

Winch 150P User Guide

Winch Plugin 2.9.0 & earlier

Item Number: 10009

Revision 03

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Contents

Revision History	iii
Section 1: Introduction	1
1.1 Basic Specifications	1
1.2 Sample Use Cases.....	1
Section 2: Safety.....	3
2.1 Technical Background	3
2.2 Terminology	3
2.2.1 Major Assemblies.....	3
2.2.2 Software and Firmware Components.....	4
2.2.3 Estimated Depth from Surface	5
2.3 Handling Recommendations.....	6
2.3.1 Handling on Land	6
2.3.2 Comparison to Home or Office Power System	7
2.3.3 Handling with the Sinker Removed	7
2.3.4 Handling in Water	8
Section 3: Operations.....	9
3.1 Pre-Launch	9
3.1.1 Configuring the Winch Plugin	9
3.1.2 Pressurize Components	11
3.1.3 Thin Line Inspection	13
3.1.4 Calibrating the Winch	13
3.1.5 Payload Installation.....	14
3.1.6 Preparing for Launch.....	14
3.2 Launch.....	15
3.2.1 Launch from Rapid Deployment Stand	16
3.2.2 Launch from a Legacy Stand	21
3.3 Recovery.....	25
3.3.1 Recovery with a Rapid Deployment Stand	25
3.3.2 Recovery with a Legacy Stand.....	29
3.4 Post-Recovery	31
3.4.1 Rinse Vehicle	32
3.4.2 Remove Biofouling.....	32
3.4.3 Motor Creep.....	32
3.4.4 Soak Winch	33
3.4.5 Store Winch	33

Section 4: Mission Operations and Planning	34
4.1 Payloads	34
4.2 Piloting Restrictions	34
4.2.1 Station Keeping	34
4.3 Manual Piloting	35
4.4 Status Indicators	35
4.4.1 Winch Vehicle Page Updates	37
Section 5: Commands	38
5.1 WGMS Standard Commands	38
5.1.1 Auto Cast Cycle	38
5.1.2 Auto Power on Sinker Payload Port	38
5.1.3 Auto Power on Thin Line	38
5.1.4 Get Last Winch Status	38
5.1.5 Get Plugin Version	39
5.1.6 Get Power Requestor Info	39
5.1.7 Get Sinker Payload Port State Including Auto Power On	39
5.1.8 Get Thin Line State Including Auto Power On	39
5.1.9 Get Winch Configuration	39
5.1.10 Go Home	39
5.1.11 Go to Estimated Depth from Surface	39
5.1.12 Power Off Sinker Payload	40
5.1.13 Power Off Thin Line / Thin Line Off	40
5.1.14 Power On Sinker Payload	40
5.1.15 Power On Thin Line / Thin Line On	40
5.1.16 Set Segment Configuration	40
5.1.17 Status	40
5.1.18 Status Report	41
5.1.19 Stop and Brake	41
5.1.20 Winch On	41
5.1.21 Winch Off	41
5.1.22 Zero Count	41
5.2 WGMS Expert Commands	41
5.2.1 Calibrate Sinker PT Sensor	41
5.2.2 Clear Auto Power Thresholds	42
5.2.3 Config Report	42
5.2.4 Force Power Off	42
5.2.5 Get Auto Power Off Threshold (Watt Hours)	42
5.2.6 Get Device Connection Info	42

5.2.7 Get Device Power Dependency Information	42
5.2.8 Get Internal Pressure	42
5.2.9 Get Motor Controller Status	42
5.2.10 Get Sinker PT Sensor calibration offsets.....	42
5.2.11 Get Water Leak Detection Status	42
5.2.12 JSON Status Report	42
5.2.13 Pay In OR Out By Cable Length From Winch	43
5.2.14 Pay In To Stop	43
5.2.15 Powercycle	43
5.2.16 Release Brake (WARNING: Do NOT use in water)	43
5.2.17 Reset Sinker PT Sensor calibration to default.....	43
5.2.18 Set Auto Power Off Threshold	43
5.2.19 Set Min and Max Working Lengths.....	43
5.2.20 Set Motor Controller Power	43
5.2.21 Set Powercycle delay	43
5.2.22 Set Umbilical Length Configuration	43
5.2.23 Set User Serial Configuration	44
5.2.24 Toggle Channel Routing	44
5.3 Vehicle Webpage Commands	44
5.3.1 Auto Cast (1)	44
5.3.2 Auto Cast (2)	45
5.3.3 Auto Power On Thin Line	45
5.3.4 Auto Pay-In.....	45
5.3.5 Brake Release (WARNING: Do NOT use in water)	45
5.3.6 Disable Auto Pay-In.....	45
5.3.7 Go Home	45
5.3.8 Go to Depth.....	45
5.3.9 Load TSMC Code	45
5.3.10 Pay-In to Stop.....	46
5.3.11 Require Depth Sensor	46
5.3.12 Stop	46
5.3.13 Thin Line On	46
5.3.14 Thin Line Off.....	46
5.3.15 Winch On	46
5.3.16 Winch Off	46
5.3.17 Zero Count	46
5.4 Winch Plugin Variable Definitions.....	46
Section 6: Maintenance	48

6.1 Installation	48
6.1.1 Attaching a Tow Cable	52
6.2 Removing a Winch	55
6.3 Inspection.....	56
6.4 Removing Thin Line without a Winch Rewinder	56
6.5 Installing Thin Line without a Winch Rewinder	59
6.6 Adjusting the Level Wind Position	63
6.7 Detaching Sinker	65
6.8 Pressurize Sinker	67
6.9 Pressurize the Winch Electronics Enclosure	69
6.10 Winch Immersion & Cleaning	70
6.10.1 Immersion Instructions.....	70
6.11 Installing Winch Hammock	75
Section 7: Troubleshooting	82
7.1 Events.....	83
7.1.1 Show that Winch (Domain) is Detected/Active	83
7.1.2 Show that Thin Line (Sinker) PDC Detected/Active	83
7.1.3 Power On Thin Line.....	84
7.2 Alarms	84
7.2.1 Water Leak Alarm	84
7.3 AMPS.....	84
7.3.1 Winch AMPS Domains Very Slow or Not Coming Up (any AMPS domains) or Increase the Winch PDC Polling Interval	84
7.3.2 Winch PDC AMPS domain fails to appear during Winch power on or if the Winch PDC AMPS domain disappears after a successful power on	84
7.3.3 Winch AMPS domain isn't found after umbilical power cycle	85
7.3.4 My Sinker is not visible in the Winch Domain (or indicates that it is unavailable).....	85
7.3.5 My winch will not pay out.....	87
7.3.6 My winch will not pay in	87
7.3.7 My Sinker Payload is Not Turning On and Cannot Communicate with it	88
7.3.8 My winch reports that Sinker depth is X and that cannot be right	90
7.3.9 The Winch is Spooling Out Uncontrolled.....	92
7.3.10 Get Winch Status using WGMS and Interpret Result	93
7.3.11 Test for Thin Line Power On state	94
7.3.12 Test and fix for wrong Thin Line Power parameters.....	94
7.3.13 Test and fix for Thin Line Modem Power not on	94

7.3.14 Test for Thin Line Modem link state	95
7.3.15 Change Depth Sensor Configuration	95
7.3.16 Change Depth Sensor Sample Rate	95
7.3.17 Test and Set Winch Motor Torque Configuration	95
7.3.18 Test for Thin Line Power On state	95
Appendix A. Pre-Launch Checklist	96
Appendix B. Post-Recovery Checklist	97

SECTION 1: INTRODUCTION

The Winch 150P is a Wave Glider accessory that enables operators to deploy sensors at variable depths up to 150 meters. The Winch mounts to the Sub and provides power and communications to subsea payloads.

1.1 Basic Specifications

Available Line Length	Up to 150m
Maximum Payload Power	Up to 10W, 12V DC
Sinker Overhead Power	Up to 3W (not counted in Max Payload Power)
Payload Communications	Ethernet at 10MB/s; RS-232 9600 baud.
Cast Speed*	20 minutes for complete 150m cast
Energy Usage*	8.5Wh for complete 150m cast
Wave Glider Speed Impact*	Retracted: 40%
(with towed acoustic array)	Extended: 80%
Payload Buoyancy	Neutral
Payload Mass (Max)	30 lbf
Winch Weight	29 lbf
Winch Negative Buoyancy	17 lbf
Sinker Weight	20 lbf
Sinker Negative Buoyancy	15 lbf
Thin Line Minimum Bend Radius	30mm
Magnetic Coupling Break-Over Load	100 lbf
Operable Sea State	1 – 5
Service Interval	Between Inspection: 2 months Thin Line Replacement: 3 months Depot: 1 year
Software Version Support	Regulus 3.2 or later, WGMS Legacy only

*These statistics are for a Winch 150P without any payload. Actual performance may vary based on conditions.

1.2 Sample Use Cases

All payloads should be attached to the end of a tow cable connected to the Sinker. This arrangement isolates the variable motion of the Sub and Sinker from the payload. Integrators may use a standard Tow Body.

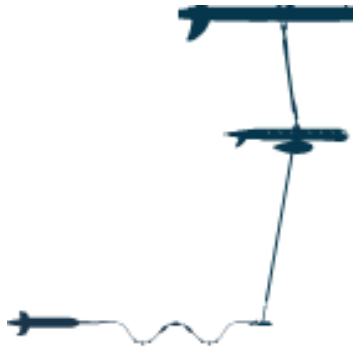


Figure 1. The Wave Glider has a Winch 150P mounted to the bottom of the Sub. A payload (bottom left) is attached via a motion-isolating tow cable to the Sinkers. Figure not to scale.

SECTION 2: SAFETY

The winch is a complex electromechanical system that contains high voltages and other potential safety hazards. It is designed with a variety of safety features; following the guidelines within this document will lead to safe and effective operation.

2.1 Technical Background

The winch transmits high voltage in the Thin Line when the sinker is powered on. Note that the outer conductor of the Thin Line is the low potential conductor.

2.2 Terminology

2.2.1 Major Assemblies

The Winch 150P consists of two major assemblies interconnected by the Thin Line.

2.2.1.1 Sub-Mounted Winch

The sub-mounted, gravity fed winch with approximately 153 meters of Thin Line, 150m of which are usable.

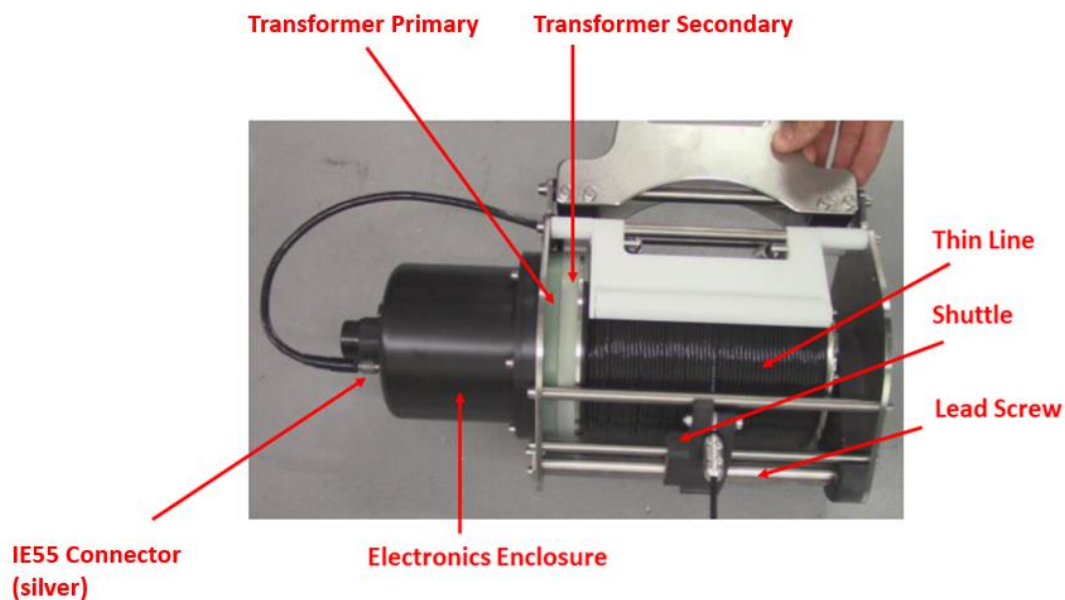


Figure 2. The sub-mounted winch with its sub-assemblies annotated.

2.2.1.1.1 Shuttle, Thin Line, Lead Screw

The shuttle, Thin Line, and lead screw all move during deployment or retrieval of the sinker; as such they represent possible pinch hazards. Do not place fingers, tools or other items near these areas when operating the winch. Ensure clothing or other loose items do not become entangled in these areas.

2.2.1.1.2 Electronics Enclosure

The electronics enclosure contains no high voltage potentials; high voltage is generated by the winch transformer and is galvanically isolated from all other electronic components. Note: the safety sticker on the electronics enclosure is a general warning to those handling the winch and Thin Line rather than a warning of high voltages internal to the winch electronics enclosure.

2.2.1.1.3 Transformer Assembly

The transformer consists of primary and secondary subassemblies. The transformer primary subassembly connects via IE-55 'cable whip' to the winch electronics enclosure (large black plastic enclosure on aft end of winch assembly). The transformer secondary subassembly generates high voltage (limited to approximately 540V with no sinker attached). During normal operation (with sinker attached), the voltage generated by the transformer – and thus present in the Thin Line – is nominally 300V, depending on factors including payload power draw.

Note that the transformer secondary assembly contains capacitors that can store high voltage potential for a significant time (many minutes, possibly hours) if it has been charged during operation. The inner conductor of the Thin Line has a positive potential relative to the outer conductor.

2.2.1.2 Sinker

The Sinker incorporates internal and external pressure and temperature sensors. Payloads can be attached via tow cable attached to the tow cable mounting brackets. See 2.3 Handling Recommendations below for more information.

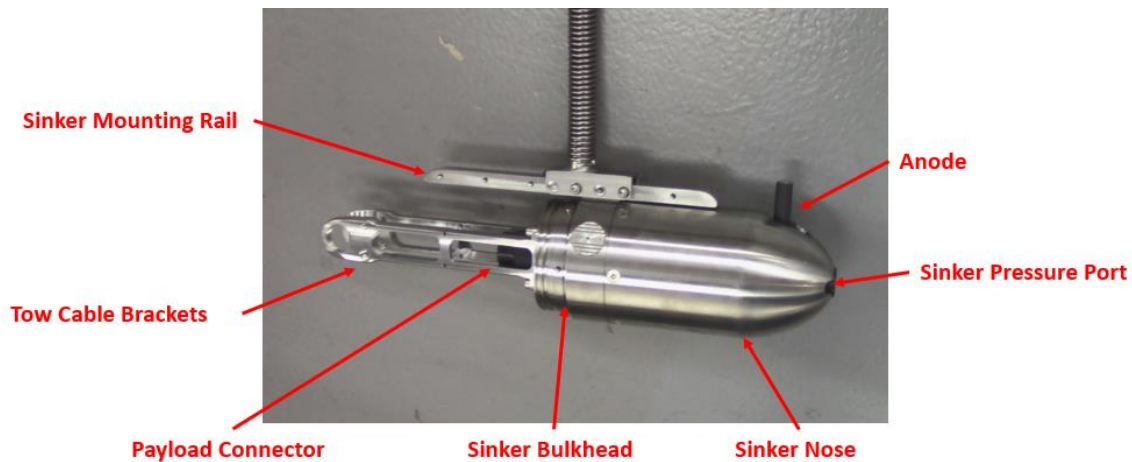


Figure 3. Sinker with components annotated.

2.2.2 Software and Firmware Components

The Winch Plugin runs on the CCU alongside Regulus, and interfaces with the Winch Firmware on the Winch Power Domain Controller via Regulus AMPS. The Winch Plugin implements user-level commands issued from shoreside interfaces. The Winch connects to the T1 port on the Thrudder.

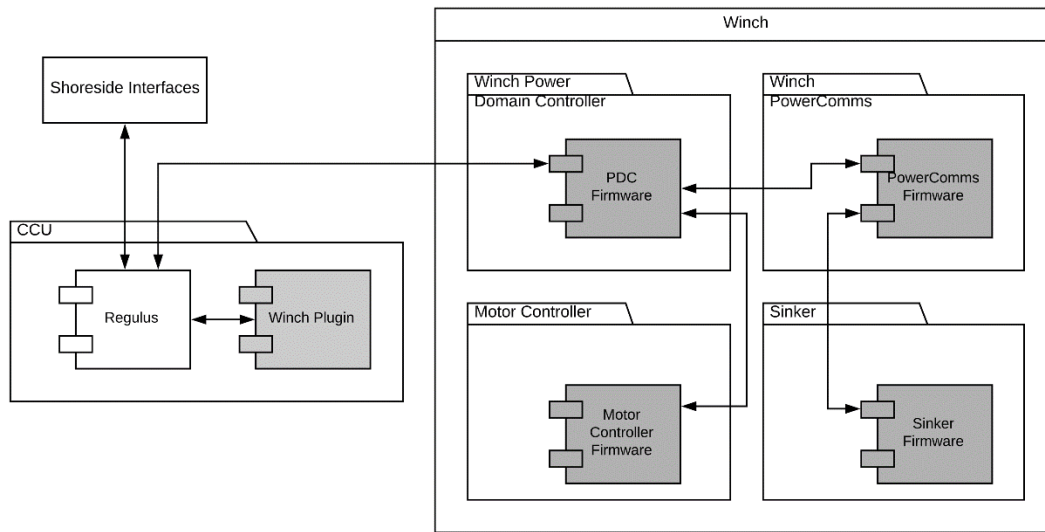


Figure 4. The Winch Plugin implements user-level commands from shoreside interfaces and passes them to the Winch via Regulus.

2.2.3 Estimated Depth from Surface

The Winch Plugin maintains a model of how much cable is payed out at all times. It converts "drum counts" into an estimation of meters of cable payed out, which is then converted to an "estimated depth from the surface" and presented to the user. In its default configuration, the Winch 150P has 150 meters of Thin Line that may be payed out and an additional reserve of Thin Line that remains wound on the drum during all normal operations.

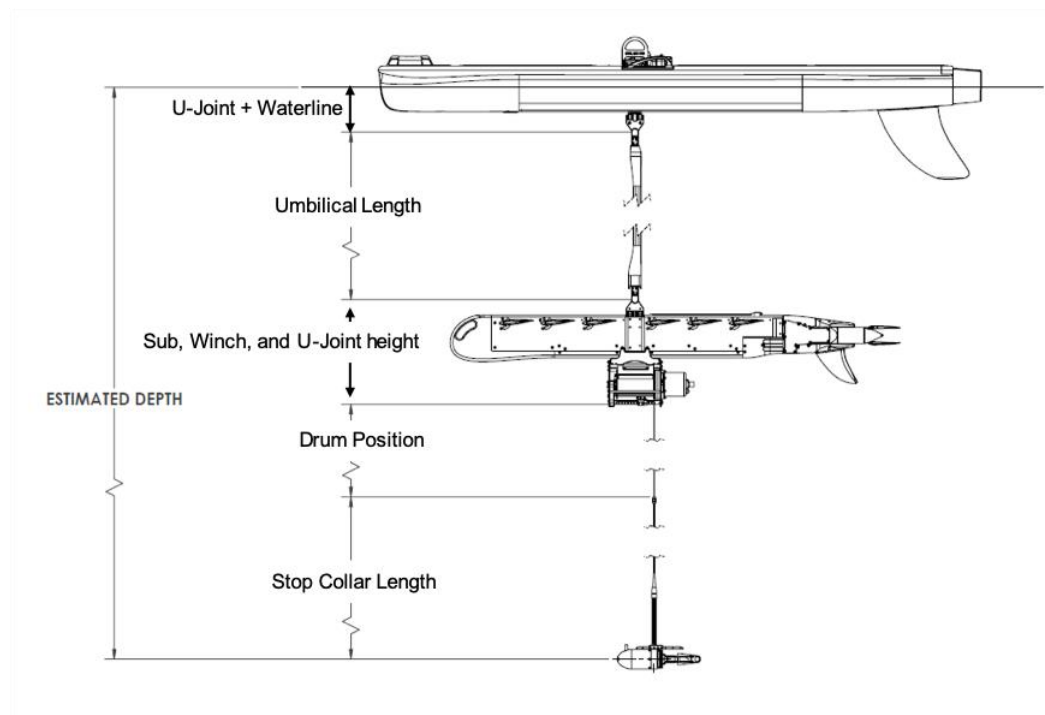


Figure 5. The annotated dimensions are summed to determine an "Estimated Depth from the Surface".

The "Estimated Depth from the Surface" is calculated by adding up the pieces in the above diagram:

- U-Joint and Waterline - 0.3 meters
- Umbilical Length – Default is 8 meters; configurable via an expert SV3 Command
- U-Joint, Sub, and Winch height - 0.7 meters
- Cable Length from Drum Position
- Stop Collar Length - 2 meters

Given the above calculations and a normal 8-meter umbilical, the “Home” position would be 11 meters, and the max depth would be 161 meters “Estimated Depth from the Surface”.

2.3 Handling Recommendations

When the blue HV indicator LED on the aft end of the winch electronics enclosure is flashing, the system is generating a high voltage. Liquid Robotics recommends not to handle the Thin Line or sinker when the LED is blinking. However, occasionally operational concerns will require handling of the Winch, Thin Line, or Sinker in this scenario.



Figure 6. Annotation of the components at the aft of the Electronics Enclosure.

It should be noted that shock hazard for DC voltages (and low frequency AC voltages) exists only when there is a significant difference in electrical potential that can be contacted by personnel. This means that simply touching one energized conductor alone does not present a shock hazard. Rather, personnel must contact two different components at significantly different potentials (and have a low enough impedance to allow current to flow in the range of several milliamperes and higher). The sections below address how and when to prevent this scenario from occurring.

2.3.1 Handling on Land

Liquid Robotics recommends handling a Winch on land with similar caution as any cable carrying hazardous voltage. The safest procedure is to power-down the Thin Line before handling. It is particularly important to have the Thin Line powered off during handling if there is a known or suspected fault. If you see or suspect any damage to the Thin Line, avoid handling it while Thin Line power is on. If the Sinker or payload do not require power or communications, you may disconnect the transformer primary from the Electronics Enclosure via the IE-55 connector. See Figure 6. Beware the presence of high voltage.

2.3.2 Comparison to Home or Office Power System

To help clarify the nature of the electrical risk, it should be noted that handling the Thin Line on land is most likely safer than handling an extension cord plugged into a wall socket, something many people routinely do without a second thought. Some explanation of the physics behind this statement follows.

The AC power supply in most buildings in the USA is ground referenced; the relatively low voltage power distributed within a building (e.g. 120V, 240V) is generated by the secondary of a step-down transformer. Typically, the secondary is connected locally to earth ground. This creates a situation that can lead to electrocution through a ground fault. Personnel may come in contact with a live conductor while also in contact with earth ground (which could be a piece of metal grounded to earth, a water pipe, the water itself, or another conductor at ground potential). To mitigate this risk new construction requires the use of Ground Fault Circuit Interrupter (GFCI) equipment on circuits where a user may contact an energized conductor and a grounded object (e.g. kitchens, bathrooms, outdoors). The GFCI senses an imbalance in the current on the hot and neutral wires and quickly disconnects the circuit from the source, preventing electrocution.

