# Michael Elliot King

## Mechanical Engineering Portfolio

✉ mk@michaelking.io  michaelelliotking.com  linkedin.com/in/michaelelliotking
☎ 1 (617) 633-0828  488 Thames St. Newport, RI 02840

**Emergency Pressure Vessel** *(Sensitive)*

*A pressure tolerant electronics enclosure storing batteries, GPS, pressure switches, and emergency circuits to monitor vehicle status and control emergency buoyancy*

- Designed novel sheet metal rack to encase array of 8 batteries that minimized parts, machining costs, and facilitated battery replacement with single screw disassembly
- Designed cantilever rack and sliding rails for easy install and removal, which I validated with FEA

**Air Bag Pressure Vessel** *(Sensitive)*

*A pressure tolerant pneumatic and electronics enclosure housing solenoid valves and relays to pneumatically inflate air bags for emergency buoyancy*

- Redesigned for usability by nesting valves into the end cap, removing supports that impeded installation, changing to more reliable fittings, and freeing up space for improved access

**Fin Adapter and Breakaway Fasteners** *(Sensitive)*

*A mechanical adapter and breakaway fasteners to hold an underwater vehicle control surface fin and isolate the actuators from large stresses*

- Designed novel-shaped adapter to increase strength while staying light by analyzing stresses (using FEA), removing unnecessary material, and splining the joint
- Designed modified fasteners to yield at precise load to limit the forces seen by the controlling actuators

**Pressure-Balanced Oil-Filled Electronics Box** *(Sensitive)*

*A full-ocean depth pressure compensated modular electronics enclosure for testing electronics in a full ocean pressure environment*

- Designed for modularity and usability during electronics tests to reduce the efforts of changing and troubleshooting of pressure tolerant sensors and circuits
- Created open-topped box with viewing window, novel hinge mechanism, minimized opening procedure, and no-mess oil fill and air bleed system

**Power System Arming Plug** *(Sensitive)*

*A manual switch embedded in an underwater vehicle for arming and disarming the power system using a waterproof proximity switch*

- Designed for usability and fail-safety, with natural mapping and a two-step locking procedure

**Light Fixture Release Mechanism Design Challenge**

*In applying for a position at a design firm I completed a conceptual design and report in 24 hours and received an offer based on my work*

- Designed the hinge and clasp mechanism for the bezel of a high end lighting fixture

### Prototype Enclosure for a Wearable Mixed-Signal Sensor Circuit

*A 3D-printed prototype for a wearable device that senses pressure change*

- Designed, printed, and assembled in 24 hours a working prototype of a hermetically-sealed enclosure to demonstrate the functionality of the sensor circuit to a potential client

### Variable-Friction Shoe-Surface Mechanism

*A mechanism to fit in the sole of a shoe and dynamically simulate the friction of a full range of surfaces*

- Designed a compact motor, gear, and lead screw system that controlled the height of a compressive and high-friction surface compared to the height of a rigid and low-friction surface

### Autonomous Underwater Vehicle

*A small unmanned underwater vehicle for an international student design team competition*

- Designed the frame, pressure vessels, and propulsion system with limited-budget including machined, 3D-printed, and hand-manufactured parts

### Autonomous Lunar Mining Robot

*A small unmanned lunar vehicle for mining lunar regolith at an international student design team competition*

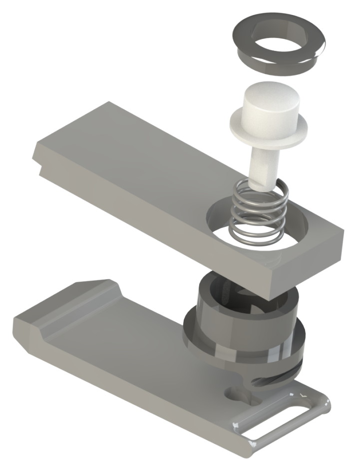
- Designed the collection and storage system including a linkage lifting mechanism, composite storage bucket, and tilting dump-truck door

# Light Fixture Release Mechanism Design Challenge

**Project:** Assessment of my design skills and process during the interview process for a design firm.

**Goal:** Conceptualize and model the bezel attachment and release mechanism for a high-end light fixture and return the design report in 24 hours

**Description:** These features have important roles in the functionality of the product; to fasten the bezel to the fixture body and easily remove it. Although important, they should not be noticed. They should work with ease, such that the user forgets they used them. The hinge and clasp must be robust and precise, to create a rigid, solid seal. The release mechanism should be easy and obvious to use but not obtrusive. The materials should reflect the quality of the product, and be simple to manufacture.



