Team Sidekick: Mars Companion Rover

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TSGC Design Challenge

<u>C3-1336:</u> Robotic Mobility for Robust, Repeatable Access to/through Extreme Terrain, Surface Topography & Harsh Environmental Conditions.

Background

Mankind's ability to explore the surfaces of other planets has been severely limited by the dangerously steep terrain of extraterrestrial craters and canyons. This makes these features much harder to investigate, even though they tend to be the most scientifically interesting. Geoscientists like our contact at UT's Jackson Geosciences School, Dr. Timothy Goudge, draw conclusions from rock records preserved on crater surfaces and cliff faces, exploring the possibility that Ancient Mars harbored conditions capable of sustaining extraterrestrial life [1]. Unfortunately, the variety of information available for examination is limited by current data collection solutions and the mobility of current ground vehicles.

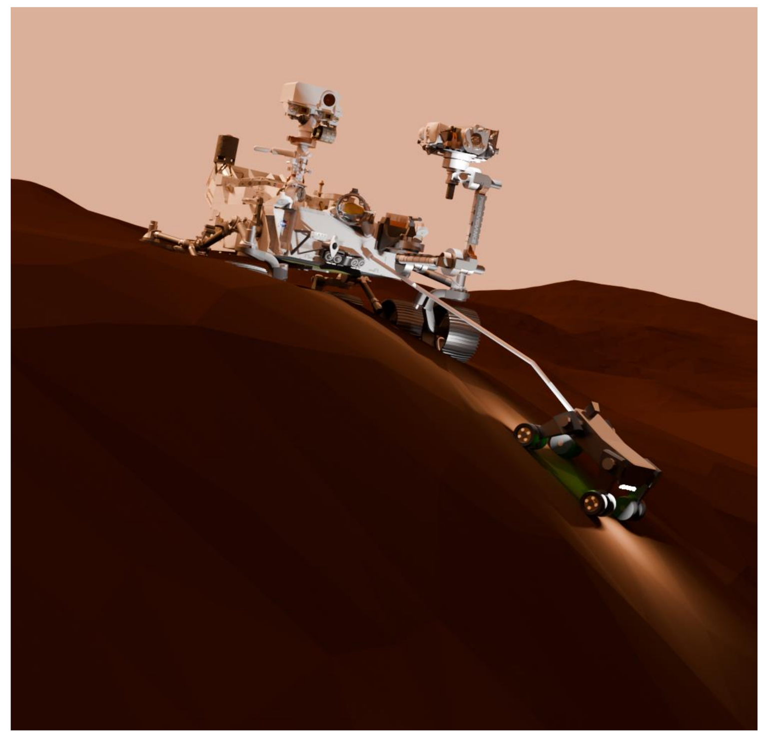
Project Concept

Recent Mars missions have introduced the idea of a companion vehicle, like Perserverance's mini-copter "Ingenuity". Project Sidekick aims to further develop the idea of a companion vehicle by adding a smaller rover, or "Sidekick", to a larger main rover that can be sent to explore treacherous terrains. Sidekick is intended to be lowered down into steep craters on the surface of Mars by a winch and cable attached to the larger rover, sending images and data back up to the surface.

Design Goals

Present day, NASA rovers **do not have the ability to scale cliffs and craters on extraterrestrial surfaces** which would allow for further investigation of deeper sedimentary layers on Mars. To fill this role, we hope to design Sidekick to:

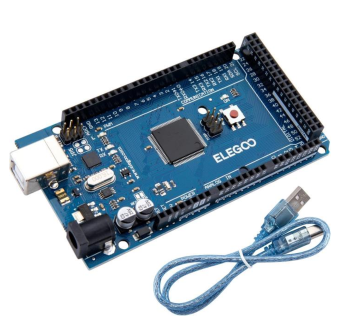
- Be durable and compact
- Have advanced mobility for vertical/steep terrain
- Be lightweight and inexpensive
- Include a robust tethering and repelling system
- Have an adaptable suspension system



