MARINE ROBOTIC VEHICLES™

ALAMO and ALTO Floats Deployment Manual

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Introduction

The purpose of this Deployment Manual is to accompany the field technician responsible for launching, either by sea or air, either an MRV Systems ALAMO™ (Air Launched Autonomous Micro-Observer) and or ALTO float into the ocean. For a successful deployment, a pilot must be involved ashore to monitor and, as required, control float operations following launch. An accompanying Piloting Manual exists to serve that pilot, and a Quick Start Guide is also available. This manual is consistent with both the Pilot Manual and Quick Start Guide.

The MRV Systems ALAMO™ and ALTO floats are unmanned autonomous underwater battery powered vehicles designed to measure various ocean properties, for example temperature and salinity as a function of depth based on the sensor package(s) installed on the float. These floats are Lagrangian drifters and cannot control the direction of travel. They can only control buoyancy and thereby its depth. To change buoyancy, the float pumps oil to an external bladder thus changing displacement. The floats' sensor package(s) are administered by the floats' main CPU and generate profile data at operator-selectable intervals during descent, park, and, principally ascent stages of the float's profile. The floats use an on-board GPS receiver to capture precise float location when at the surface and an on-board Iridium communication device to transmit data ashore and receive commands from shore. The data generated is packetized and typically transmitted in Short Burst Data (SBD) mode.

Both the ALAMO and ALTO floats currently operate the MRV Systems Firmware Architecture (MFA) for controlling the operation of the floats. The architecture functions using a number of commands and parameters. A mission configuration is a set of commands and parameters sets that direct the float to execute one or more stages of operation within each of four float states: surface, descend, park, ascend; one sequence through which defines a profile. The mission configuration can drive one or more profiles including up to three sets of profiles that have different parameter settings. Since the floats are autonomous vehicles, the commands and parameters of the mission(s) it is to perform should be programmed prior to shipment. Commands and parameters, defined in Appendix C, Command and Parameter References, are used to control the float's behavior during profile including frequency of sampling and recording, fall time, park depth, ascent rate, allowed time limits for obtaining GPS fixes and communicating via satellite, and even under-ice behavior. Three sets of these commands and parameters are stored on the float. All three are set at the factory. A permanent set is stored with the operating system software. A second set is stored in EEPROM and is drawn upon if the float reboots on its own. The third set is stored in RAM. The RAM version can be altered by hard wire or Bluetooth or by emailing the float from ashore with a binary Iridium SBD file attachment containing commands and parameter changes. The float can - and should - be commanded to update the EEPROM version from RAM upon making changes. The Iridium email communication path is also used by the float to transmit data in the same packetized SBD format to the user. It is available for the pilot to command a resend of information ashore or even execute a reboot.

Our floats are deployed in oceans around the globe and communicate to an email server or IP address of choice at some remote location. The person deploying the float is almost always not the person piloting it, hence the need for both this Deployment Manual, its accompanying Piloting, and, as desired, Quick Start Manuals.

Iridium Account

Activating an Iridium Communications account will also have been specified in the purchase agreement and is required to configure and test float to satellite communications. Each account is keyed to the unique MRV float identifying IMEI number. MRV creates and activates an Iridium account for each float during the build process. This allows MRV to receive messages during test communications before leaving the factory.

Prior to shipment, MRV will contact the customer to address final provisioning (setting email and IP addresses for the float to connect through) and arrange to transfer account ownership to the customer with the Iridium provider of their choice. For the life of most of our floats MRV monitors and evaluates performance for future product development. Subject to the purchase agreement, MRV reserves the right to including provisioning one iridium email address assigned to sbd@mrvsys.com.

