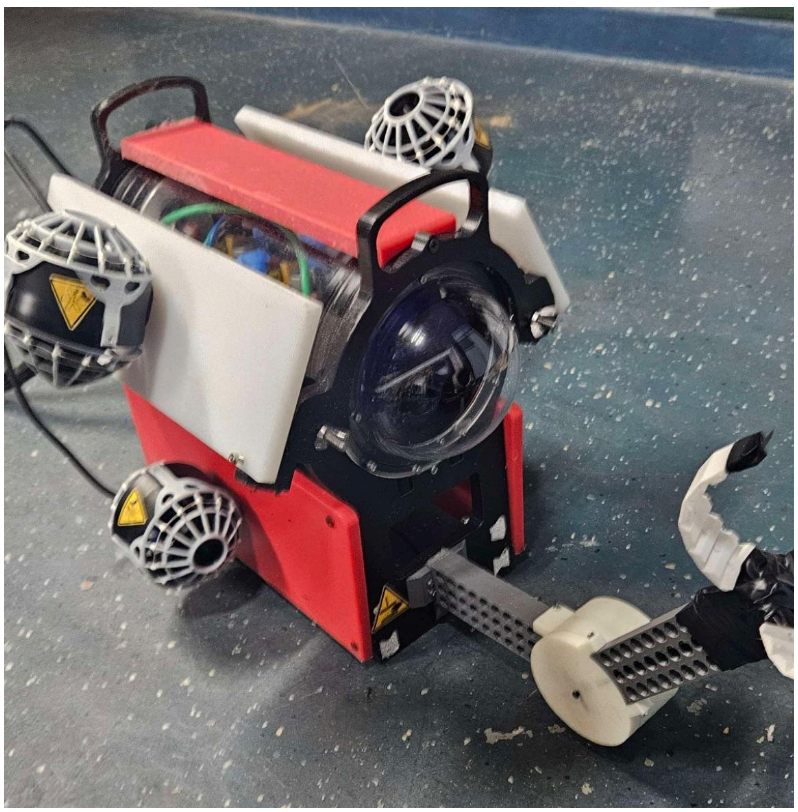
DESERT STAR ROBOTICS

ESTRELLA MOUNTAIN COMMUNITY COLLEGE

2025 TECHNICAL DOCUMENT



MENTOR: Dr. Jeff Miller

Mechanical Team Cristian Enriquez/ Robert Rivera(CFO)	**Software Team** Carlos Azabache(CTO)/ Robert Rivera(CFO)
Electrical Team Robert Rivera (CFO)/ Carlos Azabache(CTO)	**Marketing/Outreach Team** Velicity Garcia

Abstract

Estrella Mountain Community College's MATE ROV team enters this competition season with a fresh team. After placing 2nd in the MATE ROV World Championship last year as Desert Star Robotics, the original team graduated or moved on, leaving a new group of members to carry on the legacy. This year's ROV, named "Dum-E," is built to manage marine cables, support ecosystem restoration, and transport critical oceanic observation tools. With a redesigned high-density polyethylene frame, a three-prong claw, and an upgraded manipulator arm, Dum-E is engineered to meet the challenges of this season's MATE competition.

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Project Management

Chief Executive Officer: Cristian Enriquez/ Robert River
The CEO of Desert Star Robotics provides leadership and strategic direction for the entire team. He coordinates specialized teams, manages resources, and ensures clear communications and collaboration among team members. The CEO coordinates with external relations, mentors, and organizers while upholding compliance with current safety and regulatory standards. He oversees documentation, risk mitigation, and failure analysis to ensure the team's continual improvement. Through Cristian and Robert's leadership, the team stays on task and meets deadlines and goals.

Chief Financial Officer: Robert Rivera
Desert Star Robotics' CFO manages the team's budget and resources. He delegated funds to each sub-team and communicated any changes in budget status to the team. Robert ensures funds are allocated appropriately, and each team makes wise financial decisions on their portion of the project. Through the CFO's support, the team was able to work efficiently through its budget constraints.

Chief Technical Officer: Carlos Azabache
The CTO is the lead for researching and developing innovation techniques. He oversees the design, construction, and integration of the ROV's systems to ensure all electrical, software, and mechanical components function cohesively. He organizes sub-teams, is the spearhead for problem-solving and troubleshooting, and ensures competition requirements are met. Through leadership and technical knowledge, Desert Star Robotics' CTO assures DUM-E performs optimally and can functionally achieve its goals.

