

# **Liquid Robotics® Operations**

## **Wave Glider® SV3 Launch and Recovery Guide**

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**LIQUID ROBOTICS**

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## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

### Wave Glider® SV3 Launch & Recovery Guide

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### *Definitions*

**Antifouling paint:** Paint that contains biocides to prevent marine growth, also referred to as “bottom paint” on boats. Gloves should be worn when handling Wave Glider components that are coated in antifouling paint. Refer to the manufacturer’s documentation and the Material Safety Data Sheets (MSDS) for applicable safety precautions.

**Boat Pole:** A long pole used to reach out and steady the vehicle upon launch or recovery. Preferably light weight and extendable, with room at the end for a carabiner clip holder.

**Bundling Strap:** LRI provided piece of launch equipment used to hold the Float, Saddle, and Sub together on launch until quick released in the water. When strapped together as described, the Wave Glider is considered bundled. The Bundling Strap is also referred to as “Launch Strap”.

**Carabiner clip:** A quick attachment clip that positively locks, also called a “mooring clip”, “capture carabiner”, “snap hook” or “clip”. A carabiner clip holder is used to secure a carabiner clip at the end of a boat pole for attaching tag lines to the Wave Glider handles, or for attaching a hoisting cable to the Lifting Bail.

**Deployment:** The field support operation and mission. In this document, “launch” refers to the physical release of the Wave Glider vehicle.

**Fall Restraint Harness:** A harness fit to the individual that will be performing an activity near an area where falling from a distance or falling over the side of a vessel is a potential risk. The fall restraint must be load and shock rated to the individual’s body weight and to the particular fall hazard. A fall restraint should be worn when working near open fantails or gunwales without safety lines, or in situations where deck wash-over could lead to a Man Overboard.

**Float:** Surface component of the Wave Glider. Painted with a hard polyurethane paint, or an antifouling paint to prevent marine growth.

**Grappling Device:** A grappling hook or mechanical line launcher used to capture the deployed Recovery Buoy line from a safe distance on board an approaching vessel.

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**Handles:** For lifting or guiding just the Float, not for hoisting the Wave Glider system (Float + Umbilical + Sub) into or out of the water. These **handles are not load rated for the entire vehicle**. Handles are located: one on the bow of the Float (forward handle), and one on either side of the aft end of the Float (aft handles).

**Hoist (noun):** A generic term in this document to represent a variety of different types of hoisting systems and the associated winching mechanism, block and tackle, such as: A-frame, J-frame, crane, davit, boom, tuggers/winches, and capstans. All hoisting gear should be load rated to 1-tonne Safe Working Load.

**Hoist (verb):** The action of lifting an object by mechanical means.

**Job Safety Analysis (JSA):** Detailed risk analysis for entire mission and for on-deck Tool Box Meeting before each operation. Key focus is for all personnel involved in the activity to openly ask and address “How can I get hurt here today, and how can it be mitigated?”

**Lift strap:** A load rated and stamped lift strap, often referred to as a lift “sling”, is a soft fabricated strap used for hoisting objects, and is helpful to keep heavy hoisting accessories away from direct contact with the Wave Glider components that are susceptible to damage (such as, masts and solar panels).

**Lifting Bail:** Load-rated lift points on the Float for hoisting the entire Wave Glider, including the center, starboard, and port Lifting Bails. Also referred to as “Side Lifting Bails”.

**LRI:** Liquid Robotics, Incorporated.

**Material Safety Data Sheets (MSDS):** Procedures for proper handling and storage of potentially hazardous materials contained in a product, including emergency clean-up procedures for spills, and treatment for exposure to workers, or the environment.

**Multi-stage hoisting:** Lifting an object in more than one hoisting activity with 1 or 2 mechanical hoists. The Float and Sub can be lifted in series to accommodate hoisting height constraints (also referred to as a “two-point pick”).

**No Entry Zones:** Areas established by the vessel crew in which it is unsafe to stand or work. This includes the area under, and within a two meter radius, of a hoisted Wave Glider. No Entry Zones should be clearly identified during the on-deck Tool Box Meeting, and may be physically marked on deck as appropriate.

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**OSQI:** Operational Service Quality Incident Report - a report that captures significant events that introduce jeopardy or compromise to the mission objective(s).

**PPE:** Personal Protective Equipment - equipment worn to minimize exposure to serious workplace injuries or illnesses. PPE includes hard hats, gloves, eye protection, fire retardant coveralls, steel or composite-toed boots, personal flotation devices, etc.

**Recovery Buoy:** A buoy located at the end of the Wave Glider Float that is remotely deployable by means of WGMS. The buoy is attached to 12 m of load-rated floating tag line that can be grappled upon Wave Glider recovery.

**Saddle:** The Saddle nests on top of the Sub wings. The Float rests on top of the Saddle. During launch, the Saddle is recovered back to the launch vessel with the Bundling Strap trip line.

**Safe Working Load (SWL):** The approved and documented weight that a piece of lifting equipment should not exceed. Generally set at 5x the minimum breaking load rating of the piece of equipment. Safe working loads must be observed for all lifting equipment and maintenance intervals documented.

**Sea Catch™:** A hoist quick release mechanism for launching the Wave Glider from a support vessel.

**Single-stage hoisting:** Lifting an object in one phase (also referred to as a "one-point pick").

**Stand:** A rigid aluminum frame designed to hold the Wave Glider for assembly, disassembly, transportation, and maintenance. The Stand may have (locking) swivel caster wheels, in which case the Stand is often referred to as a "Cart."

**Sub:** The sub-sea component of the Wave Glider that provides vehicle propulsion, also referred to as "glider" and "wing rack".

**Sub Recovery Device:** LRI custom recovery equipment that is used to hoist the Sub by positively locking to the lowest part of the Umbilical. The device provides a hoist point, also referred to as "recovery tool".

**Team lifting:** Refer to regulatory specifications (e.g. National Institute for Occupational Safety and Health in the USA) for proper ergonomics and lifting capacities. The weight of a Wave Glider is more than one person can safely lift - team lifts and/or mechanical lifting devices are required.

**Tie-Down Strap:** Strap used to secure a load. Ratchet straps are preferred to quickly secure the bundled Wave Glider to the Stand and the entire unit to the deck of a vessel or to the bed of a transport truck for shipping.

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**Towfish:** A sensor, or multiple sensors, housed separately from the Wave Glider and towed from the Sub with a tow cable, also referred to as a “Towbody”.

**Umbilical:** Mechanically and electrically connects the Float to the Sub, providing power and communication to Sub payloads and the Rudder Module. The Umbilical is black and 4 to 5.8 meters in length and has a set of recovery hooks at the U-Joint where it connects to the Sub. The Sub Recovery Device positively locks onto the recovery hooks for hoisting the Sub in a multi-stage recovery.

**VOO:** Vessel of Opportunity - A ship or boat consigned for Wave Glider deployment, referred to in this document as vessel or support vessel. A VOO is a properly vetted platform for safe Wave Glider activities, meeting the specifications for vessel size, hoisting equipment, height over rail, maximum freeboard, etc. For more information see “Vessel Requirements” (Appendices G, H, & I).

**Wave Glider SV3:** LRI’s branding name for a core vehicle system that consists of a surface Float, Umbilical, and a Sub unit, also referred to as vehicle, system, or WG. For more information see “Wave Glider SV3 Product Specifications”.

**WGOC:** Wave Glider Operations Center - provides LRI Customer Support 24/7.

**Email:** [support@liquidr.com](mailto:support@liquidr.com)

**Phone:** +1 888-574-4574 (Toll Free in USA) or +1 408-636-4205

**Website:** [liquidr.com](http://liquidr.com)

**WGMS:** The Wave Glider Management System is a licensed, proprietary, cloud-based platform for Wave Glider piloting and communications. WGMS sends commands to the Wave Glider and receives real-time sensor data from the Wave Glider using worldwide satellite communications or a variety of local communications channels.

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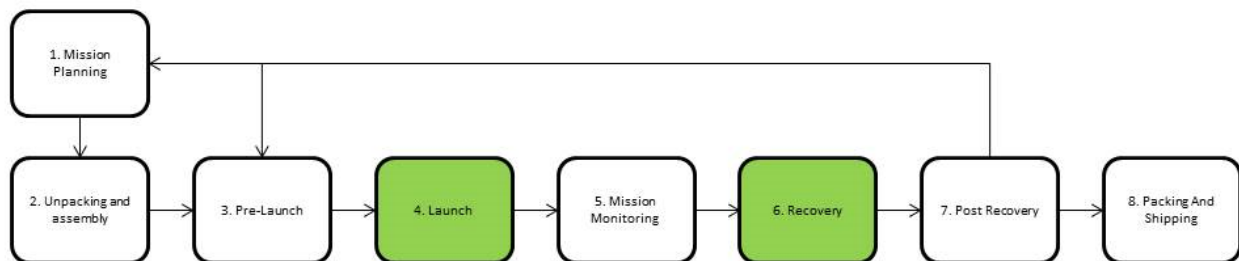
## Wave Glider SV3 Launch & Recovery Guide

### Chapter 1. Scope

This Launch and Recovery Guide provides information detailing the safe and efficient launch and recovery at-sea, of a Liquid Robotics Wave Glider SV3. This document assumes the personnel conducting launch and recovery activities have been properly trained to this procedure by LRI Lead Technicians, and that this activity will be performed by trained personnel only. Each Wave Glider deployment will be unique due to the nature and operational logistics involved with support vessels of opportunity. It is the responsibility of the Lead Technician (person in charge of at-sea activities) to ensure adequate resources and trained personnel are in place prior to attempting launch and recovery. Operations at sea pose high risk elements and the decision to attempt a deployment to conduct Wave Glider launch or recovery operations lies with the Lead Technician and the Captain at the time of the event.

The at-sea procedures outlined in this document cover phase 4 “Launch” and phase 6 “Recovery” of the Wave Glider Operational Workflow (Figure 1.1). Three options will be covered in the phase 6 recovery procedures representing various hoisting equipment and vessel configurations. The prerequisite to entering each phase is the successful completion of the previous phase.

**Figure 1.1. Wave Glider Operational Workflow**



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### Chapter 2. Purpose

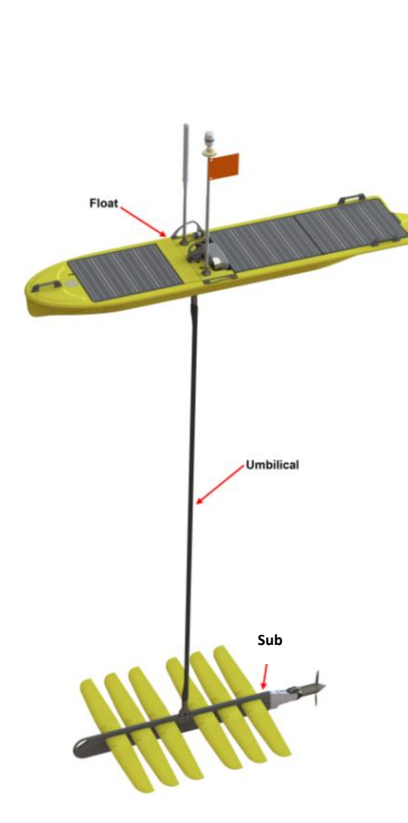
The purpose of this launch and recovery guide is to provide a safe procedure for deploying a Wave Glider SV3 (Figure 2.1 and Figure 2.2). This document outlines the basic methods using the best known safety practices at the time of writing, which continue to evolve. This document will be reviewed annually and is the responsibility of the Liquid Robotics Inc. (LRI) Field Support Operations department.

To ensure the safety of all crew, this procedure incorporates the “No-Touch” philosophy, whereby the personnel conducting the deployment (launch or recovery) take precaution to remain at safe working distances from the equipment during hoisting operations. Due to the use of vessels of opportunity, the deployment team must adjust their deck operations to existing vessel arrangements. No-Touch concepts shall be used wherever possible, and the deck operations must be reviewed and understood by all prior to attempting the deployment.

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Figure 2.1. Wave Glider SV3 Unbundled



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Figure 2.2. Wave Glider SV3 Bundled during Launch



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### Chapter 3. Personnel - Roles and Responsibilities

Personnel assigned to deployment activities include Liquid Robotics, Inc. Field Operations Technicians and other Operations staff, as well as support vessel personnel. Support vessel command structure and associated communications shall be established before any operations are conducted. A Liquid Robotics trained Lead Technician will command the deck unless the support vessel requires a member of the crew to act in this capacity (such as Deck Boss or Boatswain).

#### Minimum Personnel Required

The number of persons required for safe operations varies depending on the support vessel, the equipment deployed, and prevailing sea states. Most at-sea operations require a minimum of a Vessel Operator, Hoist Operator, Lead Tech, and two Deckhands.

#### Vessel Operator/Captain

The Vessel Operator is typically third party to LRI and is provided as part of the charter agreement.

**Job Function:** Command and control the vessel with ultimate authority to complete the mission at hand, in a safe manner for all persons on board.

**Responsibility:** The Vessel Operator is responsible for the vessel and for the safety of all persons on board. This includes constant review of changing sea states and communications with the Deck Boss for safe deck operations.

#### Deck Boss

The Deck Boss is typically third party to LRI and designated by the Vessel Operator. On smaller vessels with limited crew, the Lead Technician may fill this role as agreed and designated during the Safety Briefing.

**Job Function:** Ensure deck operations are conducted efficiently, and safely. The Wave Glider Lead Technician or other members of the deck crew may fill this role.

**Responsibility:** The Deck Boss is responsible for deck activities offshore insuring that all operations are conducted safely, cost effectively and to a high standard of quality. The Deck Boss appoints a point of contact to Hoisting Operations and is a direct line of communication with the Vessel Operator.

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### Lead Technician (Lead Tech)

**Job Function:** Point of contact to Deck Boss, and as agreed may fill Deck Boss role. Ensures Wave Glider is prepared and approved for hoisting activities.

**Responsibility:** The Lead Tech is responsible for all Wave Glider operations, ensuring the deployment activities are conducted safely, cost effectively, and to a high standard of quality. This includes confirmation that the hoisting equipment, devices, and rigging are in good operating condition. The Lead Tech operates the quick release mechanism(s) during launch and usually will be responsible for using a boat pole to attach the hoisting line to the center Lifting Bail during Wave Glider recovery.

**Embarking and Training Requirements:** Refer to client and vessel requirements prior to mobilization regarding deck safety, medical, and administrative logistics, before embarking on an excursion. Inquire with local authorities and regulatory agencies regarding travel restrictions and personal safety and security considerations.

In addition to technician skill sets described in Field Operations Technical Skill Set (see Appendix A: Reference Documents), the Lead Tech shall have at a minimum the following training or local certification equivalents, and be current on these credentials before conducting deployment activities:

Contact LRI Customer Support by email ([support@liquidr.com](mailto:support@liquidr.com)), or by phone at: +1 888-574-4574 (Toll Free in USA) or +1 408-636-4205.

- Offshore medical exam indicating fit for duty at sea; Basic Offshore Safety Induction and Emergency Training (BOSIET) and Helicopter Underwater Egress Training (HUET); First Aid, Cardiopulmonary Resuscitation (CPR), and Automated External Defibrillator (AED); minimum recommended vaccinations; Transportation Worker Identification Credential (TWIC); Passport (valid 6 months past the end date for international waters/travels); Valid Driver's License.
- Launch and Recovery Training is available through Liquid Robotics, Inc. and includes in-depth working knowledge and training on:
  - Wave Glider SV3 Pre-Launch Checklist (Appendix E)
  - Required launch and recovery equipment
  - Deployment procedures and associated techniques
  - Multiple launch and recovery iterations.
  - Wave Glider Management System (WGMS)

This training is administered through Liquid Robotics Inc., and assumes the trainee has previous maritime experience (at least 5 years work experience) launching and recovering fragile oceanographic

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equipment and sensors from similar vessels. **Proficiency in deployment activities is expected after repeated successful launch and recoveries at-sea (typically at least 6-10 events of each). No amount of simulated deployment activities are considered as acceptable substitute.**

- Additional Training: depending on the vehicle configuration, mission, and piloting responsibilities, additional training is recommended for specific sensor operations and power management techniques.

### Deckhand

**Job function:** During the launch and recovery phases of at-sea operations, Deckhands attach and tend tag lines as the vehicle is hoisted.

