



WAM-V® 16 USV for 2022 Maritime RobotX Challenge



ASSEMBLY - OPERATION - SERVICE

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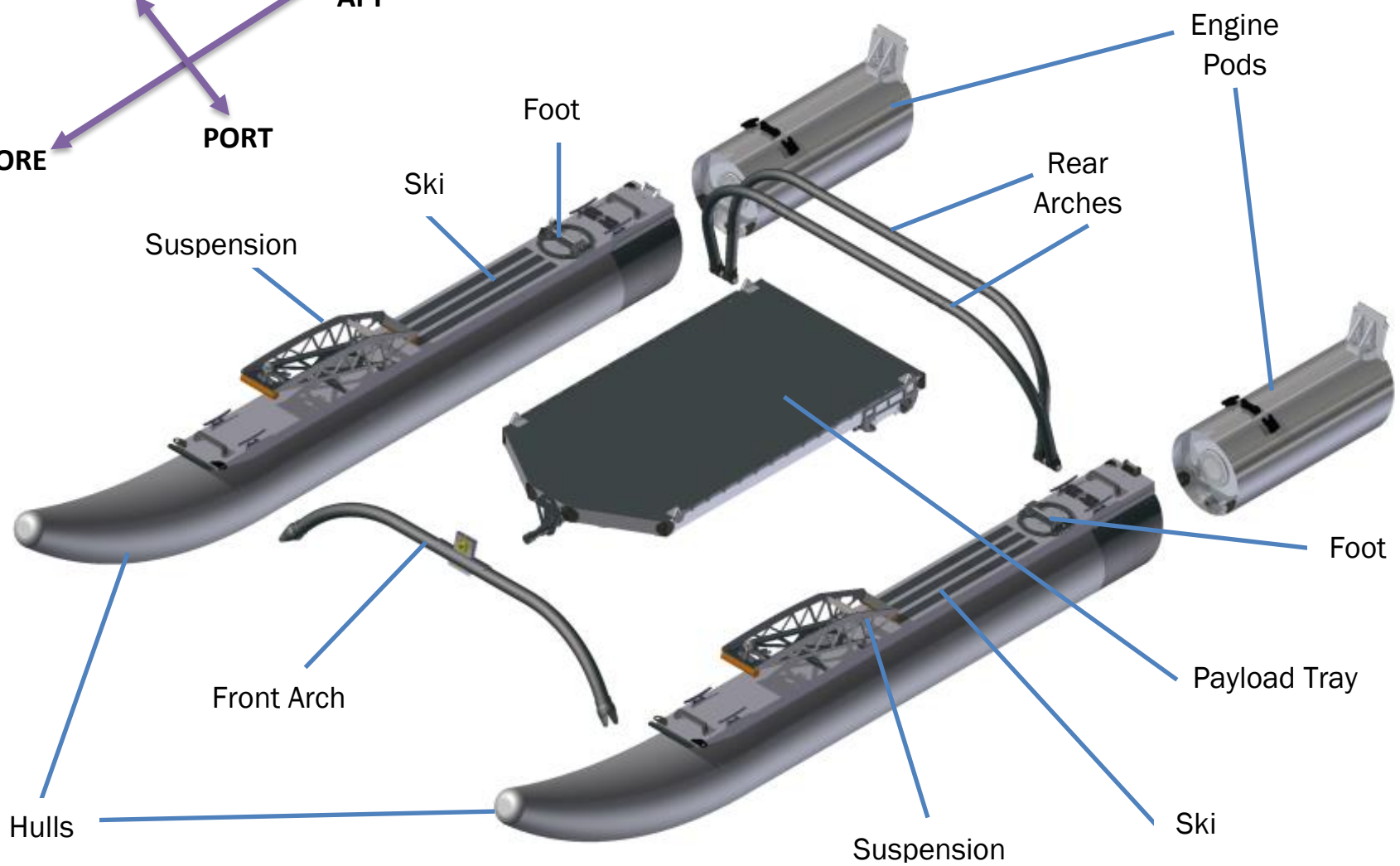
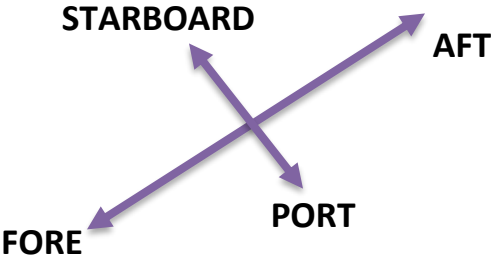
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SAFETY PRECAUTIONS

READ CAREFULLY PRIOR TO ANY OPERATION

- The WAM-V is an uncrewed surface vehicle (USV). It is not designed to carry people, and it is not safe for a person to ride on it. It is the sole responsibility of the proprietor of the WAM-V to follow all maritime rules and regulations where the vehicle is operating.
- The WAM-V provided for RobotX is not equipped with navigational lighting. It is the responsibility of the proprietor of the vessel to install navigational lighting if required by the maritime rules and regulations where the vessel is operating.
- **DO NOT** exceed the maximum design payload capacity.
- It is **CRITICAL** that **ALL** quick release locking pins are inspected before **ANY** operation to ensure that the spring-loaded retaining ball is functioning properly. Replace locking pin immediately if there is any sign of damage or if the internal spring mechanism is not functioning properly. Failure to do so may result in irreparable damage to the USV.
- Always hoist the WAM-V by securely attaching to all four payload tray lift points using hardware and slings that are appropriately rated for the load being lifted. See “4.2: LAUNCHING FROM THE SIDE DAVIT/HOIST” section of this manual for the location of the hoist points on the payload tray. **NEVER** walk beneath the USV while hoisted. **Improper use of hoisting hardware, slings, or lift points may result in INJURY OR DEATH.**
- For optimal performance, hull angle should be between zero and 3 degrees bow up. Distribute payload accordingly.
- Always use taglines to keep control of the WAM-V while it is being hoisted.
- If towing the USV, make sure to attach a tow bridle to the tow points. Never tow from the cleats or handles, as they are not designed for this application. Only use a tow bridle with the proper load rating. See the “TOWING” section for more information.

1.2. VISUAL GLOSSARY



1.3. ADDITIONAL PARTS INCLUDED

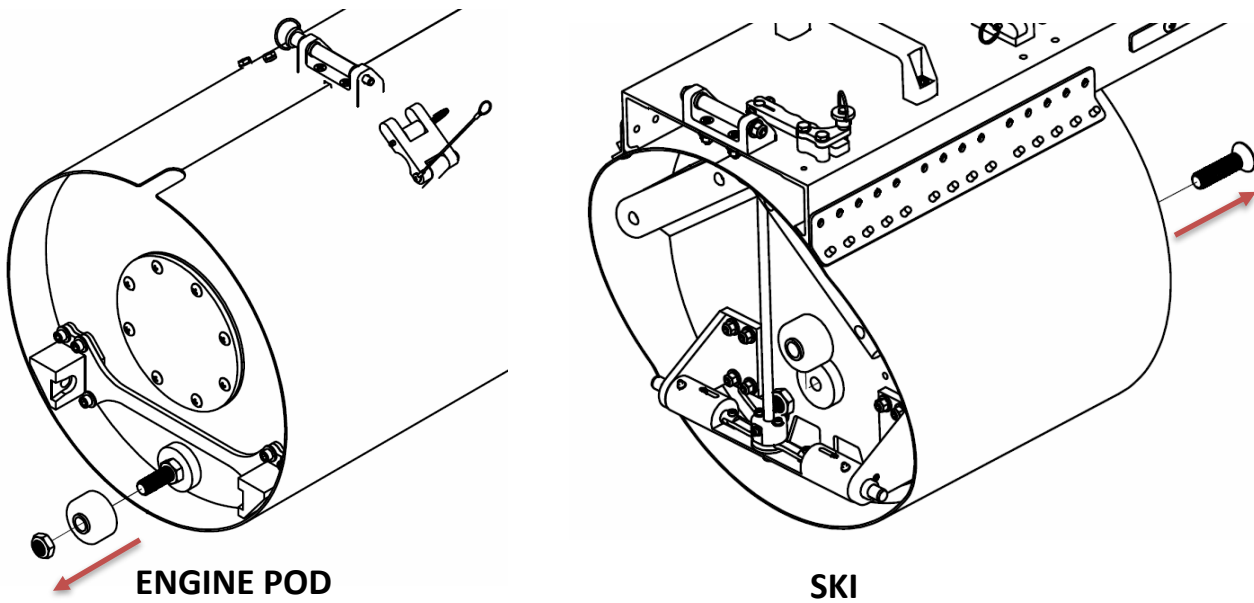
The following accessory is included with the WAM-V 16 USV:

