Maritime RobotX Challenge Primer

WAM-V Propulsion Examples

Introduction

Each team is responsible for choosing the electric propulsion system for their WAM-V. There are many options available, including many innovative propulsion designs. This document presents three examples of propulsion methods that have been applied to WAM-V and similar craft. They are described in the following sections: *Waterjets, Integrated Trolling Motors,* and *External Trolling Motors*. One additional section, *Other Alternatives,* covers other methods that can be used to design a propulsion system suitable for the WAM-V. Presentation and description of these three methods does not imply endorsement, as there are many other possible methods; these three are examples only.

Example 1: Waterjets

Florida Atlantic University (FAU) outfitted a slightly shorter (12 ft) WAM-V variant using *Graupner JET-Booster 5 Waterjets* inside of a pair of removable propulsion units that can be quickly removed and reattached. The propulsion unit is shown in Figure 1 (completed) and Figure 2 (under construction). Electric motors by Neu Motors drive the waterjets. The waterjet thrust reversing bucket and servo actuator can be seen within protective cage at stern.

Figure 1. Aft view of Waterjet Propulsion Unit

Propulsion Units

The propulsion units were designed to connect to the aft end of each inflatable demihull using an interface plate with a through pin. The units used an electric motor to drive the Graupner waterjets (see Table 1, page 4). The cross sectional shape is designed to provide some reserve buoyancy when the hulls are submerged.

Cross-sectional and isometric views are shown in Figure 3, Figure 4, and Figure 5.

