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United States of America

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Team Mountaineers: Preliminary Design Review

1. Team Structure

Leadership and Membership: West Virginia University's Team Mountaineers is composed of 9 subteams (Fig. 1). Subteam coordinators organize projects and serve as representatives to other subteams and the team as a whole. Dr. Yu Gu is the team's faculty advisor and Connor Mann leads the team as the chief executive officer. Team Mountaineers is made up of over eighty student members with approximately half working with the team as their senior design project and the remaining members being student volunteers. Team members are primarily Aerospace, Computer, Electrical, Mechanical, and Robotics engineering majors, as well as Biology, Computer Science, and Finance majors. Members join with a variety of experience levels ranging from freshman to graduate students. Approximately 25% of the team are returning members.

Communications: Each team member belongs to a minimum of two subteams, ensuring students are informed about multiple aspects of rover design. Team leads, members, and executives collaborate regularly through weekly full-team and bi-weekly subteam meetings. Outside of meetings, Slack is used as the team's primary communication platform. Google Drive is used as a file-sharing platform for designs and documentation. GitHub is used for code sharing and task management, while CAD is developed and shared using Onshape. The team conducts external communications through social media and conducts at least one outreach event per month.

2. Team Resources

Finances: Funding for Team Mountaineers is sourced through the Department of Mechanical, Materials and Aerospace Engineering, the Lane Department of Computer Science and Electrical Engineering, grants, and private donations. The team is also actively pursuing sponsorships from industry partners. Purchased items must be approved by the team's chief financial officer, Jackson Ulery. A purchase ledger is updated as items are requested to keep track of total money spent as well as other pertinent financial information. Fig. 2 below shows team expenses to date as well as anticipated expenses for each rover subsystem.

Facilities: Upon completing West Virginia University's mandatory lab safety training, team members gain 24/7 access to URC's open lab and office space. Along with the college's machine shop, the team has access to equipment for additive and subtractive manufacturing, welding, and circuit board prototyping. The team also uses an on-campus facility with an indoor rock garden to test the rover and practice for each mission prior to the competition.

3. Project Management Plan

Development Lifecycle Approach: The team uses a development lifecycle approach based on NASA's system design process. Subteams work collaboratively in parallel, allowing for continuous integration and rapid development in cases of changing requirements. The project management team supports integration and planning, ensuring Gantt Chart deadlines are met (Fig. 3). Team Mountaineers' previous rovers serve as benchmarks and testbeds, enabling early testing of subsystems. Internal competitions are held twice a year to practice each mission and improve team understanding of competition requirements.

Systems Integration and Test Plan: At the weekly full-team meeting each subteam provides a progress update and discusses necessary cross-team integration. As individual components are designed and fabricated, incremental steps are taken to verify functionality. These steps include simulations, prototypes, and tests using previously designed rovers. Components are then integrated into their respective subsystems and the entire system as the development cycle progresses. Once the rover is fabricated, weekly testing and training sessions will be conducted using a mock lander, on-campus rock garden, and off-campus sites with geographic features similar to the MDRS. These sessions progress from simulated mission tasks to entire missions as the system's reliability and operator ability mature.

4. Preliminary Technical Design

The rover's split-body chassis design, with a central rotating bearing, maximizes ground contact across challenging terrain. Modular components allow quick reconfiguration for each mission. Custom TPU treads enhance durability and performance, while 24-inch wheel-legs allow for high performance in complex environments (Fig. 4).

For the Equipment Servicing (ES) and Delivery Missions, the rover uses a palletizer-style 5-degree-of-freedom manipulator (Fig. 4). The manipulator features a horizontal linear rail to aid in completing planar tasks such as those in the ES mission. A carbon fiber four-bar mechanism allows the primary motors to be located on the shoulder of the arm, enabling the manipulator to lift larger masses. The manipulator will feature force and position feedback that will aid in reliability and ease of operation.

The rover will be powered by three off-the-shelf 40-volt batteries. A custom power distribution board includes emergency stop functionality and regulates the battery power to provide the necessary voltage and current through the rover. A dedicated payload PCB controls the motors in each payload configuration and can take input from various sensors. Communication between a LattePanda Sigma computer and other major electrical parts of the rover is facilitated with three different communications protocols: CAN (controller area network), ethernet, and USB. A Pixhawk flight controller is used with a Pixhawk GPS module and Unitree 4D lidar for localization. Fig. 5 shows a diagram of the rover's electronics system.

