IRoC-U

ISRO Robotics Challenge - URSC

Let's build a space robot

Proposal Report

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1. System Architecture

Section 1: Introduction and Power System

A full system architecture has been developed including the important sub-systems necessary to meet mission objectives. A high level summary is presented here that creates an understanding of the sub-systems, their relationships and the interface requirements that they present.

1. Power System:

- Components: The rover's power system comprises high-capacity batteries and a sophisticated power management system.
- Interdependency: The power system is vital for energizing all critical subsystems, serving as the cornerstone for the rover's overall performance.
- Interface Requirements: Strict adherence to voltage and current specifications is imperative to achieve optimal performance across subsystems.

The rover's competitive prowess is derived from its robust power system, a critical component ensuring seamless operation of all subsystems. Comprising high-capacity batteries and an intricate power management system, this subsystem acts as the lifeblood, supplying essential energy to empower the rover's diverse capabilities. In the intense competition environment, where every unit of energy holds immense value, the power system becomes the pivotal subsystem around which all others are structured. The interdependencies are evident – a robust power supply is imperative for the functionality of all other subsystems. The power system serves as the linchpin for the rover's navigation, obstacle and crater avoidance, mobility, precision in manipulator arm operations, visual sensor acuity, and sample collection and delivery. Of utmost importance is the precision of the power system's voltage interface requirements. Meeting and maintaining adherence to voltage and current specifications is crucial to align with each subsystem's unique requirements. Any deviation from these values could compromise rover mobility performance, especially in the challenging conditions presented during the competition.

Section 2: Navigation and Guidance, Obstacle & Crater Avoidance Systems

2. Navigation and Guidance System:

- Components: Inertial Measurement Unit (IMU), Depth cameras and LIDAR sensors.
- Interdependencies: Most important interdependency is on navigation, which will correctly position as well as orient the rover at any point of time during competition to maneuver accordingly.
- Interface Requirements: Standardization in data formats so that glitch free communication is possible under adverse conditions with the control system.

3. Mobility System:

- Components: Motors and specialized Steering Mechanism.
- Interdependencies: During competition challenges responsive roll out of commands for navigation, obstacle,and crater avoidance systems.
- Interface Requirements: Rovers positional accuracy and dynamic movement status update real-time feedback mechanism.

4. Obstacle Identification and Avoidance System:

- Components: Obstacle detection and dimension analysis would require special LIDAR Sensors with cameras.
- Interdependencies: We can easily share obstacle information with specific nominations to ensure smooth navigation and clear guidance for trials and instructions.
- Interface Requirements: A system which would be feasible for integration with the navigation system and that provides dynamic mapping facilities with respect to creation of challenges and effective methods of avoidance.

5. System for Crater Identification and Avoidance:

- Parts: Specialized depth cams and LIDAR sensors for identification of craters as well as the estimation of their size.
- Interdependencies: Rapid information transmission for guidance as well as navigation of the rover to get real time information concerning terrain for mapping.
- Interface Requirements: Easy linking for designing accurate paths of rovers as they navigate through any terrains.

The Navigation and Guidance System acts as the rover sensory, as well as the decision-forming center. Coupled with the navigation and guidance system are Inertial Measurement Unit (IMU), Depth cameras, LIDAR sensors whose role is to offer an information input which will be essential in ensuring accurate positioning and orientation of the rover. In a competitive landscape, where precision matters the most, this subsystem becomes the eyes and ears of the rover as it guides the rover through intricate challenges. Complimentary to the Navigation and Guidance System are the Obstacle Identification and Avoidance, and Crater Identification and Avoidance Systems. How Rover is able to use visual sensors to traverse through the arena is explained in this report.

Section 3: Manipulator Arm, Visual Sensor, Sample Collection Systems

6. Manipulator Arm System:

- Components: Robotic manipulator arm with a gripper functioning as the system's end effector.
- Intra-dependencies: System has to be in synchronization with the navigation system for sample handling tasks during competition.
- Interface Requirements: Efficiently send signals and accurately follow commands to make it easy for the arm to move and control gripping and releasing actions.

7. Visual Sensor System:

- Components: Targeting cameras.
- Dependencies: Fast data transmission to the navigation guidance system for timely decision.
- Interface Requirements: Converting data from visual sensors into identification modules improves accuracy in addressing challenges.

8. Sample Collection and Delivery System:

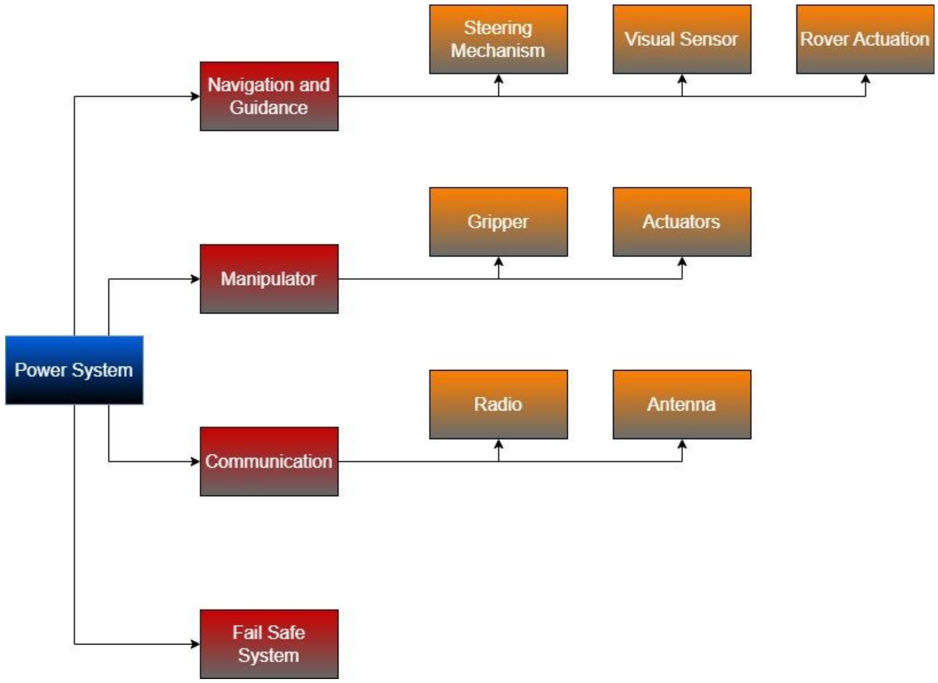
- Components: Gripper at the end effector of the manipulator arm.
- Interdependencies: Properly working with the navigation system so that while fulfilling competition objectives no error takes place in sample handling and delivery.
- Interface Requirements: Accuracy in the grip/release commands and feedback mechanisms precisely for manipulation of sample tubes.

- The rover is to traverse through the arena, and thus focus turns now onto the Mobility System. This subsystem contains motors and a dedicated Steering Mechanism by means of which it carries out precise maneuvers on the basis of inputs from the navigation, and guidance systems. This makes use of real-time feedback mechanisms ensuring accurate positioning and status of the rover ,which is the key for conquering every movement.

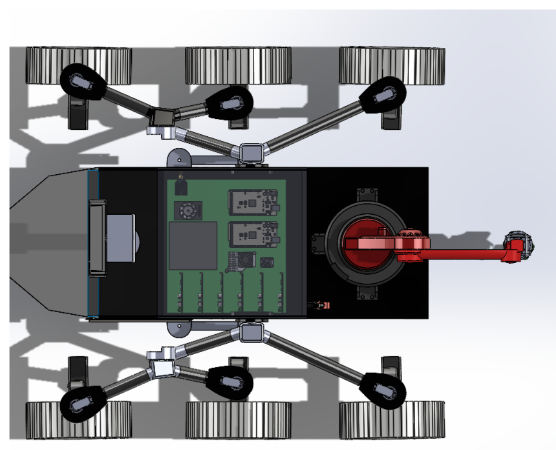
- The introduction of the Manipulator Arm System adds a level of dexterity to the rover's capabilities. This subsystem involves a robotic manipulator arm with a gripper as its end effector, working in coordination with the navigation system. This collaboration ensures efficient handling of samples during various tasks, contributing to the achievement of set goals for sample collection and timely delivery. The Visual Sensor System, consisting of purpose-designed cameras, enhances the rover's perception capabilities.

