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TECHNICAL REPORT

KRAKEN ROV



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Abstract

The Kraken ROV Team, based at the Arab Academy for Science and Technology and Maritime Transport (AASTMT) Port Said branch comprised of 36 members in 2026, is an undergraduate engineering team focused on the design, development, and testing of underwater Remotely Operated Vehicles (ROVs) to complete tasks for the 2026 MATE applications. The team presents **Kraken ROV**, a modular and cost-effective vehicle designed to perform a range of underwater tasks, including inspection, environmental monitoring, and intervention operations. This document outlines the system's design, development process, key technical features, and cost considerations.



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1. Project Management

1.1. Team Structure and Roles

The Kraken Team consists of a structured group of members organized into leadership roles and technical teams. Each member contributes to the development of the ROV through collaborative, efficient work focused on different subsystems.

- **Team Leaders:** Including CEO and CFO Responsible for planning, task distribution, and overall project supervision.
- **Technical Lead:** Oversees the technical direction of the project and ensures proper integration between all subsystems.
- **Safety Officer:** Ensures that all safety procedures and documentation are properly followed during design, testing, and operation.
- **Subsystem Leads:** Manage specific areas such as propulsion, electronics, and mechanical design, guiding team members in their tasks.
- **Team Members:** Work on different parts of the ROV, collaborating with leads to design, build and test system components.

1.2. Project Planning and Schedule

The Kraken Team followed a structured development schedule to ensure efficient preparation for the competition and successful completion of the ROV. The project began with team formation and interviews, followed by role distribution based on each member's knowledge, skills, and area of interest. The team then progressed through research, concept development, design, prototyping, manufacturing, and system integration. Throughout the project, regular weekly technical meetings, progress reviews, testing milestones, and documentation updates were conducted to monitor development and improve coordination between subsystems. In the final stage, the team focused on system testing, troubleshooting, performance optimization, and

/ driver/ operator training sessions to ensure full readiness for the competition.

Project Phase	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Team Formation / Planning	✓	✓					
Research/ Design/ Prototyping	✓	✓	✓	✓	✓		
Manufacturing/ Integration					✓	✓	
Testing					✓	✓	✓

1.3. Training and Workshops

The Kraken Team conducted regular college workshops and online training sessions to improve members' technical knowledge and prepare them for the competition. These sessions focused on ROV design, manufacturing, system integration, documentation, and problem-solving, while also helping younger members better understand the competition and develop engineering thinking. The workshops also supported teamwork, creativity, promotion, and project organization, making them an important part of the team's overall development process.

2. Design Rationale

2.1. Design Process

The Kraken ROV was engineered as a fully integrated system to successfully accomplish all MATE 2026 mission tasks through a combination of mechanical robustness, reliable electrical architecture, and software control fig (1). Mechanically, the vehicle's six-thruster configuration enables full 5-DOF maneuverability, allowing precise navigation for tasks such as transect flying, station keeping, and operating in confined structures like the subsea observatory and coral garden. The custom-designed gripper with two high-torque

servo actuation and extended linkage system ensures secure handling of mission elements including coral collection, buoy recovery, sensor installation, and connector manipulation. Electrically, the robust power distribution system with isolated converters, fuses, and ESC-controlled motors guarantee stable performance during high-load operations like lifting objects and continuous propulsion, while the tether provides reliable high-speed communication and power delivery over long distances. From a software perspective, the Raspberry Pi-based control system integrates real-time camera feedback, sensor data (IMU and pressure sensor), and PID-assisted stabilization to achieve accurate depth control and orientation, which is critical for tasks such as hovering over transects, precise placement operations, and working around delicate structures. Additionally, features like leak detection, modular control architecture, and pilot-friendly interface enhance safety, reliability, and ease of operation. Altogether, this multidisciplinary design ensures that Kraken can efficiently perform inspection, intervention, navigation, and manipulation tasks required by the MATE 2026 competition in a stable, accurate, and cost-effective manner.

2.2. Mechanical System

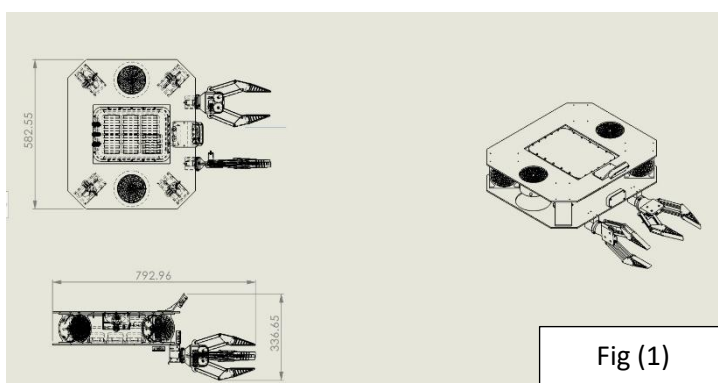
2.2.1. Frame Structure

The ROV frame was designed to provide a strong, lightweight, and compact structure capable of supporting all major subsystems, including the thrusters, enclosure, gripper mechanism, camera system, electronics, and buoyancy elements. The frame acts as the main structural body of the vehicle and plays a critical role in ensuring mechanical stability, load distribution, and hydrodynamic performance underwater. The dimensions □ Length = **792.92 mm** ,Width = **582.55 mm**,

Height = 336.65 mm.

Material Selection of the Frame Components:

Acrylic Side Plates , the main frame structure was designed using **two acrylic plates** as the primary side supports which offers light weight, good corrosion resistance, ease of fabrication and manufacturing and distributing the loads from attached components over a **larger mounting area**, which reduces **localized stress concentration** around fastening points. In addition, the plate arrangement improves overall rigidity and helps resist bending during handling and underwater operation fig (1).



The frame includes **3D printed mounts and support brackets** used to hold and position components such as thrusters, sensors, cameras, cable guides, and internal support members. Instead of applying concentrated force directly onto the acrylic plates or enclosure, the 3D printed supports help **spread mechanical loads** over a wider contact area. This reduces the risk of **cracking, deformation, or local structural failure**, especially around bolted or clamped connections.

The electronic enclosure was designed using **stainless steel** to provide strong and reliable protection for internal components and the manipulator/gripper system was manufactured using **3D printed components**.

Structural Design Considerations:

- **Load Distribution**

The frame was designed to ensure that all mounted components are arranged in a way that promotes **balanced load distribution**. Heavy

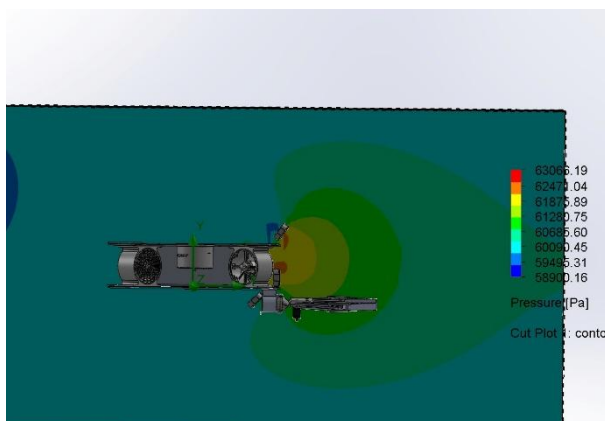
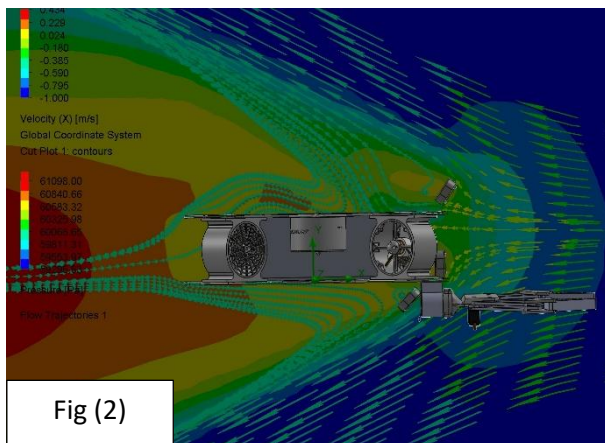
components such as the enclosure and thrusters were positioned strategically to avoid uneven loading ,frame twisting, excessive bending, instability during motion.