NAME	QTY
Inflator Pump	1

2. MECHANICAL SYSTEMS EXPLAINED

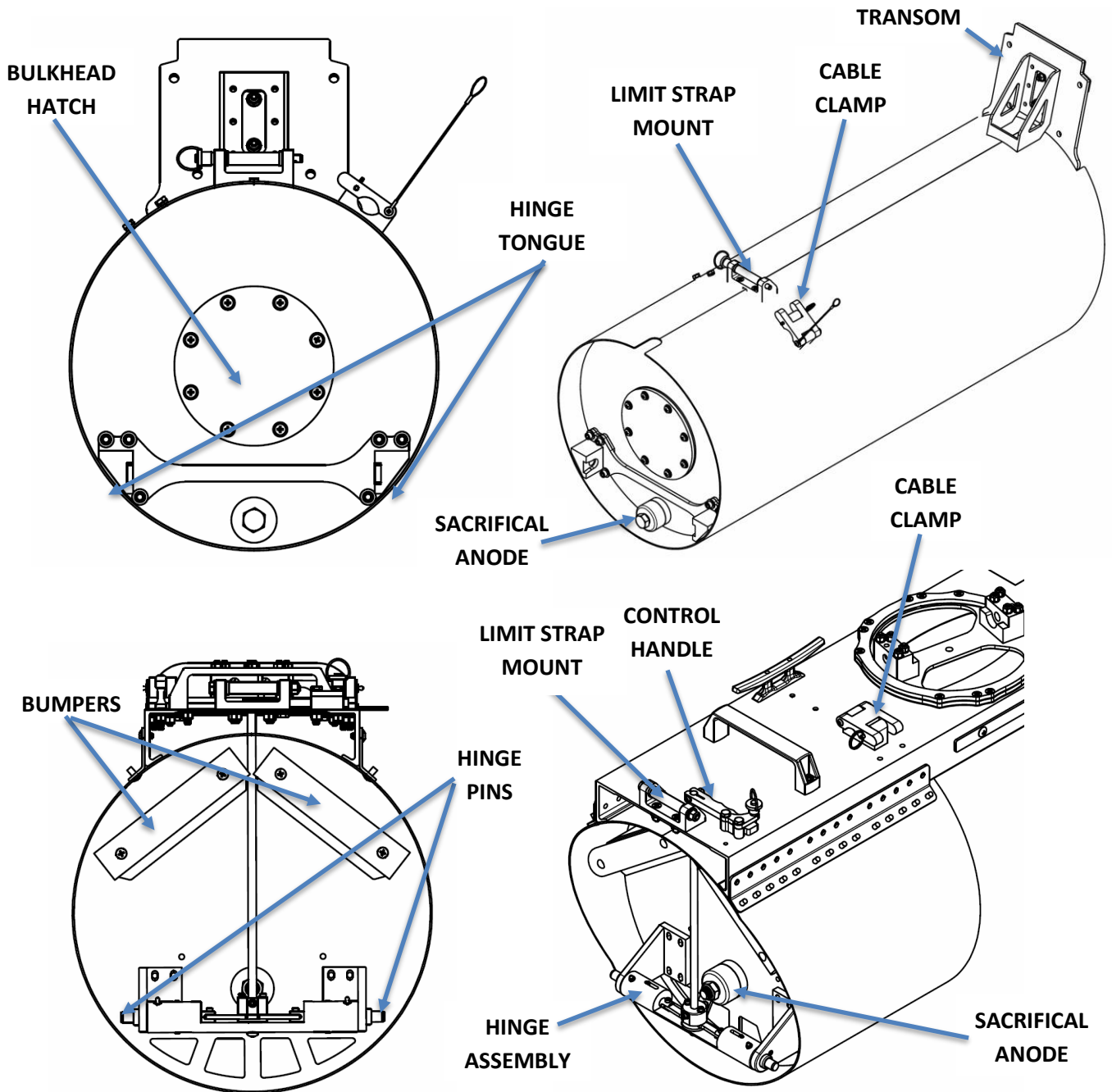
2.1. SACRIFICIAL ANODE

The motor pods and skis are both equipped with sacrificial anodes to protect against marine corrosion on critical parts. Visual inspection and proper maintenance of the anodes are essential. Be sure to check the anodes regularly and remove any accumulated marine growth. Replace the anode when it corrodes to a diameter below 1-in. **Refer to Section 5.1: Replacing Anodes.**



2.2. ENGINE POD HINGE SYSTEM

The WAM-V is equipped with a unique hinge system at the rear bulkhead of each ski. Each hinge assembly is comprised of a handle which controls the extension of a pair of two locking hinge pins. These locking pins extend into a pair of hinge tongues which are bolted securely to the motor pods. The hinged motor pods are designed to maximize propulsion in adverse sea conditions by allowing the motor pods to follow the shape of the waves behind the hulls.

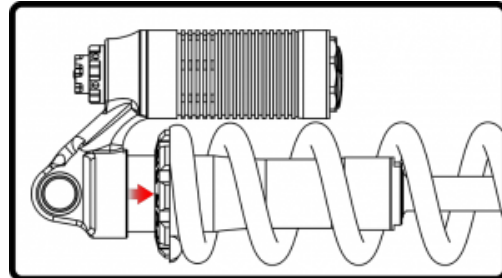


2.3. SUSPENSION SYSTEM

2.4.1 Spring Rate

The WAM-V is equipped with DVO Jade shocks specially made by DVO for Marine Advanced Robotics, Inc. As delivered, the WAM-V is pre-equipped with 350-lb coil over springs. Ideally, the suspension rocker should “sag” between the two orange bumpers **such that the payload tray deck is horizontal for a given payload.**

This sag is set by adjusting the suspension preload. Preload affects the energy in the spring. Increasing the preload will increase the ride height and reduce sag. To increase the preload on your spring (and therefore ‘raise’ the front of the payload tray), turn the Spring Adjustment Nut clockwise. The Spring Adjustment Nut (red arrow, right) can be adjusted using the MAR Suspension Adjustment Tool (below). Reducing the preload will decrease the ride height and increase sag. To reduce the preload on the spring, turn the Spring Adjustment Nut counterclockwise (no less than one turn).



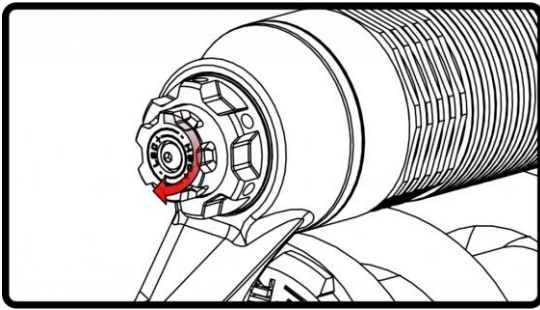
IMPORTANT: If you cannot achieve proper sag, you will need to change to a different spring, e.g., 300 lbs. or 400 lbs.



2.4.2 Damping Rate

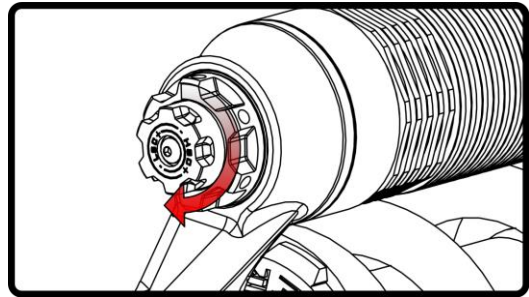
The DVO Jade dampers on the vehicle are delivered with the DVO factory settings. DVO coil shocks allow simple external adjustability of compression and rebound settings. High-Speed Compression (**HSC**) is critical to absorbing energy from high impact forces. High-Speed Rebound (**HSR**) enables a vehicle to recover quickly from deep in the suspension travel. Low-Speed Compression (**LSC**) controls small bump sensitivity and affects how the vehicle will react to weight changes. Low-Speed Rebound (**LSR**) ensures maximum traction everywhere from tall wave climbs, high-frequency wind waves, to off-camber wave cornering.

NOTE: It is important to note that each of these terms refer to the **shaft speed of the shock**, not the speed of the vehicle.



Low Speed Compression can be adjusted using the smaller, inner black knob located at the top of the shock assembly (left). Turning the knob counterclockwise will increase LSC and make it firmer. Turning it counterclockwise will make it softer.

High Speed Compression can be similarly adjusted using the green outer adjustment knob (right). Clockwise turns result in firmer damping force under fast suspension movements, and counterclockwise will soften HSC.



