RoboSub 2026 Technical Design Report
Kraken Submersibles - New Mexico State University

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***Abstract* – Kraken Submersibles presents *Nautilus*, a first-generation Autonomous Underwater Vehicle developed at New Mexico State University for the 2026 RoboSub competition. The vehicle uses a vectored eight-thruster configuration, Cube Orange+ flight controller running ArduSub, and a Jetson Orin Nano running ROS 2 Humble for onboard autonomy and perception. Navigation and sensing are supported by a Nortek Nucleus1000 DVL, dual-camera YOLO-based vision system, and a custom four-channel hydrophone array for acoustic localization. The design emphasizes modular software architecture, hardware-in-the-loop validation, and fault-tolerant operation to improve reliability during missions. Testing progresses from bench-level validation to pool deployments, guiding system refinement toward full autonomous operation.**

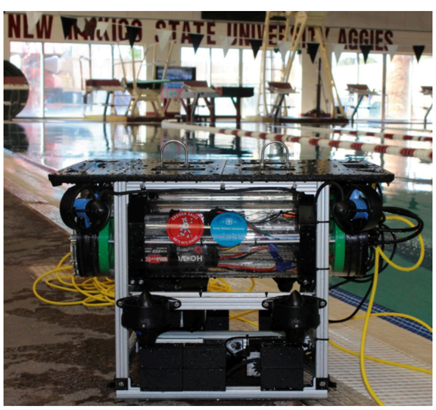

Fig. 1. *Nautilus* AUV

I. COMPETITION STRATEGY

A. Competition Vehicle - Nautilus

Nautilus is a modular autonomous underwater vehicle (AUV) developed by the Kraken Submersibles team at New Mexico State University for the RoboSub 2026 competition. Designed as a first-generation platform, the vehicle prioritizes reliability, modularity, and full task coverage capability while remaining adaptable for future development. Nautilus uses eight Blue Robotics T200 thrusters in a vectored configuration to provide full six-degree-of-freedom maneuverability for precise navigation, station keeping, and autonomous task execution. Low-level stabilization is managed by a Cube Orange+ running ArduSub, while high-level autonomy and perception are executed onboard using an NVIDIA Jetson Orin Nano running ROS 2 Humble. Navigation and localization are supported through sensor fusion using the DVL, IMU, compass, depth sensor, and onboard cameras. The vehicle also incorporates OpenCV and machine learning-based vision processing alongside a custom four-channel hydrophone system for visual and acoustic task localization throughout the competition course.

B. Course Strategy

Nautilus follows a sequential autonomous mission strategy designed around RoboSub 2026 task progression. After submerging and stabilizing at operating depth, the vehicle uses vision-based navigation to identify and traverse the gate before continuing through the slalom task using visual target tracking and closed-loop heading control. Path markers and onboard localization data guide the vehicle toward the recon bins task, where markers are deployed using camera feedback and DVL-assisted station keeping. The vehicle then transitions toward the torpedo and octagon tasks using hydrophone-based acoustic localization combined with vision-based alignment to identify targets, fire torpedoes, and perform controlled surfacing operations within the octagon. Throughout the mission, onboard autonomy software supervises task sequencing and perception while the Cube Orange+ maintains stable vehicle control, PID stabilization, and failsafe handling to ensure reliable autonomous operation during competition runs.

II. DESIGN STRATEGY

Fig. 2. 3D Model of *Nautilus* AUV

A. Frame Design

The design strategy for the Nautilus AUV frame focused on creating a structure that prioritized modularity, stability, manufacturability, and ease of subsystem integration while remaining within RoboSub competition constraints. Early frame concepts lacked the robustness and adaptability needed for future development, leading the team to redesign the structure around a modular T-slot aluminum skeleton with HDPE top plate. The design was inspired by commercial AUVs such as the BlueROV2, which demonstrated the effectiveness of a “boxy” architecture for organizing subsystems.The structure chosen provides modularity in its boxy shape and T-slot rail frame, allowing us relatively easy access to all of our subsystems and enclosures. It allows for the center of gravity and buoyancy to be actively changed to optimize static stability and responsive attitude control. The 8 thruster design provides maneuverability in 6 degrees of freedom, maximizing agility and responsiveness at the expense of straight line speed.

B. Waterproof Enclosures

The design strategy for the Nautilus AUV waterproof enclosures focused on protecting critical electronics and batteries while maintaining modularity, accessibility, and buoyancy stability. The team adopted dual 6-inch acrylic tube enclosures to physically separate the electronics and battery systems, reducing the risk of electrical damage and improving overall safety. The transparent housing allowed quick visual inspection for leaks, wiring issues, and internal component status during testing and operation. Waterproof sealing was achieved using Blue Robotics 6-inch end caps that feature dual O-rings and wet link penetrators designed to support low-voltage subsea applications. Components were mounted using modular brackets and rails so that hardware could be removed or replaced without redesigning the enclosure.

1. Design of Main Hull

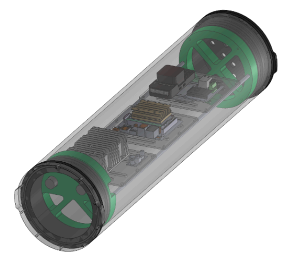

Fig. 3. 3D Model of Main Hull

The enclosure was organized to separate high-priority electronics based on function and heat generation. The NVIDIA Jetson Orin Nano, Cube Orange+ flight controller, power distribution hardware, and communication interfaces were mounted in a compact arrangement to minimize cable lengths and reduce wiring clutter. Static IP networking, MAVLink communication, and sensor integration required multiple waterproof penetrators and organized routing paths through the end caps.

