN. This procedure provides step-by-step instructions to properly reconfigure (that is, de-PIN) an Iridium SIM card installed in the glider.

Alternatively, you can de-PIN the SIM card by following the instructions on an Iridium phone handset.

21.2 Set Up SIM Card

Note

Early G3 gliders have *Persistor* processors and use PicoDOS.

Later G3S gliders have *STM32* processors and use GliderDOS.

1. Power ON the glider that is assembled as described in Chapter 4, "Re-assemble the Glider."
2. Install the Iridium SIM card.
3. To access talk iridium, type: **`talk iridium`** in the appropriate DOS (see Note above).

21.3 Check SIM

1. From talk iridium, type:

```
at+clck=?
```

Note

Several other arguments may appear in addition to **`cs`** and **`sc`**, but they are not relevant to this procedure.

2. The Low Band Transmitter (LBT) should respond with ***one*** of the following:

```
+clck:("cs","sc") -or-
+clck:("cs")
```

   If the **`sc`** argument is missing, the SIM card either:
   - Is not properly seated in the LBT, –or–
   - Requires the PIN to be deactivated.
3. If necessary, verify the SIM card is properly seated in the LBT, then repeat the check.

21.4 Deactivate PIN

Note

Perform this procedure while in the glider terminal's serial port perspective.

1. Enter the PIN by typing the command:

```
at+cpin="1111"
```

   (The PIN must be surrounded by double quotes.)

   The LBT must respond with ok.

   If the LBT responds with an error, either the code was typed incorrectly or the PIN has been changed from the factory default.

2. Repeat Step 3 as necessary to attain an ok response to this command.
3. On the terminal, type the command:

```
at+clck=?
```

4. Verify that the LBT responds with +clck:("cs","sc").
5. Type the command:

```
at+clck="sc",0,"1111"
```

   The LBT must respond with ok.

6. Power cycle the LBT.
7. On the terminal, type the command:

```
at+clck=?
```

8. Verify that the LBT responds with +clck:("cs","sc").

   The SIM card is now configured properly.

22 MicroSD Memory Card

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

22.1 Requirements

Tools: Phillips screwdriver

Materials and parts: MicroSD memory card

Personnel required: 1 electronics technician

Equipment condition: Glider is disassembled according to:

- Chapter 2, "Disassemble the Glider"
- "16.2 Removing the Payload Bay Guard Plate" on page 16-2

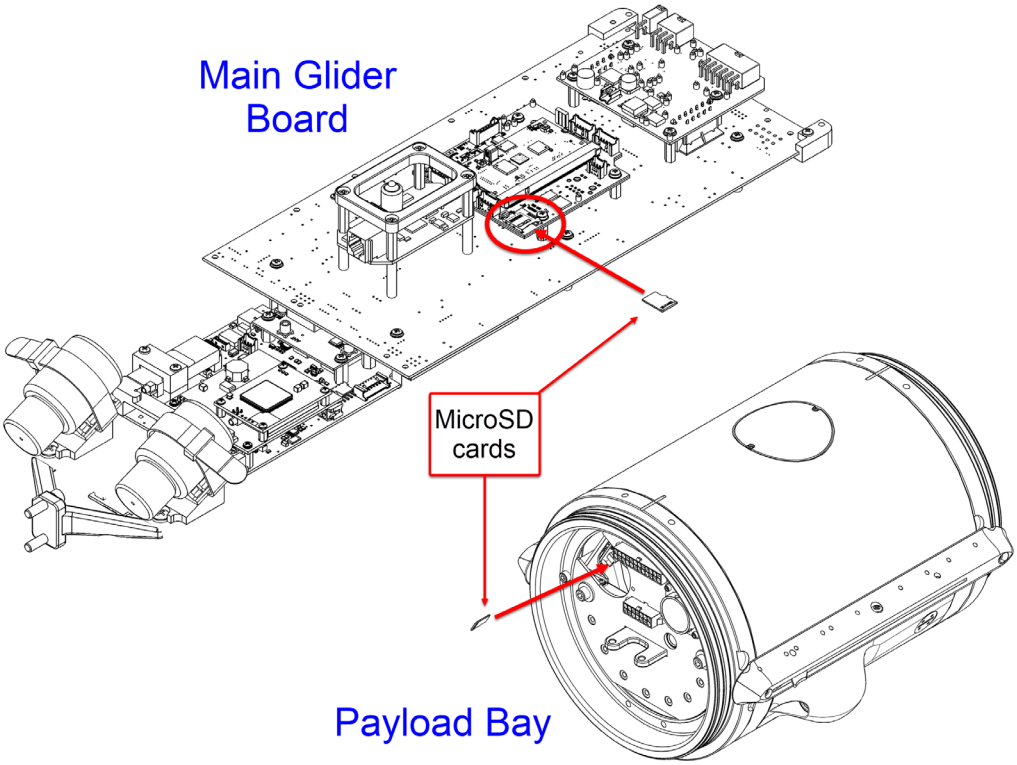

Figure 22-1: MicroSD memory card locations

22.2 Remove the MicroSD Memory Card

CAUTION

Follow standard ESD protocols. While the MicroSD card has built-in ESD protection, the SD card interface to the SOM does not.

Refer to Figure 22-1 for instructions below.

22.2.1 Payload Bay

1. Locate the memory card slot (not shown).
2. Remove the MicroSD card.

22.2.2 Glider Main Board

1. Locate the memory card slot on the main board.
2. Remove the MicroSD card.

22.3 Install the MicroSD Memory Card

22.3.1 Payload Bay

1. Install the MicroSD card.
2. Ensure the memory card's metal contacts are facing down, and slide the card into the slot until it is firmly seated.

22.3.2 Glider Main Board

1. Install the MicroSD card.
2. Ensure that the memory card's metal contacts are facing outward (toward the hull), and slide the card into slot until it is firmly seated.

