West Virginia University Student Team Lead: Stephen Jacobs (sej0015@mix.wvu.edu)
Morgantown, West Virginia Management Lead: Paige Harlan (peh0015@mix.wvu.edu)
United States of America Faculty Advisor: Dr. Yu Gu (yu.gu@mail.wvu.edu)

Team Mountaineers Preliminary Design Review

1. Team Structure

Leadership and Membership: West Virginia University's (WVU) Team Mountaineers is composed of seven sub-teams (*Figure 1*). Each sub-team is led by team coordinators who organize project activities and serve as liaisons to the other sub-teams. Mechanical and Aerospace Engineering professor Dr. Yu Gu serves as the faculty advisor to the team. Undergraduate student Stephen Jacobs serves as the overall team lead. The team consists of over seventy members, with the majority being junior or senior undergraduate students pursuing degrees in a STEM-related field. However, this is not a requirement to be on the team, as all majors and years are invited to participate. Most seniors on the team use this opportunity as their senior design project. The URC team works cooperatively with WVU Robotics as well as the WVU Robotics Club.

Communications: Communication between the sub-teams, coordinators, and advisors is carried out through in-person meetings and virtual exchanges via Slack, GrabCAD, GitHub, and Google Drive. In-person meetings facilitate discourse involving project milestones and integration of the design components amongst all members and sub-teams. Slack aids in organizing ideas, plans, and setting schedules. GrabCAD enables members to share 3D models and computer-aided design (CAD) files. Similarly, GitHub helps members to share code files. Google Drive is used to review documents, meeting minutes, documentation, tutorials, financial tracking, and archiving records from past years. External communications are carried out through multiple social media platforms as well as university-sponsored events. These methods are employed to meet the needs of our recruitment and outreach efforts.

2. Team Resources

Finances: The funding for WVU URC is sourced mainly through the university's Mechanical and Aerospace Engineering Department and the Lane Department of Computer Science & Electrical Engineering. Students also earn $4 per hour for the team by participating in recruitment and outreach events held by the university. To purchase items, sub-teams must inform the procurement team of the model and quantity of the part and a link to the purchasing site. The team then submits an online request form for the items. The request is processed, and the sub-teams are notified when their components arrive. The allocations of budget per sub-team and money spent are tracked automatically on the master purchasing document (*Figure 2*).

Facilities: Upon completing the mandatory safety training from WVU Environmental Health and Safety, team members gain 24/7 access to open lab and office spaces. The resources that are offered at the URC lab and the WVU Innovation Hub include equipment for coordinate measuring, 3D Printing, cutting/engraving/routing, milling, turning, welding, printed-circuit-board (PCB) prototyping, PCB rework, and vacuum forming. The lab is also equipped with proper safety equipment in accordance with the university guidelines.

3. Project Management Plan

Development Lifecycle Approach: In planning for the project completion this year, we utilized the knowledge of members who took part in previous years along with new research and experience to define objectives. The sub-teams followed the engineering design process, starting with the design criteria specified by the URC rules and guidelines. Science hypotheses were then formulated, mission concepts of operations were completed, solutions were brainstormed, and trade studies were used for critical design decisions. Those designs are then simulated, prototyped, tested, refined, and iterated. The sub-teams work in a parallel manner collaboratively with rapidly changing input from other sub-teams and continuous integration. The project management team works to support other sub-teams with integration and planning, as well as verifying that deadlines from the Gantt Chart are completed (*Figure 3).* Team Mountaineer's previous competition robot ASTRO is being used as a benchmark and testbed for this year's team. This resource allows the team to start testing without having to wait for first-draft designs from the sub-teams. Internal competitions were conducted throughout the year to allow members to practice the designated missions. This process also helps with continuity in developing a better rover each year.

