NC STATE UNIVERSITY

Department of Mechanical
and Aerospace Engineering

Aerospace Engineering Capstone Senior Design 2020-2021
Rover to Define Terrain
Team RTDT

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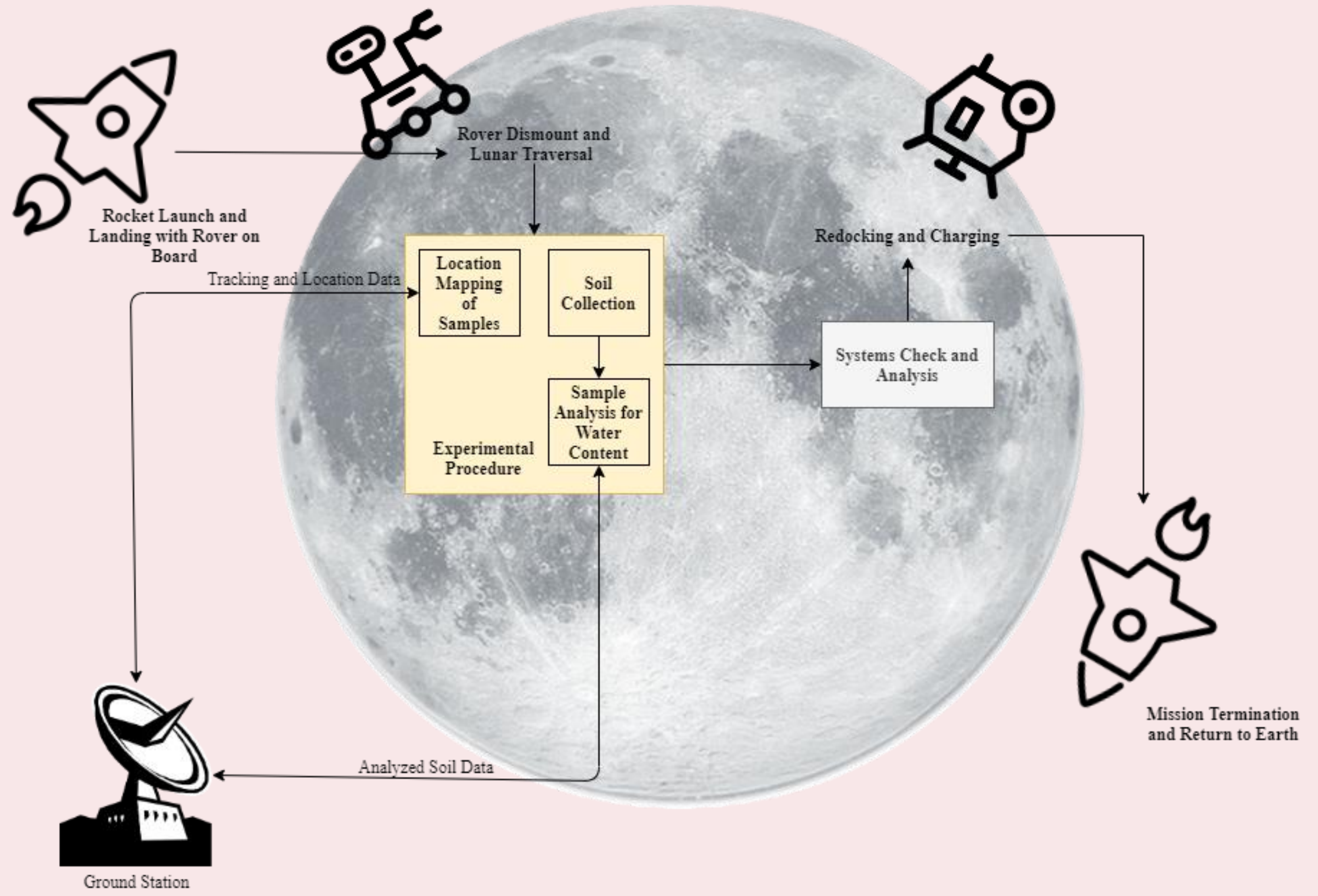
Mission Objective

