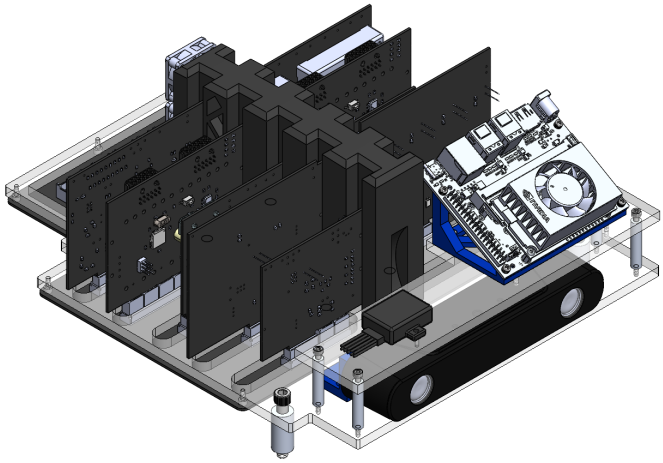
CU AUV

Cornell University Autonomous Underwater Vehicle Team

Fall 2025

Orion Racks



Technical Report

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1 Abstract

This technical documentation overviews the development of the racks with CUAUV's 2024 submarine, Orion. Its main purpose is to provide mounting locations for all electronic components inside the Upper Hull Pressure Vessel (UHPV). These components include our custom printed circuit boards (PCBs), Jetson computer, and other sensors. With the nature of the iterative design of Orion, there was no massive change in the design philosophy with respect to the racks, but rather further optimization and modification of the design of Henry's racks for Sirius.

2 Design Requirements

2.1 Constraints

- To fit within the smaller UHPV of Orion.
- To provide secure mounting of the electronic equipment within the submarine.
- To be easily accessible for quick modification of components.
- To be able to be used outside of the submarine in order to test functionality of components.

2.2 Objectives

- To decrease the weight of the overall racks assembly.
- To require as few machinable parts as possible.
- To minimize vibrations within the construction.
- To provide enough clearance for thermal performance.
- To optimize board locations for backplane trace layouts.

3 Previous Designs

3.1 Polaris (2022)

Polaris' racks consist of two primary mounting systems: the fore racks and the aft racks, both up which mount inside the UHPV on opposite sides of the midcap. In a reversal to Odysseus's rack system, the fore racks now hold the off the shelf components along with an interior camera, and the aft racks hold the custom PCBs. With the exception of the backplane, the PCBs and off-the-shelf components remained the same between Odysseus and Aurora. The re-use of the Odysseus midcap was the biggest constraint of the design, as the mounting holes and cylindrical UHPV design dictated much of the rack design.

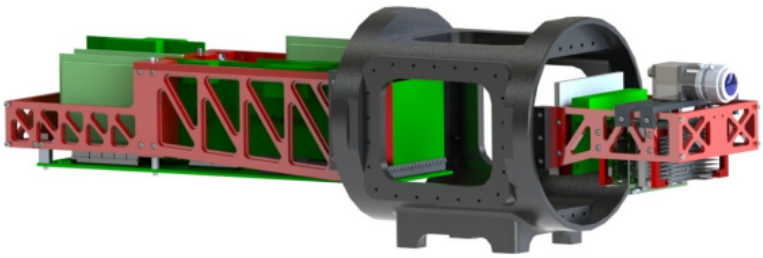


Figure 1: Polaris Racks

3.2 Sirius (2023)

Given Sirius' large departure from the 5 years or so of cylindrical submarines, the racks are quite different as well, as all components could be directly screwed into the baseplate of the UHPV instead of being cantilevered over a metal midcap. Therefore, the major chassis piece is a large aluminum plate which is laid on top of multiple cylindrical offsets from the bottom of the UHPV. This allows for a ribcage style backplane with a hollow central tower that allows for airflow within the sub.