Systems Integration and Test Plan: To ensure proper interfacing, sub-team coordinators meet weekly to communicate design changes while management notifies teams of upcoming deadlines. Full team meetings were held each week to update progress made to develop a system-level understanding. Sub-teams meet twice each week to coordinate with peers and work on group assignments. The drivetrain team performed structural testing with finite element analysis simulations and in-situ tests. Autonomy subtasks have been tested using the team's rover from 2022: ASTRO. The autonomous navigation drone will be tested in simulation before full outdoor and wind tunnel testing. The autonomy software components for marker detection and terrain identification are being tested in a variety of environments to ensure reliability. Once the rover is fabricated, the equipment servicing manipulator will be tested on a mock-lander. The extreme delivery manipulator will be tested with full mission trials outside in real-time. The science package will be tested first in a laboratory environment, then onboard in a mock terrain with extant, extinct, and sterile samples.

4. Preliminary Technical Design

The current chassis design consists of a sheet metal triangular box that ties the three mounting points of the suspension together. Two tubular struts protrude out beyond the sheet metal box and span the entire length of the chassis for manipulator mounting, transferring the load of the manipulator directly into the suspension (*Figure 4*). A double bogie-based suspension and composite wheels were chosen for this year's design, and two duplicate manipulator arms were designed with multiple end effector options to allow each arm to be specialized for their respective tasks. The payload for both the Extreme Delivery and Equipment Servicing missions will consist of the two independently controlled and actuated arms. These arms will have five degrees of freedom, and their shoulder and elbow joints will be actuated by two brushless DC motors with built-in gear reductions (*Figure 5*). The two arms will both be mounted to a set of horizontal rails that will allow them to travel the width of the robot.

The science mission will be completed using a payload containing a collector and onboard laboratory. The collector consists of an array of six isolated soil collection modules (*Figure 6*). For each module, a scoop will be used to deposit soil into the water reservoir where it is mixed to form a slurry. Peristaltic pumps will transfer each sample slurry to cuvettes contained in the onboard laboratory. A rotating carousel will transfer cuvettes to a spectrometer for inspection and testing with the goal of identifying specific compounds critical to or indicative of extant or extinct life (*Figure 7)*.

The autonomous navigation mission will be completed using a quadcopter drone (*Figure 8*). The drone uses a Pixhawk flight controller running PX4 in offboard mode along with an onboard computer for image processing, path planning, and decision-making (*Figure 9)*. The drone will visit the marker interest areas, search for markers from a safe altitude, and descend to the required altitude to signal a successfully completed marker before moving to the next waypoint.

The electronics system uses a custom-designed power distribution board to regulate the power supplied by off-the-shelf batteries to the necessary voltage levels required by other onboard components and serves as a central point for disconnecting power from all subsystems using a single E-Stop button (*Figure 10*). An additional board continuously monitors the current and voltage levels of each battery and displays the data on an LCD screen and the operators' graphical user interface. An Intel NUC 12 Pro is used as the rover's primary computer, and a single custom payload PCB uses a Raspberry Pi Pico microcontroller to interface with all of the necessary motors, sensors, and other components for each payload. This board also facilitates connections for the industry-standard CAN bus communication protocol, which simplifies the process of integrating various devices on a single network and allows for future expandability (*Figure 11*). The communications subteam is using two 900 MHz point-to-point radios for controlling the rover. The rover antenna is an omnidirectional 5 dBi whip antenna mounted on a rollable composite mast, and the base station antenna is a 120-degree, 12 dBi sector antenna.

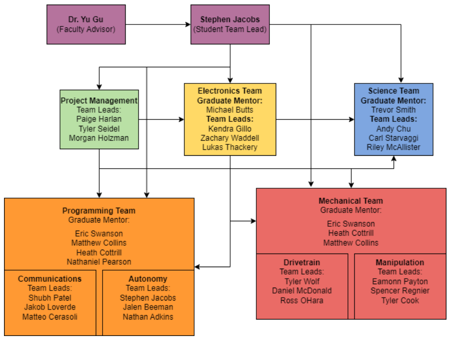

Figure 1: Team Structure Diagram

	Budget	Money Spent
Communication	$1,400	$1,404.22
Programming	$1,400	$1,566.00
Manipulation	$4,800	$2,576.64
Drive Train	$4,800	$3,499.55
Science	$4,800	$549.11
Electronics	$4,800	$213.41
Lab Equipment	$0	$0.00
Total	$22,000	$9,808.93

