Design and Development of a Lunar Exploration Rover for Extreme Terrain Navigation

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ABSTRACT

This design report outlines the design and development of a small compact robot for the NASA Lunabotics 2025 Challenge, focusing on the excavation and transportation of lunar regolith.

Team NOVA's rover features a lightweight aluminum frame, a bulldozer-style regolith collection system, and four independently powered DC motors driving a tracked mobility system. The design is built to withstand harsh conditions and rough terrain conditions**.**

PROJECT BACKGROUND

- The challenge originated from NASA's desire to give university students a chance to partner with them to design and develop lunar robots for the Artemis campaign [2].
- The current state of the art lunabot is a high-tech mining robot built with lidar-sensing technology.
- NOVA's design is built to collect regolith compared to removing space rocks.

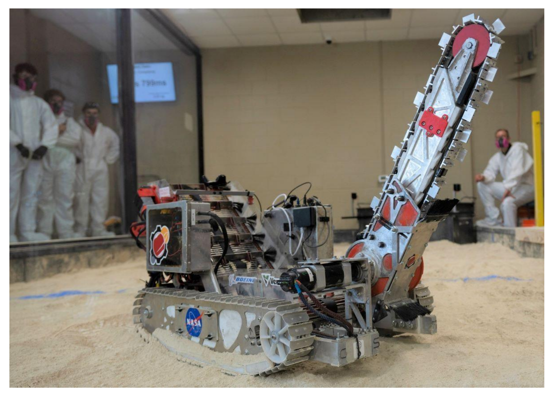

Figure 1. Iowa State MARS Atlas Robot [3]

Figure 2. Lunar Regolith [5]

OBJECTIVES

- **Project Objective:** Building a Lunar Rover capable of building a berm.
- **Berm Construction**: Build a berm using lunar regolith, which is a mound created from lunar soil, essential for simulating lunar construction techniques.
- **Utilization of Flat Space**: Leverage the flat area left after collecting regolith to create usable surfaces for essential infrastructure on the lunar surface, such as shelters, landing zones, and solar panels.
- **Documentation:** Document the process of designing and building a lunar rover.

DESIGN AND ANALYSIS

Torque required for the motors were determined from the maximum static friction force calculated.

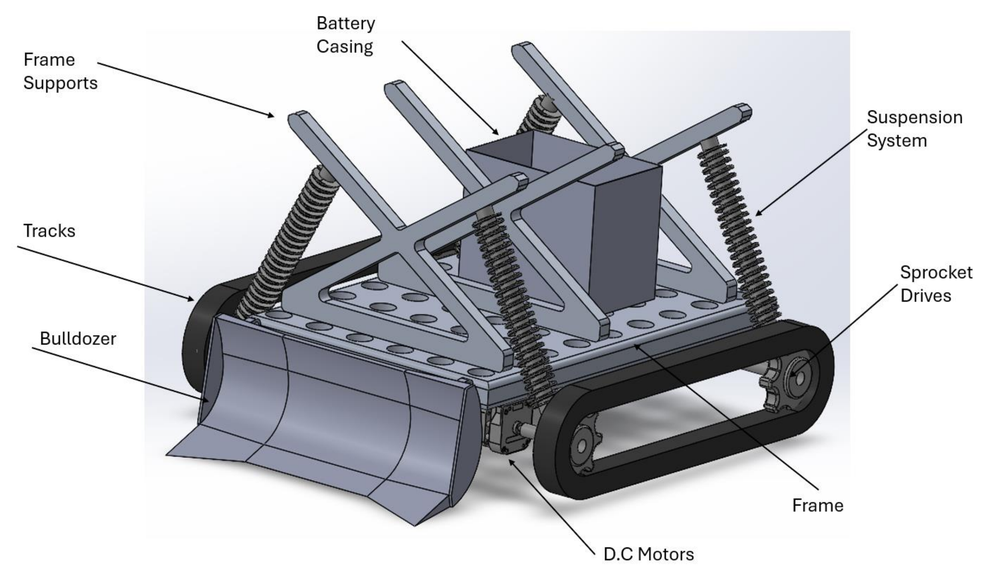

Figure 3. LunaBot Assembly.

Calculations

$$F_{friction} = 0.75 * 9.81 * 80 = 588.60\ N$$

$$T_{DC-Motor} = 588.60 * 0.127 = 74.75\ N - m$$

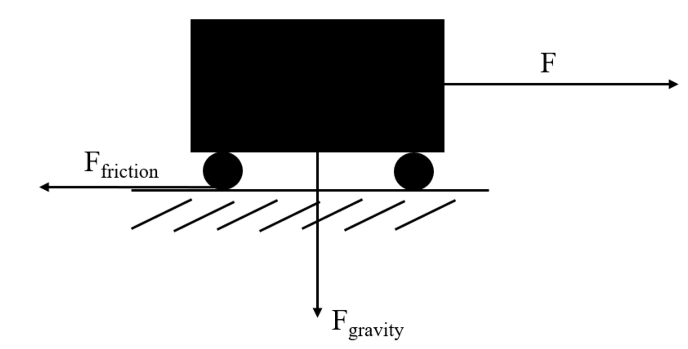

Figure 4. Freebody Diagram utilized to perform a balance of forces.

