# Project Proposal and Planning - Remote Communication System

Aztec Rover Team

**Assigned to**:
Team names here:
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**Deadline:** Dec 1, 2024
**Design Review By:** Nov 1, 2024

**For the preliminary portion, it is essential to read through and utilize the URC 2025 manual for information: [https://urc.marssociety.org/home/requirements-guidelines](https://urc.marssociety.org/home/requirements-guidelines)**

**Objective**

Write a paragraph describing the overall objective of the division and a brief description specific tasks to be accomplished by the design.

Example:

Our division is the arm, and it is responsible for tasks that involve supporting the gripper and tool mechanism. The tasks that it will be involved in are found within the equipment servicing and delivery missions, doing things such as picking up caches, various tools, maneuvering the tool part of the arm to type on a keyboard, etc.

**<u>Remote Division Objective:</u>**

Our division is the Remote division, responsible for establishing and maintaining the wireless communication systems necessary for remotely operating the rover. The primary objective of this division is to enable seamless, real-time control of the rover without any time delay, even when line-of-sight communications are compromised. Specific tasks include designing and implementing a wireless communication network that adheres to FCC standards, selecting appropriate communication devices, and ensuring compliance with regulations regarding operator licenses. Additionally, this division must document all communication devices and licenses and submit the information to the URC Director by the specified deadline. The Remote division will also ensure that any drones used for the mission comply with FAA Remote ID requirements. This communication system will facilitate remote operation in scenarios where standard wireless internet is unavailable, directly contributing to the success of the rover's tasks in the competition.

**Task List**

Compile all tasks that your division will need to approach and the specific information involved. Be sure to cite the sections that each task is derived from.

Examples:

- Pick up a metal sample tube (test tube sized) and insert it into a larger cache container (1.f.iv)
- Pick up the cache container and transport to the lander, where the cache has a handle at least 10 cm long and not more than 5 cm in diameter, weighing less than 5kg (1.f.iv)
- Capability to measure soil moisture and subsurface temperature at east 10 cm below the surface (1.f.iv)
- Autonomously enter in a code using a keyboard on the lander (1.f.iv)

**<u>Remote Division Task List:</u>**

- Use wireless communication with no time delay that can power down while other teams compete (3.b.i.)
- Develop omnidirectional or directional antennae that do not depend on first hand view by operators (3.b.iii)
- Develop base station antenna (limited to 3 m) that is located within 5 meters of the teams C2 station, and any rope or wire used for stability must be within 10 meters of the C2 station (3.b.iv)
- Communications should operate exclusively within each of the following three sub-bands: “900-Low” (902-910 MHz), “900-Mid” (911-919 MHz), and “900-High” (920-928 MHz) (3.b.v)

**Requirements/Constraints**

List down the required features, capabilities, and constraints that must be met by the design according to the manual and tasks described. Be sure to clarify what specifically are requirements and specifically what are constraints. As a quick explanation, requirements are things your design must **do**, while a constraint is something you **cannot design past.** For each requirement and constraint, cite the section that it references.

Task requirement examples:

- Arm must be able to support a 5kg object reliably while in motion (1.c.iii)
- The rover must stop within 2m of any ARCUO tag post (1.f.iv)
- The cameras must identify a 20cmx20cm ARCUO tag from a maximum 20m away (1.f.iv)
- Laboratory samples must be taken from at least 10 cm from the earth (1.b.vii)
- There must be an LED indicator on the back of the rover clearly visible in bright daylight (1.f.vi)
- The GNSS standard used shall be the WGS 84 datum (2.b.v)
- The collected sample must be sealed within a cache and returned to the C2 station, and must not be spillable and must be removable within 5 minutes after end of roving time (1.b.viii)

Etc.