- Facilitating timely decision-making in competitive scenarios involves transferring data to the navigation and guidance system. Swift transfer of visual sensor data is crucial for prompt decision-making, significantly enhancing accuracy and efficiency in the challenges of the target identification module during competition.

- The Sample Collection and Delivery System forms a closed loop, featuring a gripper at the end of the manipulator arm. This subsystem works in coordination with the navigation system to efficiently manage samples and deliver them to specified locations while accomplishing objectives in competition. This setup entails precise grip/release commands and feedback mechanisms for successful manipulation of sample tubes.



2.Roving Mechanism



The team has decided to use a 6 wheel drive rover in order to demonstrate the autonomy of navigation for the competition. The choice of the six wheel drive rover is based on its stability, traction and mobility, making it suitable for driving in challenging terrains while maintaining control and balance.

1. Wheel Configuration:

A critical design element that plays a crucial role in ensuring mobility and stability over different terrains is the alignment of the Rover's wheels. In three rows of two wheels each, the six wheels are strategically arranged in a rectangular pattern.

a. <u>Stability:</u>

The stability of the rover is enhanced by a rectangular configuration of the six wheels. This arrangement ensures a wide and balanced wheelbase, which is essential for the smooth movements of rough surfaces as well as to prevent the rover from falling off over steep surfaces. Six wheel design is adapted from the six wheel design of the Rocker-Bogie suspension system which provides stability to the entire system. The low center of gravity achieved through this configuration enhances the overall stability of the rover during its motion.

b. Weight Distribution:

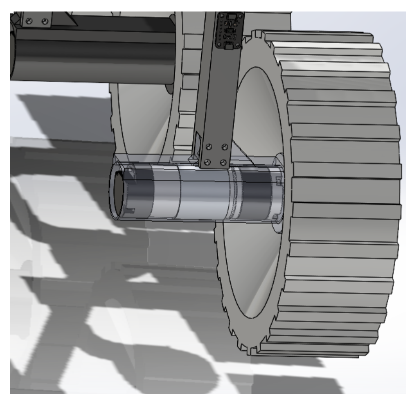
The placement of the wheels is intended to ensure a uniform distribution of weight between the rovers. It is essential for rover to have an efficient weight distribution for crossing over different terrains, as it inhibits excessive pressure on one set of wheels. In order to ensure that the rover navigates in desired manner over a number of surfaces, weight distribution also minimizes the danger of falling into soft soils or being trapped in rough terrain or getting toppled.

c. Adaptability to Uneven Terrain:

The common challenges for the Rover are uneven surfaces, craters and obstacles. With the help of a rocker bogie suspension, strategic wheels enable the rover to better adjust to changes in terrain so as to provide flexibility and stability. Wheels have extrusions spaced radially to increase friction between the surface which helps minimize slippage, increasing the rover's ability to climb up obstacles or navigate through rough terrain.

d. Wheel Design:

The rover's wheel design prioritizes grip, stability, strength-to-weight ratio, durability, and replaceability. Crafted with 3D printing using PETG, chosen for its optimal blend of strength, weight, cost, and print quality, the wheel integrates a commercially available rubber grommet for enhanced friction on the outer face. This ensures efficient motor power transfer, improved line movement, and robust steering and braking, preventing direct PETG contact with rough terrain. Dimensional considerations, such as a 22cm diameter for torque utilization and higher speed, and an 8 cm thickness for stability, provide a solid base with distributed pressure even if wheels lift. Finlike configurations on the outer surface enhance grip and redirect stresses. The iterative design process, involving finite element analysis and topology optimization in Autodesk Fusion360, achieved safety factors, stiffness maximization, and weight minimization. Ongoing work focuses on material selection for optimal manufacturing. The detailed design process is elaborated in the report.



2. Powering the Wheels:

All six wheels are powered using an independent DC motor which therefore allows us to control each motor's speed and torque independently which will help in traversing through uneven terrain and navigate rover through easily with precise motion control. This autonomy is crucial for navigating challenging landscapes and responding to dynamic environmental conditions.

The control over the speed of each motor enhances the rover's turning capabilities for smooth navigation around obstacles. This enhancement is particularly valuable on slopes, where calibrating individual motor's speed facilitates a controlled efficient ascent which provides optimized traction and stability. This dynamic control mechanism not only ensures obstacle avoidance but also significantly contributes to the rover's agility, enabling it to handle diverse terrains, including inclined surfaces.

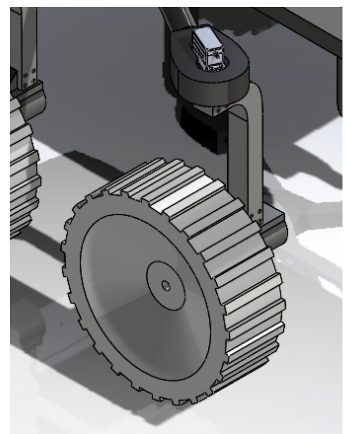
a. Adaptability to Varying Terrain:

The ability to control each wheel freely enhances the rover's adaptability toward shifting of territory conditions. By altering the speed and torque of particular wheels, the rover can viably explore through surfaces with different inclines, or impediments. This versatility is essential for guaranteeing a smooth and productive traversal over the diverse scenes that the rover may experience amid its mission.

b. Fault Tolerance:

The individual motor used for each wheel brings a level of redundancy to the rover. If one motor or wheel encounters an unavoidable issue, the rover can still function with the remaining operational wheels and motors. This increases the fault tolerance level of the rover, ensuring that it can continue its mission even after the presence of any un-operational wheel or motor.

3. Steering Mechanism:



- The rover's steering system employs sophisticated control mechanisms, featuring dedicated servo motors for each wheel to achieve precise and independent steering. This is facilitated by the rotation of the entire C-clamp mount, providing holonomic drive capabilities for movement in all directions. A Microcontroller Unit (MCU) regulates the motors, establishing a serial communication link with the central control unit for seamless coordination.

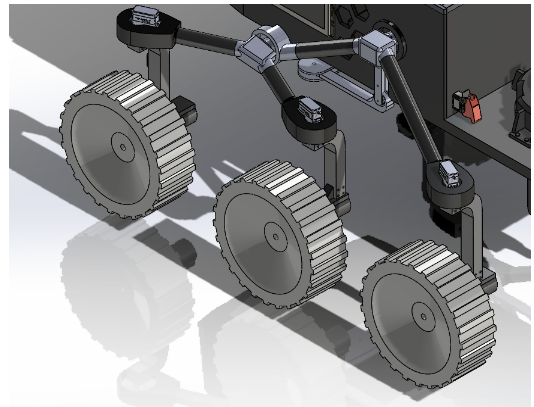
- Motorized steering enables precise turns and navigation through challenging terrains, while the smooth rotation of the wheel assembly minimizes wear and tear, ensuring long-term reliability. The holonomic drive capability allows agile movement through confined spaces, crucial for scientific experiments and exploration. Additionally, the independent movement of each wheel facilitates sharp turns, enhancing adaptability to dynamic planetary surfaces. In summary, the rover's steering system, with its motorized steering, reduced wear and tear, holonomic drive, and sharp turning capabilities, forms an integrated and efficient control system for optimal performance in diverse exploration scenarios.

- The rover incorporates motorized steering with dedicated servo motors to minimize wear and tear, while its holonomic drive capability enables independent maneuvers in confined spaces, enhancing versatility during missions. More about this is discussed further in the report.

