QUEST in Nominally Observed Spaces

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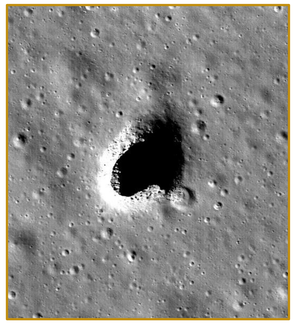
Problem Statement

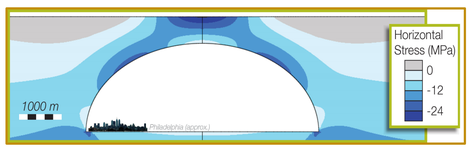
Design an Autonomous Lunar Vehicle that is capable of traversing through unexplored lunar lava tubes with the purpose of determining the environment's ability to sustain life.

Background

- Lava tubes are postulated to exist beneath the surface of the moon.
- Very little is known about these lava tubes, or whether they would be able to sustain life at all.
- Could Provide Shielding From:
  - Hazardous Elements on the Surface
  - Extreme Temperature Fluctuation
  - Lethal Radiation
  - Electrostatically-Charged Dust
  - Asteroid Impacts



Skylight in the Marius Hills



Lava Tube is potentially kilometers in scale.

Lava Tube in Lava Beds National Monument, California

Benchmarks

Sojourner - JPL

CaveR – NASA BRAILLE

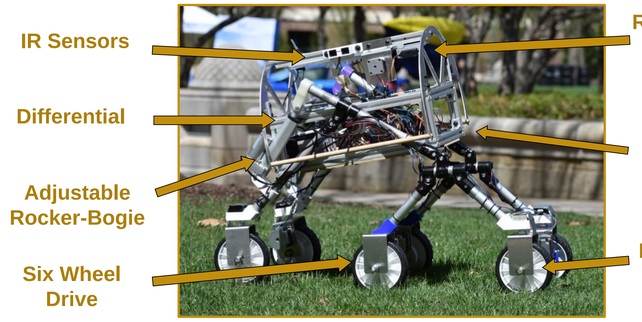
Curiosity – JPL

Axel-Rover – JPL

Scarab – Carnegie Mellon Robotics

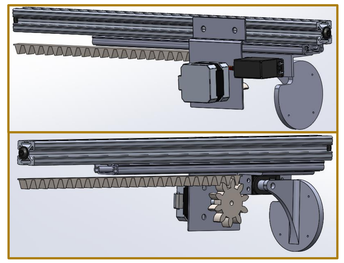
Customer Needs	CaveR	SOJOURNER	CURIOSITY	Axle-Rover	Scarab	ALV 2.0
Survive Lunar Environment						
Ease of Transport to Moon						
Traverse Lunar Terrain						
Navigate Autonomously						
Map Lava Tubes						
Fulfill Mission Duration						
Record Critical Data						
Totals	66.6	37.6	44.6	52.6	43.2	68.0

Prototype

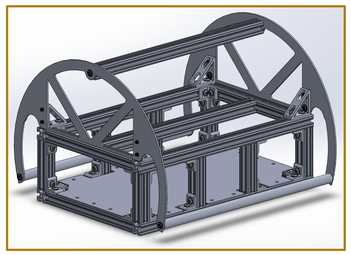


Design Specifications/ Features

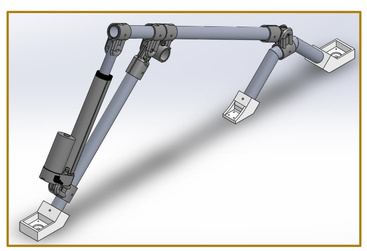
Retractable Lidar: Mapping and Navigation



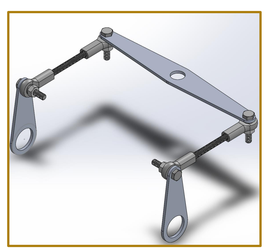
Roll Cage



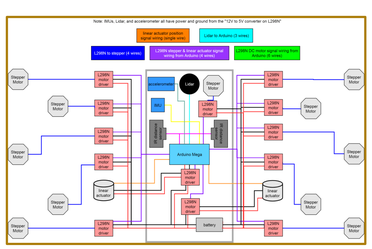
Adjustable Suspension



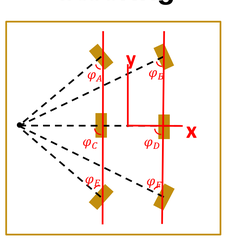
Differential



Wiring Diagram



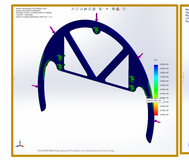
Modified Ackermann Steering



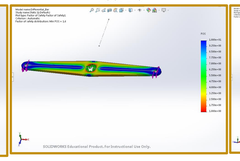
Testing/ Validation

FEA Analysis

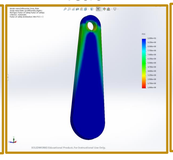
Roll bar
FOS: 2.1



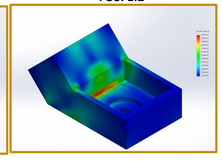
Differential Bar
FOS: 1.6



Differential Drive Plate
FOS: 3

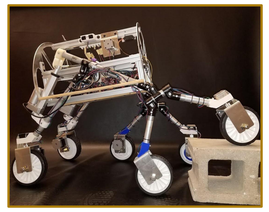


Stepper Motor Housing
FOS: 1.2



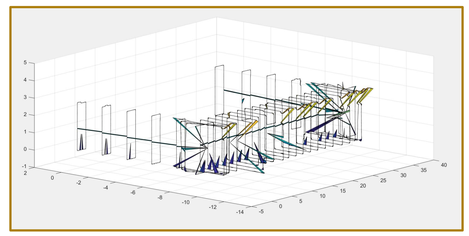
Obstacle Maneuverability/Stability

Mission Need	Technical Needs	Design Target	Test Result
Survive lunar environment	Clearance height (Ground)	0.3 m	0.4 m
Traverse lunar terrain	Passable obstacle dimensions	0.2 m	0.25 m
	Vehicle speed	0.2 m/s	0.05 m/s
	Suspension tuning (compression)	0.15 m	0.15 m
Map lava tubes	LiDAR data collection	8 kHz	4 kHz
Understand relative position	Monitor distance travel	+/- 0.5 m	+/- 0.25 m
	Monitor angular orientation	+/- 0.5°	+/- 0.1°
Navigate autonomously	Distance from walls	> 1 m	> 1 m
	Minimum tunnel height	> 1 m	> 1 m
	Collect mapping data		
Stability	Minimize Twisting	1°	< 10°

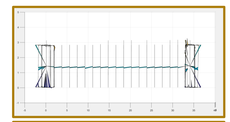


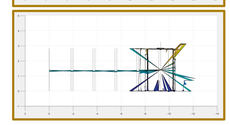
Rocker-Bogie design allows rover to traverse obstacles double the size of the wheel diameter.

Mapping/Navigation



First Floor Gatewood Wing Hallway





Future Work

- Budget restraints caused compromises in components
- Improved Motors
  - Stepper Motors with Encoders
  - Higher Holding Torque
- More powerful microcontroller or computer
- Lighter Battery (Lithium Ion vs. Lead Acid)
- Environmental Protection: dust cover/cleaning/ enclosure
- Wireless communication
- Improvement in Rolling Over
- Software Integration and Autonomy

Acknowledgements

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