There are two parts to the design.
The challenge is to design the bezel attachment and release system for a light.

- Design a release button mechanism located in the cross-hatched area.
- Design the attachment method connecting the bezel to the body.

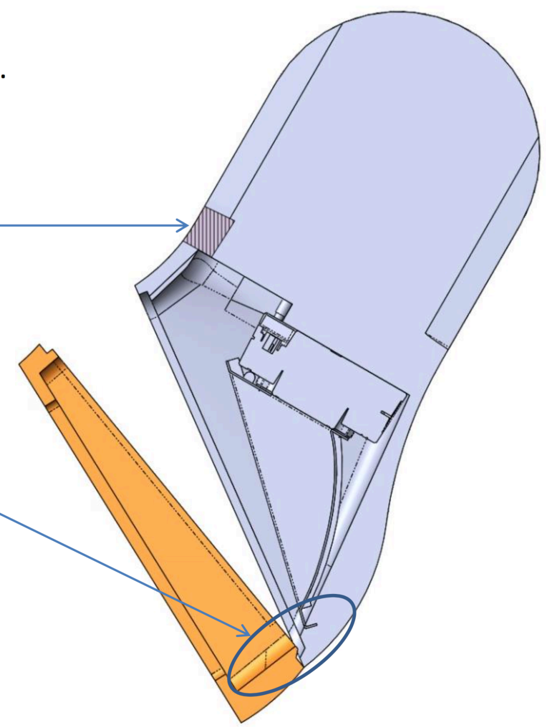


Figure 1: Bezel attachment and release mechanism for a light.

**Hinge** The hinge is a simple shape that allows the bezel to seat itself on the corner of the fixture and rotate into place. Once rotated into place, the hinge does not allow the bezel to move outward.

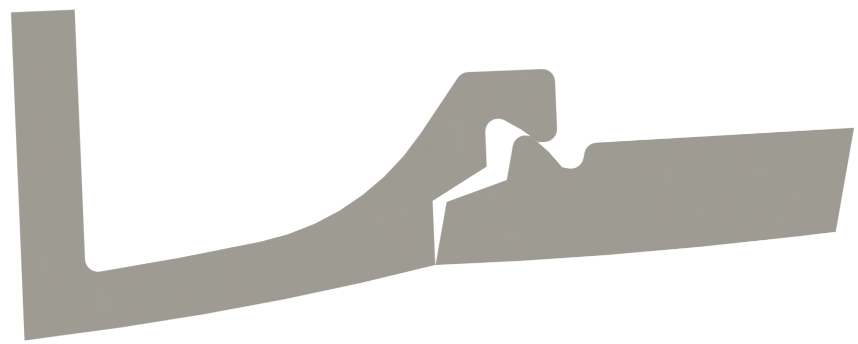


Figure 2: The hinge in the open position

**Clasp** The clasp is a wedge that applies a radial force on the body to create a snug fit against the inside of the fixture. To secure it in the axial direction, a release button hooks the clasp to lock it into place.

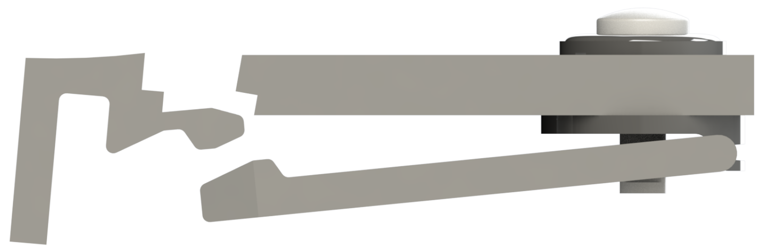


Figure 3: The clasp in the open position

**Button** The button allows the bezel to be released when pushed. Because it only unlocks the bezel, rather than push the bezel out, the button does not have to deliver much force. Additionally, it uses a lever for mechanical advantage, making the button very easy to push.