4. Suspension system

- We have used the Rocker-Bogie Suspension with a differential. This design nullifies the use of springs and shock absorbers. Instead, a pair of arms called rockers and bogies which are connected to the rocker joint is employed.

- It has two wheels on the bogie and one wheel on the rocker on each side. Rocker pivots relative to the main body and bogie pivots relatively to the other pivot point on the rocker. Rocker arms are connected to a differential pivot linkage.



- Due to the action of the differential between the left and right side of the rover, as one side of the suspension is pushed up, the opposite side is pushed down. This naturally spreads the load of the Rover across all six wheels, which minimizes the maximum loading pressure on any one wheel.
- This is particularly desirable when traversing over soft terrain, where excess ground pressure on one wheel can lead to it sinking into the ground. The differential action also keeps the rover relatively level, with the chassis maintaining an angle the average of the two rocker arm.

5. Obstacle Identification and avoidance:

- Objects, craters, and obstacles are detected by the model using YOLO(You Only Look Once), an object detection algorithm based on real time. The rover's perception capabilities are boosted by integrating a stereo depth camera on the rover.
- By using YOLO algorithm swift and accurate identification of obstacles and craters are done in the surroundings of the rover. This real-time detection provides an ease to rover for dynamic access to its environment and plan its path respectively, ensuring efficient navigation and obstacle avoidance.
- The interfacing between YOLO-based algorithm and stereo depth camera enables the rover with a robust perception system, vital for safe and intelligent traversal through diverse terrains.

6. Algorithmic Path Planning:

- The challenge of avoiding unexpected obstacles during path following is addressed by employing the Follow The Gap (FGM) method, a favored obstacle avoidance algorithm for autonomous robots. FGM guides the robot recursively to the global state, considering the angle to the goal point and distance to the nearest obstacles.
- The algorithm selects the largest gap around the robot based on gap width, with the gap angle calculated by the vector to the midpoint of the largest gap. Additionally, the avoidance angle, akin to FGM's gap center, is determined by the locus of equidistant points from obstacle circles. Integrating a 6WD rover configuration with a camera-based obstacle identification system and algorithmic path planning, the design emphasizes adaptability and capability for autonomous navigation in a simulated extraterrestrial environment.

- The comprehensive rover design incorporates a robust chassis, suspension, steering, mobility for obstacle traversal, and sensors for obstacle and crater identification, alongside visual sensors for target recognition. This multifaceted approach ensures the rover's adeptness in overcoming challenges and navigating the designated arena strategically.The detailed algorithm is elaborated further in the report.

Potential Options and Comparison:
In evaluating potential robotic locomotion options, three configurations stand out: Wheel, Tracked, and Spider-Leg. Tracked systems offer unparalleled traction in rough terrains but may lack simplicity. Spider-Leg configurations provide high maneuverability but face challenges in maintenance due to intricate leg joints. Multi-Legged Walker configurations offer stability and flexibility, albeit with potential coordination issues.Ultimately, the choice hinges on mission objectives, where precise maneuvering and stability favor the current wheel configuration.
Comparing these options reveals critical considerations:
1. <u>Stability vs. Adaptability:</u> The current six-wheeled configuration strikes a balance between stability and agility. Alternatives like tracked or spider-leg systems may prioritize agility at the expense of stability.
2.<u>Terrain Versatility:</u> While the wheel configuration suits current terrain, tracked and multi-legged walkers excel in specific terrains but struggle with others.
3. <u>Maintenance and Durability:</u> Simplifying the existing wheel configuration may enhance maintenance and durability, contrasting with complex designs like spider-leg configurations.
4. <u>Energy Efficiency:</u> Wheeled systems, requiring less power, can be more energy-efficient than multi-legged walkers.

Mechanism for Sample Pick-and-Place Activity

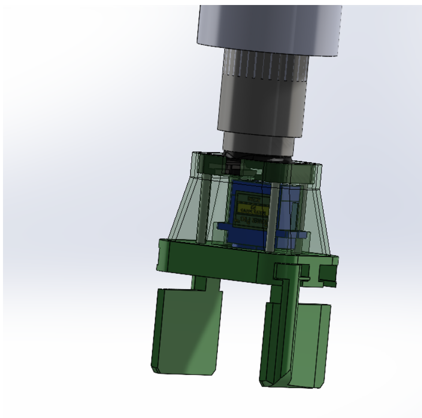
The sample picking and placing mechanism involves a manipulator arm equipped with a gripper for accurately identifying, picking up, and safely placing the sample tube onto the rover. We are using a 4-DOF RRR & R manipulator for the task. Here's a breakdown of the key steps and mechanisms involved in the sample pick-and-place activity:

a. Target Identification using Camera:

- A specialized camera positioned on the bottom-back part of the rover facilitates precision in pick-and-place operations. Placed just below the manipulator mount, the camera captures the coordinates of the test tube sample.
- Leveraging inverse kinematics, the gripper can then accurately navigate and safely pick up the test tube. This integration enhances the rover's capability to perform delicate tasks, ensuring precise handling of test samples for efficient scientific operations.

- Firstly the camera on the rover will identify the sample tube of said dimensions. The system is equipped with the video and image processing algorithms capable of recognizing characteristics of a sample tube be it size , color , etc.

b. Gripper Design and Mechanism:



In order to securely hold the identified sample tube, the manipulator arm should be enabled with a specialized designed gripper. The characteristics of the sample tube are given as (hollow cylinder with closed ends, 3D printed ABS material , red color), the gripper should be equipped with adjustable fingers to accommodate the tube's diameter and a mechanism to assure a firm grip. The gripper will be equipped with two flat fingers having rubber pads on their ends. With the help of servo motors and gears and linkages mechanism, fingers will open and close .For holding and lifting the tube, a combination of frictional and compressive forces are used. The gripper will reorient itself around the axial axis according to the orientation of the tube as detected by the camera and will then descend around the tube to grasp it. Once again it will orient itself so that collisions between the tube and the rover are avoided and then finally placing the tube in the container. Rack and pinion with servo control of fingers is incorporated in the system for linear gripping of the test tube.

c. Picking and Loading on the Rover Chassis:

The 4 DOF manipulator arm is programmed to move precisely to the location of the identified sample tube. The gripper then closes around the tube securely. Once the gripper has a firm hold, the arm lifts the sample tube from the surface and places it securely on a designated loading area on the rover chassis. A Pocket has been made on the rover to load the test tube securely.

d. Mobility and Traversal :

The rover can start its autonomous traversal to the final destination only after loading the sample tube. The manipulator arm needs to be secured to avoid interference with the rover's mobility during traversal.

e. Target Location Identification:

Identifying the target location. The sensors of the rover as well as the camera will be able to identify the target location when the rover is just about to arrive at that final point where a circle of diameter 300mm. The system responsible for the vision on the Rover should be in a position to identify the marked circle(destination) on the terrain.

f. Unloading and Placement:

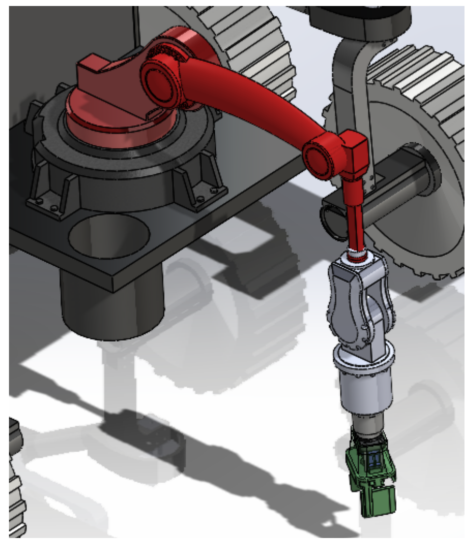
When the rover reaches the target location, the manipulator arm is deployed. The manipulator arm identifies the center of the marked circle and positions itself over that center. After that, the arm picks up the tube from the Pocket(loading area) and drops it in the marked circle in such a way that the tube must land as close to the center as possible.

g. Coordination and Control:

A combination of kinematic equations, sensor feedback, and programming algorithms are used to control each and every movement of the manipulator arm throughout the entire process. The successful execution of sample pick-and-place will only take place when there is an efficient coordination between the rover's mobility and the manipulator arm' action.

h. Safety Measures:

Uncertainty can occur anytime during the whole process. To handle such situations, safety features are necessary. They are incorporated into the rover to handle unpredictable or unexpected conditions, like obstacles or sudden terrain changes. The unexpected resistance of the manipulator arm should be taken care of by the force and torque sensing capabilities of it during pick-and-place operation.