**Responsibility:** Under the direct guidance of the Lead Technician, Deckhands are responsible for the safe handling of the launch and recovery lines and rigging. During recovery activities Deckhands utilize boat poles to attach tag lines before hoisting the vehicle aboard.

### Hoist Operator

**Job function:** During the load-out, launch, and recovery phases of at-sea operations the Hoist Operator uses the support vessel's hoist(s) to maneuver the Wave Glider on and off the vessel.

**Responsibility:** Under the direct guidance of the Lead Technician/Deck Boss, the Hoist Operator is responsible for the safe operation and maintenance of the hoist, associated rigging gear, and related equipment.

Other roles may be required on the Support Vessel of Opportunity:

- Rigger
- Safety Observer

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### Chapter 4. Safety (HSSE)

Health, Safety, Security and the Environment (HSSE) are paramount when conducting any at-sea procedures. Recognizing the inherent dangers involved in launch and recovery of ocean-going equipment, and that a certain level of risk is always present, every effort must be made by all personnel to minimize risk for all of these factors. In preparing for, and conducting these procedures, due regard must be assessed for all dangers, any of which may require a departure from this procedure. The procedures in this document focus on safety, but it is important to identify all facets of HSSE to mitigate associated risks as part of a comprehensive HSSE program, including:

#### Health:

- Containing the spread of illness and disease with proper training for best hygienic practices, including location-specific vaccinations.
- Medical exam and job function evaluation for personnel to identify specific job tasks that may cause new or recurring injuries that will affect the health and work performance of the individual.

#### Safety:

- Safety for personnel.
- Avoidance of injury or death due to lack of training, knowledge, expertise, and situational awareness, including improper methods or practices when performing a task.
- Weather and sea conditions.
- Navigation and collision.
- Limitations of the Wave Glider, associated equipment, and/or the support vessel.

#### Security:

- Security of the US Government, its allies, and their interests.
- Clear policy on unauthorized or suspicious incidents or personnel that present a danger.
- Detection and deterrence regarding access of unauthorized or dangerous personnel to company property or assets.

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#### Environment:

- Protection of the environment regarding hazardous and sometimes non-hazardous substances into the water, land, or air. Mitigated with proper training, reporting, permitting, and responsible practices.
- Prevent negative impacts to vegetation, ground water, humans, animals, insects and marine life.

#### Personal Protective Equipment (PPE)

The Deck Boss or Lead Tech must ensure that personnel involved with Wave Glider operations have been briefed on the use of PPE and employment of emergency procedures while at sea or dockside. PPE must meet local regulations, and include as a minimum: protective clothing that is environment appropriate, clearly visible, and has a low risk of becoming snagged such as mustang suits, ANSI rain gear, or coveralls; safety shoes; hard hats; USCG Type V Personal Floatation Devices (PFD) or local equivalent; safety eyewear, and safety gloves. Additional PPE may be required based on local requirements reviewed during the vessel Safety Briefing. Steel or composite-toed safety shoes must be worn at all times while working on deck or during lifting operations. No open-toed shoes are allowed on deck or around the operational area at any time. Hard hats must be worn at all times while hoisting equipment is in use. In the USA, Coast Guard approved Type V PFD work vests must be worn by riggers on the pier, by personnel operating on the pier in close proximity to the water, when conducting launch/recovery operations, when in small boats (at all times), and on larger vessels while on deck. It is good practice to wear a PFD on deck at all times, even when not required by the support vessel. Additional PPE for personnel working near open fantail areas may include tethering and fall restraint harnesses depending on industry, client, or support vessel standards.

#### Deck Safety

Support vessel configuration, hoisting apparatus, deck crew skill and experience, and sea state affect the success of the deployment. These risks can be mitigated through proper procedures and techniques, but not completely eliminated. It is important to identify potential hazards before commencing operations, such as vessel orientation to reduce swinging loads, pinch points, trip hazards, and confined spaces. Only properly trained personnel should attempt Wave Glider deployments. LRI provides highly skilled, trained Field Operations Technicians to perform deck activities, and adapts techniques to each deployment based on the vessel and hoisting configurations. The described procedure details basic configurations for the most common scenarios, and incorporates concepts to minimize the physical handling of the Wave Glider during a deployment. Hoisting safety is emphasized with the goal to keep personnel from being

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under the load and clear from No Entry Zones, established during pre-deployment risk assessments. A Permit to Work is a common requirement to ensure deck safety.

### Job Safety Analysis

Prior to beginning at-sea operations, the Lead Tech/Deck Boss conducts a safety briefing (Job Safety Analysis or JSA, often referred to as a “tool box meeting”). All deck crew team members and support vessel operators must attend. For a detailed overview of all hazards and associated mitigations, the Lead Tech/Deck Boss shall use, a JSA such as the example “Job Safety Analysis Form” before operations begin. The on-deck tool box meeting before each deck activity reviews the on-scene checklist regarding safe working areas, No Entry Zones, equipment, rigging, roles, and contingencies, in order to be clear regarding the intent, authority, and work instructions. During this brief the Deck Boss and Lead Tech are responsible for reviewing the planned operations, and all safety rules and issues, with a focus on where or how personnel might get injured, and steps to reduce these risks. During all at-sea operations, strict adherence to all launch and recovery procedures and operating protocols is maintained.

### Sea State Considerations

Safe sea state for launch and recovery operations will be in part dependent on the size and type of vessel of opportunity. In general, Wave Glider operations should not be conducted in conditions greater than Sea State 4 (World Meteorological Organization Sea State Code 4/ Douglas Sea State Code 4), which is defined as moderate wind seas (1.25 - 2.5 meters) and moderate swell (average and moderate wave). This correlates to Beaufort Scale 4 moderate breeze of 5.5-7.9 meters/second wind speed. As you approach wind speeds of Beaufort Scale 5 fresh breeze (8.0-10.7 meters/second), Wave Glider hoisting operations can become difficult to control and unsafe. Unsafe Wave Glider operating conditions often times can be identified by the Captain or Lead Tech before the support vessel departs, and may lead to delays or additional standby time at port. Sea state and prevailing weather are important factors to review when determining best vessel orientation for launch and recovery activities.

### No Entry Zones During Deployment Activities

Working in conjunction with the support vessel’s Deck Boss, the Lead Tech must identify and agree upon No Entry Zones. Any and all personnel on board are prohibited to enter a No Entry Zone, once the lift has begun. A lift operation has begun once the hoisting line is made secure to the Wave Glider. Where deck space allows, the preferred No Entry Zone around the Wave Glider lift is two meters. No personnel should enter this area without the expressed approval of the Lead Tech and the support vessel’s Deck Boss.

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Observing the two meter No Entry Zones rule requires proper tag line and/or boat (push) pole use. The Lead Tech and Deck Boss must coordinate best use of tag lines to ensure safe hoisting and control of the load. In concept, the tag lines must be sufficient to control load swing from at least two opposing directions, keeping in mind the Wave Glider is a multi-part vehicle and each piece must be controlled. For safe deployments every person involved must understand their role in controlling the Wave Glider during hoisting operations.

### Deck Communications

It is important that all deck operations participants can clearly hear and understand communications between the Captain, Deck Boss, Lead Tech, and Deckhands. This can be accomplished by loud voice commands, hand-held radios, or established hand signals. It is critical that the Lead Tech can communicate to the Deck Boss or directly to the Hoist Operator during hoisting activities, especially during multi-stage hoist situations to ensure recovery gear is applied safely to the Wave Glider. Voice commands must be repeated before an action is taken by the responsible member of the team to affirm the command was understood. Terminology must be agreed upon, for example, the terminology to use to strike an improper command, such as "stop" or "belay my last", as well as how to correct a command repeated incorrectly, such as calling out "command" then repeating the correct command. In situations where ambient noise is too loud for voice commands or radios, the Hoist Operator must have a clear view of the Lead Tech or Deck Boss that is providing hand signals. Preferred deck communications are to be established between all operations participants during the JSA meeting. During the JSA tool box meeting, the deployment team must identify the (only) person to provide commands to the Hoist Operator and the Captain.

### Radio Guard Communications

The Lead Tech is responsible for communicating with a shore-based contact (Radio Guard) for deploying at-sea. The Wave Glider Operations Center (WGOC) must hold the radio guard for the at-sea mission for LRI personnel, according to the generally accepted practices noted below:

- The WGOC Mission Plan (see Appendix A: Reference Documents) establishes and identifies the vessel name, Lead Tech name, LRI satellite phone number, and estimated departure and return times of LRI personnel to the dock.
- The Lead Tech shall contact the WGOC to confirm all information before leaving the dock and confirm the time at which the vessel is leaving and a check in time or estimated return time. The vessel should display AIS, if so equipped, for WGOC tracking of mission progress.

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- If necessary, upon arrival on location, the Lead Tech contacts the WGOC about launch or recovery operations to communicate commands or instructions for the WGOC to complete.
- The Lead Tech should update the WGOC with the vessel's ETA to the dock, or if AIS is actively being monitored, will call in when back at the dock.
- The Lead Tech contacts the WGOC to confirm all secure upon returning to the dock. If any injuries, damage to equipment, or safety concerns were experienced, the WGOC opens an Operational Service Quality Incident (OSQI) at this time for purposes of immediately reporting any incidents. For more information, see Appendix C: Operations Service Quality Incident (OSQI) Report.

### At-Sea Personnel Transfer

At-Sea transfers of LRI personnel are not advised. In cases where it is absolutely necessary to transfer LRI personnel to another vessel or platform, the WGOC must have the contact information for the new vessel and continued communications for the transport and expected arrival time to shore. Monitoring of the LRI personnel's at-sea position continues through WGOC pilot pass-down shifts until LRI personnel have communicated that they are safely back on shore.

### Hoisting Apparatus

Basic hoisting/crane safety guidelines must be followed at all times. Check with the support vessel operator for other vessel specific guidelines. Only qualified personnel shall operate hoists, cranes and other lifting machinery.

- All running rigging and hoisting gear must be inspected for wear.
- Ensure all hoisting gear is properly rated for safe working loads.
- Only one member of the deck crew shall provide hand/verbal signals to the Hoist Operator. The Deck Boss or Lead Tech provides this role.
- Suspended loads must not be left unattended.
- Team lifting concepts are incorporated for all Wave Glider movements other than during mechanical lifts.

### Hoisting Apparatus Considerations

A Vessel of Opportunity is vetted and chartered based on appropriate hoisting equipment and experienced equipment operators. The common types of vessel-provided hoisting equipment used in Wave Glider launch and recovery scenarios includes cranes, A-frames, J-frames, davits, booms, and a variety of winch combinations and associated blocks. The vessel configuration determines which lifting

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

gear is used to achieve the safest operation. Procedures and PPE are used to mitigate risk. Several factors affect the risk assessment on which hoisting gear combination to use, including:

- Height over rail and total suspended load length
- Weight of hoisting hook and/or block and associated equipment tag lines
- Sea state
- Wind speed
- Number and skill of personnel available to assist on deck
- Vessel maneuverability
- Captain's ability to view the operations unobstructed

The hoisting equipment chosen for Wave Glider recovery determines if the operation is a single-stage or multi-stage hoisting evolution and this dictates the No-Entry Zones and tag line use.

### Rigging (Block and Tackle) considerations

Additional hoisting equipment considerations include the size and set-up of the hoisting equipment. Large vessels with heavy weight capacity winches, cranes, blocks, and wire rope, may be rigged with blocks, counterweights, and wire rope terminations that may weigh more than the Wave Glider and require additional tag lines to control. Lines and slings may be required to keep vessel blocks, counterweights, and wire rope terminations out of the water, which adds additional height over rail or height over deck for the hoisting operation.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Sub Recovery Device

The Sub Recovery Device is used to hoist the Sub component of a Wave Glider during a recovery where the vessel configuration dictates that the Float and Sub are hoisted on board separately (multi-stage hoisting).

**Figure 4.1. Sub Recovery Device with Lift Strap**



The Sub Recovery Device is installed on the Umbilical and presents hazard such as the potential for partially getting under the load (if the Float is suspended in air).

Proper training is required and provided by LRI to effectively use the Sub Recovery Device. See “Recovery Rigging Equipment” and “Recovery Overview” for more information.

### Hoist/No Hoist Points

#### Hoist Points:

The Wave Glider SV3 is designed to be hoisted from the following hoist points:

- Center Lifting Bail: In a bundled configuration for launch, the Wave Glider shall be hoisted from the center Lifting Bail located on the Float.
- Side Bails: In a single-stage hoist for recovery, the entire Wave Glider vehicle can be hoisted (unbundled) by the Side Bails located on either side of the center of the Float

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

- Sub Recovery Device: is a hoist point to recover the sub during multi-stage hoisting when the device is positively attached to the umbilical
- Sub Bow: is a hoist point to recover the sub during multi-stage hoisting or to attach tag lines.

### **No Hoist Points:**

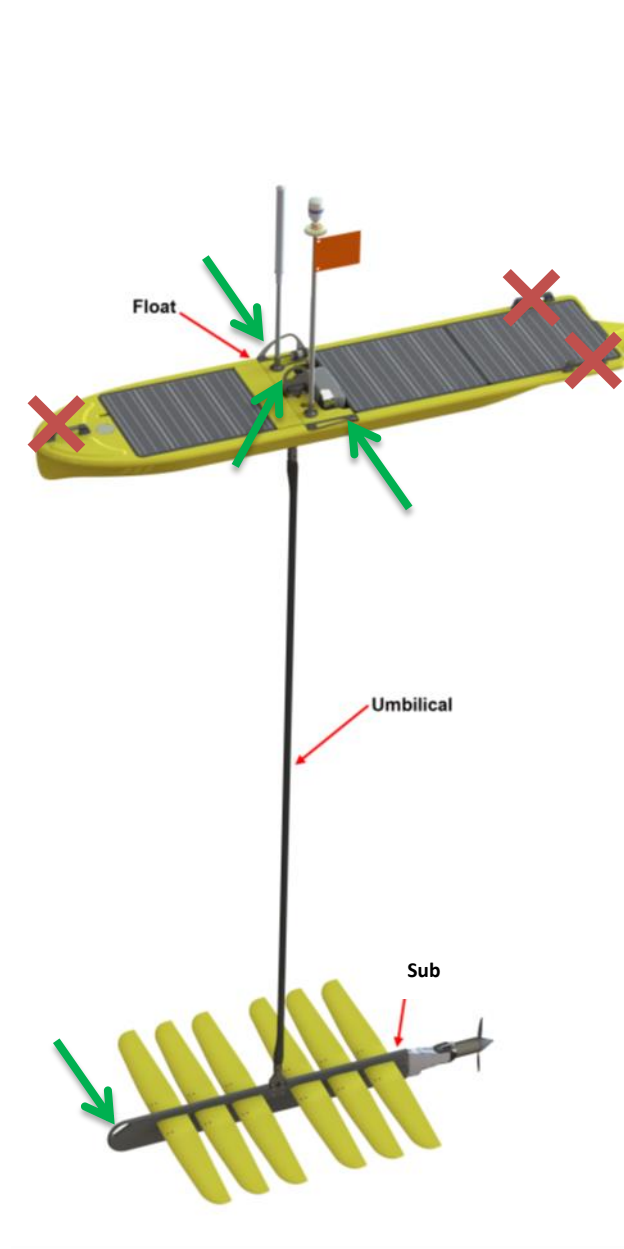
Wave Glider SV3 no hoist points are not designed to hold the weight of the vehicle; these areas are designed to assist operators for tag line use or to steady the vehicle while positioning:

- Float Handles: The handles can be used for tag lines or for manual shifting of the Wave Glider Float, but are **not load rated** for hoisting the entire Wave Glider vehicle (bundled or unbundled). One handle is located on the bow of the Float, two handles are located on the stern or tail of the float.
- Sub Thrudder Lift Eye: can be used as a handle, but is not designed to be used to lift the entire vehicle.

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 4.2. Hoist and No Hoist Points



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Chapter 5. Support Vessel Considerations

LRI charters independent vessel companies in order to perform Wave Glider deployments, and has established Vessel of Opportunity (VOO) specifications necessary for safe deployment activities.

#### Vessels of Opportunity

The VOO must be purpose built or suitably converted to undertake survey, research, or unmanned vehicle operations in the designated geographical area throughout the calendar year. The vessel must be seaworthy, capable of launch and recovery at 2 knots or less, and supplied fully equipped with current and valid certifications for its classification during the proposed time period.