23 MS Plug

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

23.1 Requirements

Tools:	15 inch-pound torque T-handle 24" extension $^{3}/_{16}$" hex bit
Materials and parts:	MS plug, $^{3}/_{8}$"
Personnel required:	1 electronics technician

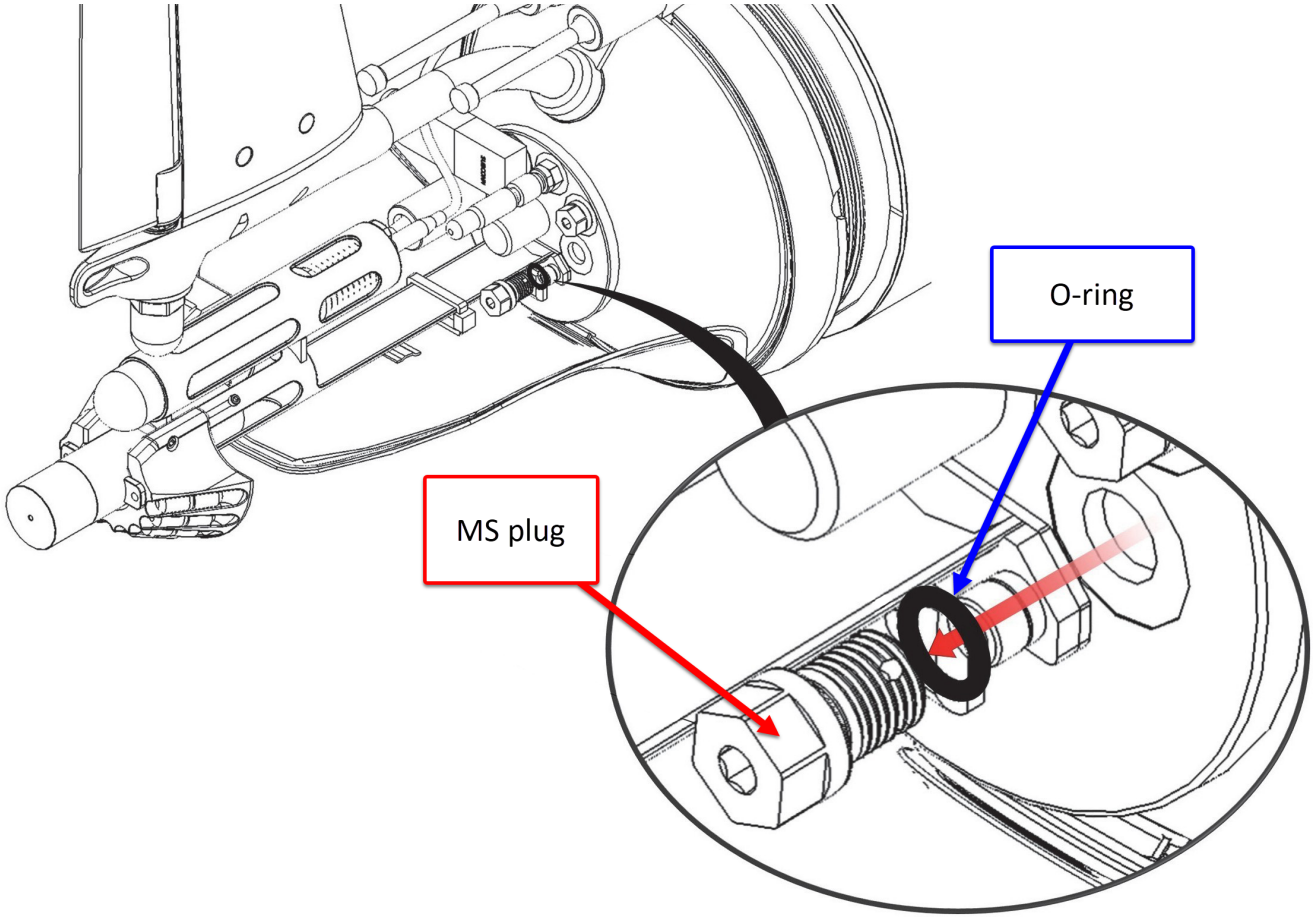

Figure 23-1: MS plug

23.2 Remove the MS Plug

WARNING

Before removing the MS plug, the internal pressure can be read from a terminal. If air is heard rushing out, this may be a sign of released hydrogen gas.

CAUTION

PEEK parts are delicate. Proper tools must be used for PEEK parts and the proper torque applied, otherwise these parts may be damaged.

Note

The MS plug should be inspected for wear and replaced if worn.

1. Using the 15 inch-pound torque T-handle, 24" extension, and $^{3}/_{16}$" hex bit, remove the MS plug.
2. Remove the 3-904 O-ring.

23.3 Install the MS Plug

WARNING

Parker O-Lube: Avoid contact with skin and eyes. If ingested immediately drink two glasses of water, induce vomiting, and seek medical attention. Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used.

CAUTION

PEEK parts are delicate. Proper tools must be used for PEEK parts and the proper torque applied; otherwise, these parts may be damaged.

Note

Petroleum Naphthenic Oil and Barium Soap, such as Parker Fibrous 884-4 O-Lube, are recommended.

1. Inspect the 3-904 O-ring for cleanliness, nicks, slices, scratches, and dents.
2. Lubricate the 3-904 O-ring.

Note

Before installing the O-ring, you must use electrician’s tape to protect the O-ring from being cut by the threads of the MS plug.

3. Install the 3-904 O-ring. Ensure that it is properly seated.
4. Using the 15 inch-pound torque T-handle, 24" extension and $^{3}/_{16}$" hex, install the MS plug on the starboard side of the aft end cap.
5. Tighten the plug to 15 inch-pounds of torque.