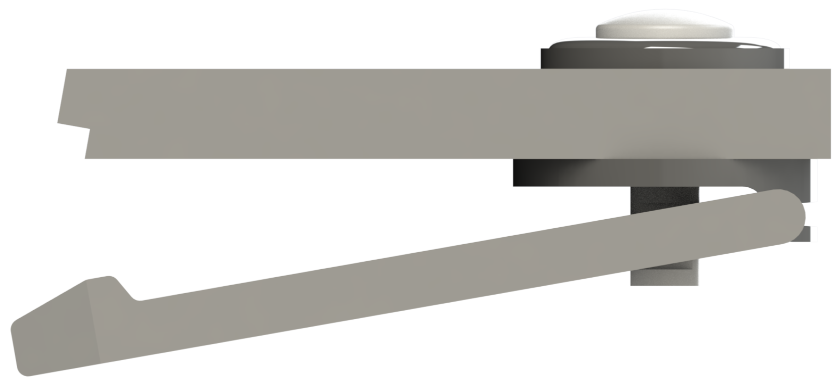


Figure 4: The button in the pressed position

The button is a spring push button design, but adds a lever underneath for mechanical advantage and extension. The fulcrum of the lever snaps into the side of the button's sleeve, and the center of the button slides into the keyhole on the lever, at the same time. The keyhole keeps the lever secured to the button, and allows for the movement of snapping the fulcrum into place.

# Electronics Enclosure

**Project:** Wearable Mixed-Signal Sensor Circuit for the McGill University Sensor Microsystems Laboratory

**Goal:** Enclose a small sensor circuit board with a hermetic seal and diaphragm to allow the measurement of pressure change under changing loads

**Description:** In order to pitch the device (sensor circuit board) to a potential client, a prototype of an enclosure was needed, with enough fidelity to sell the client on the functionality of the product. The project was given to me on very short notice over a weekend, so was completed in one day.

Figure 5: Electronics enclosure sealed

The 3D printed prototype was designed to encapsulate a small circuit board and connected battery, with a hermetic o-ring seal, and fastened with two screws. It was printed on a Makerbot Replicator 2X in one iteration.

Figure 6: Electronics enclosure open

The enclosure is a simple container and cap design, but one wall of the container is made thin (1.0mm thick) to create a flexible membrane that deforms under load, such that the pressure sensor inside can measure the change.

# Variable-Friction Shoe Surface Mechanism

**Project:** Research project for Professor Jeremy Cooperstock of The Shared Reality Lab - McGill Centre for Intelligent Machines

**Goal:** Design, manufacture, assemble, and demonstrate a mechanism to fit in a shoe that can control the coefficient of friction between the shoe and the floor surface.

**Description:** Based on research done by Guillaume Millet, Martin Otis, and Jeremy Cooperstock into various methods of varying friction during natural walking and the applications for this type of simulated environment, a fully functional prototype was created from scratch in seven months. Creating the concept involved choosing a method of deployment, researching all components and materials, calculating needed geometry and movements, designing the layout, and analyzing the stresses. The manufacturing, assembling and testing of the apparatus were completed in the next three months. This involved ordering materials and parts, machining and assembling components, developing the power and control system, and testing the mechanism prototype.

The full report can be found at michaelelliotking.com/report.