Important Components

High Torque Planetary Gear Motor 188:1

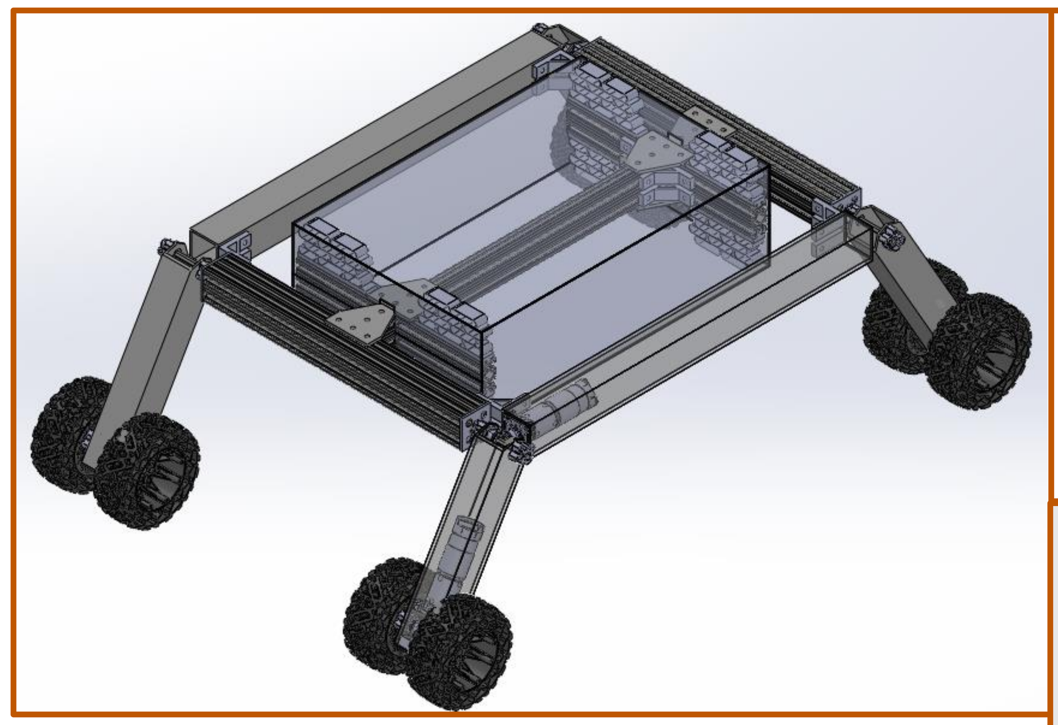
6 DOF Gyroscope (LSM6DSO)

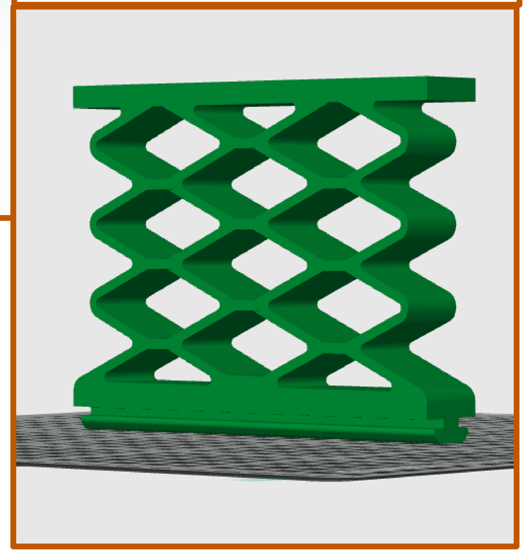


MEGA Arduino IDE Board

Ultrasonic Range Sensor (HC-SR04)