24 Attitude Sensor Wiring

24.1 Requirements

Tools:	None
Materials and parts:	Attitude sensor wiring
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

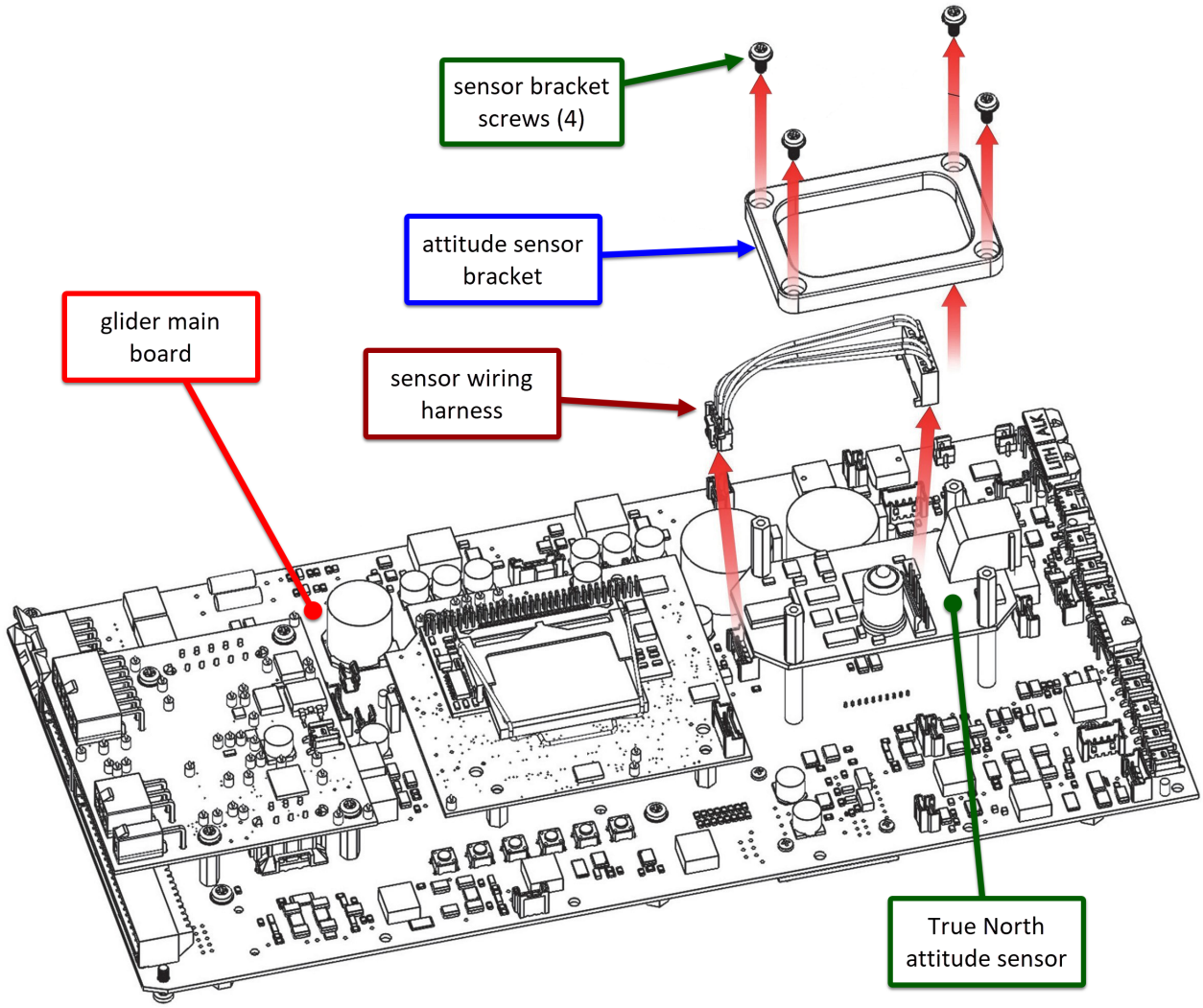

Figure 24-1: Attitude sensor wiring

24.2 Remove the Attitude Sensor Wiring

1. Remove the four sensor bracket screws holding the attitude sensor bracket in place.
2. Disconnect the attitude sensor wiring harness from the glider main board and the True North attitude sensor.
3. Remove the attitude sensor wiring harness.

24.3 Install the Attitude Sensor Wiring

CAUTION

Take care when mating connectors—the pins are delicate.

1. Connect the attitude sensor wiring harness to the True North attitude sensor and the glider main board.
2. Install the four sensor bracket screws to hold the attitude sensor bracket in place.
3. Tighten—but do not overtighten—the four sensor bracket screws.

25 True North Compass Calibration

25.1 Download Files

To download files associated with calibrating the True North compass, perform the following steps:

1. Contact glidersupport@teledyne.com.
2. Download the files Glider Support sends you to your computer.
3. Follow their instructions on where to unzip the files.

25.2 Calibrate the True North Compass

Gliders that use the True North Revolution™ compass require the compass be calibrated to ensure accurate compass readings. The calibration process:

- Compensates for any permanent or induced magnetic fields from the glider
- Must be performed after the compass is installed on the glider

The Compass Calibrator application is available and runs on Windows. The application:

- Uses a Freewave transceiver to communicate with the compass installed on the glider
- Requires no physical connection between the machine running the Compass Calibrator and the glider

You can calibrate a compass without opening its glider.

In addition to its default capability, you can configure the Compass Calibrator application to:

- Read magnetic field components from a file (rather than from the compass)
- Output calculated magnetic offsets and soft iron gains (required for calibrating the compass) to files rather than the compass

To calibrate the compass, perform the steps in **4095-CC** *Compass Calibration*.

26 Weight Release Assembly

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

26.1 Requirements

Tools:	None
Materials and parts:	Weight release assembly
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to Chapter 2, "Disassemble the Glider"