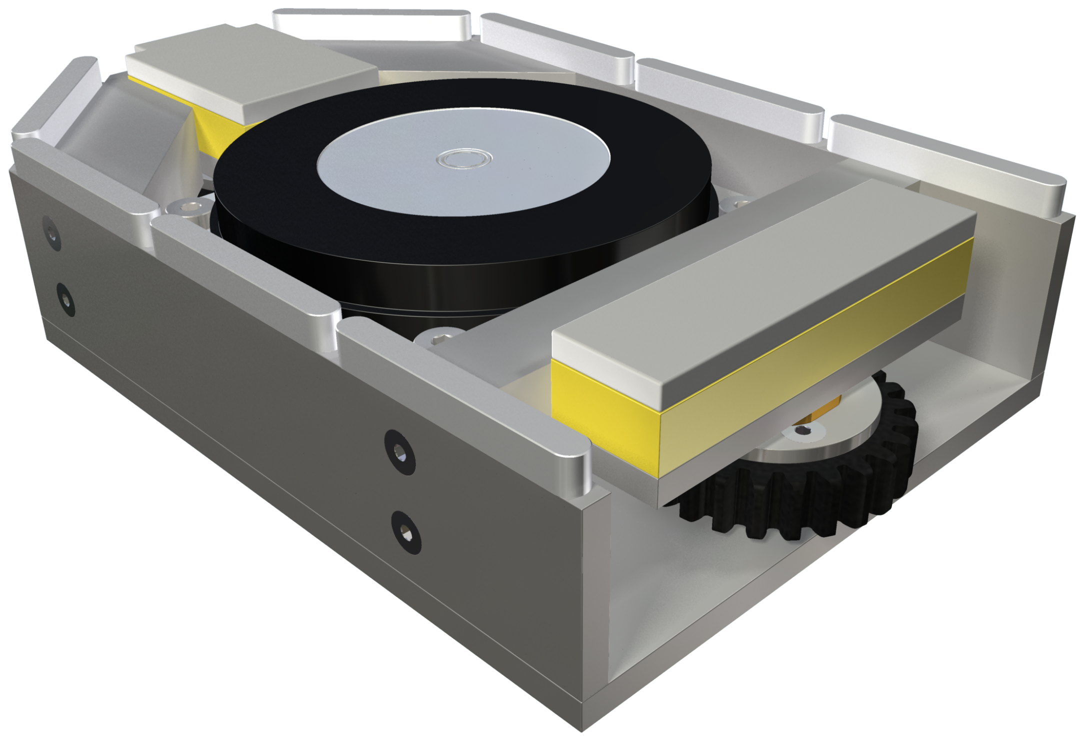


Figure 7: Assembly of the variable-friction shoe mechanism

To vary the coefficient of friction, a range of surfaces—from ice to concrete—is simulated using the combination of an adjustable, deformable high-friction material and a rigid, static low-friction material. The height of the deformable brake is adjusted to transfer more weight onto it, and because the friction force is proportional to normal force on the brake, the coefficient of friction changes with its height.

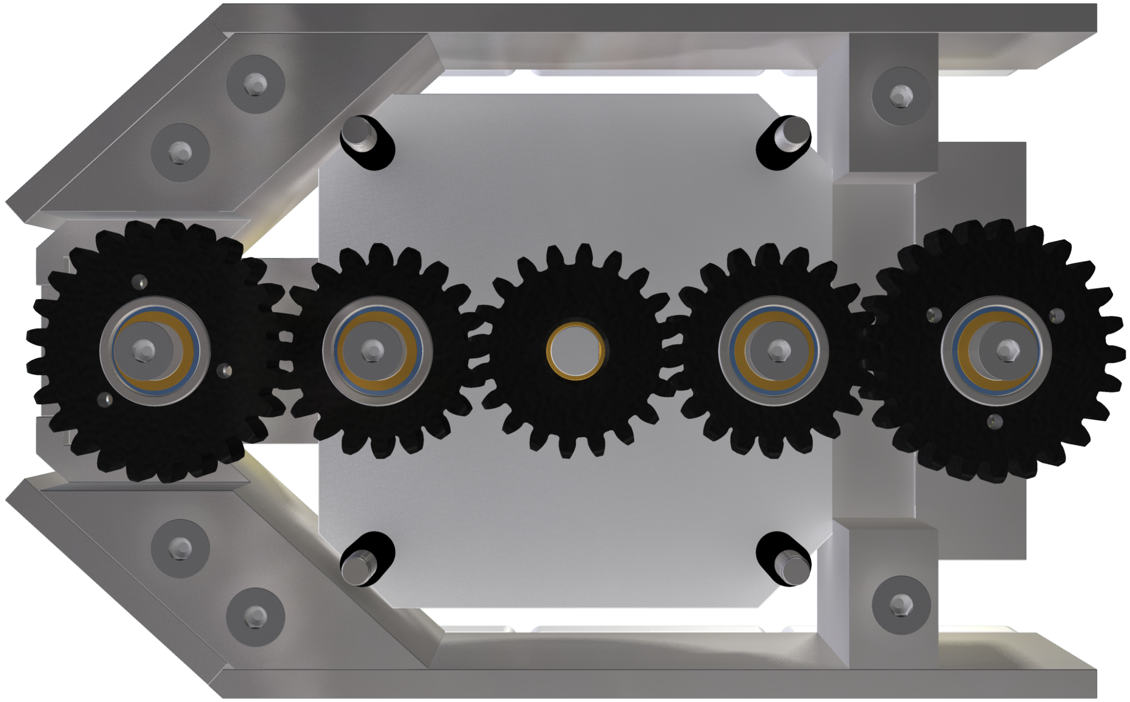


Figure 8: Bottom view of gear train and bearings

The mechanism uses a central stepper motor to drive a series of gears and a lead screw embedded in each brake to change the height of the braking surface. The drive system was designed from scratch and everything but the gears and bearings were machined in-house from aluminum and stainless.

