The objective of this project was to make Martian planetary rover more independent of ground control in the event they get stuck in foreign soil, thus significantly increasing the lifetime of these vehicles. This objective was approached through the design and validation of a low-fidelity model of the final wheel design capable of increasing its contact area with the terrain. Overall, the results from this experiment showed that this design would reduce the sinkage and slippage of a vehicle compared to rigid wheels. These finding align with terra mechanics principles, which state that distributing a load over a larger area reduce the pressure the vehicle exerts on the ground, decreasing the amount the granular terrain shifts underneath the wheel, preventing sinkage and slippage of the vehicle. The contrast between the 48% slippage of the flexible wheel and 100% slippage of the rigid wheel suggests that flexible wheels play a critical role in preventing immobilization in loose soil. It should also be noted that the difference between both slippage percents could be due to a difference in voltage between both tests of each wheel design.

No formal statistical testing was conducted due to the small sample size of data and the fact that the rigid wheel consistently failed to move, resulting in identical results across all 3 trials. Both these factors make any statistical testing results unreliable. In the future, these results could be improved by increasing the sample size by running more tests with each wheel prototype. A statistical analysis such as a t-test would be useful in this situation.

The second test provides more information on how to construct the final prototype by helping determine the best material to use for this design. Using Fusion 360, the material of the CAD model of the wheel was changed and simulated with a 200N load. Then every material’s safety factor was checked to ensure that the material won't change its shape permanently under a certain load. Four materials fit this criterion, so then their yield strength and displacement were measured. When looking at these two factors, the best material would have a really high yield strength and a high displacement. However, none of the materials showed this characteristic; most had either had a high yield strength or a high displacement. Since the four materials with an adequate safety factor had similar yield strengths, the material with the highest displacement was chosen for the final design. This was the Iron (Malleable).

Several limitations occurred during this process including the low-fidelity prototype using Earth-based granular material rather than Martian soil simulant or even a finer material such as Fillite. Furthermore, Mar's gravity is 38% of Earth's which could significantly change the way soil behaves underneath rover wheels on that planet. Additionally, the final autonomous version of the prototype has not yet been completed, due to Arduino motor and wiring issues. Despite these issues, the proof-of-concept design proved the mechanical principle behind the design.

This research contributed to the larger field of rover mobility and terra mechanics by taking inspiration from compliant wheels (Ishigami et al., 2011), origami wheels (Hu et al., 2024) and autonomous extrication strategies (Yang et al., 2025). By combining all these different ideas, this design could greatly impact the way we explore other planets, and even inaccessible areas on Earth.