Force & Stress Analysis is performed on the hinge assembly.

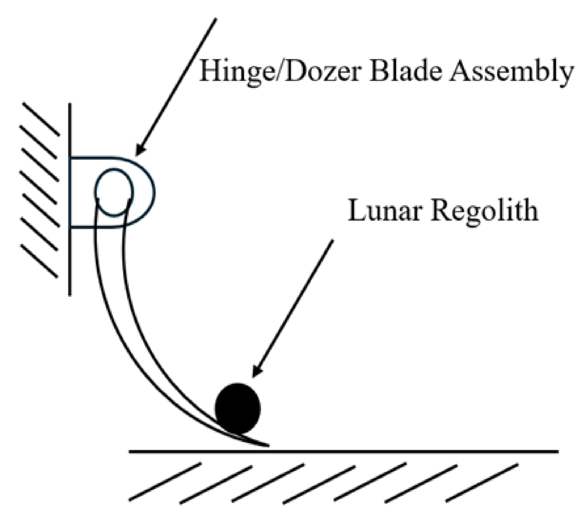

Figure 5. Schematic of Static Scenario After Bulldozing.

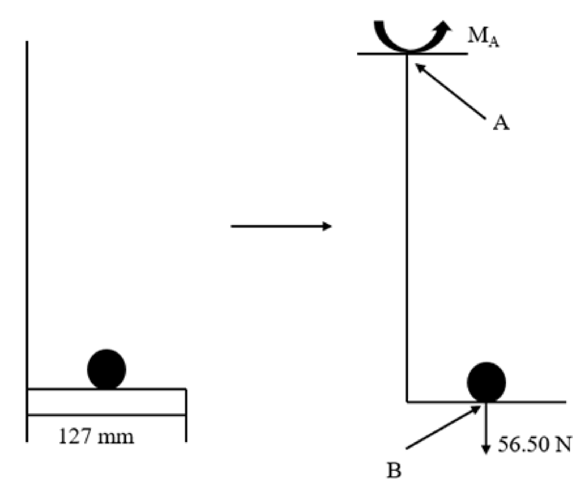

Figure 6. Simplified Scenario of Dozer Blade and Regolith Interaction.

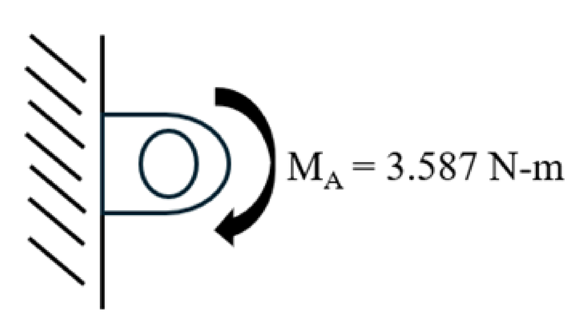

Figure 7. Scenario of Hinge Force Analysis.

Safety Factor Calculation

$$n = \frac{\frac{S_y}{2}}{\tau_{max}} = \frac{\frac{55}{2}}{18.45} = 1.49$$

RESULTS & DISCUSSION

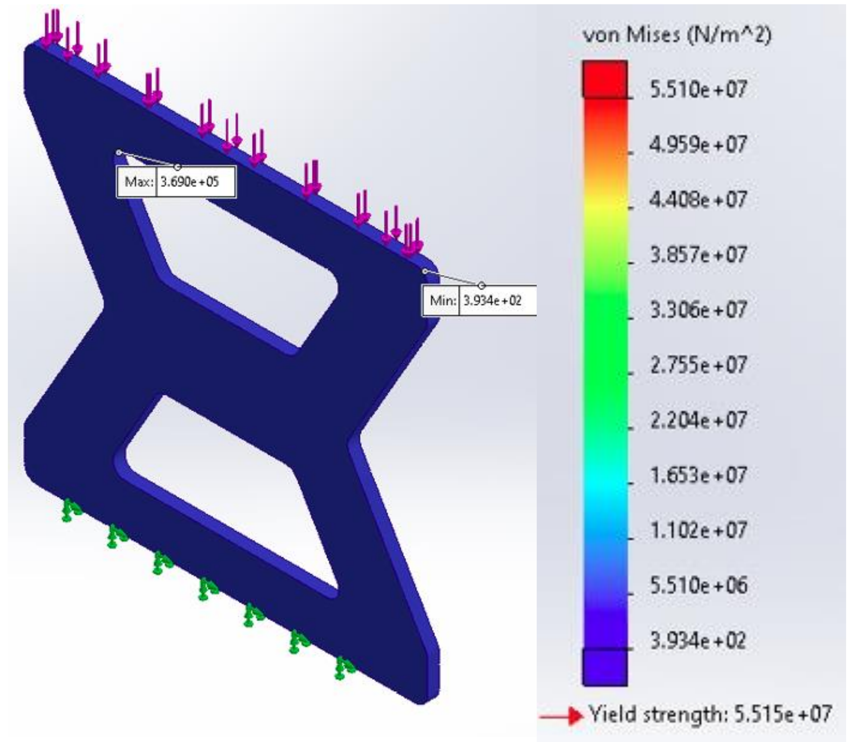

Figure 8. FEA of robot shell support.