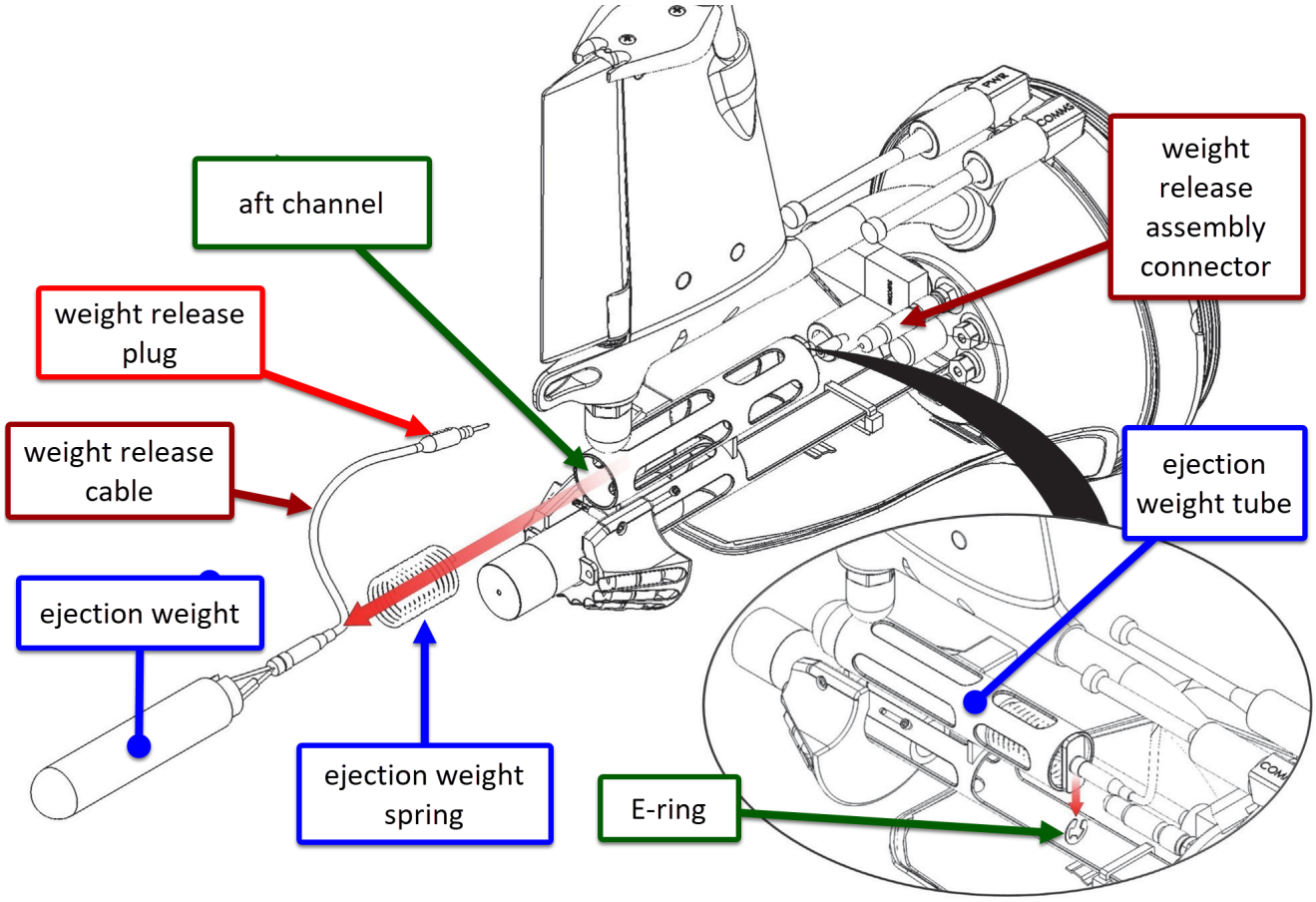

Figure 26-1: Weight release assembly

In reference to Figure 26-1:

- The **weight release assembly** includes the:
  - ejection weight
  - weight release cable and weight release plug
  - ejection weight spring
- The weight release assembly goes inside the ejection weight tube.
- The hollow area inside the tube is known as the aft channel.

26.2 Remove the Weight Release Assembly

CAUTION

The ejection weight is a heavy, spring-loaded object that has the potential to become a dangerous projectile.

Do not stand directly behind the ejection weight while removing or installing the weight release assembly.

When you release the E-ring, the glider releases the ejection weight.

Be careful: Hold onto the ejection weight during this procedure to prevent it from releasing violently.

1. Disconnect the weight release plug from the weight release assembly connector.
2. Remove the E-ring that secures the weight release assembly within the aft channel.

   It may be necessary to relieve pressure on the E-ring by depressing the ejection weight before the E-ring can be removed.
3. Pull the weight release assembly out of the aft channel. (No tools are required.)
4. Ensure the ejection weight spring remains in the aft channel.

26.3 Install the Weight Release Assembly

1. Slip the weight release cable through ejection weight spring into the aft channel.
2. Guide the weight release assembly into the aft channel.
3. Install the E-ring that secures the weight release assembly within the ejection weight tube.
4. Connect the weight release plug to the weight release assembly connector.

26.4 Replace the Burn Wire Assembly

If the burn wire assembly has been used and must be replaced:

1. The air bag must be deflated to easily remove the aft tail cowling. In GliderDOS, type:

```
put c_air_pump 0
```

2. Remove the two 10-32 SHCSs and washers that hold the aft tail cowling in place with a $^{5}/_{32}$" hex driver.
3. Slide the cowling back and around the antenna tail fin.
4. Disconnect the single-pin Mecca connector.
5. From the single-pin male Mecca connector side, remove the burn wire bushing in the jettison weight tube.
6. Remove the E-ring from the new burn wire assembly, complete with the ejection weight attached.
7. Feed the single-pin Mecca connector through the aft end of the ejection weight tube, out the hole on the forward end.
8. With one hand, push the ejection weight into the tube, compressing the ejection weight spring. At the same time, feed the Mecca wire through the hole until the burn wire bushing appears.
9. With the face of the burn wire bushing beyond the edge of the hole, slide the burn wide slightly sideways so that it is resting on the crossbar and does not fall back through the hole.
10. Replace the E-ring on the burn wire bushing, seating it fully.
11. Allow the burn wire bushing to fit back through the hole. It will be stopped by the E-ring on the face of the crossbar.
12. Reconnect to the single-pin Mecca connector using Parker O-Lube lubrication (Naphthenic Oil and Barium Soap).
13. Reattach the aft end cowling.

27 Main Hull O-Rings

WARNING

Lifting the glider requires two persons. Failure to comply with this requirement may result in injuries to personnel or damage to equipment.

27.1 Requirements

Tools:	$^{3}/_{32}$" hex wrench
Materials and parts:	Recovery spool base (200/1000M)
Personnel required:	1 electronics technician
Equipment condition:	Glider is disassembled according to: • Chapter 2, "Disassemble the Glider" • "15.2 Removing the Recovery Assembly" on page 15-2

27.2 Remove the Main Hull O-Rings

1. Separate the glider hulls and payload bay.
2. Remove the O-rings.

27.3 Install the Main Hull O-Rings

WARNING

Parker O-Lube: Avoid contact with skin and eyes. If ingested, immediately drink two glasses of water, induce vomiting, and seek medical attention. Keep away from open flames, hot surfaces, and sources of ignition. Fire extinguishers should be readily available when solvent is used.