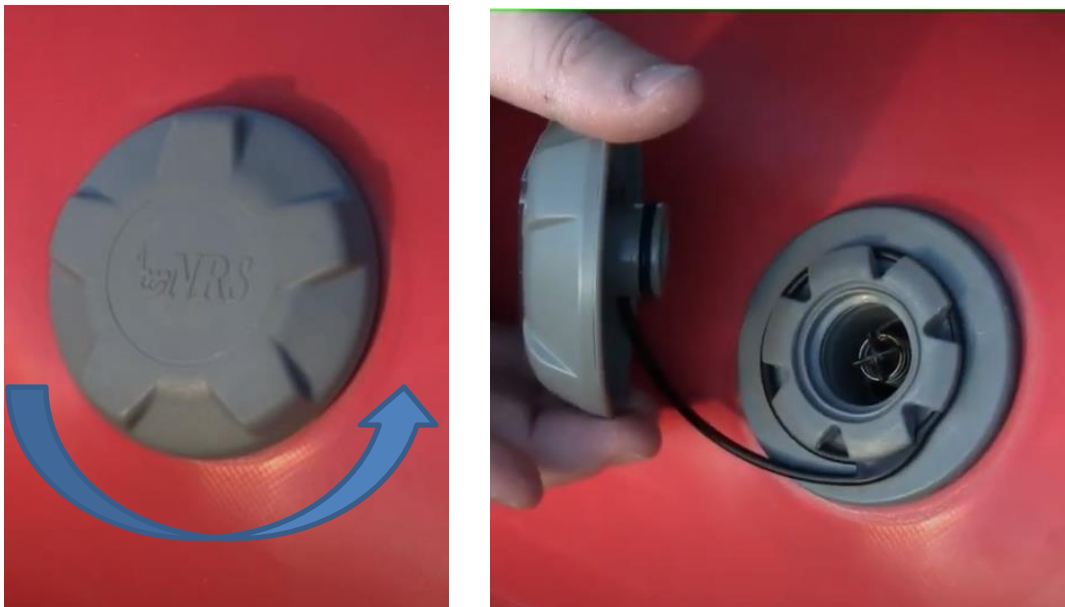
3. MECHANICAL ASSEMBLY PROCEDURES

3.1. HULL INFLATION

The inflatable hulls of the WAM-V are constructed of polyurethane fabric and are mounted to the custom rigid aluminum extrusion ski. The hulls must be fully inflated (2 – 2.5 psi or 138-172 mbar) before any vehicle assembly may proceed. Each hull contains a central baffle separating two independent inflation chambers.

The WAM-V is shipped with a Hand Pump and Adapter for the C7 Valve installed on the WAM-V hull. For more information on the hulls, including maintenance and care procedures, see Section 5.2 of this manual.

1. To inflate, remove the valve cover by rotating the cover counterclockwise and pulling it away from the valve.



NOTE: The hulls are shipped with the inflation valves in the locked-open position. The inflation valves must be unlocked before inflation. To unlock the valves, depress and rotate the central button clockwise until central release-button extends out fully.

2. Insert the inflation pump valve and rotate clockwise to lock and seal the pump to the inflation valve.



3. Inflate each hull chamber to a pressure of 2-2.5 psi or 138-172 mbar.

NOTE: Hull pressure will vary with changes in air/water temperature and exposure to direct sunlight. Each hull chamber is equipped with a PRV (pressure release valve) to protect the hulls from over inflation.

4. Replace valve covers by inserting cover and rotating clockwise until locked. These valve covers must be locked in place to ensure the inflatable hulls have an air-tight seal, and to prevent debris from entering and interfering with the valve.

3.2. HULL DEFLATION

To deflate, depress the central release-button and rotate counter-clockwise until release valve is locked in the open position. After deflation, rotate central release-button clockwise to lock the valve closed.



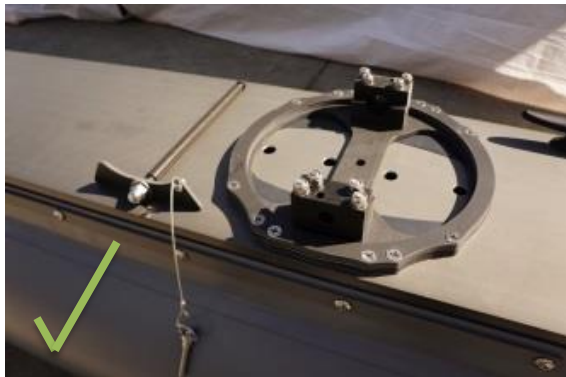
3.3. VEHICLE MECHANICAL ASSEMBLY PROCEDURE

The vehicle assembly process requires at least two people and is easiest with three people. Clear an assembly space of approximately 10-ft x 20-ft and lay out both skis roughly 96-in apart and parallel.

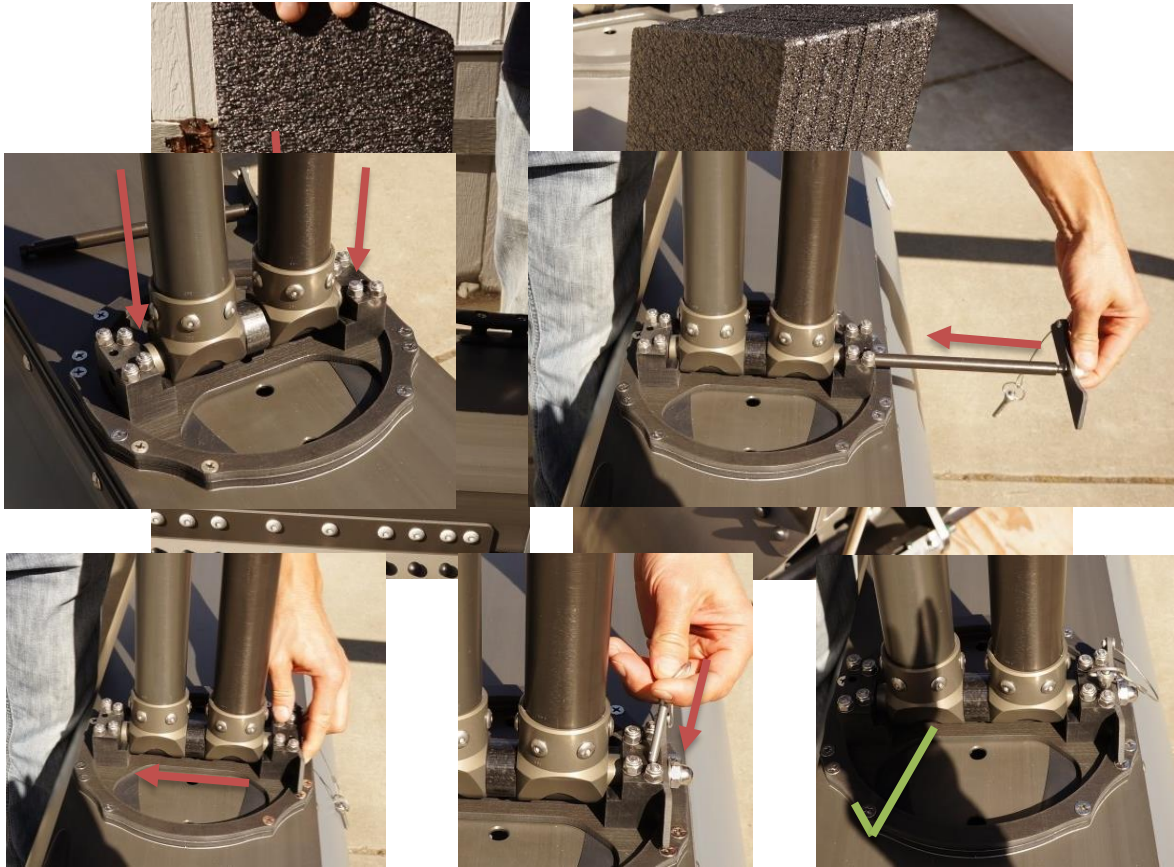
NOTE: Using carts or dollies underneath the skis will make the assembly process much easier.



1. Remove the foot pin by retracting the quick release locking pin and pulling the pin free from the black plastic saddle. Stow the foot pin safely aside, it will be needed shortly. Repeat with other ski.



2. Set both rear arch foam wedges over the aft-most ski handle.



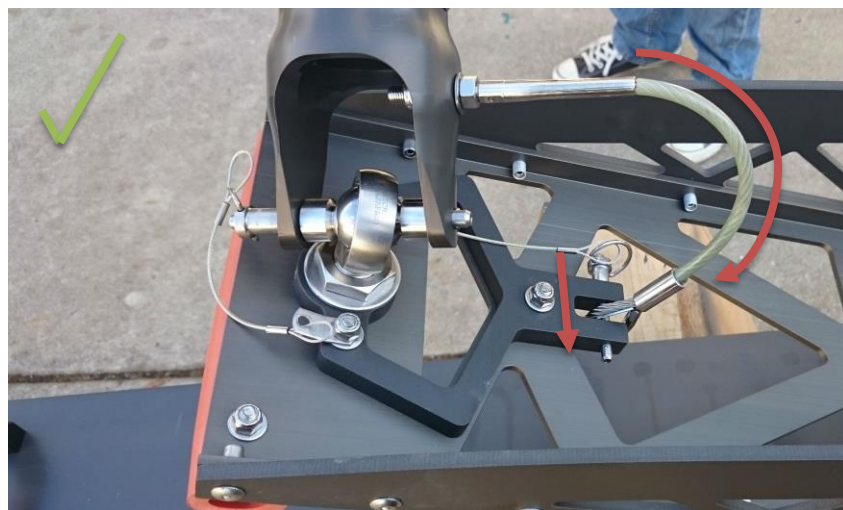
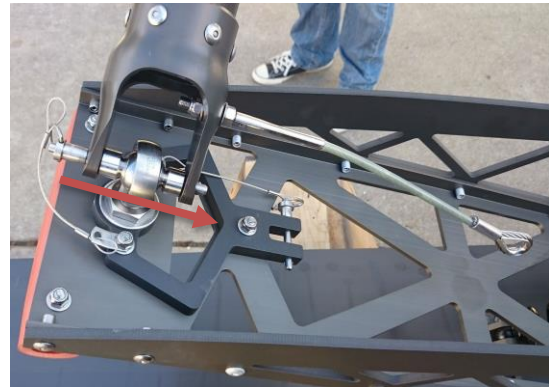
3. Carefully insert the base of the rear arch into the black plastic saddle on the foot until the pin guide is fully seated. Insert the foot pin through the outboard side of plastic saddle on the foot. Lock the foot pin in place by inserting the locking pin vertically into the handle side of the foot saddle as seen below.