Outreach and Marketing Manager: Velicity Garcia
Our marketing and outreach manager oversees the design of any company merchandise or media. Velicity coordinates with the CEO and mentor for any offsite outreach events. These events range from demonstrations to school visits. The manager must coordinate team personnel to attend and brief them on the objective of the outreach event. She also is tasked with being up-to-date on current environmental concerns and being able to communicate these concerns effectively to a wide range of audiences. Through marketing and outreach efforts, the marketing and outreach manager boosts the team's visibility and support within the community.

The team is separated into four specific sub-teams. As deadlines and priorities changed, members would fluidly move between teams except for team leaders. All leaders report to the CEO on progress and collaboration with the CTO during their engineering processes.

Electrical Team
The electrical team is in charge of all wiring and electrical components on the ROV. The electrical engineers' main tasks were soldering the control boards within the canister of Nomad and the non-ROV device. They also built and tested the 48-volt power supply box.

Software Team
The software team are the experts in all code associated with the ROV and nonROV device. They made and adjusted the code necessary to map the thrusters to the controller. Python and Arduino are the main languages the software engineers used to program Dum-e. The software engineers and electrical engineers were often collaborating and working closely together to guarantee a harmonious system.

Mechanical Team
The mechanical team is in charge of all mechanical components of the vehicle. Their main focus is the manipulator and arm. They worked closely with the electrical engineers to ensure no power conversions happened outside the vehicle's canister. Buoyancy was also a major component the electrical engineers were tasked with finding a solution to.

Marketing Team
The marketing team organizes all information and brand material pertinent to the team. They were tasked with designing a logo and finding outreach events to engage the community.

Safety

Safety Philosophy

Safety is a core value of the Desert Star Robotics team and is integrated into every aspect of our work. We are committed to maintaining a safe, respectful, and well-regulated environment for all team members. Our safety practices are guided by the safety protocols established by the MATE ROV competition, as well as institutional policies and engineering best practices.
Our safety standards and features were created based on the following key principles:

- ★ **Safety starts with design**: We incorporate risk assessment and mitigation into our ROV design to minimize hazards.
- ★ **Preparation prevents accidents:** All team members receive safety training appropriate to their roles, including proper handling of tools and equipment, electrical and mechanical systems, and poolside operations.
- ★ **Compliance is critical:** We strictly follow all MATE ROV competition safety requirements, including those related to tether management, power systems, mechanical systems, waterproofing, and poolside operations.
- ★ **Teamwork enhances safety:** Safety is a shared responsibility. We foster an environment where everyone is encouraged to discuss potential hazards and help maintain a safe workspace.
- ★ **Documentation:** We maintain up-to-date safety checklists, electronic and mechanical protocols, and incident response plans to ensure readiness and continuous improvement.

By prioritizing safety, our goal is to create a working environment that supports innovation while protecting team members and equipment.

Safety Standards

During the design, prototyping, testing, and building process of DUM-E and its components Desert Star Robotics, adhered to a code of safety standards that was emphasized and established by both the team and the EMCC MakerSpace. Most team meetings and build days happen at the EMCC MakerSpace where safety standards were already in place and enforced. These standards include:

- ★ Wearing ear and eye protection while using equipment including drills, cutting, or laser devices.
- ★ Using fume fans when soldering and assembling electrical components.
- ★ Having access to a first aid kit, and eye wash station.
- ★ Obtaining appropriate training on equipment operation and post-use clean up processes.

When building and testing the ROV outside of the campus, the team exercised the same safety procedures adhered to while on campus. This included maintaining open communications to ensure all members of the team understood proper tool and equipment handling. In addition, we made sure training and questions about equipment operation were fully addressed.

Safety Features

To ensure safety to members, customers, and the ROV itself while working with and around people, Dum-e was equipped with several safety features.

