NC STATE UNIVERSITY

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Ice CubeRover

Team FAKE (Future Applications in Known Environments) NASB
Aerospace Engineering Capstone Senior Design 2020-2021
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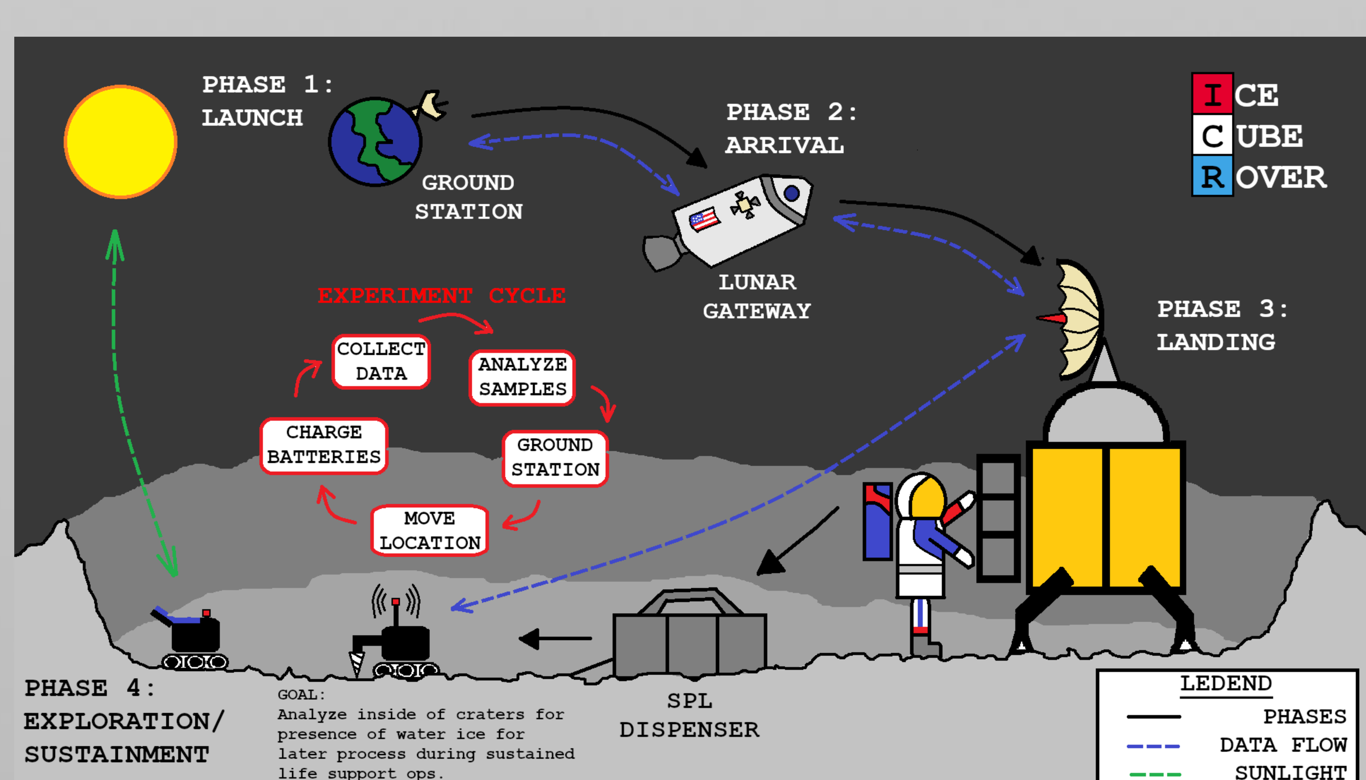
Project Overview