Ready to Deploy

From a field operation and piloting standpoint, our floats are shipped ready in all respects (vacuum set, ballasting and mission presets as agreed to in the purchase order, and in low-power sleep mode) for being deployed in a pre-specified body of water for a pre-specified type of profiling mission. They must simply be "reset" (turned on is a misnomer - resetting takes the float out of low-power mode and initiates a Built In Test (BIT, used interchangeably in this manual with Built In Self Tests - BIST)) in the field and delivered by the field technician into the water either directly or by parachute. The BIT initiates a self-test which will ideally verified by the pilot. Once in the water and free of packaging (if present), the floats will be negatively buoyant and start descending. Hydrostatic pressure as the float descends or time passed since the float was reset triggers the start of the float's mission software sequence. Typically, the float will then execute a shallow or mid-depth diagnostic profile during which it returns immediately to the surface obtains a GPS fix, and communicates ashore. After that, the float automatically begins its first in a series of normal profiles during which it normally "seeks" i.e., attempts to refine its ability to efficiently reach its park depth by controlling the duration of its initial pump when leaving the surface. Should the pilot choose, before the float communicates upon surfacing, a command to stay at the surface ("beacon mode on") may be issued via Iridium email. This will afford the pilot the opportunity to review the just-completed profile's data and alter parameters on that basis should that be desired. To restart profiling, the pilot must command "beacon mode off."

The field technician's principle functions are to 1) stage the float for deployment, 2) initiate a BIT unless it has already been performed, 3) confirm the float's proper operation by observing the illumination of the BIT light (and possibly hearing valve and pump noises during the BIT), and 4) deploy the float. Upon launching the float, the field technician's task is normally complete unless, for surface launches, there is a desire to potentially recover the float after its diagnostic profile in the event it is not functioning correctly.

MRV floats are ruggedly designed to operate in a wide variety of challenging ocean environments. However, to maximize the longevity of the unit and to prevent injury when handling the float, it is important to follow some simple safety and health precautions.

Hazardous Materials

MRV ALAMO and ALTO floats may contain hazardous materials depending on battery

and sensor choices. Relevant and current MSDS should be obtained for the following items where used in these floats:

Tadiran primary batteries comprised of Lithium, Thionyl Chloride (Li-SOCl2)

SAFT primary lithium batteries

Top of the Seabird conductivity cell contains Bis (tributyltin) oxide

Handling

The ALAMO and ALTO are high-precision instruments, and it is important that it is handled with care. Avoid any scratches to the painted or anodized surfaces. This may compromise the durability and/or longevity of the float after deployment in the ocean.

There should be no need to access either Comm port or Vacuum port prior to deployment, but should the need arise, avoid damaging anodized coatings on Comm Port and Vacuum Port plugs and ensure the plug's o-ring condition is unblemished and free of particles of any sort prior to reinstalling. Tighten finger tight with a 3/16" hex key.

Documentation and Software

Documentation, including a copy of this Deployment Manual and the accompanying Piloting Manual and sensor calibration information (provided by the manufacturer for each float delivered) is provided electronically to the customer. When your float is shipped, you will receive an e-mail notification of the shipment. Float operating software is generally not provided to the customer. A decoder for Iridium SBD messages sent by the float is available upon request. A tool for converting text-formatted mission configuration files to binary for emailing via Iridium are also available upon request. (See Appendix B)

Storage

If the float is to be stored for a length of time prior to deployment, it should be kept in unopened original packaging in a location that affords reduced likelihood of physical damage and a humidity and temperature-controlled environment. It's preferable to store floats vertically in packaging, orienting "This End Up", and on pallets or shelving.

