Technical Documentation

Eastern Edge Robotics

Memorial University of Newfoundland | St. John's, Newfoundland and Labrador, Canada

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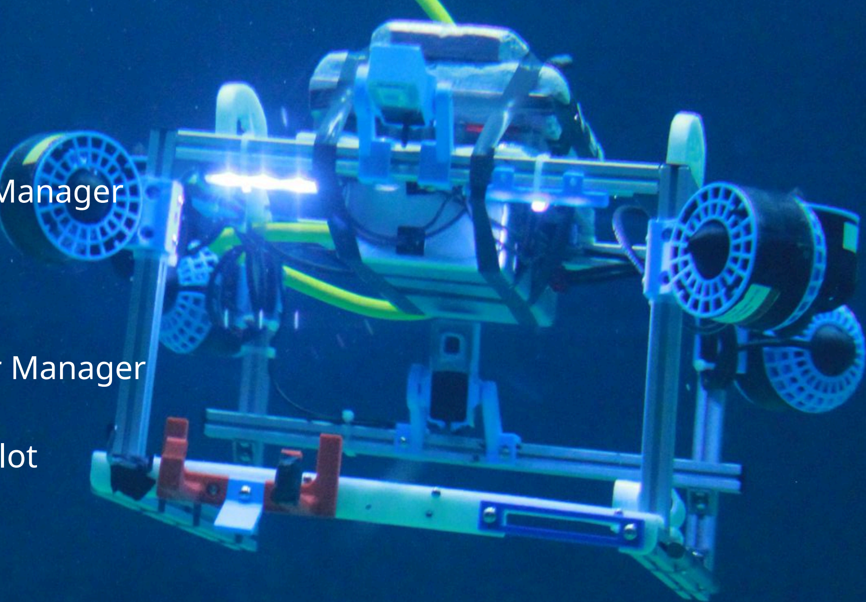


Contents

1 Abstract

In response to the Marine Advanced Technology Education (MATE) Center's Request for Proposals (RFP) [1], Eastern Edge Robotics (EER) has developed a custom Remotely Operated Vehicle (ROV), BlueStar. BlueStar was designed and constructed through the collaboration of 33 employees to aid in offshore operations in Newfoundland. The RFP has challenged EER with three offshore conditions that must be operated in: ocean waves, ocean currents, and surface ice. To meet the challenges of this RFP a user-centered design philosophy was leveraged in the design of BlueStar. Under these harsh conditions, this design philosophy removes complexity and uncertainty for the operator. BlueStar is equipped with two pre-configured tool skids for use in ocean-wave and current environments, and a vertical profiling float is deployable for operations under surface ice. Custom software has been developed for observation tasks such as coral garden modeling, invasive crab identification, and iceberg depth measurements. EER has rigorously tested BlueStar to ensure all features are intuitive and reliable in harsh ocean environments.

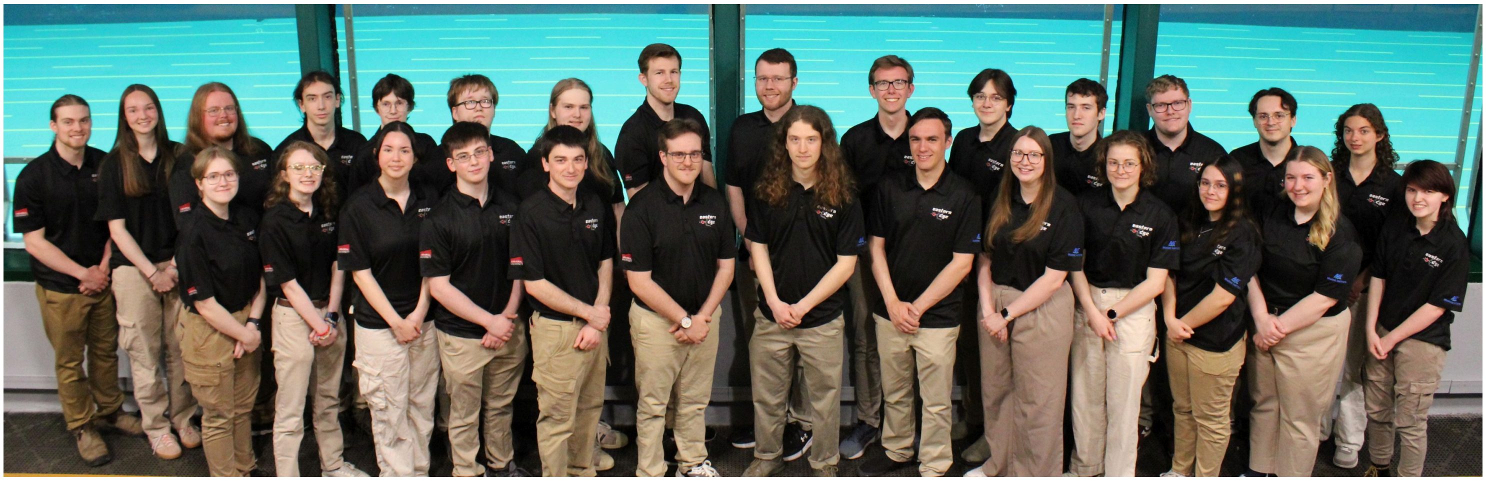


Figure 1: Eastern Edge Company Photo, Credit: Joe Singleton, 2026

Back Row: *Zach Hull, Abbey Bryden, Brandon Higdon, Ethan Preston, James Cole, Peyton Cashin, Evan Whelan, Russell Corbett, Logan Janes, Eric Goulding, Ty Freda, Colin Murphy, Liam Transue, Mark Johnson, Julia Butt*

Front Row: *Em Penney, Kaitlin Healey, Ozzy Hutchings, Patrick O'Brien, Charles Campeau, Ben Riggs, Brendan Booth, Evan Vokey, Jadzia Penney, Polina Konstantinova, Claire Harnum, Natalie Mitchell, Amelia Somers*

Missing: *Ash Peddle, Zaid Duraid, Julia Caines, Sadie Beaver, Finlay Jones, Keagan Slaney-Boland*

2 Teamwork

2.1 Company and Personnel Overview

Eastern Edge Robotics (EER) comprises 33 employees with backgrounds in Engineering, Computer Science, Nautical Science, Underwater Vehicles, Business, and Chemistry. The company follows a structure consisting of an Administrative Team and four Technical Teams: Mechanical, Payload, Electrical, and Software.

Table 1: EER Employee Roles, Credit: Mark Johnson, 2026

Employee Roles	Responsibilities
Chief Executive Officer (CEO)	Establishes team goals, ensures all major deadlines are met, and leads all internal communication.
Chief Operating Officer (COO)	Defines and maintains team budget, and ensures necessary resources are available to all employees.
Chief Marketing Officer (CMO)	Leads all external communication, including social media, recruitment, sponsorships, and community outreach.
Chief Safety Officer (CSO)	Establishes and maintains safety philosophy and protocols across all company operations.
Technical Team Leads	Manage day-to-day tasks in their respective technical team and provide technical training and mentorship to junior employees.
General Employees	Perform work on a given project under supervision of Technical Team Leads.

Each Technical Team is responsible for designated aspects of the ROV's design and testing. The responsibilities are defined as shown in Table 2.

Table 2: EER Employee Roles, Credit: Mark Johnson, 2026

Technical Team	Responsibilities
Mechanical	Chassis, waterproof enclosures, buoyancy, thruster configuration, and camera assembly.
Payload	Physical tooling to complete tasks outlined in RFP, including the vertical profiler float.
Electrical	Electrical components, including power conversion, distribution, tooling control, and tether.
Software	Control software, communication protocols, user interfaces, and software-based tasks outlined in RFP.

Figure 2: EER Organization Chart, Credit: Jadzia Penney, 2026

2.2 Scheduling

EER began development of BlueStar in September 2025 and spent approximately 10 months developing the vehicle. During this time, scheduling was crucial to ensure the company had the time to design, test, evaluate, and launch all required features to create a user-friendly system that met the RFP specifications.

In September 2025, EER created a **Gantt Chart** (Appendix B) to plan an overall schedule for major deadlines. To ensure the schedule was properly maintained, EER held **quarterly team-wide meetings** to update progress on all projects. During these meetings, Technical Team leads gave short presentations summarizing what each employee worked on and any potential roadblocks encountered in their progress. Establishing a schedule with tools such as a Gantt Chart and ClickUp (a project management software), along with regular reviews during company meetings, created a smooth yet adaptable schedule for day-to-day operations and long-term goals.

2.2.1 Resources, Procedure, and Protocols

Solving day-to-day issues was made easier by leveraging an array of **resources** to ensure company-wide communication, including Discord, Clickup, Google Drive, GitHub, and Onshape. Discord is the primary method of team communication, used for general discussions and important announcements. In addition, the company began a "Weekly-Updates" channel on Discord, requiring each employee to post a summary of their work and what issues they are currently facing. ClickUp serves as a live schedule for tracking all progress and deadlines, providing clear project timelines and task ownership, addressing scheduling issues experienced in previous RFPs. Google Drive, GitHub, and Onshape are all cloud-based file-sharing systems used for written documents, code, and Computer-Aided Design (CAD) models. In the event that a new revision of a file causes a problem for employees, these resources can be rolled back to previous versions.

