Team VISHWA

IRC - International Rover Challenge

VYOM ROVER

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Contents

1 | EXECUTIVE SUMMARY

This System Design and Development Review (SDDR) report encapsulates the comprehensive planning and conceptualization behind our Mars Rover project. The rover is meticulously engineered for Instrument Deployment and Maintenance Operations, Reconnaissance and Delivery Operations, as well as Autonomous and Astrobiology Expedition. A detailed milestone chart meticulously tracks the rover's design, production, and assembly progress, ensuring a clear path to completion. The report delves into the team's robust organizational structure and highlights the remarkable individual contributions by team members, showcasing our collective synergy and efficiency. Additionally, a thorough design approach outlines precise engineering techniques, machining procedures, and the requisite equipment for each subsystem. Furthermore, an estimated budget for the rover's design, conceptualization, and fabrication is detailed. Finally, the report culminates with the team's unwavering vision and motivation, illustrating our steadfast commitment to achieving excellence.

2 | MILESTONE CHART

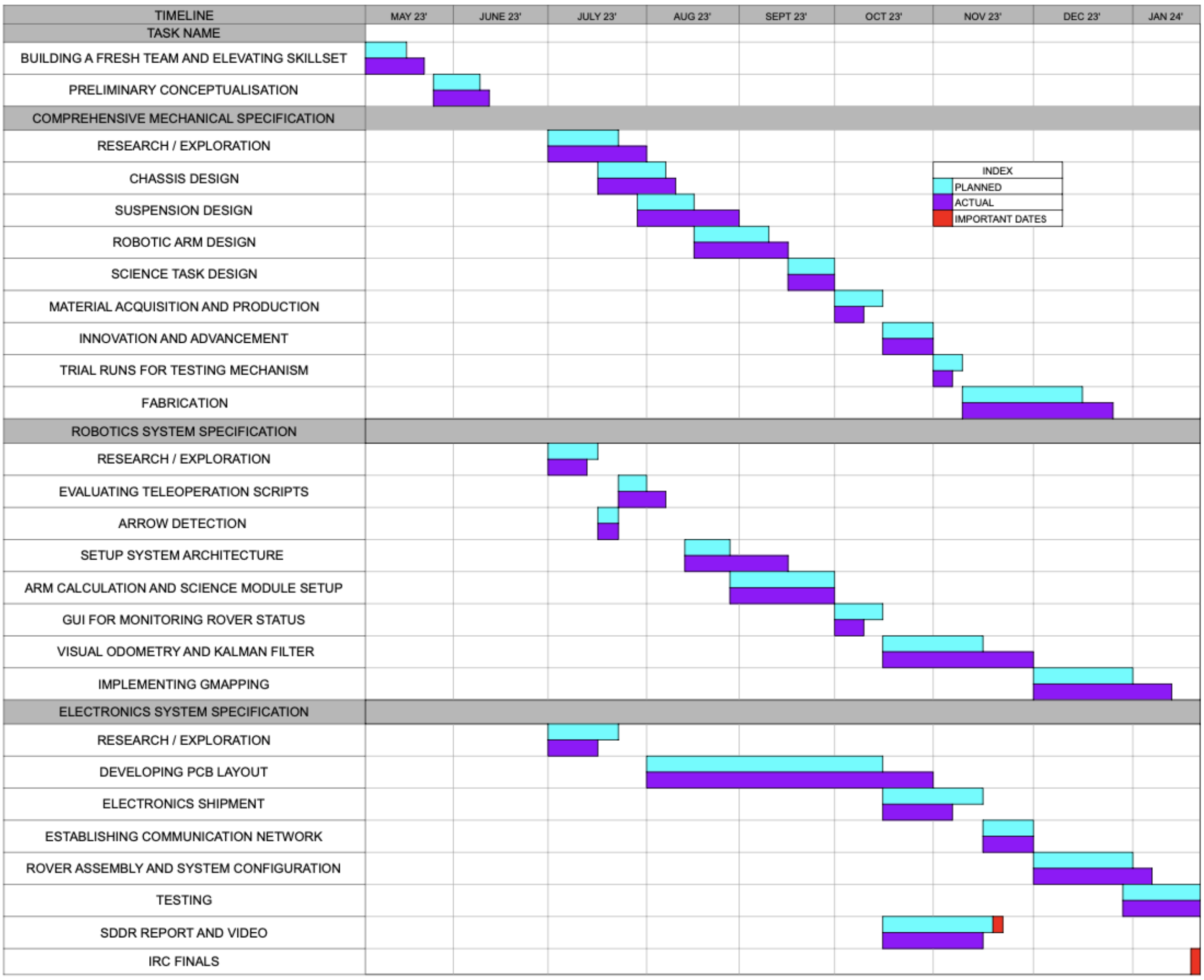

Figure 2.1: Project Timeline

3 | TEAM STRUCTURE

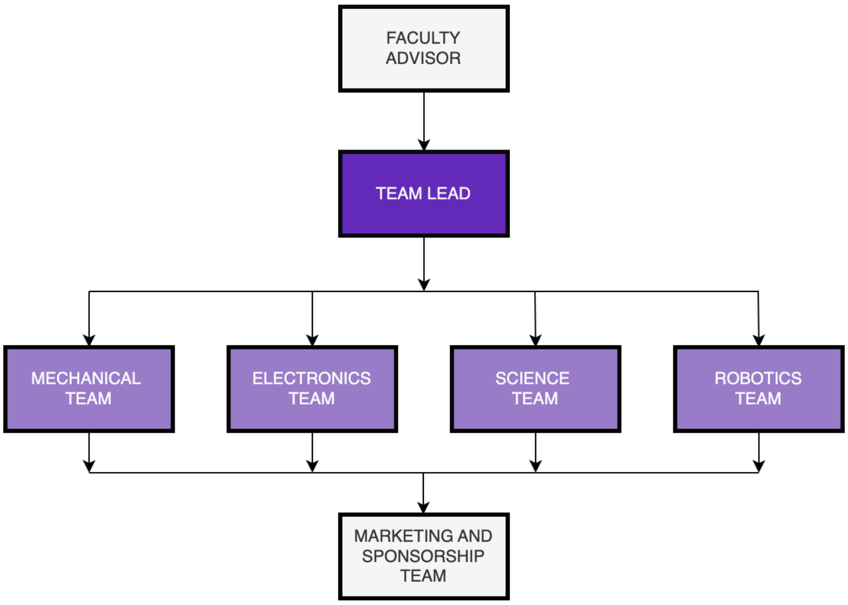

Figure 3.1: Team Structure

Team Vishwa is comprised of twenty-seven undergraduate students, divided into four distinct sub-teams: Mechanical, Electronics, Robotics, and Science. While this hierarchy serves as a broad framework, all team members actively collaborate to explore the intricate relationships between various fields and generate innovative solutions. The entire team participated in the design, testing and documentation process. We held regular meetings to update our Faculty Advisor on our progress. In light of our team's experience from the previous year in this competition and the ongoing challenges associated with securing sponsorship and funding, we've made the strategic decision to opt for a collective approach rather than setting up a separate business-focused team to explore potential funding avenues.