2. Design of Battery Hull

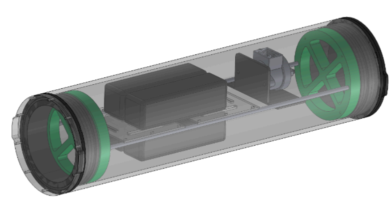

Fig. 4. 3D Model of Battery Hull

The enclosure housed the battery packs, EV200 relay, kill switch circuitry, and power distribution connections. Dedicated mounting hardware and additional center supports were designed to securely restrain the batteries during underwater maneuvers and transportation. The layout also emphasized rapid battery replacement and mission turnaround time. The hot-swappable battery configuration allowed batteries to be disconnected and replaced without disassembling the entire vehicle, improving testing efficiency and competition readiness.

C. Mechanical Subsystems

1. Gripper

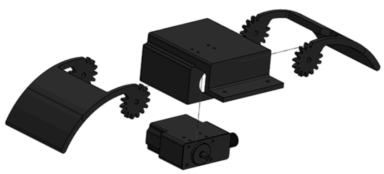

Fig. 5. Exploded 3D Model of Gripper

The gripper was designed to function using a servo-driven geared jaw mechanism and to remain compact within the frame during normal operation and extend below the vehicle only during object retrieval tasks. Jaw geometry was optimized around previous RoboSub competition objects, including ladles and small debris items, to maximize gripping effectiveness. The subsystem underwent several design iterations to address failures encountered during prototyping and underwater testing. Initial prototypes validated overall mechanism but experienced connection stripping underload and water absorption of 3D printed carbon fiber material. The final design adopted a multi-material approach that balanced durability and environmental resistance. The claws were redesigned to be modular using 6061-T6 aluminum for increased strength and long-term underwater reliability, while PETG was used in the contact surface. The modular jaws allow future teams to easily swap or redesign gripping surfaces for different competition tasks, improving adaptability and long-term usability.

2. Torpedo Launcher

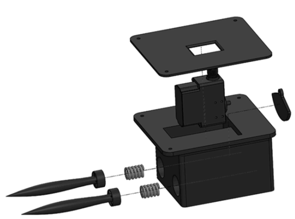

Fig. 6. Exploded 3D Model of Torpedo Launcher

The torpedo launcher was completely 3D printed out of PETG for simplicity, cost effectiveness, and strength. The design features a main housing with a waterproof servo mounted in the middle. The torpedo tubes are offset from the center on each side of the housing, running parallel to the servo. A swinging plate is connected to the servo and holds the spring loaded torpedoes in place. Actuating the servo clockwise and counterclockwise launches each torpedo respectively.

3. Dropper

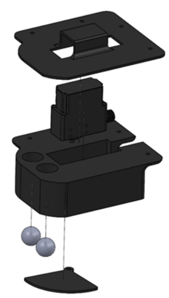

Fig. 7. Exploded 3D Model of Dropper

The dropper design was based on the torpedo, also being 3D printed out of PETG. The dropper housing holds both the steel ball markers and the vertically mounted servo motor. A swinging plate similar to that of the torpedo is connected to the servo underneath the housing, covering the holes where the markers sit. Similar to the torpedo, actuating the servo in either direction drops the respective marker.

D. Electrical Sub-System

1. Power Architecture

The vehicle electrical system uses a centralized modular power architecture designed to support high-current propulsion while maintaining stable power delivery to compute, sensing, and control systems. Primary energy is supplied by dual 14.8 V LiPo battery packs routed through an external power switch and high-current relay for system isolation and emergency shutdown. Power is then distributed via a Power Brick Mini and PM07 power distribution board to propulsion and onboard electronics. Eight Blue Robotics T200 thrusters, each driven by a dedicated ESC, provide full six-degree-of-freedom control. Multiple regulated voltage rails generated through DC-DC converters supply clean power to the Jetson Orin Nano, Cube Orange+, cameras, networking hardware, and auxiliary sensors, reducing electrical noise and improving system stability. High-level autonomy is handled by the Jetson Orin Nano, while real-time stabilization and actuator control are managed by the Cube Orange+, with navigation supported through integrated DVL, IMU, compass, and vision systems connected via an onboard Ethernet and tether interface for modularity and debugging.

2. Data Architecture

The vehicle employs a distributed data architecture to enable reliable communication between onboard compute, control, sensing, and tether systems during autonomous operation. High-level perception, mission planning, and autonomy are executed on an NVIDIA Jetson Orin Nano, while real-time stabilization and actuator control are managed by the Cube Orange+ flight controller. Sensor inputs from the DVL, IMU, compass, cameras, and acoustics system are fused to provide state estimation, navigation feedback, and mission awareness. Visual data from the ZED Mini stereo camera and IMX219 camera is processed onboard for object detection and localization support, while the Cube Orange+ uses feedback signals for closed-loop thruster control and stabilization. Internal communication is handled through a five-port Ethernet switch, enabling modular subsystem networking and simplified debugging. Tether communication is provided via a Fathom-X interface for topside telemetry, monitoring, and manual override, while peripheral microcontrollers interface directly with the control system for low-latency actuator management.

3. Acoustic Signal Processing

The Nautilus AUV uses AS-1 hydrophones as its primary acoustic sensing elements for underwater signal detection. Each hydrophone is integrated into the vehicle's waterproof wiring system and routed to a custom four-channel signal conditioning PCB that provides +24 V phantom power to PA-6 preamp buffers. This stage uses a high-impedance JFET preamplifier to amplify weak hydrophone signals while minimizing signal loss prior to digitization. The board also incorporates filtering to reduce electrical noise from onboard systems such as thrusters and power electronics, improving overall signal integrity. After conditioning, the four acoustic channels are digitized by an onboard ADC for further processing in software.