• Rigidity and Support

The combination of acrylic structural plates, stainless steel enclosure, and multiple 3D printed support elements creates a **semi-rigid modular frame**. This design increases structural stiffness while still maintaining relatively low overall weight.

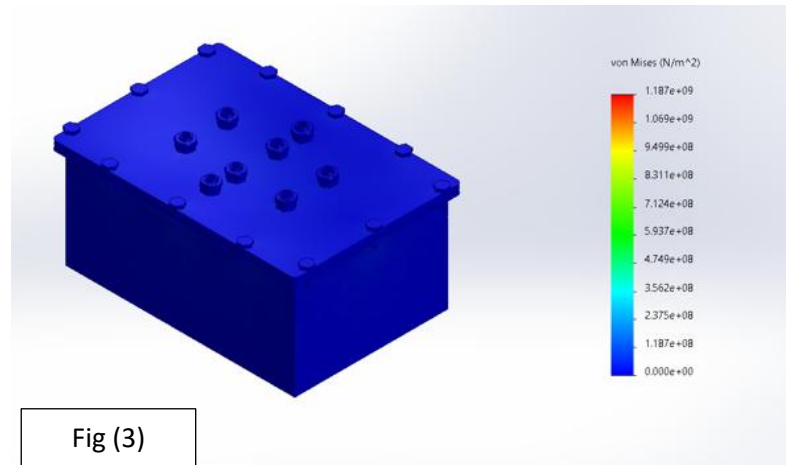
• Pressure Distribution

During underwater operation, the frame is exposed to **hydrodynamic pressure** generated by water flow and thruster-induced motion. The design helps reduce pressure-related stress through: smooth component placement , open structural layout ,reduced frontal blockage area, proper spacing between members fig (2).



2.2.2. Enclosure

The Kraken ROV enclosure is designed as the main protective housing for all sensitive electronic components, ensuring that internal control, power and sensing systems during underwater missions. The enclosure body is manufactured from 1 mm thick stainless steel with an internal space of $280 \times 180 \times 110$ mm³. Thanks to stainless steel's material properties, high structural strength is achieved in addition to corrosion resistance and the ability to withstand the external hydrostatic pressure up to 60 kPa Fig (3). To ensure complete waterproofing, a silicone rubber gasket/sealing layer is placed between the main enclosure body and the acrylic end cap Fig (3). For thermal management, stainless steel used as a passive heat transfer surface, allowing internally generated heat to be conducted through the enclosure walls and dissipated into the surrounding water, which acts as a natural cooling medium.



2.2.3. Thrusters

During the propulsion system design phase, the team evaluated commercially available underwater thrusters such as the Blue Robotics T-Series. However, due to their high cost especially since the ROV requires six thrusters for full 5-DOF maneuverability....

The team decided to develop custom thrusters by the team. Our KRAKEN is designed with 6 thrusters which are completely manufactured using 3D printed materials, as directly determine its maneuverability, stability, and hydrodynamic efficiency in underwater environments, designed around the following engineering objectives: full maneuverability in six degrees of freedom (5-DOF), high thrust-to-weight ratio, low hydrodynamic drag, power efficiency, mechanical simplicity, cost-effective implementation. The propulsion system consists of six vectored electric thrusters, arranged around the vehicle frame to allow full control of: Surge (forward/backward motion), Sway (lateral motion), Heave (vertical motion), Yaw (rotation around vertical axis), Pitch, Roll. The selection on Brushless Motors depends on their datasheet:

Parameter	Value
Max efficiency	80%
Current range	4-10 A
Power	Up to 150w
Resistance	0.090 ohms
Weight	52.7 g
Size	28 mm dia x 28 mm bell length

Configuration	Thrusters	Adv.	Dis adv.
4 Thrusters	Simple	Low cost	Limited control
6 Thrusters	Balanced	Full control	Slightly higher power
8 Thrusters	Maximum control	Complex and expensive	

SO, the six-thruster configuration was selected because it provides: Full 5-DOF maneuverability, Reduced power consumption, compared with 8 thrusters, Lower mechanical complexity, Reduced vehicle mass, Lower cost. In our comparison.

Kraken's thrusters were carefully positioned to reduce hydrodynamic interference by testing in water to exactly define the pressure ratios backward and forward. Thrust depends mainly on water density, propeller area, flow velocity, and thrust coefficient ($T = \rho AV^2 C_T$), so the thruster design was selected by balancing propeller diameter, motor RPM as we will explain (Motor Selection Table), and blade pitch for maximum propulsion performance. The propulsion system of the Kraken ROV relies on **A2212/13T 1000KV** Brushless DC Motor to drive the thrusters efficiently due to its high Efficiency, suitable Torque Output, lightweight Construction, compact Design, ESC Compatibility.

Motion Type	Axis	Description
Surge	X- axis	Forward / Backward motion
Sway	Y-axis	Left / Right motion
Heave	Z-axis	Up / Down motion
Yaw	Z-axis rotation	Heading rotational
Pitch	Y-axis rotation	Tilt forward / backward
Roll	X-axis rotation	Tilt left / right



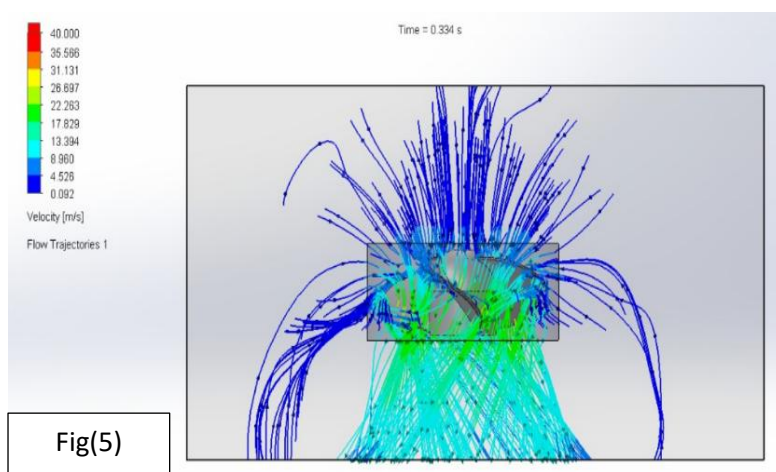
Fig (4)

Additionally, Motor Waterproofing and Insulation: Since the thrusters operate in direct contact with water, the brushless DC motors must be properly insulated to prevent electrical failure and short circuits. So, KRAKEN implemented a multi-layer insulation for each thruster motor fig (4). The primary layer is epoxy with resin around the exposed motor windings and critical electrical areas. In addition, protective polishing layer was applied after epoxy acting as a secondary barrier that improves surface sealing and reduces the possibility of micro-leakage through small imperfection. The polishing layer also provides protection against corrosion. To ensure operational safety and protect the propulsion system, each propeller is enclosed within a protective thruster shroud. The shroud prevents accidental contact with rotating blades and protects the propeller from damage due to debris or external impacts. Additionally, the shroud helps guide the water flow through the propeller, improving thrust efficiency and reducing lateral turbulence around the thruster.

2.2.4. CFD

For Thrusters CFD analysis, the regions of **high and low pressure** around the blades and housing can be identified, which are directly related to the thrust produced by the thruster. These pressure differences help explain how the

thruster generates propulsion and how efficiently it moves water to produce motion for the ROV.