Mechanical Features

ALAMO Float - Figures 1-3

Figure 1 ALAMO Floats outfitted with RBR CTDs

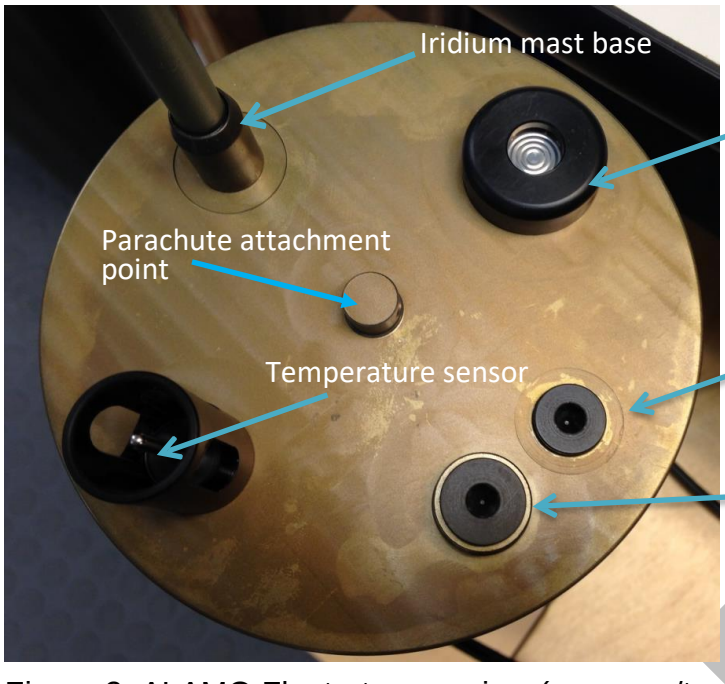

Figure 2 ALAMO Float - topcap view (pressure/temperature sensor configuration).

There should be no need to access either Comm port of Vacuum port prior to deployment, but should the need arise, avoid damaging anodized coatings on Comm Port and Vacuum Port plugs and ensure the plug's o-ring condition is unblemished and free of particles of any sort prior to reinstalling. Tighten finger tight.

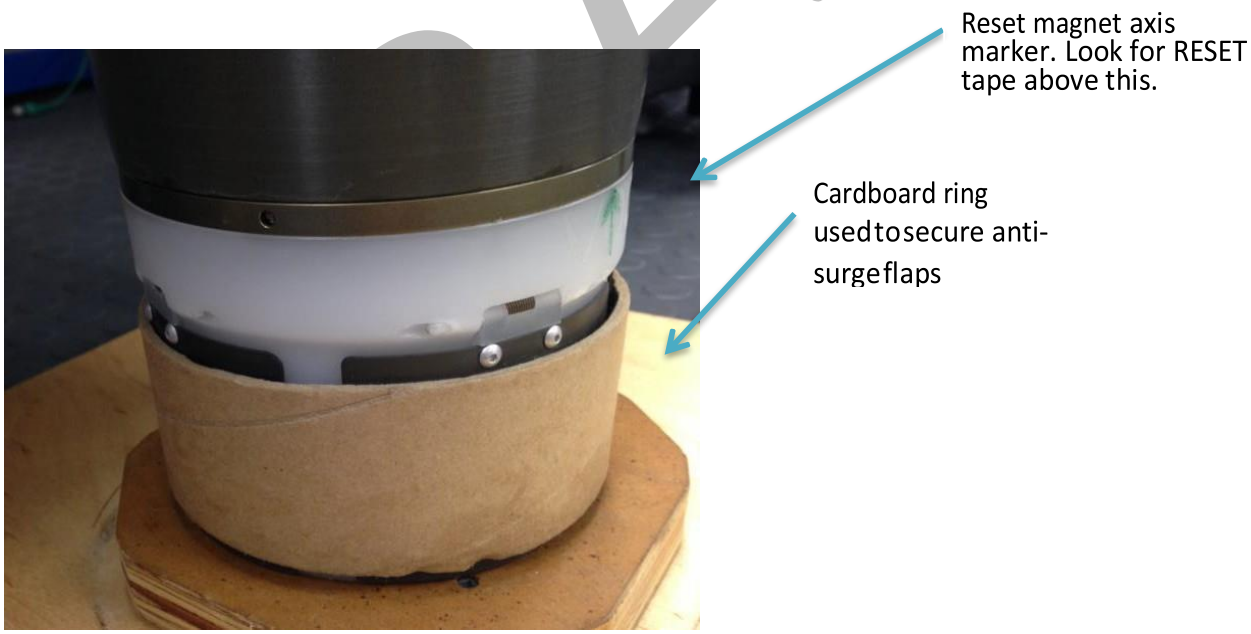

Figure 3 ALAMO Float - bottom fairing view (bottom fairing with anti-surge flaps, contained).