4. Wiring and Connectors

The vehicle uses Blue Robotics waterproof penetrators and connector systems as the primary method for passing electrical signals and power through the pressure housing. These penetrators are used for thruster leads, sensor connections, and external subsystem interfaces because they provide reliable sealing under repeated assembly and disassembly, which is important during testing and maintenance cycles.

Battery connections are handled using EC5 connectors and pre-made EC5 battery harnesses for the dual 4S lithium polymer packs. EC5 connectors were selected because they provide a secure high-current connection with low resistance and are capable of safely handling the peak loads generated by the T200 thrusters during aggressive maneuvers.

E. Software Sub-System

1. QGroundControl (ArduSub)

The vehicle uses ArduSub running on the Cube Orange+ flight controller for low-level vehicle operation and stabilization. QGroundControl is used to configure parameters, monitor telemetry, tune PID values, and test vehicle behavior during development. ArduSub was selected because it provides built-in support for underwater vehicle control, including depth hold, heading stabilization, thruster mixing, and failsafe handling, which reduced the amount of custom low-level software required by the team.

2. Control system

The control system manages vehicle movement and stabilization using PID-based control loops. The Cube Orange+ handles low-level control of the thrusters, while the Jetson Orin Nano executes higher-level autonomy and mission logic. Commands generated by the control system are sent to the ESCs, which regulate the output of the eight T200 thrusters. The thruster configuration allows the vehicle to maintain stable movement in multiple degrees of freedom while performing navigation and task operations.

3. Vision
The vision subsystem uses IMX219 cameras and a ZED Mini stereo camera to detect and localize competition objects. Image processing is performed using OpenCV-based pipelines that include color filtering, contour detection, and target tracking. Vision data is used for gate alignment, path following, and object localization during autonomous task execution. Stereo vision capabilities additionally provide depth information for improved spatial awareness.

4. Machine Learning
Machine learning methods are incorporated into the perception pipeline where increased detection reliability is required. These methods are used to improve object recognition in varying underwater lighting conditions and visually noisy environments. The system balances machine learning techniques with computationally efficient classical vision algorithms to maintain real-time performance on onboard hardware.

5. Sensors and Navigation
The navigation system combines data from the DVL, IMU, compass, cameras, and depth sensors to estimate vehicle motion and orientation underwater. Sensor measurements are fused to improve localization accuracy during autonomous operation. Navigation data is used by the mission planner to control movement between tasks and maintain stable positioning throughout competition runs.

F. Design Tradeoffs
Our design decisions prioritized modularity and agility over a specialized design optimized for speed or any single task. Its boxy frame provides a great face for actuators and vision, but sacrifices hydrodynamics and efficiency. The thrusters being offset at a 45 degree angle provides exceptional turning ability and maneuvering, but sacrifices forward power and speed. The actuator subsystems used to perform the tasks have all been designed to be completely 3D printed to allow for many design iterations in the future as we test each of them and determine if changes are needed. Our AUV was designed to be a multi-roll workhorse that is forgiving to developmental changes and optimized for task performance.

G. Buoyancy and Trim
The waterproof enclosures make the AUV inherently positively buoyant. In order to reduce the positive buoyancy, 3D printed boxes were fabricated with 1 pound of steel weights per box. These boxes were designed with modularity in mind, and can be either bolted to the T-slot frame, or stacked on top of each other. This system allows us to shift the center of buoyancy and control trim by moving the boxes around the sub.

III. TEST STRATEGY

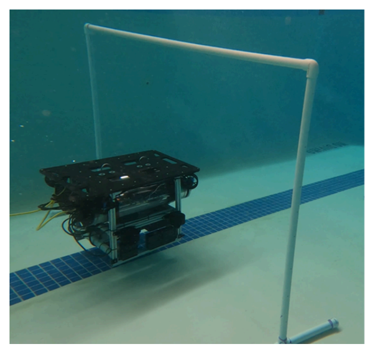

Fig. 8. *Nautilus* AUV Testing

A. Validation Testing
1. Waterproofing
Waterproof enclosure testing was conducted to verify leak-free operation prior to electronics integration. During initial assembly, minor fitment issues were identified between the inner diameter of the acrylic tubes and aluminum end caps. To improve sealing performance, the inner tube edges were chamfered to allow proper seating of the end caps and O-ring interfaces. Following this adjustment, both enclosures were assembled, mounted to the vehicle frame, and submerged to approximately 5 feet for 20 minutes. This test successfully validated

enclosure integrity, enabling early detection of sealing issues and iterative refinement of the waterproofing design to ensure a reliable, leak-resistant housing for full system integration.

2. Actuation Testing

Actuation testing was performed to verify that all mechanically driven systems showed reliable operation before full system integration. This included all three servo-driven subsystems and overall thruster response. All subsystems and thrusters were tested individually prior to integration to ensure correct wiring, adequate response, and detect any possible issues. All subsystems were then debugged to determine the required range of motion from the servos to avoid unnecessary strain on the mechanisms or any clearance issues. Subsystem task testing was done by following criteria stated from the 2025 and 2026 RoboSub handbook. Thruster control and response was tested both on a breadboard test bench and through remote operation. Once all of these tests took place, they were able to be mapped for ROV testing, then later to autonomous use through further system integration.

3. Electrical Testing

Electrical testing was conducted throughout system integration to ensure safe power distribution and proper subsystem operation. Prior to full-system activation, wiring continuity, connector polarity, and regulated power rail outputs were verified to prevent damage to sensitive electronics such as the Cube Orange+, Jetson Orin Nano, DVL, cameras, and acoustic hardware. Subsystems were then validated individually on the bench, including thrusters, servos, sensors, cameras, communication modules, and acoustic circuitry, confirming correct power-up behavior, data communication, and absence of voltage instability or electrical noise issues. Final electrical inspections were completed prior to pool testing, with particular attention given to waterproof connectors and penetrators to ensure proper installation and sealing integrity.