NOTE: *The alignment of the rear arch and black plastic saddle is critical for easy installation of the foot pin. If the foot pin does not go in easily at first, rotate the entire ski assembly slightly along its longitudinal axis (lengthwise) until the foot pin is easy to push through.*

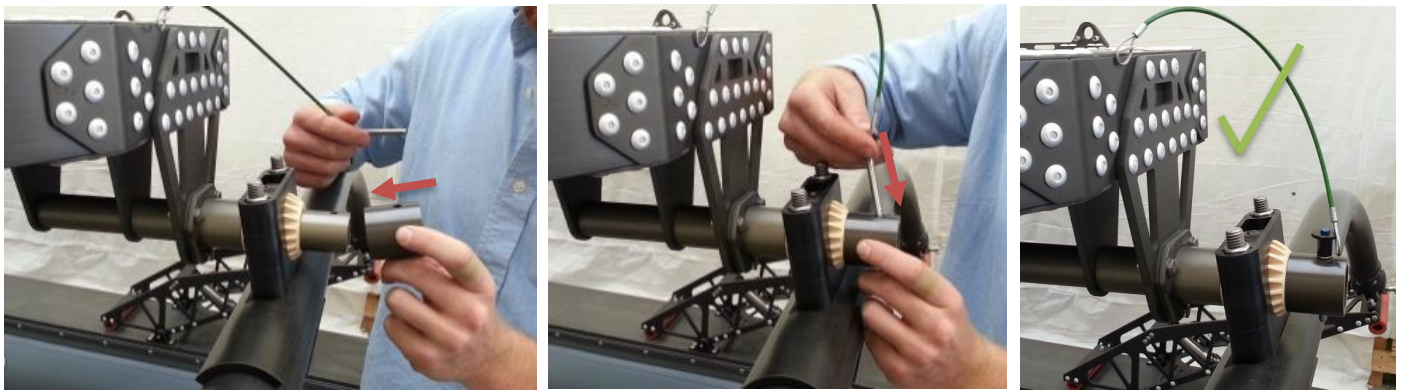
4. Lay the rear arches back until they are resting on the rear arch foam wedges installed previously. **IMPORTANT:** Resting the rear arches forward or resting them backward without the foam wedges will result in damage to the rear arch and foot assemblies. Do not rest the arches forward.



5. While holding the front arch in between the forward portion of the skis, slide the front arch clevis over the forward ball joint of the suspension assembly and insert the locking pin. Secure the front arch-suspension safety tether loop as seen below.



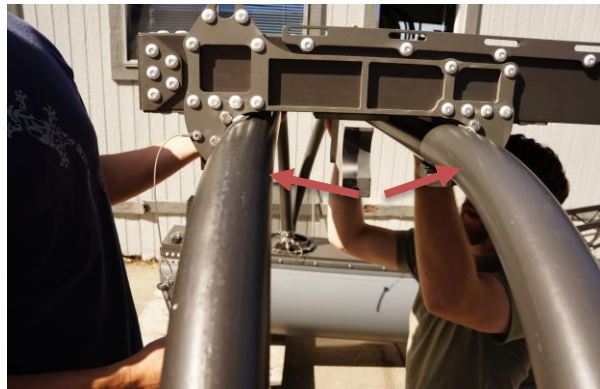
6. Repeat previous step for the opposite ski, laying the front arch forward after both quick release locking pins and front arch-suspension safety tethers are locked in place.
7. Lift the payload tray from between the front and rear arches and between the two skis. Insert the payload tray ball joint shaft into the pillow block ball joint mounted on the center of the front arch. Place the ball joint shaft retaining cap on the front of the shaft and secure it with the quick release retaining pin attached to the payload tray by inserting the retaining pin vertically through both the shaft and retaining cap.



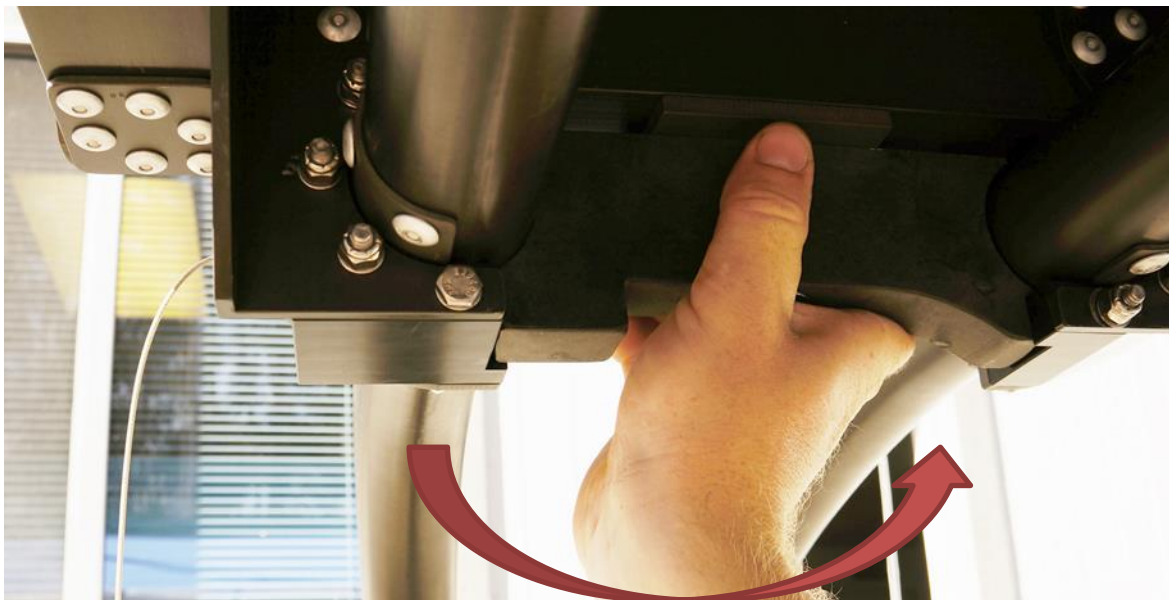
8. Move the attached front arch-payload tray safety tether eye between the forks of the front arch safety tether clevis. Insert the attached quick release locking pin through the clevis and tether eye to secure.



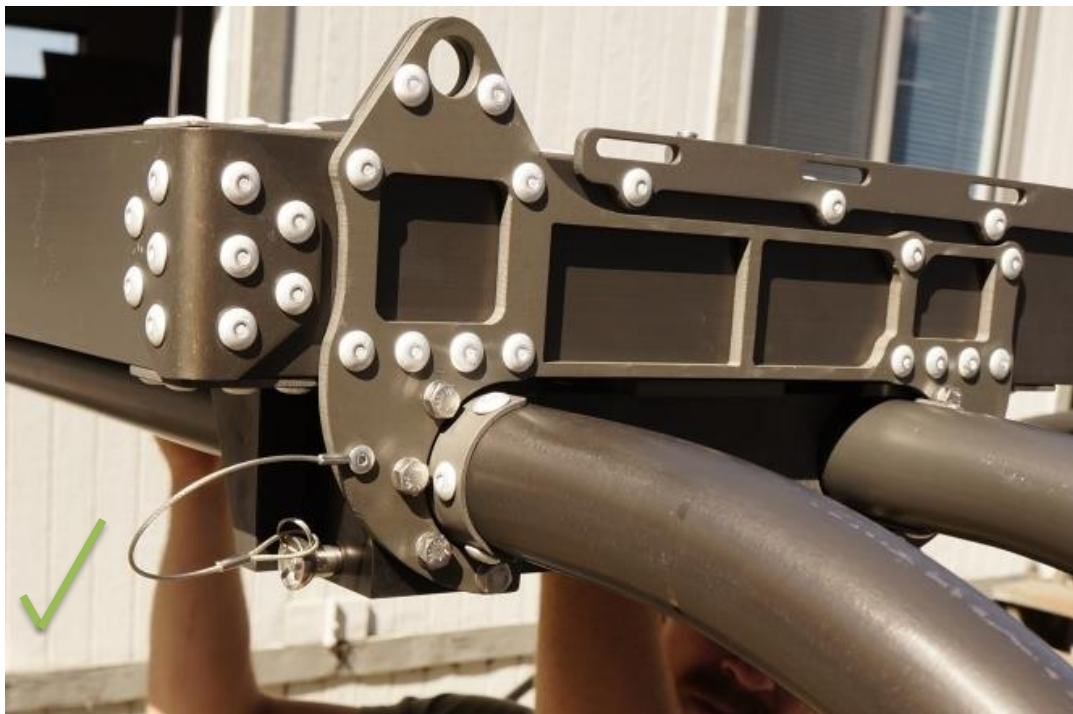
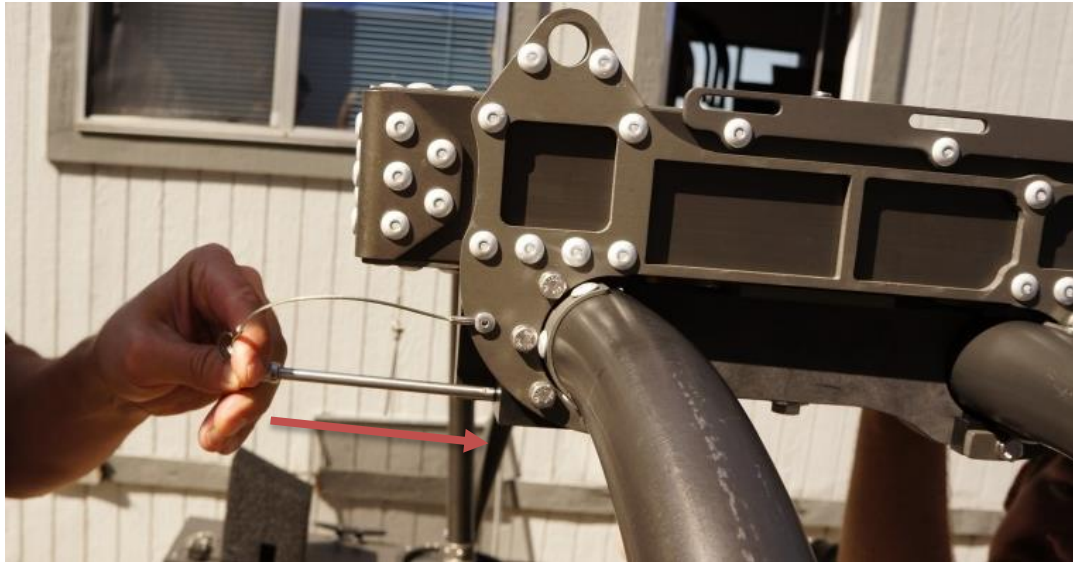
9. Lift the aft end of the payload tray until it is roughly horizontal. While holding up the payload tray, move each of the rear arches into place. Slowly lower the payload tray down onto the rear arches. **NOTE:** Make sure the rear arch clamps are in the open position before mounting.