Fig(5)

The presented pressure contour illustrates the flow interaction between the surrounding fluid and the ROV structure, with particular emphasis on the frontal region and the mounted gripper assembly fig (6).

1. High-Pressure Region (Stagnation Zone):

A pronounced high-pressure zone is visible at the forward-facing surfaces of the ROV, especially around the nose and the leading face of the gripper. This corresponds to a stagnation region where the incoming flow velocity reduces to near zero. The extent of this region appears relatively large, indicating that the frontal geometry is not sufficiently streamlined. This will contribute significantly to form drag, as discussed in classical hydrodynamic principles.

2. Flow Acceleration and Pressure Gradient:

Moving away from the stagnation zone, the pressure decreases as the flow accelerates around the body. However, the transition appears somewhat abrupt, particularly around the gripper interface. This suggests a strong pressure gradient, which increases the likelihood of boundary layer separation in downstream regions.

3. Effect of the Gripper Assembly:

The gripper introduces a substantial disturbance to the flow; it increases the effective frontal area. It creates localized high-pressure pockets on its leading surfaces. It likely induces wake formation behind its structure due to geometric discontinuities. This aligns with increased form drag, especially given the non-streamlined, angular features of the mechanism.

4. Symmetry and Flow Distribution:

The pressure distribution appears asymmetric in the vicinity of the gripper. This asymmetry can result in lateral forces and moments acting on the ROV, potentially affecting stability and control, particularly during forward motion.

5. Wake and Low-Pressure Regions:

Although not fully detailed in this contour, the downstream region (aft of the gripper and body) likely experiences low-pressure wake zones. These contribute to pressure drag and reduce overall hydrodynamic efficiency. The geometry does not appear to promote gradual pressure recovery, which is essential for minimizing drag.

6. Design Implications: Based on the observed pressure contour:

The current design is dominated by form drag rather than skin friction drag. The frontal geometry and external appendages (gripper) are primary contributors to drag. The lack of smooth, continuous curvature leads to inefficient flow behavior.

7. Recommendations:

To improve hydrodynamic performance: Introduce smoother, more streamlined leading edges (e.g., ogive or ellipsoidal nose shapes). Reduce sharp transitions between the main body and attached components.

Consider enclosing or fairing the gripper when not in use. Aim for gradual tapering toward the rear to enhance pressure recovery. Maintain symmetry wherever possible to avoid unintended lateral forces.

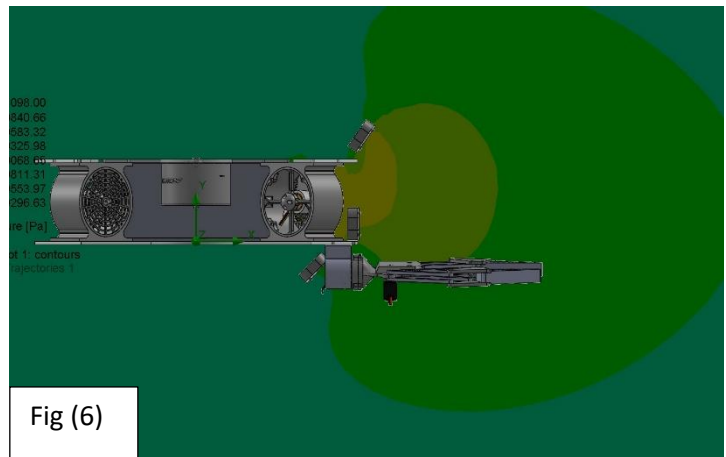
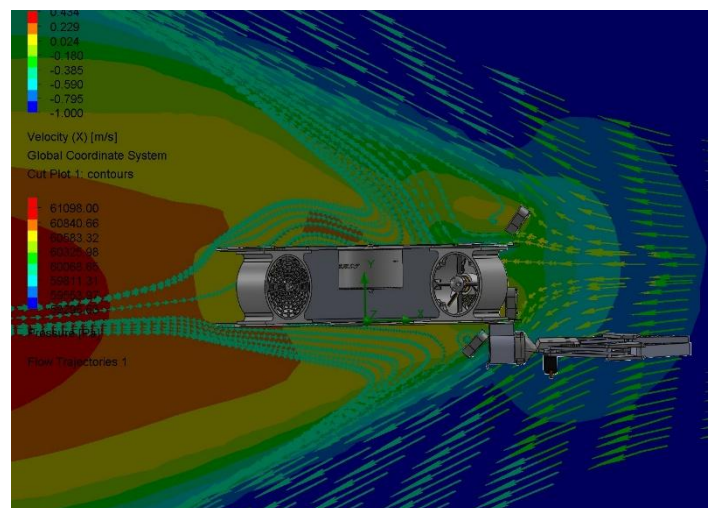


Fig (6)



2.3. Hardware System

2.3.1.1 Tether

The tether system in the Kraken ROV serves as the main physical and functional connection between the underwater vehicle and the surface control station provides a reliable pathway for **power transmission, communication signals, and system connectivity** between the onboard electronics inside the enclosure and the external operator station. The tether extends externally from the **acrylic end cap of the enclosure**, where all internal electrical systems interface

with the outside environment. The role of the **strain relief** is to absorb and redistribute external tension forces so that pulling or sudden cable loads are not directly transferred to the enclosure penetrations, connectors, or internal wiring, thereby preventing cable fatigue, loosening, insulation damage, seal failure, connector stress, and possible leakage or electrical faults. To further improve underwater performance, **foam sections are distributed along the tether** to provide **partial buoyancy**, which helps reduce the effective weight of the cable in water, minimizes sagging, reduces tether-induced disturbance on vehicle motion, and improves overall maneuverability. KRAKEN's tether is designed to maximise flexibility and durability. The tether is housed in an expandable braided flexible cable sleeve. The tether is designed to be approximately 20 metres long composed of a shielded F/FTP CAT7 ethernet cable, for its reliable high-speed data transmission and reduced interference, plus two power supply cables. The 48V main power cables are 10 AWG to achieve a voltage drop suitable for the buck convertors. The tether enters through waterproof bulkhead connector with strain relief at ROV connector, enclosure connection, and surface station ends

2.3.1.2 Tether Management Protocol

KRAKEN's tether management protocol designates a dedicated handler for safe handling of the 20m tether during ROV deployment, operation, and recovery, minimizing risks like tangling, tripping, and damage.

Generalized Note: The tether handler holds onto the tether to prevent tripping of team members.

For Pre-Deployment Preparation:

handler uncoils tether in figure-8 pattern to prevent twists or intertwining of the tether, inspect and secure strain relief at the ROV connector, enclosure connection, and surface station ends.

During underwater operation:

the tether must be carefully managed to ensure safe and reliable performance. It should have only the necessary amount of slack in the water to avoid excessive drag, which can waste thruster power, reduce maneuverability, and increase the risk of entanglement. The release and movement of the tether should be **synchronized with the ROV's motion to maintain stable CAT7** communication and smooth vehicle control. It is also important that the tether is never stepped on, as this can damage the internal Ethernet and power conductors, leading to communication loss or electrical failure. Effective operation also depends on strong

Pilot-Handler Coordination: where clear and standardized communication is maintained to avoid confusion, while the pilot should avoid obstacles, tight maneuvers, and unnecessary 360° rotations that may twist or loop the tether.

After the mission is completed, the tether should be safely disconnected from the surface control station and 48V power supply after shutdown, then coiled neatly using a reverse figure-8 method to prevent bends, tangling, and long-term cable damage during storage fig (7).