EER's **procedures** provide an essential source of information for employees to perform tasks in the correct order. These procedures avoid problems arising from misunderstood operational methods or actions in day-to-day work. Key resources commonly used by employees include the ROV Startup Guide, On-Deck Checklist, and Purchase Requisition (PR) How-To Video. The ROV Startup Guide and On-Deck Checklist, shown in Appendix A, outline the exact order for deploying BlueStar, keeping both personnel and ROV safety in mind. Additionally, for daily purchases made by an employee, the PR How-To Video explains the exact reimbursement method so no information is omitted.

Protocols at EER define "what to do and who should do it" in a variety of general situations. All employees should be taught protocols for handling on-site accidents or mission-related problems. For example, in the case of an employee injury, the **Incident/Near-Miss Form** should be completed. This provides EER with a source of information for the incident's events, which the CSO can address. When operating the ROV, protocols for deck crew members are followed according to their assigned roles and responsibilities. Roles include a Pilot, Co-pilot, Science Officer, Tether Managers, and a Deck Manager.

3 Engineering Design Rationale

EER's user-centered design philosophy focuses on developing intuitive and consistent solutions for offshore environments in Newfoundland. Creating designs that are intuitive and consistent increases the probability of success for the operator. This philosophy has resulted in an ROV ready to complete all RFP requirements.

During the development of every ROV component, the company followed a step-by-step design process, which is explained below using the Forklift tool as an example:

1. **Problem definition:** Design one tool to complete the eDNA connector, micropile release, and bubble curtain deployment missions to maximize space used and development cost.
2. **Brainstorming:** Building on a previous design, EER brainstormed what needed to be changed for this RFP. This included reinforcing the design and adjusting the tool's shape to fine-tune it for this RFP.
3. **Initial design:** A first design was created with the brainstormed changes implemented.
4. **Prototyping/testing:** The first design was fabricated and tested following the testing procedure outlined in Section 5.1.

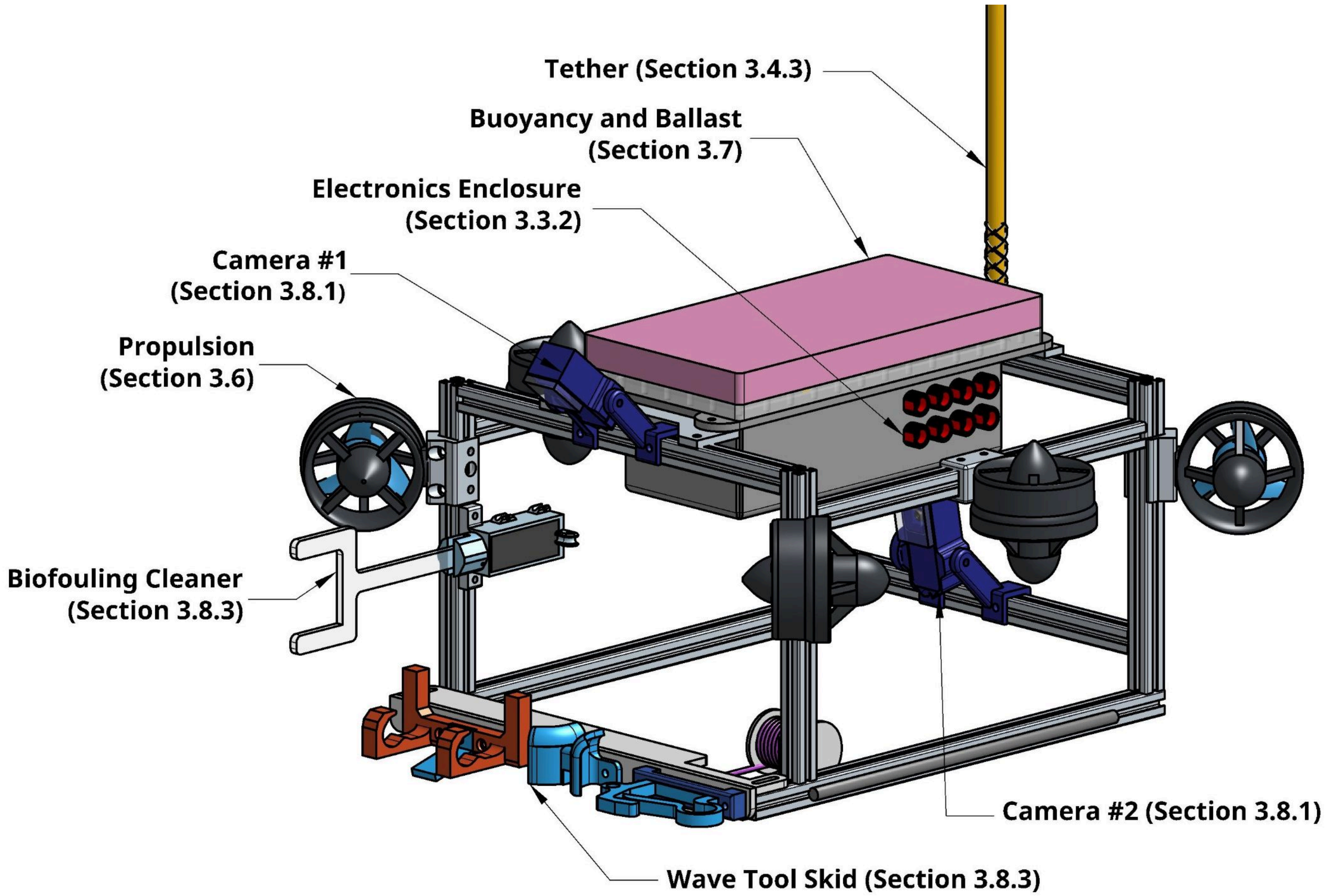


Figure 3: BlueStar Diagram, Credit: Eric Goulding, 2026

5. **Iteration/evaluation:** The first design is evaluated to determine if it is intuitive to use and meets the design requirements. If the design is not satisfactory, then step 4 is repeated.
6. **Launch final design:** Once the Forklift was mission-ready, it was implemented on BlueStar.

During the design process, all decisions have **trade-offs**, which are negative consequences associated with the chosen solution. For example, when deciding whether to build or buy the tether, EER weighed the improved buoyancy vs the increased cost. In past RFPs, EER built a tether in-house and used this experience to guide this year's decision. Following the design process above, feedback was gathered from tether managers, noting that the previous tether's buoyancy was irregular and negatively impacted ROV operations. This led to the decision to purchase a professionally made tether, with the trade-off of a high procurement cost. Every trade-off has associated limitations that should be carefully defined and evaluated in a trade study.

3.1 Innovation

When approaching new designs, the company must aim to **maximize functionality** while **minimizing cost**. When analyzing multiple years of past RFP expenditures, EER spent significant funds on its Payload system with little success in improving task efficiency at reduced cost.

In past RFPs, EER would allocate approximately $1000 of its budget to the Payload system for the development of electrically powered manipulators. However, while these manipulators were designed to improve user control, they proved difficult to iterate, time-consuming to integrate, and prone to failure. For this RFP, the company set a new budget goal of approximately $213 for tooling developments, as seen in the "R&D" section in Table 10. This pushed the company to innovate tooling for the 2026 RFP, focusing on designs that are efficient at tasks for minimal cost.

This included innovations such as two swappable tool skids between runs. These were made in-house with leftover material from prior RFPs, resulting in **zero cost to the company** for development. They provide key functionality by increasing the available space for tooling without increasing the ROV's size or compromising other tool locations. Another innovation was the Forklift, a non-powered tool capable of completing multiple precise tasks during a single mission run. This was achieved through extensive iteration testing, made possible with the inexpensive, fast-manufacturing method of 3D printing. The total cost to develop the Forklift was less than $20, providing greater functionality and reliability than tools the company has created previously for over x 10 the cost.

3.2 Problem Solving

EER approaches problems through a systematic lens. Problems are first defined and evaluation criteria are established to compare possible solutions. Once a problem is defined, the next step is to brainstorm various solutions. EER uses a round-robin brainstorming method that allows each employee to contribute ideas in an inclusive space [2]. The problem is presented to a group of employees. Each employee is allowed to present a possible solution, working in a clockwise direction around the group [2]. Employees then use the Pugh Method to evaluate potential solutions, and the chosen solution will proceed to the initial design phase of the design process (as outlined previously in Section 3).

Figure 4: Brainstorming Session, Credit: Jadzia Penney, 2026

The **Pugh Method** is a method used in **trade studies** to compare alternatives to a baseline solution [3]. First, EER defines evaluation criteria, such as cost, manufacturability, and safety. Then, a baseline solution is selected, typically a previous solution EER has implemented. Alternative solutions are compared against the baseline for the evaluation criteria. This process provides a rational method for selecting between alternatives. The Pugh Method is used by EER to identify the most viable solution to a problem, and then this solution can be pursued. Examples of trade studies using the Pugh Method are shown in Section 3.7 and Section 5.3.