10. Rotate the clamp so that it makes firm contact with the inside walls of each rear arch tube. If the clamp does not close easily, try adjusting the skis so that they are flush and parallel with respect to each other.



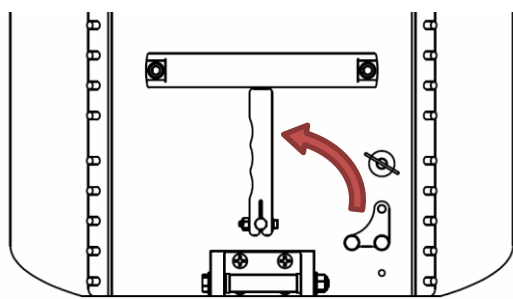
11. Once the rear arches are properly aligned inside the rear arch clamp, fully insert the quick release locking pin. Make sure the locking pin is fully engaged by giving it a firm tug.



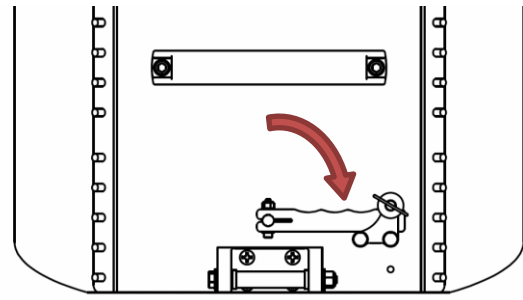
12. Remove and stow each of the rear arch foam wedges before operation. Be sure to store the foam wedges for future assembly/disassembly.

3.4. ENGINE POD INSTALLATION PROCEDURE

1. Make sure the hinge handle is in the fully *OPEN* position before trying to install the engine pod.

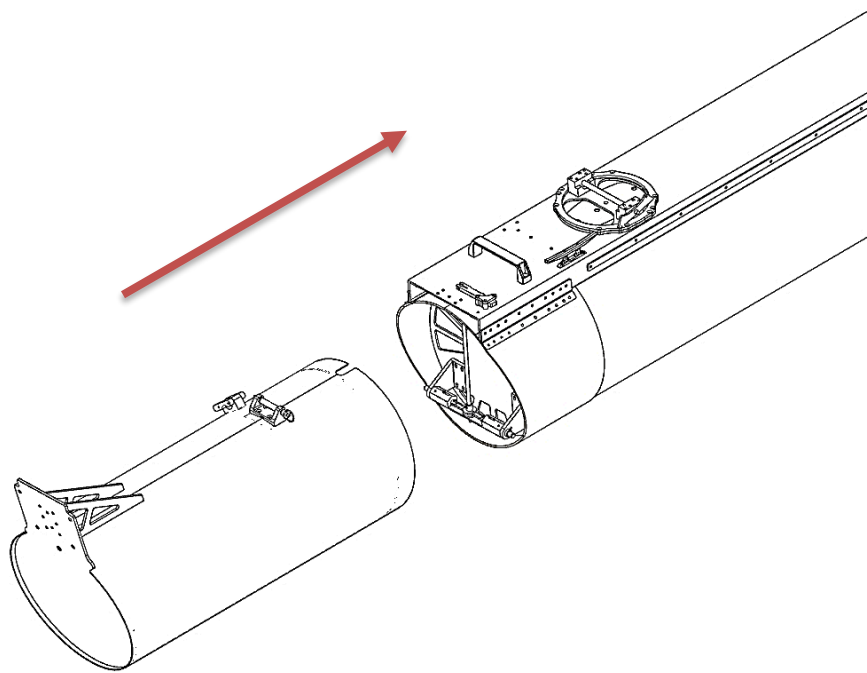


OPEN Hinge Position



CLOSED Hinge Position

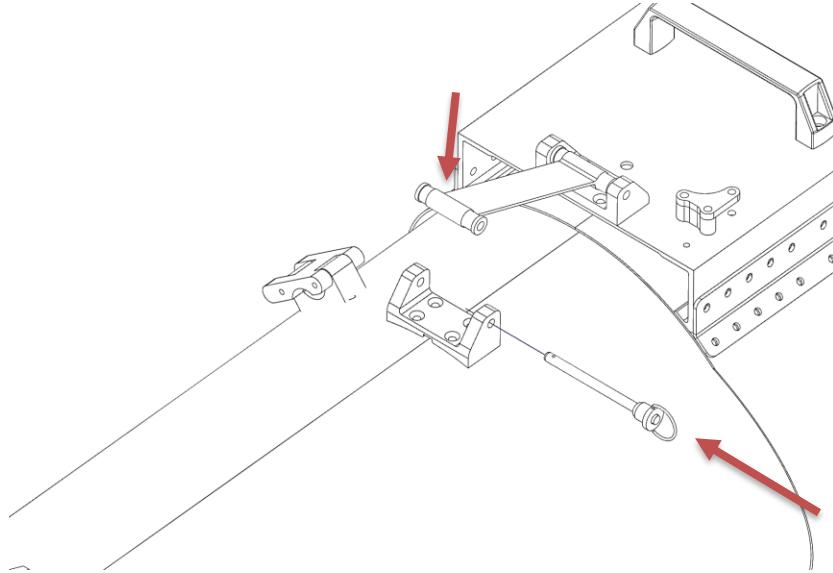
2. Pick up the engine pod and align it with the hinge at the aft ski bulkhead. Gently slide the engine pod forward, joining the hinge and tongue plate on the forward bulkhead of the engine pod.



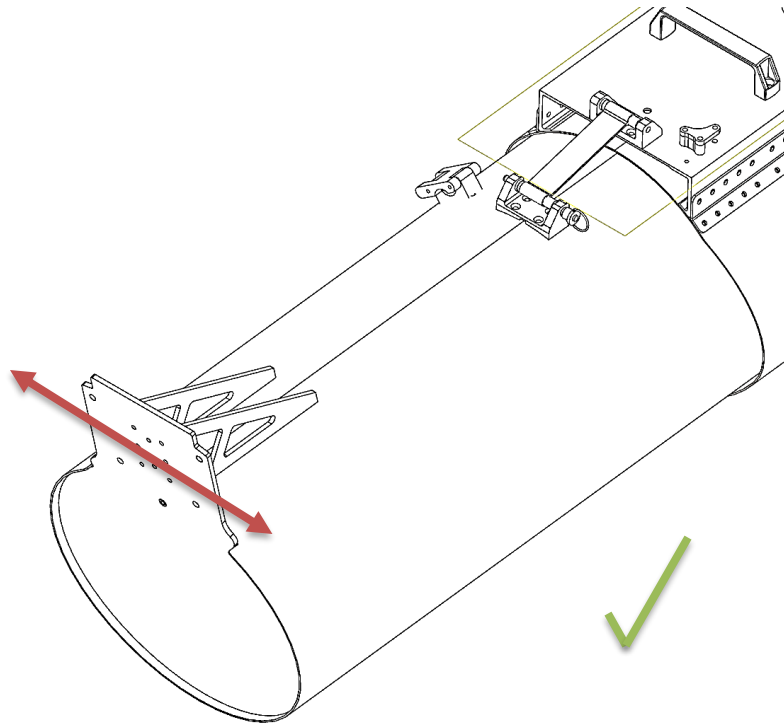
3. Rotate the hinge handle clockwise to the *CLOSED* position and insert the locking pin. Firmly pull the engine pod back to make sure the hinge is fully engaged and locked in place. Firmly pull on the quick release locking pin to make sure it is fully engaged and locked in place.