Comparison of Potential Options:

1. 4 DOF Gantry Configuration vs 4 DOF RRRR

- Gantry systems typically have a limited workspace, especially compared to robotic arms with the same number of degrees of freedom. Whereas , Robotic arms with revolute joints can have a more extended reach and access to confined spaces compared to gantry systems.
- Gantry systems can be bulky, which may be a limitation in confined spaces or environments with obstacles.

2. 3 DOF RRR vs 4 DOF RRRR

- 3 DOF : Restriction in the ability to reach certain positions and orientations for 3 DOF.
- 4 DOF : Greater flexibility in positioning and orienting objects. Generally better suited for tasks that require high precision. Improved ability to handle complex movements.More versatile for various tasks due to increased degrees of freedom.

Rationale for Selection:

The structure of a robotic arm having articulated joints combines with a resemblant gripper giving the balance between perfection and simplicity.This being the medium allows the rover to customize to the dynamic terrain such as to furnish the necessary inflexibility in direct pickup of the sample tube in a secure way. This helps the system to increase trustability by icing accurate identification of the target and its precise placement within the specified circle. This medium is fitted for independent navigation of the rover, since the conditions concerning the sample selecting and placing it in a simulated extraterrestrial terrain is fulfilled.

Emergency Response System

1. Unexpected Terrain Changes:

1. Scenario: An unforeseeable change in the terrain such as a sudden rise or fall that was not detected by the camera.
2. Emergency Response System:

- An on board immediate visual Camera and a TOF Lidar is included that continuously maps the terrain which is right ahead the rover.
- If a significant deviation is detected from the expected terrain, the rover will stop and review the path on its own.

2. Sensor Malfunction:

1. Scenario: One or more visual sensors for the detection of obstacles and craters going through a malfunctioning or a failure during this mission
2. Emergency Response System: Introduced redundancy to ensure continuity in obstacle and crater detection. Ensured that the rover could seamlessly switch to the backup secondary camera or TOF Lidar in case the primary camera encountered any faults.

3. Power Loss:

1. Scenario: Possible Place of frequent power loss due to possible technical failure or batteries going down.
2. Battery Monitoring System : Fitting the sensor for keeping a continuous monitor on the Voltage current levels of battery.
3. Emergency Response System:

- Allow the rover with a failsafe mechanism of being able to cause an emergency shutdown procedure in case power levels go below a certain threshold. This should entail prophylactic termination and stopping of all moving parts, and communication systems from continuing operation so as not to incur more damage.
- If the battery level remains critical, the rover should initiate an automatic return to the starting point.

4. Communication Breakdown:

1. Scenario: Loss of communication between the rover and the control center, hindering real-time monitoring.
2. Emergency Response System:

- In case of loss of communication, pre-program autonomous behavior of the rover. Whereby, the autonomous behavior can involve some kind of basic obstacle avoidance, and a default way towards destination. In cases whereby after being lost communication would be restored again, it should be able to come back to its normal state of operation.

5. Obstacle Jamming:

1. Scenario: The obstacle could bind or jam in between the wheels or tracks of the rover, or strike an obstacle which may cause damage on the rover or be immobilized by a damaging strike.
2. Emergency Response System:

- Incorporate a sensing system onboard capable of detecting abnormal resistance into the locomotion system. If the rover senses a big ramp on the resistance it should try to back out or something of that ilk in its path change attempt to get free of the sticking point. If it won't work, the rover should call for help or switch to some kind of safe mode in which it does nothing until someone can straighten it out.
- It should apply an automatic braking system when an obstacle being detected surely the system should reconsider surrounding before navigation continues anew.

6. Obstacle Blocking Sample Tube Pickup:

A. Emergency Response System:

- There are sensors implemented on either the manipulator arm, which can detect the obstacles just in front of the pathway of the gripper during pick up.

B. Working Principle:

- The surrounding is to be continuously monitored with the sensors just in case of any emergency during pick up.
- If an obstacle is detected, the manipulator arm can adjust its trajectory or halt the operation to prevent collisions.

7. Gripper Malfunction or Slippage:

A. Emergency Response System:

- Force and Gripping Feedback Sensors: Giving sensors to sense the force brought in when the gripper is gripping.

B. Working Principle:

- Controlling the force of gripping at all times during the pickup process.
- Setting a system that can sense slippage and initiate the condition for re-gripping activities.
- In case of detecting an excessive force, the system might cause an emergency response for a grip evaluation or ban on all activities.

8. Loss of Visual Identification for Finish Position:

A. Emergency Response System: Implementing Backup Visual Sensors andLocalization System for Redundancy: Making the visual sensors redundant by utilization of duplication copies plus localization system.

B. Working Principle:

- This unit contains several sensors that work to monitor the surrounding and given location in a continuous way. In case one of the sensors goes off or loses track of the target, it is possible for the system to use the other sensors towards maintenance of accurate positioning.
- For this reason, in case of the difficulty of identification or visualization of the finish position by optical sensors, to prevent any breakage of the equipment or misalignment that leads into the damaged polishing wheel the system may define the final position that could be noticed in the system beforehand.

9. Power Failure or Manipulator Arm Dysfunction:

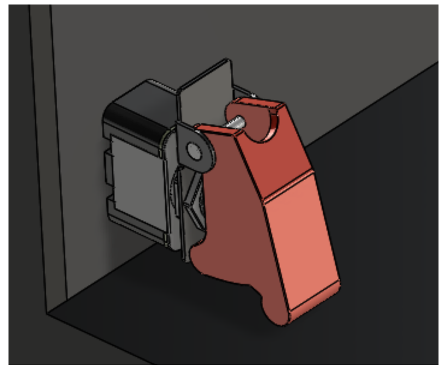
A. Emergency Response System:

- Emergency Power Supply and Fail-Safe Mechanism: The critical systems, manipulating arm, should provide a fail-safe mechanism to all the systems provided with the redundant power sources.

B. Working Principle:

- For emergency breakdown of supplies providing backup activities to support essential functions.
- Fail-safe mechanisms ensure that the manipulator arm reverts to a safe position if dysfunction is detected.

10.Mechanical or Electronic Failure of Rover:



A. Working Principle:

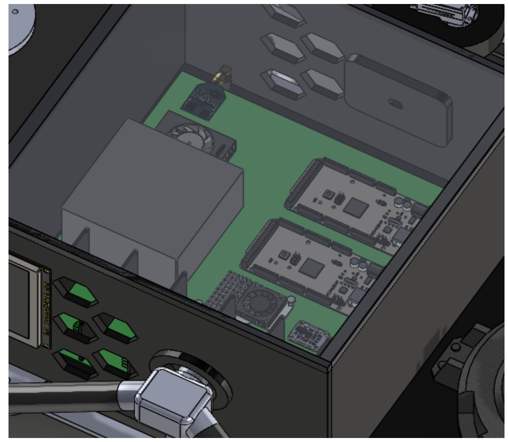
- Physical or electronic kill switch is to be integrated with a rover.
- In case of mechanical or electronic failure, a human operator can manually activate the kill switch.
- In some other cases, the ground station could remotely issue some kill switch that causes a controlled shutdown. Remotely issuing the command for this kill switch to the drone could constitute an extra layer of safety particularly where urgent human intervention might be difficult to achieve.