Deployments of the Wave Glider have been accomplished on many vessel configurations. The VOO Comparison Table details general vessel specifications.

| <u>Category</u>      | <u>Endurance</u>                                                          | <u>Typical<br/>Minimum<br/>Length</u>    | <u>Freeboard</u> | <u>Example</u>                  |
|----------------------|---------------------------------------------------------------------------|------------------------------------------|------------------|---------------------------------|
| Offshore             | Multiple Day,<br>Mission specific,<br>overnight berths<br>for male/female | 40m                                      | <3m              | Offshore Supply<br>Vessel (OSV) |
| Coastal              | < 5 days; 100 nm<br>offshore                                              | 16m                                      | <2m              | Research Vessel                 |
| Nearshore            | Day use only; <<br>30 nm offshore                                         | 8m, depending<br>on mission<br>specifics | 1m               | Converted<br>Fishing Vessel     |
| Tender/small<br>boat | Ship tender use<br>only                                                   | N/A                                      | 1m max           | Fast Rescue Boat<br>(FRB)       |

For more information on LRI's VOO requirements see "Vessel Requirements" in Appendix F, G, &H.

#### VOO Hoisting Scenario Considerations

Vetting of a VOO must include full understanding of hoisting rigging and equipment. Procedures for Wave Glider deployment assume the hoisting equipment meets the minimum requirements summarized in this section.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Hoisting operations must be vetted prior to mobilization. Safe working loads must be understood and agreed to. The VOO configuration must be vetted to understand many variables. Critical variables include:

- Dockside accessibility for hoisting.
- Dockside hoisting constraints (1-tonne minimum).
- Deck space, sufficient for Wave Glider(s) and supporting equipment.
- Hoist Operator skill proficiency and certification validity.
- No Entry Zones
- Hoisting equipment type, lifting/travel capacity:
  - Crane, A-frame, J-frame, Davit, or other.
  - Deck to waterline travel capabilities (freeboard).
  - Minimum height-over-rail requirements (3m to 10m depending on scenario).
  - Minimum distance of travel outboard (2m).
  - Minimum distance of travel inboard (2m).

### Single-Stage Hoisting (One-point Pick)

If the VOO hoisting equipment has sufficient capability, the Wave Glider is hoisted in a single stage using proper tag lines to control the assembly (assumes 7-9 m of hoisting height-over-rail to recover a fully extended Wave Glider). To reduce the height-over-rail requirement, use of multi-stage lifting techniques should be employed.

**Figure 5.1. Single-Stage Hoisting**



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# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Multi-Stage Hoisting (Two-point Pick)

Multi-stage hoisting methods are used to recover the Wave Glider when hoisting height- over-rail is limited. If the hoist does not have ample travel to recover a Wave Glider in a fully deployed length (7-9 m), multi-stage hoisting techniques must be used with either a single hoist, or a combination of two hoists.

The Float is hoisted to a height that the Umbilical is accessible; the Sub Recovery Device is sent down the Umbilical and secured to take the hoisting load from the Float. The Float is brought inboard, lowered to deck and made secure, or secured with the primary hoisting device if a second hoisting device is available to hoist the Sub. For more information see “Recovery Overview”.

**Figure 5.2. Multi-Stage Hoisting**



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Chapter 6. Hoisting and Rigging Considerations

Specific hoisting and other rigging gear are required for Wave Glider launch and recovery.

#### Launch Rigging Equipment

- Liquid Robotics Bundling Strap
  - Used to hold the Float and Sub assembly together prior to launch. Pulling the quick release line allows the bundled assembly to separate, and is designed to be activated when the Wave Glider is in water, allowing the sub to descend and begin propulsion. See “Launch Operations” for Bundling Strap use procedures.

**Figure 6.1. SV3 Bundling Strap**



- Quick Release Shackle and Lift Sling Assembly
  - A quick release shackle (for example a SeaCatch), connected to a load rated sling, is used to hoist the vehicle by the Lifting Bail into the water. A minimum safe working load of 1 tonne is required for both the quick release shackle and the lift sling. The lift sling should be of adequate length to locate the Wave Glider a safe distance below hoisting equipment.

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 6.2. SeaCatch with Lift Strap**



- **(2) 10m or longer 1cm to 2cm diameter Braided Nylon Tag Lines**
  - Two tag lines to steady the vehicle as it is lifted into the water. The bitter ends must not have any knots or hardware attached so it can be slipped during launch activities.

**Figure 6.3. Tag Line**



- **(6) 3m Tie-Down Straps**
  - Used to secure the entire Wave Glider assembly to the Stand for storage and transit. At least two tie-down or ratchet straps should be used. In addition, at least 4 tie-down or ratchet straps should be used to secure the Wave Glider assembly and Stand to the vessel deck (Figure 6.4 & 6.5).

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 6.4. Tie-Down Strap



Figure 6.5. Wave Glider Secured to Deck with Tie-Down Straps



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

- **Boat Poles**
  - Push/pull poles and/or boat poles ready with a carabiner clip (also called a mooring clip) attached to one end to secure tag lines; also used if the launch is aborted and an immediate recovery becomes necessary, or to fend the bundled Wave Glider away from the vessel and orient it prior to releasing the bundling strap. Length of boat poles should be appropriate for available deck space and distance to the water.

**Figure 6.6. Boat Pole**



### Recovery Rigging Equipment

- (2) 15m or longer 1cm to 2cm diameter Braided Nylon Tag Lines
  - At least two lines ready to control the vehicle as it is lifted from the water.
- (2) Boat Poles
  - Two boat poles, each with a carabiner clip attached to one end to secure tag lines and the lift sling to the vehicle (Figure 6.7). Length appropriate for size of vessel and freeboard.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Figure 6.7. Carabiner Clip (Attached to Boat Pole)



Figure 6.8. Boat Pole with Carabiner Clip and Tag Line



- 1m-3m Load Rated Lift Strap with Carabiner Clip
  - This assembly is attached to the Lifting Bail to hoist the Float out of the water if there is available hoist height over rail to do so. The lift strap provides a safe distance between the vehicle masts and what may be a large counterweight or heavy hoist hook on the hoisting equipment. Minimum safe working load of 1 tonne required (see Figure 6.9)

# Liquid Robotics Field Operations

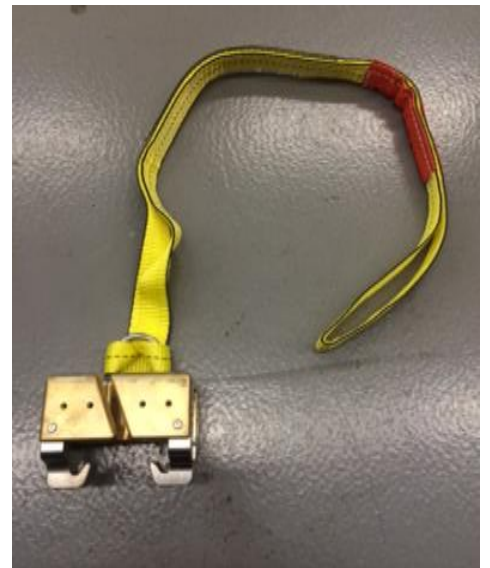
## Wave Glider SV3 Launch & Recovery Guide

**Figure 6.9. Boat Pole with Carabiner Clip and Lift Strap**



### **Sub Recovery Device with Lift Strap and Tag Line**

- The Sub Recovery Device is tethered and placed on the Umbilical and gravity-dropped down the length of the Umbilical to the Sub. The Sub Recovery Device latches onto the recovery hooks located at the bottom of the Umbilical to hoist the Sub. A lift strap shall be used between the hoisting line and the Sub Recovery device to keep shackles, large knots, or cable terminations from jamming between the Sub Recovery Device and the Umbilical (Figure 6.10). The line and lift strap must be long enough to reach the bottom of the Umbilical from the surface, which depends on the Umbilical length (typically 4m plus sea state and vessel freeboard or rail height). An additional tag line can be attached to the Sub Recovery Device to control the swing of the Sub from a safe distance. A minimum safe working load of 1 tonne is required on all hoisting equipment, line, and lift strap.
- **Figure 6.10. Sub Recovery Device with Lift Strap**



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Chapter 7. Pre-Deployment Activity and Equipment

#### Unpack and Assemble

Successful launch of a Wave Glider system relies on proper make-ready in the field. The Lead Tech (or designated trained resource) is responsible for ensuring the system is properly unpacked, assembled, mobilized for deployment, and that all pre-launch procedures are completed. Refer to the Wave Glider SV3 Unpacking & Assembly Guide for pertinent details (this Guide is listed in Appendix A: Reference Documents).

#### Minimum Equipment Requirements

##### Field Operations Kit

LRI technicians carry extensive equipment on each deployment activity. The kits contain required equipment as well as consumable parts often used during deployment. The level and amount of tools, consumables, and spare parts may vary, based on technician expertise and understanding of the current mission. Several critical components of these kits are required in order to successfully launch and recovery a Wave Glider, and must be available for every deployment. **A Sub Recovery Device must be available during all launch activities where the VOO cannot perform a single-stage hoist recovery, in case the Wave Glider needs to be recovered immediately after launch.**

##### Minimum Hardware Requirements for Wave Glider Deployment

- **Wave Glider SV3**
- **Satellite Phone** - Due to remote deployments, LRI technicians must have secure communications with the Wave Glider Operations Center (WGOC) to complete deployment checks.
- **Stand and Saddle** - Shipped with the Wave Glider, the Stand supports the Wave Glider for mobilization onto and around the deck of the VOO. The Wave Glider components stack into a bundled state on the Stand, starting with the Sub. The Saddle nests on top of the Sub. The Float rests on top of the Saddle. The bundled Wave Glider is configured so it can be hoisted free of the Stand. The Saddle is recovered using the same line that is used to release the Bundling Strap.
- **Bundling Strap** - Used to bundle the Wave Glider Float, Saddle, and Sub during hoisting activity for launch.
- **Tie-Down Straps** - (minimum 6) During mobilization activities, the bundled Wave Glider is strapped to the Stand using at least 2 tie-down straps. Additional tie-downs are used during deck operations to secure the Wave Glider and Stand to the deck using opposing forces as

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

described in International Maritime Organization (IMO) Annex 13, Safe Practice for Cargo Stowage and Securing.

- **Grappling Device** - Used to capture deployed Recovery Buoy line
- **Quick Release Shackle** - For example, SeaCatch. A quick release shackle or the equivalent. Used to connect the hoisting line to the bundled Wave Glider with a quick release mechanism. The release line removes a safety pin and then opens the mechanism, allowing Wave Glider separation from the hoist line. Minimum Safe Working Load (SWL) 1 tonne.
- **Carabiner Clips** - (minimum 3) In sufficient quantity to attach tag lines to the Wave Glider during recovery. LRI provides carabiners with mounting hardware that can be field installed onto boat poles.
- **Sub Recovery Device** - LRI uses a custom fabricated device designed to travel down the Umbilical, providing a Sub hoist point for multi-stage hoisting.
- **10m Tag Lines** (minimum 3)
- **Lifting Straps and Rigging Gear** - To facilitate hoisting clearances and safety. All lifting straps and rigging gear must be stamped with a Safe Working Load of at least 1 tonne.
- **Hand Tools and Torque Wrench** - Associated with proper assembly instructions contained in the Wave Glider SV3 Unpacking & Assembly Guide.
- **Troubleshooting Tools** - Debug cable, battery chargers, dummy plugs, tablet or laptop, etc.
- **Consumable Parts** - Loctite, lubricant, 'nyloc' hardware, cable ties, rubber bands, etc.
- **Boat Poles**- (minimum 3)

### In Field Pre-Launch Check

After Wave Glider unpacking and assembly, but prior to launch, a pre-launch check of the Wave Glider system by the Lead Tech or by other trained personnel is required using the Appendix D: Wave Glider SV3 Pre-Launch Checklist. This checklist is used to ensure the Wave Glider is both mechanically and electrically prepared for deployment. If any issues are found during this check, the deployment must be postponed until the issues are resolved or are signed off by the Project Manager. Additional pre-launch checks may be required for some payloads or in some operational regions. The Wave Glider must be powered on and have sufficient space to complete a 360 degree spin test in an area with unobstructed access to open sky for satellite communications. Approximately two hours should be allowed for each Wave Glider, to perform a thorough pre-launch check.

### WGOC Pre-Launch and Launch Checks

The WGOC will perform Pre-Launch and Launch checks to ensure the vehicle is prepped for piloting and that all systems are a go, before the Vessel of Opportunity and Lead Tech depart the launch vicinity. For more information see Appendix E: WGOC SV3 Launch, Recovery and Piloting Checklist. An unplanned

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

recovery of the vehicle may be required, if issues are found that cannot be resolved remotely by the WGOC.

### Wave Glider Transit and Storage Considerations

Deployment activities may include transporting the Wave Glider across rough terrain, securing the bundled vehicle, and/or storage of the system for an extended period. Care shall be exercised to ensure the system is secured in a standby configuration for deployment; otherwise the system should be disassembled and packed for shipment or long-term storage. Refer to the Wave Glider SV3 Disassembly & Packing SOP (see Appendix A: Reference Documents).

If the Wave Glider is to be standing by for imminent deployment, several considerations should be addressed, including:

- **Power Management and Solar Charging:**
  - Solar panels on-board a Wave Glider provide power to the internal systems and must have clear view of the sky to maintain battery levels while the vehicle is powered up.
  - Power Key must be inserted for the vehicle to be powered up, and to charge via solar panels and/or battery chargers (Figure 7.1).

**Figure 7.1. Power Key Installed**



- Any obstruction between the solar panel(s) and sky can impact charging during daylight hours. All attempts to minimize obstructions should be given priority to provide optimal charging.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

- During stowage of the Wave Glider on deck, take into consideration items such as upper decks, railings, masts and antennae, all of which may shade the solar panels and affect charging performance.
- Use of battery chargers should not be done while the vessel is underway, if the Wave Glider is exposed to a wet deck or rain. For more information, contact LRI Customer Support. For information on battery charging, see the Wave Glider SV3 Interface Control Description.
- **Tie-Down Straps:**
  - Proper load-rated tie down straps shall be used for:
    - Securing the bundled Wave Glider to the Stand (until just before launch): Run one strap across the forward solar panel, through the first and second wing, capturing the aluminum stand. The ratchet should be positioned in the space between the Float and the Wings. The aft strap should be positioned similarly between the fifth and sixth wing and also capture the Stand.
    - Securing the Stand to deck: Using opposing forces as described in International Maritime Organization (IMO) Annex 13, Safe Practice for Cargo Stowage and Securing.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

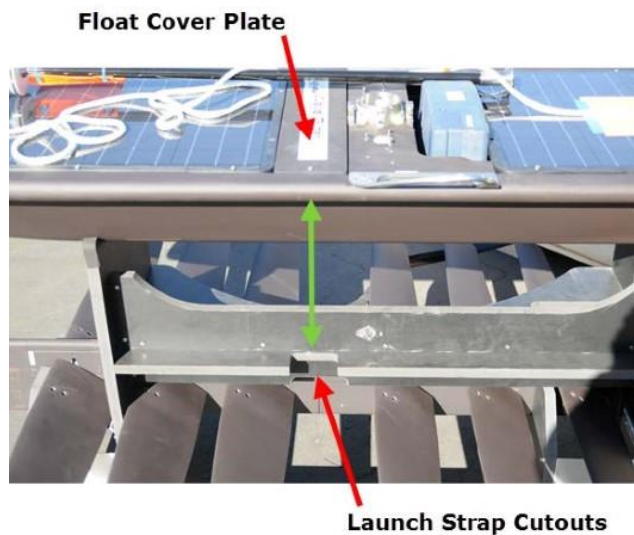
### Chapter 8. Wave Glider SV3 Launch Operations

#### Launch Overview

Launching a Wave Glider shall be done in a bundled configuration. The Sub assembly rests on the aluminum Stand. A polymer Saddle nests on top of the Sub that supports the Float. Depending on payloads, a launch-ready Wave Glider SV3 assembly weighs approximately 200-230 kg, with overall envelope dimensions of 3m long x 1.47m wide x 1.1 m tall (from the bottom of the sub to the top of the center Lifting Bail, excluding any attached masts).