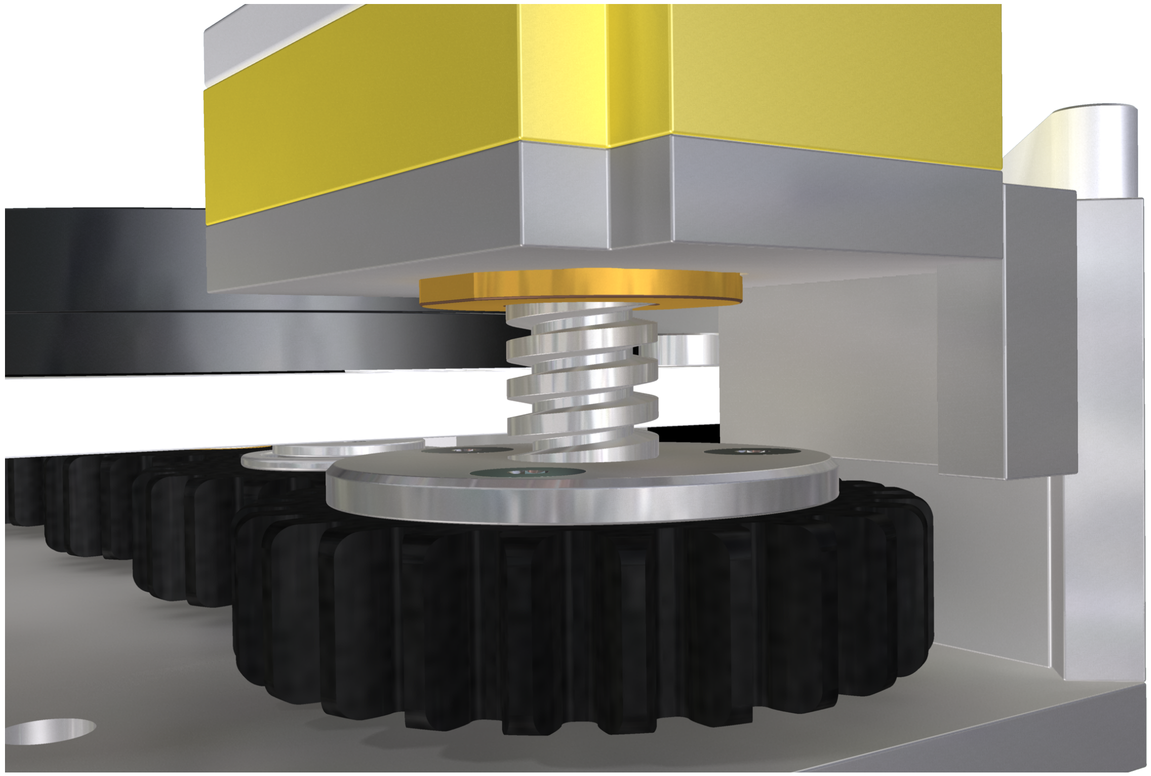


Figure 9: Cut-away view of gear, lead screw and brake

The lead screw is silver-brazed to the gear, which is threaded into the aluminum plate of the brake and sandwiched between two bearings. The brake consists of a metal plate, a piece of EVA foam for elasticity, and a strip of rubber for high-friction. The brake system allows for precise translations as small as a tenth of a millimeter, which is needed to achieve specific coefficients of friction.

# Autonomous Underwater Vehicle

**Project:** Autonomous Underwater Vehicle for the McGill Robotics Design Team

**Goal:** Design, analyze, manufacture, implement and test an A.U.V. to compete in the AUVSI Robosub Competition in San Diego, CA in July 2014.

**Description:** Two months are used to research existing teams and industry designs, develop concepts, and evaluate them based on cost, simplicity, and manufacturability. Another two months are spent designing, CADing, and running FEA, to prepare for purchasing. Machine drawings are made and materials are ordered over the next month. Following this, one month is spent on machining, printing, and manufacturing, and less than a month assembling the components. The next four months are left for unit testing, dry testing, and finally wet testing. This period is also left open for any necessary redesign and manufacturing that will inevitably take place. The vehicle must be ready for competition in June to allow for shipping and travel to San Diego. In the next few pages, some of the major components that were CADed are shown in more detail.