Design constraint examples:

- Base station antenna cannot be taller than 3m (3.b.iv)
- Chosen remote band frequencies cannot be greater than 8MHz (3.b.v)
- Rover must fit completely within a 1.2m cubed box when being inspected, but may expand past these dimensions (3.a.ii)
- Air-breathing power systems are not allowed (3.a.iv)
- The drone must carry a dummy mass of the same weight as the battery (1.d.vi)
- The robotic arm connection to the rest of the rover must readily interface with the mounting system derived from the chassis division (external)
- Division budget has been set to $1000 for the final product and R&D expenses (external)
- All research and work done must be documented within this journal (external)

**Additionally, be prepared to crawl the entire manual, as certain constraints, requirements, and considerations can be hidden within other sections of the manual, or may not be relevant to your division during design, for example:**

- All drones must not fly above 400 feet (120 m) above sea level (1.d.xi)
    - You may think this is a requirement for the drone people, but this actually indirectly creates a constraint for the vision people, as their photogrammetry compiling program cannot have image sizes greater than a certain amount of ground since the drone is not allowed to fly higher

**<u>Remote Task Requirements:</u>**

- All necessary systems, including all communications systems, must be ready to compete in no more than 15 minutes following given access to the team's command and control (C2) station (1.a.ii)
- Follow a marked path that requires precise maneuvering of the rover (1.c.iii)
- Rover should be able to find objects in an area with poor radio reception (1.c.iii)
- Operate a joystick (4-position, spring-return) to direct an antenna while observing a gauge (1.e.ii)
- Operators may teleoperate back to any previously visited object, AR tag, or GNSS coordinate for a 20% point penalty but should take the most direct reasonable route back and may not go scouting for the location (1.f.viii)
- Wireless communications with no time delay (3.b.i)
- All teams should bring at least 25 m of communications cable (3.b.iv)
- Teams must also be able to operate exclusively within each of the following three sub-bands: "900-Low" (902-910 MHz), "900-Mid" (911-919 MHz), and "900-High" (920-928 MHz). (3.b.v)

**Remote Design Constraints:**

- The gauge will be up to 20 cm away from the joystick (1.e.ii)
- Visibility of the course to the operators in the C2 station will be blocked (2.b.i)
- Rovers are not expected to travel more than 1 km from the C2 station (2.b.ii)
- Tethered power and communications are not allowed (3.a.i)
- Communication equipment must not rely on the team's ability to watch and track the rover firsthand (3.b.iii)
- Base station antenna height is limited to 3 m (3.b.iv)
- Antenna bases must be located within 5 meters of the team's C2 station, and any ropes or wires used for stability purposes only may be anchored within 10 meters of the C2 station (3.b.iv)
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**Considerations**

List down considerations that may be relevant when working on your objectives, things that may not be explicitly a requirement but will need to be considered during design. Additionally cite the sections these were identified in.

Examples:

- The surrounding area includes soft sandy areas, gravel, rough stony areas, rocks, and boulder fields (1.c.ii)
- The terrain features vertical drops, and slopes that are both steep and unstable (1.c.ii)
- The posts and gate will have 3-sided visual markers with 20x20 cm faces for the ARCUO tags (1.f.iv)
- The 3 posts have GNSS coordinates within 5-20m from each post (1.f.iv)

**Remote Considerations:**

- Visibility of the course to the operators in the C2 station will be blocked. Basic power (120V, 60Hz), tables, and chairs will be provided. All of the competition events will be held in full daylight (2.b.i)
- Rovers are not expected to travel more than 1 km fro the C2 station (2.b.ii)
- Normal wireless internet is not available in the field or at MDRS, and use of satellite internet is not allowed (3.b.i)
- Signal strength, relayed GNSS, or other strategies may be used to give feedback on antenna direction, but it is not allowed to mount a camera on top of the antenna for visual feedback (3.b.iii)

**Criteria:**

These are the factors from which a design matrix will be constructed to measure relative effectiveness of different designs

Use the objectives outlined and your requirements to establish a set of 3-8 criteria to be used in your division's design matrix

Example:

1. <u>Design Complexity</u>
    a. How intricate is this system mechanically/electrically/software wise?
    b. How long will it take to design such a system?
2. <u>Strength</u>
    a. How strong is the connection between the
    b. How difficult/cumbersome is mounting the enclosure to T-slot framing?
3. <u>Weight</u>
    a. What is the expected weight of this material?
4. <u>Manufacturability</u>
    a. How expensive is the manufacturing process for this specific design technique?
5. <u>Component Price</u>
    a. How expensive is each component needed for a specific system?
6. <u>Space Requirement</u>
    a. How much space does the design seem to need for full operation?