4. Full System Testing

Following subsystem validation, multiple full system tests were conducted in a pool environment with the Nautilus AUV operating in its complete integrated configuration. These tests evaluated buoyancy, stability, power distribution under load, sensor synchronization, and communication between the onboard computer and control systems. Multiple test runs were performed using both manual control and semi-autonomous modes to verify actuator response, vehicle handling, and system integration. Issues such as minor drift, timing inconsistencies, and parameter tuning requirements were identified across multiple trials and corrected iteratively between test sessions. Overall, full system testing confirmed integrated vehicle functionality across multiple runs and provided data to refine autonomy and improve mission reliability.

ACKNOWLEDGEMENTS

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APPENDIX A
COMPONENT LIST

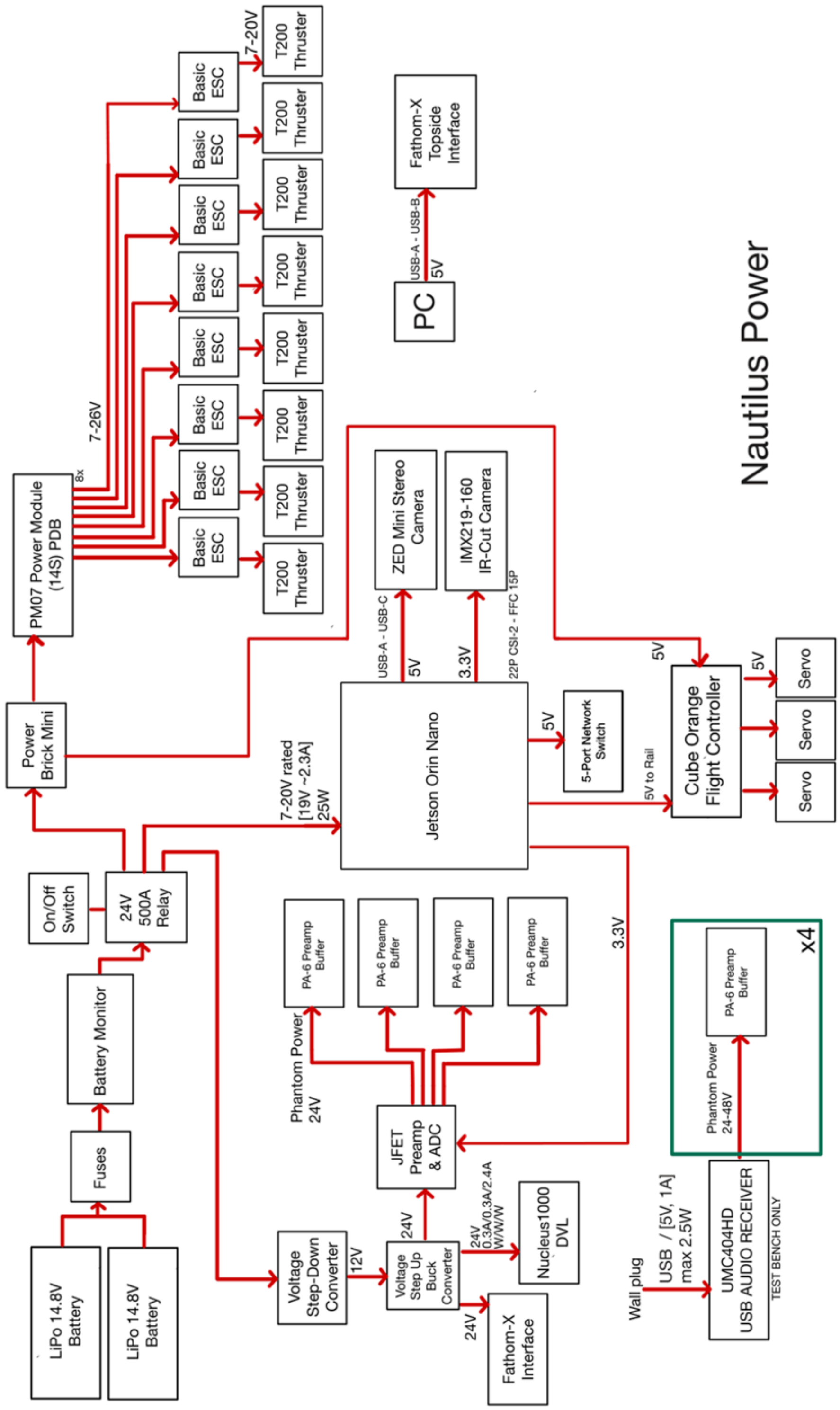
System	Item	Vendor	Unit Price	Qty	Subtotal
Computer	Jetson Orin Nano Super Developer Kit	NVIDIA	$249.00	1	$249.00
	Raspberry Pi 5	Raspberry Pi	$86.49	1	$86.49
	Arduino Nano ESP32 with Headers	Arduino	$20.90	1	$20.90
Propulsion & Control	T200 Thrusters	Blue Robotics	$230.00	8	$1,840.0 0
	Basic ESC	Blue Robotics	$40.00	8	$320.00
	T200 Mounting Bracket	Blue Robotics	$8.00	12	$96.00
	Cube Orange+ Standard Sted ADS-B	CUBEPIL OT	$384.75	1	$384.75
Frame/Enclosu re	Underwater Servo Kit	Blue Trail Eng.	$194.95	3	$584.85
	6" Acrylic Tubing (4ft)	ePlastics	$114.62	4	$458.48
	High Torque Servo	GoBILDA	$37.00	4	$148.00
	6" Tubing End Cap (Acrylic) - Blank	Blue Robotics	$53.00	2	$106.00
	6" Tubing End Cap (Aluminum) - 5 x M10	Blue Robotics	$53.00	1	$53.00
	6" Tubing End Cap (Aluminum) - 15 x M10	Blue Robotics	$58.00	1	$58.00
	6" Acrylic Tubing Seal	Blue Robotics	$90.00	4	$360.00
	1" T-slot Framing (10ft)	McMaster Carr	$47.35	2	$94.70
	1/2" HDPE Sheet	ePlastics	$87.00	2	$174.00
	1" Single Radius T-slot Framing (6ft)	McMaster Carr	$25.97	5	$129.85
	Clear Acrylic Sheet (.125")	ePlastics	$34.19	3	$102.57
	Molykote 111	Blue Robotics	$32.00	1	$32.00