Other Safety measures:

1. The integration of a 7-inch touch screen in the rover is a sophisticated technical achievement, carefully selecting size and touch features for a clear interface. Sensors like rotary encoders capture vital data, processed by a microcontroller using I2C or SPI for seamless communication with the touch screen. This integration enables accurate real-time updates on motor RPM, battery voltage, and current. The touch screen's intuitive GUI, featuring gauges and charts, allows user interaction for dynamic monitoring. Mechanical considerations address rover movement challenges, while a robust power management system, including a stable battery with voltage regulation, ensures uninterrupted functionality. Together, these elements create a comprehensive monitoring system, enhancing operational efficiency and providing instant insights for informed decision-making.

2. To regulate the internal temperature of the electronics box, two heatsinks have been strategically employed within the rover's system. These heatsinks play a crucial role in dissipating the heat generated by components such as the battery, mini PC, and MCU. Positioned to efficiently channel excess heat outside the rover, the heatsinks prevent overheating and maintain optimal operating temperatures. This temperature regulation ensures the reliable and efficient functioning of the rover, preventing any adverse effects on the performance of critical electronic components. By effectively managing thermal

conditions, the rover can operate seamlessly, avoiding potential issues associated with excessive heat buildup that could compromise its efficiency.



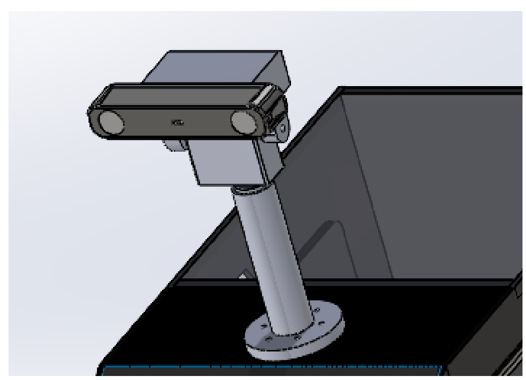
Rationale for Emergency Response System:

It proposes a reliable, safety and mission integrity oriented emergency response system with redundant sensors and fail-safe designs that greatly minimizes chances of the failure of the system. With real-time monitoring, undertaking real-time adaptation changing conditions in record time will be realized by the program. The redundancy of the sensor system and the sources of power give the other way of reinforcing the resilience of the total system. The feedback of sensors would enable autonomous decision making, making it possible to cope up with emergencies without humans' intervention. These features make it effective to the handling of the rover with the manipulator arm to be able to face unforeseen challenges in the mission in terms of safety and success at picking and placing the samples.

Software identification & Realization

1. Obstacle and crater identification Algorithm

For Obstacle and Crater identification we are using YOLO (You Only Look Once) for real-time object detection, coupled with a stereo depth camera, increasing the rover's perceptual capabilities. This sophisticated model has been meticulously trained to discern and categorize various elements in the rover's environment, specifically focusing on detecting craters, objects, and obstacles.



YOLO-based Object Detection: At the heart of this system lies YOLO, a novel object detection algorithm that is fast and highly accurate. YOLO essentially splits an image into a grid and does an object detection in each cell of the grid, thus doesn't require multiple passes over the image. Such capabilities would have found high applicability in a rover that is supposed to cross several paths requiring the ability to make decisions very fast and with accuracy at that real-time moment.

The properties such as size, shape, and color of an obstacle can act to be a simple identifier of it for use by the YOLO model of object detection. The rover hence becomes sensitive to differentiating between a wide range of objects. This adds one more level of sophistication in that it allows the software to discriminate objects based on color, which in turn allows a rover to make fine-grained decisions about when color is a relevant or incidental discriminator. A camera is mounted to give it 2 DOF to increase its FOV.

Crater Detection and Depth Visualization: Taking all this into effect on locating craters and giving a size estimate, the free-moving rover is allowed. It has been restrained lately mainly with YOLO which guarantees accurate local craters that show different sizes. This means that any crater that the rover will meet, however small it is, will be reported accordingly by the model to facilitate the rover's plan on how to maneuver out.

Further enhancement of this rover is through a stereo depth camera. The best three-dimensional visualization of the texture of surroundings is in best form with a stereo depth camera. In case of craters, this may be associated with the ability of the depth camera for measuring distances accurately towards deep part craters which is a parameter in navigation. Moreover, in worst cases a distance of 2-5 meters the crater embraces from the camera extreme capabilities are obtained to capture this depth information by a depth camera.

Intelligent Path Planning: The YOLO based object detection combines with the stereo depth camera working together making the rover decisions informed and adaptive in real-time. In near instant, models of objects or craters are recognized once the rover is posed with obstacles where spatial information comes from the depth camera itself.

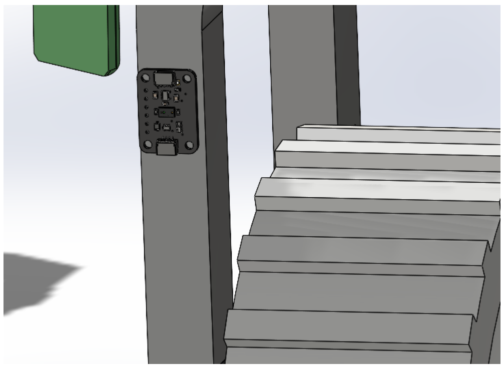
Such information is therefore processed and fused in the navigation system of the rover where it is equipped with the algorithms to form a path without hitting obstacles making safe passage through craters. This helps in ascertaining the relative size of objects and their color amongst each other, therefore giving an insight into the environment and appropriateness of actions to take towards each object.

Adaptive Color Recognition: Adding color recognition in the YOLO model adds another complexity level on the perceptual skills of the rover. By including consideration of the color in defining the obstacle to be identified, taking a color sample of the obstacle and using this sample in classifying the object makes the rover make context-aware decisions. In some cases, for example, where the material or nature of a surface determines its color, then the rover can change route. This capability is useful in situations whereby the color of objects helps to pass information about the object such as hotness.

As the rover goes over obstacles, they are classified according to the relative sizes and color by the YOLO model and passes on this level of detail into the entering navigation system. The depth camera provides spatial information whereby from it the rover is able to classify the terrain and get an understanding of spatial relationships between other obstacles and craters. With smaller obstacles, the rover is able to take minor adjustments and avoid them while for bigger ones the rover might take different paths but still get around having to navigate over them directly. In the case of the craters, the depth camera will safely keep the distance from the crater and with the information of depth the rover would be able to know where best to traverse in its path.

The rover is equipped with Time-of-Flight (TOF) based LIDAR Laser Distance Sensors placed on all six wheels at strategic places except for the YOLO based object detection system. Camera data from the rovers are supplemented by a third layer additional to sensing technology that acts as a fail-safe, for example in detecting and avoiding obstacles missed by the camera or is presently outside of the camera's field of view (FOV).

TOF-Based LIDAR Laser Distance Sensors: The Time-of-Flight (TOF) LIDAR sensors, affixed to each wheel, employ laser beams to measure object distances. Continuously scanning, they create real-time terrain maps. While the YOLO model excels in object characterization, TOF-based LIDAR adds rapid obstacle detection, crucial when the camera is momentarily occluded or objects are beyond its direct view. The dynamic interpretation of LIDAR-obtained obstacle data enables the rover's swift collision avoidance decisions. Acting as a safety net, TOF-based LIDAR ensures near real-time responsiveness critical for navigation in challenging conditions. Integrating YOLO-based object detection, stereo depth cameras, and TOF-based LIDAR provides a comprehensive rover perception system, ensuring informed navigation through varied terrains.