1. Inspect the O-rings for cleanliness, nicks, scratches, dents, and slices.
2. Lubricate the O-rings with Parker O-Lube.
3. Install the O-rings. Ensure the O-rings are seated properly.

28 Ballasting

28.1 Overview

The glider leaves the factory properly ballasted for the original configuration. Reballasting is required for configuration changes, such as swapping buoyancy module, adding/removing sensor or endurance modules; or if the target water mass will be significantly different.

The goal of ballasting is for the glider to perform optimally in the field. This is accomplished by, in order of importance:

- Adjust glider weight to be neutrally buoyant at the target water surface
- Trim the glider
- Measure glider stability (H-moment)

28.2 Requirements

Tools:	Glider Maintenance Accessory Kit
Materials and parts:	• Glider (200 or 1000 meters) • Ballast tank • Ballast weights - pie and bottle • 2 hanging scales • String (to attach scales and glider) • Dockserver workstation (FreeWave, modem, laptop, mouse) • 4095-GBPSH Glider Ballast Spreadsheet
Personnel required:	2 electronics technicians
Equipment condition:	Glider closed and vacuum set ("5.2 Check and Set the Vacuum on the Glider" on page 5-1)

28.3 Procedure

28.3.1 Set Up Ballasting Spreadsheet

Note

The Ballasting Spreadsheet is used to determine calculations required for ballasting the glider. Avoid copying and pasting cells to prevent deleting or editing formulas.

1. In the Ballasting Spreadsheet, select the Ballast tab.
2. In the first section, use the drop-down menus to enter glider type and add-ons (blue cells) to calculate Total Glider Displacement (Figure 28-1).

Figure 28-1

Figure 28-1: Glider Information for Total Glider Displacement

Glider volume measurement estimates:

Glider Type	Est. Glider Displacement, D_{glider} (L) [a]
G1 (200 m)	52.0
G1 (1000 m)	55.2
G3/G3S (200 and 1000 m)	60.5
Additional science bay	9.0

a. These volume measurements are estimates. Please reference your glider ballast sheet for your glider's displacement.

28.3.2 Connect To and Power On Glider

1. At dockserver workstation, logon and launch SFMC.
2. At the Mission Control menu, select **Glider Terminal Access**, and then select the appropriate glider.

CAUTION

Never power a glider without a vacuum.

3. At glider aft, insert green Go plug to power on glider ("19.3 Install the Go or Stop Plug" on page 19-2).

4. Once the green go plug installed, the glider should automatically boot the glider application. The *sequence initial.mi* countdown prompt displays.
5. Type **Ctrl-C** to prevent the glider from running *sequence initial.mi*. The GliderDOS prompt will display when the glider receives the command.

28.3.3 Verify Vacuum and Prepare Glider to Ballast

CAUTION

Never deploy a glider in **ballast** or **lab_mode**.

1. At GliderDOS prompt:
   a. Type **callback 30** to stop Iridium calls for 30 minutes. Repeat as necessary if more time is needed.
   b. Type **lab_mode on** to put glider in lab mode.
   c. Type **ballast** to set buoyancy pump to 0, set pitch motor to 0, and deflate air bladder.
   d. Type **report clearall** to stop buoyancy pump position output.
   e. Type **report ++m_vacuum** to display glider vacuum every time the sensor updates. Final vacuum should be **6" Hg** for a 50m, 100m, or 200m pump; and **7" Hg** for a 350m or 1000m pump **(+/- 0.2)**. Remove tail cowling and adjust vacuum if necessary ("5.2 Check and Set the Vacuum on the Glider" on page 5-1):
      i. Vacuum too high: Slowly unscrew MS plug to bleed air into the system.
      ii. Vacuum too low: Remove air using the vacuum tool while reporting vacuum values until final vacuum achieved.
      iii. Install tail cowling.
   f. Type **report clearall** to stop reporting vacuum value.
2. If vacuum adjusted, ensure glider tail cowling reinstalled.

28.3.4 Immerse Glider in Ballast Tank

CAUTION

Always ensure glider is properly sealed, vacuum is set and plugged, and all external connectors are dummy plugged prior to immersing in water.

1. Ensure glider is properly sealed, vacuum is set and plugged, and all external connectors are dummy plugged prior to immersing in water.
2. Put glider in ballast tank according to site standard op procedure.
3. Purge the nose cone and aft cover of bubbles, and ensure all exterior air is purged from the glider:

   Gently bump glider nose into tank wall and tap nose and aft cover, and roll glider from side to side until all bubbles are eliminated. HD pumps have a much larger volume that must be cleared of trapped air to ensure proper ballasting.

Note

For gliders with a Seabird CTD, verify no air is trapped within the conductivity cell by gently tapping the side, or flushing with water from a syringe. Air bubbles will affect science data reading.

4. Insert the wings into the wing rails (see Chapter 16, "Payload (Science) Bay Assembly").
   a. If the tank is not large enough to attach the wings, lay stacked wings on top of the aft hull section, aligning the holes of the wings with the aft holes of the wing rails.
   b. Hold wings in place with electrical tape around the hull and wings.

28.3.5 Calculate Glider Total Mass Adjustment

Tank water density is measured using the CTD to calculate mass adjustments required to properly ballast glider for target water conditions. This is calculated in the Tank Water/Target Water section of the Ballasting Spreadsheet (Figure 28-2).

1. At GliderDOS prompt:
   a. Type **Loadmission sci_on.mi**. Science data begins to output to the console. Allow the glider to run for approximately one minute to ensure consistent science output.
   b. Type **Loadmission sci_off.mi**.
2. In the Ballasting Spreadsheet, Tank Water section, enter science output variable values:
   a. In the Temperature field, enter the **sci_water_temp** value.
   b. In the Conductivity field, enter the **sci_water_cond** value.
3. In the Ballasting Spreadsheet, Target Water section, enter the target water temperature, and either density, salinity, or conductivity into the appropriate cells to calculate Total Mass Adjustment (yellow cell).