CRITICAL: If the hinge pins are not fully engaged within the engine pod tongue or quick release locking pin not in place, the engine pod could break free during operation resulting in substantial damage.

4. Remove the pin from the engine pod limit strap mount and insert the black plastic limit strap pin guide at the end of the nylon limit strap into the mount. Now reinsert the pin and gently tug on the pin to make sure it is fully engaged and locked in place.



5. Grip the transom of the engine pod and gently shake it laterally back and forth. This is to make sure the hinge and engine pod tongue are engaged and locked in place. If the engine pod does not come loose, then the WAM-V is now fully assembled.



4. MECHANICAL OPERATING PROCEDURES

4.1. PRE-LAUNCH CHECKLIST

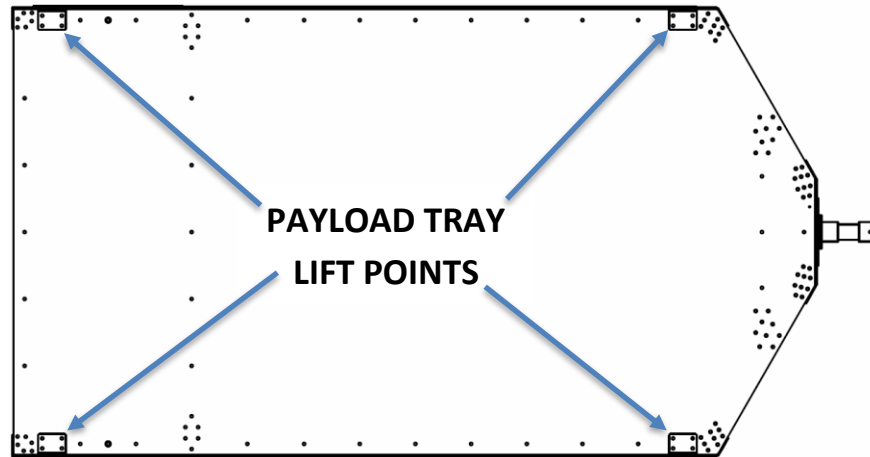
Create a written log and checklist for every launch of the WAM-V 16. It is recommended that you customize a checklist for your use-case that includes not only WAM-V operational items, but also those items specific to your payload and mission. Location, project, date, and time are basic items for this document. Every item on this list is a WAM-V specific item that should be checked and recorded for each use.

- ✓ Make note of any recent modification to the WAM-V 16 and its mounted systems.
- ✓ Check and note the hull pressure of both inflatable pontoons (2.0-2.5 psi or 138-172 mbar).
- ✓ Make sure all fasteners are in good health and tightened appropriately.
- ✓ Inspect all system components for notable wear, damage, corrosion, etc. Including:
 - Hulls, port and starboard.
 - Skis and can, port and starboard.
 - Hinges, port and starboard
 - Foot (“lazy Susan”), port and starboard.
 - Suspension, port and starboard.
 - Front arch.
 - Rear arch.
 - Payload Tray.
 - Pods, port and starboard.
 - All 12-push button Quick Release Pins (QRPs)
 - All 3 safety lanyards
- ✓ If trailering the WAM-V 16, all systems are in an appropriate condition. Including:
 - WAM-V and Motor Pods secured to trailer
 - Ball and Hitch secured and solid
 - Trailer safety chains
 - Brake lights
 - Turn signals
 - Docking lines and fenders are packed
- ✓ Before launch of WAM-V 16:
 - Alert local USCG Command Center to report vehicle activity
 - Pods are securely attached
 - Vehicle is free of all restraints
 - Docking lines and fenders

- ✓ Both motor pods are securely fastened to their respective hinges and the hinge handle locking pins are in place.
- ✓ Shock absorber is in good health.
- ✓ All quick release pins are fully engaged, undamaged, and well-lubricated.
- ✓ Hinge system is well-greased and in the CLOSED position with the locking pin installed.

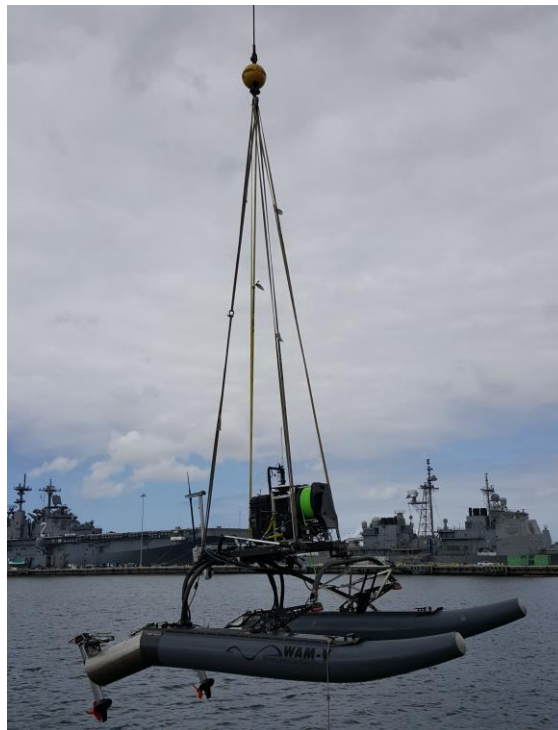
4.2. LAUNCHING FROM SIDE DAVIT/HOIST

The WAM-V is equipped with four hoist point connections on the corners of the payload tray. The WAM-V must **NEVER** be hoisted from any other points on the vehicle.



NOTE: While hoisting, be sure to securely fasten all payloads and ALWAYS use tag lines to control the vehicle while hoisted in the air.

A properly hoisted WAM-V should look like the following picture.



4.3. LAUNCHING FROM TRAILER

1. Be sure that all payloads are securely fastened to the payload tray.
2. Attach a length of rope to each ski cleat on the dock side of the USV.
3. Reverse the tow vehicle down the boat launch ramp with someone following alongside the USV holding the cleat ropes.
4. Once the USV floats freely, pull the USV off the trailer using the cleat ropes.
5. Secure the USV to the dock using the cleat ropes.

4.4. RECOVERY TO TRAILER

1. Use the tow vehicle to back the trailer down the launch ramp to an appropriate depth to embark the WAM-V 16.
2. Bring the WAM-V 16 under manual control and align it with the submerged trailer.
3. Slowly drive the WAM-V forward on to the trailer until the hulls are supported by the trailer.
4. With the WAM-V sufficiently centered over the supporting surfaces of the trailer, the trailer and WAM-V can slowly be pulled out of the water. Watch to confirm that each WAM-V hull settles on the trailer. If the WAM-V does not settle properly into position or poorly centered, back the trailer up again and adjust position.
5. Once the WAM-V and trailer have been pulled out of the water, make sure that nothing gets near the propellers and follow any necessary shutdown procedures.
6. After the WAM-V has been properly shutdown, secure WAM-V to trailer for transit.

4.5. TOWING

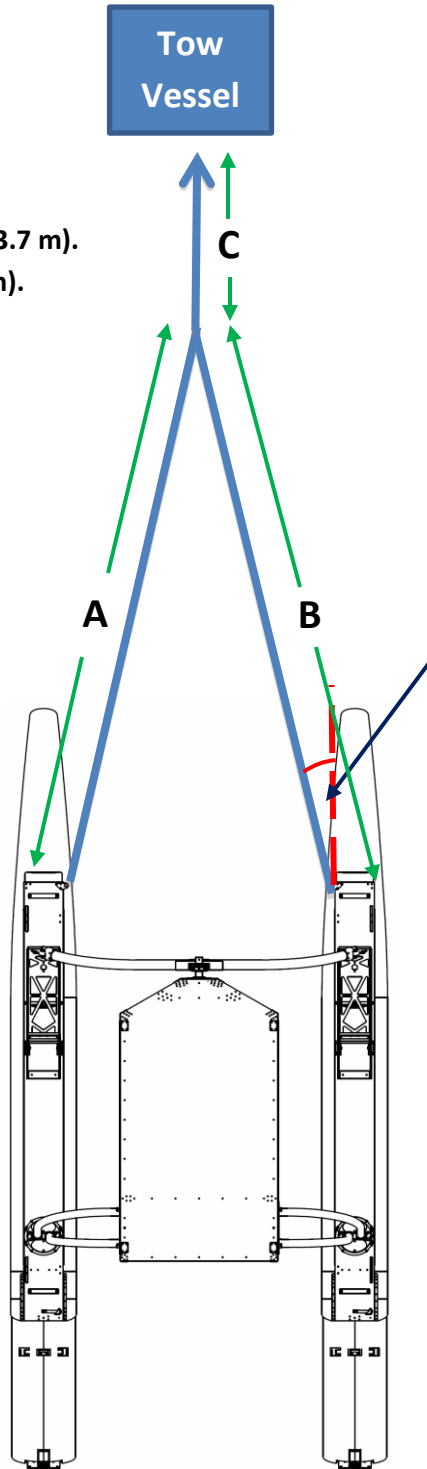
The WAM-V is equipped with tow point connections on the fore-inboard side of each ski. A tow bridle must be connected to BOTH tow point connections prior to towing. The USV should never be towed above 15 knots.