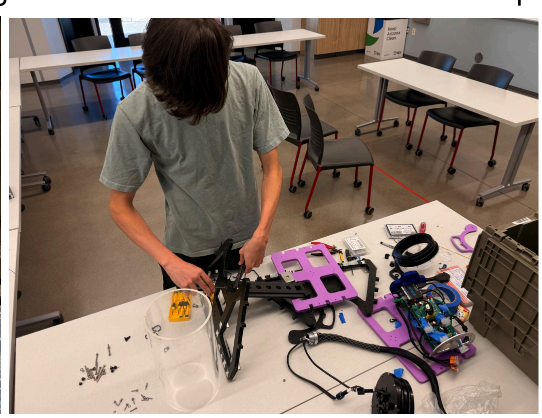
- ★ The team smoothed, sanded, and sheathed down any sharp and ridged edges of the components of the ROV by using a deburring tool.
- ★ The tether is protected with a casing to keep all the cables, ethernet, and other accessories grouped together.
- ★ Strain relief is attached to both the top and bottom sides of our tether to prevent any damaging tugs that could damage the electronic connection to the control station
- ★ In case of electrical shorts, surges, and/or damaged electrical components, fuses were added to both the top side and bottom side of the ROV. These include one 30-amp fuse for the power cable on the top side, two 20-amp fuses for both of our power supply boards, and one 7.5-amp fuse on the control board.
- ★ 3D printers accessed at EMCC were used to print shrouds specifically designed for the Blue Robotics T200 thruster motors. These shrouds are securely mounted using the built attachments for the T200 motors

Design Rationale

Desert Star Robotics aimed for simplicity and versatility this year. As a team with a large variation in member availability, it was essential that Dum-e excel in performance and be easily transportable from workstation to workstation. Our primary objective was to craft a vehicle that could fulfill the missions assigned by MATE while being user-friendly. The general simple base design was meant to empower both new and returning members to let their creativity flow while creating mission specific tools and assigning thruster positioning. It also served as an inviting introduction to the world of ROVs for beginners and newcomers.

Frame

The mechanical team opted to revise the frame design provided by MATE last year. We utilized a table saw to cut the high-density polyethylene (HDPE) sheet, employing appropriate equipment and safety protocols. We retained the same HDPE material from the previous year due to its exceptional density, strength, and melting point. The acrylic enclosure elegantly integrates within the frame it was constructed around, drawing inspiration from the previous design to generate a novel and innovative concept.



Electrical Controls

A requirement for the 48-volt system is voltage regulation occurs on the ROV itself. The electrical team worked to ensure the majority of all electronics were housed in the canister of DUM-E. The cylindrical acrylic enclosure ensured all electronics were safe guarded against leaks and accessible for any alterations. The enclosure is sealed off using two enclosure caps, one clear, acrylic dome-shaped enclosure that houses the camera, and one with holes for wires and cables to run to from the enclosure

For the hardware and electronic design, the members of the Desert Star Robotics team used the components and design provided by MATE's Eagle Ray kit. Some of the most important components are the Eagle Ray control board, with an Arduino mega, two supply boards with four ESCs (Electronic Speed Controllers) and DC to DC converters on each board for power distribution to the four T200 motors, and other passive electrical converters for the camera and ethernet code.

For the topside control system, a laptop, Xbox controller, and power supply are used to pilot and relay DUM-E's code and ensure a stream of power to the ROV.
To connect our top-side control system to the ROV, we used a 23-meter-long tether that contains our ethernet cord and power cable. The cables are contained within an expandable mesh cover and high density foam tubing inside to keep the tether buoyant. The tether is managed by one person on deck to be certain that the tether does not kink or become entangled and to manage slack the pilot needs for underwater operations.

Software

The new vehicle's control system allows for adjustments and implementation of equipment. As a result, more programming was necessary for DUM-E's controls. This year, MATE provided two different codes that both can be used for controlling the four thrusters, and servo controllers, in Arduino/Python. The software team decided to use the Arduino/Python code since a majority of members had prior experience with these languages. With the provided code, the software engineers were able to adjust and add additional programming to control the adjustable joint arm, controllable viewing camera, as well as adjustable variable speeds for the T200 thrusters. Testing in the water proved functionality and connection with the ROV is operating correctly and the code is working as expected.

Propulsion

Propulsion for our ROV is provided by four Blue Robotics T200 motors. The decision to use four thruster motors was motivated by the frame and software system proved by MATE. It had promising qualities without needing adjustments to Dum-e's frame design. This allowed the design process to remain simple, reduced financial strain for more motors, and reduced power consumption in the overall power supply. Thruster positioning was designed to go with the recommended vector profile for the thrusters that MATE recommended. The positioning allows for a great amount of motion flexibility (forward, back, up, down, left, right, and yaw), and power balance to accomplish this year's task all while being cost effective in the team's budget (Fig of the allowable degree of motion). With these more powerful motors, the pilot has more options for thrust range when accomplishing missions.