3.1 | MECHANICAL TEAM

The Mechanical sub-team was tasked with the design and fabrication of the rover's structural components, providing a robust framework that supports all other systems. Extensive research led to the selection of materials and systems capable of withstanding the harsh environmental conditions of Mars.

3.2 | ELECTRONICS TEAM

The Electronics sub-team plays a pivotal role in the rover's operation. Their primary focus lies in establishing a wireless communication system and finalizing the necessary electronics to bring each subsystem to life, including propulsion (drive), robotic arm, and scientific apparatus. This sub-team is also involved with PCB design and research related to embedded systems.

3.3 | ROBOTICS TEAM

The Robotics sub-team is responsible for creating the teleoperation and autonomous traversal control systems for the rover. They also delve into developing control systems for the robotic arm and science module. Additionally, the team has designed an user-friendly GUI for configuring the ground station, facilitating seamless full-duplex communication with the rover.

3.4 | SCIENCE TEAM

The Science sub-team plays a pivotal role in carrying out the Astrobiology Expedition. They've conducted extensive research and development to analyze Martian soil samples and detect potential signs of life. Moreover, this sub-team has developed a modular scientific instrument mechanism to carry out their research tasks efficiently.

4 | DESIGN REQUIREMENTS

4.1 | ASSUMPTIONS

4.1.1 | MECHANICAL

A. To achieve true dynamism, the rover must exhibit resilience in the face of both impact forces and elevated dynamic stresses. Using tougher materials is thus a suitable choice under these settings. Aluminum 6061 is employed as the primary structural component for chassis construction, owing to its elevated toughness, exceptional durability, and weldability.

B. In order to enhance traction, it's necessary to maximize the contact between the tires and the ground. This is achieved by employing 3D-printed hub wheels in combination with a holonomic suspension system.

C. The rover's design requirements prioritize versatility and endurance. 5 DOF is considered in the robotic arm which is intended for a variety of tasks, like lifting standard-weight objects, fixing bolts, and opening/closing drawers. Key considerations encompass lightweight construction to maximize mobility and durability to withstand the rigorous missions, ensuring efficient operation.

4.1.2 | ELECTRONICS

A. To navigate challenging terrain, the motors need to provide robust starting torque. We require motors capable of delivering precise and consistent movements. Therefore, DC motors equipped with planetary gearboxes have been selected due to their ability to offer a combination of high torque, rotational speed.

B. The robotic arm is a five-degrees-of-freedom system capable of lifting a maximum load of 5 kgs. To achieve this, we require highly precise DC planetary motors with encoders as they provide the necessary strength and efficiency.

C. In the bevel system of the end-effector, precise rotation of the DC motors is crucial for proper operation for which, we have implemented PID mechanism.

D. The communication equipment must have a high throughput while being efficient in terms of range. Therefore, 5.8 GHz communication frequencies are the best choices because of their excellent SNR features. For optimal communication, the antennas should have a medium to high gain. Hence, a gain of 9-15 dB is considered.

4.1.3 | ROBOTICS

A. Recognizing the critical need for precision when manipulating objects with the robotic arm, an essential feedback mechanism must be integrated through a closed-loop control system. In our robotic arm, we have adopted a PID (Proportional-Integral-Derivative) control system which utilizes a constant feedback loop that of the arm's position by continuously analyzing the deviation between the desired and actual positions, utilizing magnetic encoders.

B. Operating under the assumption that the competition takes place in ample daylight, we have integrated Depth Images into our autonomous navigation system. Our navigation system capitalizes on the depth-measuring capabilities of the realsense depth-camera to detect arrows and simultaneously gauge their distance, a critical element for the success of our autonomous mission.

C. Given the off-road nature of the terrain, potential inaccuracies in visual odometry data may arise. To mitigate them, we've implemented a navigation system consisting of an IMU (Inertial Measurement Unit) and GPS (Global Positional System). Their integration occurs within an extended Kalman Filter, resulting in the development of a precise 2D occupancy grid map.

4.1.4 | SCIENCE TASK

A. Planetary Conditions: Various Planetary conditons like of Mars can be understood and predicted. This includes factors like surface temperature, atmospheric pressure, radiation levels, and the chemical composition of the environment.

B. Environmental Conditions: Assumptions about the environmental conditions of the target body, including the terrain, surface features and potential hazards help guide the rover's design and navigation.

C. Contamination Control: Strict contamination control procedures are put in place to minimize the risk of introducing terrestrial life to other worlds.

4.2 | PRACTICAL REQUIREMENTS

4.2.1 | MECHANICS

The rover's mechanical subsystem should be exceedingly robust and responsive. To fulfill these criteria, it's essential to create and manufacture the mechanical parts with precision. We employed advanced machining techniques, including laser cutting and CNC machining, to attain the necessary precision.

Chassis: In the rover's chassis, we opted for a straightforward approach by employing an aluminum extrusion bar box frame. The material chosen for the rover chassis is Aluminum 6063T6, recognized for its machining and shaping versatility. To enhance structural integrity, we secured the extrusion bars with corner brackets, ensuring a robust and efficient design.

Suspension: We utilized an inverted V design to reduce weight and enhance stability for suspension design. Choice of material to Construct arms and suspension components from Aluminum 6061 for strength and weight reduction.Implemented high-torque DC motors with 120 kg-cm torque for steering and 120 kg-cm for driving. Employed planetary gearboxes to efficiently drive the wheels. Use of total eight motors, with four for steering and four for driving, along with four gearboxes to optimize wheel performance.

Wheels: Wheels is constructed using TPU to absorb shocks and maintain traction on diverse terrains.Utilized 3D printing for the wheel hub and other suspension components to allow flexibility in design and manufacturing, ensuring effective performance across various terrains.

Robotic Arm: For various tasks, a 5 DOF robotic arm has been built. The shoulders and elbows of the robotic arm were made from aluminium sheets. A two-claw gripper is employed for gripping and holding.

4.2.2 | ELECTRONICS

Power Distribution: We developed a power distribution board to supply voltages to microprocessors, motors and sensors. To get the appropriate voltages for operating various circuits, the board employs the concept of adjustable voltage regulators and Switching Regulators. LiFePO4 batteries have been utilized because they outperform lithium-ion batteries in terms of cycle life (lasting 4-5 times longer) and safety.

Propulsion: The rover is propelled by DC motors with a closed-loop design, which are controlled by custom BTS7960 driver boards. A closed-loop feedback system is constructed for rover position control using an OE37 magnetic encoder. The motors are controlled by a custom STM32F7 microcontroller breakout, which provides PWM and direction inputs to the motor driver and uses feedback to correct the rover's position. Each wheel has two motors, one controlling speed and the other controlling direction.