In contrast to the typical home/domestic AC power supply, the voltage generated by the winch transformer is not ground referenced when on land. The rotary transformer winding is isolated from ground by design; it is “floating”. Even if there were a fault in the transformer, it should not be in contact with earth ground when the Wave Glider is on land. The Winch is typically mounted to the glider, which is typically on electrically insulated stand or cart, without a direct connection to earth ground. The floating nature of the winch high voltage provides some inherent safety protection. A single connection between the Thin Line outer conductor and personnel doesn't offer a path for hazardous current flow - there needs to be another connection. For this reason, the Winch's floating power supply provides a degree of safety not present in most home/domestic and commercial/office power systems.

2.3.3 Handling with the Sinker Removed

It was noted above in Section 2.2.1.1.3 Transformer Assembly that the transformer assembly contains capacitance. In normal use, when the transformer has a Thin Line and sinker attached, this capacitance will quickly discharge when the Thin Line is powered off. However, if Thin Line power is turned on, but no sinker is attached at the end of the Thin Line, the capacitance in the Thin Line and rectifier assembly can remain charged. The energy stored in this charged capacitance is around 0.15 Joules. While this energy is unlikely to pose an electrocution risk, it is enough to produce a painful shock similar to that from an electric fence (although just a single pulse when Thin Line power is off, whereas an electric fence is typically excited with repetitive pulses).

Due to this capacitance, if working with a Thin Line or transformer secondary that has been powered without an attached sinker assembly, handle with extra caution. The capacitance can be discharged, with power off, by shorting the two conductors at either end of the Thin Line (at the sinker assembly or at the transformer assembly). When in doubt, measure the potential with a meter both before and after discharging to ensure the discharge was successful.

In addition to concerns of charged capacitance noted immediately above, the Thin Line should not be powered (turned 'on') without a Sinker electrically connected to the Thin Line. If the Thin Line is powered for any significant period without being electrically connected to the Sinker, damage to Winch electronics may result.

2.3.4 Handling in Water

When the winch is in the water and the Thin Line is powered on, avoid direct contact with Thin Line, sinker, and winch transformer assemblies, and avoid having personnel in the water. If faults are present in Winch components, handling the Winch while in the water may result in exposure to an electrical potential.

In the unlikely event that personnel are in the water when the line is powered on, they should avoid being within a few meters of the Thin Line when at depths between that of the Winch and Sinker. So long as personnel are at least one meter above the Winch or one meter below the Sinker, personnel should not be at risk. This is because the path of current should be along the length of, and somewhat parallel to, the Thin Line. (The prior scenario assumes that the sinker is hanging below the winch, as would normally be the case when in operation in the ocean – if the winch system were in a pool or test tank (where the sinker may be laterally displaced from the winch, then the relative safe zones will be different – avoid human contact/exposure in these cases)

SECTION 3: OPERATIONS

This section discusses the required procedures during normal operation of a Winch on a Wave Glider. These tasks are to be conducted in addition to normal operating procedures for a Wave Glider. Liquid Robotics recommends that the Winch is inspected after each 2 months of water time. See 6.3 Inspection for more details.

3.1 Pre-Launch

Pre-Launch procedures consist of:

1. Configuring the Winch Plugin
2. Change Steering Mode

3.1.1 Change Steering Mode

A Wave Glider with a Winch has reduced steering authority, so it is necessary to utilize proportional steering instead of low-power steering.

1. Log into the vehicle webpage.
2. Go to **Operate > Enter Script Command**.
3. Enable Expert Commands by clicking the box next to **Show Expert Commands**.
4. Find the **rudderParametersManager** section.
5. Click on **Change Steering Configuration**.
6. In the text field, enter **PROPORTIONAL** and click **Confirm**.
7. Disable Expert Commands, or refresh/close the page.
3. Pressurize Components
4. Thin Line Inspection
5. Calibrating the Winch
6. Payload Installation
7. Preparing for Launch

A checklist for these steps can be found in **Appendix A**.

Liquid Robotics recommends using Google Chrome to operate the Regulus vehicle page, as some features do not function properly with Firefox.

3.1.2 Configuring the Winch Plugin

Configuration of Winch settings via the Winch Plugin should be done with care. If unsure, skip this step and leave the default values.

1. Log into the vehicle webpage.
2. Go to **Config>Miscellaneous**
3. Go to **Winch_winch** section.
4. Liquid Robotics recommends only making changes to the following values as necessary:

Table 1. LIQUID ROBOTICS recommends reviewing these values during Pre-Launch.

Item	Description	Advisory	Default Value
Polling Interval	The time delay between status readings (1s..10m) over the CAN bus.	If the Wave Glider has many devices, payloads, and APUs, a short polling interval for the Winch 150P can result in decreased responsiveness for the other devices. In this case, consider adjusting the polling interval to between 30s and 60s. Setting this value to lower than 10s for in-water missions is not recommended. Increasing this setting would not impact shore-side users.	10 seconds
Umbilical Length	The length of the installed umbilical (meters) is used to calculate minimum Sinker depth.	Change this only if you have an umbilical that is NOT 8 meters.	8 meters
Expansion Port	The name of the device that controls power to the Winch.	Change this if the winch is being operated through another port during maintenance, etc.	T1
Segment Length	The maximum amount of winch cable that can be payed out without pauses. This value will be ignored if any of the following are true: • The value is 0. • The value exceeds the maximum working length or usable line length. Note: Shore-side users may set the segment length	Change this value if it is desirable for the winch to stop at shorter lengths for instrument measurements, etc. It should be set at default or less to reduce chance of Thin Line entanglement.	25 meters

	through an SV3 Command and this value will be enforced. See 5.1.1 Auto Cast Cycle		
Inter-Segment Wait Time	The duration the Winch pauses after paying out the amount of Thin Line specified by Segment Length.	The wait time allows for the Sinker and Payload, if attached, to settle at depth and tension the Thin Line. Shorter wait times may result in Thin Line entanglement or inaccurate readings of Estimated Depth From Surface.	60 seconds
Minimum Working Length	This Thin Line length will be used as the most reeled in position. Greater or equal to 0.	Use this for mission-specific depth control.	0 meters
Maximum Working Length	This is the maximum amount of Thin Line that can be payed out. This must be less than the Usable Line Length.	Use this for mission-specific depth control.	150 meters
Announcement Interval	The minimum interval between event announcements (5m...1hr) during an auto cast.	Consider increasing for missions in which frequent announcements result in high Iridium costs or a flooded Iridium channel.	5 minutes

3.1.3 Change Steering Mode

A Wave Glider with a Winch has reduced steering authority, so it is necessary to utilize proportional steering instead of low-power steering.

8. Log into the vehicle webpage.
9. Go to **Operate > Enter Script Command**.
10. Enable Expert Commands by clicking the box next to **Show Expert Commands**.
11. Find the **rudderParametersManager** section.
12. Click on **Change Steering Configuration**.
13. In the text field, enter **PROPORTIONAL** and click **Confirm**.
14. Disable Expert Commands, or refresh/close the page.

3.1.4 Pressurize Components

The Winch and Sinker have leak detection systems that generate alarms as a result of changes in pressure or the presence of water. The pressures identified below have been selected to minimize the likelihood of leaks developing. The pressures that the Winch controller and the Sinker controller report may be used to determine if there is a leak in either system. Both report absolute pressure and temperature values. Those values can be used in an equation ($\frac{P_1}{T_1} = \frac{P_2}{T_2}$ for an approximation of an ideal gas behavior, where P is pressure in Pascals and T is temperature in Kelvin.) to determine if the amount of air has changed. This is not (yet) automated.

Absolute pressure and temperature limits may be set within each device, and when exceeded it will trigger an EMCY message and show in the port's status bits that a fault was detected.

3.1.4.1 Winch Pressurization

The Winch Electronics Housing should be pressurized to 16 to 18 psi (110 – 124 kPa) gauge pressure using dry nitrogen to prevent condensation. It is not necessary to adjust for temperature. At the end of an 8m umbilical, water pressure will be approximately 13 psi (90 kPa). While on mission, the pressure acting on the seals should always be in the same direction. Reversing once upon launch is acceptable. See Section 6.8 Pressurize Sinker.

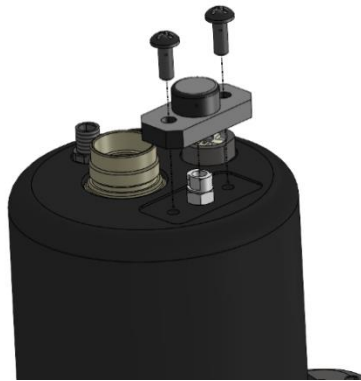


Figure 7. Exploded diagram of pressure port cover on Electronics Housing.

3.1.4.2 Sinker Pressurization

See Section 67. The Sinker should be vacuumed to a pressure between -5.8 to -8.7 psi (-40 to -60 kPa) gauge pressure. Access pressure valve by removing two M5 x 12mm 02517-05-012 screws and removing pressure port cover 07853.

The pressure inside the Sinker should always be lower than the pressure outside. When the Sinker is fully retracted, the water pressure outside the Sinker will reach about 27 psi (185 kPa) absolute. As the Sinker goes deeper, the water pressure will increase, increasing the pressure differential inside and outside the Sinker. The pressure acting on the seals should always be in the same direction. However, reversing once upon launch is acceptable.

After pressurization, the components should be left in a cool place out of the sun for 12 hours. After 12 hours or more have passed, check for a change in internal pressure via the Winch Plugin.

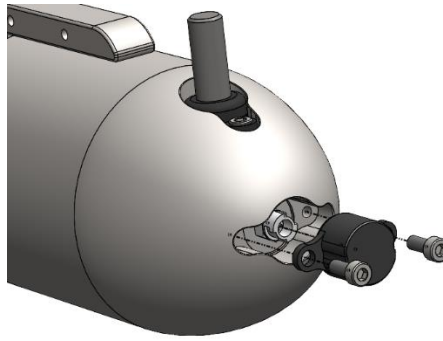


Figure 8. Exploded diagram of pressure port cover on Sinkers.

3.1.5 Thin Line Inspection

The Thin Line closest to the Sinkers is most prone to damage during operation and should be inspected for damage before use. This step should be performed using a clean container with no sharp edges, like a plastic 5-gallon bucket.

1. From the Winch Plugin, turn off the brake. Listen for it to disengage.
2. Place the Sinkers into the container.
3. Using as constant tension as possible, slowly unspool about 6m of Thin Line from the Winch into the container. While doing so, inspect the Thin Line for obvious twists, nicks, cuts, or other damage. A slight corkscrew twist near the hard stop is not uncommon and can be used depending on the mission. Contact LR Support with questions.
4. From the Winch Plugin, command the Winch to Pay in to Stop. With your hands, apply light, consistent drag to the Thin Line as it spools onto the Winch.

3.1.6 Calibrating the Winch

The Winch drum count must be properly calibrated to perform correctly when paying out the Thin Line.

When handling a Winch with a powered on Thin Line, be sure to follow proper safety precautions as described in 2.3 Handling Recommendations.

1. On WGMS or the Winch plugin on the vehicle webpage, turn on the Winch (Winch On).
2. Check if the stop on the Thin Line is flush or nearly flush with the level wind on the Winch.
 - a. If the stop is flush or nearly flush with the level wind (within 10cm, 4 inches), proceed to the next step.
 - b. If the stop is not within 10cm (4inches) of the level wind, the Thin Line must be calibrated. A second crewmember should hold the Sinkers and apply constant, light tension to the Thin Line while the first crewmember clicks on “Pay in to Home” or “Pay in to Stop”. Check that the stop on the Thin Line is flush or nearly flush with the level wind. If it is not, repeat the “Pay in to Stop” command.
3. If using WGMS, enable Expert commands.

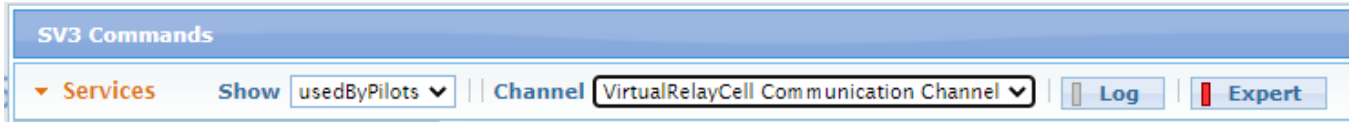


Figure 9. On WGMS, toggle Expert Commands on such that the button indicator is red.

4. Click on “Zero Count”. This will direct the Winch to interpret this drum position as the fully retracted home position.
5. Place the Sinker back in its storage location.

3.1.7 Payload Installation

The payload can currently only be mated with the Sinker via a Tow Cable. Be sure to insert a dummy plug 10361 into the Sinker payload port if not being utilized.

3.1.7.1 Payload Installation on Tow Cable

If a Tow Cable has not been attached to a Sinker, see 6.1.1 Attaching a Tow Cable.

3.1.7.2 Configuring Serial

If a Customer Payload requires a serial connection to the Sinker payload port, it must be configured after a Wave Glider is power cycled, as the configuration is not persistent. There are a series of 5 commands that need to be sent to the Winch and Sinker. These configure the Winch serial and turn on the serial port. Below are Write Console Scripts that can be sent manually via WGMS or can be automated by a Customer Payload, if desired. The Winch and Sinker must be powered on prior to sending these commands. The Winch 150P supports 9600 baud.

- Configure and Turn On User Serial
 - `%amps.writePortFields("Winch",192,11,7,"0x800<bbbbbb>")`
 - `<bbbbbb>` = Baud Rate in hex. 9600 = 02580
 - Enables this UART to run at 9600, 8, N, 1.
- Configure Winch and Sinker serial UART
 - `%amps.writePortFields("Winch",0,11,60,"0x5555")`
 - `%amps.writePortFields("Winch",192,11,66,"0x5555")`
- Route serial path from Winch PDC to Sinker payload
 - `%amps.writePortFields("Winch",192,11,13,"0x100108")`
 - `%amps.writePortFields("Winch",0,11,13,"0x17042812")`

3.1.8 Preparing for Launch

A Winch-equipped Wave Glider may be launched using a Rapid Stand or a Legacy Stand.

When a Rapid Stand is used with a Winch-equipped Wave Glider, the Winch must be pivoted up to starboard (right) with either a ratchet strap or ‘hammock’ support, before moving the cart. This is necessary to avoid damage to the winch due to the low clearance between the cart and ground. Place the Sinker in the Rapid Stand Storage Box if possible. Be careful not to get the Thin Line caught or pinched.



Figure 10. Wave Glider in Rapid Deployment Stand, configured with Winch and Tow Body, ready for hoisting and transit.

3.1.8.1 Preparing for Launch from a Legacy Stand

When preparing a Wave Glider with a Winch equipped with a Tow Body for loading, unloading, and transit using a Legacy stand, extra straps are necessary to secure the winch and other components. In Figure 11 below, the winch has been secured to the stand to allow more clearance under the winch while rolling. The Sinker has been tucked into the saddle above the winch and secured with a strap. Also, the Tow Body has been strapped to the nose of the float. The strap directly in front of the motion isolator is routed through the winch bracket on the Sub and around only the starboard side of the cart frame in order avoid placing it under the winch housing. With all of these straps in place, the vehicle and stand can be hoisted from the D-ring.



Figure 11. Wave Glider with Tow Body-equipped Winch bundled for loading and transport. Extra straps are used to secure the Winch housing to the cart frame (bottom), the Sinker to the stand, and Tow Body to the Float (top).

3.2 Launch

This section is meant to supplement the official Launch and Recovery Guides for the Rapid and Legacy Stands. This section only covers the additional information necessary if a Winch is added to the Wave

Glider configuration. Please refer to the documents: **Rapid Stand and Crate Launch & Recovery, v100/v200/v300 (10805)** and **Wave Glider SV3 Legacy Stand Launch and Recovery Guide (06135)**

3.2.1 Launch from Rapid Deployment Stand

Please review the associated document: **Rapid Stand and Crate Launch & Recovery, v100/v200/v300 (P/N 10805)**

When launching a Wave Glider with a Winch installed, one dedicated crew member is necessary (minimum) to hold and deploy the Sinker, in addition to the crew member(s) tending to the vehicle. If an acoustic streamer or Tow Body is being deployed, follow the guidance in the **Rapid Stand and Crate Launch & Recovery** document **Section 11 Tow Body Launch and Recovery** (add a second dedicated crewmember). Note that the ideal state for launch of the Winch is with the Thin Line retracted completely to the stop. If this is not possible due to crane dimensions, the Thin Line can be spooled out to accommodate the launch, where the Sinker crewmember carries the Sinker over the freeboard. Extra caution must be taken to protect the payed out section of Thin Line from contact damage on deck and from shock loading when the Sinker is lowered overboard.

1. Verify through either WGMS or the Vehicle web page that power to the Thin Line is OFF for handling. The blue flashing light on the winch body indicates power in the Thin Line and should be in the OFF state.
2. The crewmember dedicated to Sinker handling should put on suitable electric shock protection gloves, which should be worn when handling the Sinker or Thin Line during the entire Launch procedure.
3. Remove the strap holding the winch to the cart frame and rest the winch body on the ground or a piece of foam (some vehicles may have a 'hammock' installed which will cradle the winch safely, no action is necessary in this case). Take care to keep the Thin Line away from sharp or abrasive edges, and from being crushed, stepped on, or twisted.



Figure 12. On Rapid Stands without Hammock installed, the Winch must be supported and secured by ratchet strap for loading and transit (A). The strap should wrap around the Sub (B) and support the Winch up to one side (C).



Figure 13. On Rapid Stands with Hammock installed, the Winch is supported and is ready for loading and transit.

4. Inspect the launch and hoisting straps for correct configuration. Ensure that the sub strap passes through the winch mount bracket opening directly below the sub and not through the Winch.



Figure 14. Properly routed Launch and Sub straps with safety pin in place.

5. Install the Cardboard wedge to the 5th wing on the sub.
6. Stage the Tow Body or Acoustic streamer and Tow Cable on deck inboard or aft of the Wave Glider. Remove any twists in the Tow Cable. The Sinker can remain in the storage bin until the vehicle is hoisted for launch



Figure 15. Tow Body and Tow Cable staged for launch aft of the Wave Glider.

7. If present, the Tow Body or acoustic streamer should enter the water first. Have a second dedicated crew member pay out the Tow Body or acoustic streamer and Tow Cable in the water with care so that neither come into contact with the ship's propellers or hull. This crew member will ensure that the deployed section remains clear of interaction with the ship while the Wave Glider is hoisted for launch. Hold on to a section of the Tow Cable such that there is no tension on the Sinker.



Figure 16. One crewmember should manage the Tow Cable while another manages the Tow Body or acoustic streamer (A). The Tow Body or acoustic streamer should enter the water first (B). Pay out the Tow Cable while taking care that the Tow Cable and towed payload do not come into contact with the boat or propellers (C).

8. The Sinker crewmember removes the Sinker from the storage bin, and ensures that the Thin Line and Tow Cable do not drag across the deck or come into contact with sharp or abrasive surfaces. Hold the Sinker by the metal housing or Snubber; do not let it dangle by the Thin Line. Proceed with lifting the Wave Glider using a crane, as per **Rapid Stand and Crate Launch & Recovery**. The Sinker crewmember will carry the Sinker and attached section of the Tow Cable to the edge of the ship as the Wave Glider is hoisted. Stand aft or inboard of the suspended load; do not stand below the suspended load.



Figure 17. Wave Glider hoisted into position for launch (A). The Sinker crewmember follows the Wave Glider as it is hoisted and positioned over the freeboard (B).

9. At least two deckhands must tend to the vehicle as it is hoisted and staged for launch.
10. As the vehicle is hoisted, the Sinker should be supported and kept from free falling into position under the Sub; the Thin Line must not experience a shock or snap load. Walk the Sinker, following the Wave Glider as it is lifted over the rail. Have the crane operator hold the Wave Glider suspended over the water. Using the drogue or Tow Cable, whichever is directly attached to the Sinker, lower the Sinker smoothly until the Thin Line supports the Sinker. During this process, keep the Sinker aligned forward with the Wave Glider as to not introduce any twists in the Thin Line. Make sure the Sinker does not hit the side of the ship, get tangled in any lines, or that the Thin Line has looped over any of the Sub wings.



Figure 18. The Sinker should be placed over the freeboard and kept from free-falling into position (A). Lower the Sinker gently using the Tow Cable or drogue (whichever is directly attached to the Sinker) until it is fully

supported by the Thin Line (B, C, D). Verify that the Sinkers and Thin Line are suspended unencumbered from the Winch.

11. Verify that the Sinkers and Thin Line are suspended unencumbered from the Winch.



Figure 19. Wave Glider mid-launch, with the Sinkers and Tow Body deployed.

12. Release the remaining Tow Cable overboard and allow it to pay out behind the vehicle.
13. With the Sinkers overboard and the Tow Cable/sensor paid out clear of the ship, the Wave Glider can be lowered into the water and launched normally.

3.2.2 Launch from a Legacy Stand

Please review the associated document: **Launch and Recovery Guide, Legacy Stand, Wave Glider SV3 v100, v200, v300 (P/N 06135)**

When launching a Wave Glider with a Winch installed, one dedicated crew member is necessary (minimum) to hold and deploy the Sinkers, in addition to the crew who tend to the vehicle. If an acoustic streamer or Tow Body is being deployed, follow the guidance detailed in **Appendix I** of the **Launch and Recovery Guide, Legacy Stand**.

1. Verify through either WGMS or the Vehicle web page that power to the Thin Line is OFF. The blue flashing light on the Winch body indicates the power state of the Thin Line and should be in the OFF state.
2. The crewmember dedicated to Sinkers handling should put on suitable electric shock protection gloves, which should be worn when handling the Sinkers or Thin Line during the entire Launch procedure.
3. Remove the bundling straps and stage the Wave Glider for launch. Remove any straps used to secure the Winch to the cart or stand for loading and transit.
4. Have the Sinkers crewmember hold the Sinkers or place it on a piece of foam temporarily next to the sub while installing the launch strap.
5. Route the launch strap through the Winch bracket at the bottom of the sub, use only the soft shackle type launch strap.



Figure 20. Route the Launch strap through the Winch Bracket (A & B), NOT through the metal rods at the top of the Winch.

6. Attach the SeaCatch to the lifting ring with the release mechanism facing the direction it will be pulled from.
7. Install the Cardboard wedge above the 5th wing.
8. Stage the Tow Body or acoustic streamer and Tow Cable on deck and remove any twists in the Tow Cable.



Figure 21. Tow Body and Tow Cable staged for launch aft of the Wave Glider.

9. If present, the Tow Body or acoustic streamer should enter the water first. Have a second dedicated crew member pay out the Tow Body or acoustic streamer and Tow Cable in the water with care so that neither come into contact with the ship's propellers or hull. This crew member will ensure that the deployed section remains clear of interaction with the ship while the Wave Glider is hoisted for launch. Hold on to a section of the Tow Cable such that there is no tension on the Sinker.