	1/4 Inch Aluminum Rod (2ft)	McMaster Carr	$4.10	4	$16.40
Hardware	Silver Corner Bracket	McMaster Carr	$7.92	38	$300.96
	Stainless Steel Flanged Button Head Screw 10 mm (100x)	McMaster Carr	$14.36	1	
	Stainless Steel Flanged Button Head Screw 25 mm (100x)	McMaster Carr	$14.52	1	
	Stainless Steel Flanged Button Head Screw 16 mm (100x)	McMaster Carr	$16.12	1	
	Self-Aligning T-Slotted Framing Nuts (4x)	McMaster Carr	$5.09	28	$142.52
	3M Dual Lock Reclosable Fastener	3M	$21.75	1	$21.75
Power	4S Lipo Battery 14.8V 10000mAH	HOOVO	$152.00	1	$152.00
	4S Lipo Battery 14.8V 10000mAH	HOOVO	$152.00	1	$152.00
	500A battery monitor (retail)	Home Depot	$59.99	1	$59.99
	Camera IMX219-160 8MP IR-Cut	Waveshare	$31.90	2	$63.80
	On/Off Switch	Blue Robotics	$28.00	1	$28.00
	4S Battery Charger	Tenergy	$40.00	1	$40.00
	2-Pack EC5 Male Plug	RuiLing	$9.00	1	$9.00
Sensors	Doppler Velocity Log (DVL) Nucleus 1000	Nortek	$10,000.00	1	$10,000.00
	AS-1 Hydrophone	Aquarian	$413.00	4	$1,652.00
	Camera IMX219-160 8MP IR-Cut	Waveshare	$31.90	1	$31.90
	ZED Mini Stereo Camera	StereoLabs	$399.00	1	$399.00
Miscellaneous	6.67 cu. ft. Steel Cart	GORILLA CARTS	$179.99	1	$179.99
	Marine Flotation Foam (2 Qt)	Oycevila	$33.92	1	$33.92
	5KG PETG 3D Printer Filament	SUNLU	$54.99	1	$54.99
	UMMAGRIP 3-Pack	UMMAGRIP	$12.99	3	$38.97

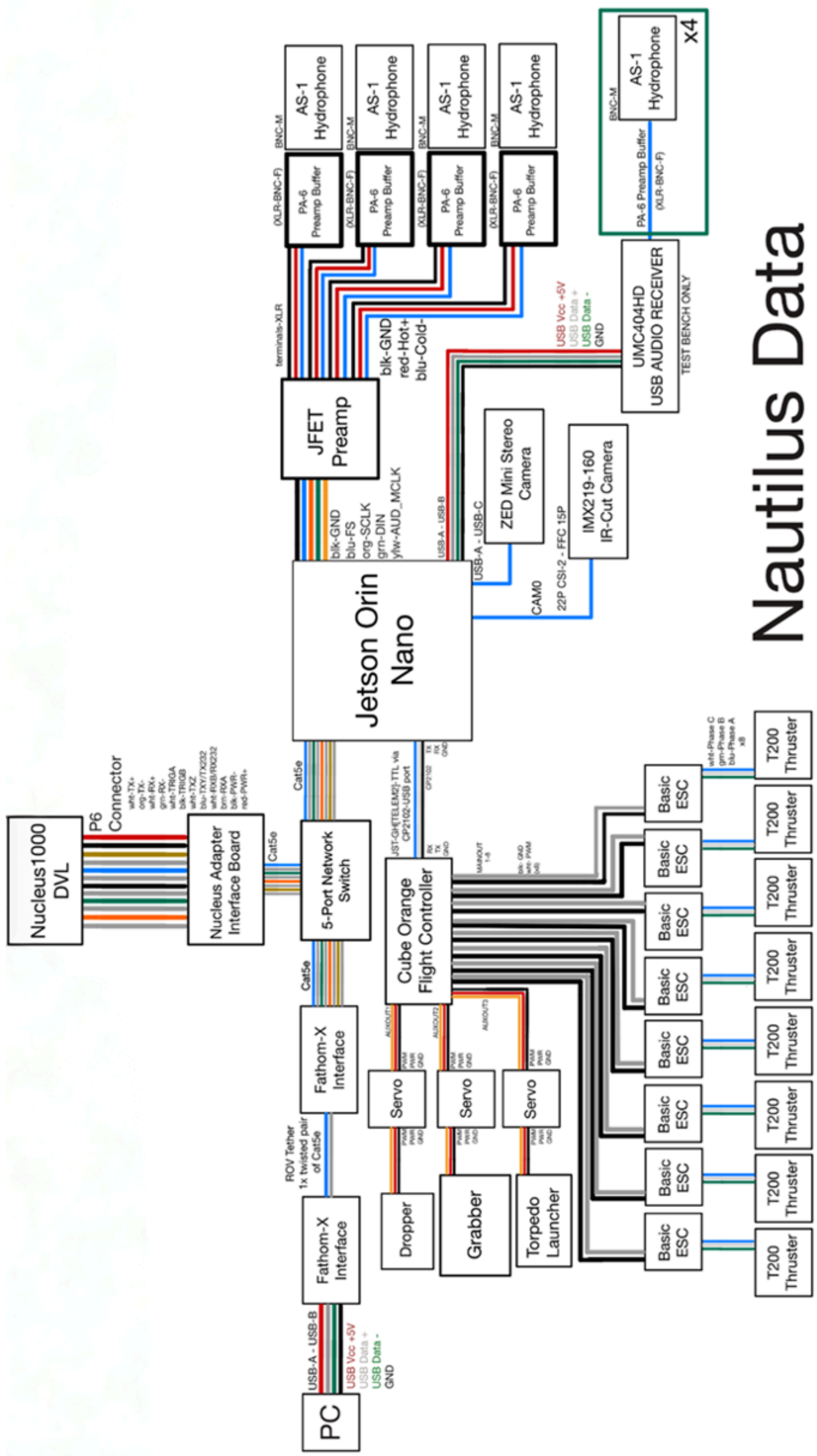
Cables & Cable Management	XT60 Battery Connector (5 ct.)	GetFPV	$6.00	2	$12.00
	High-Temperature PUR Subsea Cable (HP)	Blue Robotics	$19.00	2	$38.00
	High-Temperature PUR Subsea Cable (T200)	Blue Robotics	$12.00	2	$24.00
	PUR Subsea Cable (Lumen/Gripper Cable)	Blue Robotics	$16.00	3	$48.00
	WetLink Penetrators (M10) 4.5mm LC	Blue Robotics	$13.00	12	$156.00
	WetLink Penetrators (M10) 6.5mm LC	Blue Robotics	$13.00	15	$195.00
	WetLink Penetrators (M10) 8.5mm LC	Blue Robotics	$13.00	4	$52.00
	WetLink Penetrator Blank	Blue Robotics	$6.00	7	$42.00
	Universal Cable Jacket Stripper	Monoprice	$13.34	1	$13.34
	WetLink Penetrator Plug Wrench	BlueRobotics	$15.00	1	$15.00
	Submersible Pump Wire Splice Kit	Advance E & I	$16.00	2	$32.00
Working Materials	Workbench Mat	STREBITO	$11.19	2	$22.38
Tether	Fathom-X Tether Interface (FXTI)	Blue Robotics	$245.00	1	$245.00
	Binder 770 Bulkhead Connector	Blue Robotics	$20.00	1	$20.00
	Fathom ROV Tether	Blue Robotics	$260.00	1	$260.00
New orders	90 degree USB C-A cable	UGreen	$6.48	1	$6.48
	EC5 Connectors	Amazon	$12.99	1	$12.99
	Power Rail	Amazon	$12.99	1	$12.99
	RJ45 to JST GH Adapter	Blue Robotics	$8.00	1	$8.00
	Fathom-X Tether Interface Board	Blue Robotics	$140.00	1	$140.00