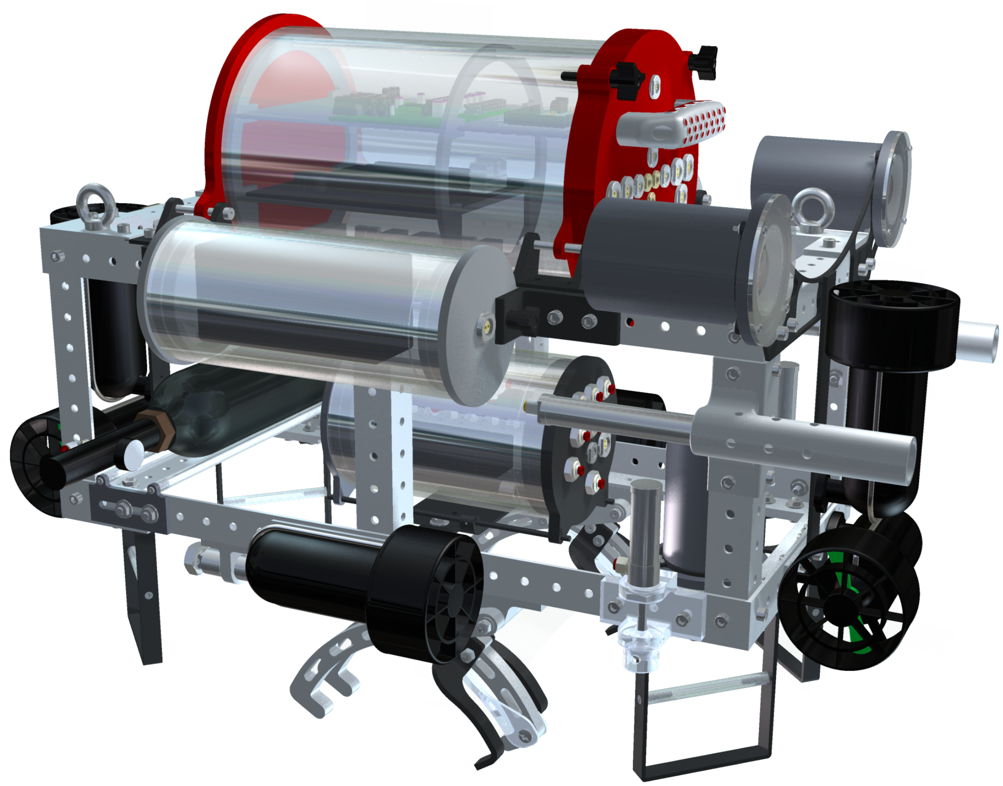


Figure 10: AUV assembly

Figure 10 shows the current CAD model of the entire AUV. It consists of a frame, a main hull pressure vessel, two battery pressure vessels, three camera pressure vessels, a pneumatic valve housing, an IMU pressure vessel, two claw mechanisms, two marker dropping devices, two pneumatic torpedoes, a $CO_2$ tank, and six thrusters. The majority of the materials are HDPE plastic, 3D-printed resin, and aluminum. All designs are from scratch, except for fasteners and electrical components.