3.3 Systems Design Approach

In EER's systems approach, the goal is to ensure seamless integration across BlueStar's systems. This means thinking of BlueStar holistically and understanding how each component is connected. For example, the mechanical and electrical teams collaborated to design the electronics enclosure, recognizing that its design affects key factors of BlueStar, such as the buoyancy, payload, and electronics systems. The collaboration among Technical Teams ensures solutions are balanced while providing all necessary functionality for the user.

3.4 Vehicle Structure

3.4.1 Chassis

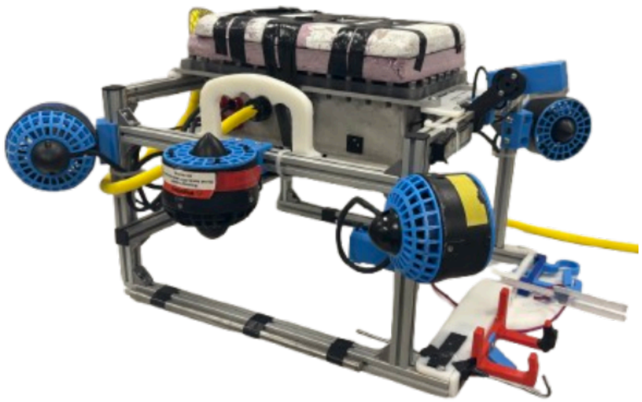


Figure 5: BlueStar, Credit: Mark Johnson, 2026

The chassis of BlueStar provides the structure to hold all physical components required for the ROV system. Its specifications include a cost of $194.53, volume of 610 x 590 x 340 mm, and a mass of 9.9 kg.

Cost: The cost of BlueStar's chassis is the result of using **20 mm x 20 mm aluminum T-slot extrusion** as the base material for its design. This material was chosen for its modularity and simplicity when cutting in-house. Aluminum extrusion provides a simple method for mounting components using **self-aligning T-nuts**. This allows the user to quickly swap between tool skids, such as those designed for the ocean wave and current missions. A key trade-off is the increased cost associated with importing aluminum extrusion and T-nuts into Newfoundland due to the materials' limited local availability.

Size: BlueStar is larger in size compared to EER's previous ROV, making it more difficult to transport to mission areas. However, this choice led to improvements in other sections of the ROV's design. Its larger size creates more space for camera views, tools, cable management, buoyancy, and ballast. Since more space is available, more components can be mounted and their locations can be adjusted based on user feedback.

Weight: A balanced approach to weight is essential when designing an ROV system. BlueStar must be light enough for operators to lift it out of the water while still retaining all required components to operate efficiently. Approximately 700 g of ballast was added to the bottom of the chassis to increase operational stability. While this accounts for a large portion of total weight, it is a necessary trade-off to stabilize the ROV in ocean waves and currents.

3.4.2 Electronics Enclosure

A key component attached to BlueStar's chassis is a **newly designed electronics enclosure**. The enclosure contains the onboard electronics system within a volume of 280 x 120 x 84 mm, sealed with an o-ring and transparent polycarbonate sheet.

Many common electrical components are rectangular, so a rectangular design was chosen for the electronics enclosure to increase packing density. The electrical and mechanical teams collaborated to save space on the ROV by reducing the size of the enclosure. This resulted in an enclosure that is 24% smaller and 20% lighter than EER's previous ROV. The extra space is used by other systems, such as cable management of propulsion and tether systems, and extra weight for ballast. A major trade-off of a smaller volume is the limited ability to add new components to the electrical system. However, it was decided that as long as the system provided all necessary functionality for the mission tasks, the overall improvements would provide a greater benefit to the user.

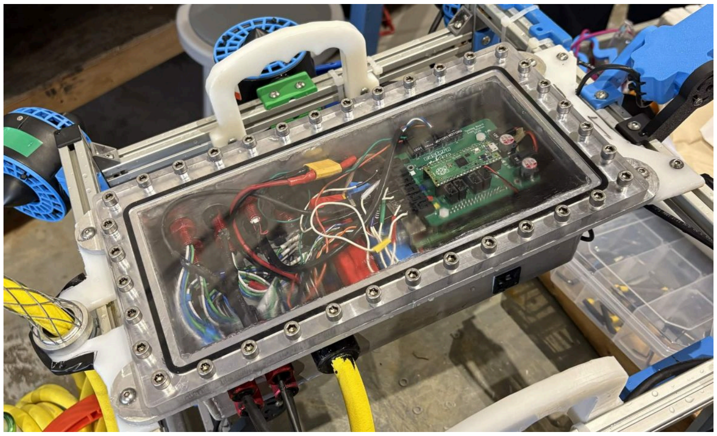


Figure 6: Electronics Enclosure,
Credit: Mark Johnson, 2026

While EER designed and tested the enclosure in-house, manufacturing was outsourced to Memorial University of Newfoundland (MUN) Tech Services. Outsourcing was used because the company lacked the equipment and training to perform sheet metal bending and welding in-house. MUN Tech Services also provided manufacturing at significantly reduced material and service costs, resulting in a $300 price reduction.

3.5 Electrical System

3.5.1 Electronics Design and Cabling

BlueStar's electrical system comprises four main components: **power conversion**, **power distribution**, the **Control Board**, and the **tether**. These components provide essential power from the 48V RFP designated source to all propulsion, tooling, sensors, and control systems on BlueStar.

The **power conversion** of BlueStar's electronics system consists of three Murata DC-DC conversion modules. This includes two 600W 48V-to-12V conversion modules connected in parallel, supplying power to the propulsion system. Additionally, one 75W 48V-to-5V conversion module powers the control system. To reduce cabling inside the enclosure and improve serviceability, all DCDC conversion modules are attached to their boards via **sockets**, allowing modules to be removed without soldering, significantly reducing user maintenance time.

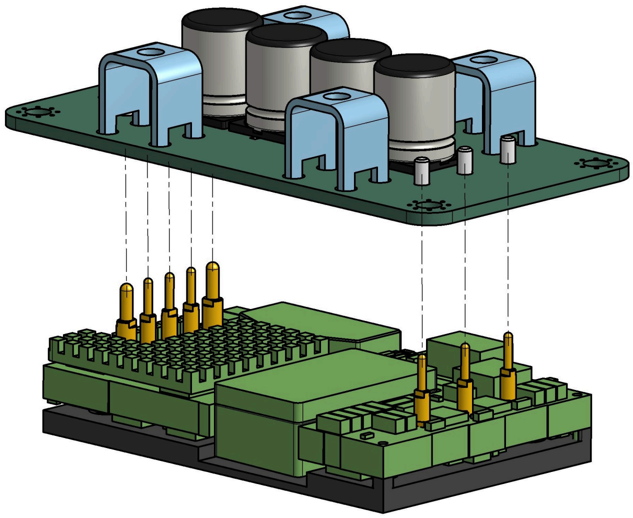


Figure 7: Socketed DCDC Conversion Modules,
Credit: Eric Goulding, 2026

BlueStar's **power distribution** distributes 12 V to the propulsion system via two custom-made aluminum bus bars. 12V and 5V power are provided to the control system via the Control Board. Compared to EER's previous ROV, the bus bars were reduced in size by 58%. This helped to achieve the goal of optimizing the size of the electronics enclosure while reducing cost by manufacturing in-house with small amounts of cheap aluminum.

3.5.2 Control Board

The **Control Board** is a custom PCB designed to fit on top of a Raspberry Pi 4 (RPi4) and supports piloting control of a variety of BlueStar's systems. The Control Board is built around a RP2040 microcontroller, which receives messages from the surface, via the RPi4. The board controls 6 thrusters, 2 LEDs, and a DC motor based on pilot input. Centralizing the control of all these components **greatly simplifies cabling**, saving space and facilitating easier maintenance in the enclosure.

Figure 8: Control Board, Credit: Evan Whelan, 2026

3.5.3 Tether

BlueStar's tether is the primary electrical and communication link between the ROV and the surface. The tether transmits power and operator control signals from the topside systems to the vehicle, and video from the ROV to the surface systems. BlueStar's tether is 20 meters long, and constructed using two 14 AWG conductors for power transmission and four twisted pairs for Ethernet communication, enclosed within a polyurethane outer jacket.

Figure 9: BlueStar's Tether Cross-Section,
Credit: Mark Johnson, 2026

In previous ROVs, EER fabricated a tether in-house using an inexpensive, simple-to-manufacture method. However, buoyancy foam had to be manually attached along the tether length, resulting in non-uniform buoyancy.

For this RFP, the company shifted towards a professionally manufactured tether. BlueStar's tether is designed by EER and manufactured by Derul Cable. It was decided to buy the tether because the company lacked the ability to manufacture a smooth, neutrally buoyant tether in-house. **Neutral buoyancy** is an important property for an ROV tether, as it minimizes the forces exerted on the vehicle by the tether during operation. A tether with excessive positive or negative buoyancy can pull on the vehicle in the water column, reducing maneuverability and increasing the likelihood of entanglement.