- Keep anti-surge flaps restrained until launch with rubber band provided
- Avoid scratching anodized coating on any surface to avoid potentially mission-compromising long-term pitting corrosion.

- Note the arrow on the fairing housing that points to the location of the reset magnet sticker 18 inches above.

ALTO Float - Figures 4-5

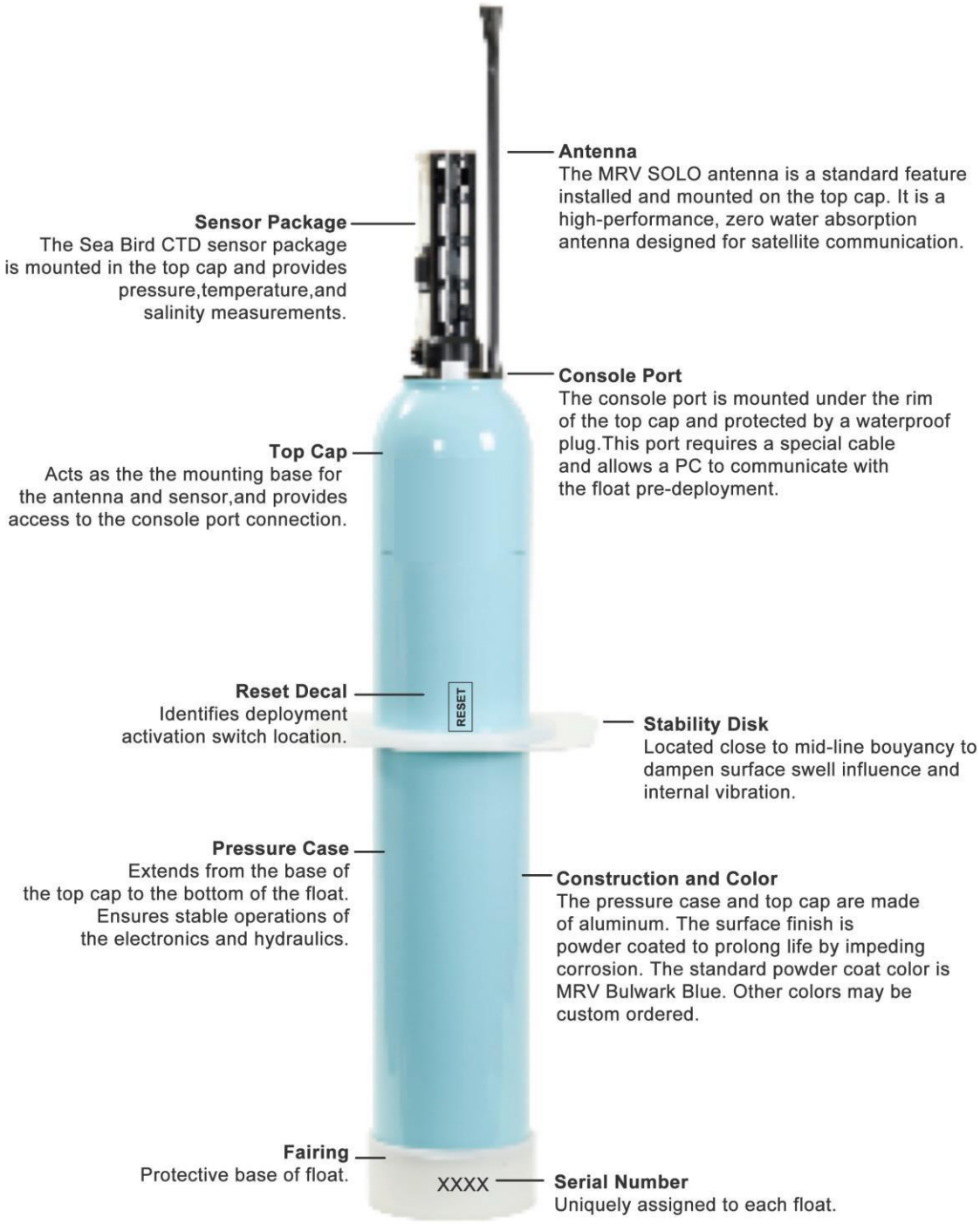

Figure 4 ALTO Float

Figure 5. ALTO Float Comm port, cap removed

A communications port is located under a removable waterproof Boss plug on the top cap. This connection sets up the interface to run MRV diagnostics and requires an MRV supplied custom communications cable.