	Servo Connection Kit	Amazon	$23.00	1	$23.00
				Total:	$20,030.96

APPENDIX B
POWER ARCHITECTURE



APPENDIX C
DATA ARCHITECTURE



APPENDIX D
CAD DRAWINGS

Figure 9. Isometric View

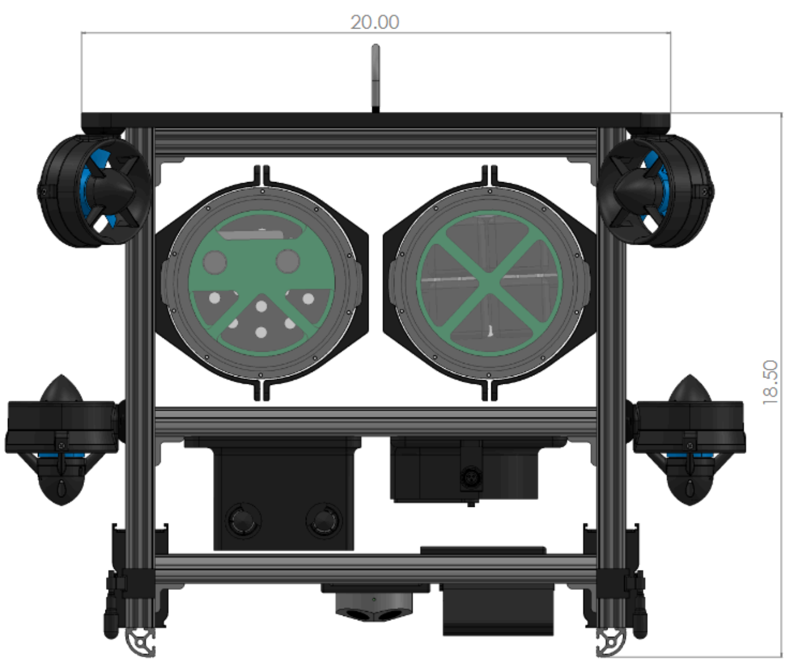


Figure 10. Front View

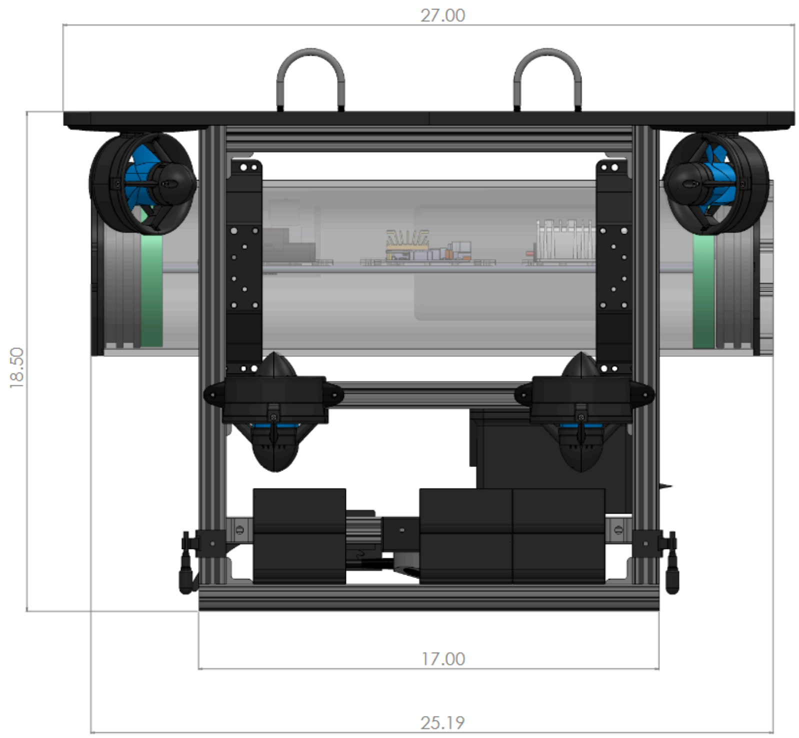