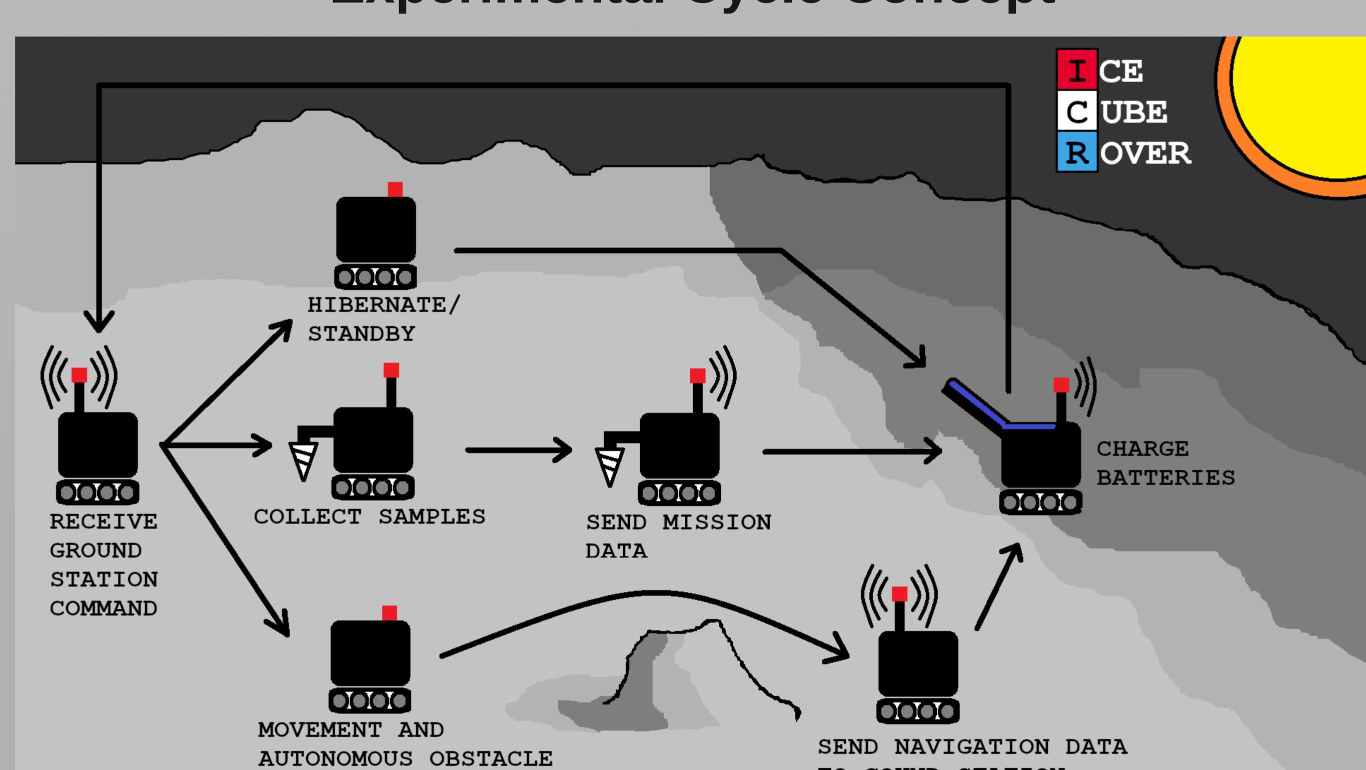
NASA plans to return to the Moon in 2024 with the Artemis Program. The long-term goal of Artemis is to create a permanent presence on the lunar surface. To achieve this, water ice will be imperative as it provides drinking water, cooling equipment, and the ability to produce rocket fuel for future missions.
Ice CubeRover will search for evidence of water ice on the lunar surface, utilizing the Artemis missions as a ride-share.
At North Carolina State University, team FAKE NASB has created a functional prototype of Ice CubeRover.

Concept of Operations



Ice CubeRover will be stored on the SPL dispenser and launched on top of the SLS. Once on the Lunar Surface, an astronaut will deploy the solar panels and antenna on the Ice CubeRover. Afterwards the Ice CubeRover will boot up and begin initial accelerometer calibration.