The ALTO includes a stability disk is attached to the outside of the pressure case at the midline center of buoyancy. The dampening disc attenuates the influence of surface swell and helps keep the antenna clear of the water.

Activation, Receipt Inspection, Deployment Readiness

Activation

Floats are shipped in a low-power state and **MUST BE ACTIVATED PRIOR TO DEPLOYMENT. Failure to perform a BIT will result in LOSS OF FLOAT.**

A float may be activated using a far-field activation magnet provided or a shorting plug to awaken the float from a low-power sleep mode. The magnet method involves swiping the magnet supplied with the float(s) across the "RESET" label (see Figure 2) beneath which, on the main CPU board inside the float, lies a magnetic switch. The shorting plug method involves removing and reinstalling the shorting plug on the float's top cap. Either method reboots the float's CPU, resets to zero a clock that counts down to a pre-programed value, MTS, Mission initial trigger start timeout, and initiates the BIT. If the float's clock reaches MTS, or if the float experiences a hydrostatic pressure limit set by the parameter MTD, Mission initial trigger depth, the float will begin its operational sequence. If the float is reset again, the clock re-zeros. Alternatively, coordinating with the pilot, the float may be returned to its low-power mode after which

another BIT will be required prior to launch.

Receipt Inspection

Electronically transmitted documentation includes a packing list against which a receipt inspection should be performed when the shipment arrives. The float is shipped ready to be air or sea deployed as called for in the purchase request - ***after a BIT is performed***. Before shipping, the float is fully tested at the factory, the internal vacuum is set, and the operational software and mission profile are programmed. Should the need arise for restoring vacuum to a float or loading an updated operational software binary file, please contact MRV Systems for assistance.

To prepare a float for any deployment method, it first must be removed from its shipping packaging.

If the float/shipping container arrive with no visible damage, **conduct a Built In Test (BIT) on the float**. A passing BIT completes delivery of the float, and it is activated for deployment or may be stored. If you see visible damage to the container or the BIT fails, contact MRV Systems for assistance. After completing the BIT, unless anticipated launch will be before MTS seconds are reached, coordinate with the pilot to return the float to a low-power state.

Equipment Needed

Figure 6 - USB-phone jack cable

- MRV-supplied custom console cable with phone jack and USB connector (Figure 6)
- MRV-supplied far field activation magnet
- MRV-supplied 5/8” box wrench (ALTO) or 3/16 Allen wrench (ALAMO)
- Computer running a terminal program software (such as TeraTerm (Windows), Serial (MacOSX), and Minicom)

PC or Laptop with Linux or Windows XP®, Windows 7® or later operating system with a USB port

Communication terminal settings:

Port (example) /dev/tty.usbserial-FTYXFW4V; 9600 baud; 8 data bits; 1 stop bit; no parity, and no flow control.

Deployment Readiness

The Air Launch (launch tube, cargo side door, and cargo aft door) and Sea Launch sections below address activation in the sequence of launches of different types.

1. Pilot communication connection established - or assumed to be in place.
2. Float, removed from its shipping container, its deployment container, and parachute (if equipped) bear no evidence of physical damage externally, and there is no known history of damage.
3. Float's last BIT date and time is known as is the need for a re-BIT based on the parameter value MTS on the float.

The pilot may send mission revisions via an Iridium email as desired that the float will retrieve when it next communicates.

Our floats include a Communications port for directly communicating with the float via laptop to download mission files, execute a BIT, evaluate parameter settings, execute various debug functions, and directly command mission initiation. Use of the Communications port is addressed in the Piloting Manual along with cautions for doing so.

Air Launch Operations

Tube-launched ALAMO

Figures 7a and 7b show an ALAMO configured for aircraft tube launching.