2. Path Planning Algorithm

Travel safety is one of the most important criteria in any of the travel paths of the rover. In order to provide safety this safety an obstacle avoidance algorithm has been developed and fed into the rover, which provides a solution to the obstacle avoidance task. This algorithm is based on selecting the largest gap followed by calculating the angle of avoidance by taking into consideration all such points which creates a locus of equidistant points from the obstacle. Planning the perfect path of the rover in such a way that the rover avoids each and every obstacle in its path and avoids collision is called Motion Planning.

The obstacle avoidance algorithm is based on the gap-based strategy. In this out of all the gaps present between the obstacles, the largest gap will be prioritized and selected by calculating the width of the gap and the angle of avoidance by taking all such points which creates a locus of equidistant points from the obstacle. In Spite of using the traditional method which uses the principle of gap center vector, this approach uses the concept of "Obstacle Circles' in order to move around the obstacle without any interference and collision.

Monte Carlo's simulation and real-world experimental tests are used which validate the working and effectiveness of the obstacle avoidance algorithm. The two methods that are

implemented in the rover's operating system using Python as independent nodes are; 1). The Obstacle Circle Method, 2). Gap-based method.
Upon performing various experimental iterations and tests, it shows that the method which uses the Gap-based approach is better because it provides safer paths for the rover to travel as compared to other methods.

The obstacle avoidance algorithm incorporated into the rover is designed in such a manner that prevents any collision with craters and obstacles in any kind of terrain. To navigate around the obstacles most efficiently and effectively, the Fast Gap Method algorithm is introduced, which selects the gaps that have maximum angles. The comparison of the Fast Gap Method(FGM) and Fast Obstacle Circle Method (FOCM) is done using Monte Carlo simulation, which shows a comparable average traveled distance of the rover for both methods.

Hardware Identification

Power System:

No.	Hardware Details	Quantity Needed	Justification
1	Battery	1	Battery will be Finalized after thorough testing and calculating the Power Budget
2	BMS	1	Enhances rover performance, ensures longevity, and monitors critical systems efficiently.

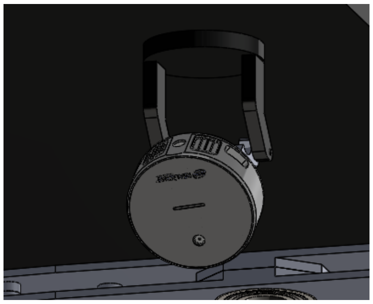
Roving Mechanism:

No.	Hardware Details	Quantity Needed	Justification
1	DC planetary Motor	6	Better RPM with the given torque compared to other motors.
2	150 Kg cm Servo	6	Better control over steering due to higher torque.
3	Custom Wheels	6	To reduce the weight compared to commercially available wheels and to design wheels which are fit for our design
4	Carbon fiber Rocker Bogie suspension Rods	-	Carbon fiber has one of the best strength to weight ratios compared to other materials like aluminum.

5	3-D Printed Couplers	-	Easy coupling, Low cost and ease in manufacturing
6	Astral Depth Camera	1	Low cost , better Vertical FOV and better depth range.
7	20 Kg cm Servo Motor for camera	2	Increases the FOV for the camera by giving it motion in 2 axes. (up-down motion and left-right motion)
8	Dual channel Motor Driver	3	Controlling 6 Planetary DC motors , 2 motors simultaneously.
9	Arduino Nano RP2040 for sensors	1	Small form factor , has on board IMU, supports Wifi/BT
10	STM32 for driving motors with feedback	1	Higher interrupt pins to not only drive the motors but also get feedback and perform corrective action
10	TOF LIDAR	6	For measuring distance accurately. Backup in case obstacle is not in FOV of the camera
11	Skull Saint Mini PC for video processing	1	Intel 11th Gen, 8GB DDR4, Better option for Image and Video Processing
12	BNO055 IMU	1	9-axis IMU with accelerometer, magnetometer and gyroscope
13	2.4 GHz XBEE S2C with Duck antenna for data transmission	2	Prior experience in using these, good enough transmit power, Circular Polarization (Antenna)

Pick and Place Mechanism:

No.	Hardware Details	Quantity Needed	Justification
1	Aluminum Manipulator Arm Link	4 Arms Custom sized	Cheap Rigidity Easy Manufacturability
2	Motors for manipulator and gripper	2 x 80 kg cm Servo 2 x 35 kg cm Servo 1 x 150 Kg cm Servo	For precise and controlled movement of the arm.

3	Camera	1	Object_detection
4	Camera Turret 	1	20kg Cm Servo to give the camera motion in 1 axes i.e up and down.

Emergency Response System:

No.	Hardware Details	Quantity Needed	Justification
1	Kill Switch	1	In case of mechanical or electronic failure, a human operator can manually activate the kill switch.
2	Screen	1	To monitor battery and motor performance
3	HeatSink and Fan	2	To regulate internal heat generated and to maintain temperature inside the electronics box

Hardware Realization Plan

No.	Hardware Details	Procurement Source (Market/Fabrication/ 3D Printing/.....)	Specifications/ Realization Plan	Quantity	Estimated Cost
1	DC planetary Motor	Market	Torque : 650kg/cm	6	30,000
2	Electronics Box/Body	Machining	CAD Modelling Machining	1	2,000
4	Limb Connectors	3D Printing	CAD Modelling	6	In house

5	Wheels	3D Printing	Diameter : 25 cm Thickness : 6-8 cm CAD Modelling	6	In house
6	Rubber Wheel Grips	Market	For wheels of Diameter : 25 cm Thickness : 6-8 cm	6	Not Sourced yet
7	Wheels Connectors (C-CLamps)	3D Printing	Cad Modelling	6	In house
8	Camera-Turret Mounts	Laser Cutting /3D Printing	Cad Modelling	2	In house
9	Carbon fiber Rocker Bogie suspension Limbs	Market	Cad Modelling	6	15,000 INR (2,429 INR / 50 cm)
11	3-D Printed Couplers	3D Printing	Cad Modelling	2	In house
12	Depth Camera	Market	Depth range : 0.6 to 8 m, VFOV: 45.7 Degree HFOV: 58 Degree	1	24,000 INR
13	Servo for Steering	Market	150 kg/cm, 180 degree Speed : 0.19sec/60°@12.6 V Dimensions : 653048	6	21,228 INR
14	Servo Motor for camera turret	Market	Rated Torque: 20Kg.cm @ 7.4V RPM : 66@7.4V (0.151sec/60°) Operating Voltage: 4 8.4 V Weight:70gm	4	5,596 INR
15	Motor Driver	Market	Dual channel	3-5	9,000-15,000 INR

16	RP2040-Zero	Market	Processor: Raspberry Pi official RP2040 mini , Dual-core Arm Cortex M0+ processor, flexible clock running up to 133 MHz, 264 KB of SRAM, and 2MB of onboard Flash memory	2	<1,000 INR
17	STM32 for driving motors with feedback	Market	Flexible board power supply: USB VBUS or external source (3.3 V, 5 V, 7 – 12 V), On-board ST-LINK/V2-1 debugger/programmer with SWD connector.	1	<2,000 INR
18	TOF LIDAR	Market	Operating voltage: 2.6V to 5.5V Supply Current: 10mA Communication: I2C protocol	6	1,632 INR
19	Skull Saint Mini PC for video processing	Market	Intel 12th Gen Alder Lake Processor, 16GB DDR5 + 512GB M.2 SSD, WIndows 11 Pro	1	23,250 INR