**<u>Remote Criteria:</u>**

1. <u>Signal Reliability</u>
    a. How well does the design maintain a strong, stable communication signal within the 1 km operational range?
    b. Does it effectively handle poor radio reception areas and blocked visibility?
    c. Does the design comply with the required frequency bands ("900-Low," "900-Mid," "900-High")? (3.b.v.)
2. <u>Setup and Deployment Time</u>
    a. Can the communication system be set up and ready to compete within the 15-minute time constraint?
    b. Does the design allow for easy assembly, antenna mounting, and configuration at the C2 station?
3. <u>Ease of Operation</u>
    a. How simple and intuitive is the joystick-controlled antenna direction system for the operators?
    b. Does the feedback system (e.g., signal strength, GNSS data) provide sufficient and clear information for operators to make accurate adjustments without visual tracking?

4. Power and Equipment Constraints
    a. Does the design operate effectively using only the basic power (120V, 60Hz) provided at the C2 station?
    b. Can the system be powered down efficiently between competition rounds as required?
5. Component Cost
    a. What is the total cost of all components (antennae, communication devices, cables, etc.) required for the system?
    b. Does the design use cost-effective materials while ensuring compliance and performance?
6. Compliance with Physical Restrictions
    a. Does the design adhere to the 3-meter height limit for the base station antenna and the specified anchoring distances (5 meters for antenna base placement, 10 meters for stabilizing ropes/wires)?
    b. Does it meet all FCC standards and regulations, including documentation and licensing requirements?
7. Design Complexity
    a. How intricate is the design mechanically, electrically, and in terms of software integration?
    b. How long is the estimated time required to develop and test this communication system?
8. Scalability and Modularity
    a. Can the design be easily modified or scaled to accommodate changes in requirements or to improve performance?
    b. Is it possible to replace or upgrade components (e.g., antenna types, communication modules) without redesign?

**Additional Considerations:**

This section contains any additional design considerations, suggestions, and links to external resources. Feel free to use this section to organize your brainstorming, such as dumping inspiration or potential avenues to explore.

**Research and Links:**

Use this section to organize any research involved in the project, as well as links to any external resources you find.

**Design Matrix:**

Here you will develop a design matrix that utilizes the above criteria. Research systems and designs that seem promising and rate their effectiveness on a chosen scale, with weights assigned to each criteria. The goal is that each design can be assessed a score to focus on one or two designs, or to focus on one or two selected components.

Here is the design matrix we used for IAM3D 2024:
https://docs.google.com/spreadsheets/d/1rP_ZkUNzlRjmGIfH3Af_i43OPHjEGXWnvIhL6dGuAzw/edit?usp=sharing

Here is the link to the design matrix for URC 2025:
https://docs.google.com/spreadsheets/d/1IZSuZrsVGGK5flU-wGaAEsoVZg8-MsoAy6uVUX6FOBs/edit?usp=sharing

# Project Documentation

This section is dedicated to documenting the various designs, as well as the progress of the project itself. **This documentation is as important as the final product. Please be thorough.**

## Design Brainstorming:

This section is dedicated to brainstorming and qualifying different designs based on the criteria listed above. Include in each design a 1-to-2 sentence abstract describing the key features of each design, a 1-to-10 ranking for how well each design meets each criteria, and any additional challenges or notes. Please copy-and-paste the given format ("Design N:") as needed.

**DESIGN N:**

Abstract:

1. Criterion 1 [Weight: ]

Possible Challenges:

Notes:

## Journal:

Use this section to document the process of iterating on each design. Record thoughts, changes, input, communication - remember, if you are unable to work on the project, whoever picks it up needs to be able to follow what you've done and why.

Example:

<u>09/24/24:</u> Project planning finished and design matrix organized. Sent to the project lead for overview

PERSON worked on the first design chosen from the design matrix, with a preliminary sketch shown below:

<u>10/24/24:</u>