Figure 2. Propulsion Unit under construction

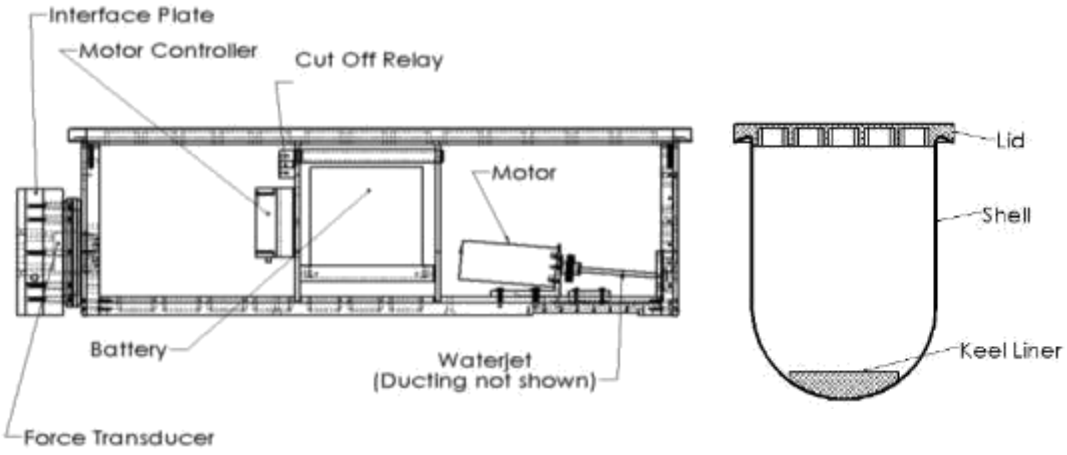

Figure 3. Side view and transverse section of the Propulsion Unit

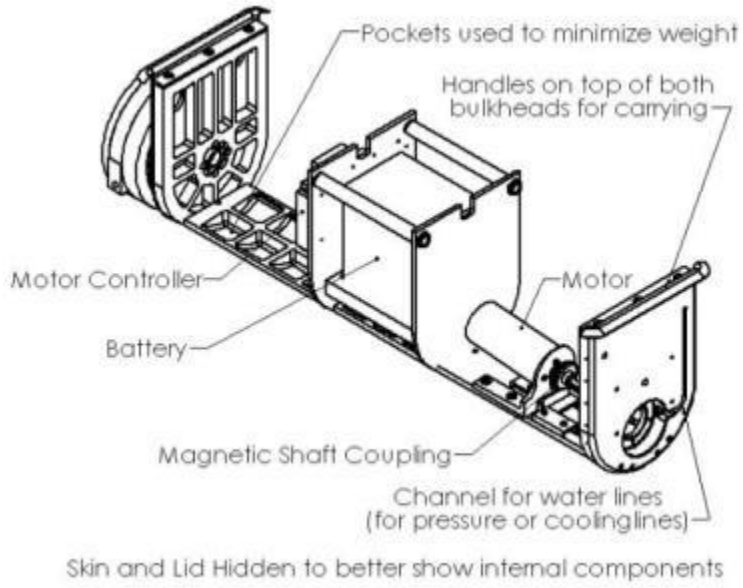

Figure 4. Isometric view of the Propulsion Unit

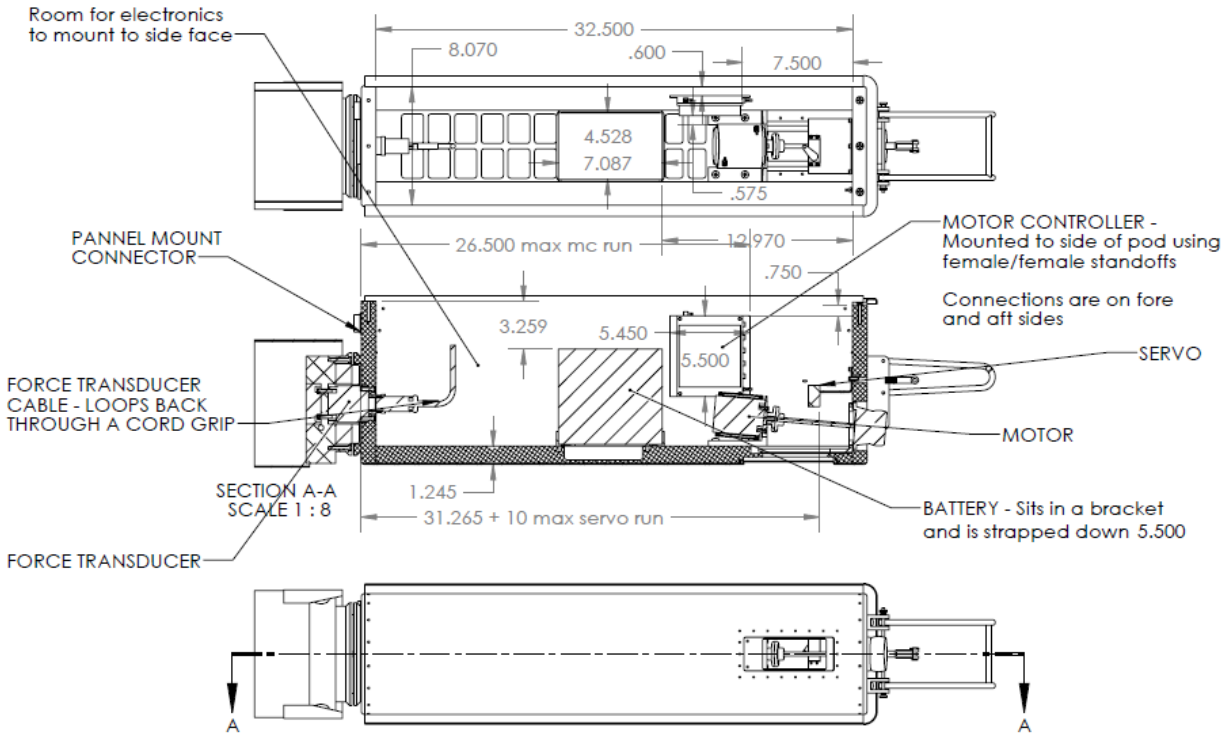

Figure 5. Top, Side and Bottom Views of the Waterjet Propulsion Unit

Batteries

Power is provided by two sets of eight removable LiPo battery packs, one set in each propulsion unit. Each set consists of four batteries arranged in parallel. As can be seen in Figure 6, access to drive motor and batteries is through top with flexible hatch, which can be opened without removing the propulsion units from the vessel. A single, custom made battery pack per propulsion unit will replace these sets in the next design iteration.

Figure 6. Battery Compartment

Motor Controllers

The motor speed is controlled by a remote control ESC, "electronic speed controller." It is unclear what the reliability of the particular ESC selected for the USV14's propulsion units might be, but experience with similar RC control ESCs in the past suggests that it would typically need to be replaced after 4-6 weeks of continuous use.

Components List

The components used in the FAU-variant propulsion units are listed in Table 1 below.

Table 1: Itemized component list for FAU-variant electric propulsion units for USV12.

Item	Qty	Reference
Graupner JET-Booster 5 Waterjets	2	Graupner USA
Shaft coupling - Magnetic Shaft coupling	2	
Push Rod Seal mounts	2	Redline Motors
Push Rod Seals	2	Aeromarine #6018
Propulsion Unit Housing Material	2	
Motors Neu Motor - 2224/24/1.5y with Hall sensors	2	www.neumotors.com
Waterjacket for cooling Motor - Neu Motor	2	www.offshoreelectrics.com
Motor Controller - Roboteq MBL1650C	2	www.roboteq.com
Batteries/Chargers - 36V 30Ah LiMnCo (Custom, Not Yet Implemented	1	www.bateryspace.com
Solid State Relays	2	
Fasteners and connectors	1	

Example 2: Integrated Trolling Motors

In this example, electric trolling motors are modified and integrated into the hulls of the **DUCKW-Ling Amphibious Vehicle.**