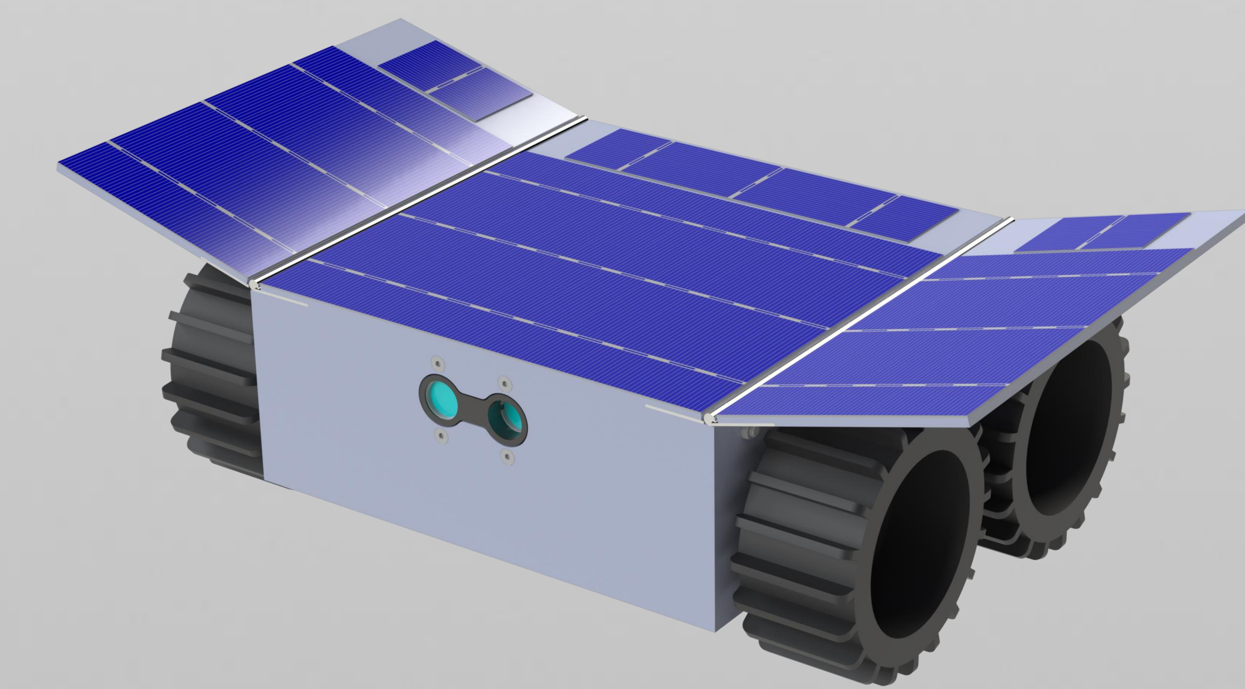
Experimental Cycle Concept



The experiment cycle consists of Ice CubeRover receiving one of three commands from the ground station. The first command is the movement command where ground station will send Ice CubeRover a position vector for Ice CubeRover to traverse to. The second command is the drill command where Ice CubeRover will take readings searching for water ice and send the collected data back to ground station. The third command is the hibernation command where Ice CubeRover will remain on standby until Ice CubeRover receives a new command from ground station. Ice CubeRover will repeat this experiment cycle until the mission is deemed complete or until Ice CubeRover suffers a critical failure.

Design Solution

The Ice CubeRover is a 6U CubeRover featuring four independent, direct-drive electric motors, with the capability to traverse regolith terrain anticipated for lunar crater surfaces. The final design solution is a product of repetitive design revision, shown below.



