Baseline Power Model for Lunar Vehicle Simulation

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Company Background:

Lunar Outpost is an industry leader in lunar surface mobility, commercial space robotics, and space resources. From our terrestrial product lines revolutionizing the air quality sector on Earth to the creation of oxygen on Mars, our impact spans the solar system. Lunar Outpost's exploration class rover, the Mobile Autonomous Prospecting Platform (MAPP), is the first commercial rover on the Moon and the first rover in history to explore the lunar South Pole.

Since our founding in 2017, Lunar Outpost has raised Venture Capital from top-tier investors and continues to attract strong investment partners as we continue to prove the opportunity that advanced mobility, robotics and autonomy provides to the new space economy and here on Earth. In 2021, Lunar Outpost announced that our commercially funded MAPP rover—including payload mass allocations for MIT and Nokia — was scheduled for delivery by an Intuitive Machines lander to the lunar South Pole. Lunar Outpost has since secured two additional contracted lunar surface missions, one of which is fully commercial and the other a NASA funded science exploration rover. In addition to the three missions above, Lunar Outpost has also won a contract with the Australian Space Agency to design and develop a lunar rover for Australia's first mission to the Moon as part of the Trailblazer program. In 2024, Lunar Outpost was awarded a Lunar Terrain Vehicle Services (LTVS) contract by NASA to develop a human-rated Moon rover as part of the Artemis campaign.

With over a dozen active contracts across commercial, defense and civil space, Lunar Outpost is The Next Leap that will enable humanity to become interplanetary.

Description of Work to be Done:

Vehicles on the Lunar surface operate under harsh conditions and are subject to uncertainty from many factors. Simulation of these vehicles with a digital twin aids in reducing this uncertainty by allowing operational characteristics to be predicted. One of the primary components of a vehicle's operation is its power use and generation. The accurate simulation of vehicle power characteristics permits accurate planning of mission profiles and determination of vehicle operation.

For this project, your team will develop, test, and characterize an accurate digital twin of the power system for lunar vehicles. The digital twin simulation will need to be configurable for different vehicles, ranging from the MAPP series of rovers to the human rated LTVS "Space Truck". Renders of these vehicles are shown in Figure 1 below.

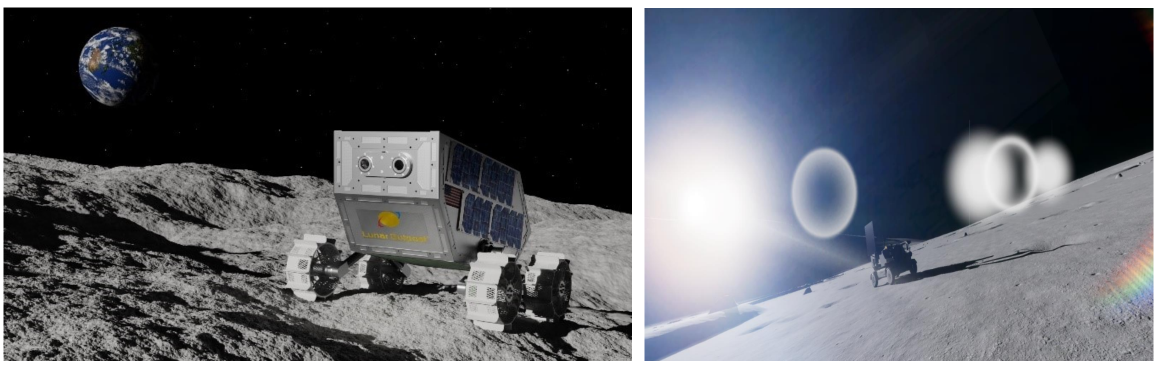

Figure 1: (Left) The LV1 MAPP rover and (Right) the LTVS rendered on the lunar surface.

Students will focus their efforts on four specific areas:

1. Development of 2nd order electrical model for generic rover architecture
2. Implementation of ROS2 node for power model
    a. Input of on/off states for payloads, flight computers, cameras, etc.
    b. Input of power draw for motors
    c. Input of power generated by solar panels
    d. Output of instantaneous power draw of total system
    e. Output of battery state of charge, rail voltages, and rail currents
    f. Output of fault states for power system
3. Characterization of model against test and design data for existing vehicles
4. Documentation of model, assumptions, use cases, and characterization

Ultimately, this software will be integrated with the digital twins of our vehicles and be used for mission planning, vehicle software testing, and system validation. An example of integration with our ground station, which was used to control the LV1 MAPP rover during its mission, is shown in Figure 2.

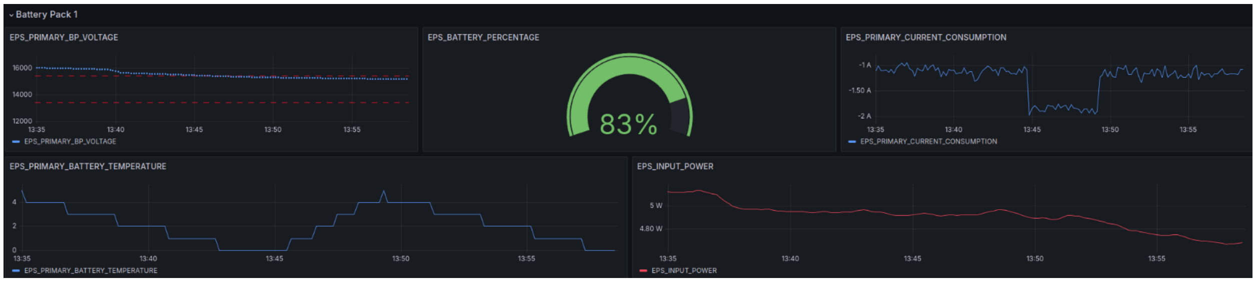

Figure 2: Ground station showing simulated data from a power simulation.

Reach Goal:

- Make the ROS2 node highly configurable
    - Define the electrical network in the launch file
    - Define fault conditions externally
    - Able to inject faults and override operating conditions

Desired Skills for Students:

- Familiarity with ROS2: creating packages, ROS topic publish/subscribe model
- Software Development: C/C++ and Python, Unit testing, Version Control with Git
- Electrical Engineering: Equivalent Circuits and Signal Processing (Kalman Filters)
- Documentation: Doxygen for code, Word or LaTeX for characterization reports

We understand not all the students in the group might have the desired technical skills. However, if they can problem solve and have a willingness to learn, they can excel in this project with the help of our talented engineers.

Preferred Team Size: 3-4 students

Given the scope of this project, a group of 4 students is preferred but 3 students could also excel given they are willing to problem solve and learn.

Internships at the End of the Course:

We are happy to consider offering internships at the end of the course.

Location Where Work Would Be Performed:

We have offices in Arvada, CO. This office is less than a 15-minute drive from CSM campus and should provide a convenient location for the students to meet. We also provide free beverages and snacks to keep the team fueled throughout the day.