Figure 28-2

	Tank Water		Target Water		Mass Change	
Temperature and		°C		°C	0.0000	grams
(Density or		g/L°C		g/L°C		
Conductivity or		s/m		s/m		
Salinity)		pss		pss		
Calculated/given Salinity	0.0000	pss	0.0000	pss		
Calculated/given Density	999.8426	g/L°C	999.8426	g/L°C	0.0000	grams
			Total Mass Adjustment:		0.0000	grams

Figure 28-2: Ballasting Spreadsheet, Total Mass Adjustment

Note

The remainder of the ballasting procedure steps through ballasting the glider for the tank, and then making the target adjustment at the end.

28.3.6 Adjust Glider Weight

The Adjust glider weight so that glider is neutrally buoyant in the tank (glider sits level in the tank with the tail fin just below the water line (Figure 28-3).

Figure 28-3

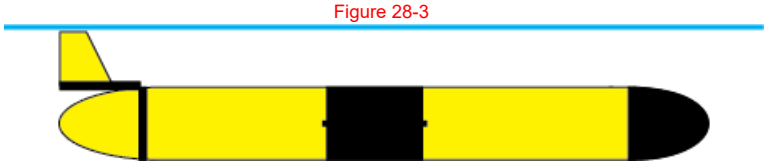

Figure 28-3: Neutrally Buoyant Glider

1. In the ballast tank, suspend the glider from the hanging scales using string tied around the glider at nose base and tail base to determine the weight of the glider in the tank. Allow scale readouts time to settle.
2. If the glider is too light (floating, no weight displays on scales) (Figure 28-4):
   a. Add weight to the hull exterior (directly below both scales) to get a reading on the scales. Note the weight of the forward and aft scales.
   b. Determine weight to be added to the hull exterior, weight in water using either of the following methods:
      - Weigh the added weight in water using the hanging scale, or
      - weigh the weight in air and apply the following correction:

        For stainless steel - external air weight times 0.875 equals the weight in water (internal weight to be added).

        For lead - external air weight times 0.912 equals the weight in water (internal weight to be added).

Figure 28-4

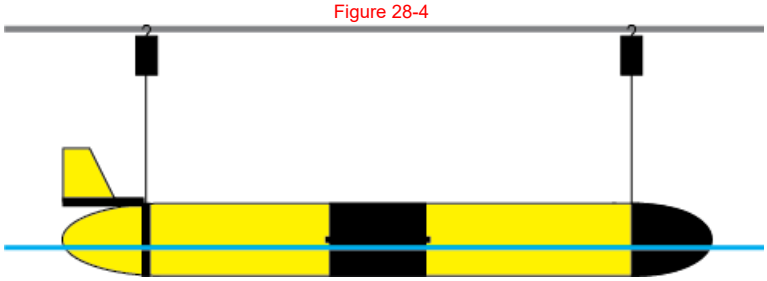

Figure 28-4: Light Glider

3. If the glider is too heavy (sinking, weight displays on scales) (Figure 28-5), note the weight of forward scales and aft scale. These values are used to determine the mass adjustment in the next step.

Figure 28-5

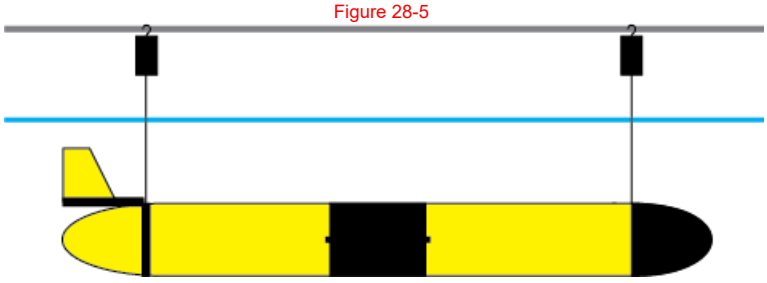

Figure 28-5: Heavy Glider

4. Remove glider from tank, open glider, and adjust the internal mass according to forward and aft weights noted in the previous step.

   Use stainless steel weights (such as pie weights) and shot in ballast bottles to adjust internal mass:

   - The forward hull section has room for two ballast bottles (see Chapter 8, "Ballast Bottles"). Gliders with a 50m, 100m, or 200m buoyancy engine have additional room for ballast in the forward sections such as an additional ballast bottle and stainless steel bar weights.
   - Payload bay forward and aft ends, the aft cap (below the main board), or the front of the energy bay or stack-on payload bay (if installed) can be fitted with pie-shaped stainless roll weights.

5. Close the glider, perform vacuum procedure ("5.2 Check and Set the Vacuum on the Glider" on page 5-1), and repeat weight adjust procedure until glider is neutrally buoyant in tank.

28.3.7 Determine H-Moment

H-moment, or horizontal moment, is the approximate measurement in millimeters of the distance between the center of buoyancy and the center of gravity of the glider. This can be thought of as similar to the measure of stability or righting moment in a boat.

Unlike a boat, a glider requires the distance between the center of gravity and buoyancy to be relatively close. This proximity and fine-tuning of this small distance is a major component of glider flight dynamics and energy consumption. The recommended distance is 4–7 mm between centers of gravity and buoyancy. The pitch motor manages some offset, provided the H-moment is ideally set from 4-7 mm.

Teledyne Webb Research provides two methods to measure the H-moment value. Both methods are outlined in the Ballasting Spreadsheet:

- Roll Method: Adding mass to the glider wing and measuring the change in roll.
- Pitch Battery Method: Commanding the glider to move the pitch battery mass and measuring the change in pitch.

Ultimately, a glider with an H-moment or distance between the center of buoyancy and gravity that is:

- Too far apart: Glider is considered too "stiff" and energy will be consumed by moving the pitch battery greater distances internally. If grossly in error, the glider may not be able to dive and climb at all and only "pancake" through the water column.
- Too close together: Glider is considered too "twitchy" or unstable and energy will be consumed by continually correcting glider pitch. If grossly in error, the glider might flip over.

28.3.7.1 Calculate H-Moment

Note

Glider ***must*** be neutral in the ballast tank before performing H-moment calculation. Calculate H-moment ***before*** making a final mass adjustment.

To calculate the H-moment using the Pitch Battery Method, with the glider powered and neutral in the tank:

1. Type **report ++ m_pitch m_battpos** to display the measured pitch (`m_pitch`) and measured battery position (`m_battpos`) of the glider every CPU cycle in radians and inches, respectively.
2. Follow the instructions for calculating the H-moment on the ballasting and H-moment calculator spreadsheet.