20	BNO055 IMU	Market	9-axis IMU: Accelerometer, Gyroscope and Magnetometer	1	1,849 INR
21	2.4 GHz XBEE S2C with Duck antenna for data transmission	Market	Frequency : 2.4GHz Sensitivity : -101 dBm VDC : 2.7 to 3.6 Tx Power : 63mW	2 (One Pair)	2,500 INR
22	Camera	Market	ESP32-CAM is a WIFI+ bluetooth dual-mode development board that uses PCB on-board antennas and cores based on ESP32 chips	1	500 INR
23	Capacitive Touch Screen	Market	7 inch, Resolution : 800×480	1	3,309 INR
24	Kill Switch	Market	Current Rating : >5A ; Voltage Rating : >33V	1	500 INR
25	Heat Sink	Market	Not yet Finalized	2	< 1,300 INR
26	Cable/Connectors	Market	-	-	7,000 INR
27	Battery	Market	Not yet Finalized	1 or 2 (Not Finalized Yet)	20,000-30,000 INR
28	BMS	Market	Not yet Finalized	1	<7,000 INR
29	PCB for Electronics Integration	PCB Printing services	-	-	<5,000 INR
30	Manipulator Arms	Aluminum from Market	Design : Cad Modelling Manufacturing : In house	5 m of Aluminium rods	1,500 for 5 m (290 INR /m)

31	Manipulator Gripper	3D Printing Machining	Cad Modelling	2	In house
32	Motors for manipulator and gripper	Market	2 x 80 kg cm Servo	2	8,998 INR
33	Motors for manipulator and gripper	Market	2 x 35 kg cm Servo	2	5,096 INR
34	Motors for manipulator and gripper	Market	1 x 150 Kg cm Servo	1	3,538 INR
35	**Total**	-	-	-	**Approx. 1,90,000 INR**

The components chosen and the budget outlined above rely on specifications from either datasheets or our past experiences, along with the **approximate maximum cost** of each component. Through proper sourcing we can even get better prices for the components. The finalization of both the components and the budget will only occur after a comprehensive testing process for all these components. We've included "Market" in the components to signify that these items are intended to be procured either from local stores or through online e-commerce websites.

Test Plan

1. Testing Procedures for Rover's Visual and Navigational Capabilities

A. Procedure:

- Identify objects, obstacles, and craters for visual sensor calibration.
- Verify sensors providing distance data for collision prevention.
- Place obstacles of varying sizes (e.g., 150mm, 300mm) in the rover's path to confirm obstacle avoidance capabilities.
- Create craters with known sizes (e.g., 50mm, 100mm radius) to verify accurate crater identification.
- Place craters of known sizes (e.g., 100mm, 200mm diameters) in the rover's path to confirm crater avoidance capabilities.
- Place sample tubes in different orientations and positions to verify the rover's ability to identify targets based on color, shape, and size criteria.
- Mark circles of various sizes and colors to verify the rover's ability to visually identify target locations.

2. Gripper Functionality Test:

A. Procedure:

- Test the gripper under various conditions (e.g., different tube orientations).

- Verify that the gripper securely holds the sample tube without causing damage.

3. Loading and Securing Test:

A. Procedure:

- Repeatedly load the sample tube onto the rover.
- Ensure that the tube is securely attached and won't dislodge during movement.

4. Autonomous Navigation Test:

A. Procedure:

- Provide a terrain map of the arena with obstacles and craters.
- Set a defined route from the starting point to the destination.
- Confirm that the rover follows the path on its own, avoiding craters and other obstacles.

5. Unloading and Placement Test

A. Procedure:

- Test unloading on various types of terrains.
- Verify that the sample tube has less error to the marked center circle.

6. Dynamic Obstacle Test:

A. Procedure:

- Introduce unexpected obstacles during the rover's navigation.
- Verify that the rover identifies and navigates around the new obstacles successfully.

7. Navigation Strategy Test:

A. Procedure:

- Develop a complex environment with multiple obstacles and craters.
- Verify that the rover adopts an efficient navigation strategy, considering obstacle dimensions and terrain conditions.

8. Power Consumption Test:

A. Procedure:

- Monitor the rover's power usage during navigation tasks.
- Ensure that the power consumption is within acceptable limits.

9. Communication Reliability Test:

A. Procedure:

- Introduce communication disruptions/obstructions during navigation deliberately.
- Ensure that the rover can overcome those obstructions and recover from communication failures.

10. End-to-End Integration Test:

A. Procedure:

- Run a series of tests from target detection and avoidance to collection and placing of sample tube on a replica of terrain through which the rover has to pass in the final stage.Ensure smooth coordination between subsystems.

11. Environmental Tests:

A. Procedure:

- Test the rover in temperature variations, dust, and low light conditions.

12. Emergency Response Test:

A. Procedure:

- Simulate scenarios like sudden obstacles or sensor malfunctions.
- Verify that the rover responds appropriately (e.g., stops or adjusts its path).

System Specifications

System	Specifications
Rover Stability	Differential Mechanism-Rover body will tilt by exactly half from which it was supposed to be without differential
Suspension	Rocker Bogie Suspension System-Classic design of suspension in rovers to increase mobility and maneuverability.
Navigation and Guidance System	Depth Camera Object Detection and Avoidance for path planning of the rover.
Test tube Collection System	4-DOF(RRRR) Manipulator for pick and place of test tube on the rover
Mobility System	Wheels or tracks for movement on planetary surfaces, and precision control for precise movement and navigation
Power System	The power of the whole system will be provided by a battery whose specifications will be decided after thorough testing and calculating power budget.
Communication System	2.4 GHz Xbee S2C radio module for communication of Rover with Ground Station.
Computing System	Skull Saint Mini PC for video processing and computing. Intel 11th Gen, 8GB DDR4, Better option for Image and Video Processing
Instrumentation and sensors System	- TOF LIDAR: To measure distance accurately. Backup in case obstacle is not in FOV of the camera

	- Dual channel Motor Driver: Controlling 6 Planetary DC motors, 2 motors simultaneously. - BNO055 IMU: 3 Axis accelerometer, magnetometer, and gyroscope to calculate various acceleration - Arduino Nano RP2040 for sensors: Small form factor, has onboard IMU, supports Wifi/BT - Astral Depth Camera: Low cost, better Vertical FOV, and better depth range.
Safety Regulation System	- Physically accessible kill Switch to shut down the whole system in any unwanted circumstances. - Heat sink/ exhaust fan over the Electronics system to dissipate the heat, in order to eliminate thermal failover of the system. - Failsafe mechanism in manipulating arm, if any unwanted circumstance arises then manipulating arm will revert to a safe position. - Force-Torque sensor will detect any external force on manipulating arm along with any malfunction by manipulating arm and take corrective actions whenever required.
User Interface System	An LED display for showing all the real time data processed by the rover such as: motor RPM, current-voltage reading, temperature reading,etc.

Project management

Our project management strategy focuses on achieving seamless task execution within defined deadlines. Each team member assumes specific responsibilities crucial to the rover project's success. Task dependencies are meticulously identified, and resources are allocated effectively to optimize performance.

We establish small, achievable goals every 2-5 days, fostering a sense of accomplishment. Recognizing the competition's unpredictable nature, we plan for contingencies to navigate challenges during development and testing.

Regular progress monitoring is fundamental, enabling us to stay on track and make necessary adjustments. Effective team communication is prioritized to enhance collaboration and address hurdles promptly.

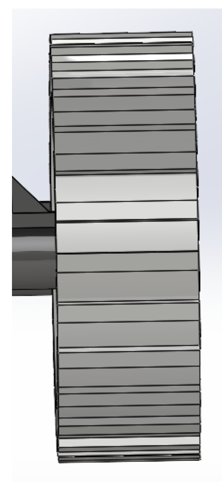
Implementing changes is key to adapting to evolving competition requirements. We maintain a continuous improvement mindset, leveraging feedback to refine processes. This proactive and adaptive approach ensures our team's competitiveness and agility throughout the rover competition.