Fig (7)

2.3.2 Electrical Sensors

The KRAKEN system utilizes an IMU (4) (Inertial measurement unit) and a pressure sensor (5) (MS5837), all connected to a common ground to ensure signal stability. Additionally, a DIY (Do It Yourself) water sensor is connected to one of the Arduino Nanos enabling rapid leak detection to protect electronics during underwater operation. Multiple tests confirmed



that a 5mm spacing between exposed copper wires in the DIY water sensor delivers optimal sensitivity and fast leak detection, ensuring reliable Arduino Nano triggered shutdowns to protect KRAKEN's electronics. (switch DIY SENSOR & pressure sensor)



2.3.3. Gripper

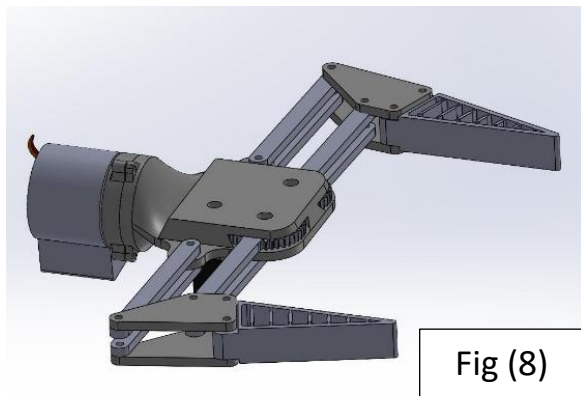


Fig (8)

The gripper mechanism is actuated by two MG995 Servo Motor units, each capable of delivering approximately 11 kg·cm of torque, enabling both rotational motion and gripping functionality. One servo provides continuous rotational positioning, allowing the gripper to achieve up to 360° rotation about its axis, while

the second servo controls the opening and closing of the gripper jaws.

The mechanical design incorporates modified linkage systems to extend the operational range of the gripper, allowing it to securely handle objects with widths of up to 17 cm. These linkages were optimized to ensure stable force transmission and consistent gripping performance across the full range of motion.

Gripping action is achieved through a gear-based transmission system, consisting of a pinion gear driving two synchronized spur gears. The driven gears were specifically modified to integrate with the gripper jaws, ensuring symmetrical motion and uniform force distribution during operation. This configuration enhances gripping stability and minimizes slippage when handling objects of varying sizes and shapes, as illustrated in the fig (8).

2.4. Control and Electrical System

2.4.1. Electronic Design and Cabling



KRAKEN's electrical system consists of two primary sections: the **Surface station**, which includes a laptop operated by the pilot; and the **Underwater Electronics**. These two components are

connected via a tether providing both power and a data link. The underwater electronics are further divided into two distinct sub-groups: the **Motor Groups** and the **Control System & LED Group**. The power distribution circuit evolved through trial-and-error: initial 3-buck-converter design

proved insufficient, but optimizing to 4 separate 48V-to-12V 30A units, ensured balanced loads, stable voltage to ESCs/servos, and fault isolation for reliable KRAKEN performance and optimum configuration. Yet, we could not stick with this design due to limited availability of resources, reverting to a more practical configuration balancing performance and availability issues for the KRAKEN ROV. The final KRAKEN power setup uses seven 48V-to-12V 20A converters.

2.4.2. Power Distribution

On the KRAKEN ROV, the 48V bus includes a bulk capacitor (1000 μ F/63V), TVS diode (SMCJ64A), ACS758 current sensor, and star grounding. Seven 48-12V 20A buck converters powering individual motors. The ACS758 current sensor provides precise, isolated 48V bus monitoring, and safety. Placed in-line post-bulk capacitor/TVS with voltage divider output to ESP32 GPIO35.

KRAKEN's ROV power distribution design efficiently steps down 48V input to 12V/5V output using buck converters. It utilises fuses, and appropriately sized wires to handle motor and control loads. The power distribution system is designed with a Littelfuse 30 A as the main protection located within 30 cm of our XT90 power connector. Along with a hardware kill switch, A normally-closed emergency stop switch, placed after the main fuse and before the tether. Pressing it physically disconnects the 48 V power.

A pre-charge circuit is placed, a switch with a 10 Ω resistor in parallel with the main switch, gets held for 2 seconds before flipping the main power. This gently charges the KRAKEN's 1000 μ F bulk capacitor, preventing massive inrush current and damaging arcing across the XT90 connector when first plugging into the 48V surface supply. It is placed after the 30A Littelfuse fuse and before the normally-closed emergency kill switch.

2.4.3.1 Motor Power Branches: Six of the seven 48V-to-12V 20A buck converters are dedicated to an individual motor, each feeding an ESC, via 12 AWG wires, then the ESC is connected to its motor for stable, isolated thruster operation.

Each ESC, preceded by a 15A fuse for thruster protection, drives one motor with twisted-pair wiring to minimise EMI (electromagnetic interference), noise and communication errors.

2.4.3.2 Control System & LED Branch

After The seventh converter (48-12 V) is then split into four branches:

1. LED bar branch (12V):
 - One 12 V branch powers two IP68 LED bars.

The LED control uses a logic-level MOSFET switched by second Arduino Nano.

2. Servo rail branch (12 - 6 V)



- Another 12 V branch feeds a 12-6 V buck converter, which supplies 3× MG995 servos.

The servo protection setup handles voltage spikes from our three MG995 servos on the 6V line with a 2200μF capacitor to smooth things out, a Schottky diode (cathode up, anode to ground) to catch back-EMF spikes, and 0.1μF ceramics at each servo.

3. Control electronics branch (12-5 V):

Another 12 V branch feeds a 12-5 V buck converter, which powers:

- Raspberry Pi 5 (8 GB)
- Arduino Nano 1
- Arduino Nano 2

All 5 V control lines are routed with 20 AWG wiring where possible to optimize weight and flexibility.

The first Arduino Nano utilises 6 PWM outputs to control the ESCs. The second Arduino Nano utilises 3 PWM outputs to control 3 MG995 Servos (at 6V)

4. Sensor & ESP32 Branch (12 - 3.3 V)

The final 12 V branch feeds a 12-3.3 V buck converter, which powers:

- ESP32-S3
- BNO055 IMU
- MS5837 pressure sensor

This ensures sensors and ESP32 run at safe 3.3 V logic levels, while the main 5 V rail powers the Pi, and Arduinos.

• **Control System Design** (Hardware Based = 2):

KRAKEN's Control Station is managed by the pilot using a PS4 controller for precise 5-DOF maneuvers and a laptop displaying Raspberry