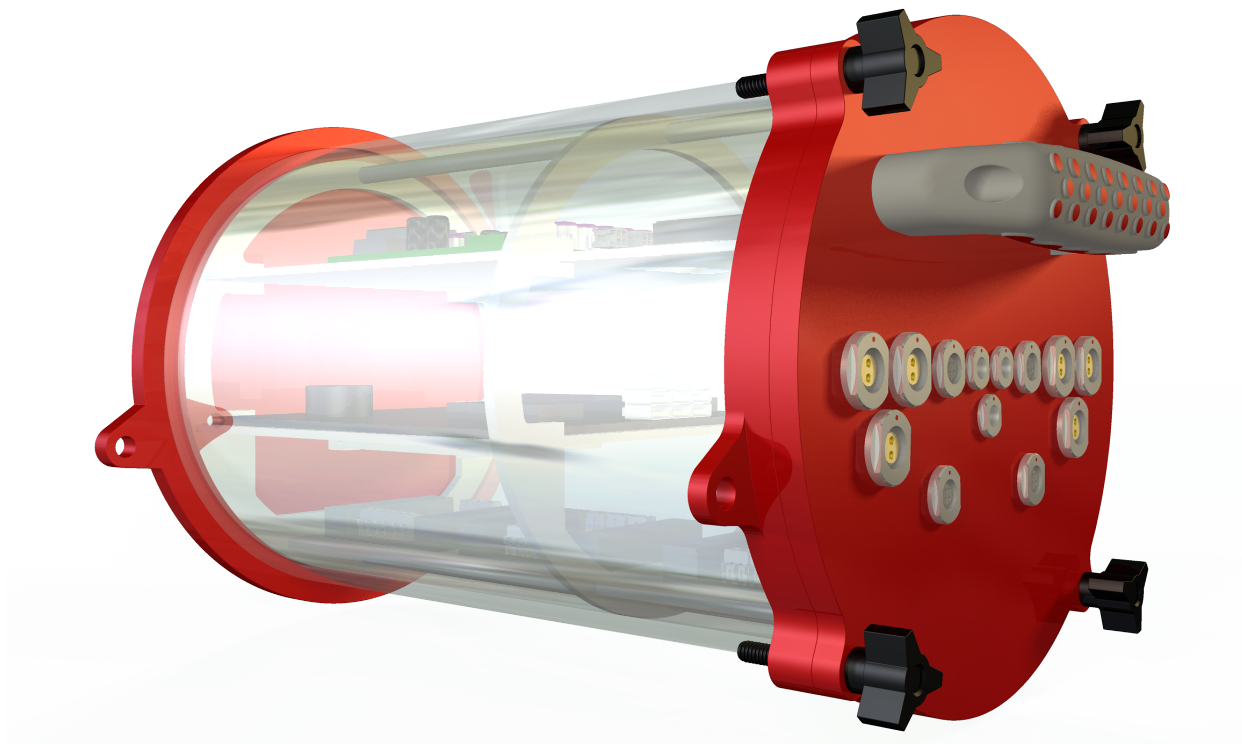


Figure 11: Main hull pressure vessel

The main hull houses most of the electronics and provides the majority of the buoyant force needed to keep the vehicle neutral and balanced. Inside, a rail system holds the electronics in place, and is removable from the front for easy access. It attaches to the top of the frame, and connects all the electronic components using a set of waterproof connectors.