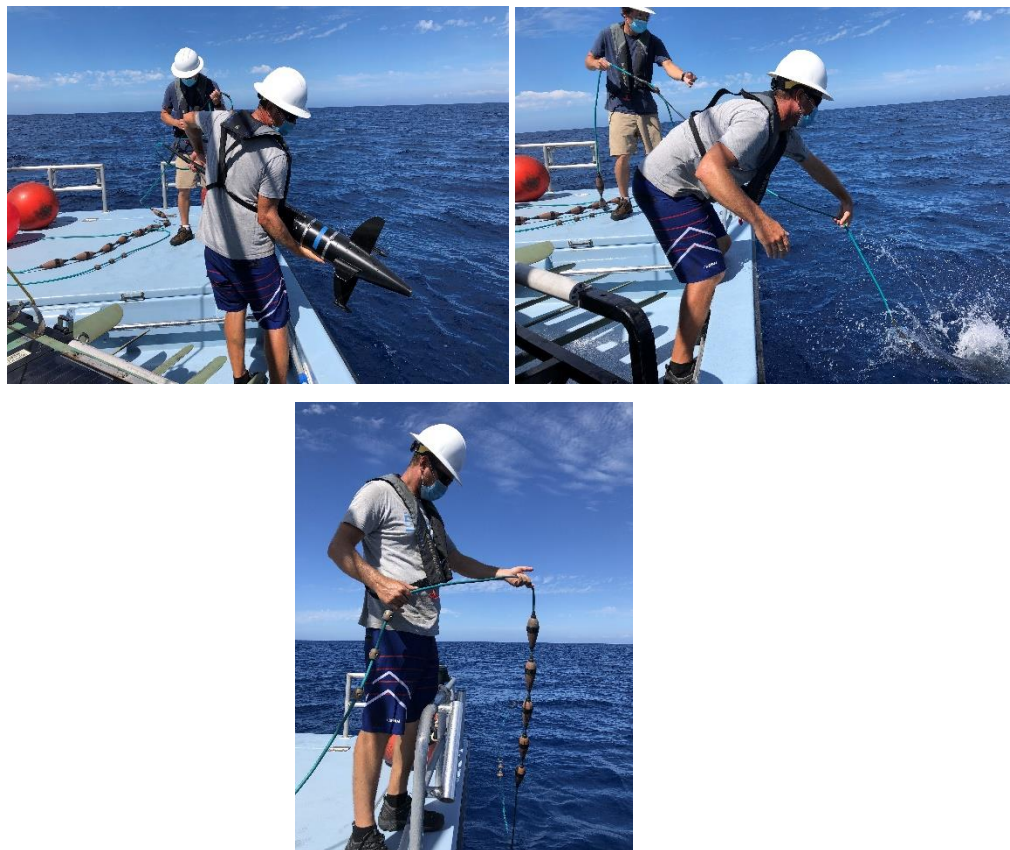


Figure 22. One crewmember should manage the Tow Cable while another manages the Tow Body or acoustic streamer (A). The Tow Body or acoustic streamer should enter the water first (B). Pay out the Tow

Cable while taking care that the Tow Cable and towed payload do not come into contact with the boat or propellers (C).

10. The Sinker crewmember removes the Sinker from the storage bin and ensures that the Thin Line and Tow Cable do not drag across the deck or come into contact with sharp or abrasive surfaces. This crewmember will carry the Sinker and attached section of the Tow Cable to the edge of the ship as the Wave Glider is hoisted. Stand aft or inboard of the suspended load; do not stand below the suspended load.
11. At least two crew members must tend to the vehicle as it is hoisted and staged for launch.
12. As the vehicle is hoisted, the Sinker should be supported and kept from free falling into position under the Sub; the Thin Line must not experience a shock or snap load. Walk the Sinker following the Wave Glider as it is lifted over the rail. Have the crane operator hold the Wave Glider suspended over the water. Using the drogue or Tow Cable, whichever is directly attached to the Sinker, lower the Sinker smoothly until the Thin Line supports the Sinker. During this process, keep the Sinker aligned forward with the Wave Glider as to not introduce any twists in the Thin Line. Make sure the Sinker does not hit the side of the ship, get tangled in any lines, or that the Thin Line has looped over any of the Sub wings.



Figure 23. The Sinker should be placed over the freeboard and kept from free-falling into position (A). Lower the Sinker gently using the Tow Cable or drogue (whichever is directly attached to the Sinker) until it is fully supported by the Thin Line (B, C, D). Verify that the Sinker and Thin Line are suspended unencumbered from the Winch.

13. Release the remaining Tow Cable overboard and allow it to pay out behind the vehicle.
14. With the Sinker overboard and the Tow Cable or acoustic streamer payed out clear of the ship, the vehicle can be lowered into the water and launched normally.

3.3 Recovery

This section is meant to supplement the official Launch and Recovery Guides for the Rapid and Legacy Stands. This section only covers the additional information necessary if a Winch is added to the Wave Glider configuration. Please refer to the documents: **Rapid Stand and Crate Launch & Recovery), v100/v200/v300 (10805)** and **Wave Glider SV3 Legacy Stand Launch and Recovery Guide (06135)**

3.3.1 Recovery with a Rapid Deployment Stand

Please review the associated document: **Rapid Stand and Crate Launch & Recovery), v100/v200/v300 (P/N 10805)**

The Multi-Stage Hoisting (1 Hoist) method (from the above document) is recommended for a Wave Glider with a Winch installed (**Section 10, Rapid Stand and Crate Launch & Recovery**). During such a recovery, at least one dedicated crew member is necessary to carry and manage the Sinker and Thin Line, in addition to the crew managing the Sub and Float. If an acoustic streamer or Tow Body was deployed, follow the guidance for launch and recovery with a Large Tow Body (**Section 11, Rapid Stand and Crate Launch & Recovery**) and add a crewmember dedicated to managing the towed equipment.

1. Verify through WGMS that power to the Thin Line is OFF.
2. The crewmember dedicated to Sinker handling should put on suitable electric shock protection gloves, which should be worn when handling the Sinker or Thin Line during the entire Recovery procedure.
3. Recover the float per guidance for a **Multi-Stage Single Hoist (1 Hoist)** recovery with Tow Body.
4. Hoist the Sub according to Wave Glider Recovery Procedure.
5. Once the Sub is suspended out of the water, have the Sinker crewmember capture the Sinker with a boat pole or by hand. Crewmembers should keep clear of the suspended load and maintain control of the Sub to minimize swinging. The Sinker crewmember will carry the Sinker along with the Sub as the Sub is hoisted on deck and placed on the Cart. This crewmember will ensure that the Thin Line does not make contact with any sharp or abrasive surfaces, and is not crushed, stepped on, or twisted.





Figure 24. The Sinker crewmember should capture the Sinker by controlling the Thin Line using a boat pole or by hand (A, B, C). When grabbing and holding the Sinker, ensure the Thin Line does not contact any sharp or abrasive surfaces, and is not crushed, stepped on, or twisted. Carry the metal housing where possible.

6. Before moving the Sub on board, have the dedicated Tow Body crewmember capture the Tow Cable and tend to the portion that is still in the water. This crewmember must ensure that the Tow Body and Tow Cable remain clear of the ship's hull and propellers.

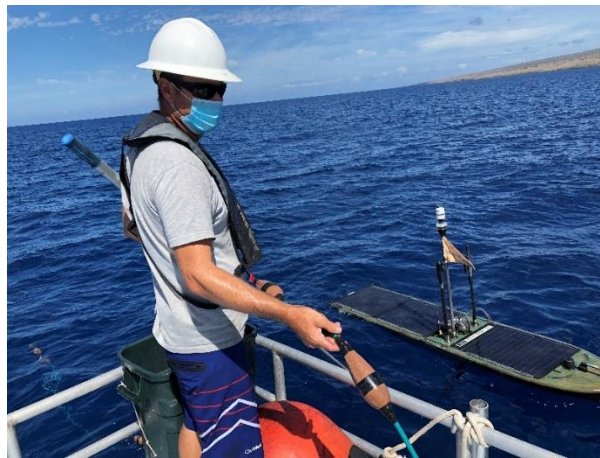


Figure 25. The Tow Cable and Tow Body/acoustic streamer crewmembers should make sure that the Tow Body and Tow Cable remain clear of the ship hull and propellers.

7. With the Sub hoisted and the Sinker and Tow Cable tended by dedicated crewmembers, have the crane operator bring the Sub on board. If possible, the Sinker crewmember should walk on the starboard side of the Sub, as this will allow them to tilt the Winch in the correct direction (to the starboard side of the Sub) on the Cart and reduce the chances for the Thin Line to be damaged. Be careful not to twist the Thin Line while maneuvering.

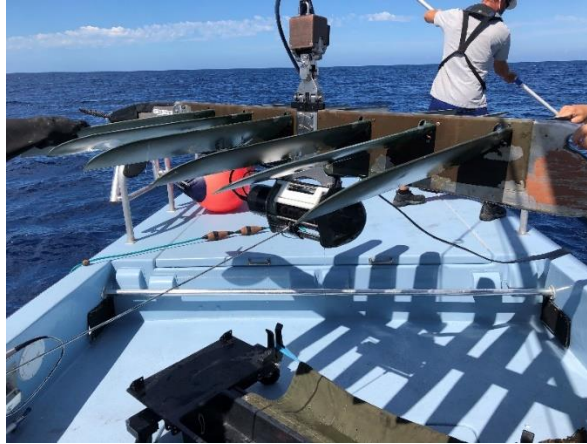


Figure 26. The Sub may be lowered into the Rapid Stand while the Tow Cable and Tow Body/acoustic streamer are being tended.

8. The Sinker crewmember should stand on the inboard side of the Sub. Land the Sub on the Cart. Take caution not to lower the Sub on top of the Thin Line, Tow Cable, or Umbilical. Depending on whether the Cart has a hammock, the lowering process may differ slightly.
 - o If the Cart does not have a hammock installed, the Winch housing must be tilted inward as the Sub is lowered onto the Cart, to avoid contact with the deck of the ship. This is performed easily by the Sinker crewmember pulling the Winch housing to the side using the Thin Line as the Sub is lowered. Pull from the Thin Line, not the Sinker. Once the Sub is on the cart, the Winch housing may rest on the deck or a piece of foam until it can be secured with a strap for transit.
 - o If the Cart has a hammock installed, no further action is necessary, the Winch will be cradled as the Sub is lowered into place.



Figure 27. The Sub being lowered onto a Cart that has a hammock installed.

9. Place the Sinker into the storage bin with the snubber (spring section) pointed away from the Sub to protect the Thin Line interface.



Figure 28. Sinker placed in the storage bin with the Snubber (spring section) pointed away from the Sub to protect the Thin Line interface. Make sure all of the Thin Line is in the storage box and not dragging on deck.

10. Have the Tow Body crewmember pull in the remaining section of Tow Cable and recover the Tow Body. As the Tow Body is brought in, coil the Tow Cable on deck safely until it can be stored on the vehicle in the Sinker tub. Using team lifting as appropriate, place the Tow Body on a purpose-built cradle or foam, clear of the recovery operations, and continue to tend the tow cable.

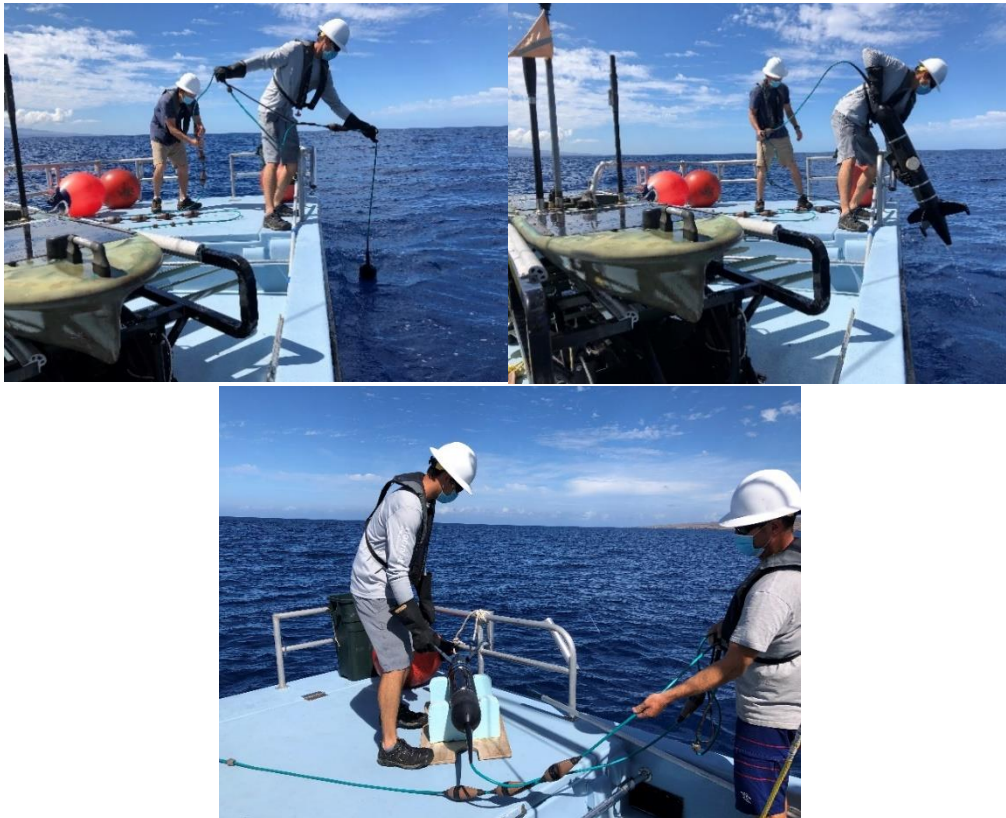


Figure 29. Pull in the Tow Cable and coil it on deck (A). Lift the Tow Body on deck (B) and place it in a cradle or on foam (C).

11. Place the empty Rapid Stand Saddle onto the Cart with the Sub and install the (2) locking pins.



Figure 30. Saddle stacked on top of the Cart. The Sub Wings have been removed in this picture; this can be done later if deck space is not limited.

12. Load the Float into the Rapid Stand Saddle per Wave Glider Recovery Procedure.

13. Secure the vehicle for transit.

- Place Tow Body in purpose-built cradle or foam, to top of, or next to the vehicle and tie down with straps.
- The Winch should be supported with either a strap or the Winch hammock.
- The Tow Cable should be stored in or on top of the storage bin, with the Sinker.
- The external wings (6) may be removed and placed in the storage bin under the Sinker/Tow Cable.
- The entire vehicle should be secured to the deck with tie-down straps.

3.3.2 Recovery with a Legacy Stand

Please review the associated document: **Launch and Recovery Guide, Legacy Stand, Wave Glider SV3 v100, v200, v300 (P/N 06135)**

When Recovering a Wave Glider with a Winch installed, one dedicated crew member is necessary (minimum) to capture and tend to the Sinker in addition to the crewmembers who tend to the vehicle. If an acoustic streamer or Tow Body was deployed, follow the guidance detailed in **Appendix I** of the **Launch and Recovery Guide, Legacy Stand**.

The Multi-Stage Hoisting (1 Hoist) method (from the above document) is recommended for a Wave Glider with a Winch installed (**Chapter 9 Launch and Recovery Guide, Legacy Stand, Wave Glider SV3 v100, v200, v300**). During such a recovery, at least one dedicated crew member is necessary to carry and manage the Sinker and Thin Line, in addition to the crew managing the Sub and Float. If an acoustic streamer or Tow Body is attached, follow the guidance for launch and recovery with a Large Tow Body (**Appendix I. Towfish Launch and Recovery Procedures**) and add a crewmember dedicated to managing the towed equipment.

1. Verify that Power to the Thin Line is OFF for recovery via WGMS.
2. The crewmember dedicated to Sinker handling should put on suitable electric shock protection gloves, which should be worn when handling the Sinker or Thin Line during the entire Recovery procedure.

3. Recover the float per guidance for a **Multi-Stage Single Hoist (1 Hoist)** recovery with Tow Body.
4. Hoist the Sub according to Wave Glider Recovery Procedure
5. Once the Sub is suspended out of the water, have the Sinker crewmember capture the Sinker with a boat pole or by hand. Crewmembers should keep clear of the suspended load and maintain control of the Sub to minimize swinging. The Sinker crewmember will carry the Sinker along with the Sub as the Sub is hoisted on deck and placed on the Cart. This crewmember will ensure that the Thin Line does not make contact with any sharp or abrasive surfaces, and is not crushed, stepped on, or twisted.



Figure 31. Figure 18. The Sinker crewmember should capture the Sinker by controlling the Thin Line using a boat pole or by hand (A, B, C). When grabbing and holding the Sinker, ensure the Thin Line does not contact any sharp or abrasive surfaces, and is not crushed, stepped on, or twisted. Carry the metal housing where possible.

6. Before moving the sub on board, have the dedicated Tow Body crewmember capture the Tow Cable and tend to the portion that is still in the water. This crewmember must ensure that the Tow Body and Tow Cable remain clear of the ship's hull and propellers.

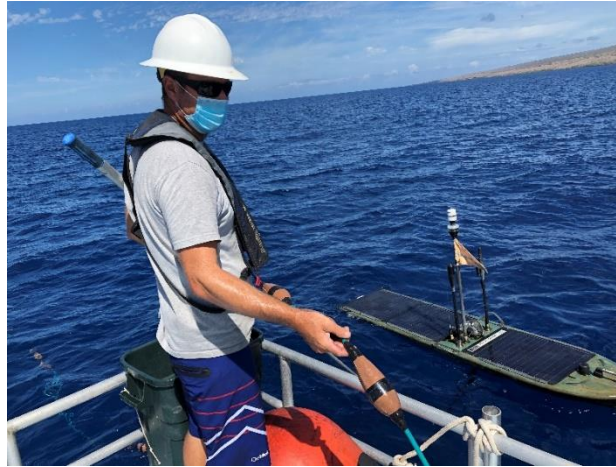


Figure 32. The Tow Cable and Tow Body/acoustic streamer crewmembers should make sure that the Tow Body and Tow Cable remain clear of the ship hull and propellers.

7. With the Sub hoisted, and the Sinker and Tow Cable tended by dedicated crewmembers, have the crane operator bring the sub on board.
- Land the Sub on the Cart. Take caution not to set the Sub on top of either the Thin Line, Tow Cable, or Umbilical. The Winch housing must be tilted slightly inward as the Sub is lowered onto the Cart to avoid contact with the deck of the ship. This is performed easily by the Sinker crewmember lightly pulling the Winch housing over with the Thin Line as the Sub is lowered. Do not pull from the Sinker. Once the Sub is on the cart, the Winch housing may rest on the deck, or a piece of foam until it can be secured with a strap to the Cart rail for transit.
8. Follow remaining steps in **Launch and Recovery Guide, Legacy Stand, Wave Glider SV3 v100, v200, v300** for recovery with a Large Towed Payload.
9. Secure the vehicle for transit.
- Place Tow Body in purpose-built cradle or foam, to top of, or next to the vehicle and tie down with straps.
- The Winch should be supported with either a strap or the Winch hammock.
- The Tow Cable should be stored in or on top of the storage bin, with the Sinker.
- The external wings (6) may be removed and placed in the storage bin under the Sinker/Tow Cable.
- The entire vehicle should be secured to the deck with tie-down straps.

3.4 Post-Recovery

The Post-Recovery tasks should be conducted within 4 hours of recovery, and no later than 8 hours after recovery. Follow Winch High Voltage Handling Recommendations in Section 2.3 at all times. The Post-Launch Procedures consist of:

1. Rinse Vehicle
2. Remove Biofouling
3. Motor Creep
4. Soak Winch

5. Store Winch

A checklist for these steps can be found in **Appendix B**.

3.4.1 Rinse Vehicle

Rinse the entirety of the vehicle, winch assembly, attached sensors, and tow cable (if present) in fresh water. Ensure that all expansion port connections are dummied off and the Winch is powered off. Take care not to damage the Thin Line, sinker pressure port, or IE-55 cable that connects to the electronics enclosure on the winch body. For these applications, running water from a hose is sufficient; use of a pressure washer is not recommended. If a pressure washer is used, take care around the above-mentioned parts in addition to the primary and secondary transformers. Rinse all metal brackets and connecting hardware. Rinse the drum and level wind with attention to crevices that may accumulate encrusted salt once the Winch dries.

3.4.2 Remove Biofouling

When operating in certain environments, biofouling may build up on a Winch and Sinker. This biofouling must be removed after each recovery to ensure optimal performance of the Winch. Follow instructions from the Inspection and Cleaning Procedures (P/N 06032) document. Pay special attention to the limit on pressure while pressure washing the Electronics Housing, as all cables (especially the IE-55 cable connecting to the Primary Transformer) can be damaged by a high-pressure stream of water.

3.4.3 Motor Creep

During extended missions, especially those in higher sea states, the Winch motor may creep and lose an accurate drum count. This may result in an inaccurate Estimated Depth from Surface. The following process checks to determine how much creep occurred, if any.

1. Access the Winch Plugin.
2. Power on the Winch, but not the Thin Line.
3. From the Winch Plugin, command the Winch to Pay in to Stop.
4. Confirm that the hard stop on the Thin Line is at the level wind guide. If it is not there be sure nothing else is prohibiting the thin line from moving and clear it if so. Repeat command.
5. Check the Drum Count on the Winch Plugin. If the value is greater than **32** counts, command the Winch to “Zero Count” (found at the bottom of the Commands page).

Command	Idle
TSMC Drum Position	0m (0)
WPDC Drum Position	0m (0)
Estimated Depth	10m
External Depth Sensor	NaN
TSMC Hardware Bits	0x7000F840
Motor Controller Temp	0.0 C
Motor Controller Voltage	0.0 V
Motor Controller Status Bits	0x0
Motor Position	0
Status Bits	0x10000
Status Time	2019-02-11T20:13:54.736Z
Auto Power On Thin Line	false

Figure 33. The Drum Count can be found at the top of the Winch Commands page in the vehicle webpage.

6. Power off the Winch.

3.4.4 Soak Winch

After each recovery, the Winch must be thoroughly rinsed and immersed in fresh water for 12 to 24 hours. Special attention should be paid to spraying water between rotary transformer halves and at ceramic bearings in order to remove saltwater. When done properly, this reduces the likelihood and size of salt crystal buildup. ***This is especially important if the Winch is to be operated dry (not submerged in water) at a later time, as salt crystals will form in bearings and other moving interfaces if this flushing is not performed.*** The Winch should be removed (see section 6.2 Removing a Winch) and placed in two 5-gallon buckets – one each for the Winch and Sinker. Take care not to crush, scrape, cut, or twist the Thin Line. If any cables are disconnected, be sure to insert the appropriate dummy plug. Fill the buckets with fresh water so that all metal components are submerged. Allow to soak for 12-24 hours.

If the Winch is intended to be stored dry for more than 3 months, then the Winch must be immersed in fresh water and the motor be actuated for one hour to further dissolve encrusted salt. See section 6.10 Winch Immersion & Cleaning for more information.