The Bundling Strap secures the Sub and Float together for launch and is tethered to the Saddle allowing Saddle retrieval after the Wave Glider has been launched. The Bundling Strap has a quick release mechanism that is activated by a trained Lead Technician during launch. Two Tie-down Straps hold the Wave Glider to the Stand until just before the vehicle is hoisted for launch. The Stand is tied-down separate of the Wave Glider, and remains on deck after the Wave Glider has been hoisted for launch.

**Figure 8.1. Wave Glider SV3 Bundling Strap Placement**



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 8.2. Bundling Strap



Figure 8.3. Bundling Strap with Quick Release Shackle Latched



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Figure 8.4. Bundling Strap Attached for Launch



Figure 8.5. Umbilical Stowed for Launch



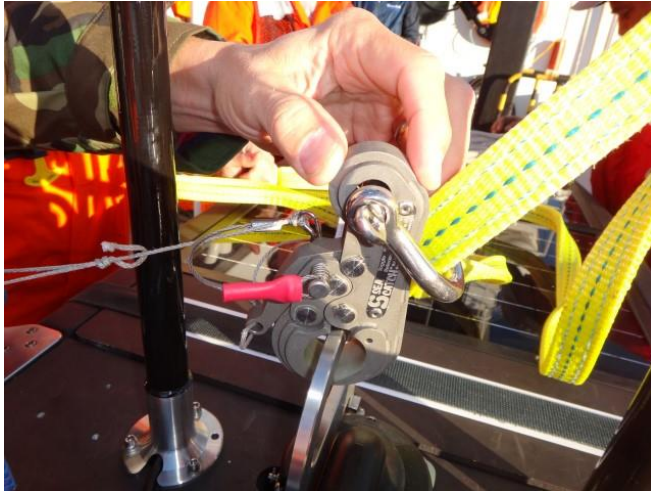
**The Wave Glider should never be launched unbundled** - the umbilical can easily become twisted and affect vehicle performance. The launch process is well developed and has a high success rate that ensures proper Wave Glider performance.

The Wave Glider is launched utilizing the Lifting Bail by attaching a quick release shackle (for example, SeaCatch) secured to the hoist line. Once lifted clear of the Stand, the assembly is positioned overboard and lowered to the waterline.

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 8.6. SeaCatch Attached for Launch**



Care must be exercised by the attending crew to minimize the swinging movement of the assembly during hoisting, by using the appropriate configuration of tag lines. The bow of the Wave Glider shall be oriented away from the vessel (45-90 degrees recommended), and the bow tag line is slipped. At splashdown, the hoisting line quick release shackle is released followed by the Bundling Strap. Once the bundling strap is tripped, the Sub dives down and away, pulling the Float away from the support vessel. The stern tag line is then slipped. Once the Float is clear of the vessel and underway, the Saddle and Bundling Strap are recovered back to the deck.

**Figure 8.7 Wave Glider Hoisted for Launch**



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# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Figure 8.8. Bow of the Wave Glider is Oriented Away from Vessel



The Wave Glider can be modified to incorporate towed sensors (towbody or towfish) and arrays, or acoustic streamers. Launching and recovering this equipment must be carefully reviewed, and techniques determined, before mission mobilization. Each case requires safety considerations. For assistance, contact LRI Customer Support for recommended launch and recovery procedures. See Appendix I: “Towfish Launch and Recovery Procedures”

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Launch Operations

**Estimated Duration: 20 minutes**

#### Launch - Required Personnel and Equipment

- 2 Deckhands
- 1 Lead Technician (may also be Deck Boss)
- 1 Hoist Operator
- 1 Captain/Vessel Operator
- PPE
- Bundling Strap and release line
- SeaCatch with pin and release line
- 2 x tag lines (10-15m)

#### Launch Procedure

1. Notify piloting operations center of deployment plan and coordinate task sequence
2. Toolkit (Job Safety Analysis (JSA)) review: discuss launch process with all participating crew. Ensure safety briefing covers the tasks expected of each crew, PPE, hoisting safety, exclusion zones, no-touch, and emergency response. Ensure clear and effective crane operator communications.
3. Prep vehicle for launch:
  - a. Move vehicle to hoisting location and orient so that the left side of the vehicle is facing inboard
  - b. Insure transit tie down straps are removed so as not to hoist the Stand during launch
  - c. Attach crane hoisting line to center Lifting Bail with a SeaCatch, oriented with release line facing the left side of the vehicle
  - d. Place tag lines on bow and stern Float handles (slipped, no knots or hardware)
  - e. Attach and check Bundling Strap is tight, tethered to the saddle u-bolt, and that the ratchet is fully locked
  - f. Ensure release line lengths are ample to trip the Sea Catch and Bundling Strap once the vehicle is in the water
  - g. Notify Wave Glider Ops Center or pilot in charge to prepare to pilot
  - h. Set rudder center (through WGMS or the Vehicle Web Page)
  - i. Request Captain orient vessel and bring to minimum speed for best control of vessel and swinging loads; once oriented, confirm all deck personnel and the vessel Captain are ready to proceed with launch.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

4. Proceed with hoisting of vehicle from center Lifting Bail; requires 3 trained personnel, one Deckhand for each tag line and one Lead Tech for the SeaCatch and Bundling Strap release lines. Lift vehicle off the deck and into the water keeping control of fore and aft tag lines, never using the release lines for the SeaCatch or Bundling Strap as tag lines
5. Vehicle shall be oriented with the bow of the Wave Glider at a 45-90 degree angle away from vessel
6. Deckhands: point the bow of the Wave Glider away from vessel, and slip the bow line as the vehicle is set into the water
7. Lead Tech: pulls SeaCatch pin and release-line, continuing to pull the winch hoisting line clear of vehicle masts **before the hoisting line goes slack**
8. Lead Tech: pulls Bundling Strap release-line (releasing Sub to dive 4m)
9. Deckhand: slips the stern tag line
10. Lead Tech: retrieves Saddle back to vessel
11. Notify Wave Glider Ops Center or pilot in charge to confirm vehicle is in water for piloting
12. Secure launch equipment on deck
13. WGOC performs remote testing and confirms successful launch and releases vessel to next tasking.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Chapter 9. Wave Glider SV3 Recovery Operations

#### Recovery Overview

The at-sea configuration of the Wave Glider is the surface Float connected with a 4-6m Umbilical to the Sub component. Recovery of the Wave Glider can be accomplished in 3 different ways dependent on vessel configuration and hoisting equipment. VOOs should be vetted in advance of recovery operations to determine the safest recovery option for a particular mission, vehicle configuration, and sea state.

#### Recovery options include:

- **Single-Stage Hoisting:** Recovering the entire Wave Glider on deck in a single hoisting evolution, using one mechanical hoist, such as a crane. This requires 7-9 meters height over rail for a Wave Glider SV3 with a 4 m Umbilical.
- **Multi-Stage Hoisting (2 hoists):** Recovering the Wave Glider in a multi-stage hoisting evolution, using two mechanical hoists, one hoist for recovering the Float and one for recovering the Sub.
- **Multi-Stage Hoisting (1 hoist):** Recovering the Wave Glider in a multi-stage hoisting evolution using one mechanical hoist.

#### Recovery Buoy and Release Mechanism

To facilitate recovery of the Wave Glider system, a buoy with 12 m of floating line attached to it can be deployed (remotely via software command) from the aft end of the Float. The line is stored in a Line Locker below the aft solar panel.

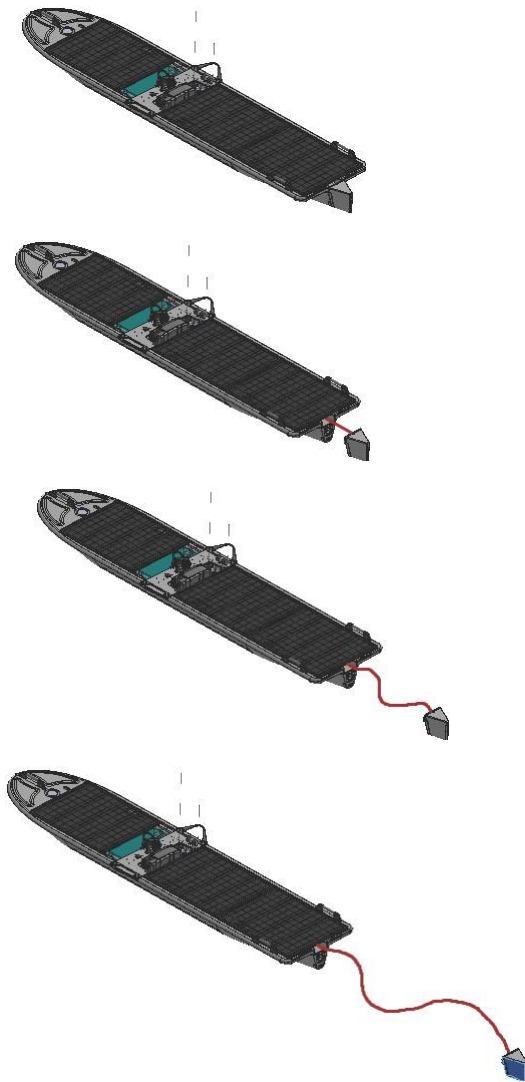
Two spring loaded latches retain the buoy by clasping a latch plate that extends from the buoy. When the release command is issued, a linear actuator forces a piston to open the latches and the buoy is released from the Float. The piston is designed to overcome any potential bio fouling.

When the buoy is released, drag on the buoy from water resistance will pull the line out of the line locker. A grappling hook can be used to capture the trailing line so it can be used as tag line.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Figure 9.1. Recovery Buoy Release Sequence



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

Figure 9.2. Grappling the Recovery Buoy Line



The Recovery Buoy, and the hardware where the line attaches to the Recovery Buoy, will not support the weight of the Wave Glider system. **Do not attempt to lift the Wave Glider system by the Recovery Buoy.**

The Recovery Buoy can be manually reloaded into the Wave Glider Float. First make sure there are no knots or biofouling on the line. Next, push the line into the Line Locker like a painter line, so that the last part of the line to be pushed (closest to the buoy) will be the first section that deploys out of the Line Locker. **Do not coil or knot the line in the Line Locker.**

If necessary, the Recovery Buoy can be manually released from the Float by inserting a 6" screw driver or similar object into a hole in the Recovery Buoy and pressing to release the latch.

### Vessel Approach

To allow for proper interception and recovery, Wave Glider heading and prevailing sea state must be assessed by the vessel Captain and crew. It may be prudent to change the course of the Wave Glider to allow for a safer vessel recovery orientation in relation to the Wave Glider.

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide



The Wave Glider is always in motion, on average making way at 1+ knots, and will not stop moving once it is alongside. It is important that the support vessel always be downwind of the vehicle as it approaches for recovery.

Figure 9.3. Side Recovery: Vessel and Wave Glider Orientation

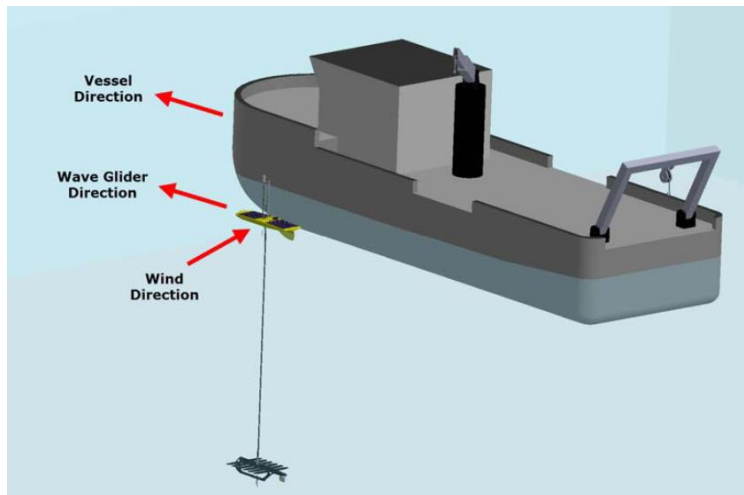
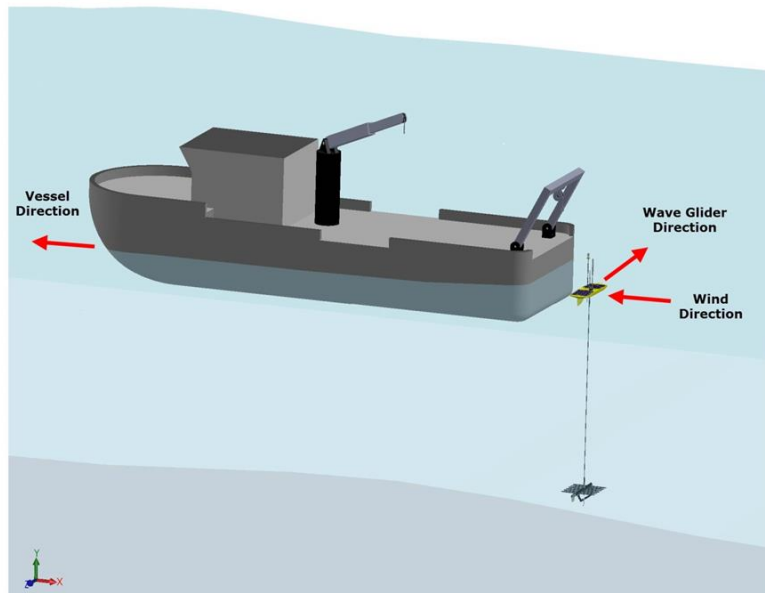


Figure 9.4. Stern Recovery: Vessel and Wave Glider Orientation



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

## Recovery Operations

**Estimated Duration: 45 minutes**

### Recovery - Required Personnel and Equipment

- 2-3 Deckhands
- 1 Lead Technician (may also be Deck Boss)
- 1 Hoist Operator
- 1 Captain/Vessel Operator
- PPE
- 2 x boat poles rigged with carabineer clip mounts and carabineer clips with tag lines attached (15-20m)
- 1 x boat pole with carabineer clip mount and carabineer clip attached with a shackle or lift strap to the hoist cable.
- Grappling hook (20 m of line)
- Sub Recovery Device attached to 1-2 m lift strap, and hoist line (if multi-stage hoisting)

### Single-Stage Hoisting: (1 hoist, 7-9 meters height over Rail)

1. Perform safety briefing and related checklist 30 minutes prior to recovery. For more Information, see the LRI Appendix B: Job Safety Analysis Form.
2. Notify the Wave Glider Operations Center (WGOC)/shore side support to send vehicle commands for recovery, or from the vessel, send a command to put the Wave Glider on a fixed heading that best aligns with vessel position for stable recovery
3. Confirm with Captain that the vessel is ready to approach the vehicle, and bring to minimum speed for best control of vessel and swinging loads.
4. Ensure deck crew and Hoist Operator is ready
5. Deploy Recovery Buoy to use as a tag line: In WGMS, Under SV3 commands → Devices → float recovery device, type in 30 (sec delay) and "Deploy". Recovery buoy will slowly pay out 12 m of floating line
6. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle
7. Deckhand: Grapple the Recovery Buoy line and pull Wave Glider Float to the vessel to gain access to the side Lifting Bails
8. Deckhands: With boat poles and carabineer clips, attach tag lines to the Float fore and aft handles

**Note: bow and stern handles are NOT hoist points.**

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

9. Lead Tech/Deck Boss: Attach crane hoisting wire to the side Lifting Bail closest to the vessel with a boat pole and carabineer clip. Signal the Hoist Operator to lift the Float out of the water. The Float and masts will roll out away from the vessel (Figure 9.5 & 9.6).
10. Deckhands: Keep tension on the Float tag lines to ensure the Float remains horizontal and to minimize swing. A tag line that is free to move down the Umbilical can be attached (positively or with two bitter ends) to control the Sub, and pull the Sub on deck, keeping personnel out from under the overhead load. The Sub Recovery Device with strap and tag line can be used for this purpose, or a slip line.
11. Lead Tech/Deck Boss: Signal the Hoist Operator to stop hoisting when the Sub is just under the surface of the water. If conditions allow, the Lead Tech attaches a tag line to the bow of the Sub using a boat pole with carabineer clip (Figure 9.7).
12. Lead Tech/Deck Boss: Signal the Hoist Operator to continue hoisting the entire assembly until the Sub clears the rail or deck (Figure 9.8).
13. All tag lines should be pulled from opposing directions to minimize swing. Deck personnel must stay out from under the load
14. Lead Tech/Deck Boss: Signal the Hoist Operator to move the load inboard
15. Lead Tech: Guide the Sub onto the Stand with tag lines as the Hoist Operator lowers the load to deck (also see No-Touch Recovery Option, Figure 9.9)
16. Lead Tech: Places Saddle on the Sub
17. Deckhands: Guide the Float on the Saddle as the Hoist Operator continues to lower the Float
18. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in the Wave Glider SV3 Unpacking and Assembly Guide.
19. Remove hoist line from Float
20. Secure the bundled Wave Glider and Stand to appropriate storage location on deck for transit, routine maintenance, and post-mission cleaning
21. Notify WGOC or shore-side support to confirm Wave Glider recovered and vessel float plan
22. Follow post-mission procedures for routine maintenance and cleaning. Refer to the Wave Glider SV3 Maintenance, Inspection, and Cleaning SOP.