Figure 10: 2025 ROV tether,
Credit: Mark Johnson, 2026

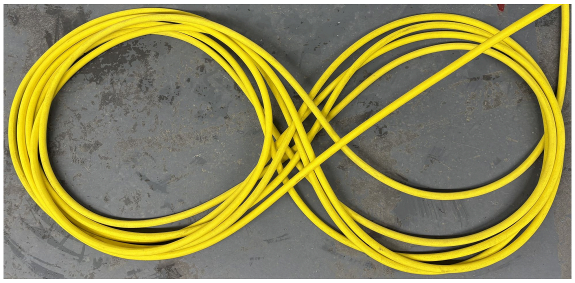


Figure 11: BlueStar's Tether,
Credit: Mark Johnson, 2026

The major **trade-off** of the new tether was the high upfront cost of $702.74. Due to a minimum order quantity of 100 m, the actual market value of BlueStar's tether is $140.55. While the upfront cost is high, 100m is enough length to make 5 tethers, meaning EER can use the same professional-made tether for at least the next 5 years.

The tether has two sides, topsides at the surface and an ROV side attached to BlueStar's electronics enclosure. A topsides box connects the tether to the 48V power supply and control laptop. For safety, a metal Kellems grip is attached to each side to act as **strain relief**. The ROV side allows tether managers to pull up the ROV by its tether in case of an emergency and the topsides grip prevents damage to surface electronics if pulled on accident.

Tether Management Protocol: During operations, two employees are designated as **Tether Managers**, and are responsible for controlling BlueStar's tether during mission runs. The Primary Tether Manager ensures the appropriate length is in the water for the pilot, adding or removing extra as needed. The Secondary Tether Manager places excess length in a "figure-eight" pattern, as shown in Figure 11, to reduce strain and keep the surrounding deck clear. The full tether management protocol is shown in Appendix A.

3.6 Control System

3.6.1 Software-Based Control System

To command BlueStar, a software-based control system was designed to provide a configurable and intuitive method for the pilot to complete mission tasks. First, EER defined the system requirements to achieve this design. This included a modular interface to allow the user to redefine controls, quick methods to change thruster power per task, and integration of mission task programs. These design requirements were documented in ClickUp, to track progress towards implementation.

The requirements allow the pilot to **customize the controls** to their preference, making them comfortable when operating BlueStar. Finally, the RFP outlines tasks that require the implementation of computer vision features. These requirements focus the design on improving the piloting experience while ensuring all functionality needed to complete the RFP is available. Control system requirements are verified by their ability to complete all RFP tasks in an efficient manner.

Once the requirements were defined, a diagram of how the control system links with the overall system was developed, shown in Figure 12. This diagram helped establish the control system's design architecture, taking into account the end systems affected, such as BlueStar, the Pilot Interface, and the Science Officer Interface.

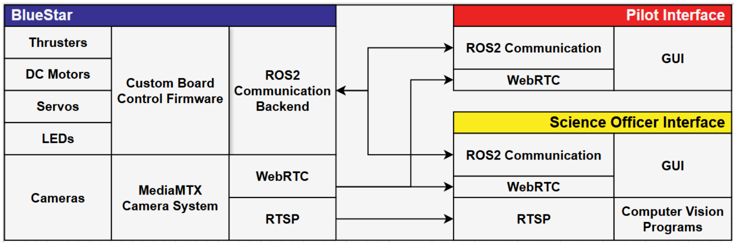


Figure 12: Control System Diagram, Credit: Peyton Cashin, 2026

Figure 13: Topsides Control Station, Credit: Mark Johnson, 2026

A **limitation** in the current software design is the user's inability to modify visual layouts in BlueStar's Graphical User Interface (GUI). While the controls and power can be customized, the user cannot easily change the camera size/location in the GUI without taking extended periods of time or relying on a software employee for changes. In future RFPs, this could be improved by providing an easy set of controls or predefined layouts/sizes in the interface that can change per the pilot's preference.

Additionally, there is no easy way for data analysis users (defined as "Science Officers") to access cameras or mission task software using the current control system. However, a solution was developed by creating a modified version of the piloting GUI specifically for Science Officer usage. This version retained the same camera layout shown in Figure 14, with added functionality including a screenshot mode for photogrammetry of coral, as well as the ability to run iceberg depth-measurement and crab-detection software.

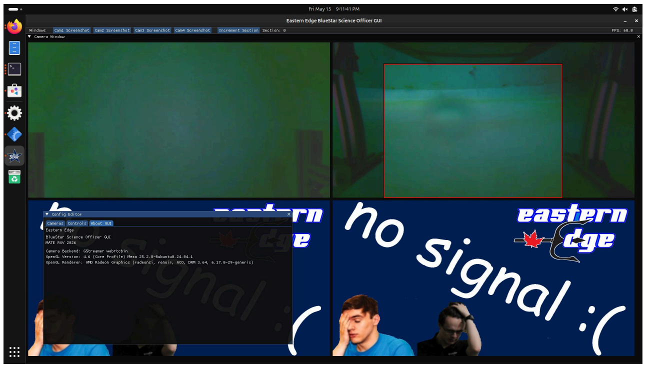


Figure 14: Science Officer GUI, Credit: Peyton Cashin, 2026

Throughout the software development process, GitHub was used as a company-wide platform for **version control**. GitHub makes it easy to track features and modules, and keeps a history of all commits in case of a software-breaking change. The use of extensive version control helped create an open environment where employees could test without fear of impeding functionality in existing code for the user. Employees can test new features on their own or with BlueStar as needed before being approved for final integration. Additionally, EER's GitHub is publicly available for other companies to test with their ROV systems and give feedback.

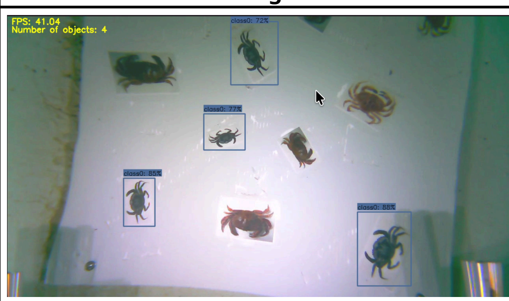
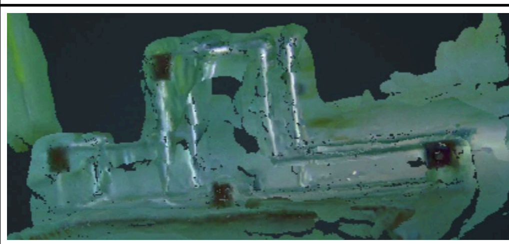
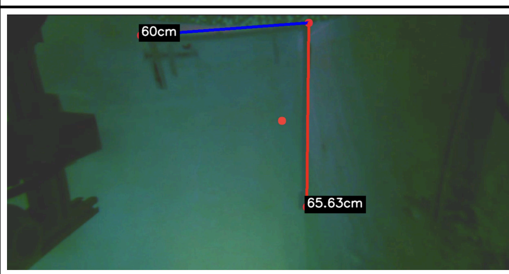
3.6.2 Mission Task Software

Three brand-new programs used by the Science Officer during operations were **key innovations** that optimized data collection tasks.

3.7 Propulsion

The propulsion subsystem of BlueStar consists of six Blue Robotics T200 thruster units arranged to provide five degrees of freedom (DOF): heave, surge, sway, roll, and yaw. This configuration is achieved by mounting two ver-

Table 3: Mission Task Software, Credit: Peyton Cashin, 2026

Name	Image	Description
Autonomous Invasive Crab Detection		An image recognition program detects invasive green crabs off the shore of Newfoundland. This software draws bounding boxes around each invasive crab, with the confidence level indicated in the corner.
Photogrammetry Coral Garden Modeling		To survey coral gardens, WebODM is used to create a photogrammetry model [4]. The Science Officer GUI takes rapid photos and automatically uploads to WebODM for processing.
Iceberg Keel Depth Measurement		BlueStar analyzes iceberg depth using a custom measurement program. The Science Officer takes a set of photos, selects 3 reference points, and the depth is automatically calculated.

tical thrusters on the left and right sides of the chassis, along with four horizontal thrusters positioned at 45° on its external corners. This setup provides precise control, enabling the pilot to move BlueStar accurately for missions such as retrieving coral samples or flying a transect in a current.

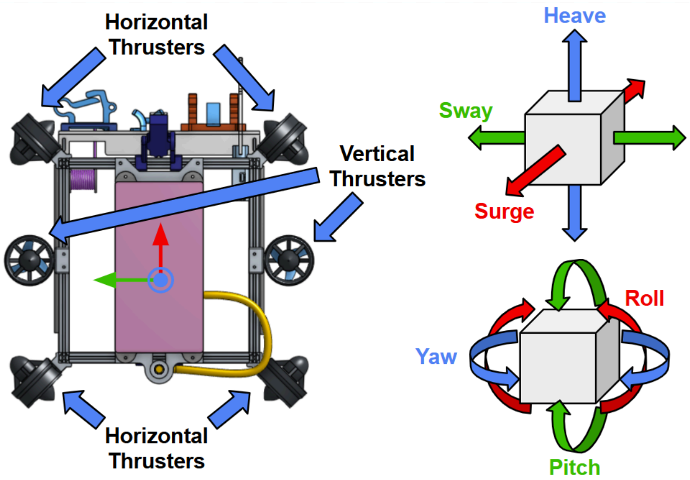


Figure 15: Thruster Configuration and DOFs, Credit: Mark Johnson, 2026

This layout provides BlueStar with sufficient maneuverability for both navigation and manipulation. Heave is required to lift objects, such as recovering old eDNA sensors. While yaw controls rotation when aligning with components, such as connecting the sensor to the port on the subsea observatory.