1. Prior to loading the float on the plane, but not more than the time delay programmed with the parameter MTS (Mission initial trigger start timeout), conduct a BIT as follows:

a) Remove float from its beige plastic protective shell (if equipped).

b) With the float in a location to "see the sky" that will allow an Iridium connection, "Launch" end (parachute and antenna end) up, power up the float and start the BIT by swiping a magnet across the "RESET" label visible on the float's pressure casing (Figure 1 above).

c) Allow 30 minutes to complete a BIT, and confirm with the pilot the BIT was successful.

d) Replace the float in its beige plastic tube (if equipped), "Launch" end up as before, retie the spectra line to hold the float in the beige plastic tube.

2. Load the float on the aircraft and store it for takeoff.

3. When ready to launch the float, remove the float from its beige plastic protective shell (if equipped).

4. Load float in launch tube with "Launch" end (with long cardboard protective sleeve containing parachute) first. (Figure 7b)

a) Hold onto the base of the float and do not allow suction to pull the float fully into the launch tube **<u>until the next step is completed</u>**.

b) Disconnect the Velcro strip to release the obstructive device (Figure 8a). Cut the ribbon to remove the Velcro strip and discard.

c) Lower the float fully into the launch tube.

5. Launch the float from its tube to deploy it.

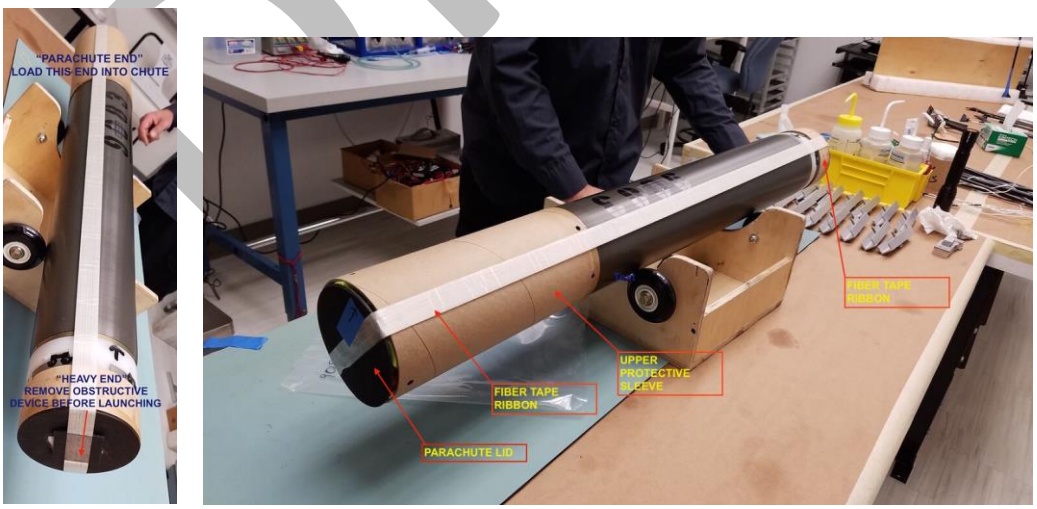

Figure 7a (left) and 7b (right). ALAMO with parachute ready for aircraft tube-launch.

Aft- and Side-door-launched ALAMO

1. Perform steps 1-3 above for a Tube-launched ALAMO.

2. When ready to launch, carefully disconnect the Velcro strip to release the obstructive device (Figure 8a) **while holding the fiber tape ribbon snuggly to the base of the float** to retain the pilot chute within the cardboard protective sleeve.