Robotic Arm: The arm requires two planetary gear motors at the shoulder and elbows to achieve its 5 degrees of freedom. The bevel system requires two DC motors that roll to a precise position. To achieve this, we require magnetic rotary encoder that provides precise details of the motor position. The arm's base must support the entire weight of the arm; therefore, we have opted for DC worm gear motors. These motors are known for their ability to generate high torque, making them ideal for tasks that involve lifting or moving heavy loads.

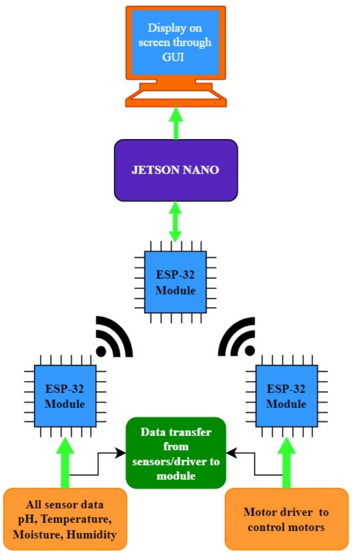

Figure 4.1: Communication Arch.

Science Task: For Science, ESP32 devkit is used for controlling various sensors and motors. In total, 4 Peristaltic Pumps, a servo, two Worm-Gear Motors, a Johnson Motor are used.

Communication: We are using the 5.8 GHz frequency spectrum (corresponding to the IEEE 802.11 standard) with Ubiquiti Rocket M5 for manual control to communicate between the rover and the base station. The Ubiquiti Rocket M5 is a high-performance wireless access point designed for demanding outdoor environments. Operating on the 5 GHz frequency band, it offers robust, long-range wireless connectivity. With a durable, weatherproof design, it's well-suited for applications such as point-to-point and point-to-multipoint links, making it ideal for wireless backhaul or bridging solutions. Sensor data and control commands are sent between the rover and the base station at a net data transfer rate of 150mbps. An omnidirectional antenna is connected to the 5.8GHz transmitter. IP cameras are connected to a PoE switch using a PoE splitter, and the feed is transmitted via the antenna on the rover.

4.2.3 | ROBOTICS

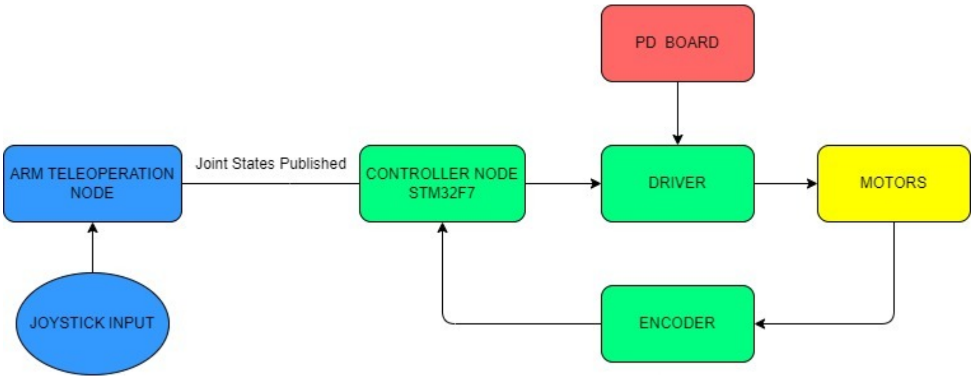

Figure 4.2: Rover Control Sturcture

The JETSON NANO onboard computer is vital for our rover's autonomous functions, handling path planning, arrow detection, and traffic cone identification. These tasks are computationally intense, especially in real-time scenarios. Arrow detection has been implemented using cascade classification. We've strategically divided control tasks between base station and onboard computers, enhancing mission efficiency and responsiveness. Coordination relies on a shared ROSMASTER hosted on the base station, linking all computers and the JETSON NANO for seamless collaboration. To ensure continuous camera feeds, an Onboard Depth Camera (Intel realsense) with two sensors triangulates pixels, offering depth perception for object recognition. This aids in recognizing object distances and tracking multiple objects within scenes, enhancing our rover's capabilities during the autonomous mission.

Graphical User Interface: A custom GUI is designed to monitor the rover's state, sensor data, and other crucial information at the base station. The astrobiology mission requires sensor data from many sensors deployed on the rover. To check the necessary conditions for life, the controllers must be able to relay the data to the GUI using which we draw inferences from the tests performed on the soil. The GUI allows us to visualize the sensor data in a more human-understandable fashion to make sure only the right inferences are drawn from the tests.

4.2.4 | SCIENCE TASK

pH, Temperature, Pressure and Moisture sensor: Presence of life is more expected in the regions where atmospheric conditions supports respiration. The Science sub-system uses various ESP-based electronic micro-sensors to test the atmospheric conditions before collecting soil samples. All the sensors would be connected to ESP module through jumper-wires. The gas, infrared and pressure sensors would be used to check preliminary requirements at desired site. After collecting soil, it's physical parameters like pH, temperature and moisture will be tested.

Thermal Imaging: Body temperature of a living being is comparatively higher than the surrounding temperature. So, we can predict the presence of life using thermal imaging. Infrared sensor will detect the temperature of surrounding objects and will indicate the presence of life.

Integration with Rover system: Rover's mobility, power and communication systems should have to be integrated seamlessly. The science subsystem should be compatible with rover's overall architecture.

Robustness: Designing the science instruments to withstand the harsh environmental conditions of the target planet, including extreme temperatures, radiation, and dust is a must. Proper shielding and thermal control are essential.

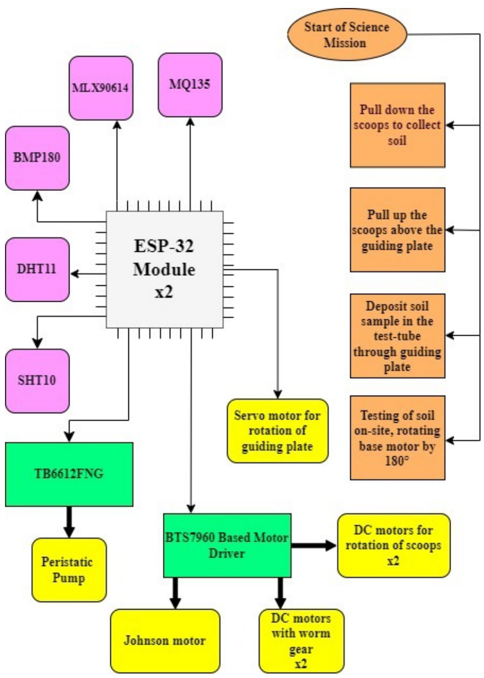

Figure 4.3: Science Task Structure

5 | TECHNICAL DESIGN ASPECTS

5.1 | MECHANICS

Chassis: The rover's chassis is constructed using a box-type frame made from aluminium extrusion bars. Aluminium extrusion bars are selected to reduce the overall weight of the chassis. These extrusion bars exhibit an excellent rigidity-flexibility ratio. The ability to balance rigidity and flexibility ensures that the rover can withstand shocks and vibrations. Extrusion bars are relatively inexpensive to manufacture. Material used for rover's chassis is aluminium 6063T6 alloy. Aluminium 6063T6 is known for its ease of machining and forming. Aluminium 6063T6 offers a balance between strength and weight, exhibits good resistance to corrosion, ensuring the rover's longevity.