Figure 11. Side View

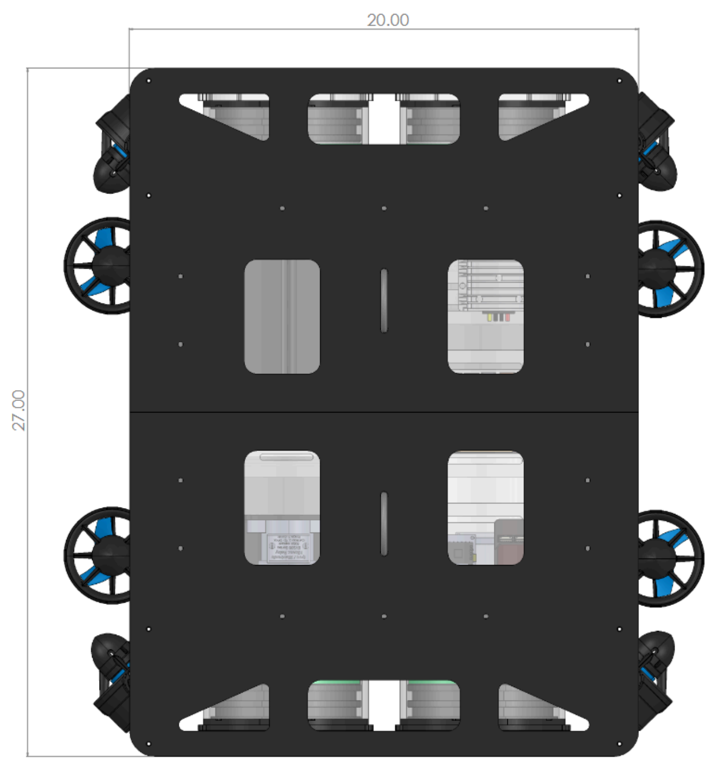


Figure 12. Top View

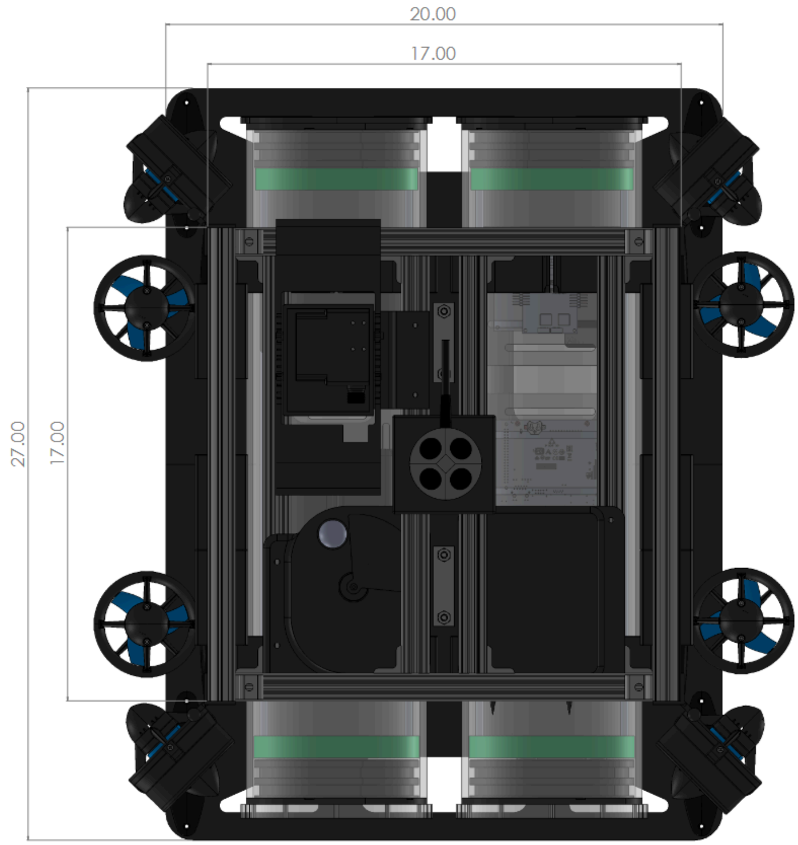


Figure 13. Bottom View

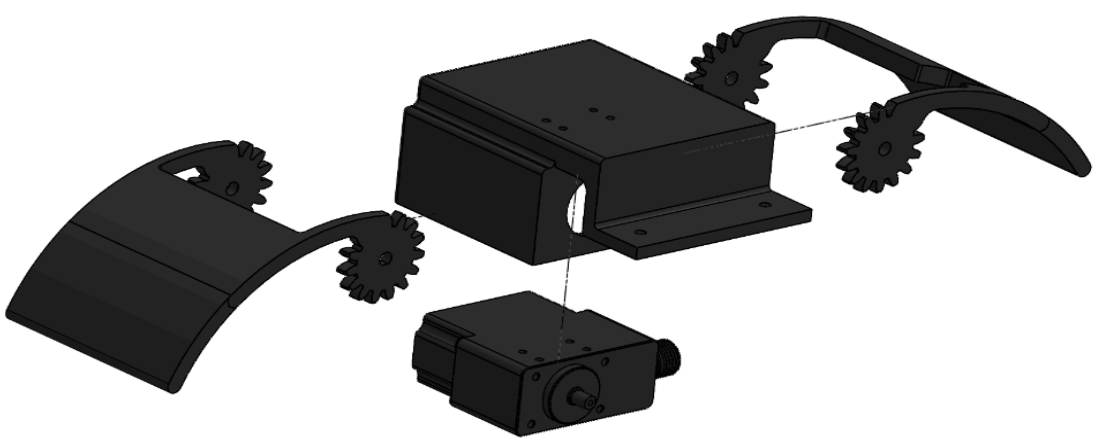


Figure 14. Grabber Exploded View

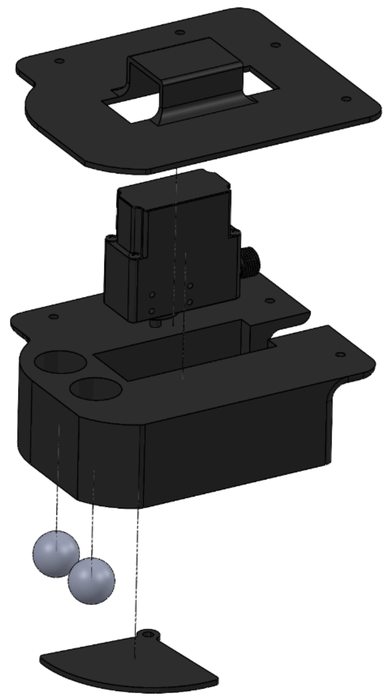