Buoyancy

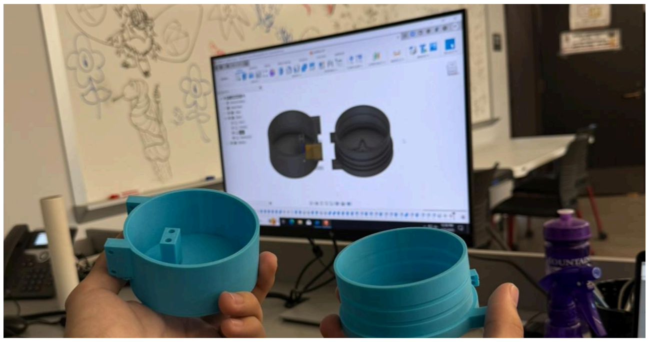
For Dum-e's buoyancy, the goal was to come close to or achieve neutral buoyancy. To do so, the team took the assembled ROV to a pool and, after doing safety checks, docked it into the water. The air within the enclosure made the vehicle positively buoyant. To combat the positive buoyancy, the mechanical team added weights around the Dum-e, and repeatedly tested buoyancy of Dum-e until approximate neutral buoyancy was achieved (Fig 11).

Payloads and Tools

Camera
The ROV's camera acts as the pilot's eyes underwater so they can see from the ROV's perspective. The team decided to use the one wide view camera for the perspective and viewpoint of the ROV. Attached to that camera is a servo controller that allows the camera's viewing angles to be adjusted by various degrees to truly get a sense of control and observation for all visual preferences.

Claw (electrical):
The mechanical team wanted to create and expand on a new arm for the ROV. So we decided to begin work on a servo operated arm, with a claw. The design would make it easier to perform the tasks of the missions that required the ability to twist and bend the arm. A servo has it's benefits, as it is easy to use and does not require significant power consumption. Coding a servo is also very simple to program any desired position into the ROV and its control scheme. Making the servo arm much easier to control. Waterproofing the servo proved much more difficult than was imagined. A joint with an O-ring secured in place would house the servo inside, keeping water outside and the servo protected, as well as securing the holes needed for the connections to be run through. This joint was resin printed and was completed after many weeks and trials and errors. Noting that the arm is completed and is only needing the claw to be

finished and programed to be fully operational for the ROV



Testing and Troubleshooting

This is this version of the team's first year working on the ROV development and competition. The team prototyped and tested the material before moving on to the final product, ensuring the design of the frame and the claw was looking good. Electrical components were tested using a multimeter to see conductivity in the electrical works before use. We used the standard industry solder requirements and multimeter to check the quality and conductivity of the solder joints. After numerous attempts with much trial and error, the gripper was tested and put through many challenges before integrating it onto the ROV. The T200 from blue robotics thrusters needed to be tested in the water since they are water lubricated. DUM-E was capable of functioning while the power was off. It was fully submerged underwater to check for any air leaks. This ensured we reduce the risk of damaging the electronics underwater. Afterward, we tested the ROV's maneuverability, camera view, and actuator arm by performing various tasks underwater.

Challenges

Challenges Faced – Desert Star Robotics 2025

1. Team Turnover and Recruitment

This year's Desert Star Robotics team began with seven interested students, but due to conflicting schedules, work, and academics, participation dropped to just three. We lost one member early in the season but were able to recruit two more by late March, ending with three technical members and one focused on marketing. With no returning members from the 2024 team, which placed second at Worlds, we had no prior experience.

2. Learning Technical Skills from Scratch

We had to quickly learn tools and systems like Fusion 360, Arduino, joystick controls, and electronics integration. With no prior experience, tasks took longer and required trial and error, making the learning curve steep.

3. Time Constraints and Deadline Pressure

Due to early design delays and part shortages, much of the work had to be completed in the final weeks. This included wiring, testing buoyancy, and filming demo footage. Even small errors, like broken servos, became major setbacks when time was short.

4. Limited Water Testing

As a team based in Arizona, we had no access to an on-campus pool or regular water testing site. Most testing had to be simulated or done dry, with only a few short opportunities for real pool testing. This made it difficult to fine tune buoyancy, thruster performance, and the claw mechanism.

5. Restricted Access to Equipment

Our workspace the campus MakerSpace had limited hours and occasional closures. Key tools like 3D printers and soldering stations weren't always available when needed, which slowed our progress and created bottlenecks.