3.4.5 Store Winch

Air dry the Winch and install all dust caps and dummy plugs.

SECTION 4: MISSION PLANNING AND OPERATIONS

The addition of a Winch affects a Wave Glider's performance and places restrictions on how it must be piloted to prevent twisting of the Thin Line and prevent damage to the Sinker. The Sinker can be slow to respond to changes in Wave Glider heading, resulting in twists in the Thin Line that can persist even when the Thin Line is retracted onto the drum. This can affect Winch functionality over time.

4.1 Payloads

At this time, Liquid Robotics recommends that all payloads be attached to a Winch 150P only via a tow cable. Attaching directly to the Sinker may result in premature spring failure and subsequent physical loss of Sinker and payload.

Payloads shall be up to 30 lbs (14kg) dry, neutrally buoyant, and neutrally trimmed.

4.2 Piloting Restrictions and Guidelines

Liquid Robotics recommends the following guidelines for mission planning and operation:

- Fixed heading turns should be of no more than 60 degrees.
- Waypoints should be spaced at least 170 meters (~0.1nm) when operating without a towed payload. When a payload is being towed, add the length of the Tow Cable, Payload, and drogue to the minimum spacing.
- For every right turn, make a similar left turn, and vice versa. Do not let the number of turns in a single direction accumulate, and do not utilize a holding pattern around a single waypoint.
 - Repeated 360° turns in a single direction – particularly in areas with strong directional current – may lead to twists building up in the Thin Line, resulting in damage to the Thin Line.
- When Wave Gliders just need to travel in a straight line, fixed headings should be used to point straight into oncoming currents.
- The Thin Line must be powered on for payloads to receive power.
- Great care should be paid to depth of water during all mission planning and operation, especially when casting the Winch to prevent Sinker contact with the ocean floor or other obstacles.
- If mission navigation is critical near marine traffic, manual navigation is recommended – turn off auto-avoidance.
 - If manual navigation is not possible, decrease the auto-avoidance standoff distance to reduce the likelihood of unexpected sharp turns made to avoid AIS vessels.

4.2.1 Station Keeping

Liquid Robotics recommends two station-keeping courses that have been found to reduce the likelihood of twists in the Thin Line.

4.2.1.1 *Figure Eight*

Employing the recommendations above results in a figure eight course where the straight legs are about 0.5 nautical mile long, and the minimum distance between the rounding points is 170 meters.

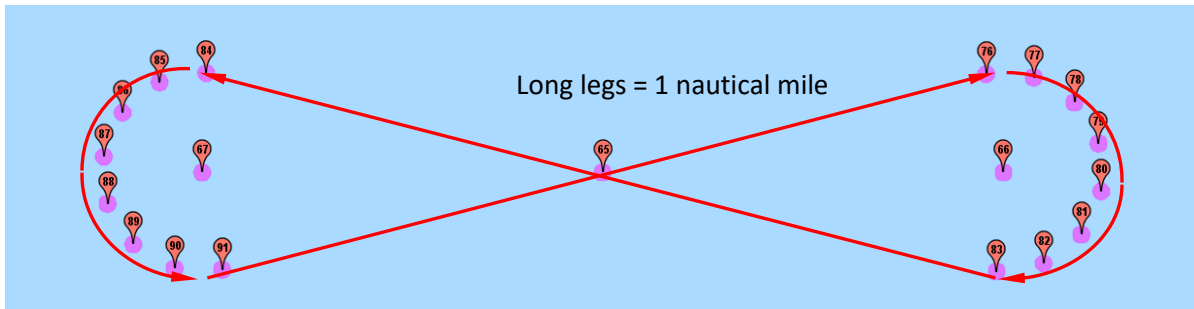


Figure 34. Liquid Robotics recommends a figure eight course with leg lengths of 1 nautical mile and spacing between rounding points of at least 170 meters, at minimum, for station keeping.

4.2.1.2 Bow Tie

For short periods of time (e.g. less than 2 hours), a four-point course may be used, with the guiding principle of “for every right turn, make a left turn” informing the waypoint order shown below. For periods longer than 2 hours, the Figure Eight course is preferred.

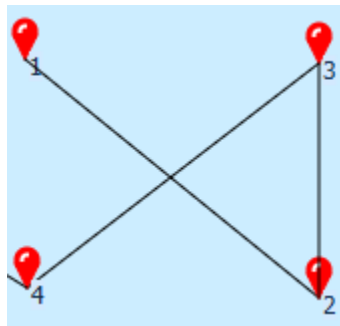


Figure 35. For short periods of less than 2 hours, a simple 4-point bow-tie course is acceptable but discouraged. Pilots should default to the figure eight course.

4.2.2 High Sea State

The Winch 150P should not be operated (e.g. retracted and extended) above WMO sea state 5. Should a Wave Glider with a Winch encounter higher sea states, the Sinker should be payed out to 20m or more to reduce Winch swinging and the likelihood of damage to the Winch, Thin Line, Sinker, and Sub.

4.3 Manual Piloting

When following a pre-built course is not desired or possible, Liquid Robotics recommends a fixed heading into on-coming current to allow the Winch and its payload to remain streamed out behind the Sub. Watch circles are highly discouraged for any extended period of time. Box courses and rectangles with legs of at least 170m are preferred to watch circles, but less desirable than a figure-8 or bowtie course.

If a Wave Glider must be manually turned outside of a set course, on average it will take 8 minutes for the Wave Glider to travel 165 meters. With a safe maximum turn of 60 degrees, and allowing time for the winch to settle, it will take around 24 minutes to fully turn the wave glider 180 degrees.

See the **GUIDE, PILOTING, WINCH 150P (11018)** for the full set of piloting guidelines.

4.4 Status Indicators

Status values are updated at the Polling Interval set via the Winch Plugin.

Command	Idle
TSMC Drum Position	0m (0)
WPDC Drum Position	0m (0)
Estimated Depth	10m
External Depth Sensor	NaN
TSMC Hardware Bits	0x7000F840
Motor Controller Temp	0.0 C
Motor Controller Voltage	0.0 V
Motor Controller Status Bits	0x0
Motor Position	0
Status Bits	0x10000
Status Time	2019-02-11T20:13:54.736Z
Auto Power On Thin Line	false

Figure 36. The Winch Plugin presents user with the current status of the Winch.

Table 2. Each item on the Winch status page is explained.

Indicator	Description
Command	Displays which command is currently executing on the Winch Power Domain Controller. Displays “Idle” if no command is executing.
TSMC Drum Position	Report by the motor controller the estimated (calculated) amount of line spooled out relative to the home position (zero meters). The format is in meters and in parenthesis the corresponding number of drum counts (in 1/16 th counts per drum revolution).
WPDC Drum Position	Report by the WPDC the estimated (calculated) amount of line spooled out relative to the home position (zero meters). The format is in meters and in parenthesis the corresponding number of drum counts (in 1/16 th counts per drum revolution). At this time do not depend on this value for anything. Eventually it will be used to validate the motor controller counts and indicate any cable slippage.
Estimated Depth	Approximate depth of the payload (relative to the Wave Glider float) as calculated by the Winch Plugin using the Motor Controller (TSMC) drum position.
External Depth Sensor	Report of the depth of the Sinker as derived from its onboard pressure sensor. Displays in meters. This value is only valid when Sinker is powered up and communicating with the WPDC. If this value does not make sense or “never” changes it might be because the communications is not there or the sensor update rate is set to very long.

TSMC Hardware Bits	Used for debugging by Liquid Robotics.
Motor Controller Temp	Used for debugging by Liquid Robotics. The temperature of the Motor Controller in degrees Celsius. It is not unusual for this temperature to exceed 60C. Concern is warranted once the temperature approaches 85C.
Motor Controller Voltage	Used for debugging by Liquid Robotics. Fluctuates during use. Start being concerned about being able to winch up when values go below 11.0V.
Motor Controller Status Bits	Used for debugging by Liquid Robotics.
Motor Position	Used for debugging by Liquid Robotics.
Status Bits	Used for debugging by Liquid Robotics.
Status Time	The last time (UTC) that the status was updated.
Auto Power On Thin Line	When set to 'true', the Thin Line (Sinker) will be powered up after the Winch is powered up and running. A value of 'false' will require a manual operation to turn the Thin Line (Sinker) on.

4.4.1 Winch Vehicle Page Updates

Status updates might appear to happen quickly at times and very slowly at other times. Because the Winch vehicle page is live data and can be access via Cellular/VPN service, a user can see updates as quickly as every second if the vehicle is close to or on shore. Factors that will slow or stop status updates include:

- Cellular coverage
- VPN connectivity
- Vehicle Management Computer load
- Overall time required to complete the latest command and return ACK/NACK

Therefore, inconsistent and delayed updates should not be an immediate source of alarm. If cell coverage is lost permanently, then a user may run Get Latest Winch Status through Iridium on WGMS to check for latest status

NOTE: If the user runs commands on the Winch Vehicle Page, most of them will not send status to WGMS, except for the auto cast asynchronous updates.

SECTION 5: COMMANDS

This section provides detailed information into user-accessible commands that may be issued to the Winch either via the Winch Commands page on WGMS or the vehicle webpage. Standard Commands are those that Liquid Robotics anticipates a user may utilize in most conditions. Expert Commands are rarely used. Extreme caution should be utilized when using Expert Commands, as improper use may render a Winch unusable.

Note that this version of the User Guide is valid for Winch Plugin versions 2.9.0 and earlier.

5.1 WGMS Standard Commands

5.1.1 Auto Cast Cycle

Begin executing pay out/pay in cycle with time delay and repeat interval. Stops any other auto cast functions. The Winch will report events to shore indicating status or an error if it fails. If it fails, the auto cast cycle will stop, the brake will engage, and the cable will stay payed out wherever it is. User may abort auto cast at any time with Stop.

Note that the Winch normally pauses at fixed segment lengths during Pay-Out in order to allow neutrally-buoyant components – such as payloads, tow cables, and Sinkers – to settle at their appropriate depths according to the amount of Thin Line payed out.

This command is accessible from the Winch Commands page.

Parameter List:

- Pay Out To Estimated Depth (meters) (From Surface)
- Sleep at Depth (for example, \"5m\" for 5 minutes)
- Pay In To Estimated Depth (meters) (From Surface)
- Repeat Delay (for example, \"1h\" for 1 hour, 0=no repeat)

5.1.2 Auto Power on Sinker Payload Port

Powers on the Sinker Payload Port once the Winch is powered on. Requires Thin Line to be on.

This command can be accessed only on WGMS.

Parameter List:

- True = Will power on Sinker Payload Port when the Winch is powered on
- False = Will not auto power on Sinker Payload Port (default)

5.1.3 Auto Power on Thin Line

This controls whether the Thin Line powers on when the Winch is powered on.

Note that this means high voltage will be present in the Thin Line soon after the Winch is powered on.

Parameter List:

- True = Will power on Thin Line once the Winch is powered on
- False = Will not auto power on Thin Line (default)

5.1.4 Get Last Winch Status

Returns the last known Winch status.

Output Example:

```
EstimatedDepthFromSurface=-19.8m PressureDepthAtSinker=-0.3
TemperatureAtSinker=27.8 kPaPressureAtSinker=98.3 CablePayOutLength=-29.8m
```

5.1.5 Get Plugin Version

Returns the installed plugin software version.

Output Example:

```
Winch 2.9.0-RC2 build 3 origin/2.9.0-RC2 built-by awsbuilduser
```

5.1.6 Get Power Requestor Info

Return the complete list of power requesters. A '<-' denotes chained power requests.

5.1.7 Get Sinker Payload Port State Including Auto Power On

Get the power status of the Sinker Payload Port and whether "Auto Power on Sinker Payload Port" is true or false.

5.1.8 Get Thin Line State Including Auto Power On

Get the power **status** of the Thin Line and whether Auto Power On Sinker Payload Port is On

Powers on the Sinker Payload Port once the Winch is powered on. Requires Thin Line to be powered on.

Response key:

- True = Will power on Sinker Payload Port when the Winch is powered on
- False = Will not auto power on Sinker Payload Port (default)

Output Example:

Thin Line is ON and will not autostart during Winch power on

5.1.9 Get Winch Configuration

Returns the Winch Configuration values as described in 3.1.2 Configuring the Winch Plugin,

Output Example:

```
modelName="150m Winch" modelCode=100 cableDia=0m mdRatioDen=18
mdRatioNum=1183 spoolOD=0.1m stopCollarLengthM=2m turnsPerLayer=57.0
reelCapacityM=160m reserveLineLengthM=3m minReserveLineLengthM=3m
maxReserveLineLengthM=10m usableLineLengthM=150m calculatedTotalLengthM=153m
insideOutLengthAtTurns(totalLengthNP)154.3m numTurnsTotal=442
segmentLengthM=23.3m interSegmentWaitTimeSec=0 payOutSpeedMetersPerMinute=480
reelInTorque_mA=8000 TimeStampOfWinchCache=CONTROL_OR_STATUS:9502720
```

5.1.10 Go Home

This will adjust the winch to its home position. The home position is, by default, the zero position.

5.1.11 Go to Estimated Depth from Surface

Commands the Winch to pay out cable until the Sinker reaches the entered depth from the surface (in meters), according to the method used to calculate depth discussed in 2.2.3 Estimated Depth from Surface. This command obeys minimum and maximum working depths.

If the Sinker is on, it will provide the user depth from pressure in meters. It will not inform the Winch how much to pay out to achieve the commanded Estimated Depth.

Parameters:

- Depth (meters)

5.1.12 Power Off Sinker Payload

Turns off power to the Sinker Payload Port. Requires the Thin Line to be on.

5.1.13 Power Off Thin Line / Thin Line Off

Powers off the Thin Line. Please note that high voltage may remain present in the Thin Line due to stored capacitance.

5.1.14 Power On Sinker Payload

Powers on the Sinker Payload Port.

5.1.15 Power On Thin Line / Thin Line On

Powers on the Thin Line.

5.1.16 Set Segment Configuration

Set the winch's segment length and inter segment wait time. The Winch normally pauses at fixed segment lengths during Pay-Out in order to allow neutrally-buoyant components – such as payloads, tow cables, and Sinks – to settle at their appropriate depths according to the amount of Thin Line payed out.

The default values are set on initial configuration of the Winch and vary by Winch application. See 3.1.2 Configuring the Winch Plugin. Current-profiling missions have used default segment lengths like 3m, 10m, and 30m. Current-profiling missions have used inter-segment wait times of 15 seconds, 60 seconds, or longer, depending on the system connected to the sinker. For a very long/large payload with a tow cable, this might be measured in minutes. A segment length of zero or an inter segment wait time of zero will mean it ignores segments during a Pay-Out command and the entire available working length will be payed out without pauses.

Note that Segment Configuration only affects pay out commands; the Winch does not pause during Pay-In.

Parameters:

- segment length (meters) [floating point, min: zero, max: usable line length]
- wait time (seconds) [integer, min: zero, max: 3600 seconds (one hour)]

5.1.17 Status

Returns a detailed Winch status.

Output Example: (Also see 0)

```
EstimatedDepthFromSurface=-19.8m PressureDepthAtSinker=-0.3
TemperatureAtSinker=27.9 kPaPressureAtSinker=98.3 CablePayOutLength=-29.8m
powerState=ON (3w6d5h54m48.401s), virtualDevice=true, Requires: T1(ON),
Requested by: pilotRequest, powerThreadActive=false xp=T1, PDCWinch found.
```

PDCSinker found. Thin LinePowerComs found, 1 websocket clients:
[/10.20.25.132:50499], Happy

5.1.18 Status Report

Returns detailed Winch hardware information, including domains, port IDs, PDC port addresses, connected modules, and other information.

Output Example:

```
PDCInfo: domain=Winch moduleAddr=192 moduleType=PDCSinker portAddress=1
portID=0xf0000001 portIdName=PDCInfo, PDCSearch: domain=Winch moduleAddr=0
moduleType=PDCWinch portAddress=5 portID=0xf0010000 portIdName=PDCSearch,
PDCStatusAndDiagnostics: domain=Winch moduleAddr=0 moduleType=PDCWinch
portAddress=6 portID=0x600a0000 portIdName=PressureAndTemperatureInternal,
Regulator: domain=Winch moduleAddr=0 moduleType=PDCWinch portAddress=3
portIdName=PDCStatusAndDiagnostics, Power: domain=Winch moduleAddr=192
moduleType=PDCSinker portAddress=4 portID=0x40020000 portIdName=Power,
PressureAndTemperatureExternal: domain=Winch moduleAddr=192
moduleType=PDCSinker portAddress=8 portID=0x600a0000
portIdName=PressureAndTemperatureExternal,
PressureAndTemperatureHighSensitivity: domain=Winch moduleAddr=192
moduleType=PDCSinker portAddress=7 portID=0x600a0000 portIdName=PressureAndT
```

5.1.19 Stop and Brake

Stops Winch motion and aborts ongoing commands, powers off the motor controller, and applies the drum brake. This can be used to terminate an autocast or cast in progress.

5.1.20 Winch On

This command sends power to the Winch and waits for the Winch AMPS Domain to enumerate.

5.1.21 Winch Off

This command powers off the Winch. This will affect Thin Line and Sinker Payload power.

5.1.22 Zero Count

This command sets the current drum position to zero (i.e. the winch will act in the current position as if it is fully retracted to the stop collar). Estimated Depth from Surface will be calculated using this drum position as fully retracted.

5.2 WGMS Expert Commands

Commands in this section are for use by experts only. Some commands in this section carry the possibility of damaging a Winch when used improperly. Proceed with caution and at your own risk. Contact Liquid Robotics with questions.

5.2.1 Calibrate Sinker PT Sensor

Allows an offset to be used to make the depth sensor report accurate depth considering atmospheric pressure and known cable length. Enter absolute air Pressure and Temperature values of the Sinker's

environment. Allow the Sinker to come to temperature equilibrium with the air being measured. Calibration offsets will be automatically calculated and set in Sinker PDC.

Parameters:

- Pressure at sea level (kPa, absolute) [double]
- Temperature at sea level (°C) [double]

5.2.2 Clear Auto Power Thresholds

Clears the power thresholds set for the Winch to Auto Power Off.

5.2.3 Config Report

Returns a configuration report for the Winch.

5.2.4 Force Power Off

Forces the Winch to power off at the Regulus level. Use only if the Winch will not otherwise power off.

5.2.5 Get Auto Power Off Threshold (Watt Hours)

Returns the power level at which the Winch will automatically power off.

5.2.6 Get Device Connection Info

Returns domain, module, and port of the device.

5.2.7 Get Device Power Dependency Information

Returns all power requestors that request the device stay powered on.

5.2.8 Get Internal Pressure

Read the value – ensure comms to the sinker by sending this.

5.2.9 Get Motor Controller Status

Get the Motor Controller status. Generally used for engineering debug purposes.

5.2.10 Get Sinker PT Sensor calibration offsets

Read Sinker calibration offsets from Sinker PDC – used to calibrate the sinker pressure/temp sensor. Get the absolute pressure at sea level from a measurement device, or via the following:

```
java.net.URL(String.format("https://api.openweathermap.org/data/2.5/weather?lat=%f&lon=%f&appid=a31a12d74f8664d0dc77ea31d41d97de", lat, lon));
```

```
result = String.format("Offset P = %.2f kPa | Offset T = %.1f C | Sensor P = %.2f kPa | Sensor T = %.1f C | Surface P = %.2f kPa | Surface T = %.1f C",
```

5.2.11 Get Water Leak Detection Status

Returns whether Water Leak Detection detects a leak.

```
WaterDetect_0x6009_0000 waterDetect =
GetWaterDetect(WinchDeviceIdentifiers.PDCWinch);
Pair<Boolean, String> out = waterDetect.CheckForLeaks();
```

5.2.12 JSON Status Report

Returns a JSON object reporting Winch status.

5.2.13 Pay In OR Out By Cable Length From Winch

Specify the desired **total** length of Thin Line to be payed out from the Winch. Subject to Winch working limits.

Parameters:

- Cable Length (m) [double]

5.2.14 Pay In To Stop

Bring up the Sinker as far as mechanically possible.

5.2.15 Powercycle

Power off the winch, wait power cycle delay, then power on. Take caution with sensors attached to the winch; ensure they shut down gracefully before using this command.

5.2.16 Release Brake (WARNING: Do NOT use in water)

Release the restraint that holds the Winch reel (and thus, Thin Line) in place.

5.2.17 Reset Sinker PT Sensor calibration to default

Zero the offsets associated with the depth sensing PT sensor.

5.2.18 Set Auto Power Off Threshold

Set Regulus to automatically power off the Winch at a certain power level.

Parameter:

- Watt-Hours (Wh) [float]

5.2.19 Set Min and Max Working Lengths

Allow the user to specify allowable depths within to operate. Only “go home” and “pay in to stop” commands are accepted for moving Sinker outside this range.

Parameters:

- Minimum Working Length (meters) [double]
- Maximum Working Length (meters) [double]

5.2.20 Set Motor Controller Power

Not typically used. Allows for different “strengths” of motor pulling power.

Parameter:

- Power (true=on, false=off) [bool]

5.2.21 Set Powercycle delay

Regulus command that sets how long the system will wait before powering the winch on, after a Powercycle shuts it down.

Parameter:

- TimeInterval (e.g. 2s,3h,4d) [string]

5.2.22 Set Umbilical Length Configuration

Set the length of the umbilical used by the vehicle. Do not change this while in water.

Parameter:

- Umbilical Length (meters) [int]

5.2.23 Set User Serial Configuration

Set up User Serial configuration for serial communications.

5.2.24 Toggle Channel Routing

Toggle Channel Routing to PDC Winch or PDC Sinker"

Parameter:

- PowerState (true=on, false=off)

5.3 Vehicle Webpage Commands

Controlling a Winch using the vehicle webpage should only be done by experts, and as such, all commands on the vehicle webpage are considered expert commands. Note that commands run through the vehicle webpage will not send status updates to WGMS. However, asynchronous updates, such as auto cast status, will appear in WGMS.

Commands

Auto Cast	to 50 meters, wait for 2m, pay in to 15 meters and repeat after 1h
Auto Cast	at 00:00:00 to 50 meters, wait for 2m, pay in to 15 meters
Auto Power On Thin Line	☐ Auto Power?
Auto Pay-In	after 2h idle
Brake Release	
Disable Auto Pay-In	
Go Home	
Go To Depth	50 meters
Load TSMC Code	
Pay In to Stop	
Require Depth Sensor	☐ required
Stop	
Thin Line On	
Thin Line Off	
Winch On	
Winch Off	
Zero Count	

Figure 37. The Winch Commands page can be accessed via the vehicle webpage.

5.3.1 Auto Cast (1)

Begin executing pay out/pay in cycle with time delay and repeat interval. Executing this command clears any other auto cast functions that are in progress. The Wave Glider will report events to shore indicating status or an error in the case of failure. If a failure occurs, the auto cast cycle will stop, the brake will engage, and the cable will stay payed out wherever it is. User may abort auto cast at any time with Stop.