A **trade-off** of this setup is that BlueStar cannot perform pitch with its vertical propulsion. However, it was determined that pitch was not necessary to complete the RFP, as tooling can be designed to hold objects at an angle, instead of pitching the ROV. Adding additional thrusters would increase overall size, power consumption, cost, and weight, while reducing the available tool-mounting space. The two vertical thrusters cannot supply enough force to lift heavier objects. This is remedied by adding a lift bag to the tooling, which helps carry heavy objects, such as the lobster pot, and ascend to the surface quickly.

The Blue Robotics T200 thrusters were purchased last year for their high thrust-to-weight ratio and reliable performance at 12 V operation. Each thruster cost approximately $238, which is a heavy cost to incur for the company. While additional T200 or other thrusters could have been purchased for this RFP, it was determined with the Pugh Method that continuing with the same 6 thrusters was ideal. A set of criteria were established including thruster-to-weight efficiency, ability to meet the mission requirements, cost, and power consumption. This criteria proved that the 6 T200s could provide the same ability to complete the mission tasks while not incurring additional cost or drop in performance.

Table 4: Pugh Matrix Study of Thruster Options, Credit: Eric Goulding, 2026

Decision Criteria	Thruster Options		
	Purchasing two additional T200s	Reusing 6 Previous T200s	Purchasing New, Cheaper Thrusters
Thrust-to-Weight Ratio	S	S	–
Mission Requirements	S	S	S
Cost	–	S	–
Power Consumption	–	S	+
Sum of Positives	0	0	1
Sum of Negatives	2	0	2
Sum of Sames	2	4	1
Selected Thruster		✓	

3.8 Buoyancy and Ballast

BlueStar's buoyancy and ballast system comprises passive foam mounted on the top of the chassis and metal dive weights on the bottom. The buoyancy foam and ballast are shown in Figure Figure 3, made from extruded polystyrene foam and stainless steel dive weights.

A lack of buoyancy and ballast causes **instability** for pilots during mission runs, especially in high currents and waves present in Newfoundland's coastal environment. Since the center of mass for BlueStar is near its geometric center, the ROV will rotate around this point when pushed in the water. Positioning buoyancy at the top of the chassis and ballast at the bottom provides the maximum counterbalance moment to **keep the ROV stable** during the high currents and waves.

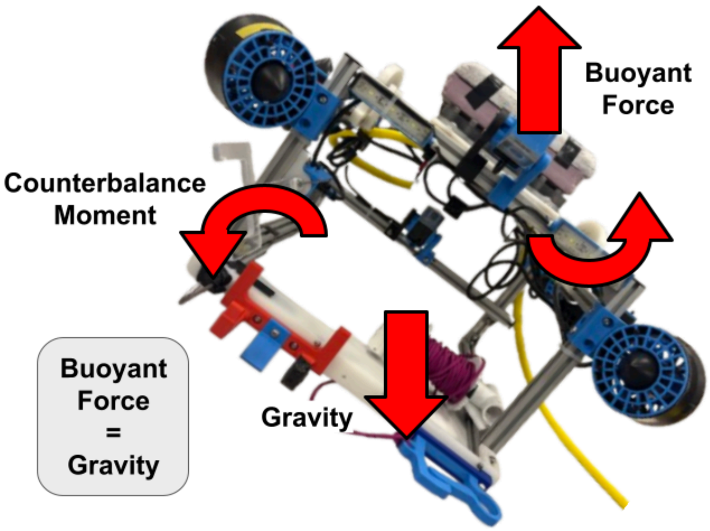


Figure 16: BlueStar's Buoyancy Forces and Moments, Credit: Mark Johnson, 2026

3.9 Payload System

3.9.1 Cameras

BlueStar has two cameras to allow the pilot to perform mission tasks and the Science Officer to utilize the image processing software. Two cameras are the minimum number required to provide **depth perception** for the pilot so they can judge the size and distance of objects in front of them. While more cameras would provide better spatial awareness, adding more cameras would increase computational load on the onboard RPi4 and increase the overall cost and development time of BlueStar.

While designing the camera system for BlueStar, EER's highest priority was ensuring the cameras were reliable and user-friendly. Last year, custom-made cylindrical enclosures had problems with leaking o-ring seals. To remedy this problem, a new enclosure design was created by encasing the camera hardware in **epoxy and silicone**. This method solved the previous leaking issues caused by temporary seals and proved to be very cost-effective compared to purchasing market enclosures. Also, the company chose the Arducam Wide Angle Camera Module 3, based on the evaluation in Section 5.3. Their smaller assembly size allows them to be mounted in positions not possible with larger camera modules, giving better views for the pilot.

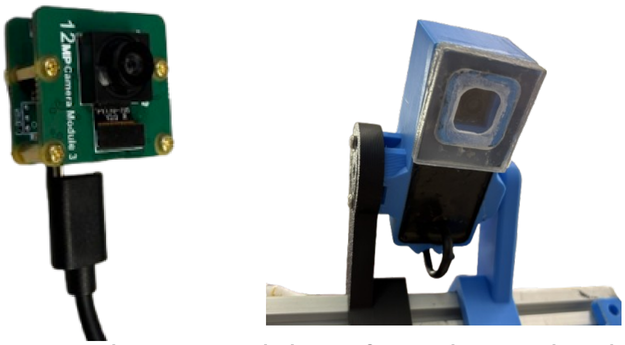


Figure 17: Arducam Module (Left) and Potted Arducam Module (Right), Credit: Mark Johnson, 2026

One camera (Camera 1 in Figure 3) is positioned at the **front of the chassis**, directly above the tooling skid. This camera primarily provides a top-down view for detecting crab species, flying transects, and installing micropiles, which all take place directly below the ROV. The second camera (Camera 2 in Figure 3) is positioned on the **back of the chassis**, providing the main view for the pilot during movement. This camera is ideal for viewing in front and on the edges of the ROV chassis, which is important for general piloting and in tasks such as surveying icebergs.

3.9.2 Tooling

When developing BlueStar's payload system, EER focused on building cost-effective and user-friendly tooling. Each tool was designed to address the problems outlined in the RFP mission tasks, following the design process outlined in Section 3. All tooling for BlueStar was designed and **built in-house**. The majority of tooling uses inexpensive materials such as 3D-printed plastic, PVC piping, and metal rods, helping keep costs low when numerous iterations were required.

In this approach, a key decision for each tool was whether to use an active or passive design. Active designs use an external power source, such as electricity or pneumatics, to drive component motion. Passive designs have no external power source and rely solely on non-movable parts or energy generated by propulsion to perform their functions. While BlueStar's control system can actuate active tooling, they are more difficult to iterate due to longer integration time into the overall system. For this reason, EER chose to prioritize passive designs, allowing more time for **iterations and improvements** across all tooling.

The main challenge for this year's RFP is the requirement to operate the ROV in two ocean environments, including wave and current conditions. To address this challenge, EER has developed an innovative method for mounting tools to BlueStar that has not been used in the company's previous ROVs. EER built two custom tool skids, one for each ROV mission environment. The tool skids are held in place by two drop-in T-nuts, providing a quick way to **swap between them** as environments change. These skids greatly increase operational efficiency by allowing a larger number of available tools for the pilot without increasing the ROV's size.

3.9.3 Tool Skids & General Tooling

Figure 18: Ocean Current Tool Skid, Credit: Mark Johnson, 2026

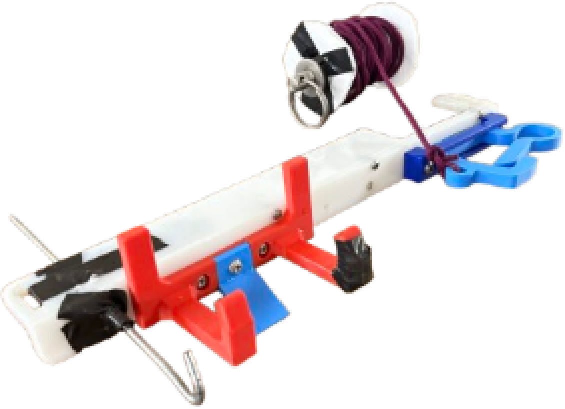


Figure 19: Ocean Wave Tool Skid, Credit: Mark Johnson, 2026

In addition to the two tooling skids, BlueStar is equipped with other **general tooling** that can be used across both mission environments as required, which is outlined in Table 7.