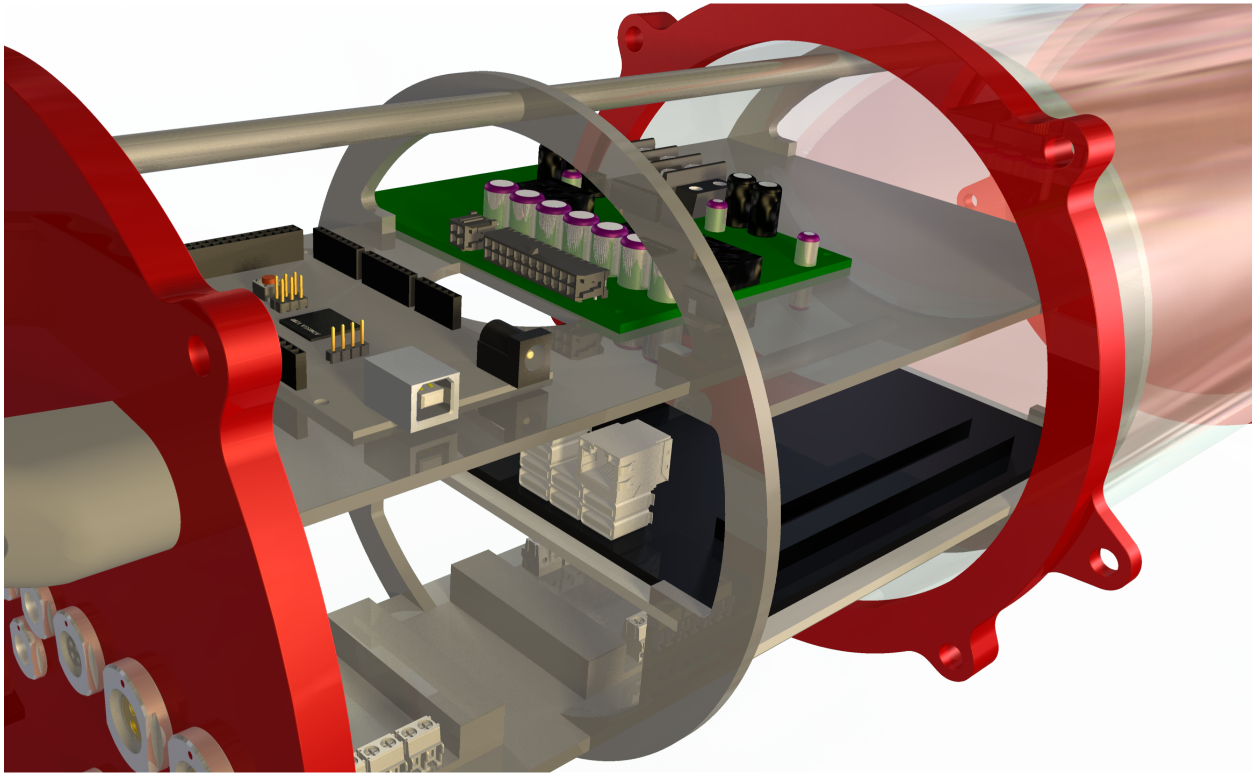


Figure 12: Internal electronics rack

Inside is the custom-built, on-board computer, as well as three motor controllers, an Arduino Mega, and a custom-built power distribution PCB board. These electronics are needed to manage the six thrusters, the sensor array, and the computer vision system. The frame is made of aluminum rails, with plastic racks, and uses a face O-ring with four nuts and vacuum seal to keep it water-tight.

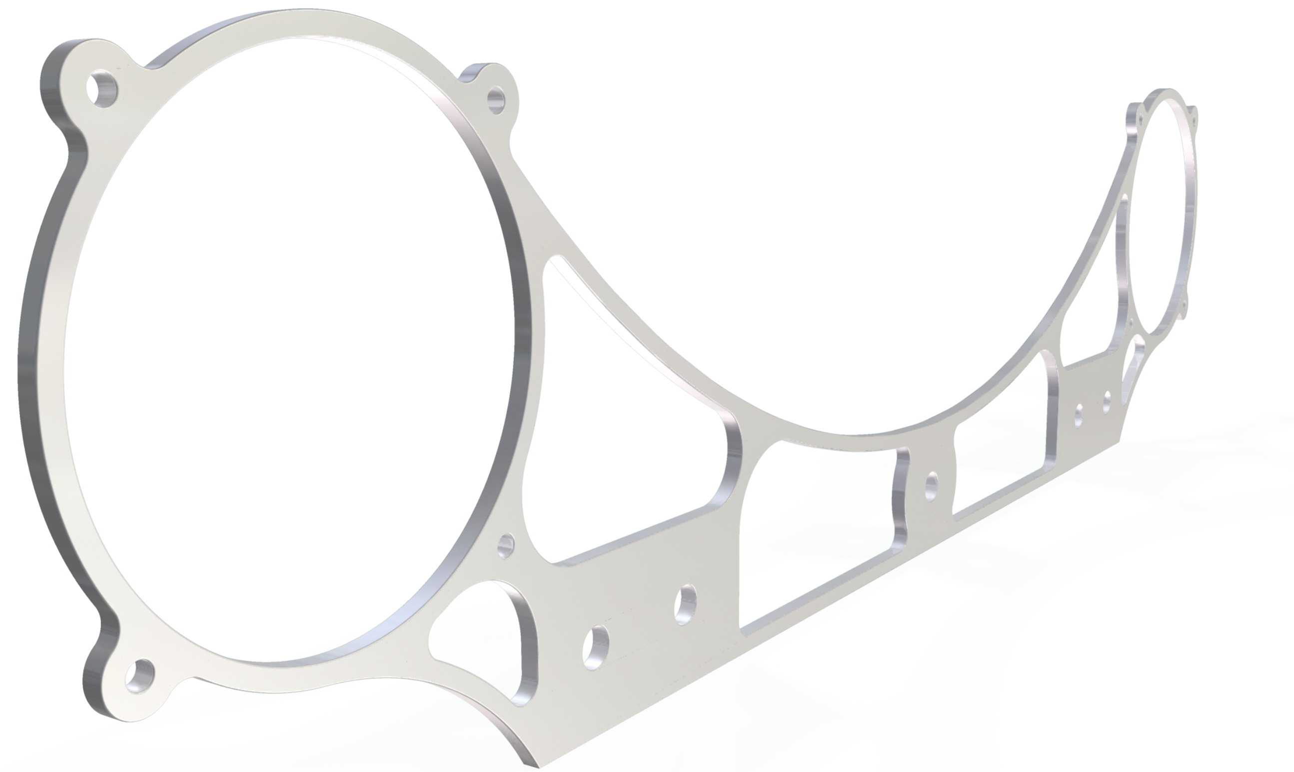


Figure 13: Front-facing CNCed camera bracket

The front-facing camera bracket connects two cameras to the bow to allow for stereo vision. The bracket is CNCed from a sheet of aluminum for rigidity and shaped to maximize the distance between the cameras and reduce weight. Like all the machined aluminum parts, it will be anodized following machining to prevent corrosion.