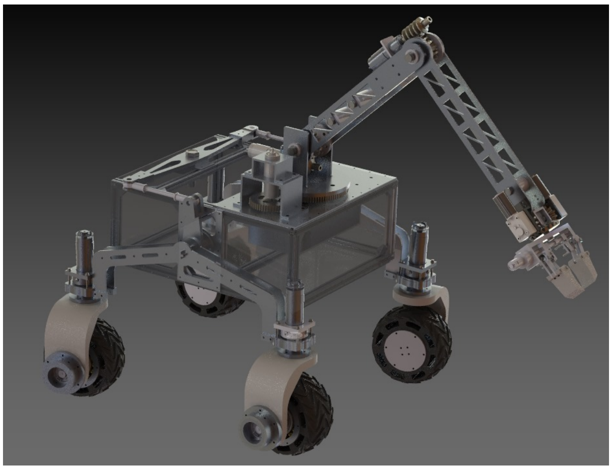

Figure 5.1: Rover Model

Suspension: The suspension system of the rover combines a unique design which features with inverted V design which reduces weight and enhance stability. Each wheel is equipped with individual high-torque motors to provide precise control and maneuverability. To ensure strength and durability, the arms and suspension components are constructed using Aluminum 6061. This material is known for its excellent strength-to-weight ratio. Each wheel is driven by a high-torque DC motor of 50 kg-cm for steering and 120 kg-cm for driving. Planetary gearboxes are employed to provide the necessary gear reduction, allowing the motors to efficiently drive the wheels. The rover is equipped with a total of eight motors, with four of them dedicated to steering and the other four for driving along with four gearboxes to optimize the wheel's performance.The wheels are constructed using TPU. TPU is chosen for its ability to absorb shocks and maintain good traction on various terrains. The wheel hub, as well as other components of the suspension system, are 3D printed. This system ensures the rover's ability to navigate diverse terrains and will perform tasks effectively.

Robotic Arm: The rover is equipped with a 5 DOF robotic arm, for endurance tasks such as lifting objects of standard weight and other tasks like fixing bolts and opening or closing drawers, etc. The arm is made of Al6061 sheets for better strength to weight ratio and less weight. This time, we have used planetary gear motors coupled with worm gears of 15:1 reduction ratio to provide high torque at elbow and shoulder joints and also with increased range of angular motion and minimal backlash. A bevel gear system is used to achieve pitching and rolling motion of the end effector. The claw has a screw gripper-based mechanism which can grip objects upto 8-9 CM diameter. The base consists of spur gear system coupled with planetary gear motor to provide sufficient torque for base rotation as well as support system for base shaft to avoid cantilevering of the arm. Weight optimization is performed at appropriate regions to reduce the overall weight of the arm.

5.2 | ELECTRONICS

Propulsion and Robotic Arm: Joystick commands in the form of pulse width modulated signals are sent to the STM board, which then forwards them to the custom motor drivers that control the eight DC motors responsible for steering and speed. OE37 magnetic encoders are used to obtain the position and degree of rotation achieved by the wheels. This information is then fed back to the STM board for proper PID control. The Robotic Arm also uses a similar type of PID control. The STM32 microcontroller precisely controls the angles of movement. It is chosen due to its higher efficiency in performing complex tasks. The motors are driven by an H-Bridge TB6600 motor driver.

Power Distribution: The circuitry converts voltage from batteries to a specific voltage using voltage regulators and switching regulators. Adjustable voltage converters are used to convert 12V to 5V, 3.7V, and 3.3V. Switching buck-boost converters are used to obtain 7V, 9V, and 24V from 12V. All this circuitry is integrated into a single Printed Circuit Board.

Science Task: In the scientific system, two ESP-32 modules are utilized to control the behavior of sensors and motor drivers, each serving specific functions.

Sensor Control Module (ESP-32_1): This ESP-32 module is responsible for collecting and transferring data from various sensors, including: DHT-11, MQ135, SHT-10, MLX90614 and BMP-180. It gathers data from these sensors and facilitates its transfer for further processing.

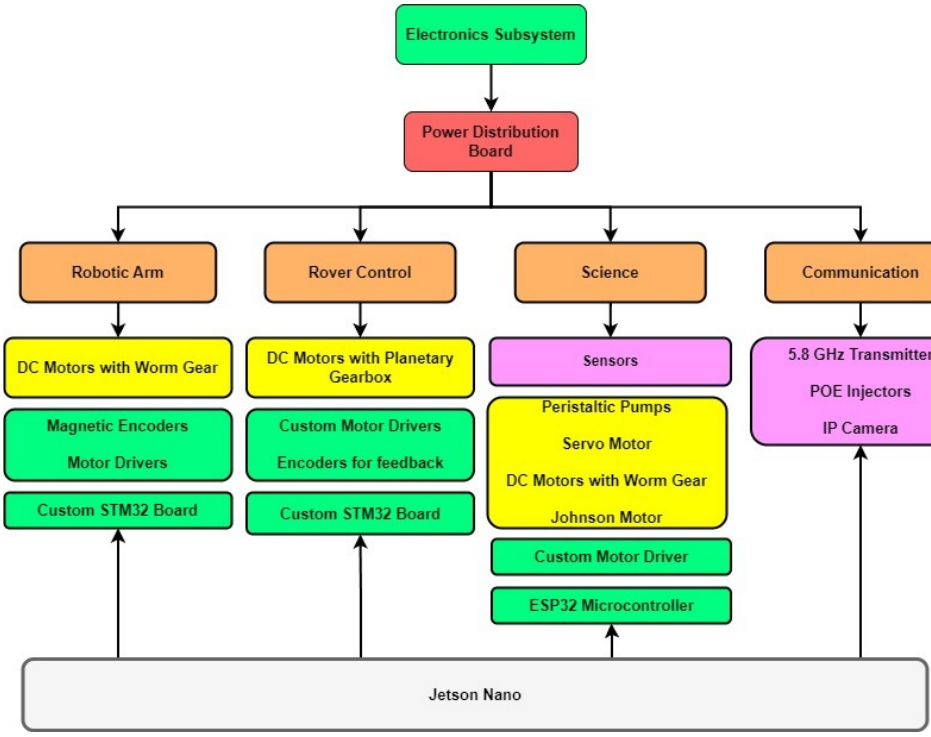

Figure 5.2: Electronics Structure

Motor Control Module (ESP-32_2): The second ESP-32 module is dedicated to controlling motor drivers, specifically using these ICs:

- BTS7960 (controlling the Johnsons motor for linear motion)
- TB6612FNG (controlling the two worm gear motors for soil collection and dumping)
- BTS7960 (controlling the DC motors at the base of the test-tube container for mixing solutions)

It manages the motor drivers, ensuring precise control over various motors in the system.