Figure 15. Dropper Exploded View

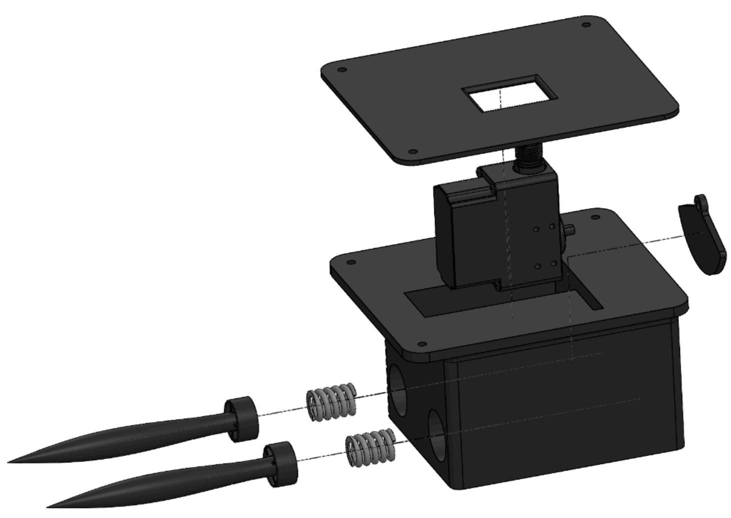


Figure 16. Torpedo Launcher Exploded View

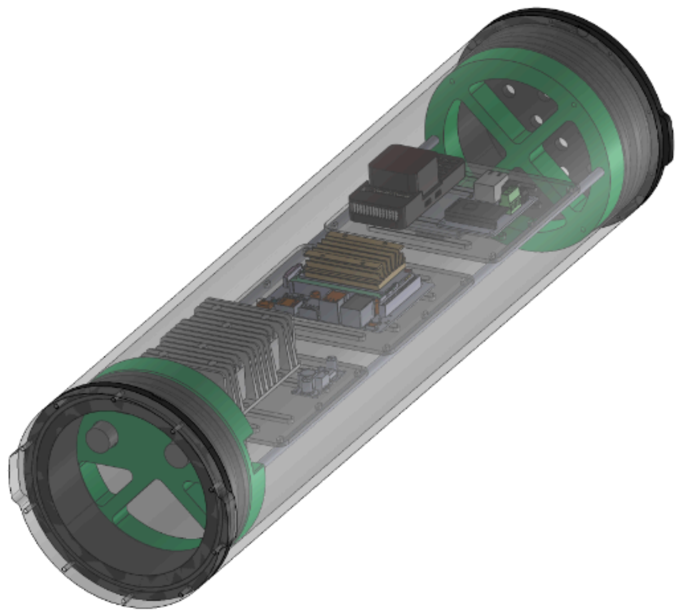


Figure 17. Electronics Bay

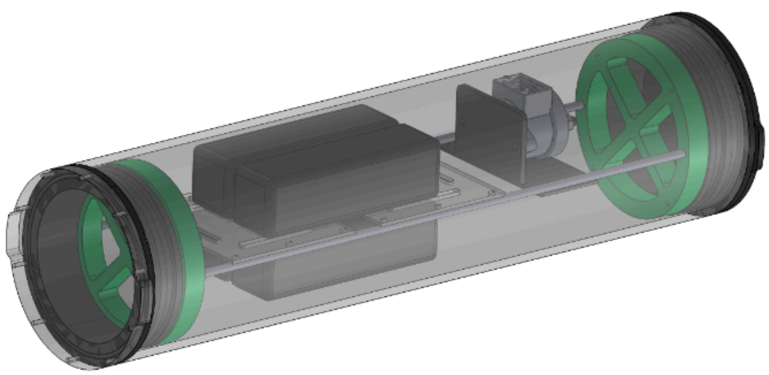


Figure 18. Battery Bay