Parameter List:

- Pay Out To Estimated Depth (meters) (From Surface)
- Sleep at Depth (for example, \"5m\" for 5 minutes)

- Pay In To Estimated Depth (meters) (From Surface)
- Repeat Delay (for example, \"1h\" for 1 hour, 0=no repeat)

5.3.2 Auto Cast (2)

Set up a single Auto Cast.

Parameter List:

- Time (HH:MM:SS)
- Pay Out to Estimated Depth (meters) (From Surface)
- Sleep at Depth (for example, \"5m\" for 5 minutes)
- Pay In To Estimated Depth (meters) (From Surface)

5.3.3 Auto Power On Thin Line

This controls whether the Thin Line powers on when the Winch is powered on.

Note that this means high voltage will be present in the Thin Line whenever the Winch is powered on.

Parameter List:

- True = Will power on Thin Line when the Winch is powered on
- False = Will not auto power on Thin Line (default)

5.3.4 Auto Pay-In

(Not implemented)

5.3.5 Brake Release (WARNING: Do NOT use in water)

Do NOT use this while the vehicle is in the water. Doing so will result in loss of Sinker and Payload.

This releases the drum brake. This should not be used when in water, as a released brake will spool the entire Thin Line out, including the last turn, which can result in Thin Line damage and possible breakage.

5.3.6 Disable Auto Pay-In

Not implemented.

5.3.7 Go Home

Pays in to the zero position.

5.3.8 Go to Depth

Commands the Winch to pay out cable until the Sinker reaches the entered depth from the surface (in meters), according to the method used to calculate depth discussed in 2.2.3 Estimated Depth from Surface. This command obeys minimum and maximum working depths.

If the sinker is on, it will provide the user depth from pressure in meters. It will not inform the Winch how much to pay out to achieve the commanded Estimated Depth.

Parameters:

- Depth (meters)

5.3.9 Load TSMC Code

Do NOT utilize this command unless directly instructed by Liquid Robotics engineering.

5.3.10 Pay-In to Stop

Pays in to the physical stopper clamped on the Thin Line, typically 2m from Sinker.

5.3.11 Require Depth Sensor

Determines whether depth sensor input is required to move to a target depth.

This is unchecked by default. This has expert command-like consequences for users who do not know about it; if the depth sensor input is required, casting can fail.

Parameter List:

- True = Depth Sensor is required to pay out to depth.
- False = Depth Sensor is not required to pay out to depth.

5.3.12 Stop

Stops Winch motion and aborts ongoing commands, powers off the motor controller, and applies the drum brake. This can be used to terminate an autocast or cast in progress.

5.3.13 Thin Line On

Powers on the Thin Line and Sinker.

5.3.14 Thin Line Off

Powers off the Thin Line and Sinker.

5.3.15 Winch On

This command sends power to the Winch and waits for the Winch AMPS Domain to enumerate.

5.3.16 Winch Off

This command powers off the Winch. This will affect Thin Line and Sinker Payload power.

5.3.17 Zero Count

This command sets the current drum position to zero (i.e. the winch will act in the current position as if it is fully retracted to the stop collar). Estimated Depth from Surface will be calculated using this drum position as fully retracted.

5.4 Winch Plugin Variable Definitions

Name	Definition

SECTION 6: MAINTENANCE

The Winch requires certain maintenance tasks to be performed, some of which must be conducted at fixed intervals. The table below lists the recommended maintenance tasks and intervals.

Table 3. Maintenance tasks and intervals.

Part #	Description	Months In Water												Actions
		1	2	3	4	5	6	7	8	9	10	11	12	
--	Rinsing	Post-recovery												3.4.4 Soak Winch
--	Inspection		X			X			X			X		6.3 Inspection
10734	Thin Line Replacement			X			X			X				Liquid Robotics recommends returning a Winch to LR for replacement. It can be done with a Winch Rewinder or by following sections 6.4 and 6.5 .
07425-03 (v300) or 08691-03 (v100/200)	Expansion Cable Replacement						X							See sections 6.2 Removing a Winch and 0Error! Not a valid bookmark self-reference..
--	Depot Repair												X	Return to Liquid Robotics for repair and inspection. Thin Line and Expansion Cable will be replaced by Liquid Robotics.

6.1 Installation

Installation of a Winch onto a Wave Glider should be performed with two people. Note that all Winches are not compatible with all Wave Gliders, as v100's, v200's, and v300's have different cabling and mounting hole positions. These differences do not affect the process and steps in installing a Winch. If you desire to connect a winch to another version of Wave Glider, contact Liquid Robotics sales for appropriate kit.

Components:

- Winch, Thin Line, Sinkers
- Wave Glider Sub
- Souriau cable (T1-Winch)
- NUT, HEX, NYLON LOCK, 316 SS, M6x1

Materials:

- 2-3x Zip ties
- 1" thick deformable foam

Tools:

- 10mm socket wrench
- Safety wire pliers

- Torque wrench
 1. During installation, take care not to allow the Thin Line to be crushed, pinched, kinked, or otherwise damaged. Retract the winch cable as far as it will go, leaving only the last two meters of Thin Line with the protective tubing exposed.
 2. Place the sub in the stand as explained in the Launch and Recovery Guide for your Wave Glider model.
 3. Put a piece of thick foam or other padding under the sub to prevent sensitive parts of the Winch from grinding against the ground. An inch of foam should be sufficient in most cases.
 4. Put a piece of foam under the Winch to protect the Thin Line from being pinched between the winch parts and any hard surface(s) like the floor, pavement etc.

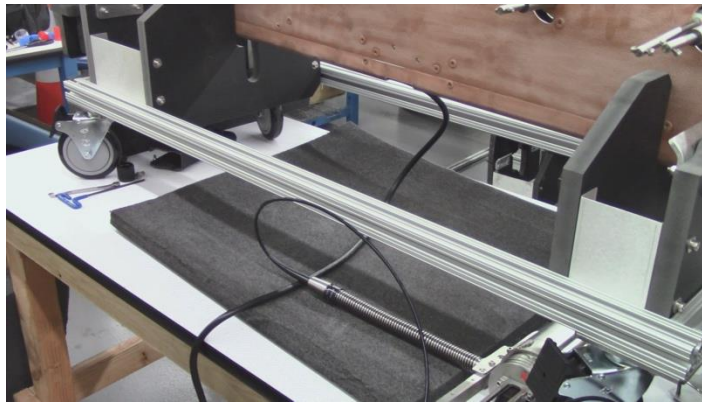


Figure 38. Foam laid out underneath a Cart to protect the Winch.

- a. Ensure that the 1.4 or 2-meter Souriau expansion cable which connects the Winch to the Thrudder is routed through the sub properly, with one end plugged into the Thrudder and the other end protruding from the bottom of the sub below the umbilical. Route the cable from the Thrudder port, passing through the sub weight bar, exiting just above the Winch, and passing rearward through the slot in the plastic part of the Winch Mounting Bracket.



Figure 39. Souriau cable routed forward from the T1 port.

5. With the help of another person, lift the Winch into place under the sub.

The Winch mounting plates fit around the spine of the sub, with the holes in the mounting plates lining up with the holes in the sub spine below the umbilical.

6. As you lift the Winch into place, make sure the free end of the Souriau expansion cable is routed through the groove in the rear plastic bearing piece in the mounting bracket. Do not pry, hammer, or strike the winch housing or bracket.

The plastic electronics enclosure on the Winch should face rearward (black cylinder in picture below on aft end of winch).



Figure 40. Align the Winch bracket with the threaded holes on the Sub. Route the Souriau expansion cable rearward in the plastic bearing.

7. Install the 2 M6 hex-head cap screws and 2 locknuts. Torque to 40 in-lb [4.5 N-m].
8. Connect the expansion port cable to the bulkhead connector on the rear face of the Winch.
9. Make sure that the small 'IE 55' drum cable is also plugged into its connector on the rear face of the Winch. This is the small ~ 1/2" diameter connector with twist-down retention collar. The

drum cable should have a service loop as shown and should be tied to the 12 pin Souriau expansion cable with a zip tie. Ensure that the drum cable is not under tension between the point where it is tied to the 12 pin Winch electrical cable and where it enters the pale green/white disk. (Shown in the picture below between the portion of the drum that holds the Thin Line, on the right and the metal end of the winch where black electronics housing is mounted on the left). There should be no visible gap between the two green/white disks, as there is a spring that pushes the two disk faces together.

10. If using a 2-meter expansion port cable, coil excess cable into a neat loop around the end of the Winch.



Figure 41. Excess cable wrapped around the Winch body.

11. Use (3) zip ties as shown to secure the expansion port cable to itself.
12. Make sure there is enough slack in the expansion port cable for the Winch to fully swing left and right without pulling on the cable.



Figure 42. Swing the Winch left and right to the stops to make sure there is enough slack in the expansion cable.

13. If using a 1.4-meter expansion cable (Winch specific), there is no need to loop around the electronics housing. Secure the drum cable to the (T1) expansion cable with (1) zip tie. Ensure that the connector is keyed properly, and that the locking sleeve has been threaded in completely. Only tighten the expansion cable by hand.



Figure 43. Winch-specific expansion cable arranged properly.

14. Check that the correct Winch Plugin and Regulus versions are installed. Check on the official plugin release version and compare to the version displayed on the vehicle webpage plugins page. Contact Liquid Robotics Technical Support for assistance.

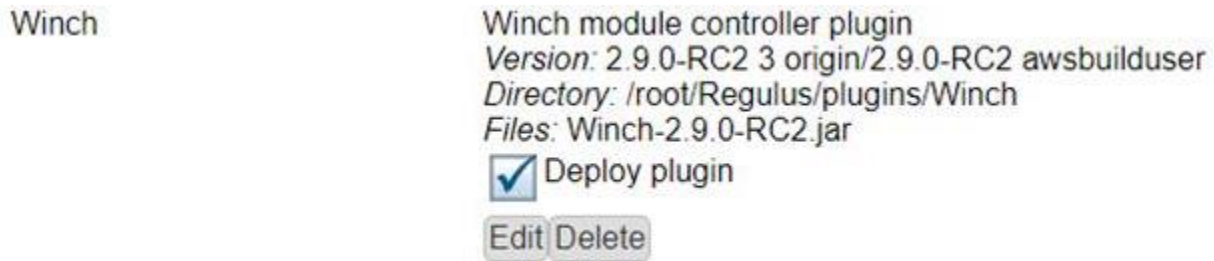


Figure 44. Vehicle webpage plugin page. Compare the "Version" to the official plugin release version.

6.1.1 Attaching a Tow Cable

A tow cable is required for attaching a payload to the Sinkers.

Components:

- ASSY, TOW CABLE, BLUE (P/N 06167 rev E)

Materials:

- Loctite 243
- Zip ties

Tools:

- 4mm Allen key
- 8mm wrench or socket

Instructions:

1. Remove the Tow Cable attachment brackets from the back of the Sinkers and separate the two halves.



Figure 45. The tow cable attachment bracket removed from the Sinker (A) and separated (B).

2. Seat one half of the bracket on one side of the Tow Cable pivot point and route the ribbon cable through the plastic guides on the brackets as shown.

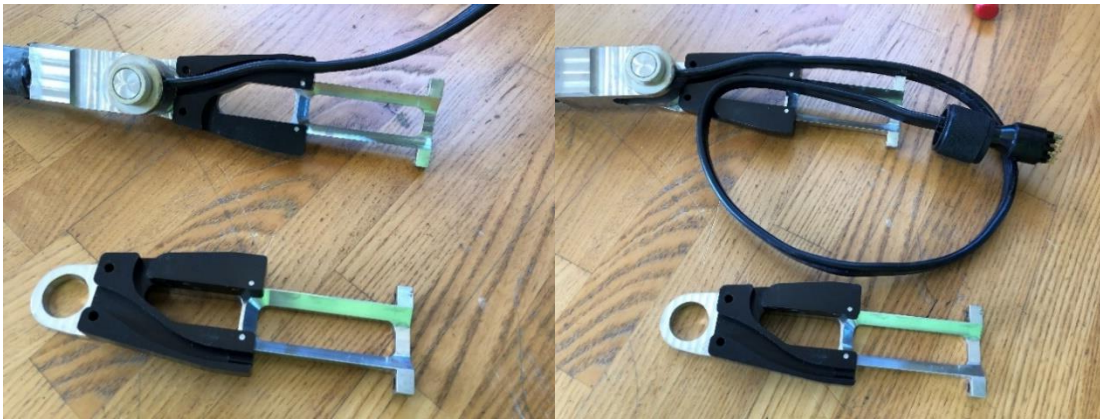


Figure 46. One of the two brackets seated on the Tow Cable pivot (A) and the ribbon cable routed through the plastic guide (B).

3. Attach the two halves of the Tow Cable bracket together. Apply Loctite 243 to only the thread interface of the screws that will be in contact with the opposite bracket side. Torque to 12 in-lb [1.4 N-m]. Loctite 243 should not be applied to the threads where the Nylock nuts seat. Install the locknuts to both sides of the bracket.



Figure 47. Apply Loctite 243 to the threads only where they will interface with the opposite bracket side (A). Use the two (2) screws to secure the two halves of the Tow Cable attachment brackets together.

4. Connect the tow cable connector to the connector on the aft end of the Sinkers.



Figure 48. Tow Cable connected to the bulkhead on the back of the Sinkers. Route the ribbon cable as shown.

5. Position the bracket to be attached to the Sinkers by sliding it forward over the Tow Cable connector. Check that the ribbon cable slides through the guides in the black plastic bracket without binding.
6. Fasten the tow cable attachment brackets to the aft end of the Sinkers using 4x M5x0.8 x 18mm 316 SS screws with lock washers and Loctite 243. Torque to 32 in-lb [3.6 N-m].



Figure 49. Secure the Tow Cable attachment brackets to the back of the Sinkers using 4x M5x18mm 316 stainless screws.

7. Wrap any excess cable around the tow cable attach bracket and secure with zip ties.

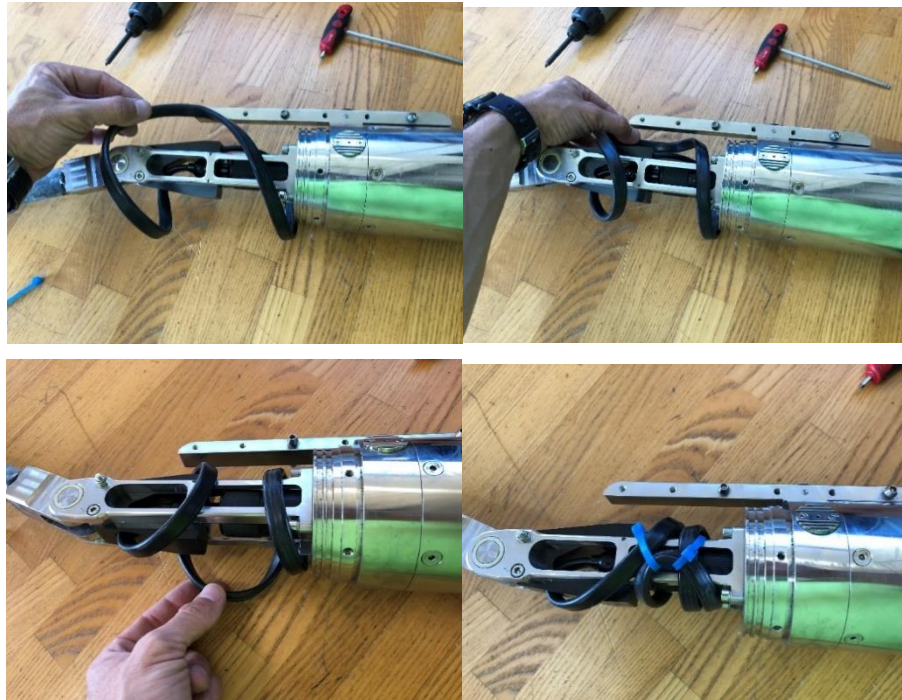


Figure 50. Wrap excess ribbon cable around the Tow Cable attachment brackets and secure with Zip ties.

6.2 Removing a Winch

Components:

- Dummy plug for T1 (Souriau or Teledyne)

Materials:

- Soft foam/block to support Winch

Tools:

- Allen keys
- Socket wrench

Instructions:

1. Ensure that the winch is payed in all the way, and that the stopper on the Thin Line has reached the Shuttle. Having the Thin Line reeled in completely will help to protect it against accidental damage. If the Sinker and Thin Line have not been reeled in all the way, do so.
 - Power on the Winch and click the Pay in to Stop button on WGMS or the Winch plugin on the vehicle webpage.
 - Once the stopper reaches the shuttle, let the status return to Idle before clicking the Zero the Count button. This will reset the drum count to reflect the last full-length spool wind more accurately.
 - Power OFF the Winch

2. Disconnect the expansion port cable on the Winch Electronics Enclosure.
3. Support the Winch in a manner as to protect the Thin Line and guard against falling. This can be done by placing a piece of foam under the sub/cart if the vehicle is on a stand. If using a lift or gantry to suspend the sub, observe safe lifting practices and support the Winch before removal of the bracket screws.
4. With another person supporting the Winch, remove the two locknuts and hex head cap screws holding the bracket and Winch assembly to the Sub.
5. Pull the Winch and brackets off the Sub together as one unit.
6. Remove the Thrudder cover and rear sub weight bar cover.
7. Disconnect the expansion cable from T1 and install a dummy plug in its place.
8. Remove the expansion cable from the sub weight bar cover.
9. Replace the Thrudder cover and sub weight bar covers.

6.3 Inspection

For every 2 months of in-water time, the Winch should be recovered and preemptively inspected for damage. Remove twists and knots in the Tow Cable. Remove biofouling from the Tow Cable, paws, and level wind.

Inspect the Thin Line on the spool for twists and overlap or gaps in the winding.

If they are present, command the Winch to Release Brake and unspool into a clean 5-gallon bucket one layer of the Thin Line winding or until the Thin Line appears normal, whichever is greater. See section 6.4 Removing Thin Line without a Winch Rewinder for more information. Once the Thin Line is unspooled, inspect the outer insulation for cuts, exposed strength member (braided metal under the insulation),

Be careful not to cut, crush, or twist the Thin Line. If any of these are present, Liquid Robotics recommends replacing the Thin Line to prevent failure. Liquid Robotics recommends returning the Winch to Liquid Robotics for Thin Line replacement.

If the Thin Line is wound smoothly on the spool without twists, gaps, or overlap, the vehicle and Winch may be returned to service without further action.

6.4 Removing Thin Line without a Winch Rewinder

Removing and installing a Thin Line without a Winch Winder is not recommended. Contact Liquid Robotics for assistance.

Components:

- Winch
- Wave Glider or CCU
- 1x DUMMY, CABLE TERMINUS, THIN LINE (P/N 11331)

Materials:

- Spool for Thin Line, or 5-gallon bucket

- Isopropyl alcohol
- Kimwipe (non-linting wipe)

Tools:

- Computer with access to vehicle webpage or WGMS
- Needle-nose pliers

Instructions:

1. From the vehicle webpage or WGMS, Power On the Winch, and make sure the Thin Line is powered off. If it automatically turned on with the Winch, command Thin Line Off, and wait at least 5 minutes after the blue light on the Electronics enclosure for any high voltage in the Thin Line to dissipate. Command “Brake Release”.
2. Manually unspool the Thin Line from the drum. This is preferably done onto an external spool but can also be done into a 5-gallon bucket. Make sure the Thin Line does not contact any sharp edges. As the last wrap of cable is being spooled off the Winch, release tension on the Thin Line to prevent putting a kink in the cable where it exits the **fiberglass cable clamp 07508**.
3. When all the Thin Line is spooled off, unhook one end of each of the 2x **extension springs 07471** using needle-nose pliers or looped zip-tie. Be careful to store the pins if they fall out.

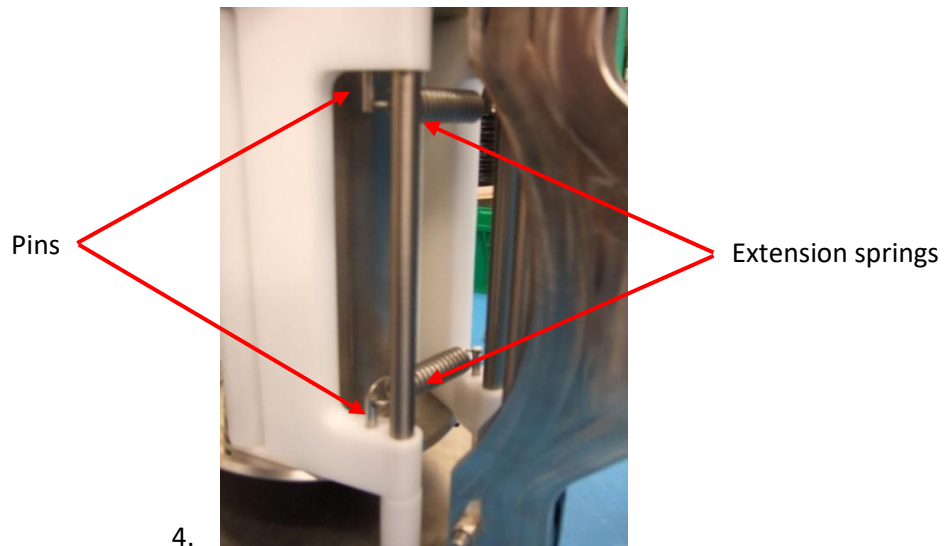


Figure 51. Two springs pull the two white paws together.

5. Remove the 6mm shoulder screw and locknut from the **level wind body 07436**, being careful not to lose the nylon spacer. Pull the Thin Line out of the level wind body.



Figure 52. To remove the Thin Line from the level wind body (black), remove the shoulder screw, self locking nut, and nylon spacer. Slip the Thin Line out of the gap.

6. Remove the 1x **M5X8mm** from the **Terminus Cover 11050** to remove the cover.

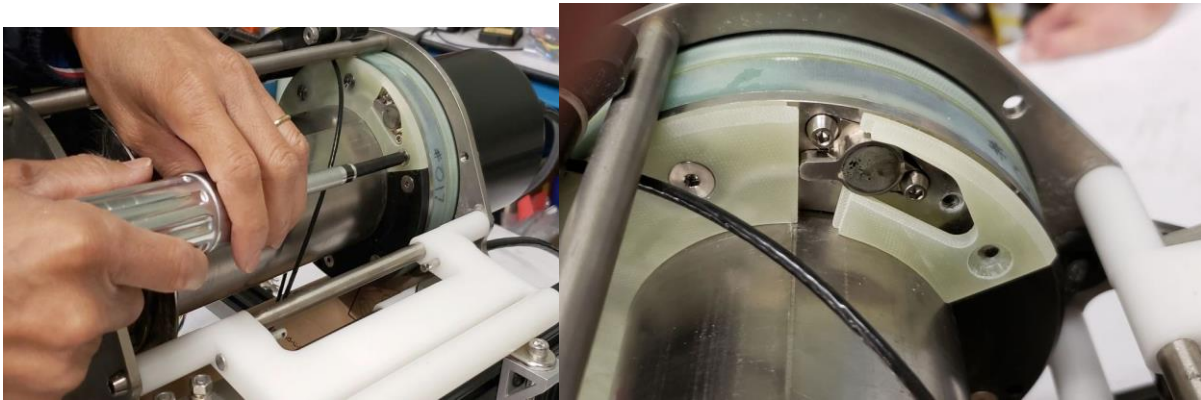


Figure 53. Remove the one M5 flat head cap screw from the Terminus Cover (A). Slide the Terminus Cover out (B).