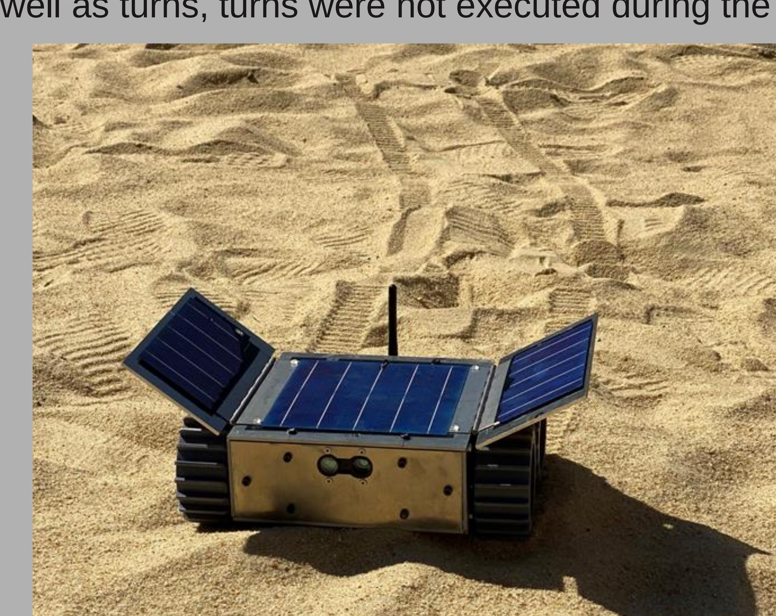
The following tables show the power and mass requirements of the finalized design.

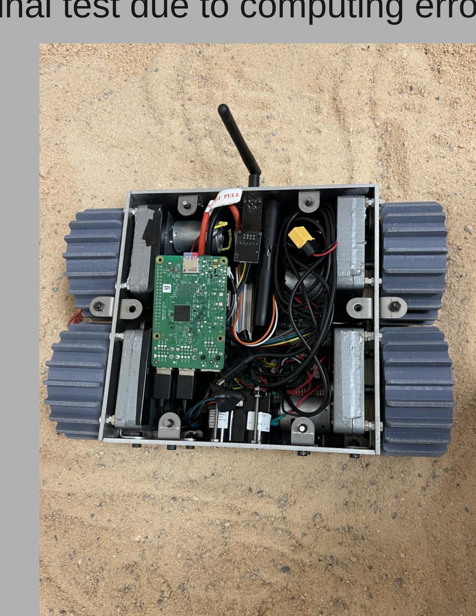
Component	Voltage Draw	Current Draw	Drawn From
Raspberry Pi	5 V	2.4 A	Power Block
Arduino Nano (Com.)	5 V	200 mA	Raspberry Pi Serial Port
Arduino Nano (GNC)	5 V	200 mA	Raspberry Pi Serial Port
Arduino Nano (Prop.)	5 V	200 mA	Raspberry Pi Serial Port
Accelerometer	3.3 V	10 mA	Raspberry Pi 3.3V Pin
Motor H-Bridge (x2)	12 V	1.3 A	Battery

Parameter	Value
Mass	4.717 Kg
Maximum Velocity	5 cm/s
Maximum Slope	15 degrees
Battery Lifetime	2 hours
Ground Clearance	2.75 cm

Testing & Prototype

Extensive testing was performed throughout the design process to ensure proper functionality of all systems. Once assembled, this culminated into a final test of the Ice CubeRover prototype. Videos of testing throughout manufacturing and the final test can be seen by scanning the QR code below.
Ice CubeRover traversed the Wolf Ridge beach volleyball court, which was intended to simulate lunar regolith, successfully. While it was expected that Ice CubeRover would perform both straight movement as well as turns, turns were not executed during the final test due to computing errors.