**No-Touch Recovery Option.** In Step 15, the Hoist Operator lowers the Sub directly to the deck (Figure 9.9), followed by the Float (Figure 9.10) while Deckhands and Lead Tech use opposing tag lines to steady the vehicle. If the Sub or Float has delicate sensors that may be damaged by setting them directly on the deck, use rubber deck mats, a foam landing pad, or other available bumpers such as a tire to protect the sensor(s) from sitting on deck. Use team lifting to set Sub on Stand, followed by the Saddle. Use the hoist to guide the Float to the Saddle. Continue to Step 18.

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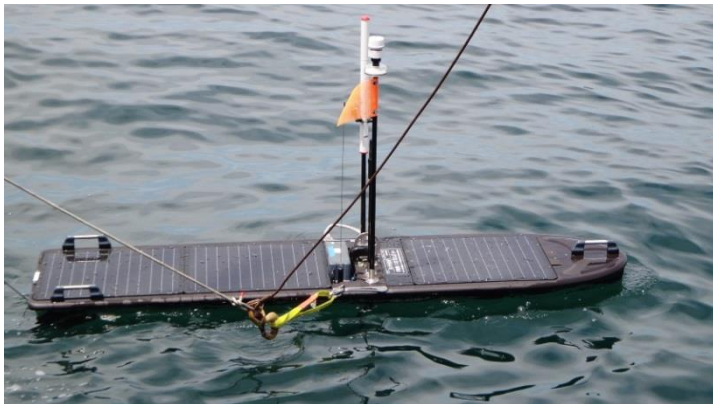
## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 9.5. Attach Hoisting Wire to the Side Lifting Bail with Carabiner Clip



Figure 9.6. Prepare to Hoist Float



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 9.7. Attach a Tag Line to the Bow of the Sub**



**Figure 9.8. Continue Hoisting Until the Sub Clears the Rail**



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 9.9. Lower Sub to Deck

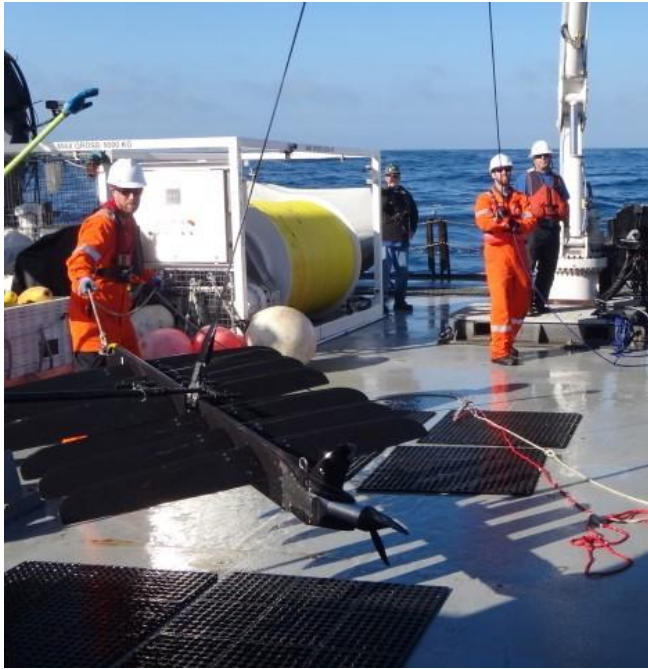


Figure 9.10. Lower Float to Deck



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Multi-Stage Hoisting (2 Hoists)

1. Perform safety briefing and related checklist 30 minutes prior to recovery. For more information see Appendix B: Job Safety Analysis Form
2. Notify the Wave Glider Operations Center (WGOC)/shore side support to send vehicle commands for recovery, or from the vessel, send a command to put the Wave Glider on a fixed heading that best aligns with vessel position for stable recovery
3. Confirm with Captain that the vessel is ready to approach the vehicle, and bring to minimum speed for best control of vessel and swinging loads.
4. Ensure deck crew and Hoist Operator is ready
5. Deploy Recovery Buoy to use as a tag line: In WGMS, Under SV3 commands→Devices→float recovery device, type in 30 (sec delay) and “Deploy”. Recovery buoy will slowly pay out 12 m of floating line
6. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle
7. Deckhand: Grapple the Recovery Buoy line and pull Wave Glider Float to the vessel where the side Lifting Bails are easy to access
8. Deckhands: With boat poles and carabineer clips, attach tag lines to the Float fore and aft handles.

**Note: bow and stern handles are NOT hoist points**

9. Lead Tech/Deck Boss: Attach hoisting wire to the side Lifting Bail closest to the vessel with a boat pole and carabineer clip. Signal the Hoist Operator to lift the Float out of the water. The Float and masts will roll out away from the vessel (Figure 9.11).
10. Hoist the Float out of the water until umbilical is accessible without getting under the load (Figure 9.12)
11. Lead Tech/Deck Boss: Attach Sub Recovery Device to umbilical with lift strap and tag line (or second hoist line)
12. Send Sub Recovery Device down umbilical while holding the tag or hoist line. The device will positively latch onto the recovery hooks on the bottom of the Umbilical. If you are unsure that the device has locked on, raise it up and down until you feel the hooks positively lock (Figure 9.13)
13. Lead Tech/Deck Boss: Signal the Hoist Operator to hoist the Sub to just below the surface of the water; this will take the load off the Float as it is lowered to the deck
14. Lower the Float to the Saddle on deck. Deckhands: guide Float to sit in an upright position. Pull the umbilical to the starboard side of the vehicle
15. Secure the Float to the deck through pad eyes/tie downs. Once the load is secure, detach the hoisting cable

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

16. Lead Tech: Attach a tag line to the bow of the Sub while it is just at the surface with a boat pole and carabineer clip (Figure 9.14)
17. Hoist the Sub and position it onto the Stand on deck or simply lie the Sub on deck if No Touch\* conditions dictate (Figure 9.15). The Wave Glider can then be re-bundled on deck to prepare for at sea storage and vessel transit
18. Lead Tech: Place Saddle on the Sub
19. Deckhands: Guide the Float on the Saddle as the Hoist Operator continues to lower the Float. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in the Wave Glider SV3 Unpacking and Assembly Guide
20. Remove hoist line from Float
21. Secure the bundled Wave Glider and Stand to appropriate storage location on deck for transit, routine maintenance, and post-mission cleaning
22. Notify WGO or shore-side support to confirm Wave Glider recovered and vessel float plan
23. Follow post-mission procedures for routine maintenance and cleaning. Refer to the Wave Glider SV3 Maintenance, Inspection, and Cleaning SOP.

**No-Touch Recovery Option.** In Step 15, the Hoist Operator lowers the Sub directly to the deck, followed by the Float while Deckhands and Lead Tech use opposing tag lines to steady the vehicle. If the Sub or Float has delicate sensors that may be damaged by setting them directly on the deck, use rubber deck mats, a foam landing pad, or other available bumpers such as a tire to protect the sensor(s) from sitting on deck. Use team lifting to set Sub on Stand, followed by the Saddle. Use the hoist to guide the Float to the Saddle. Continue to Step 18.

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 9.11. Attach Hoisting Wire to the Side Lifting Bail with Carabiner Clip**



**Figure 9.12. Hoist the Float out of the Water to Access Umbilical**



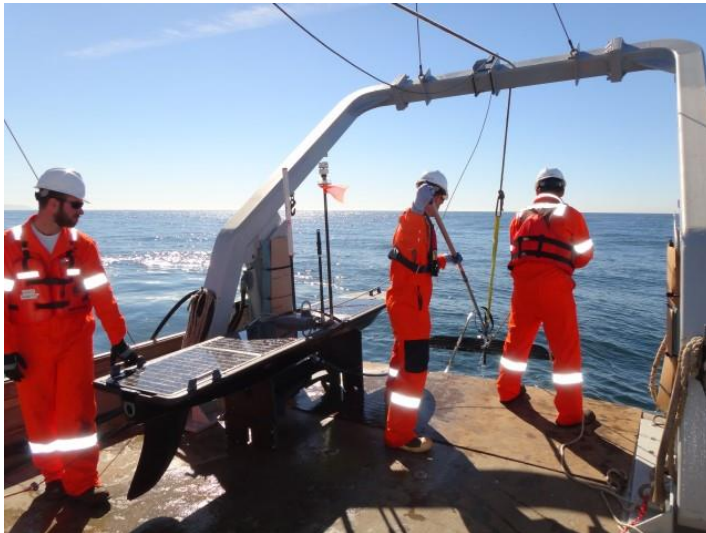
## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 9.13. Send Sub Recovery Device Down Umbilical**



**Figure 9.14. Attach Tag Line to Bow of Sub**



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 9.15. Hoist Sub to the Deck



# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Multi-Stage Hoisting (1 Hoist)

1. Perform safety briefing and related checklist 30 minutes prior to recovery. For more information see the LRI Appendix B: Job Safety Analysis Form
2. Notify the Wave Glider Operations Center (WGOC)/shore side support to send vehicle commands for recovery, or from the vessel, send a command to put the Wave Glider on a fixed heading that best aligns with vessel position for stable recovery
3. Confirm with Captain that the vessel is ready to approach the vehicle, and bring to minimum speed for best control of vessel and swinging loads.
4. Ensure deck crew and Hoist Operator is ready
5. Deploy Recovery Buoy to use as a tag line: In WGMS, Under SV3 commands→Devices→float recovery device, type in 30 (sec delay) and "Deploy". Recovery buoy will slowly pay out 12 m of floating line
6. Vessel approaches Wave Glider from downwind to avoid drifting over the vehicle
7. Deckhand: Grapple the Recovery Buoy line and pull Wave Glider Float to the vessel where the side Lifting Bails are easy to access
8. Deckhands: With boat poles and carabineer clips, attach tag lines to the Float fore and aft handles. Note: bow and stern handles are NOT hoist points.
9. Lead Tech/Deck Boss: Attach crane hoisting wire to the side Lifting Bail closest to the vessel with a boat pole and carabineer clip. Signal the Hoist Operator to lift the Float out of the water. The Float and masts will roll out away from the vessel (Figure 9.16)
10. Hoist the Float out of the water until umbilical is accessible without getting under the load
11. Lead Tech/Deck Boss: Attach Sub Recovery Device to umbilical with lift strap and a 5m tag line that is load rated for hoisting
12. Send Sub Recovery Device down umbilical while holding the tag line. The device will positively latch onto the recovery hooks on the bottom of the Umbilical. If you are unsure that the device has locked on, raise it up and down until you feel the hooks positively lock (Figure 9.17)
13. Continue to hoist the Float as high as possible, then tie off the Sub Recovery Device tag line on a load rated cleat or railing. This will take the load off the Float as it is lowered to the deck (Figure 9.18)
14. Lead Tech/Deck Boss: Signal the Hoist Operator to bring the Float inboard. As the Float is lowered, the load is being suspended on the Sub Recovery Device line
15. Lower the Float to the Saddle on deck; secure the Float to the deck through pad eyes/tie down straps. Once the load is secure, detach the Float hoisting cable
16. Connect the tag line on Sub Recovery device to the hoisting cable and continue to hoist the Sub up to just below the surface (Figure 9.19)

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

17. Lead Tech: Attach a tag line on the bow of the Sub with a boat pole and a mooring clip to control swing (Figure 9.20). Continue to hoist the Sub, setting the Sub on the Stand, or directly to the deck (Figure 9.21)
18. Check for twists in the umbilical and use the davit cable to pick and spin the Float as needed
19. Bundle the vehicle on the stand for next launch and secure to the deck for transit
20. Check that the umbilical is not twisted before storing. Hoist the float and carefully spin to untwist the umbilical if needed, then fold and store the Umbilical as illustrated in the Wave Glider SV3 Unpacking and Assembly Guide. The folded Umbilical is held together with a large rubber band and rests on top of the Sub wings. For more information on proper storage of the Umbilical, review the Wave Glider SV3 Unpacking and Assembly Guide.

**Figure 9.16. Hoist Float out of the Water**



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

**Figure 9.17. Send Sub Recovery Device Down Umbilical**



**Figure 9.18 Hoist the Float as High as Possible; Tie off the Sub Recovery Device Tag Line**



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 9.19. Connect Sub Recovery Device Tag Line to the Hoisting Cable



Figure 9.20 Connect a Tag Line to the Bow of the Sub



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

Figure 9.21 Continue Hoisting Sub to the Deck



## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Appendix A. Reference Documents

For access to the documents listed below, Contact LRI Customer Support at:

Email: [support@liquidr.com](mailto:support@liquidr.com)

Phone: +1 888-574-4574 (Toll Free in USA) or +1 408-636-4205

- *Field Operations Technician Skill Set*
- *WGOc Mission Plan*
- *Wave Glider SV3 Unpacking and Assembly (P/N 05813)*
- *Wave Glider SV3 Maintenance, Inspection, and Cleaning SOP (P/N 06032)*
- *Wave Glider SV3 Disassembly and Pack (P/N 06033)*
- *International Maritime Organization (IMO) Annex 13, Safe Practice for Cargo Stowage and Securing*

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Appendix B. Job Safety Analysis Form

|                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Job Safety Analysis (Example)</b>                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                       | Date:                                                                                                                                                                                                                                                                                                                                                |
| Title of Job/Operation:                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                       | Log Number:                                                                                                                                                                                                                                                                                                                                          |
| Employee Name and Job Title:                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                       | Analyst and Date:                                                                                                                                                                                                                                                                                                                                    |
| Field Team:                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                       | Approved By and Date:                                                                                                                                                                                                                                                                                                                                |
| Personal Protective Equipment:                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                      |
| Sequence of Basic Job Steps                                                                                                                                                                                                     | Incidents / Hazards*                                                                                                                                                                                                                                                                  | Recommended Safe Job Procedures                                                                                                                                                                                                                                                                                                                      |
| <b>Deck Rigging for Transit:</b><br><br>Safely positioning Wave Glider on deployment deck.<br><br>Safely connecting Wave Glider on Glider stand to the Deck.<br><br>Properly securing all associated shackles with safety wire. | Damage to equipment and personnel from unsecured lifting practices.<br><br>Heavy loads create pinch points and can lead to muscle strain.<br><br>Pinching, muscle strains and slips, trips and falls.<br><br>Associated gear becomes loose and loss of equipment becomes a potential. | Use safe lifting techniques with proper equipment. Use tag lines to secure lift.<br><br>Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and connectors ready.<br><br>Work at safe pace.<br><br>All connecting gear will have safety wire secured after all connectors have been checked for tightness. |
| <b>Deployment:</b><br><br><u>Wave Glider</u><br><br>1-Attach quick release                                                                                                                                                      | Damage to equipment and                                                                                                                                                                                                                                                               | Proper lifting communication. Rated                                                                                                                                                                                                                                                                                                                  |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>bundling strap used to tie the float and glider together during the lift. Attach a minimum of 2 tag lines. Using a second quick release device, safely lift the bundled Wave Glider over the side of vessel with crane</p> <p>2-Using a well-choreographed effort, the crane operator lowers the Wave Glider to the sea surface while the tag lines are managed to correctly orient the wave glider. To avoid developing slack in the hoisting line, as soon as the wave glider touches the water, the crane quick release mechanism is released and the crane can be secured.</p> <p>2b-Spotter watches winch cable to ensure proper amount of winch line remains on drum.</p> <p>3-As soon as the bundled wave glider is released from the hoisting gear, the nose of the wave glider should be oriented away from the ship, the front tag line slipped first, the bundling strap triggered, and finally</p> | <p>personnel from unsecured lifting practices</p> <p>Pinch points, overhead loads and entanglement hazards can lead to injury and equipment damage.</p> <p>Risk of entanglement or being caught in bite of control lines.</p> <p>Overhead loads.</p> <p>Damage to equipment. Entanglement of wave glider in ship propulsion.</p> <p>Over the side operation risks MOB potential</p> <p>Improperly managed tag lines or improper piloting leading to uncontrolled swing of suspended wave glider</p> | <p>gear - multiple tag lines to control swing. Stay out from under crane load.</p> <p>Keep communications clear. Know your path to safety, and work at a efficient and safe pace. Stay out from under crane.</p> <p>Captain keeps vessel properly oriented. Crew keeps clear path for gear to egress vessel. Keep deck clear of all potential objects of conflict. Good communication and know safe zones. Captain gives final go command after crew communicates readiness.</p> <p>Everyone has the right and responsibility to stop operation for any concerns, questions or suggestions that may make the operation safer and or more efficient.</p> <p>Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and connectors ready.</p> <p>All connecting gear will have safety wire secured after all connectors have been checked for tightness.</p> |
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## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