The communications system facilitates control and video transmission between the rover and the base station using a 2.4 GHz system. Auxiliary control signals will be transmitted through RF modems operating in the 900 MHz band in non-line-of-sight zones. Furthermore, redundant video will be sent back to the base station using 424 MHz amateur television transmission methods.

The rover's control software will utilize the ROS2 framework for handling communication between system components, while custom libraries interface with the rover's hardware devices (Fig. 6). The rover's autonomous navigation stack will be controlled at the top level by a network of nodes that handle past, present, and future waypoints using confidence-based decision making. Dijkstra's algorithm, in combination with user-defined inputs, will be used to plan multiple routes between objectives on a global map composed of lidar data. As the rover travels between objectives, local path planning will be handled through a combination of the CMU TARE planner and feedback-based obstacle avoidance, allowing the rover to choose the optimal route toward the goal. Once the rover arrives at an objective, it will engage in a spiral search pattern, expanding from the center, until it recognizes an object, at which point it will begin navigating towards it. A YOLO v11 model will be used to detect ArUco markers, hammers, and water bottles in a variety of environments.

During the ES mission, the rover's manipulator will be autonomously controlled using a combination of reinforcement learning and the MoveIt platform to type on the keyboard. The manipulator will use a camera to determine all key positions from recognized keys and the known keyboard size. From this, the desired string can be input and the manipulator will plan its path to press each key.

Visible light spectroscopy will allow for the detection of carbon-containing molecules, typically arranged in an alternating double-bond fashion like those found in chlorophylls and carotenoids (organics commonly present in soil). Resultant wavelengths from photon absorption can indicate either extinct bicarbonates or extant life presence. Other biomolecules, including proteins, starches, lipids, and pigmented compounds can be confirmed as extant life evidence through colorimetric Baeyer's reagent testing. The rover will use a gimballed camera to document each site and take the panoramic photo. Surface soil will be collected with a spinning drum collector, mixed into a solution with isopropyl alcohol, and transported to a collection area via peristaltic pumps. The pumps will then move the solution to a rotating carousel of cuvettes where mixing and spectroscopy will be performed. To collect subsurface samples, a core drill will excavate to the desired depth, at which point its rotation will be reversed to open a hollow internal compartment where the soil sample will be stored. Once collection is complete, the drill will be rotated in the opposite direction to seal the cache, allowing for later delivery. Figs. 7 and 8 show the science mission flowchart and CAD of the rover's science configuration, respectively.

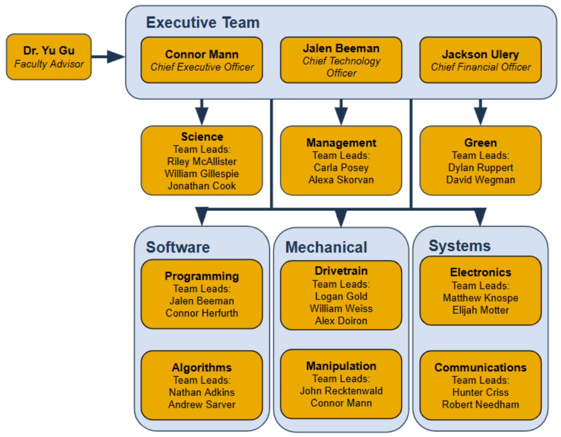

Figure 1. Team Structure

Income		
Income to Date		$40,000
WVU MAE Department		$20,000
WVU CSEE Department		$20,000
Anticipated Income		$5,000
NASA Space Grant Consortium		$5,000
Total Income		**$45,000**
Subsytem	**Cost to Date**	**Anticipated Cost**
Electronics	$2,594	$5,800
Drivetrain	$504	$5,500
Manipulation	$338	$3,300
Science	$32	$2,800
Programming	$1,522	$2,000
Communications	$1,022	$1,500
Rover Budget	**$6,012**	**$20,900**
Lab Equipment	$3,423	$4,000
Total Spent	**$9,435**	**$24,900**
Backup Parts	-	$5,000
Travel to Utah	-	$12,000
Rover Shipping	-	$2,000
Anticipated Costs		**$19,000**
Current Budget Surplus	**$35,565**	
Anticipated Budget Surplus	**$1,100**	