Table 5: Ocean Current Skid Tooling, Credit: Mark Johnson, 2025

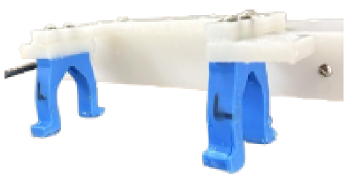
Tool Name	Image	Description
Coral Clips		Two 3D printed clips were designed for a snap fit when pressed against coral species. They hold coral tightly to avoid losing samples in ocean currents.
Tent Pegs		Stainless steel Tent Pegs protrude far from the ROV, allowing the pilot to hook two basket star coral at once. The long length and tight angle hook prevent the samples from falling out due to currents.

Table 6: Ocean Wave Skid Tooling, Credit: Mark Johnson, 2025

Tool Name	Image	Description
Tent Peg		A single Tent Peg reaches a short distance out on the Wave Tool Skid. Its thin yet strong structure makes it an ideal tool for carrying eDNA sensors.
Forklift		The Forklift is a multipurpose, 3D-printed tool capable of placing bubble curtains and installing eDNA connectors.
Magnet		A high-strength magnet is attached to one of the Forklift forks. This allows the pilot to pull the pin required to release the micropile during Micropile Installation without dropping it, preventing debris.
Recovery Line		For BlueStar's Recovery Line, paracord is wrapped around a plastic spool. This provides a smooth, strong surface for the paracord to slide across as it unspools. A 3D-printed clip provides a secure attachment method to the buoy anchor for recovery.

Table 7: General Tooling, Credit: Mark Johnson, 2025

Tool Name	Image	Description
Lift Bag		A lift bag is available to increase BlueStar's upward force and vertical speed. With only two vertical thrusters, lifting the 20N lobster pot can cause heavy strain on the ROV's propulsion system. Pumping air into the lift bag with a bicycle pump increases BlueStar's buoyant force.
LEDs		BlueStar uses two dimmable LEDs mounted on the top front of the chassis. These LEDs are reused from the previous RFP. Pilots can illuminate areas in front of the ROV to provide clearer images and more accurate color when using crab detection, iceberg depth measurement, or coral photogrammetry software.
Biofouling Cleaner		A waterproofed DC motor with a two-prong fork is used to remove biofouling from the Holyrood subsea observatory camera.

3.10 Vertical Profiler

BlueStar's vertical profiling float is a **sensor** designed to collect **pressure and time data** at specific depths beneath sea ice and relay it to the surface control station once recovered. The float can maintain a depth at both 2.5 m and 0.4 m under sea ice, with an approximate accuracy of +/- 30 cm, within the RFP-required +/- 33 cm. The Science Officer can analyze the collected data to determine whether the float functioned as expected.

BlueStar's profiler design achieves its required depth targets through a DC-motor-powered syringe that intakes and releases water. This creates a variable buoyancy engine, displacing air with water (or vice-versa) to change the density of the profiler. The motor is controlled using a PID control loop and a pressure sensor for precise depth control. The profiler is designed to be easy to start via an onboard power switch and features an LED array to signal completed profiles to nearby ROVs.

Figure 20: Vertical Profiling Float, Credit: Charles Campeau, 2026

3.11 Build vs Buy, New vs Used

Given a limited time-frame to develop BlueStar, EER must carefully evaluate whether to **build** a given vehicle component in-house, or **purchase** a off-the-shelf solution. The benefits of building components in-house include tailoring components to user preferences, lower costs, and increased employee knowledge. Benefits of buying components include reducing employee workload, faster turnaround times, and access to parts that cannot be made in-house. Purchasing a neutrally buoyant tether for BlueStar was a key build vs buy decision. This tether is easier to manage in ocean currents and wave conditions, with the **trade-off** of a higher procurement cost. Another key build vs buy decision was BlueStar's tooling. Purchasing tooling for BlueStar would have reduced development time, but building the tools in-house allows EER to **optimize each tool** for its specific RFP task.

Developing a consistent ROV also requires careful consideration of **new vs used** decisions. A major component that was newly developed for BlueStar is the electronics enclosure. An old, larger enclosure could have been reused for this RFP, saving money and development time. However, EER decided that a smaller enclosure would greatly benefit BlueStar by creating more space for cabling. Another important new vs used decision was the propulsion system. EER considered a variety of options, including purchasing more thrusters or switching to another type. After weighing possible solutions using a Pugh Matrix (Table 4), it was decided to **reuse** Blue Robotics T200 thrusters, as this would significantly reduce BlueStar's development cost.

4 Safety

The goal of EER's safety rationale is "no one gets hurt". At EER, the safety culture is present to support employees as they perform their work, not impede them. This includes providing proper procedures, educational opportunities, protective equipment, and design methods that all employees can access. The CSO has established company safety based on MATE ROV and Oceaneering HSE Employee Handbook standards [5], along with any BlueStar-specific features or procedures.

4.1 Personal Safety

EER has adopted an incremental approach to **personnel safety**, leveraging both available company safety resources and peer-to-peer safety collaboration.

- During orientation, the workplace rules are introduced to each employee. This includes the major hazards present, such as fiber-optic tethers from previous RFPs (now substituted for safer copper-based tethers), the location of Personal Protective Equipment (PPE) such as safety glasses, and rules such as never working alone.
- Employees are also expected to complete the Student Design Hub Safety Training course, a short course offered by MUN. This course covers workshop safety for all tools and equipment used in EER's ROV shop and similar working environments.
- Senior employees take on a mentorship role to provide guidance and training to junior employees on safe work practices and use of equipment.

4.2 Equipment Safety

Whether it's an employee operating BlueStar on a mission or a bandsaw in the shop, EER takes great care to ensure everyone applies **equipment safety** for their own well-being. It must be known which equipment is dangerous and how it can be controlled by implementing specific methods and design features.

- All powered tooling, including bandsaws, 3D printers, Dremels, and more, have procedures taught and supervised by senior employees to reduce potential harm during BlueStar's development.
- BlueStar is designed not to detrimentally affect or endanger employees, the marine environment, or itself during operation.
  - Custom 3D-printed guards are attached to all thrusters, and sharp edges of the structure have been filed down. This prevents small objects, such as fingers, from being crushed by rotating components and prevents the ROV from causing lacerations.
  - All topsides control equipment meets a minimum IP30 rating, protecting BlueStar's electrical system from damage caused by tools and wires during user maintenance.
  - Tooling is specifically designed to collect coral samples in a minimally invasive manner by only touching their substrates.
  - Image processing is used to model large coral gardens and measure iceberg keel depth. This ensures no contact is made with either of these elements during operation. Functioning as a method to protect the marine environment and prevent damage to the ROV from colliding with hard surfaces like ice.

4.3 Operational Safety

EER is always open to modifying its **operational safety** procedures when records demonstrate a potential shortfall. Three main forms provide a record of work performed and incidents for evaluation, which the company stores via Google Drive.

- A **Job Safety and Environmental Analysis (JSEA)** is completed prior to any work commencing at EER. The JSEA offers employees a guide while they self-evaluate their environment (including location, personnel, potential hazards, and mitigating risks) and the impact of their actions on themselves and others.
- If an accident or near-miss occurred, employees would use the **Incident/Near-Miss form**. This provides a method for describing

the situation and explaining how existing safety procedures may need to be updated to prevent future occurrences.

- The **Unsafe Work Refusal form** is used when an employee feels unsafe when completing an assigned task. This gives the employees the power to refuse any work they feel uncomfortable performing and provide feedback to improve work in the future.

Operational safety is also considered when operating BlueStar. Checklists are created in collaboration with the deck team to ensure maximum safety during deployment, tether management, and actions in the event of communication loss with the ROV. These checklists ensure that all personnel are protected during the entire time the ROV is powered, and can be viewed in Appendix A.

5 Critical Analysis

5.1 Testing

During the development of BlueStar, EER used a three-step testing methodology to verify the safety and reliability of all ROV components for the user. The first step in the process is **isolated testing**, ensuring that each unit functions as intended with limited external factors present. Secondly, **integration testing** combines isolated components into a larger assembly to test system functionality. Finally, **water testing** verifies that the systems can function at the required depth of 5 m and 15 minute mission time underwater for the pilot's benefit. No component of BlueStar is considered complete until it passes all three tests consecutively, and then it can be deployed for use during operation.

This methodology is exemplified in the development of the new camera assemblies (see Section 3.9.1).

1. **Isolated Testing:** The camera's electronic hardware and 3D-printed enclosures were initially tested separately from each other and from the rest of BlueStar's assembly. The electronics were tested to determine whether they could produce an ideal video for the pilot using a reliable non-ROV power source and communication method reflective of BlueStar's computational system, such as a laptop. These separate tests proved that the cameras were capable of producing a clear, low-latency video feed with a sufficient frame rate for piloting underwater and completing autonomous tasks. The 3D-printed assembly was tested for dimensional accuracy, and sealing was verified to prevent epoxy and silicone from leaking during curing.
2. **Integration Testing:** Once each component was tested to confirm individual functionality, they were assembled and sealed with epoxy for integration into the ROV systems. Before full integration, the components were retested with a non-ROV power source and communication device to ensure the assembly maintained functionality after the epoxy cured. Next, the cameras were integrated into BlueStar's control system by connecting to the RPi4 via potted cables. The assemblies were tested for proper control functionality across factors such as video quality, latency, and computational load when utilized with BlueStar's piloting interface and autonomous software. During integration testing, it was found that the computational load imposed by the cameras caused the RPi4 to overheat. To remedy this, a heatsink and fan were added, which solved the overheating problem.
3. **Water Testing**: Finally, once the cameras were integrated into BlueStar's control and mechanical systems, they could be tested in water for reliability and used in mission practice for final approval by the pilot. The

primary consideration during water testing was the cameras' ability to remain functional at depth and for extended periods underwater. Once its reliability was verified, the usability of the system was tested by completing mission tasks with pilot feedback. A key finding was that the color contrast displayed by the cameras was significantly worse underwater, resulting in poor visibility for modeling coral and distinguishing crab species. This required iterations in the color display of the camera systems until the pilot approved satisfactory visibility, verifying they were ideal for completing the mission tasks.