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|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>the aft tag line allowed to slip as the wave glider moves away under its own power.</p> <p>4-Wave glider saddle is then pulled back to ship. Tag lines are pulled in. Winch line is then re-spoiled and crane stowed by crane operator</p>                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                   | <p>Proper tending of all lines over the side to manage potential in water wave glider or ship entanglement.</p> <p>Proper piloting and weather limitations</p> <p>Use of appropriate boat poles. Tethered deck hands.</p>                                                                                                                                                                                                                                                                                                                              |
| <p><b>Retrieval:</b></p> <p>1-Wave glider is put on desired course that will best allow ship to approach the wave glider at close range.</p> <p>2-Crane is positioned over the edge of the vessel with as little scope as possible. The crane line or cable is attached to a quick release retrieval hook that connects to the end of a boat pole.</p> <p>3-As soon as the vessel is within range of the boat pole, the hoisting line is attached to the center lifting point of the float, and slack is removed from the hoisting line to avoid entanglement in Wave</p> | <p>Damage to equipment and personnel from unsecured lifting practices</p> <p>Pinch points, overhead loads and entanglement hazards can lead to injury and equipment damage.</p> <p>Risk of entanglement or being caught in bite of control lines.</p> <p>Overhead loads.</p> <p>Damage to equipment. Entanglement of wave glider in ship propulsion.</p> <p>Over the side operation risks MOB</p> | <p>Proper lifting communication. Rated gear - multiple tag lines to control swing. Stay out from under crane load.</p> <p>Keep communications clear. Know your path to safety, and work at a efficient and safe pace. Stay out from under crane.</p> <p>Captain keeps vessel properly oriented. Crew keeps clear path for gear to egress vessel. Keep deck clear of all potential objects of conflict. Good communication and know safe zones. Captain gives final go command after crew communicates readiness.</p> <p>Everyone has the right and</p> |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Glider antenna's, and to assist in maintaining control of the float near the vessel.</p> <p>4-Fore and aft handle on the Wave Glider are hooked with tag lines.</p> <p>5-The crane operator lifts the float out of the water up to rail height. Once the umbilical is accessible, a tag line is placed around the umbilical.</p> <p>6-The crane continues to lift the float until the glider reaches the surface of the water. A tag line is attached to the nose of the wave glider while the wave glider is still in the water.</p> <p>7. Once a tag line is on the glider, the entire assembly is lifted high enough to get the glider onto the vessel deck. The glider is set on the deck as gently as possible, followed by the float being brought to the deck and placed on the float cradle.</p> | <p>potential</p> <p>Improperly managed tag lines or improper piloting leading to uncontrolled swing of suspended wave glider</p> | <p>responsibility to stop operation for any concerns, questions or suggestions that may make the operation safer and or more efficient.</p> <p>Work in pairs and safe speeds. Good communication with primary coordinator. Have proper tools and connectors ready.</p> <p>All connecting gear will have safety wire secured after all connectors have been checked for tightness.</p> <p>Proper tending of all lines over the side to manage potential in water wave glider or ship entanglement.</p> <p>Proper piloting and weather limitations</p> <p>Use of appropriate boat poles. Tethered deck hands.</p> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

|                                                                                                                                                                                                                                                                       |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| <p>8-After the float and glider are on the deck of the vessel and all tag lines and the crane are secure, the entire Wave Glider Assembly is restacked on the proper stand, and is then strapped to the deck for stability until ready to re-crate for transport.</p> |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

### Appendix C. Operation Service Quality Incident (OSQI) Form

| Operations Service Quality Incident (OSQI) REPORT                                                                                                                |                                  |                                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|---------------------------------------|
| Date of incident/hazard (report ID):<br>OSQI [yyymmdd description - rev.<br>yyymmdd]                                                                             | Time: [hh:mm UTC]                | Location (lat/lon;<br>address):<br>[] |
| <b>Report Author :</b>                                                                                                                                           |                                  |                                       |
| Name:<br>[]                                                                                                                                                      | Telephone:<br>[]                 |                                       |
| Title:<br>[]                                                                                                                                                     | Email:<br>[]                     |                                       |
| <b>Injury Information (if applicable):</b>                                                                                                                       |                                  |                                       |
| Name(s) of injured:<br>[]                                                                                                                                        | Telephone:<br>[]                 |                                       |
| Description of injuries:<br>[]                                                                                                                                   |                                  |                                       |
| Treatment details: <input type="checkbox"/> None <input type="checkbox"/> First Aid <input type="checkbox"/> Medivac/EMS <input type="checkbox"/> Return to Work |                                  |                                       |
| Medical Facility Details(name, address, telephone #):<br>[]                                                                                                      |                                  |                                       |
| <b>Vessel Related Information (if applicable):</b>                                                                                                               |                                  |                                       |
| Name of Vessel(s) involved:<br>[]                                                                                                                                | Vessel ID or Doc # (USCG):<br>[] |                                       |
| Name of Vessel Operator/Captain:<br>[]                                                                                                                           | Telephone:<br>[]                 |                                       |
| Name of Vessel Owner:<br>[]                                                                                                                                      | Telephone:<br>[]                 |                                       |
| Last Known Speed & Course:<br>[]                                                                                                                                 | Sea State (Douglas Scale):<br>[] | Wind/Waves:<br>[]                     |
| Brief Description of Incident, Known Damage or Near Miss:<br>[]                                                                                                  |                                  |                                       |
| <b>Wave Glider or Equipment Related Information (if applicable):</b>                                                                                             |                                  |                                       |
| Name of Wave Glider(s) or Equipment involved:<br>[]                                                                                                              | Last Known Speed & Course:<br>[] |                                       |
| Name of Wave Glider Pilot/Program Manager/Customer:                                                                                                              | Telephone(s):                    |                                       |

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

|                                                                                                                                                                                                                                                                                                                                                                                                   |  |                                    |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------|--|
| <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                              |  | <input type="text"/>               |  |
| Confirmation of LNM and other permits of operations:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                      |  |                                    |  |
| Brief Description of Incident, Known Damage or Near Miss:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                 |  |                                    |  |
| <b>Description of Incident or Hazard (chronology of events):</b>                                                                                                                                                                                                                                                                                                                                  |  |                                    |  |
| <input type="text"/> [00:00z], [Event]<br><input type="text"/> [00:00z], [Tier2 engaged]<br><input type="text"/> [00:00z], [Subject matter expert, PM, and client engaged as applicable]<br><input type="text"/> [00:00z], [Text notification to executive staff, PM, and WGOc as applicable... followed by hourly updates]<br><input type="text"/> [00:00z], [Remedy and closure communications] |  |                                    |  |
| <b>Witness Names (Witness Statement Forms Attached, if applicable):</b>                                                                                                                                                                                                                                                                                                                           |  |                                    |  |
| Witness 1: <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                   |  | Telephone: <input type="text"/>    |  |
| Witness 2: <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                   |  | Telephone: <input type="text"/>    |  |
| Witness 3: <input type="text"/>                                                                                                                                                                                                                                                                                                                                                                   |  | Telephone: <input type="text"/>    |  |
| *All witness forms to be filed with supervisor no later than COB on day or accident/incident.                                                                                                                                                                                                                                                                                                     |  |                                    |  |
| <b>Agencies Contacted:</b>                                                                                                                                                                                                                                                                                                                                                                        |  |                                    |  |
| <input type="checkbox"/> 911/EMS <input type="checkbox"/> Coast Guard <input type="checkbox"/> Harbor Authorities/DOT <input type="checkbox"/> Other                                                                                                                                                                                                                                              |  |                                    |  |
| <b>LRI Accident Investigation Coordination &amp; Escalation:</b>                                                                                                                                                                                                                                                                                                                                  |  |                                    |  |
| LRI Primary Coordinator Contacted (Supervisor, Manager, Director, VP):<br><input type="text"/>                                                                                                                                                                                                                                                                                                    |  | Telephone:<br><input type="text"/> |  |
| LRI HR Contacted:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                                                         |  | Telephone:<br><input type="text"/> |  |
| Insurance Rep Contacted:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                                                  |  | Telephone:<br><input type="text"/> |  |
| Legal Rep Contacted:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                                                      |  | Telephone:<br><input type="text"/> |  |
| HAZMAT Response Summary:<br><input type="text"/>                                                                                                                                                                                                                                                                                                                                                  |  |                                    |  |
| <b>Signatures:</b>                                                                                                                                                                                                                                                                                                                                                                                |  |                                    |  |
| Author Signature: <input type="text"/>                                                                                                                                                                                                                                                                                                                                                            |  | Date: <input type="text"/>         |  |
| Supervisor Signature: <input type="text"/>                                                                                                                                                                                                                                                                                                                                                        |  | Date: <input type="text"/>         |  |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

\*Report to be filed with LRI Primary Coordinator no more than 24 hrs following incident/accident.

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Appendix D. Wave Glider SV3 Pre-Launch Checklist

| Wave Glider SV3 Pre-Launch Checklist |                 |
|--------------------------------------|-----------------|
| Date / Time (UTC):                   | Project:        |
| Technician(s):                       | Ship / Op Area: |

| Prelaunch Setup (Setup > All Vehicle Parameters)                        |          |                                     |          |
|-------------------------------------------------------------------------|----------|-------------------------------------|----------|
| Item/Procedure                                                          | Initials | Item/Procedure                      | Initials |
| Update Regulus if needed, Power Cycle CCU (power plug)                  |          | Auto Avoidance = <b>no</b> check    |          |
| waterSpeed: Assume that the vessel is in the water = <b>no</b> check    |          | AutoOff Speed = 0, AutoOn Speed = 0 |          |
| waterSpeed: The vessel is in the water = <b>no</b> check (auto, verify) |          | Line Following = <b>no</b> check    |          |

| Mechanical Checks |                             |                                     |                                                           |  |
|-------------------|-----------------------------|-------------------------------------|-----------------------------------------------------------|--|
| Float             | Wet-mates connected/lubed   |                                     | Port, O1: CCU, WSS, mid and aft solar                     |  |
|                   | Connector covers secure     |                                     | Stbd, O2: CCU, BRM, fwd solar, RTE, LED                   |  |
|                   | Drybox secure               |                                     | Contained by foam, payloads, panels. No loose hardware.   |  |
|                   | Contact info secure         |                                     |                                                           |  |
|                   | Hull                        |                                     | Condition (new, scuffed, scratched, dinged etc)           |  |
|                   | Skeg/Fin                    |                                     | Screws secure, no cracks                                  |  |
| Sub               | Hardware secure             |                                     |                                                           |  |
|                   | Umbilical visual inspection |                                     | Free of voids/defects                                     |  |
|                   | Roll pins inserted          |                                     | Flushed with surface                                      |  |
|                   | Wings                       |                                     | Hardware secure with Loctite                              |  |
|                   | Thrudder                    | Oil Filled <input type="checkbox"/> | Hardware secure. No protrusion of aft screws (top/bottom) |  |

| Vehicle / WGMS Configurations  |                          |                                     |          |
|--------------------------------|--------------------------|-------------------------------------|----------|
| Item/Procedure                 | Readings                 | Specifications                      | Initials |
| SV3 WGMS Name                  |                          |                                     |          |
| Float Name                     |                          |                                     |          |
| Glider Name                    |                          |                                     |          |
| Thrudder Serial Number         | Manuf. SN:    PDC HW ID: | Label on housing, AMPS HW ID last 6 |          |
| Onboard Server WiFi IP         | 192.168.100.1            | IP                                  |          |
| Onboard Server Virtual Cell IP |                          | IP 10.20.15.XXX                     |          |
| <b>Tracking</b>                |                          |                                     |          |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

|                             |                                                                                                                                                                                    |  |              |                                                   |  |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------|---------------------------------------------------|--|
| Resilient Tracker WGMS Name | Battery:                                                                                                                                                                           |  | Report Rate: | WGMS Communications Window 13.8V max, Dead at 8V. |  |
|                             |                                                                                                                                                                                    |  | 10min/12hr   |                                                   |  |
| Nano Tracker WGMS Name      | Battery:                                                                                                                                                                           |  | Report Rate: | WGMS Communications Window 1.95 A-Hr max          |  |
|                             |                                                                                                                                                                                    |  |              |                                                   |  |
| Topside RDF Frequency       |                                                                                                                                                                                    |  | 15X.XXX      |                                                   |  |
|                             |                                                                                                                                                                                    |  |              |                                                   |  |
| <b>Ports</b>                | Onboard: RTE <input type="checkbox"/> AIS <input type="checkbox"/> WX Station (S4) <input type="checkbox"/> Water Speed <input type="checkbox"/> Lightbar <input type="checkbox"/> |  |              |                                                   |  |
| XP 1 (G1)                   |                                                                                                                                                                                    |  |              | Description                                       |  |
| XP 2 (G2)                   |                                                                                                                                                                                    |  |              | Description                                       |  |
| XP 3 (G3)                   |                                                                                                                                                                                    |  |              | Description                                       |  |
| XP Sub (XP on Thrudder)     |                                                                                                                                                                                    |  |              | Description                                       |  |
| Payload 1 (S1)              |                                                                                                                                                                                    |  |              | Description                                       |  |
| Payload 2 (S2)              |                                                                                                                                                                                    |  |              | Description                                       |  |
| Payload 3 (S3)              |                                                                                                                                                                                    |  |              | Description                                       |  |
|                             |                                                                                                                                                                                    |  |              |                                                   |  |
| <b>WGMS</b>                 |                                                                                                                                                                                    |  |              |                                                   |  |
| Organization                |                                                                                                                                                                                    |  |              |                                                   |  |
| Escalation List             |                                                                                                                                                                                    |  |              | Created and Populated                             |  |
| Event Definitions           |                                                                                                                                                                                    |  |              | Compare Against Standard List                     |  |
| Vehicle Op Area Defined     |                                                                                                                                                                                    |  |              | Poly Name, Alarms Enabled                         |  |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Appendix E. WGOC Launch and Recovery Piloting Checklist

| Wave Glider Pre-Launch & Launch                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                          |          |
|--------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|----------|
| T-24 Hours                                                         | Yes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | No                       | Comments |
| Environmental Window Confirmed :                                   | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| Operational Logistics Confirmed:                                   | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| Pre-launch Checklist Submitted (FieldOps):                         | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| Departure and Deployment Area ETAs:                                | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| Shore-side Instructions Acknowledged:                              | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| Launch Authorization:                                              | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| WGMS Components page populated                                     | <input type="checkbox"/>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <input type="checkbox"/> |          |
| T-30 Minutes                                                       | Completed/Comments                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                          |          |
| Launch Crew ETA Notification and Pilot-in-Charge WGMS UI Settings: | <input type="checkbox"/> ETA to launch area(s)<br><input type="checkbox"/> Check special shore-side support needs & execute accordingly<br><input type="checkbox"/> Confirm all payloads powered on (except for those that must be wet 1 <sup>st</sup> )<br><input type="checkbox"/> Engage PIC map options (vehicle selections, RV obstacles, pilot tools, current layers, nautical charts) & escalation lists<br><input type="checkbox"/> Check AMPs pages for power reports<br><input type="checkbox"/> Scan OpArea & validate device reporting |                          |          |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

|                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                   | <input type="checkbox"/> WGMS comment on developments<br><input type="checkbox"/> Set TRR to two minutes just prior to deployment<br><input type="checkbox"/> Threat Evasion deactivated                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>T-0 (Verified By Water Speed)</b>                                              | <b>Completed/Comments</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Note: Inform vessel/crew of any attention required throughout the process.</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Establish Safe Navigation:</b>                                                 | <input type="checkbox"/> Verify FMBC is On (Inoperable with SV3 at the moment)<br><input type="checkbox"/> If outside cell range, set default comms to Iridium<br><input type="checkbox"/> Light on, set course for desired OpArea, line-following on, all devices on<br><input type="checkbox"/> Confirm desired/sub heading alignment<br><input type="checkbox"/> Post ACKD of commands, AMPS pages for power draws                                                                                                                                                                                                                                                                           |
| <b>Vehicle/Payload Performance Check:</b>                                         | <input type="checkbox"/> Conduct core system and device validations (current draw on PLs, iPIB, umbilical, light; battery power; CCDB/RM/PL/Thruder pres/temp/humidity; device data validation)<br><u>Navigational Checks</u><br><input type="checkbox"/> Cycle Rudder through left, right and center positions, note vehicle is turning<br><input type="checkbox"/> Follow sequential or custom course, verify vehicle is targeting correct waypoint<br><input type="checkbox"/> Engage thruster at slow (75 rpm) and fast (>250 rpm) speeds, observe vehicle performance for at least three telemetry reports<br><input type="checkbox"/> Verify thruster auto settings specified for mission |
| <b>Begin Mission:</b>                                                             | <input type="checkbox"/> Begin mission engaged (appropriate mission selected)<br><input type="checkbox"/> Set TRR to 5 minutes, light off<br><input type="checkbox"/> Release vessel and launch crew<br><input type="checkbox"/> WGMS comment (successful deployment by vessel, time in water)                                                                                                                                                                                                                                                                                                                                                                                                  |