Check out the link at the QR code below for test videos

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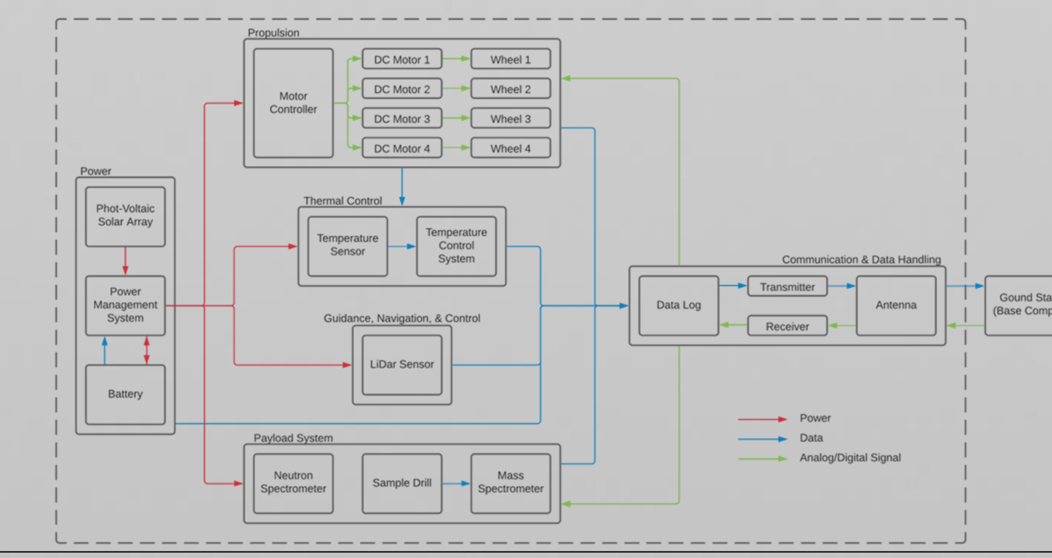
Functional Block Diagram

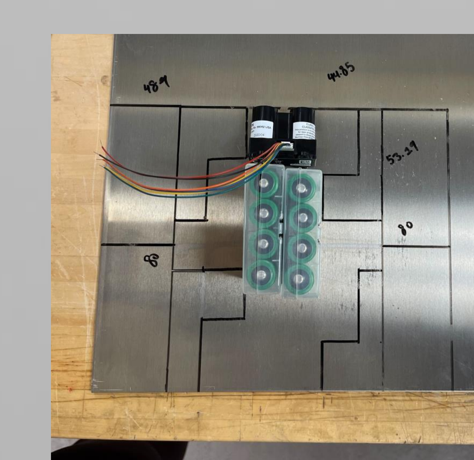
The functional block diagram shows the power, data, and signal connections between the subsystems and the internal components of the rover. The flow of power and data throughout the rover is shown along with the signal with the ground station. When the rover is organized like this, it helps show that all the sub-systems that require power, such as the propulsion, thermal, and GNC, are getting it, and that all the sub-systems are communicating with one another through data or an analog/digital signal.

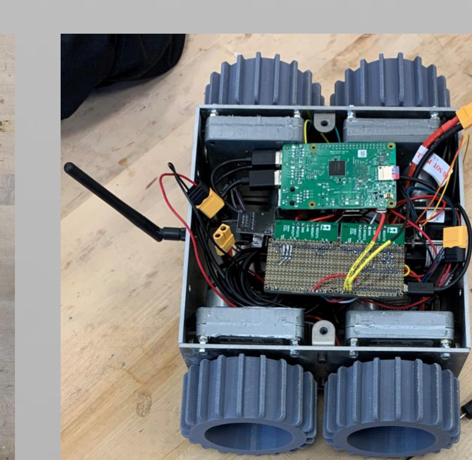


Manufacturing

Ice CubeRover's manufacturing process consisted of three key stages: structural planning, component installation, and final prototype assembly.

1) Structural Planning
Aluminum 6061 sheet metal was cut for the rover chassis with component layouts marked for each subsystem to identify any initial sizing issues. Corner bracket configurations were used to securely connect each of the chassis' panels.





2) Component Integration
Interconnections between subsystem components were tested prior to installation for issues ensuring no faulty components were installed, with emphasis on the power system and Raspberry Pi.

3) Final Prototype Assembly
For the final assembly, the top structural panel was designed to allow access to the internal subsystem components in case of component failure during testing or operation. Additionally, insulating material was used to protect the internal electrical components from the aluminum panels. All components were installed in accordance with their respective location in the CAD model, shown to the right in an exploded view.