Figure 2: Budget Info

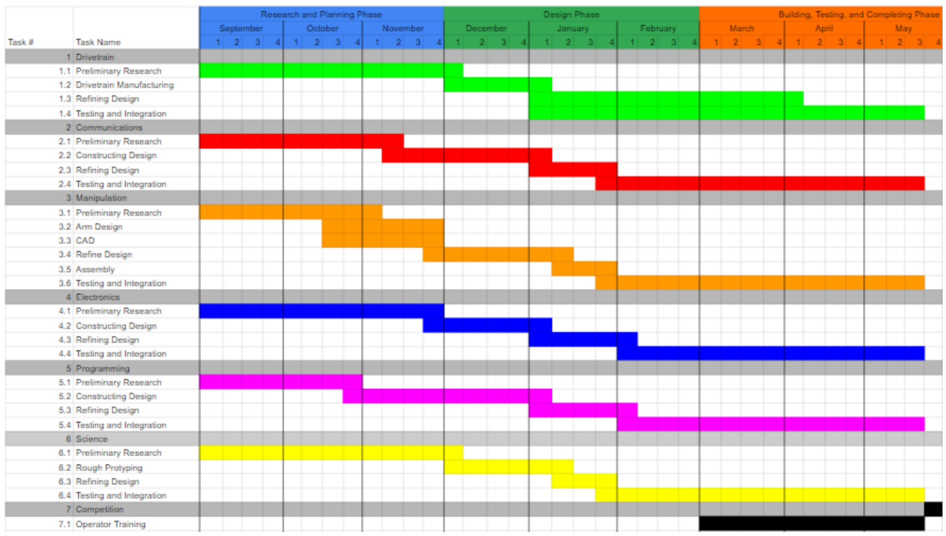

Figure 3: Gantt Chart

Figure 4: Chassis Design

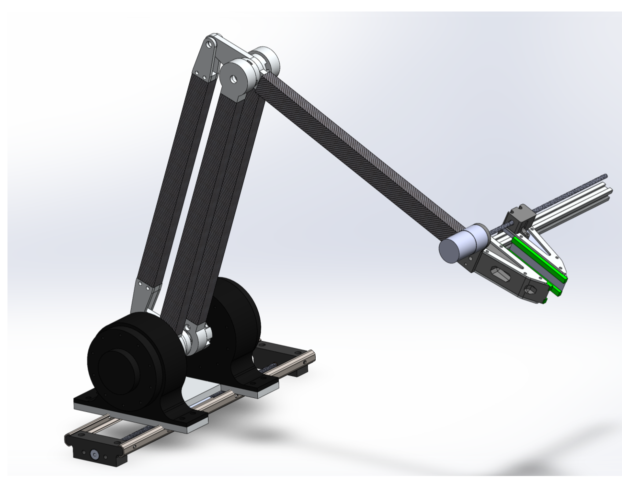

Figure 5: Manipulator Arm Design

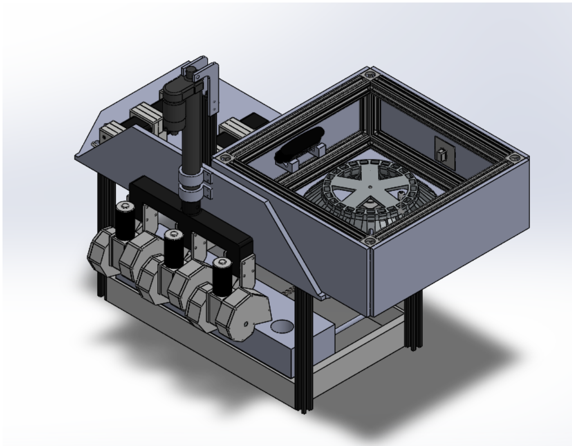

Figure 6: Science Package

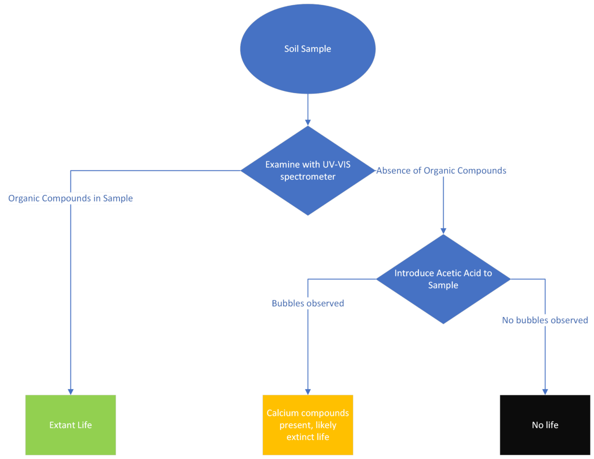