NASA Artemis Mission Patch

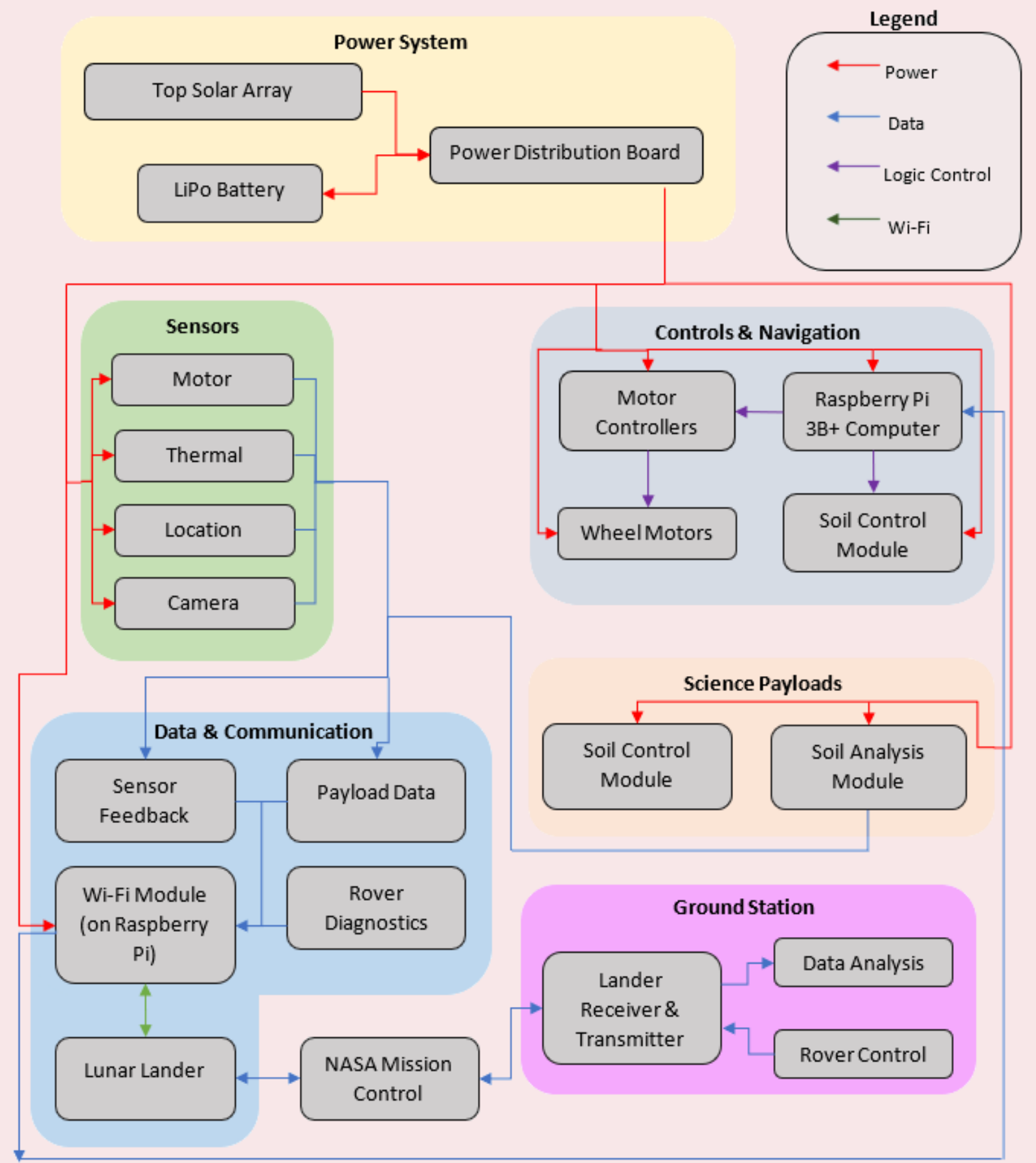
- RTDT's main objective is to map water ice deposits as part of NASA's Artemis mission.
- This will be accomplished using a 6U (12x24x36cm) CubeRover in order to best meet budgetary and weight requirements.
- Water ice is vital to the development of lunar space operations, with uses including:
  - Drinking water
  - Oxygen
  - Rocket fuel