7. Remove the 2x **M4X6mm** in order to remove the Thin Line Terminus.



Figure 54. Remove the two M4 cap screws securing the Thin Line Terminus to the Secondary Transformer.

8. Remove the 3x **M5X8mm** securing the **Cable Clamp 07508** to the Secondary Transformer. Then lift off the fiberglass Thin Line clamp and the cable at the same time and remove from the Winch. Try not to allow the Thin Line to slip out of the serpentine groove on the backside of the fiberglass Thin Line clamp. If it slips out, simply re-insert it.

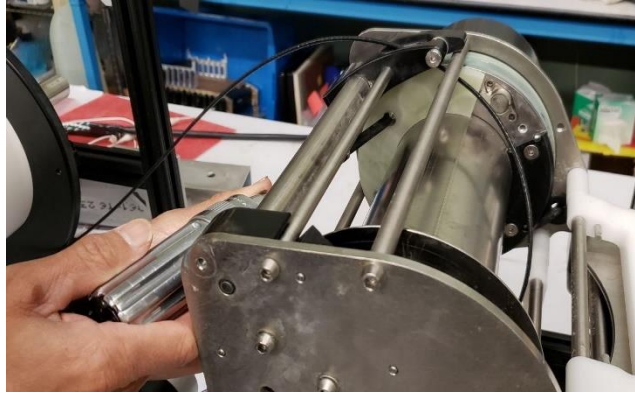


Figure 55. Remove the three M5 flat head screws securing the Cable Clamp to the Secondary Transformer.

9. Inspect and clean the o-ring sealing surface on the 2-pin connector of the secondary transformer with a non-linting wipe (Kimwipe) and isopropyl alcohol.

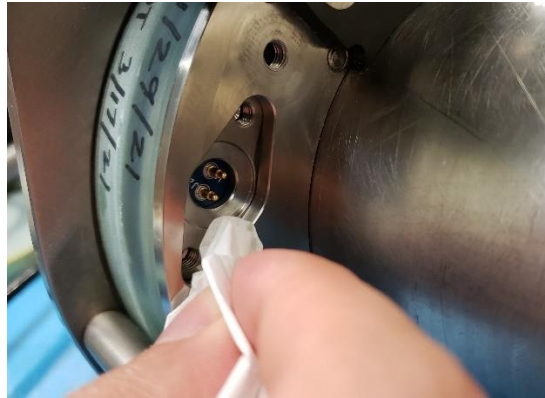


Figure 56. Clean the exposed 2-pin connector on the secondary transformer using a non-linting wipe (Kimwipe) and isopropyl alcohol.

10. Install **O-ring 02544-013** onto the **DUMMY, CABLE TERMINUS, THIN LINE**. Insert the dummy plug to cover the exposed 2-pin connector on the secondary transformer. Secure with the two M4 screws from Step 6.

6.5 Installing Thin Line without a Winch Rewinder

Removing and installing a Thin Line without a Winch Rewinder is not recommended. Contact Liquid Robotics for assistance.

Components:

- 1x Winch 150P
- 1x Thin Line
- 1x Wave Glider or CCU

Materials:

- Isopropyl alcohol
- Kimwipe (non-linting wipe)
- Dow Corning 111 O-Ring Silicone lubricant
- Loctite 243
- Zip tie

Tools:

- Torque wrench
- Needle nose pliers

Instructions:

1. Before connecting the Thin Line to the spool assembly, the spool needs to be positioned at a particular quadrant. The edge of the black Delrin cable spacer should be positioned just right behind the level wind body as shown. The spool can be rotated by powering on the Winch from WGMS or a vehicle webpage and running the command “Brake Release”.

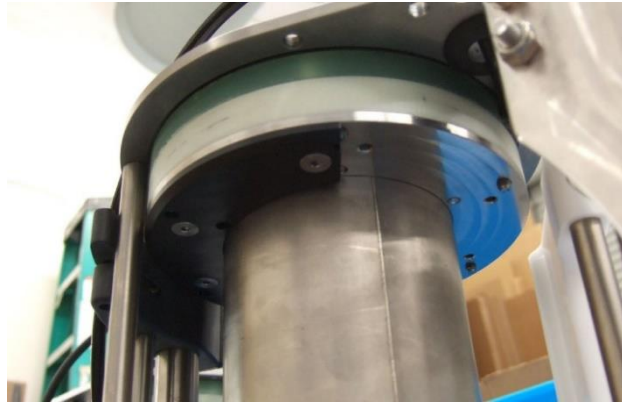


Figure 57. The black Delrin cable spacer attached to the spool should be adjacent to the level wind.

2. Remove the dummy plug from the Transformer Secondary. Save the 2x **M4x0.7 6mm screws**.
3. Inspect and clean the O-ring sealing surface on the 2-pin connector of the secondary transformer with isopropyl alcohol. Be careful not to damage spring loaded contact pins when cleaning O-ring surface. Ensure no stray fibers of swab or other cleaning material remain on O-ring surface. Ensure cavity containing spring loaded contact pins is also clean and free of contaminants. Ensure alcohol has totally dried before reinstallation of thin line terminus.



Figure 58. Clean the exposed 2-pin connector on the secondary transformer using a non-linting wipe (Kimwipe) and isopropyl alcohol.

4. Inspect and clean the O-ring groove of the Thin Line connector terminus with a non-linting wipe (Kimwipe) and isopropyl alcohol. Grease **O-ring 02544-013** with **Dow Corning 111** and place the O-ring in the Thin Line terminus groove.



Figure 59. Clean the exposed 2-pin Thin Line Terminus a non-linting wipe (Kimwipe) and isopropyl alcohol. Place the lubricated O-ring in the groove on the Thin Line connector terminus(B).

5. Mount the **cable clamp 07508** and Thin Line Terminus on the spool over their respective mounting holes. Loosely attach the cable clamp to the spool with 3x **M5X8mm screws** and make sure that the terminus fit correctly over its mounting holes. Use Loctite 243 on the screws but do not torque at this time.



Figure 60. Route the Cable Clamp through the spool shroud and over the proper mounting holes (A). Loosely secure the Cable Clamp with 3x M5 flat head screws while making sure the Thin Line Terminus aligns properly. (B)

6. Secure the connector with 2x **M4X6mm screws**. Use Loctite 243 and torque to 12 in-lbs [1.4 N-m]. Alternate between the 2 screws and tighten a bit at a time to make sure the terminus mounts flush.

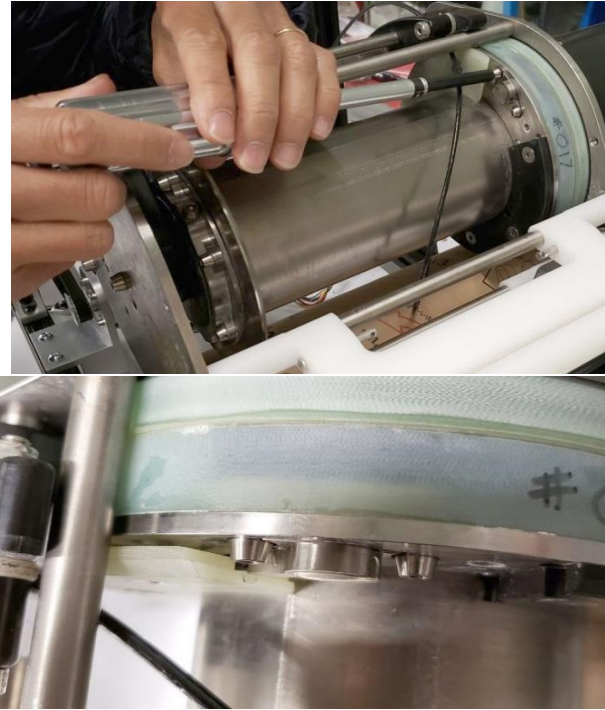


Figure 61. Secure the Thin Line Terminus with two M4 screws such that the terminus flanges are flush with the metal spool end plates.

7. Go back and tighten the 3x **M5x0.8 8mm screws** on the Cable Clamp from step 5. Torque to 24 in-lbs [2.7 N-m].
8. Position **Terminus Cover 11050** over the Thin Line Terminus and secure with 1x **M5x0.8 8mm screw**. Use Loctite 243 and torque the screw to 24 in-lbs [2.7 N-m].

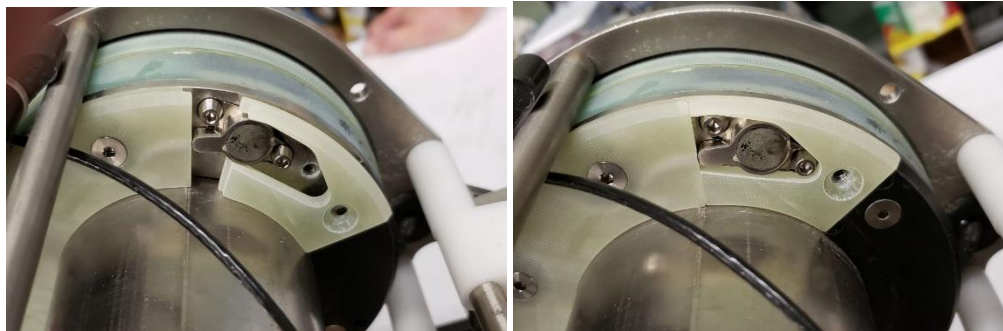


Figure 62. Slide the Terminus Cover into position (A) and secure with a M5x8mm FHCS.

9. Trap the thin line in the level wind body by installing **nylon spacer 09283**, **M5x0.8 30mm Shoulder screw** and **M5 Nylock hex nut**. Tighten the nut until there is still about 0.5 mm side to side movement of the shoulder screw.



Figure 63. Secure the shoulder screw, nylock, and nylon spacer. Slip the Thin Line out of the gap. Tighten the nut until there is still about 0.5 mm side to side movement of the shoulder screw.

10. To complete the paws assembly, connect 2x **extension springs 07471** to the opposing pin. An effective way to pull on the spring is to make a loose loop with a zip tie and use it to pull the extension spring until it can be hooked into the pin with needle-nose pliers.

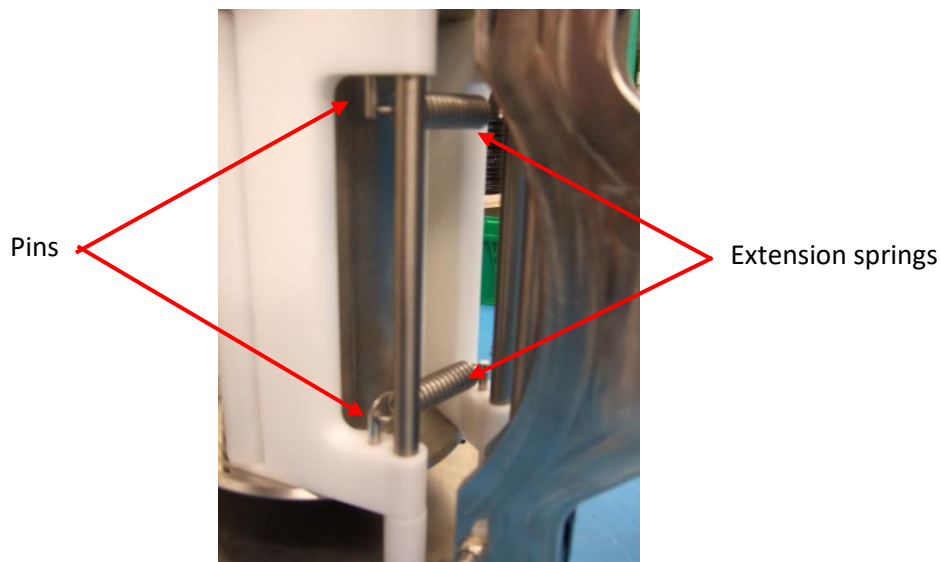


Figure 64. Two springs pull the two white paws together.

11. Adjust the Level Wind position all the way rearward per section 6.6 Adjusting the Level Wind Position.
12. On WGMS or the vehicle webpage, command “Go Home”.
13. Use a towel or glove to apply constant tension to the Thin Line. Hold the Thin Line perpendicular to the level wind as line is spooled onto winch drum.
14. Be ready to command “Stop” in case the Thin Line gets twisted or kinked.
15. Pay in until the Winch automatically stops at the stopper. Issue the command “Zero Count”.

6.6 Adjusting the Level Wind Position

Adjusting the level wind position should be performed if the winch cable has been replaced or the level wind position was changed for some reason.

Materials:

- Loctite 243

Tools:

- Computer with access to vehicle webpage or WGMS

Instructions:

1. Remove 2x screws **M8x1.25 10mm** from the **level wind screw retainer 07788** and pull the level wind screw retainer and **level wind screw 07426** towards the rear of the Winch until you can see the **gear 07957** on the front of the level wind screw.

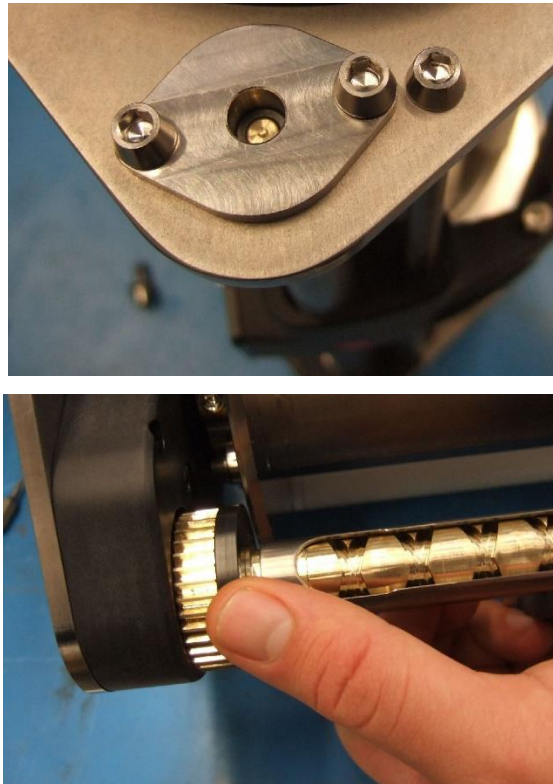


Figure 65. Remove the 2x screws on the left securing the level wind screw retainer (A). After removing the retainer, pull the level wind screw towards the rear of the Winch until the gear at the front of the Winch is visible and disengaged from the gear train (B).

2. Rotate the level wind screw as needed to move the level wind body forward or backward.
3. Align the step on the level wind screw retainer with the notch on the level wind screw guard and install flush to the end plate. Secure the retainer and the shaft next to it with 3x **M5x0.8 10mm screws**. Use Loctite 243 and torque to 32 in-lbs [3.6 N-m].

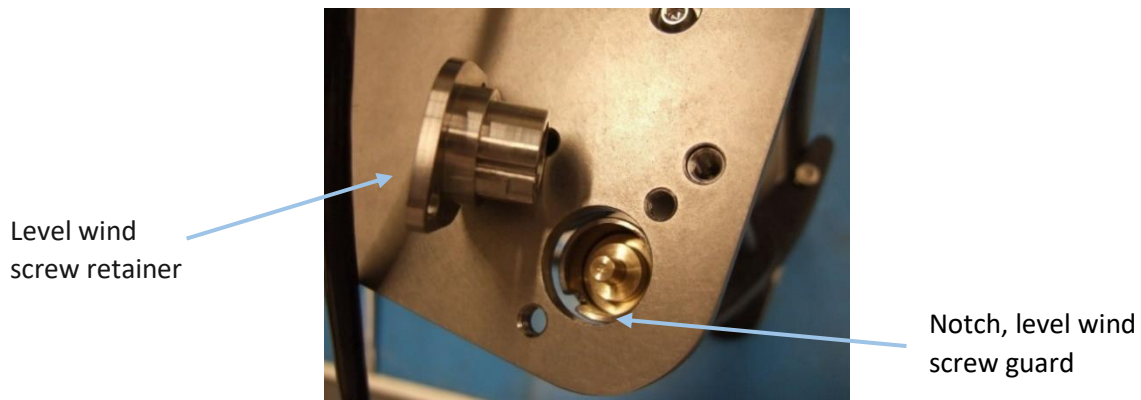


Figure 66. Align the key in the level wind screw retainer with the notch in the level wind screw guard.

4. Check that the level wind body is in the right place and that it will travel in the correct direction by paying out some cable and noting the movement of the level wind. From the vehicle webpage or WGMS, Power On the Winch, and make sure the Thin Line is powered off. If it automatically turned on with the Winch, command Thin Line Off, and wait for the blue light on the Winch to turn off for any high voltage in the Thin Line to dissipate. Command "Brake Release". While taking care not to twist or kink the Thin Line, pull on the Thin Line with constant tension. If it is going in the opposite direction as the Thin Line winding on the drum, the follower may have been installed incorrectly (if it was removed) or the level wind mechanism will have to be moved through a full 'sweep' of travel to make it move in the other direction (repeat Steps 1 to 3).

6.7 Detaching Sinker

Tools:

- Port Fill Valve Tube Coupler (03941)
- Allen key

Instructions:

1. Equalize Sinker pressure with atmosphere by removing the cover on the front of the Sinker. Using the **Port Fill Valve Tube Coupler 03941** or a blunt object, gently depress the valve core to allow Sinker pressure to equalize with atmospheric pressure. Ensure there was no water present in the valve or on the tool used to depress the valve core since it could be sucked inside during the pressure equalizing process.
2. Remove the 4x **M8x1.25 10mm screws** from the lower end of the Sinker Snubber. Gently lift the Sinker Snubber assembly off the **sinker rail 08153**. The coiled Thin Line will still be attached to the Sinker, so be careful not to stress the termination.



Figure 67. Remove the four screws attaching the Snubber to the Sinkers. There are two on each opposing side.

3. Remove the 2x **M8x1.25 10mm screws** from the sinker rail and gently lift the rail off the sinker. The **penetrator 08154** will come with the rail.



Figure 68. Remove the two socket head cap screws attaching the rail to the Sinkers.

4. Disconnect the lower termination to the Sinkers.



Figure 69. Disconnect the black connector between the Sinkers and the penetrator.

5. Remove the 2x **M4 set screws 08158** that hold the penetrator into the rail and remove the penetrator from the rail. Protect the O-rings on the penetrator with a plastic bag to keep them clean.



Figure 70. Remove and store the two set screws securing the penetrator in place.

6.8 Pressurize Sinkers

The Sinker is negatively pressurized to reduce the likelihood of leaks occurring on mission. This is tested for leaks before missions.

Materials:

- Dow Corning 111 O-Ring Silicone lubricant
- Loctite 243

Tools:

- KIT, SINKER VACUUM 11628
- Air pressure gauge, vacuum
- 3mm Allen key
- 4mm Allen key
- Computer with access to WGMS or vehicle web page

Instructions:

1. Ready the Sinker housing for pressurization by removing the fill port cover, and cleaning and lubricating the fill port.

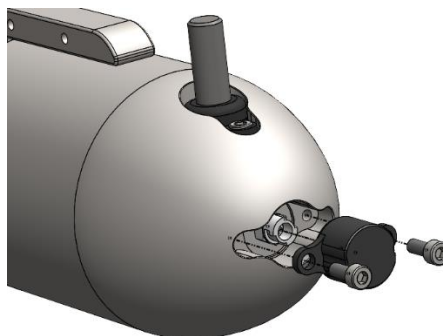


Figure 71. Exploded diagram of pressure port cover on Sinker.

2. Pressurize the Sinker using the **KIT, SINKER VACUUM 11628**. Attach the **tube coupling 03941** to the fill port, and using the included syringe 11629 and, pull a vacuum in the Sinker. Measure the internal pressure, which should be within the range of **-5.8 to -8.7 psi (-40 to -60 kPa) gauge pressure**. Check for immediate leaks, note down the pressure, and leave overnight if possible. It is not necessary to adjust for temperature.
3. To check the internal pressure of the Sinker, you may use a pressure gauge that measures relative pressure, or you may use the Sinker internal sensor.
 - a. Turn ON Winch and Thin Line power, let the Sinker enumerate (up to 10 min).
 - b. Get the internal pressure of the Sinker.
 - i. From WGMS select:
 1. **SV3 Commands >> Services >> Winch_winch >> Expert >> Get Internal Pressure**
 2. Once the command Acks, hover the cursor over the Combined Acks column entry. The internal temperature and pressure of the winch housing and Sinker will be displayed.
 - ii. From the Vehicle Web Page:
 1. Go to: **Operate >> Winch**
 2. Turn ON Winch and Thin Line power. Let the Sinker enumerate (up to 10 min, the Sinker will be enumerated when from the AMPS Domain page under, Winch Domain, “**Slot 192: Sinker PDC**” is visible at the bottom of the listed domains).
 3. Go to: **Setup >> All Vehicle parameters**
 4. Check the: **Show Expert Commands** box
 5. Use Control + F to search for “winch” on the page
 6. In the WGMSGenericAlarmReporter (wgmsAlarmReporter) section click: **Get Internal Pressure >> Confirm**
4. Note the pressure, temperature, and time. Check the pressure again in 24 hours to see if pressure has changed by more than 1 psi (7 kPa) while adjusting for temperature using the equation $\frac{P_1}{T_1} = \frac{P_2}{T_2}$. If there are no leaks, proceed to step 5.
 - a. If overnight observation is not possible, submerge the pressurized sinker in fresh water and watch for bubbles or leaks.
 - b. If there is a leak, the seals must be inspected and cleaned or replaced. Look for cracks in the O-ring rubber or debris crossing the path of the seal. Repeat the pressure test.
5. Inspect and clean the pressure port cover, O-ring, and O-ring seat before installing the cover. Use Loctite 243 and torque screws to 16 in-lb. [1.8 N-m].

6.9 Pressurize the Winch Electronics Enclosure

Materials:

- Clean dry nitrogen fill tank
- Dow Corning Molykote 111 O-Ring Silicone lubricant
- Isopropyl alcohol
- Non-linting wipes (Kimwipe)

Tools:

- 4mm Allen key
- Computer with access to WGMS or Vehicle Web page

Instructions:

The Winch electronics enclosure should be positively pressurized between the values of **16-18 psi (110 – 124 kPa) gauge pressure** during the Pre-Launch process. It is not necessary to adjust for temperature. Pressurization of this enclosure also pressurizes the winch motor and other internal components; therefore, it is very important to verify that it has no leaks prior to deployment or any sort of submersion.

1. The fill valve is accessed by removing the pressure port cover held in place by two plastic screws. Take care to retain the small O-ring and screws with the cover. Clean the pressure port cover with isopropyl alcohol and non-linting wipes (Kimwipes).



Figure 72. Exploded diagram of pressure port cover on Electronics Housing.

