Hardware Design of an Improved ROV

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Remotely Operated Vehicles (ROVs) are essential to oceanographic research. However, navigating and controlling these vehicles from afar-and even autonomously-presents unique problems that terrestrial robots do not face: GPS signals cannot penetrate underwater, and cameras are ineffectual in the dark and featureless conditions. My lab, the Dynamical Systems and Control Lab (DSCL), develops alternative systems for controlling and navigating underwater vehicles. Ship and robot time for testing these systems, however, is prohibitively expensive, so the lab tests these systems on analogous robotic testbed vehicles within a tank in the lab.

My own work has focused specifically on improving the design of the lab's current testbed, the JHU ROV, in a new iteration of the robot, the JHU ROVII. I designed it with the following improvements in mind:

- Autonomous operation
- Size reduction
- Easier maintenance
- Improved wiring
- Component standardization

The project was split into three primary components:

1. Power system design
2. Component housing design
3. Structure and layout

Power System Design

In order to enable autonomous operation, an onboard power supply is required. Along with labmate Rachel Hegeman, I selected the Inspired Energy PH3059 lithium-ion smart batteries for their superior power density and introspection capabilities.

In order to provide the requisite 3 kW of peak power and sustain untethered operations for approximately an hour, 30 of these batteries were needed. To prevent imbalances in voltage among these from causing over- and back-current, a resistor and diode were placed in series with each of the batteries. The behavior of this circuit was simulated in LTSPice, and resistance was optimized to reduce overcurrent below the 15 A limit of the batteries while minimizing power loss.

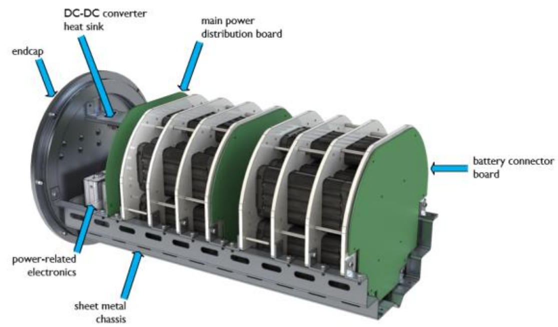
Component Housing Design

Power Housing

The power housing was designed with the following goals in mind:

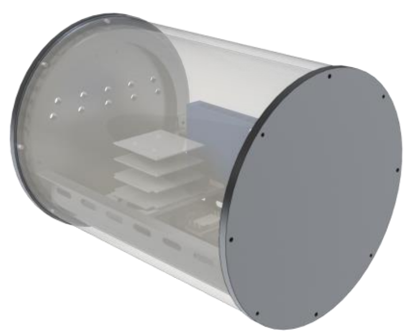
- Effectively dissipate heat
- Use standard, COTS parts
- Ease access, maintenance
- Simplify wiring
- Minimize size

Shown below is the design, with key components indicated:



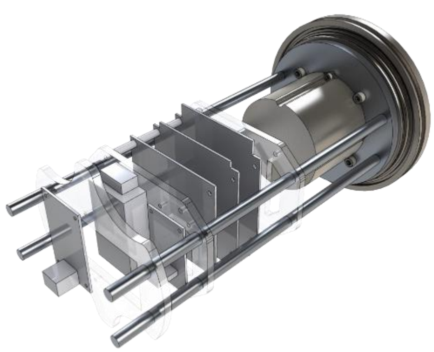
Electronics Housing

The electronics housing had similar design considerations, and was additionally designed to use the same endcaps, tube, and chassis as the power housing. These similarities, part of the effort to standardize parts, can be seen in the rendering of the housing below:

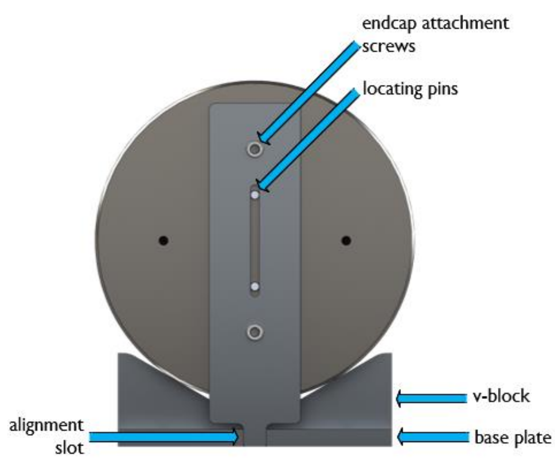


KVH Housing

In designing a housing for the KVH 1775 Inertial Measurement Unit (IMU), the foremost concern was alignment. The IMU had to be ultimately be aligned with the Doppler Velocity Log (DVL) elsewhere on the vehicle to accurately calculate position. This meant that the IMU had to be precisely aligned with the endcap, which itself had to be aligned with a mounting plate, which was aligned to the rest of the vehicle, which was aligned with the DVL. This was accomplished through the usage of precisely-machined locating pins and slots.



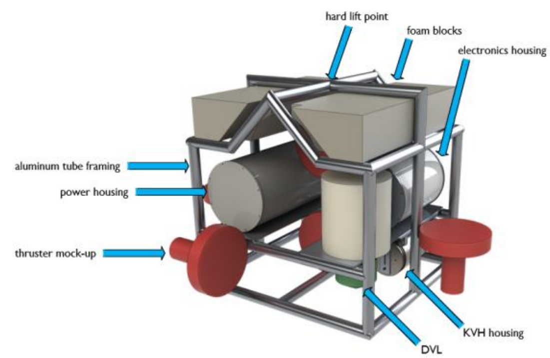
Interior of the KVH housing



Exterior of the housing, with key locating features shown

Structure and Layout

Once I had designed all of the housings, I designed a layout and structure to accommodate them. As I did so, I kept the following goals in mind: minimize size, avoid obstructing thrusters, and ease access and maintenance. The final frame was 42 x 35 x 29 (L x W x H) inches, a significant reduction in footprint from the original vehicle's dimensions of 52 x 33 x 22 inches.



Rendering of the layout and frame, with key elements highlighted