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|  |                                                                                                                                                                                                                                                                                                              |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <div><input type="checkbox"/> Distribute communications to key stake holders</div> <div><input type="checkbox"/> Engage alarm generation on Op Polygons upon reaching given boundaries</div> <div><input type="checkbox"/> Activate Encrypted Comms</div> <div><input type="checkbox"/> Update NS case</div> |
|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

#### Appendix F. Nearshore Vessel Requirements

| 1. General                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Length                                                                                                                                                                                                                                                                                                                                           | 8m minimum depending on Mission specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Endurance and Navigational Limits                                                                                                                                                                                                                                                                                                                | Less than 1 day and less than 30nm offshore.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Speed                                                                                                                                                                                                                                                                                                                                            | Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Classification                                                                                                                                                                                                                                                                                                                                   | ABS, Lloyds, SOLAS A or equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Vessel Control                                                                                                                                                                                                                                                                                                                                   | Ability to maintain steerage at 1 to 3 knots.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Navigation                                                                                                                                                                                                                                                                                                                                       | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Magnetic compass</li> <li>• Satellite positioning receiver</li> <li>• Marine echosounder, with hull-mounted transducer</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Communications                                                                                                                                                                                                                                                                                                                                   | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Multi-channel Marine VHF R/T</li> <li>• Cellular phone (or Satellite Phone if operating outside cellular service areas)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Pier-side facilities or Vessel supplied support                                                                                                                                                                                                                                                                                                  | Minimum mobilization/demobilization requirements: <ul style="list-style-type: none"> <li>• Minimum 1 tonne hoisting capability required to load vehicle and related support equipment at pier.</li> <li>• Ability to load a fully assembled wave glider from shore to vessel or vice versa:               <ul style="list-style-type: none"> <li>○ Assembled Wave Glider Size and Weight:                   <ul style="list-style-type: none"> <li>▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts. Maximum 200kg.</li> <li>▪ SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg.</li> </ul> </li> </ul> </li> </ul> |
| 2. Vessel Facilities                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Toilets                                                                                                                                                                                                                                                                                                                                          | Marine toilet for missions greater than 4 hours                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

|                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Freshwater                    | Reasonable amount of potable water available for all crew members for expected mission duration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>3. Vessel Lab Space</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Electrical Power              | 120VAC/60Hz, or 220V/50Hz power desirable. Power and outlet type to be noted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>4. Vessel Working Deck</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Free Board and Rail Height    | 1m maximum on working decks, as low as possible without being awash preferred. Max rail height 1m, or removable safety lines.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Working Space                 | Minimum 2m from working rail or stern, by 4m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Storage Space                 | <p>Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or recovery of any vehicles. Minimum storage dimensions per Wave Glider are:</p> <ul style="list-style-type: none"> <li>SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts</li> <li>SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Hoisting/Lifting Gear         | <p>Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for lifting/hoisting to be included and noted.</p> <ul style="list-style-type: none"> <li>Minimum "Distance Outboard": 1m</li> <li>Minimum "Distance Inboard": 1m</li> <li>Minimum SWL: 1-tonne</li> <li>Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred.</li> <li>Maximum weight of cable counterweight: 15kg</li> <li>Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static</li> <li>Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static.</li> <li>Minimum Hoist "Height Over Rail" Requirement: <ul style="list-style-type: none"> <li>Minimum Single Pick Height Over Rail: 9.0m</li> <li>Minimum Double Pick Height Over Rail: 3.0m</li> <li>Minimum Hoist Cable Length: 15m + "Height Over Water" + Length</li> </ul> </li> </ul> |

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|                                                         |                                                                                                                                                                                                                                                                                                                                                                                               |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                         | Required to Maintain Safe “Minimum Scope”                                                                                                                                                                                                                                                                                                                                                     |
| Visibility                                              | Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be visible from the vessel controls and communications via line-of-sight                                                                                                                                                                                               |
| <b>5. HSSE (Health Safety Security and Environment)</b> |                                                                                                                                                                                                                                                                                                                                                                                               |
| Requirement                                             | The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.                                                                                                                                                                |
| Staffing                                                | Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.                                   |
| Survival suits                                          | In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working in latitudes above 32 degrees north and below 32 degrees south.                                                                                                                                                             |
| Notices                                                 | Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel’s crew will be in English for all safety notices and procedures.                                                                                                                                                                                                        |
| Briefings                                               | Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.                                                                                                                                                  |
| PPE                                                     | <p>All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc):</p> <ul style="list-style-type: none"> <li>• Safety toed shoes</li> <li>• PFD</li> <li>• Hard hat</li> </ul>                                                                                                       |
| Vessel Response Plan                                    | The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with |

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|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at <a href="http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf">http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf</a>. For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.</p> |
|--|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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## Wave Glider SV3 Launch & Recovery Guide

### Appendix G. Coastal Vessel Requirements

| 1. General                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Length                                                                                                                                                                                                                                                                                                                                           | 16m minimum depending on Mission specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Endurance and Navigational Limits                                                                                                                                                                                                                                                                                                                | Less than 5 days and less than 100nm offshore                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Speed                                                                                                                                                                                                                                                                                                                                            | Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Classification                                                                                                                                                                                                                                                                                                                                   | ABS, Lloyds, SOLAS A or equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Vessel Control                                                                                                                                                                                                                                                                                                                                   | Twin screw with ability to maintain steerage at 1 to 3 knots. Dynamic positioning, Z-drive, bow thruster or alternative station keeping controls are desirable.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Navigation                                                                                                                                                                                                                                                                                                                                       | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Magnetic compass</li> <li>• Marine radar</li> <li>• Satellite positioning receiver</li> <li>• Marine echosounder, with hull-mounted transducer</li> <li>• Electronic charts (e.g. Nobeltec)</li> <li>• Bridge control of engines and thrusters</li> </ul>                                                                                                                                                                                                                                                                         |
| Communications                                                                                                                                                                                                                                                                                                                                   | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Multi-channel Marine VHF R/T capable of working all frequencies and with a dual watch facility</li> <li>• Satellite communications telephone, e-mail, data and facsimile desirable</li> <li>• Cellular phone (or Satellite Phone if operating outside cellular service areas)</li> <li>• Voice two-way communications system linking the Vessel bridge, deck, and Wave Glider operation room/dry lab</li> <li>• Hand-held radios for operating in areas of the Vessel not covered by the internal communication system</li> </ul> |
| Antenna Masts                                                                                                                                                                                                                                                                                                                                    | Mission specific ability to mount multiple antennas (e.g. GPS, RF, etc).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Pier-side facilities or Vessel                                                                                                                                                                                                                                                                                                                   | Minimum mobilization/demobilization requirements: <ul style="list-style-type: none"> <li>• Minimum 1 tonne hoisting capability required to load vehicle and related</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                   |

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|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| supplied support                | <p>support equipment at pier.</p> <ul style="list-style-type: none"> <li>• Ability to load a fully assembled wave glider from shore to vessel or vice versa</li> <li>• Mission Specific: Secure storage space of LRI assets for mobilization, demobilization and to accept LRI equipment shipments. Shipping crates to be stored in a secured area during the duration of the mission, in addition to a minimum of 1 week before and after the mission for mobilization and demobilization. <ul style="list-style-type: none"> <li>○ Shipping Crate Size and Weight: Float, Glider and Parts crate to ship for each vehicle required for mission. Tow-Body crate is a mission specific requirement. Crates can be stacked 3 high. <ul style="list-style-type: none"> <li>▪ SV2 Float: 2.3m x 0.8m x 0.8m, 135kg – 225kg</li> <li>▪ SV2 Glider: 2.1m x 0.5m x 0.5m, 75kg</li> <li>▪ SV3 Float: 3.0m x 0.9m x 0.6m, 163kg – 225kg</li> <li>▪ SV3 Glider: 2.3m x 0.5m x 0.5m, 135kg</li> <li>▪ Parts Crate: 1.5m x 0.8m x 0.6m, 90kg – 225kg</li> <li>▪ Tow Body: 1.5m x 0.8m x 0.6m, 90kg – 135kg</li> </ul> </li> <li>○ Assembled Wave Glider Size and Weight: <ul style="list-style-type: none"> <li>▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts. Maximum 200kg.</li> <li>▪ SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg.</li> </ul> </li> </ul> </li> <li>• Assembly and Disassembly Space: <ul style="list-style-type: none"> <li>○ Minimum 3m x 4m of clean, dry space, with access to 110V to 220V power outlet within 15m of location. Power and outlet type to be noted.</li> <li>○ Internet access via WiFi or 3G cellular service. Cellular data providers available on-site to be noted.</li> <li>○ Area must allow for the delivery of shipping crates via forklift, pallet jack, or similar. Direct access to shipping crate storage area preferred.</li> <li>○ Area must allow a fully assembled vehicle to be rolled in and out.</li> <li>○ Climate controlled space preferred.</li> </ul> </li> </ul> |
| <b>2. Vessel Facilities</b>     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Wave Glider Crew Accommodations | For Missions greater than 18 hours, individual berths should be available for each member of the wave glider mission crew. Maximum occupancy of 8 persons per room.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Male-Female Facilities          | For overnight missions, male/female staffing must be accommodated including bunk and head privacy between men and women. Head/shower must have a locking door.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Toilets and showers             | 1 toilet per every 8 persons for single day operations. 1 toilet and 1 shower per every 6 persons for overnight operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

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| Freshwater                    | Sufficient potable water in the form of storage tanks and water making facilities such as to ensure adequate supplies for all personnel for a minimum endurance 1.2 times the mission length. Additional drinking water is required for warm climates.                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Galley                        | Large enough for half the ship's complement at one sitting and a cooking staff for 24-hour operation. Three meals a day and cold food snacks for 3 <sup>rd</sup> shift.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>3. Vessel Lab Space</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Wave Glider Control Space     | Minimum 1.0m x 0.5m per wave glider mission crew member, of well-lit countertop or desk space. Area must be clean, dry, well-ventilated and air-conditioned, with access to power and satellite network connections. Space shall include a cable run allowing antenna cables to be routed into this space. Area must be allocated for exclusive use by the wave glider mission crew for the entire mission, and cannot be used for other operations or tasks. Space cannot be cleared for routine vessel servicing tasks and should only be disturbed by Vessel crew in emergency situations.                                                                                                          |
| Electrical Power              | 7Kva of clean 120VAC/60Hz, or 220V/50Hz. Power and outlet type to be noted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>4. Vessel Working Deck</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Free Board and Rail Height    | 2m maximum on working decks, as low as possible without being awash preferred. Max rail height 1m, or removable safety lines.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Working Space                 | Minimum 3m from working rail or stern, by 5m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Storage Space                 | Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or recovery of any vehicles. Minimum storage dimensions per Wave Glider are: <ul style="list-style-type: none"> <li>SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts</li> <li>SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts</li> </ul> |
| Hoisting/Lifting Gear         | Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for                                                                                                                                                                                                                                                                                                                                                                                                                                                            |

# Liquid Robotics Field Operations

## Wave Glider SV3 Launch & Recovery Guide

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|                                                         | <p>lifting/hoisting to be included and noted.</p> <ul style="list-style-type: none"> <li>• Minimum “Distance Outboard”: 2m</li> <li>• Minimum “Distance Inboard”: 1m</li> <li>• Minimum SWL: 1-tonne</li> <li>• Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred.</li> <li>• Maximum weight of cable counterweight: 15kg</li> <li>• Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static</li> <li>• Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static.</li> <li>• Minimum Hoist “Height Over Rail” Requirement: <ul style="list-style-type: none"> <li>○ Minimum Single Pick Height Over Rail: 9.0m</li> <li>○ Minimum Double Pick Height Over Rail: 3.0m</li> <li>○ Minimum Hoist Cable Length: 15m + “Height Over Water” + Length Required to Maintain Safe “Minimum Scope”</li> </ul> </li> </ul> |
| Visibility                                              | <p>Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be either visible from the vessel controls and communications via line-of-sight or good quality closed-circuit TV pictures of such areas</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>5. HSSE (Health Safety Security and Environment)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Requirement                                             | <p>The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Staffing                                                | <p>Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Survival suits                                          | <p>In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working in latitudes above 32 degrees north and below 32 degrees south.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Notices                                                 | <p>Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel’s crew will be in English for all safety notices and procedures.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

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| Briefings            | Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Drills               | For missions greater than 48 hours, a lifeboat and fire drill will be undertaken on passage to site at the commencement of a Wave Glider cruise. Safety drills will be programmed to ensure practice in a variety of potential emergency response procedures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Personnel training   | All personnel are to be trained and certified in sea survival, fire fighting, first aid/emergency medical skills to IPITO, UKOOA, STCW or equivalent internationally recognized standards.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| PPE                  | <p>All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc):</p> <ul style="list-style-type: none"> <li>• Safety toed shoes</li> <li>• PFD</li> <li>• Hard hat</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Vessel Response Plan | <p>The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at <a href="http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf">http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf</a>. For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.</p> |