2. The electronics enclosure should be filled to **16-18 psi (110 – 124 kPa) gauge pressure** with nitrogen and purged three (3) times to ensure the Winch's internal atmosphere is clean, dry, and of high nitrogen content. Make note of the final pressure.
3. Inspect, clean, and lubricate the small pressure port cover O-ring with Dow Corning Molykote 111. Clean the pressure port cap groove and seat. Install the pressure port cap and verify that the Winch holds constant pressure for 24 hours. Torque screws to 10 in-lb. [1.1 N-m]. If a loss of pressure is noted, inspect, clean, and lubricate the main O-ring as well as the pressure port cover assembly. Replace these parts as necessary. Re-pressurize the Winch enclosure and repeat 24-hour leak check, allow for minute changes in pressure due to temperature change.

- a. Use the equation $P_1/T_1 = P_2/T_2$ to account for minute changes in pressure due to temperature change, where temperature is in Kelvin.
4. Check the internal pressure of the Winch Electronics Housing via WGMS or the Vehicle webpage.
 - a. Turn ON Winch and Thin Line power, let the Sinker enumerate (up to 10 min).
 - b. In WGMS select:
 - i. **SV3 Commands >> Services >> Winch_winch >> Expert >> Get Internal Pressure**
 - ii. Once the command Acks, hover the cursor over the Combined Acks column entry. The internal temperature and pressure of the winch housing and Sinker will be displayed.
 - c. From the Vehicle Web Page:
 - i. Go to: **Operate >> Winch**
 - ii. Turn ON Winch and Thin Line power. Let the Sinker enumerate (up to 10 min, the Sinker will be enumerated when from the AMPS Domain page under, Winch Domain, “**Slot 192: Sinker PDC**” is visible at the bottom of the listed domains).
 - iii. Go to: **Setup >> All Vehicle parameters.**
 - iv. Check the: **Show Expert Commands** box.
 - v. Use Control + F to search for “winch”.
 - vi. In the WGMSGenericAlarmReporter (wgmsAlarmReporter) section click: **Get Internal Pressure >> Confirm**

6.10 Winch Immersion & Cleaning

After each recovery, the Winch must be rinsed and immersed in fresh water. Special attention should be paid to spraying water between rotary transformer halves to remove saltwater. When done properly, this reduces the likelihood and size of salt crystal buildup. ***This is especially important if the Winch is to be operated dry (not submerged in water) at a later time, as salt crystals will form in bearings and other moving interfaces if this flushing is not performed.*** If so, the Winch must be immersed in fresh water and the motor must be actuated for one hour to dissolved encrusted salt. Before this can occur, the Winch must be removed from the Sub (See Section 6.2 Removing a Winch).

If you have a Winch Rewinder, follow instructions in the Winch Rewinder User Guide (P/N 10742) to set up a Winch Rewinder to remove the Thin Line. Then proceed to 6.10.1 Immersion Instructions. If you do not have a Winch Rewinder, go to section 6.4 Removing Thin Line without a Winch Rewinder. Then proceed to 6.10.1 Immersion Instructions.

6.10.1 Immersion Instructions

Materials:

- 1x **Thin Line Terminus Dummy Cap 11331**
- 1x **O-RING, N70, AS568-013 02544-013**

- 2x **M4x0.7, 6mm Screw**
- 1x **Transformer Secondary Dummy Plug 11331**
- 1x 5-gallon bucket or similar container that can fit a Winch
- ~3 gallons fresh water

Tools:

- Computer with access to vehicle webpage or WGMS

Instructions:

If the Souriau expansion cable is disconnected, re-connect the Winch to the T1 port on the Thrudder.

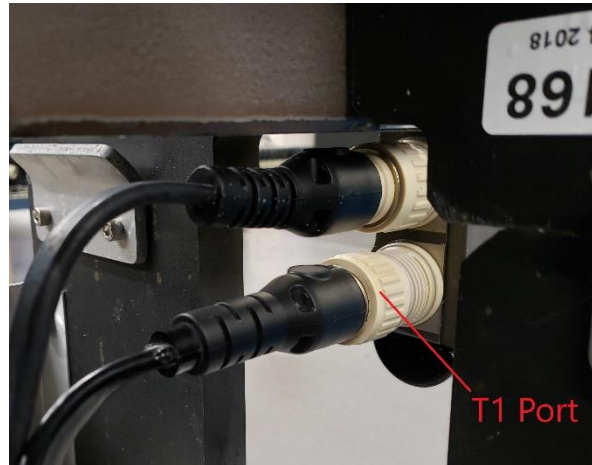


Figure 73. Winch electrically connected to the T1 port on the Thrudder.

Ensure a **DUMMY, CABLE TERMINUS, THIN LINE (P/N 11331)** is in place on the Winch to cover the pins to the Thin Line. Place the Winch into a 5-gallon bucket such that there is no strain on either end of the Souriau expansion cable.



Figure 74. Winch in a 5-gallon bucket while electrically connected to the T1 port.

Fill the bucket with fresh water until the two metal endplates are completely submerged.



Figure 75. Winch in bucket filled with fresh water above the nearest silver end plate.

Access the Wave Glider's webpage and navigate to the "Winch" page under the "Operate" dropdown menu.

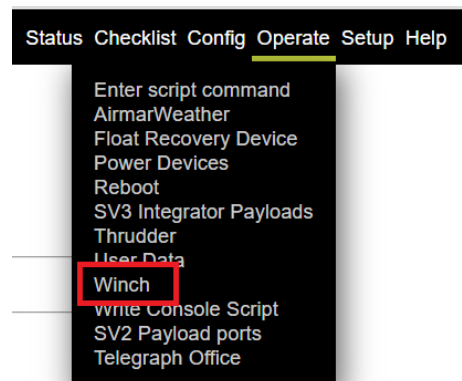


Figure 76. On the "Operate" tab on the Wave Glider's vehicle webpage, select "Winch".

Power on the Winch using the "Winch On" button.

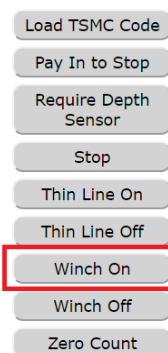


Figure 77. From the Winch Commands page in the vehicle webpage, click the "Winch On" button to power on the Winch.

Run the "Go Home" function to operate the Winch continuously for one hour.

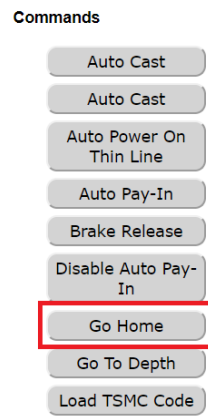


Figure 78. On the Winch Commands page in the vehicle webpage, click on the "Go Home" button in order to run the Winch.

After an hour has passed, press the "Stop" button to stop the Winch.

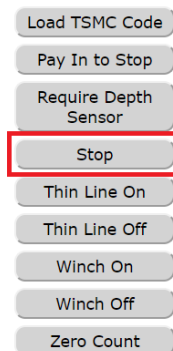


Figure 79. On the Winch Commands page in the vehicle webpage, click on the "Stop" button to stop the drum.

Power off the Winch with the "Winch Off" button.

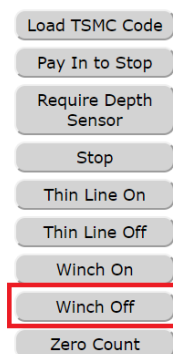


Figure 80. On the Winch Commands page in the vehicle webpage, click on the "Winch Off" button to power off the Winch.

Reinstall the Thin Line to the Winch. If you have a Winch Rewinder, follow instructions in the **Winch Rewinder User Guide (P/N 10742)** to wind the Thin Line onto a Winch. If you do not have a Winch Rewinder, see 6.5 Installing Thin Line. If applicable, reinstall the Winch onto a Wave Glider (See 0

Table 3. Maintenance tasks and intervals.

Part #	Description	Months In Water												Actions
		1	2	3	4	5	6	7	8	9	10	11	12	
--	Rinsing	Post-recovery												3.4.4 Soak Winch
--	Inspection		X			X			X			X		6.3 Inspection
10734	Thin Line Replacement			X			X			X				Liquid Robotics recommends returning a Winch to LR for replacement. It can be done with a Winch Rewinder or by following sections 6.4 and 6.5 .
07425-03 (v300) or 08691-03 (v100/200)	Expansion Cable Replacement						X							See sections 6.2 Removing a Winch and 0Error! Not a valid bookmark self-reference..
--	Depot Repair												X	Return to Liquid Robotics for repair and inspection. Thin Line and Expansion Cable will be replaced by Liquid Robotics.

Installation).

6.11 Installing Winch Hammock

The Winch Hammock serves to support the Winch and keep it from dragging on the ground when a Rapid Stand is moved. The retrofit kit to add a Winch Hammock to a Rapid Stand is KIT, WINCH HAMMOCK, RAPID STAND (P/N 11683). If the Rapid Stand has an L-Drop adapter kit installed, it must be removed and a SUB CRADLE, FIXED, RAPID CART (P/N 09075) must be installed.

Materials:

- Loctite 243

Tools:

- 5mm, 6mm Allen keys
- Torque wrench

Instructions:

1. Unstack the float and sub from the Rapid Stand Cart before beginning. The float can be left in the rapid saddle and lifted off as one unit, take care not to pinch or crush the umbilical in the process.



Figure 81. Rapid Stand with Wave Glider unstacked. Sub has been placed on a Legacy Stand cart.

2. If the Rapid Stand Cart has an L-Drop adapter kit installed, it must be removed, and the rear fixed Sub Cradle reinstalled. If the cart is stock, skip to step 3.
 - a. Pull out the 2 pins that attach the outer L-Drop wing support arm. Remove the support arm.



Figure 82. Rapid cart with L-Drop adapter Kit installed.

- b. Remove the Inner sub wing support arm from the cart. It is attached from below by 2x M6 screws.



Figure 83. Rapid Cart with outer L-Drop wing support removed.

- c. Attach the stock fixed sub cradle (09075) to the cart with 2x **M8x1.25 35mm screws** in a parallel orientation with the inner edge of the cart. Use Loctite 243 and torque to 60 in-lbs [6.8 N-m].



Figure 84. Mount the stock fixed sub cradle to the cart.

3. Rear Sub Cradle installation: Attach one of the slotted sub guides, through the top positioning holes (for v200 and v300) with the pins that were removed as shown.



Figure 85. Rear Sub Cradle configured for v200 and v300 sub (through upper alignment holes).

4. Front Sub Cradle installation: Remove the two pins at the front Sub Cradle and replace with the remaining slotted Sub Cradle. For v200 and v300 use the lower set of positioning holes; for v100 use the upper set.



Figure 86. Front Sub Cradle configured for v200 and v300 sub (through lower alignment holes).

5. Insert the self-aligning roll-in T-Nuts (3ea.) (11468 rev 01) into the channel on the cart cross member.



Figure 87. T-Nuts placed in the crossmember channel with flat side up.

6. There are three sets of two eyes. Fold **the tarpaulin 11404** in half so that the eyes overlap each other. Capture each pair with a **M6x1 25mm screw** and a **SS M6 flat washer**. Move the T-Nuts within the channel to line up with the eyes of the tarpaulin. Place one flat washer onto one M6 screw and apply Loctite 243. Fasten both eyes of the tarpaulin to the crossmember using the T-nut and torque the 3x **M6x1 25mm screws** to 30 in-lb [3.4 N-m].



Figure 88. Secure each pair of eyes in the tarpaulin with a M6 screw and washer.

7. The Tarpaulin should be fastened to the cart at 3 places, roughly centered on the crossmember.



Figure 89. Tarpaulin folded in half and secured with 3x M6 screws.

8. Route the free end of the cam strap (00705 rev A) through the slot of the rear sub cradle.



Figure 90. Strap threaded into the slot in the rear sub cradle.

9. Route both ends of the cam strap through the inside of the tarpaulin to the front sub cradle.



Figure 91. Route the strap through the slot in the tarpaulin.

10. Route the free end through the slot of the front sub cradle, and back into the cam.



Figure 92. Strap routed through the front sub cradle slot and through the strap cam.

11. Tighten the cam strap and position it so that the clasp will be hidden within the tarpaulin. Tie the excess tail of the strap with an overhand knot so that the strap does not lose tension under use. Pull the knot tight and repeat with the remaining material. Hide the remainder of the strap tail within the tarp.



Figure 93. Overhand knot tied right against the strap cam to prevent it from loosening during use.

12. Cover the strap cam with the tarp and check that there is enough tension to support the winch. The winch hammock is now installed and ready for use.



Figure 94. Strap cam and excess strap tucked away into the slot in the tarpaulin.

13. The tarpaulin can be lowered to access or remove the winch is necessary. The cam strap can be loosened or removed, and the tarpaulin pushed out of the way.



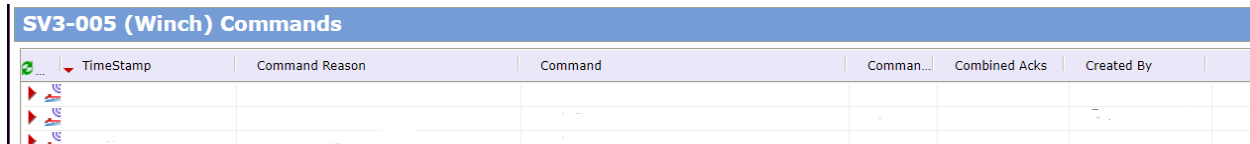
Figure 95. Tarpaulin with the strap loosened to allow access to a Winch mounted to a Sub.

SECTION 7: TROUBLESHOOTING

Certain alarms and events that will be reported to shoreside servicers under certain circumstances. The plugin's Winch Monitor periodically runs in the background and checks status of the components of the Winch, e.g., from Winch PDC and Sinker PDC.

7.1 Events

Events are notifications to WGMS that do not require user action. The Winch Plugin will report status in the Commands section on WGMS and on the vehicle webpage.



SV3-005 (Winch) Commands					
TimeStamp	Command Reason	Command	Comman...	Combined Acks	Created By
2019-03-21T16:25:31.604Z	0x10000 unpowered brake-hold	0 NOP (busy)			

Figure 96. Commands section of WGMS.

7.1.1 Show that Winch (Domain) is Detected/Active

When the Winch is powered on and the AMPS domain is found, the plugin will report status and configuration:

- Winch Detected: DepthEstimatedFromSurface=10m PressureDepthAtSinker=NotAvailable PayOutLength=0m winchStatus=0x10000 unpowered brake-hold Timestamp=2019-03-21T16:25:31.604Z command=0 NOP (busy)
- Winch Configuration: segmentLengthM=0m minWorkingLenM=0m maxWorkingLenM=150m interSegmentWaitTimeSec=15 payOutSpeedMetersPerMinute=480 reelInTorque_mA=8000 TimestampOfWinchCache=CONTROL_OR_STATUS:65536 10.286s ago
- modelName="150m Winch" modelCode=100 cableDia=0.0031m mdRatioDen=18 mdRatioNum=1183 spoolOD=0.0889m stopCollarLengthM=2m turnsPerLayer=57.0 reelCapacityM=160m
- reserveLineLengthM=3m usableLineLengthM=150m calculatedTotalLengthM=153m numTurnsTotal=442

Alternate methods for determining if Winch is active is by:

- WGMS: Use 5.1.17 and then read the reported data. (see 0) The string contains enough information to yay or nay.
- Web page: Go to: Operate > Winch. Check out the status “LEDs”.
- Web page: (Not quite as accurate) Go to: Status > AMPS and see if Winch Domain is present. Then within that domain, see how it has been up.

7.1.2 Show that Thin Line (Sinker) PDC Detected/Active

When the Thin Line PDC is available in Regulus, the plugin will report status and if “Auto Power on the Thin Line” is enabled or disabled:

- Winch Thin Line Power Comms module is available. Will not power on the Thin Line, as auto power on Thin Line is disabled
- Winch Thin Line Power Comms module is available. Auto power on Thin Line enabled, will attempt to power on the Thin Line

Alternate methods for determining if Sinker PDC up and active:

- Web page: Go to: Status > AMPS and open Winch Domain. See if Slot 192 is present and does **not** show “Module Not Available!” under Slot 192’ Module Type.
- Via a Write Console Script command: `amps.portDumpNC("Winch", 192, 0, 0, 128)`. Expect a response—not a NAK or time out.
- Web page: Go to: Operate > Winch. Check out the status “LEDs”. (Thin Line On) In reality this only shows that the power on command was sent to the Thin Line. It is no guarantee that a connection has been made.)

7.1.3 Power On Thin Line

If auto power on Thin Line is enabled, it will report status:

- Winch: Automatically powered on the Thin Line. Will look for the PDC Sinkerm

When the Thin Line is powered on, it will report status when the SPDC is available:

- Winch: Found PDC Sinker. Sinker External Pressure should now be available

If the user serial configuration stored on the SPDC is different from what is stored in the plugin, the plugin will update the SPDC for user serial config:

- Winch: Updated user serial configuration on the PDC Sinker: SerialConfig: 9600 baud OneStopBit NoParity EightBits

7.2 Alarms

Alarms are notifications to WGMS that indicate critical failures in the Winch 150P system. All standard Regulus and AMPS alarms also apply. There are no alarms at this time.

7.2.1 Water Leak Alarm

The Winch Monitor will periodically check the Winch PDC and Sinker PDC for water leak alarms. If it detects an alarm or fault, it will report to WGMS that there is a problem and send the Water Leak Detection status of the relevant PDC. This alarm will only be reported once after the Winch is powered on. It will not report again until the Winch is power cycled through the plugin commands.

For example:

- PDCWinch leak detected for the first time. ERROR: Water Detect in PDCWinch has fault(s): LeakDetectAlert LeakDetectFault OnTime 92s OffTime 0s DetectionAverage -1515870810mV DetectionMin -1515870811mV DetectionMax -1515870811mV

In this case, there is some kind of fault in the sensor and is reporting nonsense values. Probable causes include a damaged sensor or faulty connection.

If the fault repeats, it will report an event to the WGMS Command Log, to help confirm that the water leak alarm or fault is stable, for example:

- PDCWinch has had 10 consecutive leak reports. This is an informational message indicating that the device is definitely leaking or the sensor is broken.

7.3 AMPS

This section provides AMPS-related troubleshooting for Winch 150P issues. However, note that, on a vehicle with many AMPS devices, e.g., APUs and integrator payloads, there may be some cases that AMPS seems to be very slow.

7.3.1 Winch AMPS Domains Very Slow or Not Coming Up (any AMPS domains) or Increase the Winch PDC Polling Interval

- Please be patient, contact Liquid Robotics if this is a persistent problem

7.3.2 Winch PDC AMPS domain fails to appear during Winch power on or if the Winch PDC AMPS domain disappears after a successful power on

- Is the Thrudder responding?
 - If not, need to power cycle the Thrudder.
 - Can unplug U1, or power cycle through the vehicle AMPS page
- If the Thrudder is responding
 - Power cycle the Winch and see if it comes online (Winch Off -> Winch On)

- Wait to see if “Winch Found” (green light) appears on the vehicle Winch page (up to 10 minutes).
- If the Winch isn’t showing up “Winch not found” (red light) and no AMPS domain appears on the vehicle’s AMPS page.
- Note that the “Unknown” domain with only “Slot 0” is the Winch domain.
- If only the PDC shows up, it may be that there is an issue with the PowerComms board.
- If the Winch AMPS domain is not there, then there is some communication issue.
- Winch OFF
- Power cycle the Thrudder or the Umbilical
 - Can unplug U1 or power cycle the Umbilical through the AMPS vehicle page
- After the Thrudder AMPS domain is available, Winch ON.
- Wait to see if “Winch Found” (green light)
- If Winch is never found, then there may be another problem. See next section.

7.3.3 Winch AMPS domain isn’t found after umbilical power cycle

- See previous section first. If that doesn’t work, there may be an electrical problem
- May try to plug the Winch directly into another expansion port, e.g. G3
- Winch OFF
- Go to Config -> Miscellaneous
- Find " Winch_winch: name of the device that controls power to the Winch (default: T1)"
- Change to “G3” (or whichever expansion port is appropriate)
- Press OK in the bottom right of the page
- Power Winch ON (WGMS: 5.1.20, webpage: 5.3.15)
- Is the “Winch Found” (green light) on G3?
- If not, must contact Customer Support. There may be an issue with the Winch PDC and/or wiring

7.3.4 My Sinkers are not visible in the Winch Domain (or indicates that it is unavailable)

- Thin Line power to Sinkers has not been turned on.

Confirm by: Use web page or console command: see [Table 1](#)

Fix by:

- Turn **off** Thin Line (and modem) power.

NOTE: Thin Line sometimes does not turn on without implicitly turning it off first, regardless of reported state. See 7.3.7.1

- WGMS: 5.1.13
 - Web page: 5.3.14
- Turn **on** Thin Line (and modem) power.
 - WGMS: 5.1.15
 - Web page: 5.3.13
 - Now wait... (Zzz...)

- If the Winch is out of the water: Thin Line power unreliable (blue light off or *irregularly* blinking)

If the Winch and Thin Line are powered on, the blue light should flash with an **approximately three second interval**. If not, this could be due to any or multiple of the following causes:

- Power control parameters not programmed with correct values. See 7.3.12 for check and possible fix.
 - There are electrical problems in the high voltage conversion path (transformer secondary, Thin Line, and Sinker).
 - Defect in the Thin Line. Look for damage to the insulating jacket, including kinks or cuts. This requires replacement of the Thin Line.
 - The IE-55 connector from the Transformer Primary to the Electronics Enclosure may be damaged or disconnected. Inspect for damage to the cable. The connector may be inspected for damage by disconnecting and examining for signs of water ingress, which is typically signified by green or white corrosion by-products.
 - The Sinker is not (properly) plugged in, or there is a connector problem.
- Sinker does not have proper power.

• **ADD THIS SECTION WHEN THE SINKER HV WIDGET HAS BEEN COMPLETED**

- Cannot communicate with Sinker due to no power to upper modem.
 - Confirm and fix using: 7.3.13

Note: The command to turn the Thin Line power on (above) should turn on the power to the modem. (It should be coded as a both or neither state.)

- Cannot communicate with Sinker due to no coax bit set, meaning modems are not communicating to each other.

Confirm using: 7.3.14

- Ethernet bit indicates no connection.

Confirm using: 7.3.14

This does not matter only in the sense of the plugin communicating with the Sinker. It will matter when the user attempts to send Ethernet packets to and receive packets from the user payload attached to the Sinker.

- Slot 192: Sinker PDC module does not show in Winch domain list of slots or shows as "Module Not Available!". (See web page: Status > AMPS: Winch Domain.)
 - For WGMS
 - Send a Retrieve Power Status command
 - More Command > Retrieve Power Status
 - Look at AMPS Output Power
 - Click on the vehicle icon
 - Click the drop down in the top center of the page that says, "Vehicle Form" and select "Vehicle Data Form"
 - Click "Amps Output Power"

- The power domain of the winch will have 3 ports if sinker is not on/found, and 4 port with the sinker (Module 192 is the sinker)

The current firmware may not allow the Host (not so much the plugin) to recognize the presence of the Sinker for a long time. The longer the Winch Domain has been up before turning on the Sinker, and the timing is worst case, it will take four hours to establish that connection. All the while the Sinker is connected and responsive to direct commands.