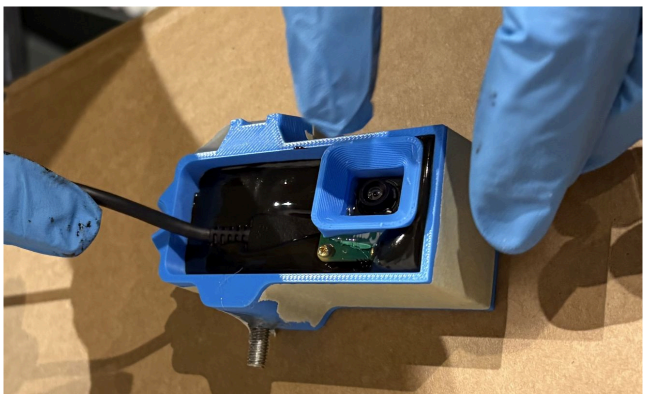


Figure 21: Camera Epoxying, Credit: Ty Freda, 2026

Software Testing: During the testing of BlueStar's image processing systems, employees conducted extensive testing to confirm functionality when in subsea environments. **EER's autonomous invasive green crab model** is trained and tested on image data provided by the MATE RFP [6]. **Isolated testing** was performed out-of-water with a laptop camera, as seen in Figure 22, initially identifying green crabs with a 75 - 90% confidence, with no observed false-positives. However, testing with the ROV cameras in **integration** introduced additional variables such as lower image quality, reflections, and FOV reduction, which reduced confidence levels. With further image training, the model passed both integration and **water testing**, capable of detecting green crabs with a confidence of over 95%, providing high accuracy to users when analyzing and reporting invasive species.

Figure 22: Crab Detection Testing, Credit: Patrick O'Brien, 2026

5.2 Troubleshooting

When developing BlueStar, EER encountered a variety of issues that required vehicle troubleshooting. To support employees during troubleshooting, EER has established a four-step Root Cause Analysis troubleshooting plan: **1) problem definition**, **2) data collection**, **3) determining cause**, and **4) implementing solutions**. Using a systematic troubleshooting process provides a clear set of steps to identify the immediate problem, find its source, and implement a solution, so BlueStar can return to operational standards.

An example of this systematic approach in use was when a significant leak was **defined as a problem** in the electronics enclosure during testing. In order to collect data, a vacuum was pulled on the enclosure and soapy water was sprayed to test for leaks in the penetrators. However, the penetrators showed no sign of leaks, **eliminating them as a potential cause**. This prompted employees to try a new method of data collection, taping pieces of paper nearby welded edges inside of the enclosure. This proved successful in **identifying the cause of the leak**, resulting from a poorly executed weld at the corner of the enclosure. Brainstorming **identified possible solutions**, but the final decision was to use epoxy to fill the crack and avoid potentially costly and time-consuming solutions, such as rewelding. Finally, the epoxy **solution was executed** and retested extensively to verify its ability to solve the sealing issue.

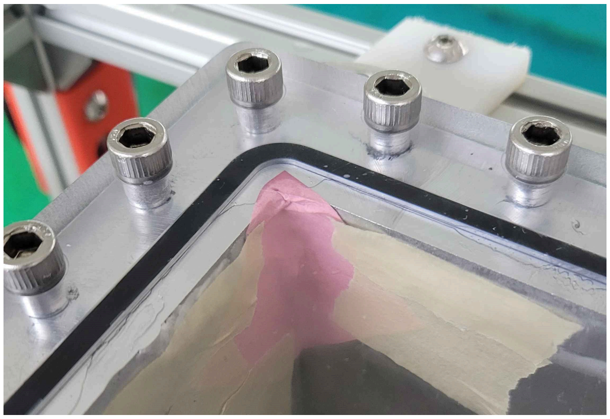


Figure 23: Paper Leak Test, Credit: Eric Goulding, 2026

Using this systematic approach, EER correctly identified the problem, collected data, identified the cause, and developed an executable solution to move forward. Without this method, problems such as the enclosure leak could have persisted longer and significantly delayed BlueStar's development.

5.3 Evaluation of Design Options

When choosing among various design options, prototyping and testing are essential to create points of comparison. These points of comparison can then be evaluated to provide quantitative and qualitative reasoning to inform design decisions.

For the camera hardware system, EER prototyped and tested 3 different camera module assemblies. Performance data was collected for comparison in a Pugh Matrix Method. The criteria chosen to compare was the computational load, latency, frame rate, and the overall dimensions found in the prototypes. The Raspberry Pi v3 Wide (Ethernet) was selected as the point of comparison for alternatives, where S is the same, + is a positive, and – is a negative [3].

Table 8: Pugh Matrix Study of Camera Options, Credit: Eric Goulding, 2026

Decision Criteria	Camera System Options		
	Raspberry Pi V3 Wide (USB)	Raspberry Pi V3 Wide (Ethernet)	Arducam Wide Angle Camera Module 3
Reliability	–	S	+
Latency	S	S	–
Frame Rate	S	S	–
Size	–	S	+
Sum of Positives	0	0	2
Sum of Negatives	2	0	2
Sum of Sames	2	4	0
Selected Camera			✓

Based on the comparisons made, EER chose the Arducam Wide Angle Camera Module 3. While some trade-offs include higher latency and lower frame rate, they excel in their reliability and size. This made the Arducams ideal for reducing computational load on the RPi4 with multiple cameras and for placing them at viewing locations unavailable with bigger modules.

6 Budget

The EER budget for the 2026 RFP was developed based on previous successful RFP budgets, historical operating costs, and expected contributions from recurring sponsors. To plan expenditures continuously, monthly budget meetings were held with team leads and company mentors. The first meeting established a budget through estimating the cost of BlueStar's development, safety requirements, new equipment, marketing, competition fees, and general company expenses. Future meetings reviewed past expenditures, updating the budget to reflect any required changes and additional funding acquired. The majority of available funds are allocated to essential items, such as ROV development.

As shown in Table 10, the total budget for the 2026 RFP amounted to $8344.22, with expenditures of $5559.25. Of these expenditures, $1803.67 was allocated to new components for BlueStar, $1793.24 to new equipment for employees, and the remainder for other miscellaneous costs, including administration, taxes, and shipping.

To meet the defined budget, EER optimizes spending by making strategic build-versus-buy and new-versus-reuse decisions. EER strongly emphasizes reusing in-stock components before issuing new purchase orders to save on cost. For example, the Research & Development (R&D) category only accounts for a small cost of $110.36. This is due to initial designs and iterations prioritizing cheap materials such as 3D printing filament, PVC piping, plastic sheets, and more, which are regularly available in-house from previous RFPs. Alternatively, other decisions, such as purchasing a new tether for $702.74 and outsourcing the enclosure's manufacturing, were necessary to meet established design criteria. EER initially accounted for these design decisions by setting high budgets for sections such as ROV Electronics and ROV Frame, as shown in Table 10.

With the 2026 MATE World Championship being held in EER's hometown and facilities in St. John's, Newfoundland, there will be no travel budget. All money raised above the vehicle and operating budgets will be saved for travel in future years or invested in equipment and resources. During the 2025-2026 season, EER raised $12,630.18 from long-standing sponsors, with additional support secured through employee-led outreach, public engagement, and institutional partnerships. These efforts yielded an additional $5, 666.95 in new funding, bringing the total to $18,297.13, which is $11,358.10 more than the 2025 contract (not including travel fundraising).