Design Components





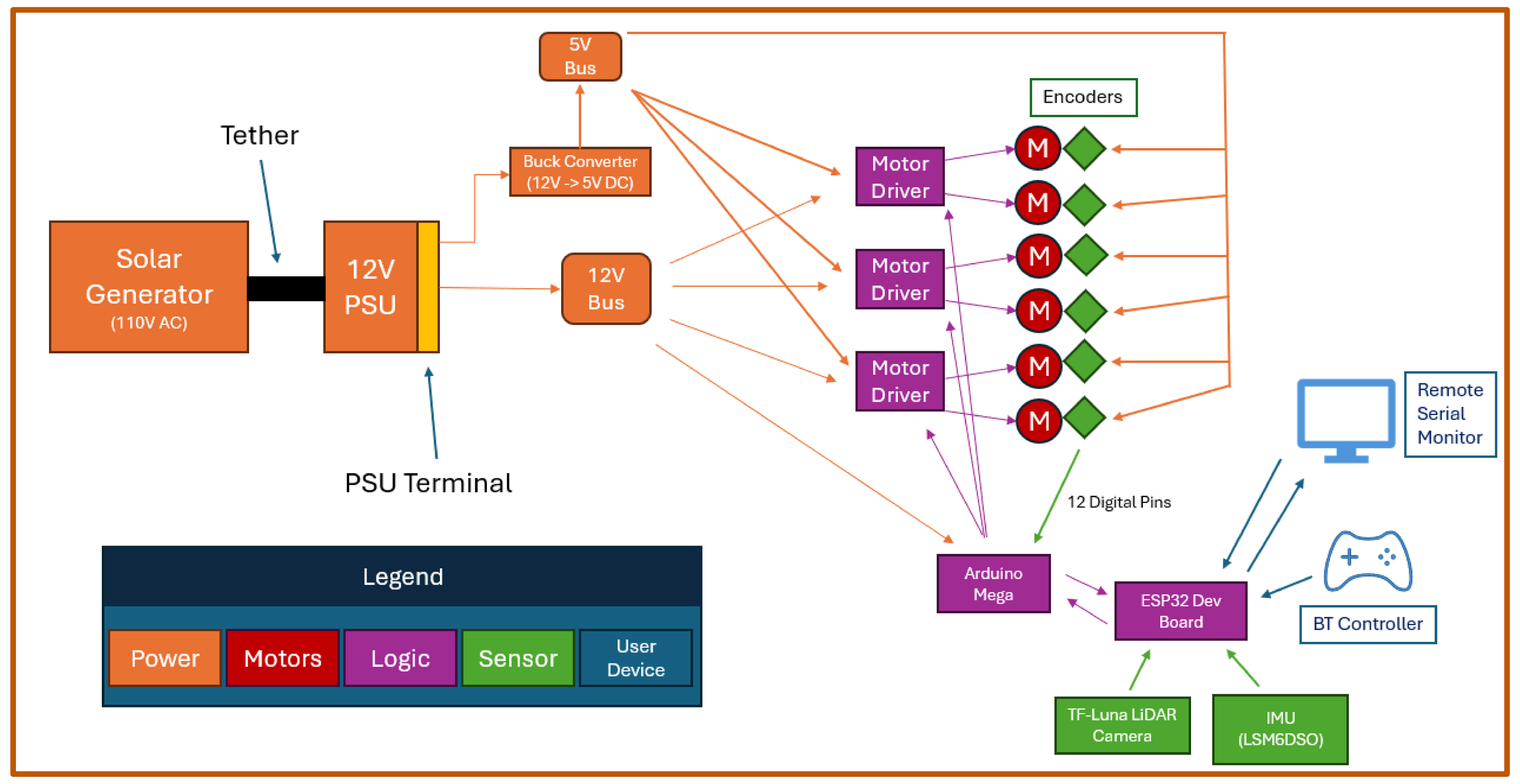
Payload – A wooden housing for all the onboard electronics and sensors. The payload is mounted on the frame using custom printed TPU suspension springs, which protect the contents from vibrational shock.

Frame – Made of aluminum extrusions and T-slots. The frame supports the motorized arms and shields the payload.

Motorized Arms – Two sets of rotating arms, one for the front wheels and one for the back wheels. They can be actuated independently, allowing the rover to conform to the tilt of the crater face.

Drive Wheels – Four motor driven wheels. Each wheel has a TPU printed tire wrapped around a PETG printed hub.

Electrical System Flowchart



To Navigate steep terrain, Sidekick must (a) manage ground clearance, (b) move with precision, and (c) self-stabilize to protect sensitive instruments onboard. These needs justify a closed-loop control system. Since the user should only be expected to provide high-level inputs (via serial input or remote control), Sidekick uses flashed firmware with layers dedicated to environmental interpretation, response variable calculation, and hardware power delivery. The master microcontroller (Arduino) executes these functions by sending 5V signals to motor boards which can divert the 12V power required by the high torque motors. Sidekick's hardware and software architectures allow for reliable performance with minimal user input.

Future Work

Sidekick still requires further development, iterations, and testing to accomplish our design challenge and its associated design goals. The plastic arm supports would be machined out of 6061 aluminum to better support the wheel arms and to minimize the risk of fracture and vibration. Additionally, a redesign for the placement of the arm actuation motor would help distribute the arm weight, decreasing the amount of torque necessary to rotate the arms. Once these modifications have been made, further field tests will need to be performed to fully demonstrate Sidekick's ability to maneuver over unpredictable and inclined terrains. This includes developing a tether rig to attach to Sidekick, simulating its descent down steep inclines while also exchanging power and data with the vehicle at a distance. Finally, with the full electronics system vetted, there is an opportunity to condense the entire system into a much more compact and reliable circuit board. This electronics redesign would be accompanied by an over hall of the payload assembly.

Conclusion

In its current state, our prototype demonstrates a variety of design considerations that could improve the abilities of a robotic companion. With further iteration, the Sidekick concept could one day be utilized in a real robotic space mission. Sidekick could be sent to retrieve data down steep rock faces and crater walls without endangering the main rover, resulting in an exploratory mission that's both safe and lucrative.

Acknowledgments

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References

[1] "Assessing the Mineralogy of the Watershed and Fan Deposits of the Jezero Crater Paleolake System, Mars," Journal of Geophysical Research: Planets, vol. 120, no. 4, pp. 775-808, https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2014JE004782 (accessed Feb. 17, 2025).