28.3.7.2 Adjust H-Moment

1. A properly ballasted glider will measure between 4-7mm H-moment. For operations that intend to employ heavy thruster use, a higher H-moment (~5.5-7 mm) may be beneficial.
   - To increase the H-moment, the mass should be moved from high to low.
   - To decrease the H-moment, the mass should be moved from low to high.
2. To achieve proper neutral pitch, weights may need to be shifted fore or aft internally. The pie-shaped weights attached to the payload bay are often used to make these adjustments.

28.3.8 Target Adjustment

CAUTION

The weight of the glider must be adjusted when transferred between bodies of water with different densities and temperatures.

1. At this stage, the glider should be neutrally buoyant in the tank, and a target adjustment must be made to adjust the glider to be properly ballasted for the surface of the target water. Use the Target Mass Adjustment calculated in step 28.3.5Calculate Glider Total Mass Adjustment. Figure 28-6 shows the equation used to calculate this adjustment in the Ballast Spreadsheet.

Figure 28-6

$$W = D_{glider}\left[\propto_{glider} P_{target\ water}\left(T_{target\ water} - T_{tank\ water}\right) + \left(\frac{P_{target\ water}}{P_{tank\ water}} - 1\right)\right]$$

Figure 28-6: Weight adjustment between bodies of water

Parameters:

W	= Weight to adjust the glider (g)
D_{glider}	= Displacement of glider (assumed to be equal to the glider's weight)
α_{glider}	= Thermal coefficient of expansion for the glider (= 53.5 x 10^{-6})
$P_{target\ water}$	= Density of target water (in g/L)
$P_{tank\ water}$	= Density of tank water (in g/L)
$T_{target\ water}$	= Temperature of target water (in °C)
$T_{tank\ water}$	= Temperature of tank water (in °C)

Part II: Parts and Equipment Returns

29 Parts List and Equipment Returns

29.1 Ancillary Glider Equipment

This equipment is shown in the table below:

Table 29-1: Ancillary Glider Equipment

Equipment Type	Description
Ballast tank	Minimum size: 8' (2.5 m) long x 4' (1.2 m) X 3' (1 m). This is for a manual setup of the glider. A way to get the glider in and out of the tank (i.e., an overhead winch, a low enough tank to go over the side, or some lifting device).
Vacuum pump	Thomas model #2688CE44, available from Grainger (Grainger item #5Z350) or equivalent, to pull the glider's vacuum.
Gram scale	0-2 kg; to measure the internal ballast.
Hanging gram scale	To measure the weight of the glider in the ballast tank.
Lead shot or ballast material	—
Iridium account	See Appendix F in the *Slocum G3S Glider Operator Manual* for more information.
Argos account and ID	See Appendix G in the *Slocum G3S Glider Operator Manual* for more information.
Land phone line	To receive Iridium satellite or RUDICS (introduced in 2008 and is available for data transfer).

29.2 Returning Equipment for Repair or Refurbishment

Note

Never return equipment without first requesting and receiving an RMA and return instructions.

1. Before requesting an RMA, contact Teledyne Webb Research Customer Support at glidersupport@teledyne.com to discuss the issue, in case it can be resolved remotely.
2. If the issue cannot be resolved remotely, submit an RMA request at the following link:
   http://www.teledynemarine.com/webb-research/rma/

29.2.1 Typical Crate Dimensions

Note

All large crates (APEX and GLIDER) must be metal banded.

Teledyne Webb Research ships APEX and GLIDER by air. We strongly discourage truck transport over long distances due to the likelihood of additional damages during shipping.

These dimensions are shown in Table 29-2 below:

Table 29-2: Typical Crate Dimensions

Product Type	Crate Dimensions
Slocum glider Glider (large gray shipping crate)	95" x 29" x 34" @ 429 lbs If returning the glider with lithium batteries installed, follow IATA shipping, labeling, and documentation requirements.
Slocum glider glider battery crate (alkaline)	34" x 12" x 12" @ 70 lbs
Slocum glider glider lithium battery box	1 UN certified cardboard box 34" x 27" x 15" @ 80 lbs If returning lithium batteries, follow IATA shipping, labeling, and documentation requirements.

29.2.2 Additional Instructions

This section applies to gliders or anything else that requires more information.

Gliders

Use the original shipping crate. Ensure both black ratchet straps are securely fastened around the glider and are firmly holding the glider and cart into the brackets.

- If the glider either has leaked or is suspected of leaking, and may contain seawater, please remove the seal plug for shipping.
- If no leak is suspected, please return the gliders with the appropriate vacuum set.

For deep gliders, fully retract the oil.

If you are in any doubt or need any additional assistance, contact customer support at glidersupport@teledyne.com.

Part III: Appendices

A Abbreviations and Acronyms

This appendix includes the abbreviations and acronyms pertaining to Slocum gliders.

Table A-1: Abbreviations and Acronyms

Abbreviation or Acronym	Description
AC or ac	Alternating Current
ASSY	Assembly
BAM	Beam Attenuation Meter
CTD	Conductivity/Temperature/Depth
COTS	Commercial Off-The-Shelf
DC or dc	Direct Current
DG	Dangerous Goods
GLMPC	Glider Mission Planning and Control
GMC	Glider Mission Control
GPS	Global Positioning System
IR	Infrared
ISO	International Organization for Standardization
ISU	Iridium Subscriber Unit
LNA	Low Noise Amplifier
MS Plug	Military Standard vacuum seal plug
MSDS	Material Safety Data Sheet
OC	Operations Center
OEM	Original Equipment Manufacturer
QCP	Quality Control Process
PEEK	PolyEther Ether Ketone
PPE	Personal Protective Equipment
RHEL	Red Hat Enterprise Linux
RHN	Red Hat Network
RUDICS	Router-based Unrestricted Digital Internetworking Connectivity System
SE	Systems Engineering
SHCS	Socket Head Cap Screw
SN	Serial Number
SOP	Standard Operating Procedure
SSL	Secure Sockets Layer
STE	Secure Telephone Equipment
TWR	Teledyne Webb Research
U.S.	United States
USB	Universal Serial Bus
UUV	Unmanned Undersea Vehicle
VAC	Volts Alternating Current

B Magnetic Field Components Example

This appendix includes an example of what a generated list of magnetic field components looks like (see Chapter 25, "True North Compass Calibration" for details).