Table 9: BlueStar Fairmarket Value,
Credit: Russell Corbett, 2026

Category	Item	Type	Value (USD)
Topside	Controller	Reused	$21.93
Topside	Laptop	Reused	$757.03
Topside	Control Box	New	$245.71
Electronics	Tether	New	$140.55
Electronics	Boards, Components	New and Reused	$563.72
Electronics	Cameras	New	$203.20
Electronics	Thrusters	Reused	$1380.00
Electronics	ESCs	Reused	$240.00
Electronics	Miscellaneous	New	$109.04
Vehicle Structure	Chassis, Enclosure, etc	New	$738.88
Payload	Tooling	New	$92.21
Vertical Profiler	Electronics	New and Reused	$197.64
Vertical Profiler	Acrylic Tube	Reused	$98.80
		Total:	$4788.71

Table 10: 2026 Budget,
Credit: Russell Corbett, 2026

Category	Items	Budgeted (USD)	Spent (USD)
Safety	PPE	$73.11	$120.25
Equipment	Power Supply, etc	$1817.22	$1057.43
R&D	Miscellaneous	$212.86	$110.36
Vehicle Structure	Chassis, Enclosure, Hardware	$642.99	$425.32
Electronics	PCBs, Tether	$3009.15	$1070.35
Vertical Profiler	Electronics	$180.58	$197.64
Corporate Responsibility	Marketing Materials	$146.21	$109.66
Competition Fees	Registration, Fluid Power Quiz	$675.00	$675.00
Company General Expenses	Shirts, Website, Orientation	$1586.10	$1793.24
	Total:	$8344.22	$5559.25

Table 11: 2026 Funding,
Credit: Russell Corbett, 2026

Category	Name	Amount (USD)	Date Received
	Remaining 2025 Balance	$441.91	
Ratification	MUN Student Union	$259.33	Nov 7, 2025
Sponsorship	Automotive Supplies 1985 Ltd.	$2849.81	Nov 15 2025
Sponsorship	PEGNL	$712.05	Nov 19, 2025
Sponsorship	Fisheries and Marine Institute	$3556.87	Nov 22, 2025
Fundraising	Popcorn Sale	$52.11	Nov 25, 2025
Grant	MUN Student LIFE Fund	$1785.55	Dec 1, 2025
Sponsorship	ERINL	$1813.53	Dec 17, 2025
Sponsorship	CoLab	$1813.53	Dec 17, 2025
Sponsorship	Solace Power	$363.62	Dec 22, 2025
Sponsorship	MUN Student Design Hub	$4648.82	Feb 27, 2026
	Total:	$18297.13	

7 Acknowledgements

EER would like to thank the following organizations for their financial support in developing BlueStar and the MATE ROV Competition, both regionally in Newfoundland and Labrador and internationally: Equinor; Hibernia; Cenovus Energy; Kraken Robotics; Newdock; DOF; Pan Maritime; Cooke; SubC Imaging; Seamor; GRI Simulations; Subsea7; Angler Solutions; DeepTrekker; Blu-Sub Mechatronics; Fortis; Instrumar; Incose; Government of Newfoundland and Labrador; Atlantic Canada Opportunities Agency, Government of Canada; Marine Technology Society; Fisheries and Marine Institute of Memorial University of Newfoundland; Memorial University of Newfoundland; PEGNL; CoLab Software; Energy Research and Innovation Newfoundland; Memorial University Student Union; Solace Power; Memorial University Student Design Hub; Memorial University Tech Services.

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8 References

[1] "MATE ROV Competition." [Online]. Available: https://materovcompetition.org/

[2] "What is Round-Robin Brainstorming?." [Online]. Available: https://online.visual-paradigm.com/knowledge/brainstorming/what-is-round-robin-brainstor

[3] P. J. Baker and J. T. Whalen, *Survey of Trade Study Methods for Practical Decision-Making*. NASA Independent Verification & Validation Facility, 2015.

[4] "WebODM." [Online]. Available: https://webodm.org/

[5] *Americas Region HSE Employee Handbook 2018 Version 3.0*. Oceaneering, 2018.

[6] "Product Demonstration Resources." [Online]. Available: https://materovcompetition.org/explorer

Appendix A ROV Startup Guide and On-Deck Checklist

Pre-deployment Construction Checklist

- ☐ Area clear and safe
- ☐ Power supply is powered off
- ☐ Cables/ tether are undamaged
- ☐ Tether strain relief is attached
- ☐ Check to make sure the electronics are properly plugged in
- ☐ Grease and tighten penetrators
- ☐ Grease the enclosures O-ring
- ☐ Close the enclosure by tightening screws in an alternating pattern
- ☐ When the enclosure is closed, add the vent plug and tighten
- ☐ Visually inspect the ROV to check for any damage and to make sure the ROV is safe for water
- ☐ Leak test ROV for 15 minutes
- ☐ Check for water in the enclosure
- ☐ If there are no leaks: the ROV is ready. Proceed to deployment
- ☐ Leaks: Disassemble and inspect ROV

Deployment (Power On)

- ☐ Pilot sets up topside laptop
- ☐ ROV is connected to power supply
- ☐ Co-Pilot calls Power On
- ☐ Tether is coiled by deck crew
- ☐ Tether managers place ROV in the water
- ☐ Pilot calls "Performing thruster test"
- ☐ Pilot ensures all thrusters are functioning properly
- ☐ Pilot checks cameras to ensure proper feed and positioning
- ☐ If all systems are okay, proceed to Launch Procedure

Launch Procedure (Deck Crew)

- ☐ Pilot calls power on, and power is turned on with disabled controls
- ☐ Deck crew calls hands-off
- ☐ Deck crew removes their hands from the ROV
- ☐ Piloting begins

Mid-Mission (Deck Crew)

- ☐ When the ROV is visible in the moon pool, the deck crew calls surface
- ☐ Pilot calls safe when controls are disabled
- ☐ Hands-on is called by the deck crew when they have made contact with the ROV

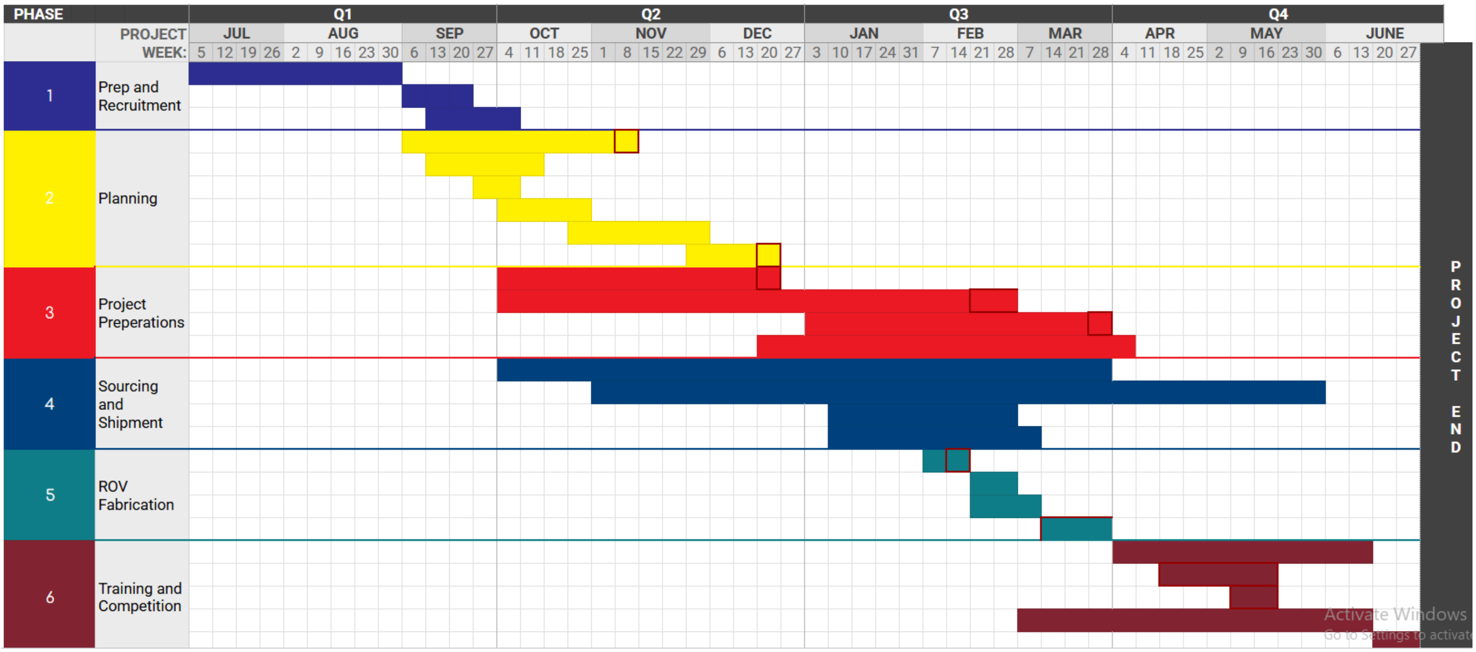
Loss of Communication

- ☐ Steps are attempted in order. If a step is successful, the mission resumes
- ☐ After 2.5 seconds without topside communication, thrusters turn off
- ☐ Co-Pilot inspects tether and surface connections to the laptop
- ☐ Pilot attempts rebooting the control system
- ☐ Co-Pilot attempts rebooting *BlueStar* by cycling power supply
- ☐ Power down ROV, call Power Off
- ☐ Manual retrieval of ROV using tether
- ☐ Confirm no leaks and begin troubleshooting
- ☐ Isolate the cause and document

Tether Protocol

- ☐ Tether Managers conduct an inspection of the tether, looking for any damage
- ☐ Lead Tether Manager secures the tether topside strain relief to the anchor point
- ☐ Lead Tether Manager maintains an appropriate amount of tether in the water for the pilot.
- ☐ Secondary Tether Manager ensures an organized tether, keeping the deck clean.
- ☐ Tether Managers coil tether into a figure-eight at end of mission.

Appendix B Gantt Chart



Appendix C *BlueStar* SID