3. Toss the float from the aircraft aft- or side-door (Figure 8b) to deploy.

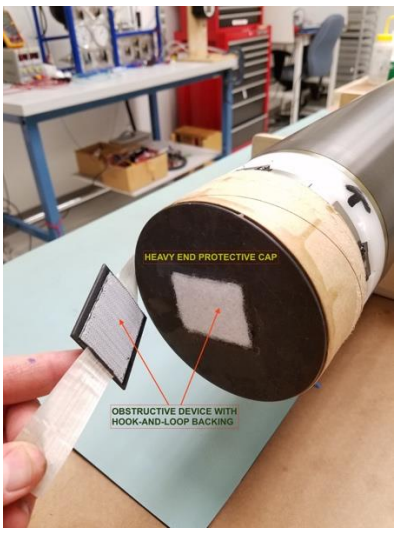

Figure 8a (left) and 8b (right)

Note that the "Obstructive device" referenced in Figure 6a above, used to retain the parachute protective lid capping the cardboard protective sleeve at the top of the float, is a patch of Velcro. Figure 8b (right) ALAMO, in the process of being aft-door launched from an aircraft. This configuration works the same way for a side-door launch. In Figure 8b, the Velcro has been detached and the fiber tape ribbon is flying free of the float's base to allow the pilot chute to spring free of the protective cardboard protective sleeve.

Aft-door-launched ALTO

1. Prior to loading the float on the plane, but not more than the time delay programmed with the parameter MTS (Mission initial trigger start timeout), conduct a BIT as follows:

    a) Expose the "RESET" site on the float's pressure casing through the designated cardboard flaps located on the top side of the shipping/deployment box (Figure 9b)

    b) With the float, right side up, in a location to "see the sky" that will allow an Iridium connection, power up the float and start the BIT by swiping a magnet across the "RESET" label visible on the float's pressure casing.

    c) Allow 30 minutes to complete a BIT, and confirm with the pilot the BIT was successful.

2. Load the float in its shipping/deployment box on the aircraft and store it for takeoff.

3. When ready to launch the float, connect float's parachute "D" ring to the static line in the aircraft near the aircraft aft door.

4. Standing clear of the static line, (aft door) roll the float down the aft ramp, parachute-end first, and out of the aircraft. **WE DO NOT HAVE A PICTURE SHOWING STATIC LINE TO PILOT CHUTE "D" RING …**

5. Retrieve the static line and pilot chute cap.

Figure 9a and 9b. ALTO with parachute ready for aircraft aft cargo-door launch. **THIS IS NOT CORRECT. THIS IS A PALLET OF SIX ALTOS READY FOR SHIPMENT. IT SHOWS THE LOCATION OF THE CARDBOARD FLAPS THAT AFFORD ACCESS TO THE RESET LABEL…** Note location of the access window for the RESET label (Figure 9b).

Figure 9c ALTO in protective bag with harness in shipping crate showing parachute end.

Sea Launch Operations

Sea-launched ALAMO

1. Prior to launching the float, but not more than the time delay programmed with the parameter MTS (Mission initial trigger start timeout), conduct a BIT as follows:

a) With the float in a location to "see the sky" that will allow an Iridium connection, power up the float and start the BIT by swiping a magnet across the "RESET" label visible on the float's pressure casing (Figure 1).

c) Allow 30 minutes to complete a BIT, and confirm with the pilot the BIT was successful.

2. When ready to launch the float, remove the float from its protective container exposing the launch box with soluble strap link at base (Figure 10).

3. Drop it over the side, base first, to deploy it.

Figure 10. ALAMO ready for sea launch showing soluble strap link at base.

Sea-launched ALTO

1. Prior to launching the float, but not more than the time delay programmed with the parameter MTS (Mission initial trigger start timeout) conduct a BIT as follows:

a) Expose the "RESET" site on the float's pressure casing through the designated cardboard flaps located on the top side of the shipping/deployment box (Figure 8)

b) With the float, right side up, in a location to "see the sky" that will allow an Iridium connection, power up the float and start the BIT by swiping a magnet across the "RESET" label visible on the float's pressure casing.

c) Allow 30 minutes to complete a BIT, and confirm with the pilot the BIT was successful.

2. Lower the float within its box by its harness over the side and into the water (Figure 11).

3. Release the harness.

4. Within a few minutes after having been lowered into the water in its box, the float will sink from the cardboard box and begin a diagnostic profile.

Figure 11. ALTO float with over-the-side launch harness in hand.