Figure 2. Budget

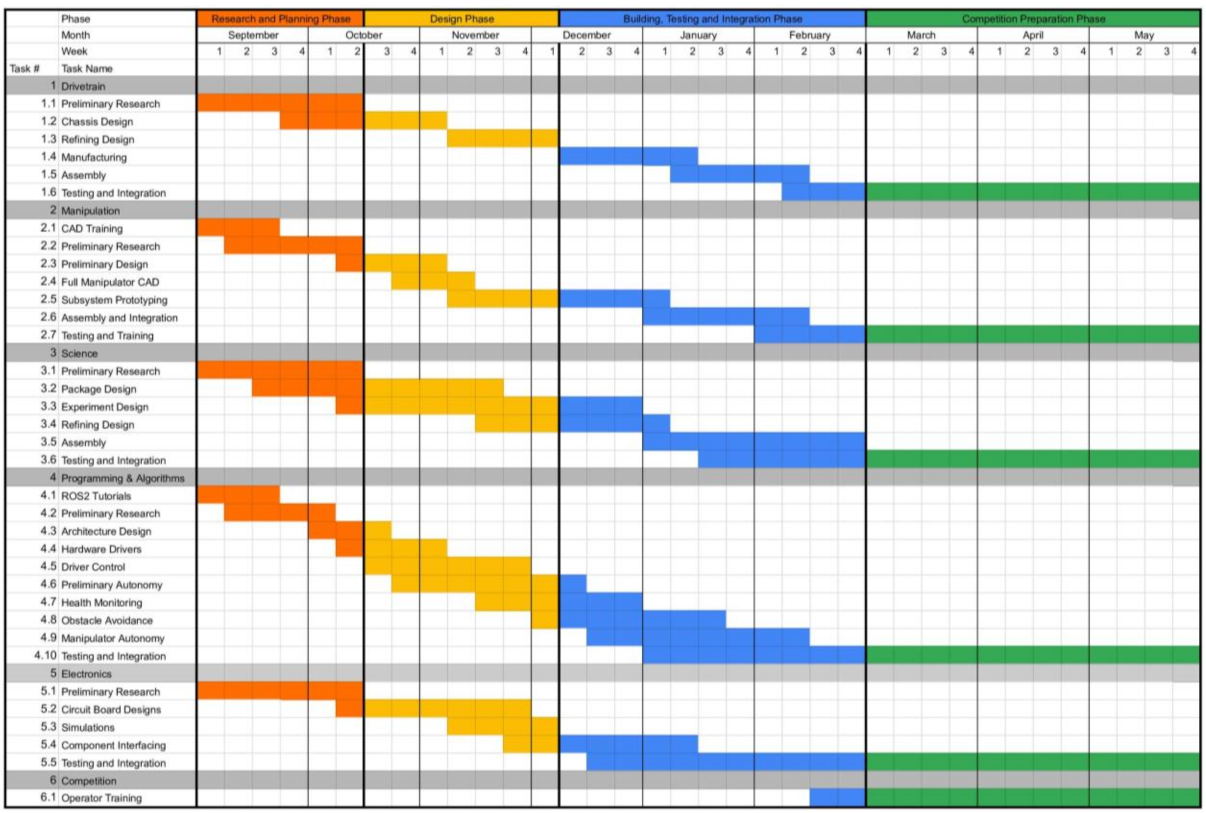

Figure 3. Subteam Gantt Chart

Figure 4. Rover in Manipulation Configuration

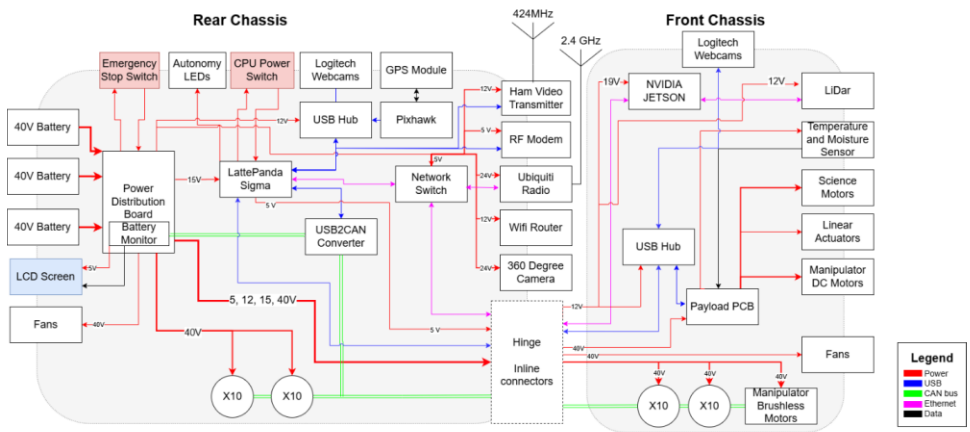

Figure 5. Electronic System Diagram