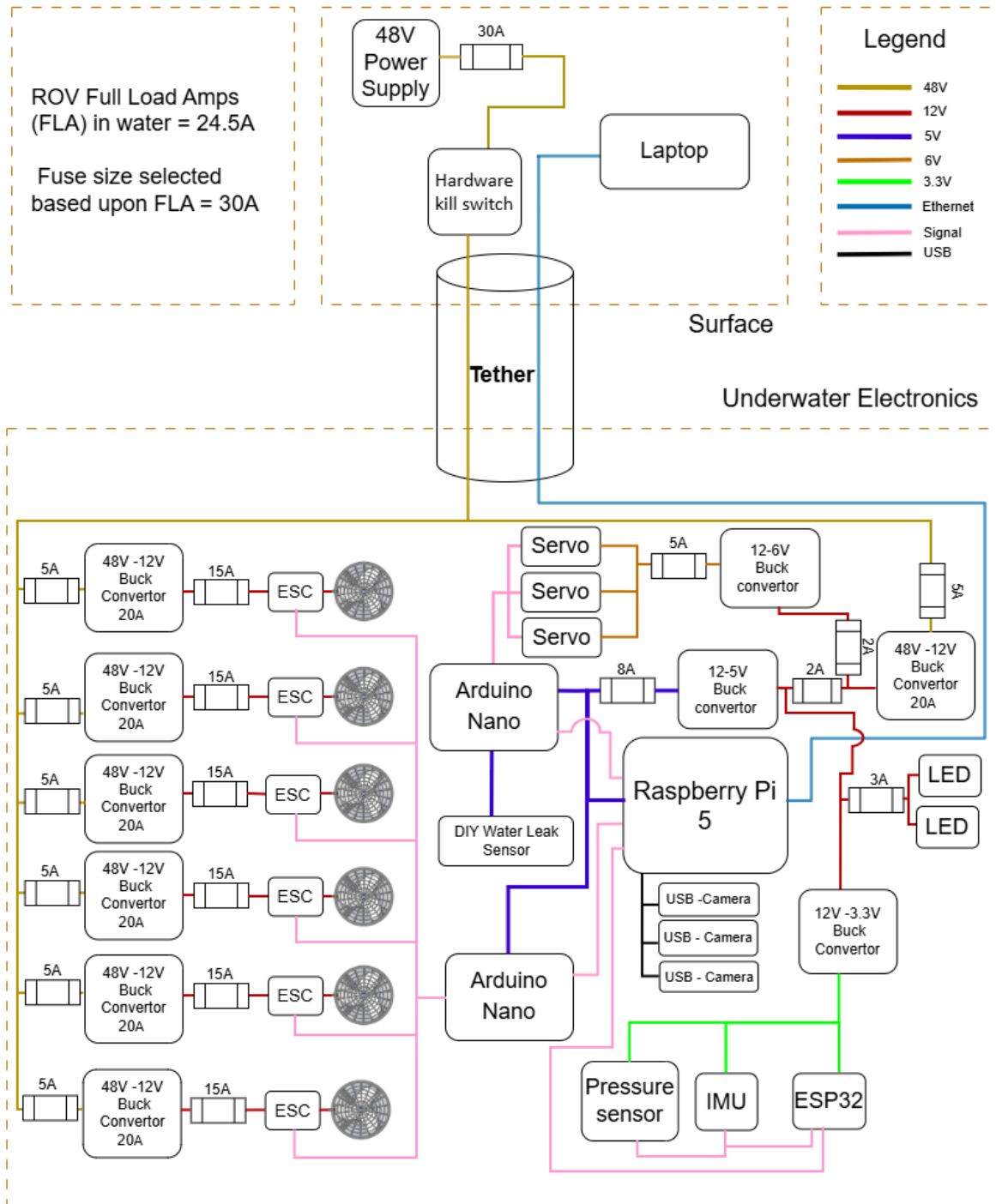
Pi 5 feeds: videos via CAT7, IMU/MS5837 data, and water leak alerts

from Arduino Nano's DIY sensor; for real-time monitoring and logging.

• **Underwater Electronics:**

The team chose to connect surface and Underwater Electronics with an Ethernet cable (CAT7) running along the tether for high-speed and EMI-resistant data transmission to the Raspberry Pi 5, ensuring stable pilot control during tether-managed maneuvers. A custom-built control PCB streamlines KRAKEN's hardware by integrating the ESP32, Arduino Nanos, and sensors on one board for cleaner wiring, better EMI protection, and reliable 5-DOF control across the 20m tether; the Pi 5 is not integrated and connects separately

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2.5. Software System

2.5.1. Control Station



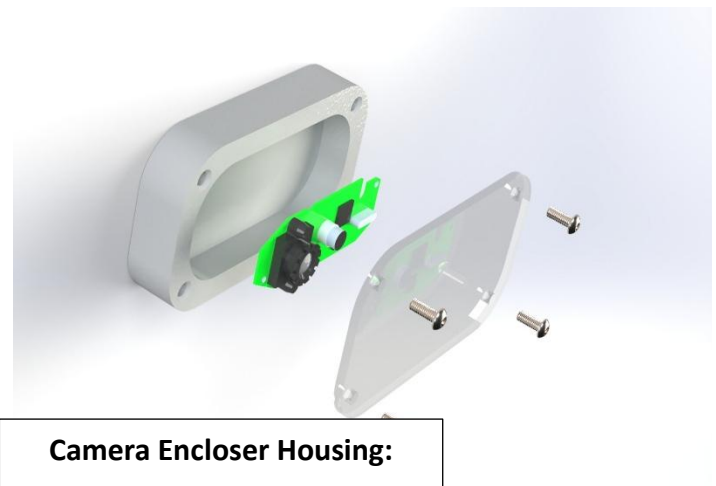
The control station is the collection of equipment the pilot uses to operate the ROV. KRAKEN's control station consists of a Ps4 controller with a specific control configuration as shown, in which the laptop is connected to the ROV directly via ethernet "CAT 7 FTP". It should be noted that while we utilize this specific laptop, KRAKEN's control system is compatible with any computer with an ethernet port. The ROV's Raspberry Pi 5 works as a DHCP server, enabling zero-configuration, router less operation with any ethernet-enabled surface station to maximize ease of deployment by customers. This design is intentionally

simple, ensuring efficient, reliable processes for setup and teardown during MATE operations.

2.5.2. Camera and Housing



We are using 3 cameras of "Logitech C270 HD Webcam" as the primary visual sensor for this current stage of prototyping for the ROV fig (8). The advantages of this camera are that it is compatible with Linux-based operating systems and has a small circuit board that makes it easy to integrate into waterproof cases.



Camera's configuration is: One main front camera "KRAKEN's eye" that helps the pilot to see while operating different tasks, the second camera sits between the manipulators and provides the user with the view to

precisely control the manipulators while performing different gripping tasks as: Task 1.1, 2.3, 2.4, 2.5, and task 3. The last camera is downwards facing camera that enables the

pilot to have a view of the environment as the ROV descends and for tasks as: Task 1.3 and task 2.1. As this project continues to grow, we will be able to upgrade to a high-definition 60 fps 1080p or 4K sensor that will allow us to achieve professional-grade results for underwater exploration achieve professional-grade results for underwater exploration.

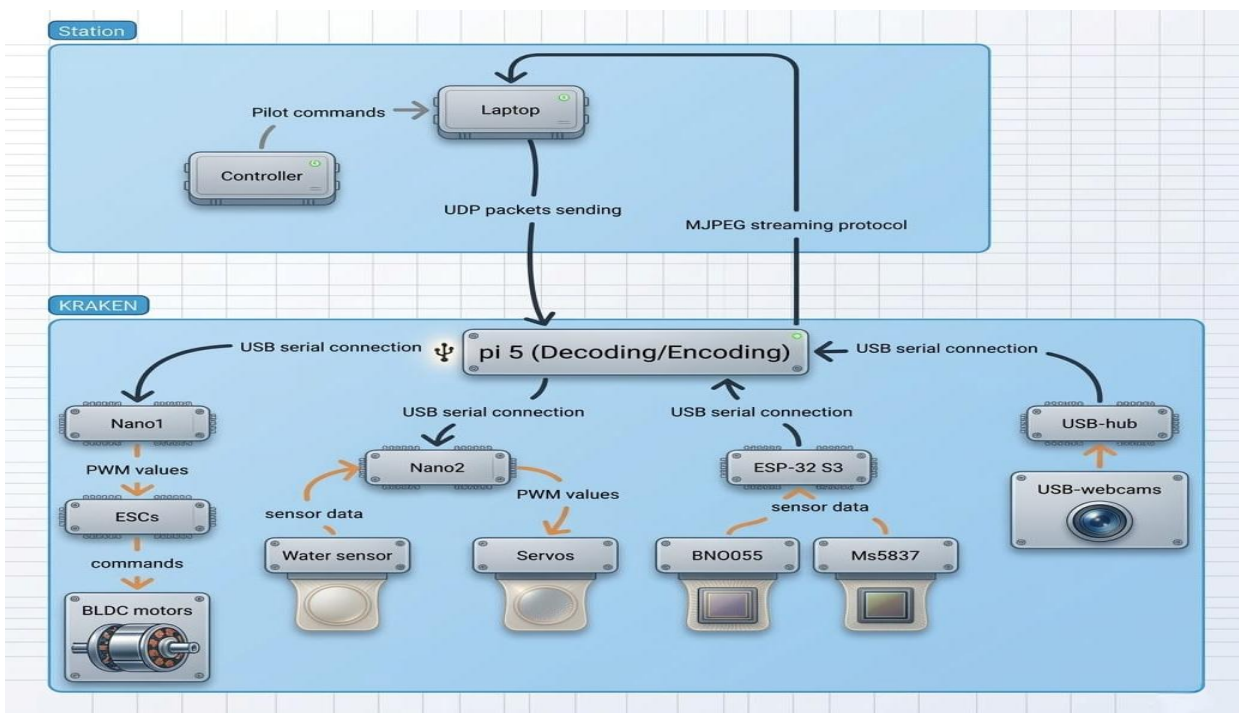
Obstacles Encountered: One

Design objective was to reduce tether girth to maintain ROV flexibility. Several camera interface options were considered to reduce the need for bulky external cabling, and the Raspberry Pi (MIPI) camera was initially considered for this role. However, it was found that there were problems with interference and insulation, which affected video stability. As such, the team had to make some changes by making a design pivot in favor of a USB webcam, which offers a reliable and shielded connection for the pilot video.