6. Small Team and Heavy Workload

With only four students total and three working on the technical build, each team member had to take on multiple roles. There was no room for specialization, and everyone worked across mechanical, electrical, software, and documentation tasks.

7. Delays in Ordering and Receiving Parts

All of our part orders had to go through multiple people, involving multiple levels of approval and slow package transfers. Parts were sometimes delayed due to supply chain issues or administrative steps.

8. Integration and Design Challenges

Mechanical and electrical systems required constant adjustments. The custom three-prong claw took several redesigns to function properly. We also ran into issues with servo wiring, power routing, and signal conflicts between microcontrollers.

9. Communication Difficulties

Since we're a commuter college team, we couldn't meet regularly in person. Most of our collaboration took place over Discord, which helped but wasn't always efficient. Coordination and troubleshooting were harder without face-to-face meetings.

10. Limited Availability and Burnout

All team members were full-time students, and most had one or two jobs. It was difficult to find enough time for the project. Despite careful scheduling, we constantly had to balance the ROV build with other priorities, often at the cost of rest and personal time.

11. Servo Waterproofing Issues

One of our most time-consuming problems came from trying to waterproof the joint for the claw servo. What should've been a minor task took over five weeks of design, prototyping, and testing due to leaks and binding issues. It became one of the biggest obstacles in the build process.

Budget

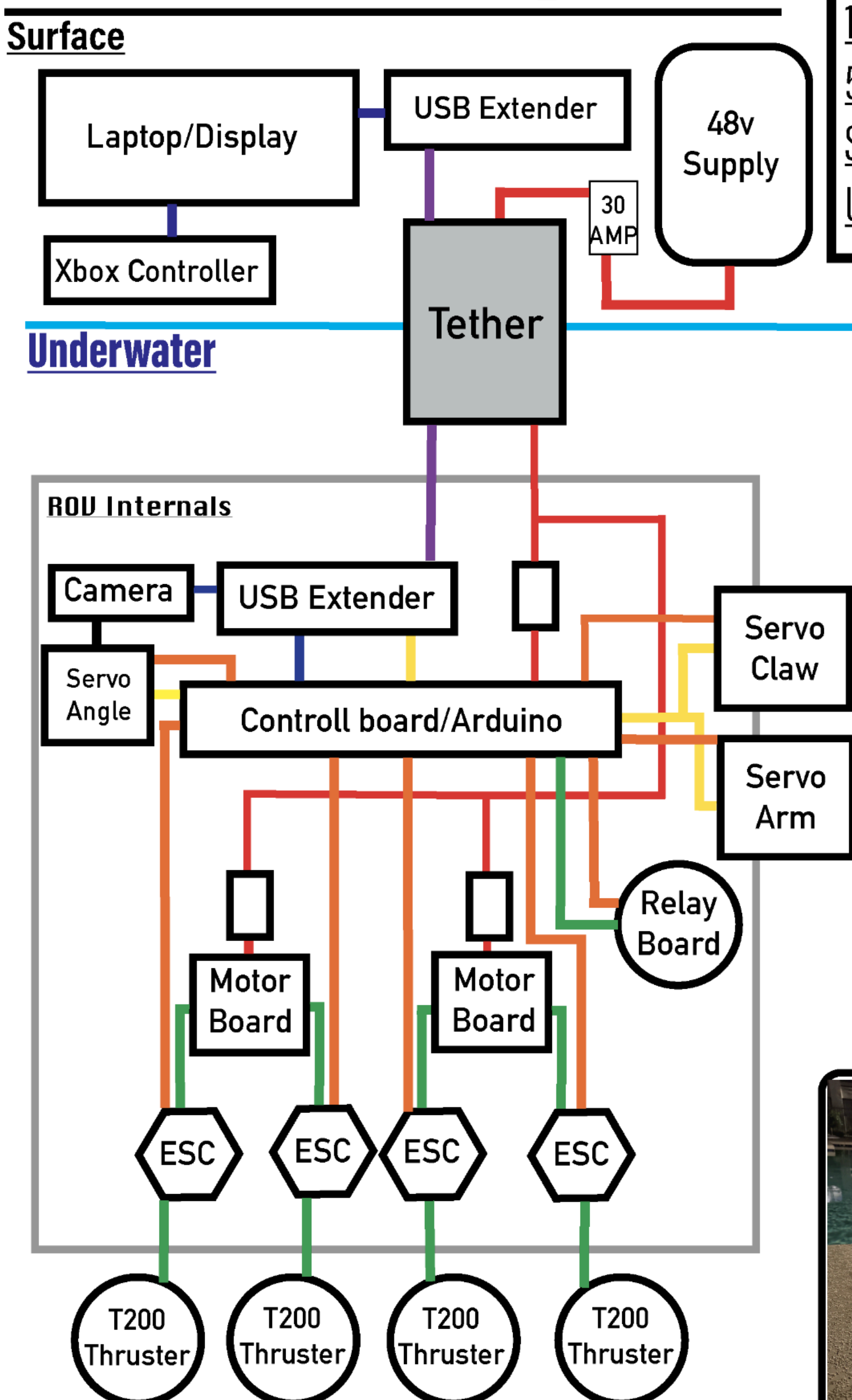
Income Source	Amount		Production and Operations Budget and Cost Analysis	Projected Cost
Estrella Mountain Community College	$15,000		**Available Funds**	$15,500.00
Estrella Foundation	$500		**Total Production Expenses**	$568.42
			Total Operational Expenses	
			Total Expenses	
			MATE Reimbursements for registration and travel	
			Remaining Funds	
Production Budget				
ROV Component	**Budget**	**New/ Reuse**	**Description**	**Cost**
Frame	$500			
		New	(4) HDPE Cutting Boards	$80.15
		New	6” acrylic dome for frame	$255.42
		New	O-rings	$25.93
Thrusters	$0			
		Reuse	(4) Blue Robotics T200 Thrusters	$0
Tether & Connectors	$0			
		Reuse	Eagle Ray tether and connectors	$0
Computer	$0			
		Reuse	EMCC MacBook Air Laptop	$0
Controller	$0			
		Reuse	Xbox Controller	$0