NOTE: Never attach the towing bridle to any other than the tow points (e.g., ski cleats, ski handles, etc.).

Tow Bridle Lengths:

A = B = minimum of 12 ft (3.7 m).

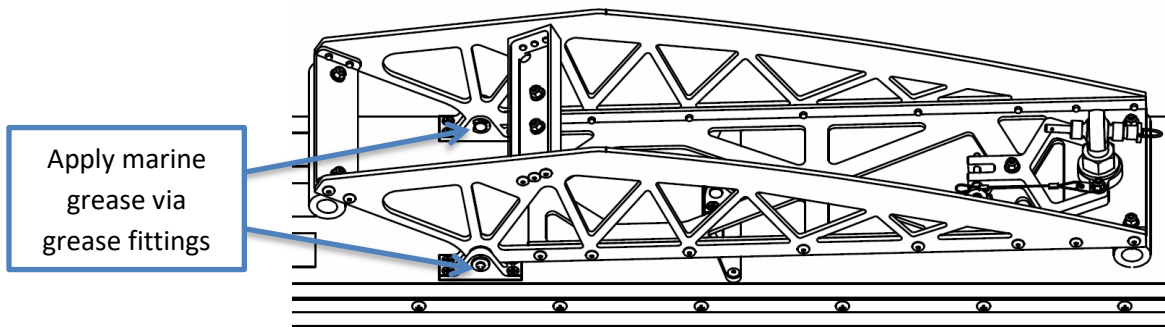
C = minimum of 40 ft (12 m).



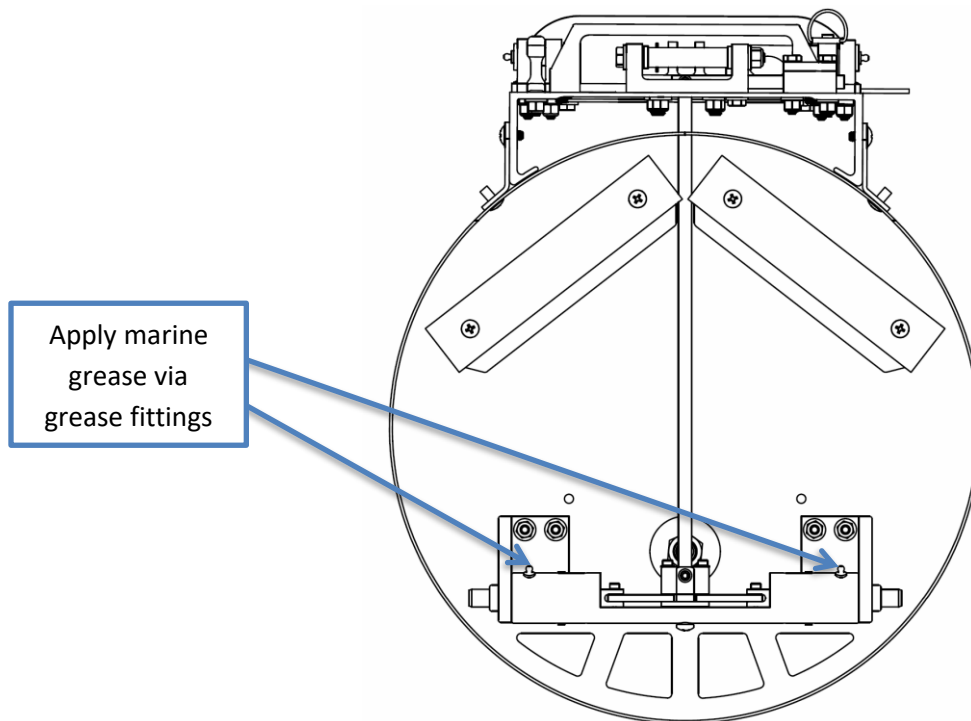
This angle of the tow bridle must be 30 degrees or less to minimize loading. Failure to do so could result in unnecessary loading and lead to failure.

4.6. POST-RECOVERY SERVICE AND INSPECTION

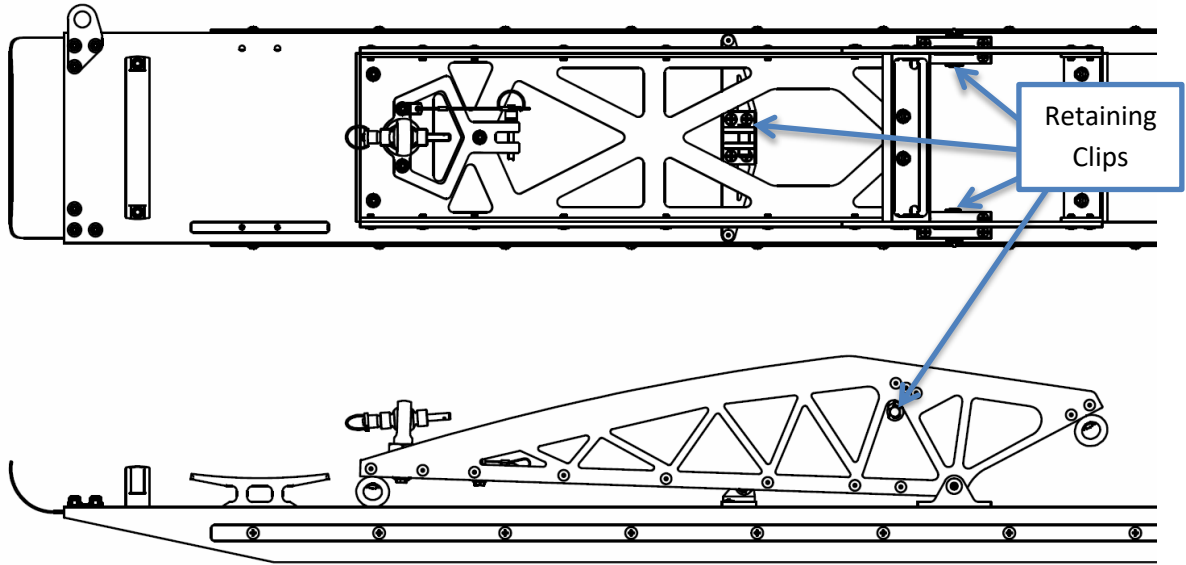
1. It is **CRITICAL** to thoroughly rinse the ENTIRE vehicle with fresh water after EVERY use. If the WAM-V has been used in a saltwater environment, it is recommended to use a salt deposit removing solution such as Salt-Away, or similar, prior to freshwater rinse.
2. Handwash the shocks with Dawn-brand dish soap and water, then lightly rinse with fresh water. Never directly spray the shocks with high pressure water, as this may cause irreparable internal damage.
3. Ensure the suspension rocker pin joints are liberally greased via the grease fittings on the outside of each pin.



4. Ensure the hinge assembly is liberally greased via the grease fittings near the hinge pins.

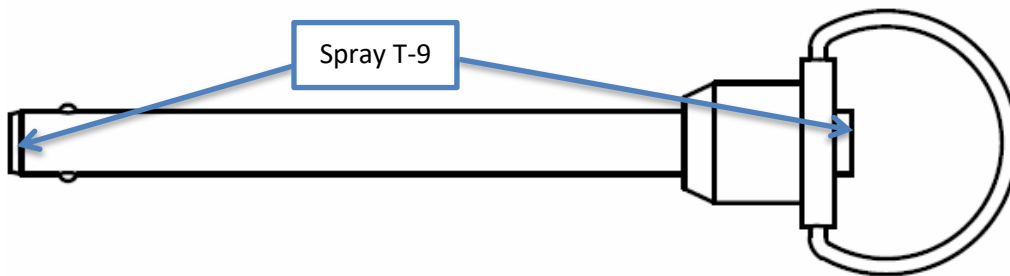


5. Inspect the suspension rocker retaining clips for damage. If damaged or missing, replace immediately. (Shock removed from figure for clarity)

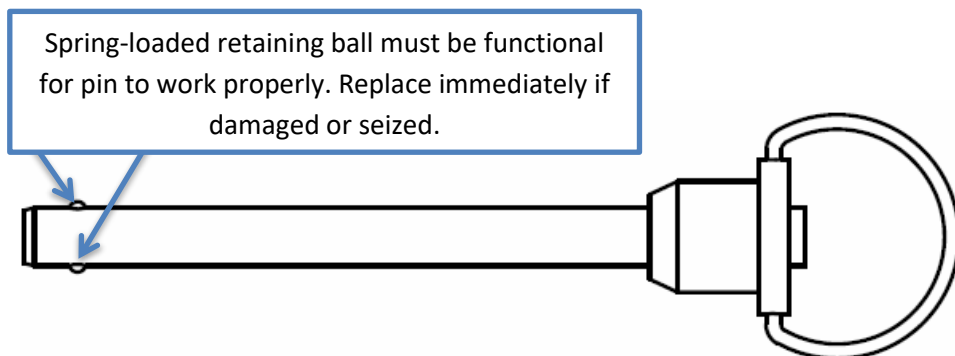


6. Using the Boeshield T-9 included with the WAM-V, generously lubricate the quick release pins throughout the entire USV. This will extend the service life of the pins.