## Liquid Robotics Field Operations

### Wave Glider SV3 Launch & Recovery Guide

## Appendix H. Offshore Vessel Requirements

| 1. General                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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| The Vessel will have been purpose built or suitably converted to undertake survey or unmanned vehicle operations in the designated geographical area during the requested season. The Vessel will be seaworthy and will be supplied fully equipped, with current and valid certification for its classification during the proposed time period. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Length                                                                                                                                                                                                                                                                                                                                           | 40m minimum depending on Mission specifications                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Endurance and Navigational Limits                                                                                                                                                                                                                                                                                                                | Mission specific                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Speed                                                                                                                                                                                                                                                                                                                                            | Minimum 10 knot top speed for transiting with ability to maintain steerage at 1 to 3 knots speed for launch/recovery                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Classification                                                                                                                                                                                                                                                                                                                                   | ABS, Lloyds, SOLAS A or equivalent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Vessel Control                                                                                                                                                                                                                                                                                                                                   | Twin screw with ability to maintain steerage at 1 to 3 knots. Dynamic positioning, Z-drive, bow thruster or alternative station keeping controls are desirable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Navigation                                                                                                                                                                                                                                                                                                                                       | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Gyrocompass in addition to magnetic compass</li> <li>• Marine radar</li> <li>• Satellite positioning receiver</li> <li>• Marine echosounder, with hull-mounted transducer</li> <li>• Electronic charts (e.g. Nobeltec)</li> <li>• Weather fax or internet access for near real-time weather updates</li> <li>• Bridge control of engines and thrusters</li> </ul>                                                                                                                                                                                                                                                                        |
| Communications                                                                                                                                                                                                                                                                                                                                   | Minimum Instrumentation Requirements: <ul style="list-style-type: none"> <li>• Multi-channel Marine VHF R/T capable of working all frequencies and with a dual watch facility</li> <li>• Ship-Shore R/T with a minimum range of 300 kilometers, or capable of communicating with the nearest offshore support base offering emergency response facilities, whichever is the greater range</li> <li>• Satellite communications telephone, e-mail, data and facsimile</li> <li>• Voice two-way communications system linking the Vessel bridge, deck, and Wave Glider operation room/dry lab</li> <li>• Hand-held radios for operating in areas of the Vessel not covered by the internal communication system</li> </ul> |
| Antenna Masts                                                                                                                                                                                                                                                                                                                                    | Mission specific ability to mount multiple antennas (e.g. GPS, RF, etc).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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| Pier-side facilities or Vessel supplied support | <p>Minimum mobilization/demobilization requirements:</p> <ul style="list-style-type: none"> <li>• 24 hour access to dockage equipped Vessel shore power.</li> <li>• Minimum 1 tonne hoisting capability required to load vehicle and related support equipment at pier.</li> <li>• Forklift (minimum 1 tonne) available during mobilization and demobilization.</li> <li>• Secure storage space of LRI assets for mobilization, demobilization and to accept LRI equipment shipments. Shipping crates to be stored in a secured area during the duration of the mission, in addition to a minimum of 1 week before and after the mission for mobilization and demobilization. <ul style="list-style-type: none"> <li>○ Shipping Crate Size and Weight: Float, Glider and Parts crate to ship for each vehicle required for mission. Tow-Body crate is a mission specific requirement. Crates can be stacked 3 high. <ul style="list-style-type: none"> <li>▪ SV2 Float: 2.3m x 0.8m x 0.8m, 135kg – 225kg</li> <li>▪ SV2 Glider: 2.1m x 0.5m x 0.5m, 75kg</li> <li>▪ SV3 Float: 3.0m x 0.9m x 0.6m, 163kg – 225kg</li> <li>▪ SV3 Glider: 2.3m x 0.5m x 0.5m, 135kg</li> <li>▪ Parts Crate: 1.5m x 0.8m x 0.6m, 90kg – 225kg</li> <li>▪ Tow Body: 1.5m x 0.8m x 0.6m, 90kg – 135kg</li> </ul> </li> <li>○ Assembled Wave Glider Size and Weight: <ul style="list-style-type: none"> <li>▪ SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5m tall without masts. Maximum 200kg.</li> <li>▪ SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts, Maximum 220kg.</li> </ul> </li> </ul> </li> <li>• Assembly and Disassembly Space: <ul style="list-style-type: none"> <li>○ Minimum 3m x 4m of clean, dry space, with access to 110V to 220V power outlet within 15m of location. Power and outlet type to be noted.</li> <li>○ Internet access via WiFi or 3G cellular service. Cellular data providers available on-site to be noted.</li> <li>○ Area must allow for the delivery of shipping crates via forklift, pallet jack, or similar. Direct access to shipping crate storage area preferred.</li> <li>○ Area must allow a fully assembled vehicle to be rolled in and out.</li> <li>○ Climate controlled space preferred.</li> </ul> </li> </ul> |
| <b>2. Vessel Facilities</b>                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Wave Glider Crew Accommodations                 | For Missions greater than 18 hours, individual berths should be available for each member of the wave glider mission crew. Maximum occupancy of 8 persons per room.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Male-Female Facilities                          | For overnight missions, male/female staffing must be accommodated including bunk and head privacy between men and women. Head/shower must have a locking door. For long duration missions greater than 14 days, rooms and heads should be separated by hard doors that lock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

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| Toilets and showers           | 1 toilet per every 8 persons for single day operations. 1 toilet and 1 shower per every 6 persons for overnight operations.                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Freshwater                    | Sufficient potable water in the form of storage tanks and water making facilities such as to ensure adequate supplies for all personnel for a minimum endurance 1.2 times the mission length. Additional drinking water is required for warm climates.                                                                                                                                                                                                                                                                                                                                        |
| Galley                        | Large enough for half the ship's complement at one sitting and a cooking staff for 24-hour operation. Three meals a day and cold food snacks for 3 <sup>rd</sup> shift.                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Laundry                       | Washers and dryers available to the Wave Glider crew for missions over 7 days.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>3. Vessel Lab Space</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Wave Glider Control Space     | Minimum 1.0m x 0.5m per wave glider mission crew member, of well-lit countertop or desk space. Area must be clean, dry, well-ventilated and air-conditioned, with access to power and satellite network connections. Space shall include a cable run allowing antenna cables to be routed into this space. Area must be allocated for exclusive use by the wave glider mission crew for the entire mission, and cannot be used for other operations or tasks. Space cannot be cleared for routine vessel servicing tasks and should only be disturbed by Vessel crew in emergency situations. |
| Electrical Power              | 7Kva of clean 120VAC/60Hz, or 220V/50Hz. Power and outlet type to be noted.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>4. Vessel Working Deck</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Free Board and Rail Height    | 3m maximum on working decks, as low as possible without being awash preferred. Free board greater than 2m may require a small boat to assist in recovery operations. Max rail height 1m, or removable safety lines.                                                                                                                                                                                                                                                                                                                                                                           |
| Working Space                 | Minimum 3m from working rail or stern, by 5m along the working rail or stern of open deck space, with unimpeded access to overhead hoisting/lifting gear.                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Storage Space                 | Wave Gliders must be capable of being stored for transit in a space free of typical deck wash. Wave Gliders must be able to be moved directly from the storage location to the working area via hoisting or by rolling of vehicle cart or pallet jack, with minimal rearranging of other Wave Gliders or deck gear. Working space can be used for storage space during transit if it will not impact deployment or                                                                                                                                                                            |

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|                                                         | <p>recovery of any vehicles. Minimum storage dimensions per Wave Glider are:</p> <ul style="list-style-type: none"> <li>SV2: 1.5m x 3m deck by 2.5m tall with masts, or 1.5 m tall without masts</li> <li>SV3: 2m x 4m deck by 2.5m tall with masts, or 1.5m tall without masts</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Hoisting/Lifting Gear                                   | <p>Hoisting/Lifting system (A-frame, J-frame, Articulating Crane, Boom, etc) with sufficient height to lift a 2.5m tall object from the working deck over any side or stern rails, and to the water, or vice-versa. All associated rigging for lifting/hoisting to be included and noted.</p> <ul style="list-style-type: none"> <li>Minimum "Distance Outboard": 2m</li> <li>Minimum "Distance Inboard": 1m</li> <li>Minimum SWL: 1-tonne</li> <li>Maximum wire rope diameter: 1.0cm. Polypro or similar line preferred.</li> <li>Maximum weight of cable counterweight: 45kg</li> <li>Deployment Package: Bottom of wave glider to lifting bail 1.5m; Mast 1.0m above lifting bail; Maximum 225kg static</li> <li>Recovery Package: Bottom of wave glider to lifting bail 8.0m; Mast 1.0m above lifting bail; Maximum 225kg static.</li> <li>Minimum Hoist "Height Over Rail" Requirement: <ul style="list-style-type: none"> <li>Minimum Single Pick Height Over Rail: 9.0m</li> <li>Minimum Double Pick Height Over Rail: 3.0m</li> <li>Minimum Hoist Cable Length: 15m + "Height Over Water" + Length Required to Maintain Safe "Minimum Scope"</li> </ul> </li> </ul> |
| Visibility                                              | <p>Vessel deck areas will have good lighting. All areas of the Vessel used for the Wave Glider deployment / recovery will be either visible from the vessel controls and communications via line-of-sight or good quality closed-circuit TV pictures of such areas</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>5. HSSE (Health Safety Security and Environment)</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Requirement                                             | <p>The Vessel will be fully classed and equipped to meet international safety requirements in conformance with SOLAS specifications. All safety equipment will be fully certified and properly maintained to same specifications.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Staffing                                                | <p>Vessel shall be staffed to meet US Coast Guard or prevailing local regulations for watch standing. In addition to LRI staff, deck operations must be staffed, per the mission plan, with appropriately trained staff to handle Vessel operation, hoisting and lifting gear, a deck boss, and sufficient line handlers depending on sea conditions expected.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Survival suits                                          | <p>In conformance with SOLAS - Survival suits will be available in all cabins sufficient to cover the maximum number of personnel allowed on the vessel when working</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

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|                      | in latitudes above 32 degrees north and below 32 degrees south.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Notices              | Notices will be displayed in appropriate locations throughout the Vessel. The languages of the majority of the Vessel's crew will be in English for all safety notices and procedures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Briefings            | Personnel joining the Vessel will be fully briefed on the location and use of the safety equipment. This briefing will take place prior to Vessel departure to site and at any other time deemed appropriate by the Master and/or Charterer.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Drills               | A lifeboat and fire drill will be undertaken on passage to site at the commencement of a Wave Glider cruise. Safety drills will be conducted at not less than seven days intervals thereafter. Safety drills will be programmed to ensure practice in a variety of potential emergency response procedures.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Personnel training   | All personnel are to be trained and certified in sea survival, fire fighting, first aid/emergency medical skills to IPITO, UKOOA, STCW or equivalent internationally recognized standards.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| PPE                  | <p>All personnel directly involved in Wave Glider launch and recovery deck operations must wear at a minimum, local regulatory agency approved (e.g. OSHA, USCG, CE, etc):</p> <ul style="list-style-type: none"> <li>• Safety toed shoes</li> <li>• PFD</li> <li>• Hard hat</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Vessel Response Plan | <p>The Vessel is to carry safety and emergency plans in compliance with international, and national (in its country of registry and place of operation) regulations. Owners of non-tank vessels trading to the United States are now required to submit a Vessel Response Plan (VRP) to the United States Coast Guard no later than 8 August 2005. The VRP's must be prepared in accordance with Navigation and Vessel Inspection Circular (NVIC) 01-05 which is available at <a href="http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf">http://www.uscg.mil/hq/g-m/nvic/NVIC%2001-05.doc.pdf</a>. For the purpose of preparing a VRP, a non-tank vessel is a self-propelled vessel of 400 gross tons or greater, other than a tank vessel, that carries oil of any kind as fuel for main propulsion and that is either a vessel of the United States or a foreign vessel that operates on the navigable water of the United States (internal waters and the 3-nm wide territorial sea). As the Coast Guard expects that it will take at least one month to conduct an initial review of submitted plans, timely submission is essential.</p> |

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## Wave Glider SV3 Launch & Recovery Guide

### Appendix I. Towfish Launch and Recovery Procedures

A towfish is a sensor package that is towed from the Sub of the Wave Glider with a tow cable. Also referred to as towbody, this includes acoustic sensors such as streamers and arrays. The type of towfish and vessel configuration determines preferred launch and recovery procedures. The tow cable can range in length from 5-8m, and is ballasted to tow horizontally below the Wave Glider Sub.

The following three examples typify towfish used for a variety of Wave Glider applications.

**1. Small towfish:** 15 kg or less, 1 person hand-deployable, such as a light weight magnetometer

**a. Requirements:**

- i. 1 person (dedicated crewmember)
- ii. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched
- iii. Daylight and visibility to monitor the towfish
- iv. Vessel shall be dead in the water
- v. Sea state 3 or less

**b. Launch:**

- i. Crewmember 1: hold towfish in one hand, and tend the towcable with the other hand to ensure it does not tangle in the Wave Glider wings upon launch. Stage the towfish to be close to the water for release.
- ii. Follow Wave Glider Launch Procedure (release hoist line and Bundling Strap).
- iii. Crewmember 1: Allow the Sub to gently pull the small towfish into the water upon release of the Bundling Strap.
- iv. Exercise extreme caution to avoid towfish contact with the side or stern of the vessel.

**c. Recovery:**

- i. Follow Wave Glider Recovery Procedure and hoist the Sub 1-2 m outboard to keep the towfish clear of the vessel. Depending on tow cable length and height over rail, recover the towfish before the Sub to ensure it is safe.
- ii. Crewmember 1: use a boat pole to grab tow cable as the Sub is hoisted to the surface.
- iii. Crewmember 1: Retrieve towfish by hand, be careful to not hit the towfish on the side of the vessel.

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- iv. Crewmember 1: Place towfish on purpose-built cradle or foam, clear of the recovery operations, and continue to tend the towcable.
  - v. Resume Sub hoisting and Wave Glider Recovery Procedure.
- 2. Large towfish:** greater than 15 kg, 2-person or mechanical hoist deployable, such as echosounder transducers, turbidity sensors, or fluorometers, in a torpedo shaped housing.
- a. Requirements:**
    - i. 1-2 personnel (1 dedicated crewmember)
    - ii. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched
    - iii. Daylight and visibility to monitor the towfish
    - iv. Vessel shall be dead in the water
    - v. Sea state 3 or less
  - b. Launch:**
    - i. Vessel arrives on station and orients for Wave Glider launch.
    - ii. Stage Wave Glider at launch location on the vessel.
    - iii. Request permission from the Captain to launch towfish, confirm all participants are ready to launch.
    - iv. Crewmembers 1&2: Carefully lower towfish into the water and tend the towfish with the tow cable and a boat pole if necessary. Hold onto tow cable.
    - v. Follow the Wave Glider Launch Procedure; hoist the Wave Glider into the water.
    - vi. Crewmember 1: release towcable once the Wave Glider is in the water. The tow cable and towfish should sink below the level of the Sub.
    - vii. Immediately release the Wave Glider from the hoisting cable and trip the Bundling Strap release. The Wave Glider pulls away from the vessel.
  - c. Recovery:**
    - i. The following procedure assumes a robust and heavy towfish. If the sensor is very sensitive to damage, follow the Small Towfish Recovery Procedures.
    - ii. Follow Wave Glider Recovery procedures.
      - 1. Do not set the Sub directly onto the tow cable attachment/port on deck, this can damage the cable.
  - d.** Regardless of the recovery method used, the tow cable and towfish can be pulled onto the deck by hand last (after the entire Wave Glider is on deck). 2 crewmembers are required for heavy towfish.

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3. **Acoustic Streamer:** length will vary (30m or longer), 1-2 person hand deployable from a coil on deck or mechanical spool.

- a. **Requirements:**

- i. 2 personnel (1 dedicated crewmember)
    - ii. Vessel has low height-over-rail, a cut out, or open deck at the location where the Wave Glider will be launched
    - iii. Daylight and visibility to monitor the streamer to ensure it is not being fed into the vessel's propeller(s).
    - iv. Vessel shall be dead in the water
    - v. Sea state 3 or less

- b. **Launch:**

- i. Vessel arrives on station and orients to allow best drift of the streamer away from vessel.
    - ii. Stage Wave Glider at launch location on the vessel. This can be at the stern of the vessel, where the streamer is payed out directly aft, or against one of the aft rails where the streamer is payed out as far aft as possible.
    - iii. Request permission from the Captain to launch streamer, confirm all participants are ready to launch.
    - iv. Crewmember 1: hold the end of the streamer and pay out several meters of streamer with assistance from Crewmember 2 to feed the streamer into the water.
    - v. A large loop forms providing drag on the streamer which assists in paying the streamer away from the vessel. Toss the end of the streamer into the water once the streamer is clearly floating and/or sinking away from the vessel. If the streamer starts drifting under the vessel, or is being carried into the stern due to current, retrieve the streamer to the deck, reorient the vessel, and repeat.
    - vi. Once the streamer is completely deployed in the water, Crewmember 1 tends the tow cable that attaches the streamer to the bottom of the Wave Glider Sub by hand to ensure it does not tangle in the wings as the vehicle is hoisted into the water.
    - vii. Follow the Wave Glider Launch Procedure; hoist the Wave Glider into the water.
    - viii. Crewmember 1: release tow cable once the Wave Glider is in the water. The tow cable and streamer should sink below the level of the Sub.

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- ix. Immediately release the Wave Glider from the hoisting cable and trip the Bundling Strap release. The Wave Glider pulls the streamer away from the vessel, and if properly ballasted, the streamer should not be visible on the surface.
- c. **Recovery:**
  - i. Follow Wave Glider Recovery procedures.
    - 1. Use caution in approaching the Wave Glider as the streamer may not be towing directly behind the Sub. It is best to try to pilot the Wave Glider on a course to intercept the vessel while the vessel maintains the most stable position for recovery, going dead in the water at close proximity to the Wave Glider.
    - 2. Do not set the Sub directly onto the tow cable attachment/port on deck, this can damage the cable.
  - ii. Regardless of the recovery method used, the tow cable and streamer can be pulled onto the deck by hand last (after the entire Wave Glider is on deck). 2 crewmembers are required for large diameter streamer for hand coiling on deck.