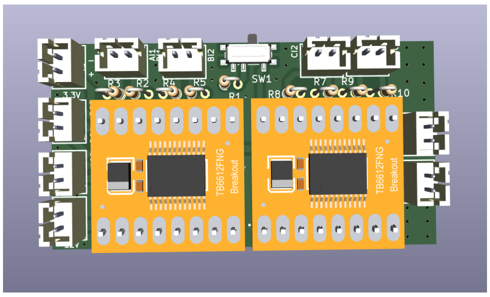

Figure 5.3: Custom Motor Driver

Motor Description: The Johnsons motor, attached to the extrusion bar for linear scooping motion, is under the control of the BTS7960 motor driver. Two worm gear motors are used to rotate the scoops for soil collection and dumping, with control provided by the BTS7960 motor driver. A servo motor is responsible for rotating the guide plate, preventing the scoops from stopping when collecting soil samples. Additionally, two DC motors, mounted at the base of the test-tube container, are utilized to rotate the test tubes for proper mixing of solutions. This system's configuration enables precise control over various components, ensuring the efficient collection, movement and processing of soil samples and solution mixing.

Communication: Jetson Nano which is main control unit of rover, is connected in a local network with the base station via ethernet to Rocket M5AC radio. Serial connection is utilized between the Jetson and other microcontroller to transfer control commands issued by the base station. The video stream is transmitted directly to the base station across the 5.8GHz frequency band which yields high bandwidth, low interference and great speed.

5.3 | ROBOTICS

Rover Teleoperation: In the development of the rover's teleoperation control system, a primary focus was placed on achieving responsiveness and minimizing latency. The control architecture involves the base station publishing motor values for the rover via a ROS-topic, accessible through the shared ROSMASTER. Rosserial is a communication framework for the Robot Operating System (ROS), designed to enable communication between embedded systems, such as microcontrollers, and the ROS ecosystem. It facilitates the integration of low-level hardware components

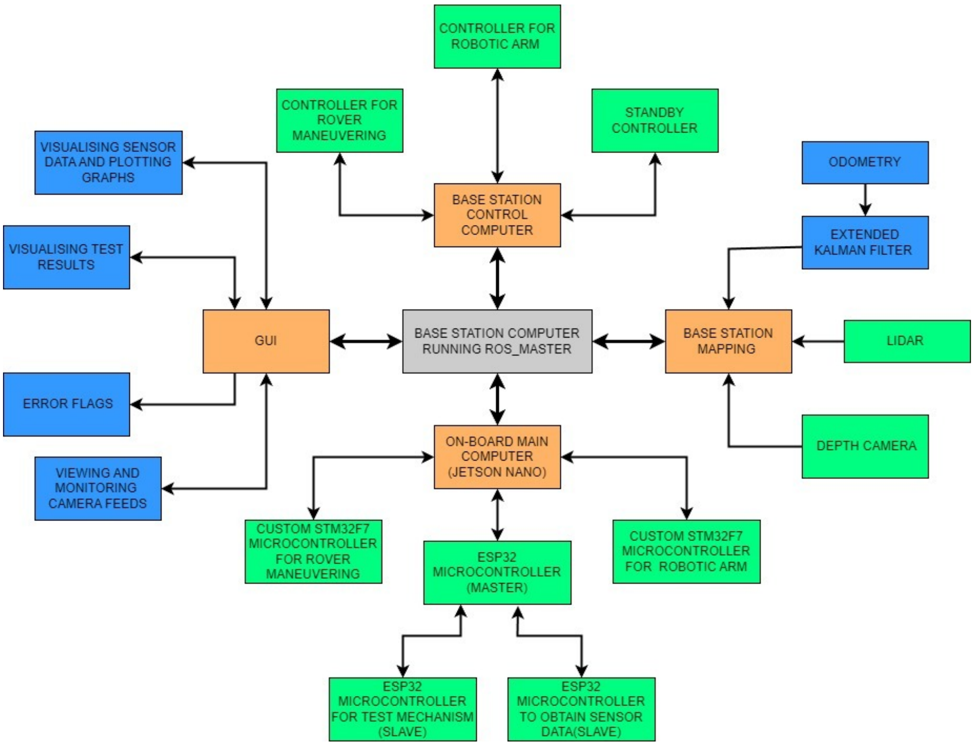

Figure 5.4: Rover Teleoperation Structure

and sensors with ROS, which is widely used for tasks like perception, control, and decision-making. A rosserial node on a Jetson-Nano acts as an intermediary, facilitating communication with the microcontroller, which subsequently transmits the necessary signals to the rover's motors. This control system was built from the ground up and offers both differential and holonomic drive modes. Notably, the base station controller has the flexibility to select the drive mode that best suits the specific maneuvering requirements, enhancing the rover's overall versatility.

Robotic Arm Teleoperation: Our 5-degree-of-freedom robotic arm is under the control of a closed-loop control system, offering precise and reliable operation. The arm's unique setup involves one planetary geared DC motor, two planetary gear motors for the initial three degrees of freedom, and a bevel geared DC motor, along with an additional DC motor, for the remaining two degrees of freedom, which control the gripper. Ensuring the arm's safety and preventing it from entering any unrecoverable positions demands careful consideration of joint limits and its specific dimensions. To facilitate control, velocity and position commands for the robotic arm are generated via a custom control algorithm at the base station. Similar to the rover teleoperation process, the Jetson Nano relays these commands to the microcontroller designated for the robotic arm via ROSSERIAL. The microcontroller leverages potentiometer readings from the robotic arm's joints to compute position errors, enabling precise adjustments to achieve the desired arm positions.