Propulsion System

When water-borne, the vehicle is propelled using a pair of 2-bladed, 12-volt Minn Kota electric trolling motors. Each propulsion unit is capable of producing up to 133 Newtons of thrust. The motors are mounted to the hull using a through hole that requires very little modification of the original trolling motor. A benefit of this arrangement is that the trolling motors are widely available commercial parts. The motors typically last about 9-12 months under continuous and fairly rough use before needing to be replaced, but they are otherwise maintenance free. Each unit costs about $USD100, is readily available at most

Figure 7. Close-up of Hull-mounted Trolling Motors

Figure 8. Aft View of DUCKW-Ling Amphibious Vehicle

fishing/boating stores, and takes about 20-30 minutes to replace.

Example 3: External Trolling Motors

In this example, trolling motors are fitted externally to modified propulsion pods on a 14' WAM-V USVe Variant.

Propulsion Units

In this example, Torqeedo 1003 outboard electric motors were mounted onto modified propulsion pods.

This approach required more extensive modifications for implementation on 14' WAM-V USV. The faring and shaft had to be modified, and the mounting mechanism for the motor required modification. Also, the team had to develop a steering mechanism to control the vehicle.

The surface vessel was able to achieve a maximum speed of 10 knots, sacrificing some endurance. Maximum endurance at full power could be increased with additional batteries, and a three-blade propeller was available as an option for higher speed operations.

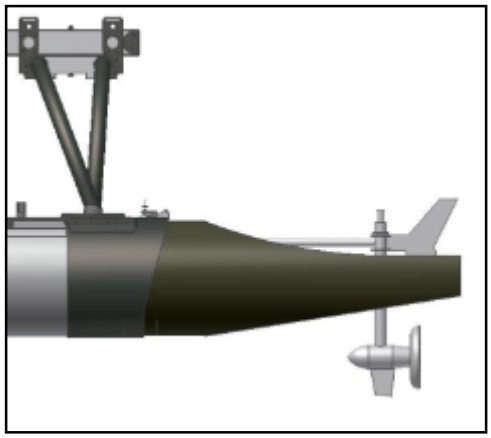

Figure 9. Concept Drawing of Torqeedo on WAM-V

Figure 10. Example of Torqueedo mounted on WAM-V

Battery	520 Wh Li-ion
Comparable petrol outboard (propulsive power)	3 hp
Static thrust	68 lbs
Motor weight	19.6 lbs
Battery weight	9.9 lbs
Full power endurance	0:35 hrs
Half power endurance	3:30 hrs
Slow speed endurance	6:20 hrs

The propulsion pods were secured to the WAM-V using the mechanism described in the *Other Alternatives* section.

Other Alternatives

If the Team chooses a custom propulsion solution, an entirely new pod (with propulsion) may be attached using the hinge torque plate assembly, shown in Figure 11 and Figure 12, to construct a compatible connection to WAM-V.

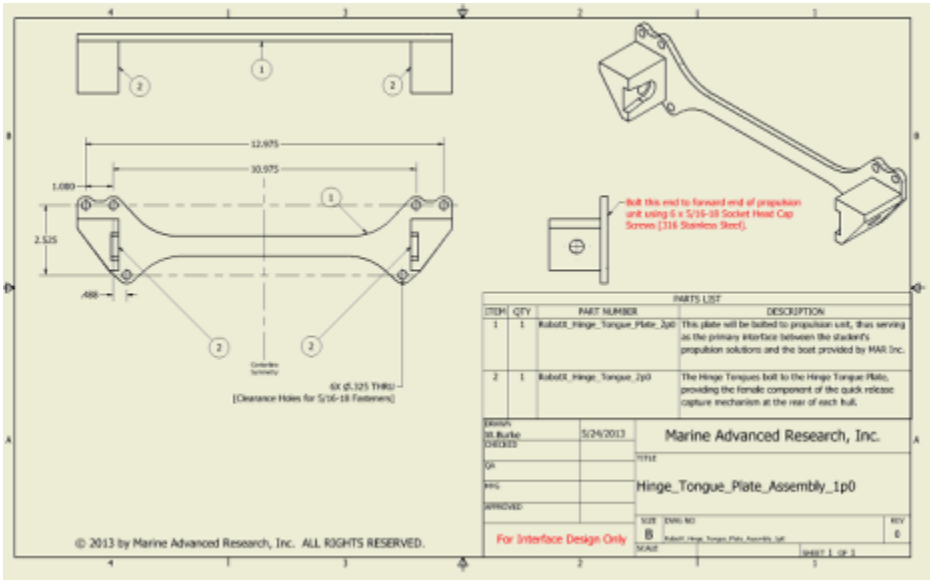

Figure 11. Blueprint for Hinge Torque Plate Assembly

Figure 12. Hinge Torque Plate Assembly