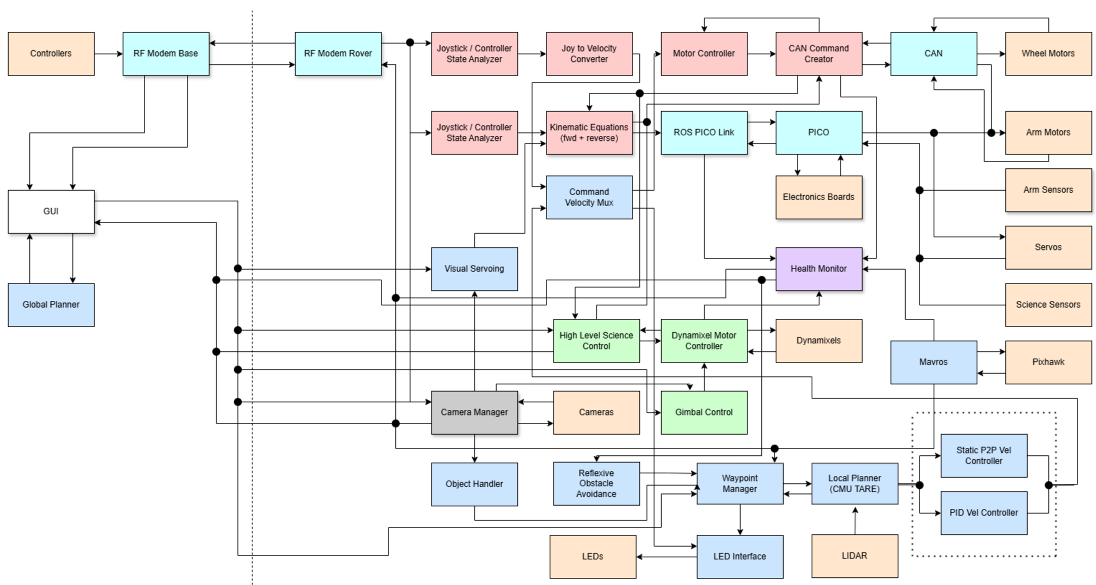

Figure 4. Rover Software Architecture

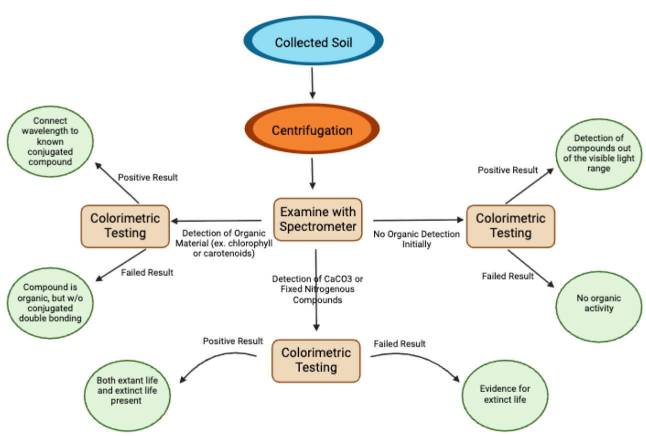

Figure 5. Science Mission Flowchart.

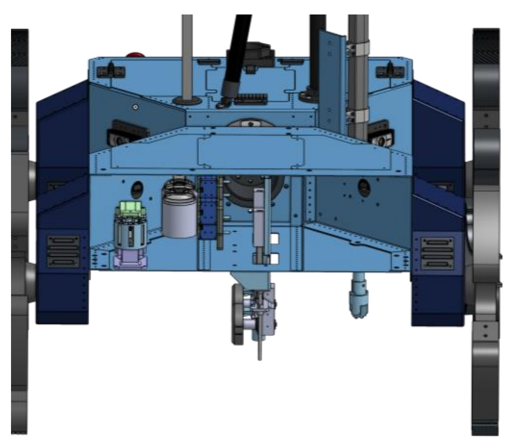

Figure 6. Section View of Rover in Science Configuration