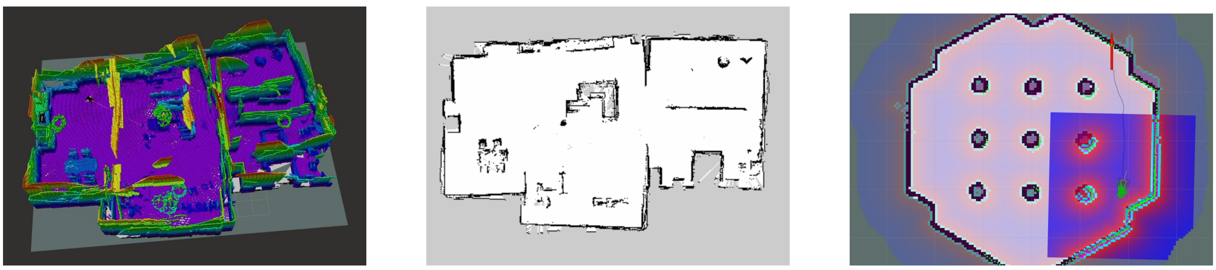

Figure 5.5: Obtained 2D Occupancy Grid

Mapping: Our mapping process relies on acquiring depth images and rover odometry data. The depth camera transmits depth images and visual odometry information through ROS topics from the onboard Intel realsense depth camera. To refine odometry data for the 2D map, we employ an Extended Kalman Filter at the base station. The 2D occupancy grid map for the rover is generated using G mapping, incorporating the odometry data post-Extended Kalman filtering. In addition, we utilize RTAB-map, leveraging visual odometry data obtained from the onboard depth camera.Our rover's capabilities are further enhanced through the integration of Frontier Exploration, allowing for simultaneous path planning and mapping.Additionally, arrow detection is implemented to facilitate autonomous traversal, enriching the rover's autonomous navigation capabilities.

Arrow Detection: We rely on the OpenCV library and Haar cascade classification method to detect arrows and determine their directions, a pivotal task that the rover performs autonomously. This approach provides us with a high level of accuracy in arrow detection. We use the distance value from the generated point cloud of the depth camera at the coordinates (x, y) where the arrow was detected. The direction and distance information of the arrows are then published to the autonomous traversal control node, which operates on the onboard computer and communicates over a ROS-topic. The control node is responsible for making decisions and maneuvering the rover based on this information, ensuring its smooth and autonomous navigation.

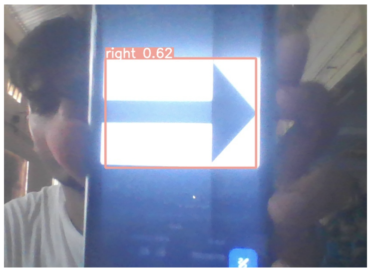

Figure 5.6: Arrow Detection

GUI: The design process involved utilizing QT Creator. Our GUI is constructed entirely with Qt objects, and we customize the properties of these objects by harnessing data obtained through subscriptions to various rosserial nodes. To visualize real-time data, we employ qcustomplot.cpp to create dynamic graphs. This graphical representation not only enhances the overall visual appeal but also expedites data analysis, enabling quicker and more insightful inferences to be drawn from the information.

5.4 | SCIENCE TASK

Soil Collection and Transfer Mechanism:

1. **Scooping Mechanism:** The scooping mechanism consists of 2 buckets/scoops that dig up to 5cm in soil. A worm gear motor of 40kg.cm torque is attached to each scoop via coupling to carry out the digging and dropping of soil.
2. **Soil Transfer:** The collected soil in scoops is dropped on a guide plate which precisely divides and transfers dropped soil into two test tubes. This is done with the help of guide vanes attached to the plate.
3. **Mixing:** For chemical testing of soil, it is very important that soil should be properly mixed with chemicals and water. Thus, rotation mechanism is introduced to rotate the test tubes which mixes the soil, chemical, and water.

Figure 5.7: Developed GUI

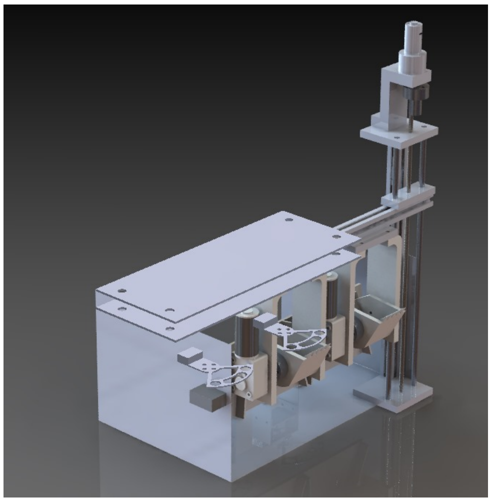

Figure 5.8: Science Task Model

Chemicals to be identified: Aldehydes, Carbohydrates

Identification of aldehydes: Aldehydes support life by participating in essential metabolic pathways, serving as energy sources and intermediates for biosynthesis, contributing to cellular signaling, and playing a role in the detoxification of toxic compounds.

- **Schiff's Test:** Appearance of pink, red or magenta color indicates the presence of aldehyde group.
- Schiff's reagent is prepared by passing Sulphur Dioxide into a solution of the dye fuchsin. The solution becomes colorless due to the formation of an additional product. Aldehydes abstract sulphurous acid from Schiff's reagent and restore the pink color. The coloration is due to the formation of complex compound. Ketones, in general, do not respond to this reaction.

Identification of carbohydrates: Carbohydrates are the key source of energy used by living things. Also serve as extracellular structural elements as in cell wall of bacteria and plant. Hence, the test for carbohydrates will be very much useful for knowing the life availability on different celestial bodies.

- **Iodine test:** This test is specific for polysaccharides.
- Procedure for Iodine test:
  Take 2 ml of the given solution in a test tube.
  Add 2-3 drops of iodine reagent in the above test tube.
  Wait for some time.
  After adding iodine in the solution, if color changes to blue then this confirms the presence of starch in the solution.