Electronics	$300			
		New	Servo motors for gripper	$136.80
Supplies	$200			
		New	3D printer filament, hardware, epoxy, glue, tape,	$70.12
Production Budget	$1000	**Production Expenses**		$568.42
Operational Budget				
Task	**Budget**	**Description**		**Cost**
Team Shirts	$500	Printed/embroidered t-shirts and polos		$445.15
Props	$300.00	PVC and connectors		$94.87
MATE Competition Registration	$550.00	MATE Competition registration paid for by MATE		$0
Printing	$100.00	Print poster and documents at EMCC MakerSpace		$0
Airfare & Baggage	$5000.00	Tickets for five students and chaperone on Delta Airlines (PHX-DTW) + baggage		$3,402
Lodging	$5000.00	Lodging for five students and chaperone at		
Per Diem	$3085.60	Meals		$3085.60
Operational Budget	$14,535.60	**Operational Expenses**		

Desert Star Robotics
Estrella Mountain Community College

System Integrated Diagram

EMCCs Desert Star Robotics



Legend

- Ethernet: purple
- 48v Power: red
- 12v Power: green
- 5v Power: yellow
- Signal: orange
- USB: blue

UnderWater FLAs

Top T200 Thruster:

-Pull: 9.68A Full thrust
-Volatge: 12v

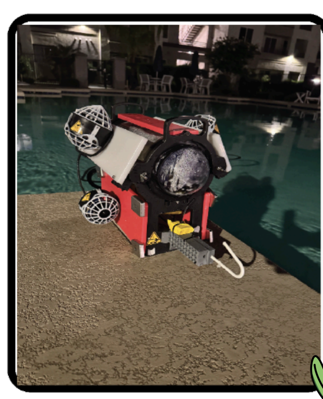
Bottom T200 Thruster:

-Pull: 5.2A Full thrust
-Volatge: 12v

Total T200 FLA:
Thrusters: 14.8A

Servos FLA:

-Volatge: 5V
-Total FLA: 3.1



Acknowledgements

Desert Star Robotics would like to thank Estrella Mountain Community College for their continued financial and administrative support. In particular, we want to thank Ray Surdilla (Life Sciences), Roxana Ortiz (Financial Services), Steven Shapiro (MakerSpace), and Monique Miranda (Life Sciences) for working out all the finances and logistics to support our work at the college and travel to the World Championship in Michigan. The team is also grateful to the employees and management team of EMCC's MakerSpace for providing us with tools and workspace. We also thank Dr. Jeff Miller, our mentor for his time and support. As well as a special thanks to the previous team and their efforts. Lastly, the team would like to acknowledge MATE and MTS for financial support and for continuing to challenge, engage, and offer opportunities to students around the world.