2.5.3. Control Systems and Sensors

Main control system: Our system consists of two main computers, The laptop which is connected to the pi 5 using an ethernet cable enabling it to give pilot commands and stream cameras. The pi 5 “KRAKEN’s brain” is connected to 3-USB cameras using a sub-hub, 2 Arduino nano, and an ESP-32 S3. This system makes the KRAKEN’s brain “the pi 5” able to get commands via the ethernet cable and analyze them and give them to the proper microcontroller, and stream cameras and sensors data at the same time. Each Arduino Nano is responsible for a specific control part. The first one “NANO1” is connected to 6 ESCs controlling the 6 BLDC motors. The second one “NANO2” is connected to the 3 servos controlling the grippers system and the water leakage sensor. The ESP-32 S3 is used for the Ms5837 Sensor and Adafruit BNO055 sensors to use their real-time data in processing automotive system as maintain depth system and orientation system.

Strength of this System: The best part of this design is that it is modular. This means that the system separates the processing tasks from the actual motor control tasks. By using the



Raspberry Pi to talk to the flight controller, the system is more stable and less likely to crash. It also gives the system a great chance to expand in the future by adding new features such as automatic driving or object detection. The best part of using the Ethernet connection is that it is much faster than the other options. This system is also very easy to maintain. This is because, as it follows a step-by-step pattern, it is easy for the team to quickly determine what part, such as the PC, the Pi, or the controller, is having an issue. This organized system, combined with "plug and play" USB components, makes it easy for repairs or changes in parts to be made while the robot is in operation.

Limitation of the System: The problem with putting several computers and power components inside the box is that it gets hot, and if the heat is not removed, the components may slow down or even break during the tasks.

Navigation System: This system is very simple as the pilot sends commands using the controller, our laptop generates packets with these PWM "Pulse-Width-Modulation" values and after compressing these packets, they are sent through the ethernet cable to the pi 5 which decode the packets and send the commands to the nano1 and nano2.

Depth maintenance system: To ensure the ROV is always at a steady level while on a mission, the team developed a "depth maintenance system," which is like a vertical stabilizer. This is done using the MS5837 pressure sensor to see how deep the ROV is underwater at any given time. By utilizing rapid complex calculations, the ROV can fight against changes in buoyancy that would usually push the ROV towards the surface or the bottom of the ocean. When the pilot engages the "depth lock," the ROV is kept at a certain coordinate underwater. This is a hard problem to tackle on its own, as the ROV is

always fighting to stay at a steady level underwater.

Why use Ms5837 Sensor instead of Depth Sensor:

The MS5837 pressure sensor is an integral part of the design, which is used to sense the hydrostatic pressure, the ambient temperature, and the depth with high precision. The changes in pressure, which are measured with high precision and accuracy, enable the ROV to hold a constant position in the vertical plane despite changes in the environment. As this module is already part of our existing hardware inventory, which was used in the previous phase of the project, it has been decided to use this module instead of producing a new alternative, which would have proved to be costly for the project

- **PID Assistance:**

To achieve operational stability, the ROV has a highly complex control mechanism, which is comprised mainly of a PID (Proportional-Integral-Derivative) regulation system. The PID regulation system is a mathematical model, which is used to automatically balance the "error" between the pilot's set point and the actual orientation, which is being measured by the BNO055 sensor. The PID regulation system has the "proportional muscle" to adjust the ROV's orientation, the "integral memory" to remove constant leaning, and the "derivative braking" to avoid overcorrection, thus automatically canceling the impact of any hydrodynamic force. To improve this mechanism, a Kalman filter is used to filter raw data in the accelerometer and gyroscopic readings. The angular stability is complemented by a depth maintenance system, which uses the MS5837 pressure sensor, a component reused from existing hardware to reduce costs, to measure hydrostatic pressure with very high precision.

- **Kalman Filter:**

The Kalman filter is an advanced mathematical technique that is used to create optimal state estimation results by combining different sensory inputs. When it comes to underwater robotics, this sophisticated algorithm combines the fluctuations of the BNO055 sensor's accelerometer with the stability of the gyroscopic measurements to reduce the effects of noise. This process constantly predicts the future orientation of the ROV and corrects it according to the real-time measurements. This effectively reduces the drift of the signals and any errors that may be present. The use of the Kalman filter ensures that the navigation system of the ROV is resistant to the random disturbances that are present in the sub-aquatic environment.

Water Leakage System: To protect the electronics from damage, the team decided to install a water sensor “DIY” into the safety system. This sensor is one of the most important parts of the emergency system, as it will always be checking for water inside the dry electronics box. This will allow us to create an alarm for our ROV, ensuring that we can retrieve it safely if water does leak in before any damage could occur. This will also be an important safety feature for our future, as we will be able to protect our expensive electronics from damage.



Self-Locking System (Future work): We aim to include a "self-locking" system to control the angular stability of the vehicle. This proposed feature will count on the BNO055 absolute orientation sensor to identify and correct unwanted pitch, roll, and yaw caused by the turbulent currents. The ROV will be able to correct the external forces acting on the chassis by using high-frequency algorithmic adjustments, thus eliminating the need for the pilot to manually correct the attitude. This automation will enable the ROV to be perfectly leveled, removing the need for the pilot to correct the attitude. This will enable the pilot to focus on the lateral movement and gripper operations.

Difference between self-locking and depth maintenance: Although the two systems work together to lock the ROV in place, they work in different ways to control movement. The self-locking system works on the rotation and balance of the robot, ensuring that the robot does not tilt or spin in the wrong direction. This is achieved by the BNO055 sensor. On the other hand, the depth maintenance system works on the vertical position of the robot, ensuring that the robot does not move up and down. This is achieved by the MS5837 sensor.

2.6. Float

2.6.1. Mechanical System

To enhance precise depth control, our float was designed with a reduced total length of 65 cm. Our design posed a challenge in component organization, which we addressed by separating the structure of the float's component zone into different sections. The Component Zone uses a dual-pillar modular structure to provide stability and organized component placement. Two vertical support pillars extend along the enclosure and carry multiple circular mounting plates, creating separate levels where subsystem components are securely installed. This layered arrangement improves weight distribution along the float's axis, enhancing stability while also

simplifying cable management and reducing internal crowding. The modular design allows the structure to be easily disassembled and reassembled when needed, enabling quick fault repair, maintenance, or future system upgrades without removing the entire assembly. The Suction Zone controls buoyancy by regulating water volume inside two syringe chambers. A Stepper Motor

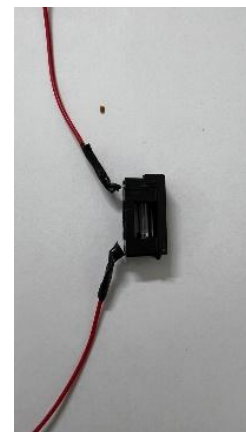
drives a lead screw that moves the plungers vertically, allowing water intake or release to control sinking and rising motion. The dual-syringe arrangement improves balance by distributing mass symmetrically, while guide rods maintain alignment and ensure smooth operation. The mechanism provides precise depth control with a simple and maintainable design.