No.	Task	Main Responsibility	Deadline for Completion	Estimated Cost	Secondary Responsibility
1	Algorithm and Electronics Development for Roving Mechanism	Aryan Shah	10-01-2024	-	Jaydeep Solanki
2	Mechanical Design of the whole Rover	Haard Patel	10-01-2024	-	Mohammed Oves Malekji
3	Manufacturing, Robust testing, and Integration	Arya Patel	16-01-2024	30,000 INR	Ameya Kale
4	Algorithm Development for Roving and Pick and Place	Jaydeep Solanki	10-01-2024	-	Yashvi Tanwar
5	Roving and Manipulator control	Keshav Vyas	16-01-2024	45,000 INR	Vivek Samani
6	Power system design and sensor control	Vivek Samani	16-01-2024	50,000 INR	Keshav Vyas
7	Manufacturing and material Procurement	Ameya Kale	16-01-2024	30,000 INR	Vinit Tandel

8	Mechanical Design for Pick and Place mechanism	Mohammed Oves Malekji	10-01-2024	-	Vinit Tandel
9	Algorithm Development	Yashvi Tanwar	10-01-2024	-	-
10	Mechanical design and Manufacturing	Vinit Tandel	10-01-2024	-	-

- The cost mentioned in the above table is the approximate cost needed, only till 15th of January, for the basic development of the rover which includes basic prototyping of the rover and algorithm and motor testing.
- Once preliminary manufacturing , designing and testing is over , we will move on to integration of all systems and integrated testing.
- The team will be able to give the detailed breakdown of the budget once the components are finalized after the design and algorithms are tested robustly.

Novelty in the overall proposal



A. **Wheel Design:** We have designed the wheel according to the following requirements

1. Proper grip and traction to ensure high power transfer
2. Stable base for rover
3. High strength to weight ratio
4. High durability as well as replaceability

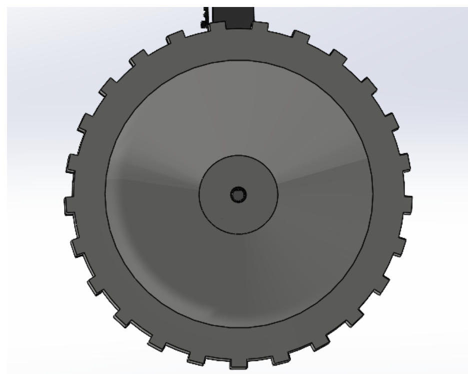
To achieve these goals, the following designing parameters were decided, according to given reasons

1. *3d printing using PETG*: 3d printing gave us more freedom with the design and allowed us to introduce some innovative characteristics as well as designing procedures into the design itself. This manufacturing method also allowed us to smoothly combine other parts such as the motor mounts. Amongst the available materials, PETG gave the best combination of strength, weight, print quality, cost and handling. Further research is still going on towards material selection to ensure that the wheel is manufactured as optimally as possible.

2. *Rubber covering*: A commercially available rubber sleeve will be used to cover the outer face of the wheel to increase the coefficient of friction drastically. This ensures that the maximum amount of motor power is transmitted to the ground, allowing for better rover movement, steering and braking. This also protects the inner PETG by prohibiting the PETG

from directly coming in contact with the rough ground and providing some damping for minor shocks.

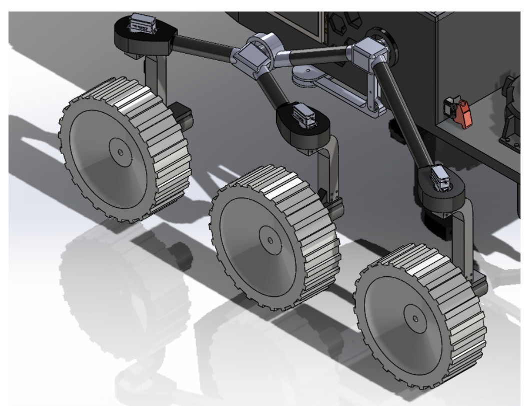
3. *Dimensions*: Minimizing the weight was a priority, so we have chosen dimensions so that the wheel can function optimally in as low weight as possible. A 22cm diameter wheel allows us space for properly placing the driving motors, ensuring proper use of the torque and increasing speed of the rover, all the while fitting inside the given bounding box. 8cm thickness provides the rover with a stable base, even when 1 or 2 wheels have lifted into the air. It also distributes the pressure enough so that the wheel does not have to endure high stresses.



4. *Fins*: Fin-like structures have been added on the outside surface. These have been added to increase the grip of the wheel and provide a place for stress concentrations so that the inner side of the wheel does not bear high stress. They also provide a sort of hook for the rubber sleeve so that it fits better over the 3d printed wheel.

Utilizing Autodesk Fusion 360, we employed a rigorous iterative approach integrating finite element analysis and topology optimization to design the wheels. An initial basic design underwent static analysis for suitability, with subsequent iterations employing topology optimization to maximize stiffness and minimize weight, contingent upon a safety factor exceeding 3. The optimized designs were converted to solid bodies, reintegrated into the optimization loop. This iterative process ensured the creation of a wheel design meeting specified requirements with optimal weight efficiency.

B. Steering mechanism

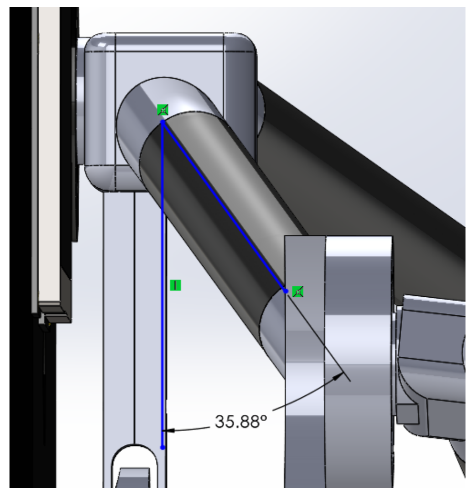


The rover's steering system utilizes independent motor control for precise movement. Each wheel, housed in a C-clamp mount, has a dedicated motor for steering, allowing independent rotation. A servo motor facilitates rotation of the entire wheel assembly, enabling precise control, reducing wheel wear, and supporting sharp turns. To manage motor functions, a Microcontroller Unit (MCU) is employed, establishing serial communication with the central control unit. This MCU integration enhances the rover's responsiveness and maneuverability. The approach is equally applicable to steering motors. Overall, our rover boasts an integrated and efficient control system, ensuring optimum performance through coordinated motor control and MCU integration.

- Motorized Steering: Each wheel has a dedicated servo motor that initiates the steering motion. A motor in this context allows rotation of the whole individual wheel assembly.
- Reduced Wear and Tear: This minimizes any stress that is being put on the constituents of the wheel, more so towards the lifetime operation of the wheel whose effect is usually ensuring that the rover stays mobile all through its mission.
- Holonomic Drive Capability: A steering system of the rover takes a holonomic drive system. Holonomic drive means, considering any move, moving on its side but not necessarily all wheels. It is to provide a certain degree of agility.

The benefit of such capability allows the Rover to provide an independent maneuver in navigating through confined spaces or feeling obstacles. The same becomes handy during scientific experiments and precise movements along an exploration path.

C. Rocker Bogie Suspension Optimization



The rocker bogie suspension utilizes angled links with a 36-degree orientation, departing from the traditional 90-degree configuration. This specific angle optimizes weight distribution across the suspension system, strategically reducing stress on individual wheels compared to the equal load distribution in a 90-degree setup. The departure from the norm represents a tailored engineering solution, enhancing stability and performance in challenging terrains. The deliberate 36-degree angle reflects a novel paradigm in load dynamics, particularly beneficial for off-road scenarios like the Martian terrain. This innovative design fosters a nuanced sharing of forces, improving overall mobility and reliability. The departure from tradition in the rocker bogie configuration introduces efficiency and adaptability, marking a new era in addressing challenges posed by rugged landscapes.