NOTE: The use of substitute lubricants (e.g., WD-40) is discouraged.

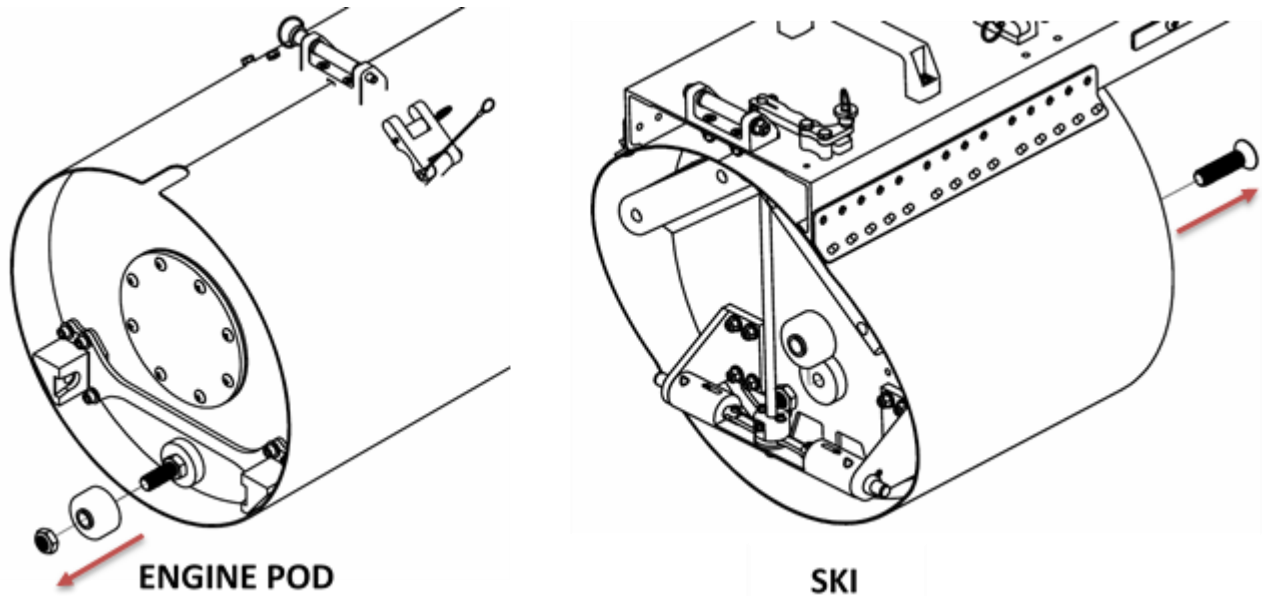


7. Inspect all quick release pins for proper function of the spring retention mechanism. Test by trying to remove each pin without depressing the release button. If the pin comes free, replace immediately.



5. MECHANICAL SERVICE AND MAINTENANCE

5.1. REPLACING ANODES



ENGINE POD: The anode on the engine pod is replaced by simply removing the 5/8-11 nylon-insert locknut that affixes the anode to the bulkhead. After which, the depleted sacrificial anode may be replaced with a new sacrificial anode. Reverse the previous steps to install the new anode. It is CRITICAL not to loosen the nut behind the anode. This nut keeps the stainless-steel stud from loosening and breaking the engine pod's waterproof seal.

SKI: Completely deflate the inflatable hulls. Move the deflated hull out of the way. Using a 3/8-inch hex key, completely remove the stainless-steel bolt from the bulkhead. The depleted sacrificial anode on the opposite side of the bulkhead should now be free for removal. Apply fresh marine grease to the stainless-steel bolt to aid in the bolt's reinstallation. Using the 3/8-inch hex key, reinsert and tighten the bolt into the hole from which it came. With the new sacrificial anode and bolt in place, the 5/8-11 nylon-insert locknut should be tightened onto the bolt while firmly holding the 3/8-inch hex key on the reverse side to keep the bolt from loosening.

NOTE: The nylon-insert inside the locknut grips the bolt threads to resist loosening. The nylon-insert locknuts should be reused no more than twice, after which its holding power is significantly reduced.

5.2. INFLATABLE HULL CARE, MAINTENANCE & REPAIR

The inflatable hulls are manufactured by Maravia Rafts exclusively for the WAM-V. These hulls are constructed using Thermofused™ Seam Construction and Urethane Seamless Encapsulation, processes developed by Maravia to seal the hull with urethane inside and out, resulting in a tough, durable, puncture-resistant fabric.

For Inflation and Deflation Procedure, refer to Section 3.1: Mechanical Assembly Procedures.

Each vehicle is shipped with a hand pump with pressure gauge, and an adapter to fit the C7 inflator valves installed on the WAM-V hull. Electric pumps may also be used for inflation. Although the hulls are fitted with pressure release valves, these should not be relied on to achieve the proper inflation; use the supplied gauge or similar to ensure proper inflation pressures.

Due to the regular expansion and contraction of air volume with temperature changes, slight deflation of the hulls may occur over time, and may be more significant during large temperature changes. Hull pressure will vary with changes in air/water temperature and exposure to direct sunlight. Each hull chamber is equipped with a PRV (pressure release valve) to protect the hulls from over inflation. When the WAM-V is in a higher temperature area, such as a summer day on a trailer over hot pavement, the air in the hulls expands and may be released slowly through the PRV. When the WAM-V then cools off, the air contracts and the pressure inside the hull drops, resulting in normal deflation over time or with regular heating and cooling cycles. For the best performance and optimal operation of the WAM-V, it is recommended to inflate the hulls at the beginning of each day of operation.

Large temperature changes may result in noticeable deflation after as few as three days after the last inflation. If significant deflation or loss of hull pressure occurs in a shorter amount of time, check the hulls for noticeable leaks or damage that may have occurred during shipping or operation. Small punctures can be discovered by fully inflating the hulls and lightly spraying the hull with a mixture of water and a few drops of mild dish soap, and observing for resulting bubbles at the suspected leak. If significant deflation occurs and no damage is present, contact Marine Advanced Robotics.

Thoroughly clean the hulls with Dawn-brand dish soap and a soft bristle brush once every 90 days. The hull manufacturer discourages the use of other off-the-shelf cleaners or detergents. Maravia also strongly cautions against using metal brushes or wire fiber scrub pads. Keep the pressure relief and inflation valves clean and free of debris.

Covering the WAM-V with a tarp, including the hulls, will significantly improve the service life of the USV and inflatable hulls. Custom-fitted WAM-V UV-protective covers can be ordered from Marine Advanced Robotics.

In the unlikely event of a puncture, a hull repair kit is available from Marine Advanced Robotics. Contact us for information on Hull Repair Kits.

For more information about the hulls, visit: <https://www.maravia.com/post/owner-s-manual>

6. REPLACEMENT PARTS

The following is a list of common replacement parts for the WAM-V. All the listed parts are available through McMaster-Carr. McMaster-Carr is available everywhere inside the United States. Customers outside the United States should contact Marine Advanced Robotics, Inc. for replacement hardware.

WEBSITE: www.mcmaster.com

PHONE: (562) 692-5911

NAME	LOCATION	McMaster-Carr
Quick Release Pin - 0.188" diameter; 2.00" long	Cable Clamps	98404A020
Quick Release Pin - 0.250" diameter; 1.25" long	Foot - Rear Arch	92384A035
Quick Release Pin - 0.250" diameter; 1.50" long	Suspension - Front Arch Safety Tether	92384A036
Quick Release Pin - 0.250" diameter; 1.75" long	Payload Tray - Front Arch Safety Tether	92384A037
Quick Release Pin - 0.250" diameter; 1.75" long	Payload Tray - Front Arch	94748A227
Quick Release Pin - 0.250" diameter; 4.00" long	Payload Tray - Rear Arch	92384A045
Quick Release Pin - 0.3125" diameter; 3.00" long	Suspension - Front Arch	92384A061
Quick Release Pin - 0.3125" diameter; 3.50" long	Engine Pod Limit Strap	92384A063
E-Clip Retaining Ring (5 pack)	Suspension - Ski	94981A210
Sacrificial Anode	Engine Pod & Ski	3590K2

NOTE: The sacrificial anode is manufactured by Martyr Anodes (P/N# CMH2B2A).

For replacement parts not mentioned on this list, please contact Marine Advanced Robotics, Inc. at info@wam-v.com.