Concept of Operations



Mission ConOps Diagram

Functional Block Diagram



Cube Rover Functional Block Diagram

Design Solution

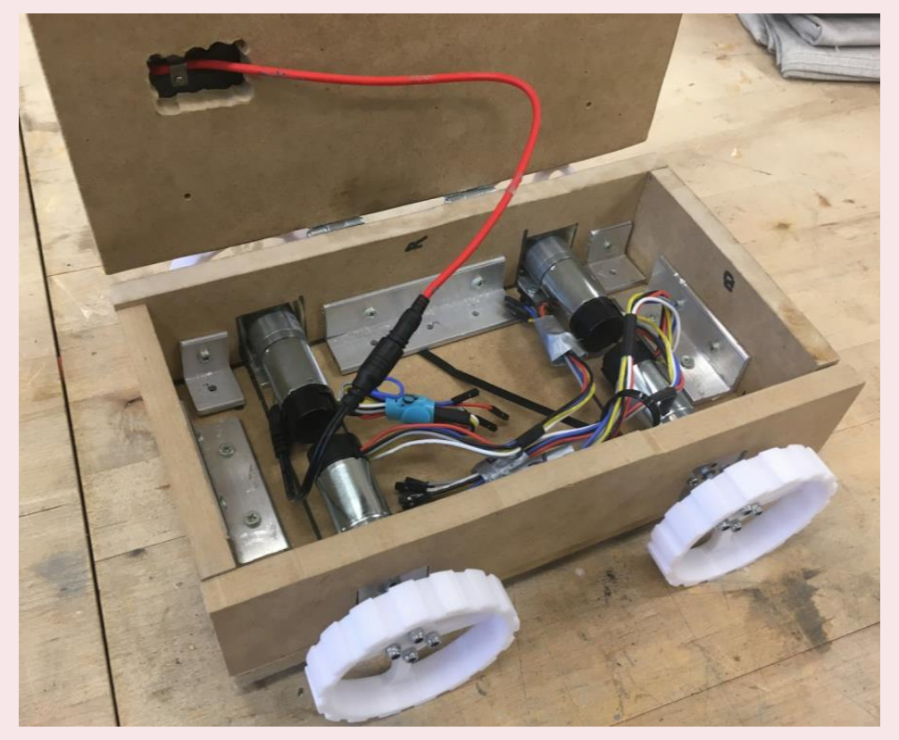
Structure
- Fiberboard chassis
- Aluminum bracket fasteners
- PLA Filament Wheels
- Hinge lid for interior access
- Polymer mesh electronics board

GNC and Propulsion
- CQRobot Ocean: 164.63:1 brushed DC Gear Motor
- L298N H-Bridge Motor Driver
- MPU-6050 IMU
- Python code commanding inputs through Rasp.Pi to drivers

Communications and Data Handling
- Raspberry Pi 3B+
- Arducam 5MP Camera Module
- WLAN 2.4 GHz with TCP socket programming
- Server-client model (Rover – server; Lander – client)