5.5 | ROVER

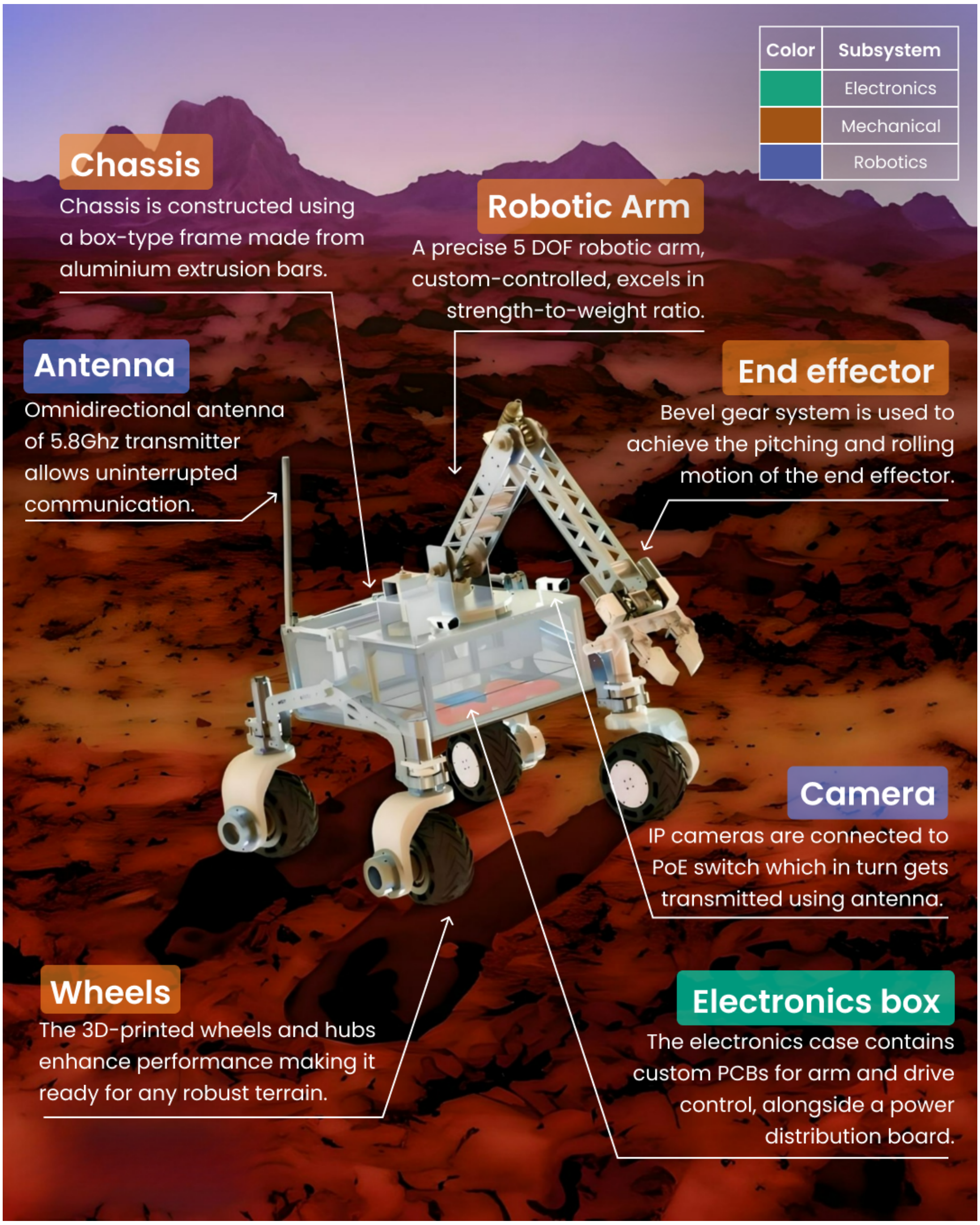

Figure 5.9: VYOM

6 | APPROXIMATE BUDGET FOR ROVER DESIGN

Sr No	Component	Quantity	MRP with GST
Microcomputer			
1	Jetson Nano B01	1	18,000
2	Heat Sink Fan	1	2,000
3	Depth Camera	1	35,000
Rover Control			
1	Custom STM32 Board	1	3500
2	Custom Motor Drivers	8	1500
3	46A Mosfet BTN8962	16	6720
4	Planetary DC Motors	8	16800
5	OE-37 Magnetic Encoders	8	2800
Power Distribution			
1	Custom Power Distribution Board	3	3800
2	Batteries in PDs - 12.8V each [6Ah]	4	8000
3	Batteries for Drive - 12.8V each [12Ah]	1	3000
4	Batteries for Comms - 12.8V each [12Ah]	2	6000
5	Batteries for Robotic Arm - 12,8V each[12Ah]	1	3000
Robotic Arm			
1	Custom STM32 Board	1	3500
2	Custom Motor Drivers	5	937
3	46A Mosfet BTN8962	10	4200
4	OE-37 Magnetic Encoders	5	1750
5	DC motor(Worm Gearbox)	2	8000
6	Planetary DC Motor	1	2100
7	Worm Gear Motors	2	4000
8	DC motor(End Effector)	1	1200
Communications			
1	Ubiquiti Rocket M5	2	36750
2	Omnidirectional Antenna	1	20915
3	Sector Antenna	1	19800
4	RJ45 Cat 7 High-Speed Gigabit Ethernet	10	4875
5	TP-Link TL-SF1005D 5-port Switch	2	1800
6	TP-LinkTL-POE150S POE Injector	4	7000
7	PoE Switch	1	3000
8	IP Camera	5	10000
9	DC-AC converter	1	1099
10	GPS Antenna	1	11000

Science Task			
1	ESP-32	3	1200
2	Custom Motor Driver(BTS7960)	5	937
3	46A Mosfet BTN8962	10	4200
4	Custom Motor Driver(TB6612FNG)	1	3000
5	DHT-11	2	260
6	MQ135	2	300
7	SHT-10	2	4000
8	MLX90614	2	3000
9	BMP-180	1	50
10	Servo Motor	1	500
11	Worm Gear DC Motor	2	4000
12	Johnson DC Motor	3	3600
13	Peristatic pumps	4	1600
Mechanical			
	Aluminium sheets (8*4 sheets)	1	12090
	Aluminium bars (13 feet)	2	900
	Angle brackets	60	4500
	Sliding nuts	10	250
	Acrylic sheet (8feets×4feets , 5mm)	1	7000
	Bolts (M4, M5, M8)	15 each	4780
	Bearings	20	3500
	CNC Machining		45000
	Laser Cutting		36000
Total			**392,713**

6.1 | RESOURCES MANAGEMENT

Collective efforts and the reputation of our institution have landed us a few sponsorships including the ones for the 3D printed parts and electronics. In addition to this, our institution's Student Activities group is helping us with the maximum amount of funds. Our team's unwavering dedication to this project is exemplified by our robust efforts in crowdfunding. We're actively engaging in various initiatives and outreach programs to raise funds, demonstrating our commitment to realizing the vision of this innovative rover project. The collaborative spirit and collective determination within our team continues to drive us toward the successful execution of this ambitious endeavor. We've uplifted our partnership percentage with longstanding sponsors, enhancing financial management through increased available funds.

7 | OUR INSPIRATION AND VISION FOR IRC 2024

7.1 | INSPIRATION

We are Team Vishwa, a proud constituent of VJTI's official Astronomy and Space Science Club, dedicated to propelling VJTI into the realms of excellence in astronautics. Students from different branches have come together and are working hard to make this dream a reality. Together, we strive to carve a path towards stellar achievements in the field of space exploration.

As third-year students, we've made significant progress, thanks to the guidance of our seniors and the wisdom passed down by our accomplished alumni. Our enthusiasm and love for this domain and competition drove us to devote our full attention and effort to making this CAD design a reality. We're navigating the complexities of fundraising with determination, reaching out to potential backers and sponsors who share our passion for space exploration. It's a challenging but rewarding aspect of the project, teaching us valuable lessons in resource management, networking, and the art of presenting our ideas persuasively. Every contribution, whether technical or financial, is a step forward in our quest to leave a lasting mark in the world of space exploration.