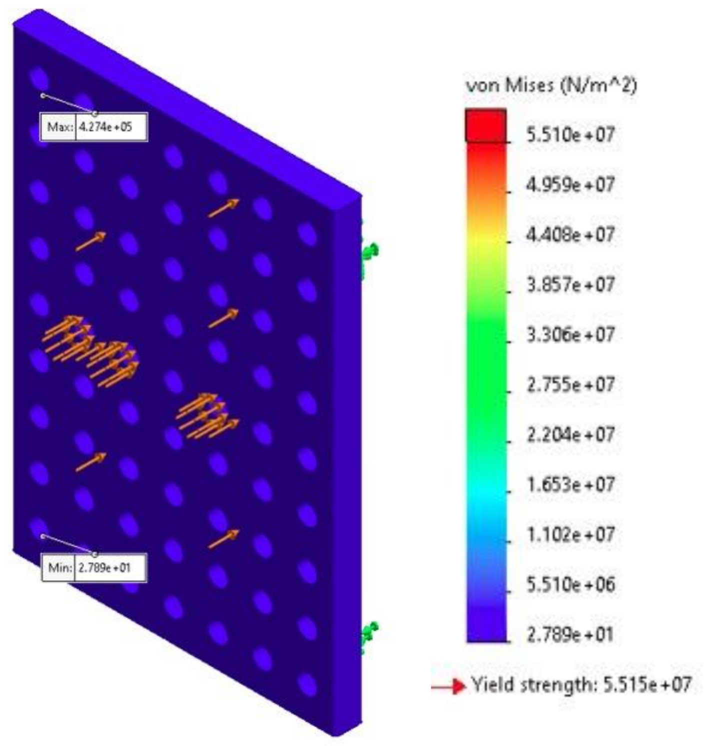

Figure 9. FEA of the Robot Frame.

- **6061 Aluminum Frame and Frame Supports.**
- **60 kg Mass without Electrical Components.**
- **Individual Suspension System.**
- **Caterpillar Tracks.**
- **4 Independent D.C Motors.**
- **Battery is used as a counterweight.**

If you have any questions, you can email Team Nova at:

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FUTURE WORK

- The Lunabot must receive a command to run autonomously through a single board computer equipped a microprocessor called a microcontroller
- DC Motors are comprised of gears in a box creating torque and thus speed, allowing the Lunabot wheels and linear actuator to move.
- A motor driver is important since it powers the motors and actuators for the Lunabot to move.
- Once the actuator is connected to a power source, it will rotate the motor, and the stroke rod will extend the actuator [4]. This will perform the regolith collection for the design challenge.

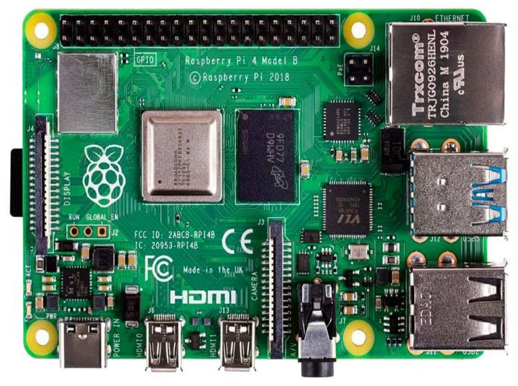

Figure 10. Microcontroller [3]

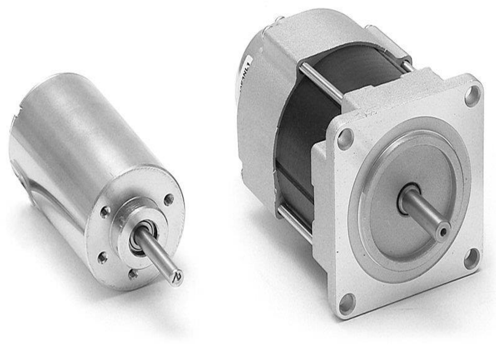

Figure 11. Microcontroller [6]

CONCLUSIONS

The approach was to build a rover similar to a bulldozer. With components such as tank treads and a soft suspension, it is ensured that the rover will be able to transverse the rough terrain encountered in the moon. Coupled with a Dozer Blade, the rover is able to collect regolith with the purpose of building a berm.

Acknowledgements

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References

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