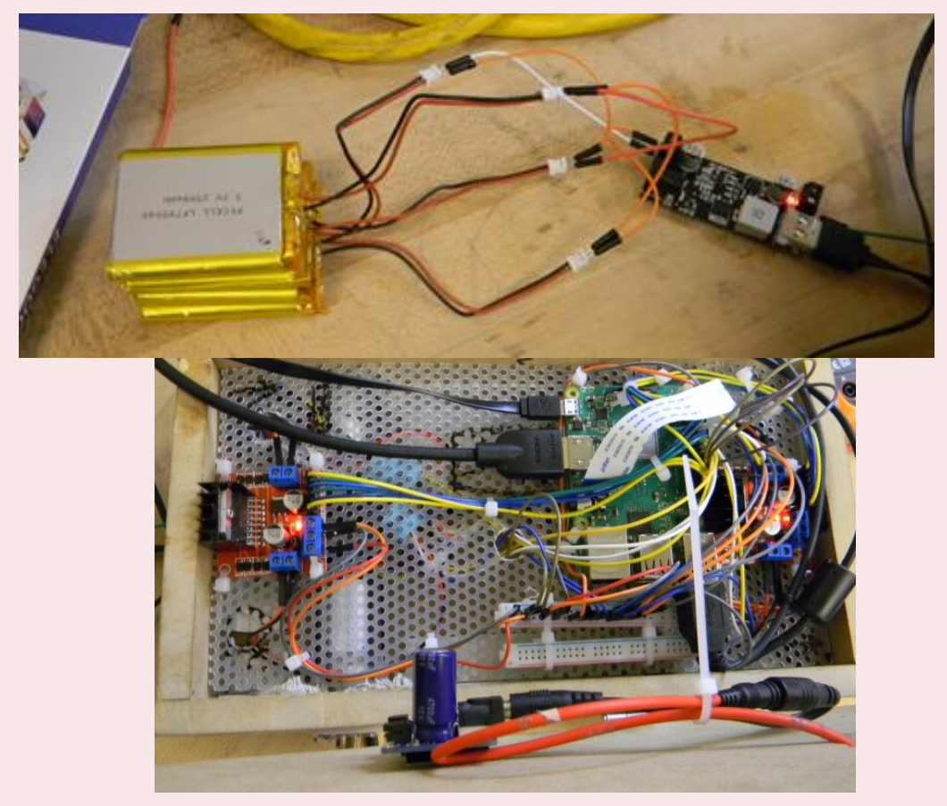
Power
- Four 3.7V, 2500 mAh LiPo batteries in series
- 5V step-down buck converter
- 6V, 1.5 A solar panel for backup power through a single battery solar charging board