A typical file contains over 3,000 lines.

B.1 Shortened Example List

Revolution Data:

0	0	2845	4736	10364	0
0	0	2845	4736	10364	0
0	0	2777	4645	10323	0
0	0	2773	4654	10303	0
0	0	2905	4816	10380	0
0	0	2825	4695	10312	0
0	0	2852	4815	10300	0
0	0	2820	4752	10338	0
0	0	2755	4814	10246	0
0	0	2800	4919	10329	0
0	0	2700	4900	10253	0
0	0	2790	5001	10241	0
0	0	2832	5118	10312	0
0	0	2740	4976	10258	0
0	0	2661	5008	10234	0
0	0	2746	5075	10221	0
0	0	2695	5145	10308	0
0	0	2641	5120	10232	0
0	0	2621	5292	10291	0
0	0	2586	5187	10232	0
0	0	2513	5291	10212	0
0	0	2459	5338	10337	0
0	0	2294	5394	10262	0
0	0	2297	5452	10249	0
0	0	2275	5624	10337	0
0	0	2108	5580	10236	0
0	0	2073	5691	10235	0
0	0	1977	5760	10315	0
0	0	1882	5824	10226	0
0	0	1918	5989	10220	0
0	0	1867	5977	10185	0
0	0	1805	6148	10152	0
0	0	1707	6149	10201	0
0	0	1558	6143	10197	0
0	0	1415	6165	10199	0
0	0	1502	6309	10280	0

0	0	1255	6250	10247	0
0	0	1114	6233	10238	0
0	0	1168	6377	10263	0
0	0	1051	6356	10320	0
0	0	943	6316	10300	0
0	0	959	6395	10319	0
0	0	905	6424	10386	0
0	0	627	6375	10311	0
0	0	552	6503	10397	0
0	0	427	6468	10350	0
0	0	302	6478	10339	0
0	0	258	6610	10438	0
0	0	137	6576	10353	0
0	0	46	6629	10336	0
0	0	-14	6696	10349	0
0	0	-115	6725	10384	0
0	0	-254	6718	10334	0
0	0	-325	6739	10331	0
0	0	-335	6873	10337	0
0	0	-565	6808	10331	0
0	0	-691	6820	10314	0
0	0	-641	6944	10409	0
0	0	-858	6844	10375	0
0	0	-987	6852	10341	0
0	0	-1086	7002	10382	0
0	0	-1205	6906	10396	0
0	0	-1335	6831	10374	0
0	0	-1386	6853	10373	0
0	0	-1386	6863	10402	0
0	0	-1657	6783	10402	0
0	0	-1778	6723	10391	0
0	0	-1782	6825	10485	0
0	0	-1874	6737	10462	0
0	0	-1988	6665	10464	0
0	0	-2137	6695	10486	0
0	0	-2245	6588	10538	0
0	0	-2480	6543	10491	0
0	0	-2529	6576	10568	0
0	0	-2710	6470	10529	0
0	0	-2720	6494	10506	0
0	0	-2895	6382	10552	0
0	0	-3033	6364	10537	0
0	0	-3050	6333	10531	0
0	0	-3042	6390	10655	0
0	0	-3152	6279	10592	0
0	0	-3277	6237	10575	0

0	0	-3333	6234	10601	0
0	0	-3591	6047	10592	0
0	0	-3642	5998	10583	0
0	0	-3746	5896	10692	0
0	0	-3871	5844	10648	0
0	0	-3872	5811	10649	0
0	0	-3900	5856	10708	0
0	0	-4016	5652	10682	0
0	0	-4091	5570	10670	0
0	0	-4151	5580	10692	0
0	0	-4208	5500	10749	0
0	0	-4408	5316	10725	0
0	0	-4371	5319	10744	0
0	0	-4512	5128	10756	0
0	0	-4641	5039	10740	0
0	0	-4624	5048	10757	0
0	0	-4649	4995	10825	0
0	0	-4767	4880	10796	0
0	0	-4744	4792	10821	0
0	0	-4774	4756	10887	0
0	0	-4922	4562	10827	0
0	0	-4913	4552	10819	0
0	0	-4995	4479	10910	0
0	0	-5118	4335	10845	0
0	0	-5214	4289	10854	0
0	0	-5136	4170	10900	0
0	0	-5182	4046	10875	0
0	0	-5224	3995	10859	0
0	0	-5186	3964	10925	0
0	0	-5240	3838	10918	0
0	0	-5311	3711	10921	0
0	0	-5313	3620	10914	0
0	0	-5238	3632	10956	0
0	0	-5283	3377	10975	0
0	0	-5350	3264	10959	0
0	0	-5257	3288	11051	0
0	0	-5314	3180	11084	0
0	0	-5344	3049	11017	0
0	0	-5296	2975	11045	0
0	0	-5313	2845	11061	0
0	0	-5304	2673	11047	0
0	0	-5305	2620	11061	0
0	0	-5324	2521	11154	0
0	0	-5371	2439	11080	0
0	0	-5399	2341	11081	0
0	0	-5291	2269	11128	0

0	0	-5296	2158	11116	0
0	0	-5236	2090	11182	0
0	0	-5281	1931	11208	0
0	0	-5347	1857	11124	0
0	0	-5308	1784	11121	0
0	0	-5253	1818	11177	0
0	0	-5288	1709	11209	0
0	0	-5282	1555	11139	0
0	0	-5278	1504	11116	0
0	0	-5192	1316	11188	0
0	0	-5203	1226	11160	0
0	0	-5186	1115	11146	0
0	0	-5019	1139	11264	0
0	0	-5011	1045	11256	0
0	0	-4924	840	11196	0
0	0	-4869	844	11268	0
0	0	-4918	567	11221	0
0	0	-4853	500	11223	0
0	0	-4736	502	11292	0
0	0	-4708	404	11269	0
0	0	-4702	318	11239	0
0	0	-4579	258	11293	0
0	0	-4529	94	11249	0
0	0	-4602	25	11254	0
0	0	-4500	-73	11238	0
0	0	-4359	-55	11319	0
0	0	-4328	-200	11277	0

. . . and so on.