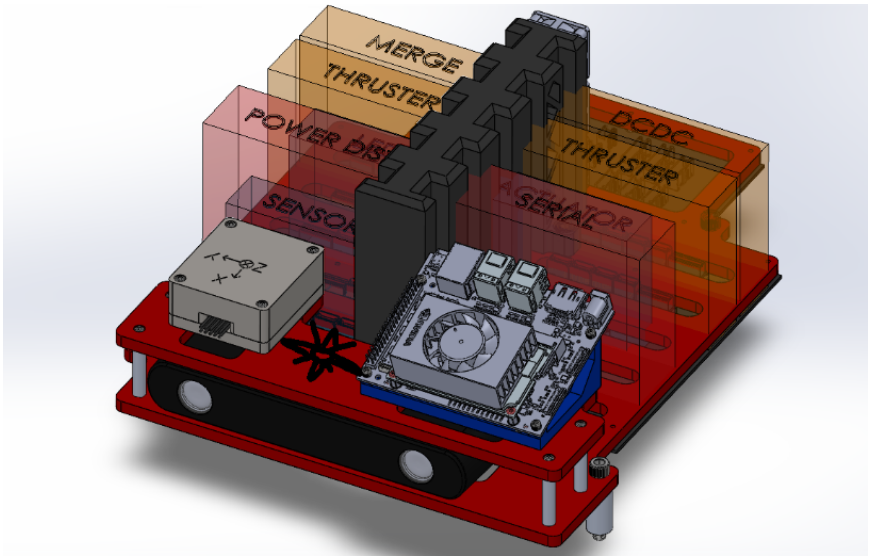


Figure 2: Sirius Racks

4 High Level Description

Once again, Orion's racks are an iterative improvement over Sirius', and these are the changes that have been made to each section:

4.1 Backplane Support

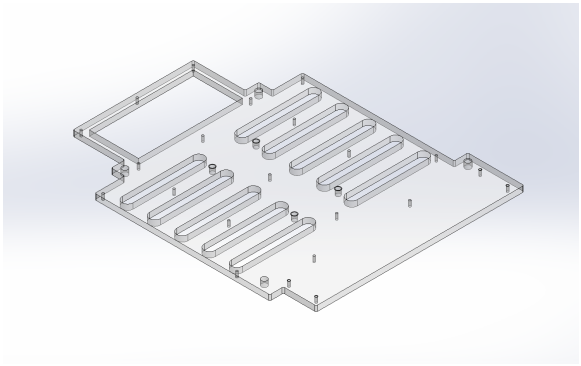


Figure 3: Backplane

Given the main objective of minimizing size, minor dimensional changes were made to the backplane support piece in order to decrease the overall length. Primarily, the space in between the boards that do not require cooling is now shrunk, leading to an extra inch shaved off the length. Additionally, we have found that it is not necessary to machine this plate out of aluminum and will instead be using laser cut acrylic, saving us weight, and also making this component easier to manufacture. Given the static and vibrational simulations, we have found no real-world decrease of functionality with this design change.

4.2 Cooling Tower

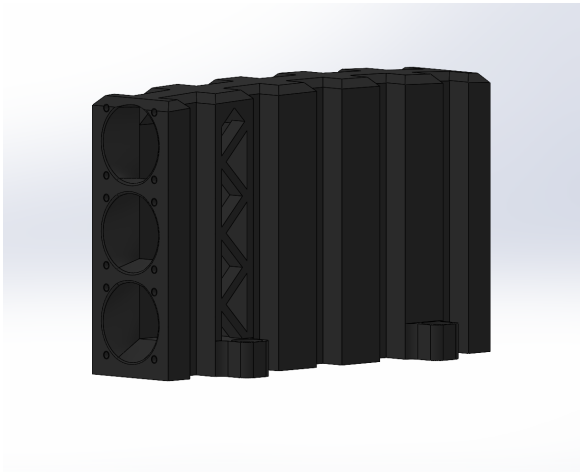


Figure 4: Cooling Tower

These changes have been made to the cooling tower within the middle of the backplane. Last year we had acquired wedge locks to constrain the boards within their spaces in the cooling tower, although it was never used. This has been properly implemented this year. Additionally, although the onyx material was nice, it has proven to be largely unnecessary, and will rather be FDM printed for cost, ease of manufacturing, and its slightly more plastic nature, allowing for slightly looser tolerances that prevent parts breaking due to over constraining. Additionally, the top surface of the cooling tower is curved to allow cables to be pulled off while the lid is closing.

4.3 Front Mounting

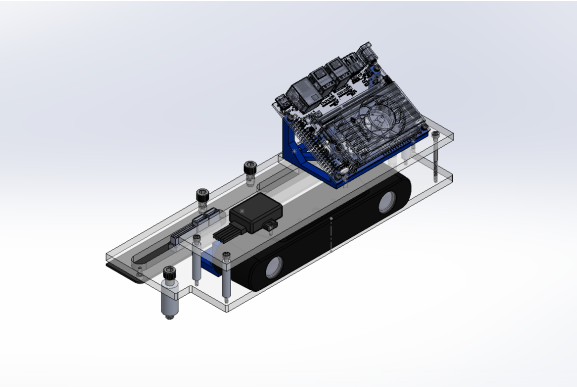


Figure 5: Front Mounting

In order to optimize space, there is a section above the zed camera of a different acrylic plate to allow more components to be mounted. Compared to last year, this segment is both closer to the main boards and also smaller to accommodate Orion's space constraints. Further optimization of the length has been made by slightly shifting the zed camera to overhang in front of the acrylic panel. Additionally, we have found that we no longer need an IMU sensor shield as the sensor works fine in plain air. Jetson is additionally mounted at a steeper angle in order to both save on space and provide better routing accessibility for the ethernet cable that comes out of it.