7.2 | LEARNING

Creating a rover within Team Vishwa has been an unparalleled learning experience for us. It's a rare opportunity where the best minds from various engineering branches converge to craft something truly fascinating. The rover project holds special significance as it allows each team member to fulfill a shared aspiration of engineering—the creation of a robot.

Beyond the thrill of competition, the International Rover Challenge (IRC) serves as a platform for translating theoretical knowledge into practical application. Unlike hackathons or programming challenges that often focus on a single perspective, IRC demands a holistic approach, considering the entire engineering system. This multifaceted view has expanded our understanding, pushing us to explore the intricacies of integrated design.

The journey with IRC has taught us the value of perseverance and the satisfaction that comes with turning hours of hard work into a tangible reality. It's more than just a competition; it's a transformative experience that will be etched in our memories, reminding us of the joy that comes from overcoming challenges and seeing our collective efforts materialize into a functioning rover. This is a chapter in our lives that we'll carry with pride and fondness.

7.3 | VISION

Our vision for Team Vishwa is fueled by the belief that we have a real shot at victory in the International Rover Challenge (IRC). The confidence stems from the fact that our team is a powerhouse of talent, with members hailing from various collegiate societies that have clinched major global honors. Whether it's AIAA in the USA, SAE BAJA, software hackathons, or internships with esteemed organizations like Godrej and BARC, our diverse experiences form a solid foundation.

We see our participation in IRC as an opportunity to synergize these varied skill sets, creating a rover design that not only stands out but also makes a meaningful impact on space exploration. It's about harnessing the collective expertise of our members to forge a path of success and leave an indelible mark on the frontier of rover technology.

7.4 | PREPARATIONS DONE TILL NOW

7.4.1 | Material procurement:

All necessary mechanical materials, encompassing sheet metal, bearings, and assorted nut bolts, have been acquired. Currently, these parts are undergoing machining and laser-cutting processes. Concurrently, the electronic components for the rover have been procured, with several already in transit via international shipment. Furthermore, the printed circuit boards (PCBs) are presently undergoing the manufacturing phase.

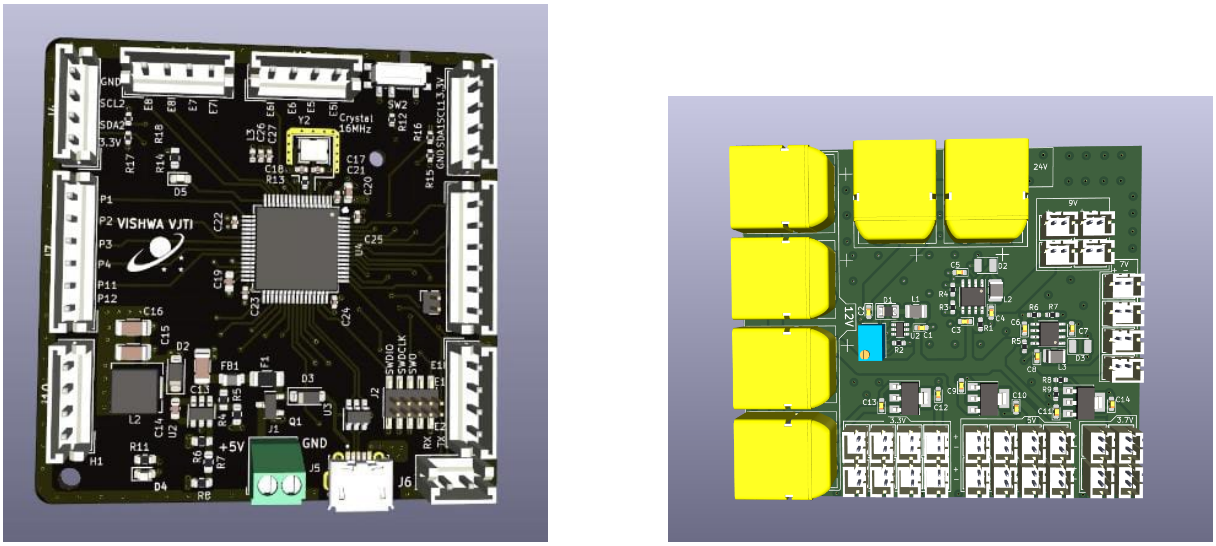

Figure 7.1: Custom PCBs

7.4.2 | 3D printed parts:

The manufacturing of the 3D printed parts for the science mechanism is complete, advancing the building process for the science module. However, the wheels are still undergoing the 3D printing process and necessitate additional time before completion.The project also encompasses the utilization of a 3D-printed encoder casing, specifically designed for seamlessly mounting the encoder onto the motor.

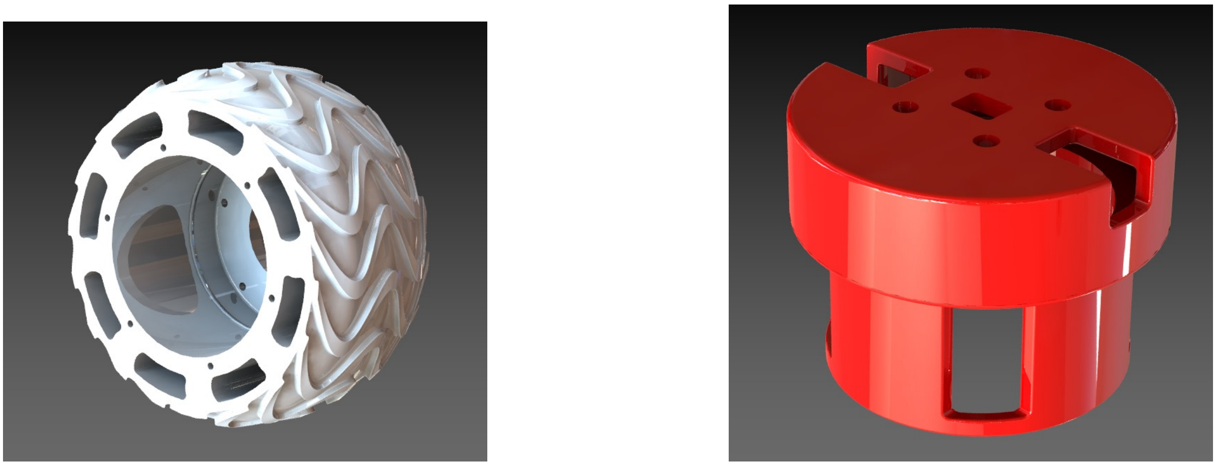

Figure 7.2: 3D Printing CADs

7.4.3 | Rover's Software:

The software and coding part of the rover control and autonomous systems are being optimized. It is ready to test as soon as we receive the shipment of all the required electronics.