One fix is to cycle power to the Winch domain and then soon after that comes up, turn on Thin Line. That should reduce the maximum waiting time to less than five minutes.

Note: When turning off the Thin Line, it may never disappear as an entry in the Winch Domain. Although it may eventually add a statement in the Slot 192 paragraph (on the web page) "Module Not Available!". Therefore, when turning the Thin Line on again, watch for that statement to go away. (Same kind of timing as first turning on.)

7.3.5 My winch will not pay out

- Determine the depth the Sinker is reported to be:
 - WGMS: Use 5.1.17 to determine the amount of line spooled out. Use 5.1.9 to get relevant configuration settings.
 - Web page: Go to: Operate > Winch. See value for (TSMC) Drum position. See web page for relevant configuration settings.

If the line length out (drum position) is at or greater than the "usableLineLengthM" (Web: "Usable Line Length") value or the "maxWorkingLenM" (Web: "Maximum Working Length") value, then the Winch will deny further spooling out.

- Are the above-mentioned parameters set wrong?

These should not be arbitrarily changed. Especially the "Usable Line Length". If this is changed such that the value allows for more line to be spooled out than available, it will very likely damage the Thin Line, and possibly drop the Sinker and all that is attached to the bottom of the sea. The "Maximum Working Length" value is safer to adjust, since it limits its values to be between the "Minimum Working Length" and "Usable Line Length".

- The Sinker may have dropped off.

See 7.3.4.

- If available, read the Sinker's reported depth and correlate to the amount of line spooled out. If the two are identical, it could be:
 - The brake may not be releasing.
 - The Thin Line may not be neatly spooled onto the drum and may be overlapping or crossed over or grooved such that it pinches the line above it.
 - There may be a mechanical or electrical fault with the motor and/or gearing. Or the bearings have swollen and ceased up.

If there is no match, see 7.3.8.

7.3.6 My winch will not pay in

- Determine the depth the Sinker is reported to be:
 - WGMS: Use 5.1.17 to determine the amount of line spooled out (CablePayOutLength).

Use 5.1.9 to get relevant configuration settings.

- Web page: Go to: Operate > Winch. See value for (TSMC) Drum position.
See web page for relevant configuration settings.

If the line length out (drum position) is at or less than zero (home position) or the “minWorkingLenM” (Web: “Minimum Working Length”) value, then the Winch will deny further reeling in.

- Are the above-mentioned parameters set wrong?

The zero (home) position is set and determined when the Thin Line is wound onto the drum, or when recalibrated prior to a mission. It should not be reset wantonly. Only in case of an accidental power failure where the drum counts get corrupted may the home position change to some place it should not be. See 7.3.8 to check.

Unless the “Go Home” (WGMS or Web) was issued, the Sinker will not be reeled in to a depth less than the minimum working depth.

- If available, read the Sinker’s reported depth and correlate to the amount of line spooled out. If the two are identical, it could be:
 - Thin Line/Sinker/Payload may be snagged on something. (Caught a fish or a crab pot?)
 - Biofouling may have affected the thickness of the Thin Line such that it cannot be pulled through the cable guide.
 - The Thin Line may not be neatly spooled onto the drum and may have bunched up such that in some places it is too “thick” to fit on the drum.
 - The brake may not be releasing.
 - The setting that controls the motor power may not be set correctly.
On the Winch web page read the value named: “Reel-In Torque (mA)” in the Configuration section. It should read 8000.
To read and change this value without Winch web page, see 7.3.17.
 - There may be a electrical or mechanical fault with the motor and/or gearing.

If there is no match, see 7.3.8.

7.3.7 My Sinker Payload is Not Turning On and Cannot Communicate with it

The assumptions made here is: The entire Winch system reports and appears to be working.

There are several interpretations for this:

- Turning on the payload makes the Sinker disappear.
- The payload is not powering up.
- I’m not getting serial data from my payload.
- I’m not getting ethernet data from my payload.

7.3.7.1 Winch Plugin Shows Incorrect Power State

There is a known bug with the Winch Plugin with respect to the Sinker payload power. If the Thin Line or Winch was previously powered down without first turning off the Sinker payload port, the Plugin will not turn on the port. The command response will be “Sinker Payload Port was already on.” In this condition, the Sinker payload port needs to be powered off, then back on. A good power sequence will respond with “Sinker Payload Port is powered on.”

7.3.7.2 Payload not powering up

Use 5.1.7 to check reported state.

Or use Web page (Status > AMPS, Winch Domain, slot 192 port 4 status). Status with bit 0 set indicates that the port thinks power is on. Other bits set may indicate failure conditions. (Not bit 15—see appropriate port description document for more details on status field states.)

If it reports that it is not powered up, use 5.1.14 to power it up.

If powered up, check WGMS power reports or Web page (Status > AMPS, Winch Domain, slot 192 port 4 power draw). (These are rather crude averages. A better, “instantaneous” (last sample) can be obtained by send the write console script command: `amps.portDumpNC("Winch",192,4,131,4)`. Four hexadecimal values will be returned that report status, power (mW), voltage (mV), and current (mA). If LSB of status is zero, then power to the user port is not turned on. Otherwise, the other values may help in determining if the payload is drawing the correct amount of power. These values are sensed near the connector that connects to the user gear.

Decide from these numbers if there is a problem with this power port.

7.3.7.3 Not getting serial data from payload

To get data from (and to) the User payload via a serial connection, a complete path must be configured: from the User payload attached to the Sinkers, all the way to a Payload box on the Float. And the serial communications parameters must be configured at both ends.

To reset the User serial configuration, see Section 3.1.7.2 Configuring Serial.

NOTE: Once the final routing step has been taken, the WINCH PDC loses access to its console port.

To check the settings, send the following write console script commands and look for expected results. Any deviation may indicate why there is a lack of communication.

o <code>amps.portDumpNC("Winch",192,11,7,1).</code>	Expected result: 0x80002580
o <code>amps.portDumpNC("Winch",0,11,60,1).</code>	Expected result: 0x00005555
o <code>amps.portDumpNC("Winch",192,11,66,1).</code>	Expected result: 0x00005555
o <code>amps.portDumpNC("Winch",192,11,19,1).</code>	Expected result: 0x00100108
o <code>amps.portDumpNC("Winch",0,11,13,1).</code>	Expected result: 0x17042812

The only deviation allowed is in the first response. The above example is set up for the most standard operation, 9600 Baud, 8N1 with path active. (See Port description document for port 0x6010_2100 for additional configuration settings.)

7.3.7.4 Not getting ethernet data from payload

The ethernet port is always on when the sinker payload port is powered. If there is no ethernet from the sinker payload, but everything else on the winch is working, there may be an issue with the ethernet path between the winch and the payload in the float

Check to make sure the float payload is able to communicate over ethernet to the CCU.

- o If this is a SMC based payload:
 - o Send a payload command to verify the payload is talking over ethernet to the CCU
 - `Gx_PayloadInterface.GetModules()`
 - o Try to ping the winch payload from the float payload

- `Gx_PayloadInterface.Runshell("ping -c 5 xxx.xxx.xxx.xxx")`
 - Where xxx.xxx.xxx.xxx is the IP of the winch payload

Check the ethernet switch configuration is correct (v300 only).

- Check the current configuration of the switch. If this has been changed from “default”, it will respond with the name of the custom configuration, otherwise, it should respond with “default”
 - `ethernetSwitch.identifySwitchConfig()`
- If the ethernet switch configuration is not correct
 - Get list of ethernet switch configurations
 - `ethernetSwitch.listNamedConfigsUI()`
 - Set the ethernet switch configuration
 - `ethernetSwitch.selectNamedConfig(Configuration_Name)`

If ethernet is still not working, try power cycling both the float payload and the winch payload. If this does not resolve the issue, contact LR Customer Support for further diagnostic steps.

7.3.8 My winch reports that Sinker depth is X and that cannot be right

Determining whether depth value is wrong, and which one: (while out on mission and Sinker is not actively being raised or lowered)

WGMS

- Get a report that contains depth values.
- Make sure “Vehicle” > Commands window is open.
- Click on: SV3 Commands > Services > Winch_winch: Status
- Wait for the Commands window to update
- If result is Acked (see Comman... column), copy and paste the contents in a text file so it can be read. (For any other result check the WGMS manual for next step.)
- Look at the values for EstimatedDepthFromSurface and PressureDepthAtSinker.

Web page

- Open the vehicle’s web page.
- Select Operate > Winch
- Read: EstimatedDepthFromSurface value (referred to below as Estimated Depth) (see 2.2.3)
- Read: PressureDepthAtSinker value (referred to below as External Depth Sensor)

Validation

- Estimated Depth and External Depth Sensor should be similar values.
- If they are not, what is the expected depth of the seafloor and what impact, if any, does that have on either of the above values? If the seafloor interferes, then the External Depth Sensor output should be close to the seafloor depth.
- If the seafloor is not a possible cause, and the values for Estimated Depth and External Depth Sensor are sufficiently different then:
 1. External Depth Sensor shows NaN
 - This shows that the sensor has not been read. Causes might be:
 - Sinker is not active. See: 7.3.4

- Tried to get a reading too soon after the Sinker powered up. (Wait for it...) There will be no results returned before the Sinker is ready.
 - Waiting for it does not help (up to 30 minutes) or the wait is too long:
 - Plugin update rate is not set to a reasonable value. See: 3.1.2
 - Sensor sample rate is not set correctly. Test and fix: 7.3.15
 - The Wave Glider is unable to connect to Iridium.
 - Dump sensor port contents for later debugging.
Send write console command:
`amps.portDumpNC("Winch",192,8,0,128)` and record the response for analysis by manufacturer.
 - Sensor is dead. Contact Liquid Robotics.
2. External Depth Sensor shows an unreasonable value. (Reasonableness is determined by user knowledge of the operating conditions.)
- See list above as if it reads NaN. The value might be out of date or may not have been initialized on startup.
 - At this point it is assumed that communications to the Sinker have been proven to work.
 - Sinker is snagged on something that alters its depth.
 - The sensor is misconfigured.
 - The depth sensor requires configuration of the sensor itself. See 7.3.15 and 7.3.16 for checking for configuration setting.
 - The depth offset is misconfigured.
 - This is best when done with Sinker right at the surface of the water (not on mission). Read current offset: 5.2.10
 - See if these values might make sense. If not, reset to default: 5.2.17 This is one option if no device is available to measure local pressure and temperature. The variation of air pressure is not that large. But if the Sinker is at sea level, then the offset can be manually derived.
 - Calibrate offset: 5.2.1 This option works if there is a local barometer at hand. Use the barometer reading and enter that value for pressure.
 - Be careful adjusting temperature. The recommendation for temperature is to read what the Sinker gives and put that value back in unless the external temperature influences are minimal. Even a little bit of sun hitting the Sinker will affect the readout and will probably be much different from what is read with a handheld thermometer. If temperature calibration is critical, then it is best to be calibrated in a lab.
 - Sensor is bad. Contact Liquid Robotics.
3. External Depth Sensor shows a reasonable value. (Reasonableness is determined by user knowledge of the operating conditions.)
- Value does not change.
 - See list above as if it reads NaN. The value might be out of date or may not have been initialized on startup — it just happens to be reasonable.
 - Value rarely changes.

- The assumption here is that the plugin sample rate is already set to a reasonable time and the user has waited at least that long before determining the value does not change. Try: 7.3.16
 - Value changes quickly but stays less than expected depth. Not sure what to say here. Caught a fish?
 - External Depth Sensor values look good. Declare sensor OK. On to checking out Estimated Depth.
- 4. Estimated Depth not close to External Depth Sensor values. (Estimated Depth values will not change when Winch is stopped.) “Not close” is determined by user and knowledge of probable Sinker position under Winch.
 - Could be in a sea state well beyond spec. Very large surface waves will affect the External Depth Sensor value while the Estimated Depth value remains the same.
 - (TSMC) Drum Position and WPDC Drum Position are not tracking. These values should be nearly identical, but at this time of the development there are glitches that may make these values develop a large delta. If they are close, then one can assume that no drum slippage has occurred. Not necessarily so when they differ. Eventually, yes.
 - Estimated Depth value “off” at any depth, but the delta remains near constant.
 - There may have been a power glitch that corrupted the drum count. Once corrupted, the error remains until the drum count is reset to zero at the home position.
 - The drum count may have been zeroed when the Thin Line was not reeled-in to the stop (at the home position).

A fix would be to reel the Thin Line in to the stop (home) position using 5.2.14 or 5.3.10 commands. If it cannot be visually confirmed that the stop is at the home position, then reading the value of External Depth Sensor (by using 7.3.10 or read it from the web page—see above). If that reading is at, or near expected, depth, then the assumption can be made that it is in the home position. (If not, there may be biofouling or irregular winding of the Thin Line that prevents it from winding all the way up. If so, then it is time to service the Winch.) Read the D1 value again (see above). It should be close to zero. If not, then it confirms a reason for the delta between calculated and actual.

 - Run 5.1.22 or 5.3.17 to zero the count.
 - Estimated Depth value incorrect by value that is inconsistent or that varies by depth.

The one reason could be is that the Winch configuration has been corrupted. It will need to be checked and possibly reset, see 3.1.2 Configuring the Winch Plugin.

7.3.9 The Winch is Spooling Out Uncontrolled

This would be rare if it were caught while using Iridium and WGMS only. The update rate is probably too slow to identify it as a runaway. (Needs to know that it is past its target and still going.)

This may be observed while using a cell connection or faster and the Winch update rate is in the order of seconds. Then by watching the Winch web page one can follow the numbers and estimated line lengths

and compare those against the programmed configuration of “Maximum Working Length” and “Usable Line Length”.

In the latter case, press (click on) the “Stop” button.

Note: It has been noticed, albeit extremely rarely, that this does not stop Winch action. In that case turn the Winch (power) off. This will remove the power to the brake solenoid, and the brake will resume its normally closed (engaged) position. But now further monitoring is disabled until the Winch is powered up again and the Web page resumes reporting.

The Thin Line, Sinker, or the payload snag on something that pulls with a large force (>100lbf, >445N) may result in overcoming brake’s holding force and the Thin Line unspooling. It is unlikely that the Wave Glider attempting to swim after being snagged is sufficient to overcome the brake’s holding force.

7.3.10 Get Winch Status using WGMS and Interpret Result

Use 5.1.17 to obtain status. There are several possible responses to this command:

- There is a communications issue that results not in an “ACK” response in the “Vehicle Commands” window. For non-ACK states in the “Comman...” column see a WGMS User Guide (P/N 05910) for their meaning.
- In case of an “ACK” response, retrieve the result string (in “Combined Acks” column). Two responses are analyzed here. Others that are possible may show up but ought to be similar enough to determine the state of the Winch system.
 - `EstimatedDepthFromSurface=10m CablePayOutLength=0m powerState=OFF (41.001s), virtualDevice=true, Requires: T1(OFF), powerThreadActive=false xp=T1, winch amps domain not found, 1 websocket clients: [/10.20.252.33:62076], Unhappy`

Where:

- `EstimatedDepthFromSurface`: 2.2.3
- `CablePayOutLength`: The amount of Thin Line spooled out.
- `powerState`: Winch system power state and how long it has been on or off.
- `virtualDevice`: Indicates if the device is physical or virtual. (T1 is the physical device)
- `Requires`: The devices required for the winch to work
 - `T1: (OFF)`: Indicates that the T1 (the port that is feeding power and comms to the Winch) is off.
 - `powerThreadActive`: Indicates if AMPS is currently powering on/off the required devices
 - `xp`: Indicated Expansion Port (Should be T1)
 - `winch amps domain not found`: Indicates that the Winch Domain is not present.
 - `1 websocket clients`: Indicates if there are any clients/browsers opened to the winch webpage
 - `Unhappy`: Indicates if the service is able to talk to the AMPS domain or not

- EstimatedDepthFromSurface=10m CablePayOutLength=0m powerState=ON (8m55.471s), virtualDevice=true, Requires: T1(ON), Requested by: pilotRequest, powerThreadActive=false xp=T1, PDCWinch found. Thin LinePowerComs found, 1 websocket clients: [/10.20.252.33:62076], Happy

Where:

- EstimatedDepthFromSurface: 2.2.3
- CablePayOutLength: The amount of Thin Line spooled out.
- powerState: Winch system power state and how long it has been on or off.
- virtualDevice: Indicates if the device is physical or virtual.
- Requires: Probably conditions the plugin needs to have satisfied for the Winch (Domain) to be active.
 - T1: (OFF): Indicates that the T1 (the port that is feeding power and comms to the Winch) is off.
 - Requested by: Indicates who/what is requesting the device to be power on
 - powerThreadActive: Indicates if AMPS is currently powering on/off the required devices
 - xp: Indicates Expansion Port (should be T1)
 - PDCWinch found: Indicates that the Winch Domain is present.
 - Thin LinePowerComs found: Indicates that the PowerComms module is present and communicates.
 - 1 websocket clients: Indicates if there are any clients/browsers opened to the winch webpage
 - Happy: Indicates if the service is able to talk to the AMPS domain or not

7.3.11 Test for Thin Line Power On state

Send write console command: `amps.portDumpNC("Winch",1,5,0,1)`

In the response, the least significant bit indicates programmed power state. 0 = Off, 1 = On.

If there is no response or a NAK response, there may be something physically wrong with the PowerComms module.

7.3.12 Test and fix for wrong Thin Line Power parameters

Send write console command: `amps.portDumpNC("Winch",1,5,0,6)`

The expected response is:

`0x00000001 0x00010000 0x00003A98 0x00002710 0x000003E8 0x00000064`

If any of these are different, then either the default has changed, or it is not a standard powered winch. Please contact manufacturer. If known to be the standard Winch, reprogram values by sending the following write console script command: `amps.writePortFields("Winch",1,5,0,"1, 0x10000, 0x3a98, 0x2710, 0x3e8, 0x64")`

7.3.13 Test and fix for Thin Line Modem Power not on

Send write console command: `amps.portDumpNC("Winch",1,6,0,1)`

In the response, the least significant bit indicates programmed modem power state. 0 = Off, 1 = On.

To manually turn the power on, send the following write console script command:

```
amps.writePortFields("Winch",1,6,0,"1")
```

7.3.14 Test for Thin Line Modem link state

Send write console command: `amps.portDumpNC("Winch",1,6,0,1)`

The response is: `0x128C0001`. Bit 25 = '1' (part of the '2' digit) indicates coax link bit. I.e., can find slave modem. Bit 16 = 0 (part of the 'C' digit) indicates an Ethernet link to the master modem.

There is no easy fix if this is not so. Reasons could range from the modems being bad or mis-programmed, to a corruption in the Thin Line electrical path, such as a damaged cable, connector, or other components.

7.3.15 Change Depth Sensor Configuration

Send write console command: `amps.portDumpNC("Winch",192,8,1,1)`

Use the response but modify **only** bits 27-26. All other bits **must** be set back to just read state. These two bits represent a variation in the sensor as to how pressure and temperature are read. Only two possible settings valid: a value of 0 and 1 (2 & 3 will give unknown results) must be placed in those bits. For instance, in case of a response of: `0x20001C01`, which shows a "type 0" setting, replace it with `0x24001C01` to get a "type 1" setting. In this case send the write console script command:
`amps.writePortFields("Winch",192,8,1,"0x24001C01")`

Note: This procedure may be combined with 7.3.16.

7.3.16 Change Depth Sensor Sample Rate

Send write console command: `amps.portDumpNC("Winch",192,8,1,1)`

Use the response but modify **only** bits 21-16 and 7-0. All other bits **must** be set back to just read state. Bits 7-0 represent one-minute increments in sample time, while bits 21-16 represent one-second increments. For instance, in case of a response of: `0x20001C01`, which shows a one-minute sample time, replace it with `0x20021C00` to get a two-second sample rate. In this case send the write console script command: `amps.writePortFields("Winch",192,8,1,"0x20021C00")`. Note that the sample times are added for second resolution, and the total **must** be greater than zero.

Note: this procedure may be combined with 7.3.15.

7.3.17 Test and Set Winch Motor Torque Configuration

Send write console command: `amps.portDumpNC("Winch",0,8,10,1)`

The expected response is: `0x00001F40`. If it is not, sent write console command:

```
amps.writePortFields("Winch",0,8,10,"0x1f40").
```

7.3.18 Test for Thin Line Power On state

Send write console command: `amps.portDumpNC("Winch",1,5,0,1)`

In the response, the least significant bit indicates programmed power state. 0 = Off, 1 = On.

APPENDIX A. PRE-LAUNCH CHECKLIST

Fill out this checklist while conducting the Winch Pre-Launch Procedure in Section 3.1 with access to the Winch Commands page via the vehicle webpage.

Item	Sign-off
1. Winch Plugin Configured	☐ _____
2. Steering mode is Proportional	☐ _____
3. Inspect the Winch and Sinker for physical damage	☐ _____
4. Internal pressures	
4.1. Winch Pressure	☐ _____ psi / mbar
4.2. Sinker Pressure	☐ _____ psi / mbar
5. Brake disengages	☐ _____
6. Thin Line inspection	
6.1. Freely unspools	☐ _____
6.2. No damage (twists, nicks, cuts)	☐ _____
7. Brake Engages	☐ _____
8. Pay in to Stop	
8.1. Fully retracts to hard stop	☐ _____
8.2. Backs off from hard stop a little	☐ _____
9. Tow Cable / Drogue and dummy plug installed	Tow Cable / Drogue + plug ☐ _____
10. Payload installed (if no payload, dummy plug installed) Skip if drogue installed on Sinker.	Payload / plug ☐ _____
11. Winch secured to Sub (screws torqued to 40 in-lb [4.5 N-m].)	☐ _____
12. Electrical Checkout	
12.1. Winch appears in AMPS	☐ _____
12.2. Sinker appears in AMPS	☐ _____

APPENDIX B. POST-RECOVERY CHECKLIST

Fill out this checklist while conducting the Winch Post- Procedure in Section 3.4 with access to the Winch Commands page via the vehicle webpage. Follow proper High Voltage handling procedures described in Section 2.3 Handling Recommendations.

Item	Sign-off
1. Inspect the Winch and Sinker for physical damage	☐ _____
2. Motor Creep 2.1. Pay in to Stop 2.2. Drum count 2.3. If greater than 32, Zero Count	☐ _____ ☐ _____
3. Rinse Winch & Sinker	☐ _____
4. Remove Biofouling, follow policies described in Section 4 of Wave Glider SV3 v300 Maintenance Guide 10859	☐ _____
5. Soak Winch & Sinker in fresh water fully immersed for at least 4 hours, ideally 24 hours (See 3.4.4 Soak Winch) 5.1. Thin Line was reinstalled	☐ _____ ☐ _____
6. Install dust caps / dummy plugs on: 6.1. Winch: Souriau/Teledyne 6.2. Sinker: Souriau/Teledyne	☐ _____ ☐ _____
7. Air dry & store.	☐ _____