4.4 Test Bench

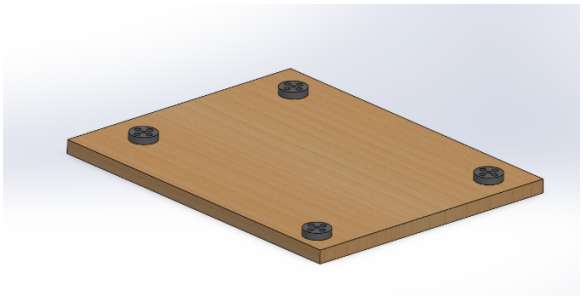


Figure 6: Bench

A point of feedback we received from the electrical subteam was the desire to work on the whole rack system outside of the submarine, which used to not be possible, as the aluminum standoffs would not be enough to support the racks on a flat surface. Therefore, by mounting tapped holes within a board of MDF, this allows for a mounting surface outside of the submarine that makes the components more accessible while troubleshooting.

5 Current Status

As standard practice, all design work for these racks have been completed, and will be manufactured during JanMan. There will be some amount of further collaboration with Jeffrey in order to provide details about the design that needs to be incorporated into electrical components. This subsystem should be complete by mid-February for utilization by the rest of the team.

6 Future Improvements

Given the complete absence of machine parts within this design, it can be easily iterated on, even if things come up later on during the year. Given the relatively small number of changes that Orion has compared to Sirius, I do believe that the next year's sub will be more radically different, and therefore May stray away from the square design of this submarine and therefore these racks. With the optimization role that I have played this year, I also believe that this design does not have many more problems to be solved, and therefore I hope that this design can be referenced by future years when similar submarines are built.

Appendices

A Purchased Components

Component	Qty.
0.25” 12”x18” Acrylic Sheet	1
1/4-20 Partial Threaded Screw	1 box
4-40 Partial Threaded Screw	1 box
1/4-20 Standoffs	6

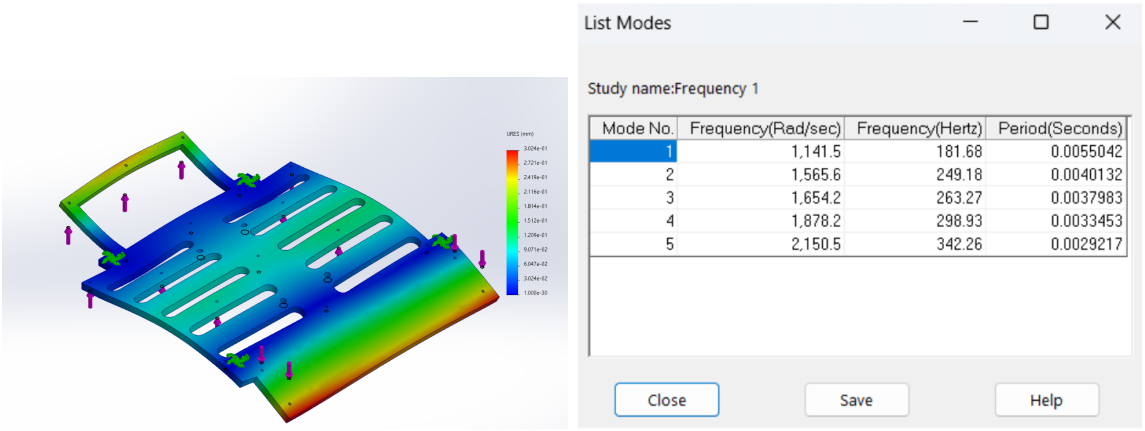
B Finite Element Analysis

B.1 Backplate

As the main load bearing fixture within my assembly, I wanted to make sure that the acrylic plate would not break during standard operation of the submarine. Therefore I ran static loading and vibrational simulations of the component, the results of which have turned out to validate my design.

Table 1: Fore Endcap Analysis Data

Max Stress	1954 psi
Factor of Safety	6.14
Max Deformation	0.01164 in



(a) Strain Simulation (b) Vibrational Simulation

Figure 1: Backplane SolidWroks Simulation Results