Manufacturing

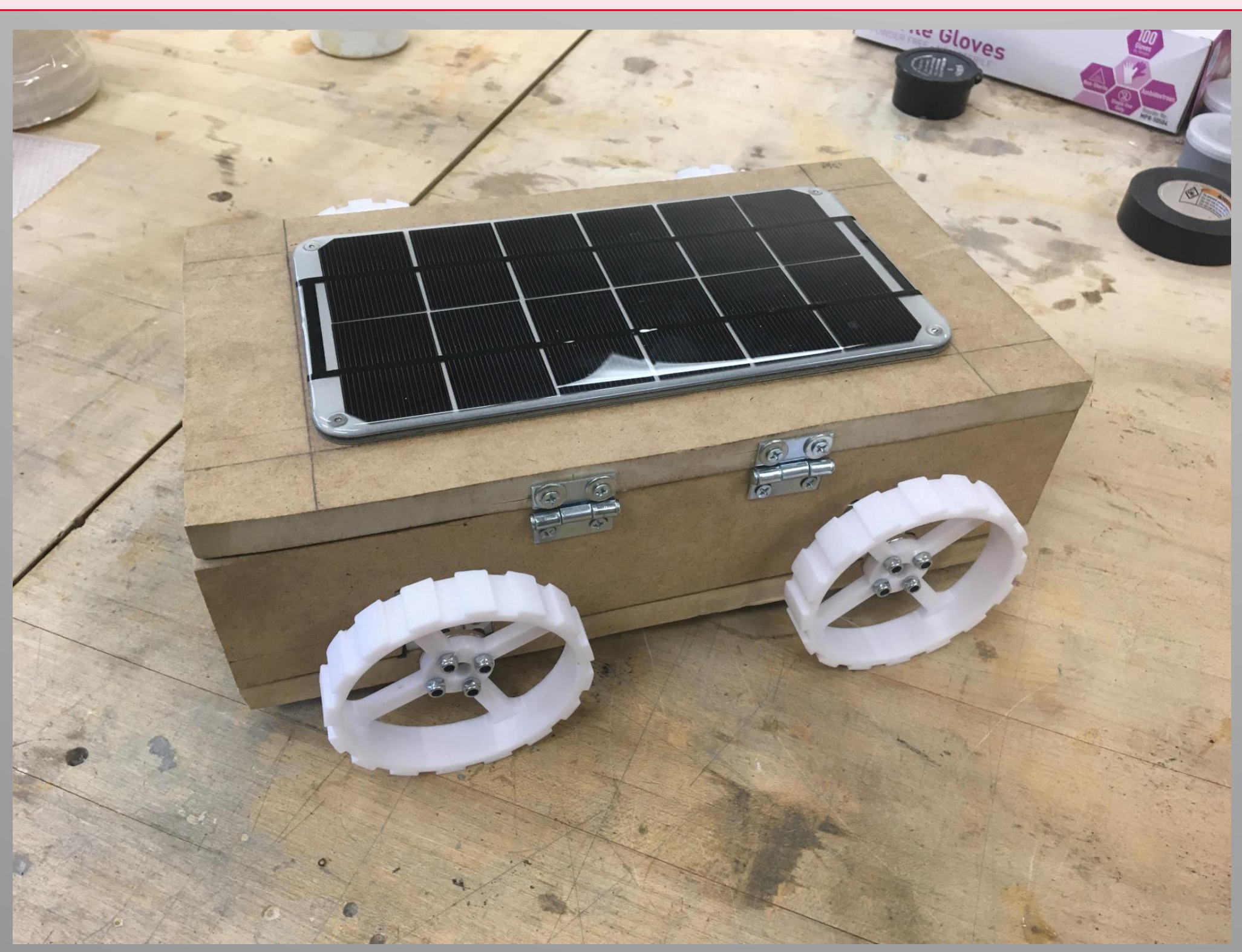


Empty Rover with Mounted Motors

- **Chassis Assembly**
  - Fiberboard held by aluminum brackets
  - Dimensioned, cut, and assembled using table saw, drill press, and power drill in Senior Design Lab
  - Four motors mounted symmetrically through square extrusions
- **Wheels**
  - 3D design created in SolidWorks
  - Printed using PLA filament
- **Electronics Board**
  - Created around dissemination of power through the Raspberry Pi 3B+
  - Inputted battery power through buck converter to input constant 5V to Rasp.Pi
  - Power supplied through GPIO to motor drivers, accelerometers, camera, thermal sensor