2.6.2. Electrical System

The float control system is designed using one microcontroller which is an ESP32, which manages communication with the ground station, collects pressure readings from the pressure sensor, and transmits depth-control instructions. The ESP32 is also interfaced with a real-time clock (RTC) module to provide accurate timing and synchronization functions. The ESP32 operates the Stepper Motor (12-24 V that drives a syringe-based mechanism.

Power for the entire system is supplied by two

1.2-V Eneloop AA rechargeable battery connected, consisting of a total of eight



batteries. Each battery provides 200 mA; therefore, the configuration results in a total available current of 400 mA (0.4 A) while maintaining a constant output voltage of 9.6 V for the system, and a 5-ampere fuse is included to ensure

electrical safety and protect the circuit from overcurrent conditions.

2.6.3. Communication

The float communicates with the station over Wi-Fi using an HTTP-based server-client model. The ESP32 acts as a Wi-Fi access point. It allows the station to connect and request data via HTTP. After successfully receiving the data, the station sends an acknowledgment.

Fig () The body of the enclosure and the housing with a total length of 65 cm

Total power consumption = 27,503 mW

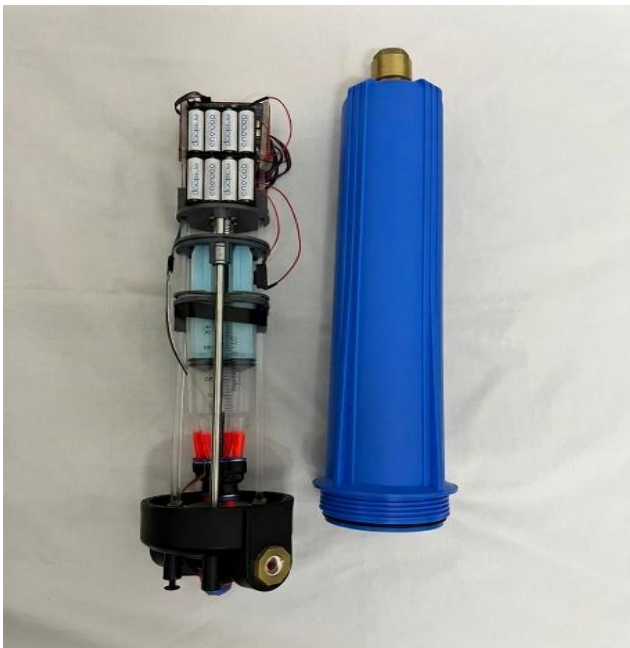
$\approx 27.5\text{w}$

FUSE CALCULATION:

$$\text{Fuse } (I) = \frac{27.5}{12} = 2.29 \text{ A}$$

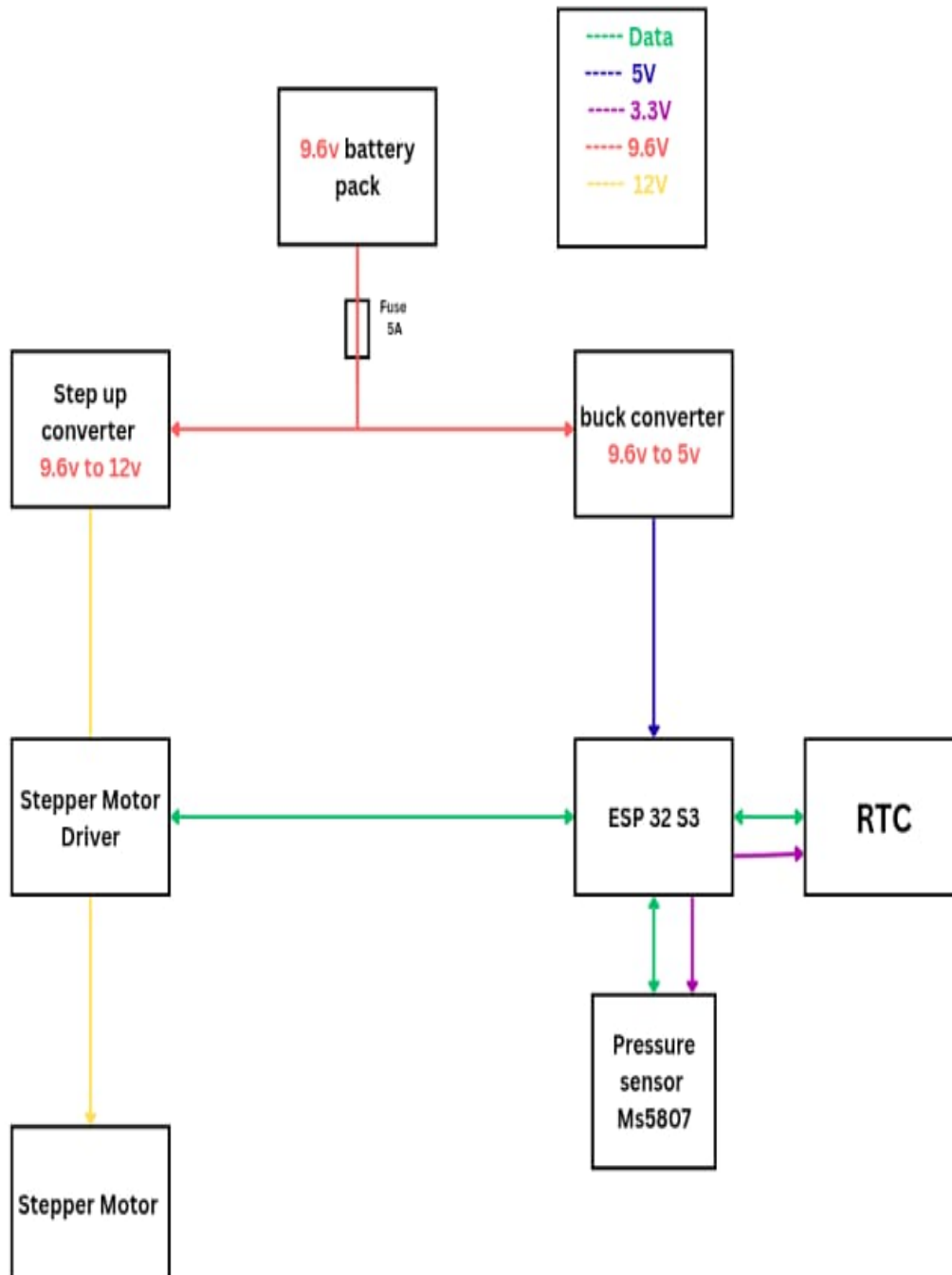


Port said 2026 Float NRD



FLOAT SID

Full Load Amps (FLA) in water = 2.29 A
 Fuse size selected based upon
 FLA = 5 A



3.Safety

KRAKEN takes safety seriously. We look for risks in every part of the project. This includes when we are designing, making, testing and using the Remotely Operated Vehicle system. The ROV system is very complicated. It has parts like power distribution, thrusters, sensors, and it must work underwater. So, safety is a priority when we are designing the system. KRAKEN makes sure that all the parts and the way we do things meet the standards for engineering and safety rules for competitions. We want to reduce mistakes that people make to stop equipment from failing and make sure the system and the environment around it interact safely.