Figure 7: Preliminary Science Test Plan

Figure 8: Autonomy Drone

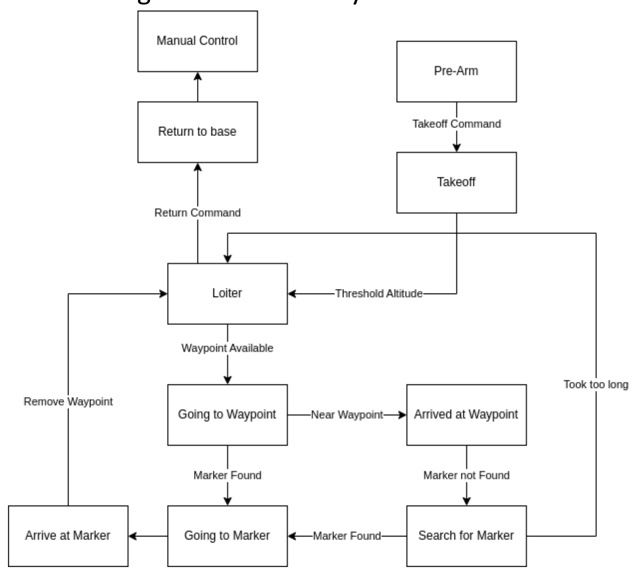

Figure 9: Autonomy State Machine Diagram

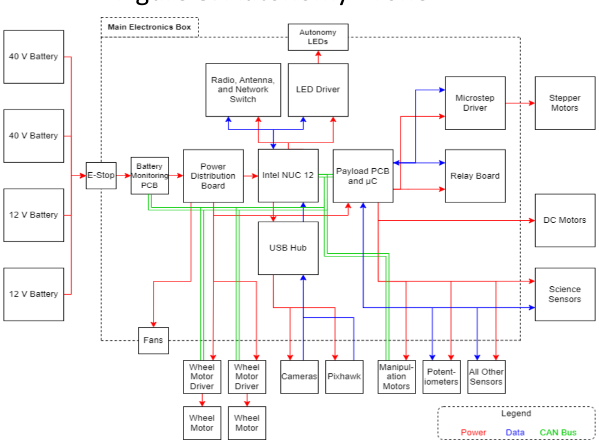

Figure 10: Diagram for Main Electronics System

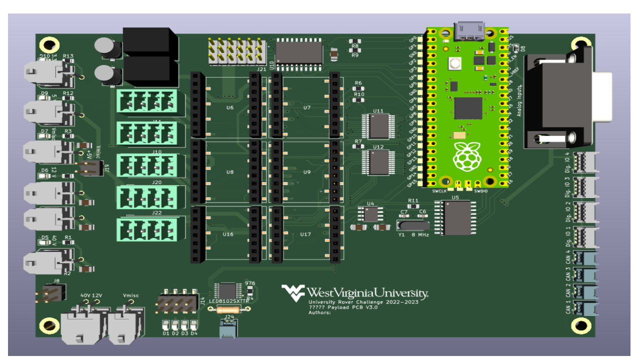

Figure 11: Payload PCB