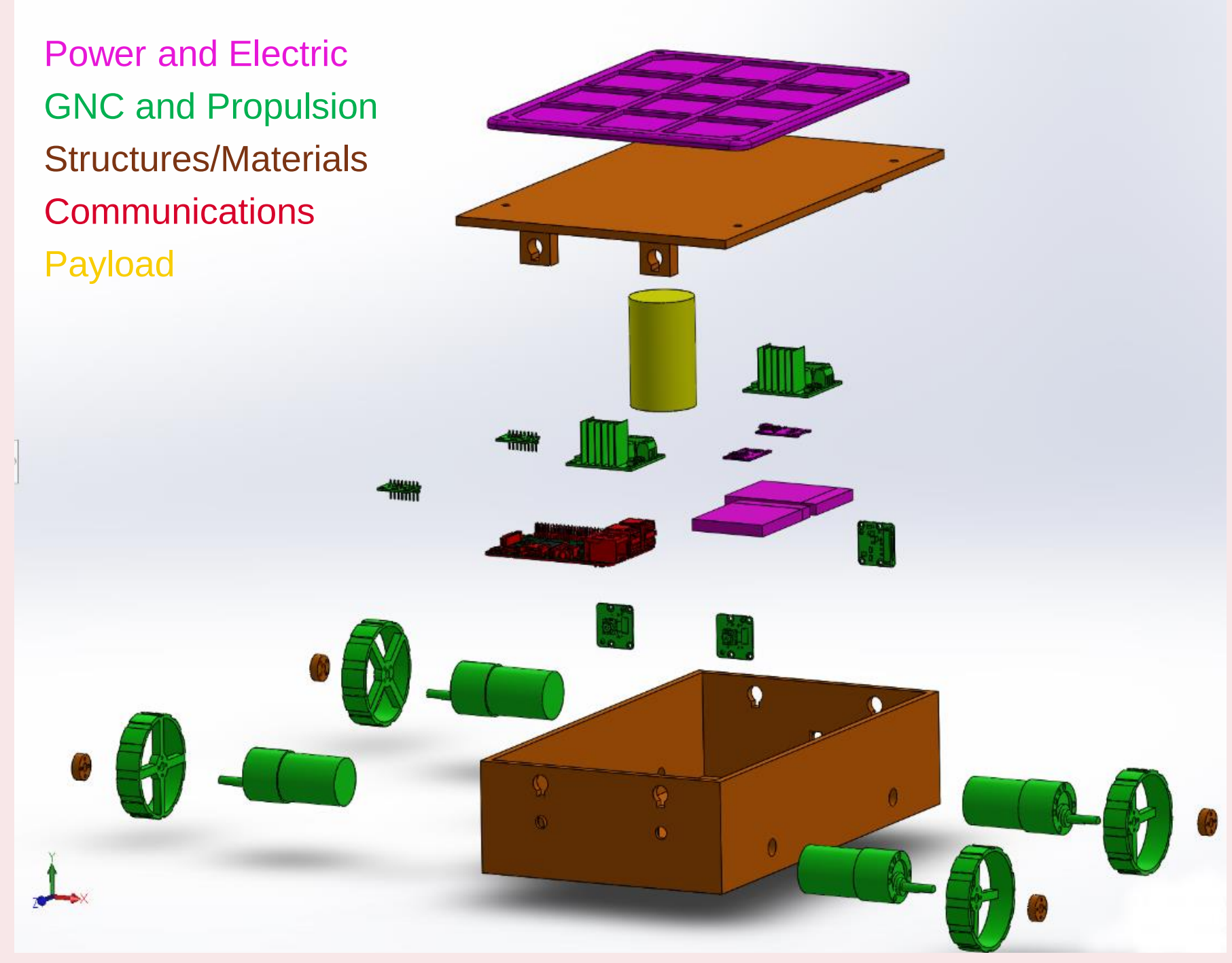
Battery and Buck Converter (above)
Electronics Board (below)



RTDT Prototype CubeRover Exterior

RTDT Prototype CubeRover Interior

CAD Model



CAD Model of Rover, Colored by Subsystem

Testing

Subsystem testing was performed to validate system cohesion and design feasibility. Through this testing, we identified key changes needed to complete the rover design and allow for successful flight testing. This includes increasing the radius of our wheels to prevent the chassis from being buried into the sand of our test pit.

Testing of Rover's Maneuver Capabilities

- Primarily tests focused on examining rover's navigation success.
- Tested operational modes of forward travel, backward travel, skid turning, standby, and imaging.
- Standby operation includes measuring temperate and time.
- Imaging operation uses Camera Module to image region in front of rover.

Structural integrity of the rover under expected lunar conditions was measured using a simulated dust chamber which examined the rover's ability to shield internal electronics from lunar regolith intrusion. Additionally, low temperature thermal effects on batteries were examined by measuring power output of batteries after being placed in freezer.

Conclusion/Future Development

- RTDT's CubeRover has completed the FRR and Flight Test stage as of April 2021, proving the operational capacity of the vehicle design.
- Further work must be accomplished in order to bring the CubeRover to a mission-ready design.
  - This includes the development and implementation of a proper imaging spectrometer from a scientific customer.
  - Additionally, for a more permanent solution, space grade material and custom electronics need to be acquired for mission survival.