Fig(9)



3.1. Personnel Safety

All members of KRAKEN must go through safety training before we start any work. This training teaches them about being safe with electricity, how to handle tools and equipment properly and what to do in case of an emergency. We are very careful when we are doing things that could be dangerous, like soldering, working with circuits and using machines. When we are putting the system together and testing it, we must wear protective gear like masks and insulated

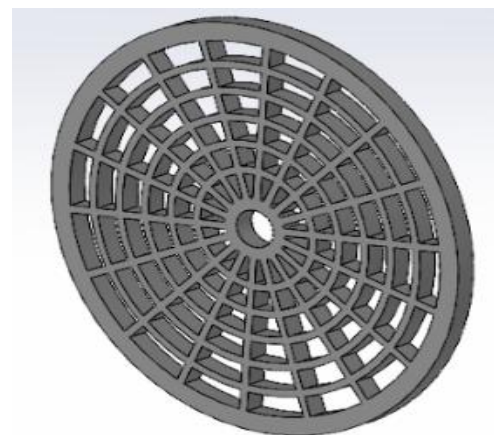
gloves. Only members who have been trained are allowed to do tasks like turning on the system or putting the ROV in the water. This way of doing things reduces the chance of accidents happening because someone does not know what we are doing fig(9).

3.2. Electrical Safety

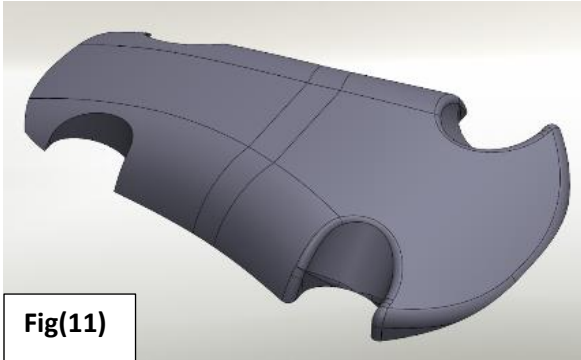
The electrical system of the ROV works at 12 volts. Use a lot of power. This can cause problems like things getting hot, short circuits and parts getting damaged. To reduce these risks, we choose wires that can handle power. They are covered to prevent exposure. We also use parts like fuses and voltage regulators to keep the system working and to prevent too much power from going through. We use converters to reduce the voltage for sensitive electronics, so we work well. Before using the system, we make sure all the electrical connections are securely sealed and tested, and there are no wires exposed.

3.3. Mechanical Safety:

The ROV has thrusters and moving parts, which can be dangerous when it is working. To make it safer, we put guards on the thrusters to prevent accidents and stop cables or debris from getting tangled fig(10)/ fig(11)



The frame of the system is made smoothly, so there are no edges that can hurt someone while handling it (Fig). All the parts are attached securely, so they do not come loose when the system is moving or vibrating. We are very careful with cables, so they do not get in the way of the moving parts, and the system stays safe.



Fig(11)

3.4. Operational Safety

Before putting the ROV in the water, we check the system to make sure everything is working and safe. We check the connections, test the thrusters and make sure the sensors are working right. While the system is working, we watch it from the control station all the time. If something is not right, we fix it immediately. We have plans about what to do in case of an emergency, including turning off the system right away if something goes wrong. We keep the area where the ROV is working free of things that could get in the way or interfere with the system.

3.5. Environmental Safety

KRAKEN wants to make sure we do not hurt the environment while working. The ROV is designed to work underwater without releasing things into the water. We use materials that are safe for the underwater environment. When we are working near areas like underwater structures or places where marine animals live, we are very careful not to cause damage or disturb the animals. We make sure the ROV does not bother life, and we follow good practices to keep the environment safe.

3.6. Safety Procedures

To keep safety standards the same, KRAKEN uses set procedures for all parts of the project. Before using the system, we go through a checklist to make sure everything is ready. We first test the ROV in a place to make sure it works safely before we use it fully. If something goes wrong, we turn off the system to find out what the problem is, then maintain all the parts of the system, including the electrical parts, cables and mechanical parts to make sure it is safe and works well for a long time.

4. Critical Analysis

4.1. Budget

Budget Allocation Category	Description	2026
Lab Safety	Items used for Lab Safety.	710 L.E
Tools & Equipment	Items used in lab fabrication.	7931 L.E
Research and Development	Prototypes and materials.	2100 L.E
ROV Surface Station	Surface station items.	725 L.E
ROV Structure	Frame, tether, pressure hold.	19879 L.E
ROV Electronics	Sensors, converters, cameras, Microcontrollers.	38496 L.E
Float	Onboard float items.	7788 L.E
Competition Logistics	Shipping costs.	2414 L.E
Competition Fees	Shipping costs.	32660 L.E
Competition Travel	Travel cost.	1500 L.E
Total Cost		114203 L.E

4.2. Resources and References

For Mechanical Section: Design and simulation programs like; SolidWorks, AutoCAD, SolidWorks Simulation, AI websites and physics resources for hydrodynamic and pressure analysis SERWAY references, how to mechatronics site.

For Electrical and Software Section: Christ, R. D., & Wernli Sr, R. L. (2013). The ROV manual: a user guide for remotely operated vehicles, compilers for coding (try & error), GitHub Documentation, Microsoft Outlook help, Google Drive help and Raspberry Pi Documentation

4.3 Future plans

The Kraken ROV team plans to enhance the system by improving autonomy, vision, and overall efficiency. Future upgrades include integrating high-resolution cameras with computer vision, implementing advanced control systems for better stability and semi-autonomous operation, and optimizing the mechanical design for reduced weight and drag. The electrical system will be refined with improved power management and custom PCBs, while the gripper will be upgraded for greater versatility. Additionally, the buoyancy system will be improved for more precise depth control, ensuring higher performance and reliability in future MATE competitions.

4.4. Lessons Learned

Throughout the development of the Kraken ROV, the team gained valuable technical and non-technical experience. Technically, we learned the importance of system integration, iterative testing, and troubleshooting, especially in areas such as power distribution, waterproofing, sensor calibration, and control system stability. We also developed strong skills in programming, electronics design, and mechanical fabrication. On the non-technical side, the project enhanced our teamwork, communication, and time management abilities,

as coordinating across multiple subsystems required clear planning and collaboration. Additionally, we improved our problem-solving mindset, adaptability, and decision-making under constraints such as limited resources and time. Academically, the project helped us bridge theoretical knowledge with real-world engineering applications, deepening our understanding of robotics, control systems, and design processes.

4.5. Build vs. Buy

We followed a build-dominant approach in our ROV project, where we made and integrated most of the components ourselves, especially the mechanical parts such as the frame, mounts, and structural elements. Although this was much more difficult than simply purchasing ready-made parts, it gave us better control over design, weight, cost, and compatibility. However, for some specialized components that are difficult to manufacture reliably, such as thrusters and certain electronic parts, we chose to buy them from trusted suppliers and websites. This approach helped us balance practicality, performance, and hands-on engineering experience.

- **Buy:**

Component	Justification
Raspberry Pi 5	Excellent processing power, fit for our system.
Buck Converters	Selected for its high-efficiency step-down
Cameras	delivers appropriate visibility for the pilot during MATE tasks
Arduino Nano	Compact, reliable PWM control for thrusters/servos
IMU and MS5837	Precise 9-DOF absolute orientation and depth data.
Brushless Motors	Compact, high efficiency, reliable

- **Build:**

Component	Justification
DIY water sensor	Simple conductivity circuit to detect leaks fast.
Control PCB	simplifies wiring, efficient and takes up little space
Thrusters	All 3d printed parts
Tether	Collecting all data cables and power

4.6. Acknowledge

We would like to express our sincere gratitude to everyone who supported us and gave us the opportunity to participate in this competition. First and foremost, we are deeply thankful to **The Arab Academy for Science, Technology and Maritime Transport (AASTMT)** for its valuable support, encouragement, and financial assistance, which helped us take part in this experience and continue developing our project. We also extend our appreciation to **Mate Egypt and the organizers and sponsors of the competition** for providing us with this important opportunity to participate, learn, and challenge ourselves in a real engineering environment. As this is our first time joining this competition, this experience has been especially meaningful for us, and we are truly grateful to everyone who contributed to making it possible