MARSRAM

Team 22: NASA Robotic Mining Competition

Team Members

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Advisor

Dr. Jonathan Clark

Sponsor

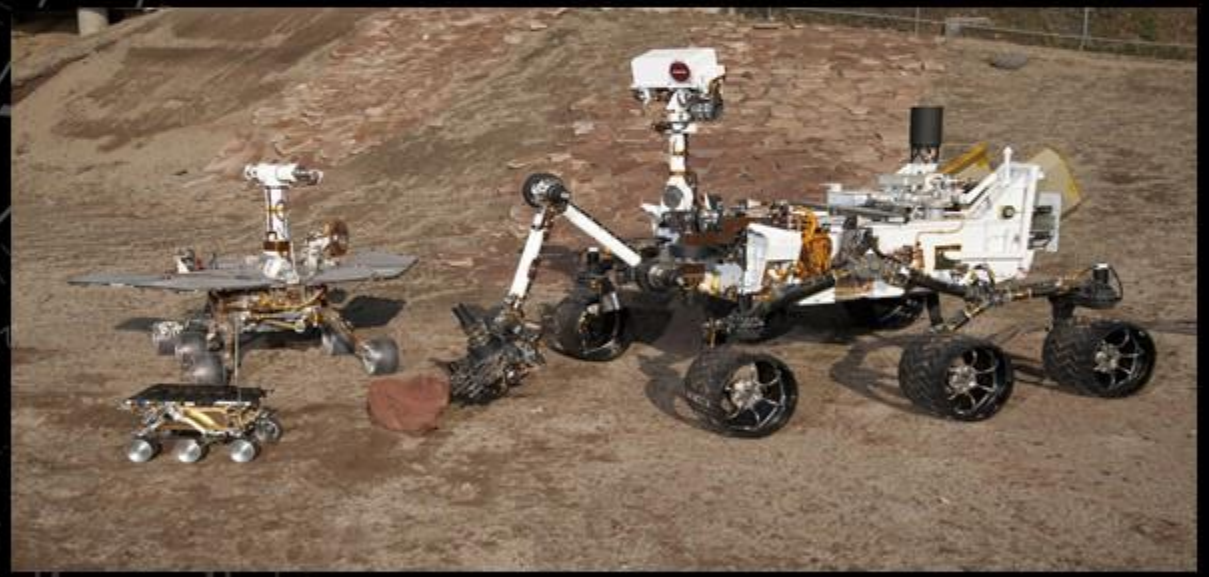
Florida Space Grant Consortium

PROJECT SCOPE

1. On-Site Mining
   - Design/Build a mining robot
2. Systems Engineering Paper
   - Discuss the design philosophy
3. STEM Outreach Report
   - Detail the K-12 outreach events
4. Slide Presentation & Demonstration
5. Social Media and Public Engagement

ON-SITE MINING

"Design and build a mining robot that can traverse the chaotic Martian terrain and excavate the basaltic regolith simulant and ice simulant and return them for deposit into a collector bin."



WHY MARS?

Why should we go to Mars?

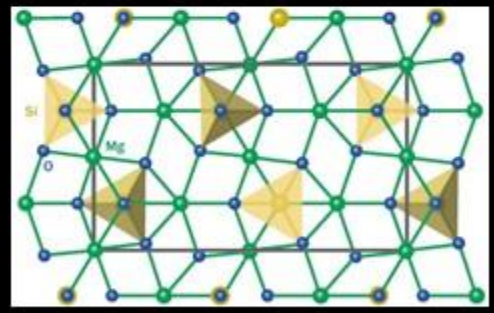
Past, Present, Future

1. Mars' formation and evolution
   - Climate
   - Surface Features
   - Chemistry
2. Are we alone?
   - Previous mission data suggests Mars was habitable

Why should we mine regolith?

Olivine $(Mg_2Fe_2)SiO_4$

1. Build Structures
   - Bunks, Greenhouses, Research Labs
2. Rocket Fuel for missions FROM Mars
   - Methane



Perchlorates (ClO_4^-)

1. In-Situ Resources to support human life
   - Oxygen
2. Rocket Fuel for missions FROM Mars
   - Oxygen, Chlorine

HOUSE OF QUALITY

Engineering Characteristics:

1. Speed
2. Size
3. Controls
4. Cost
5. Weight
6. Ease of Manufacturing
7. Material Properties

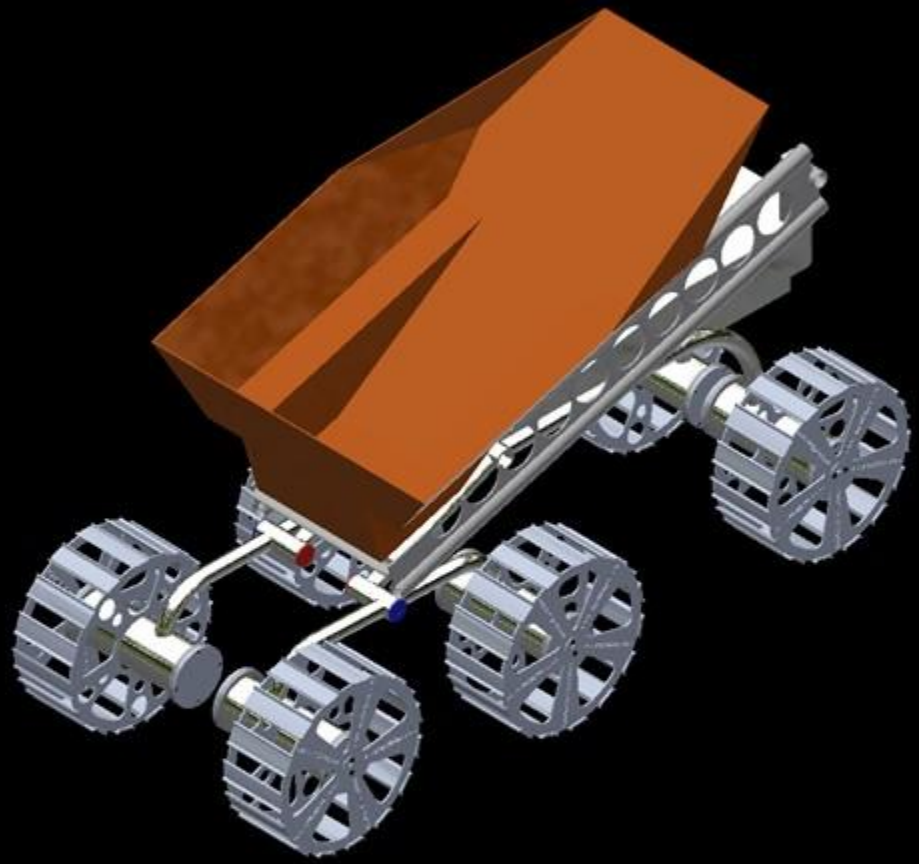
Correlations:
- ⊕ Strong Positive
- \+ Positive
- ⊖ Strong Negative
- \- Negative

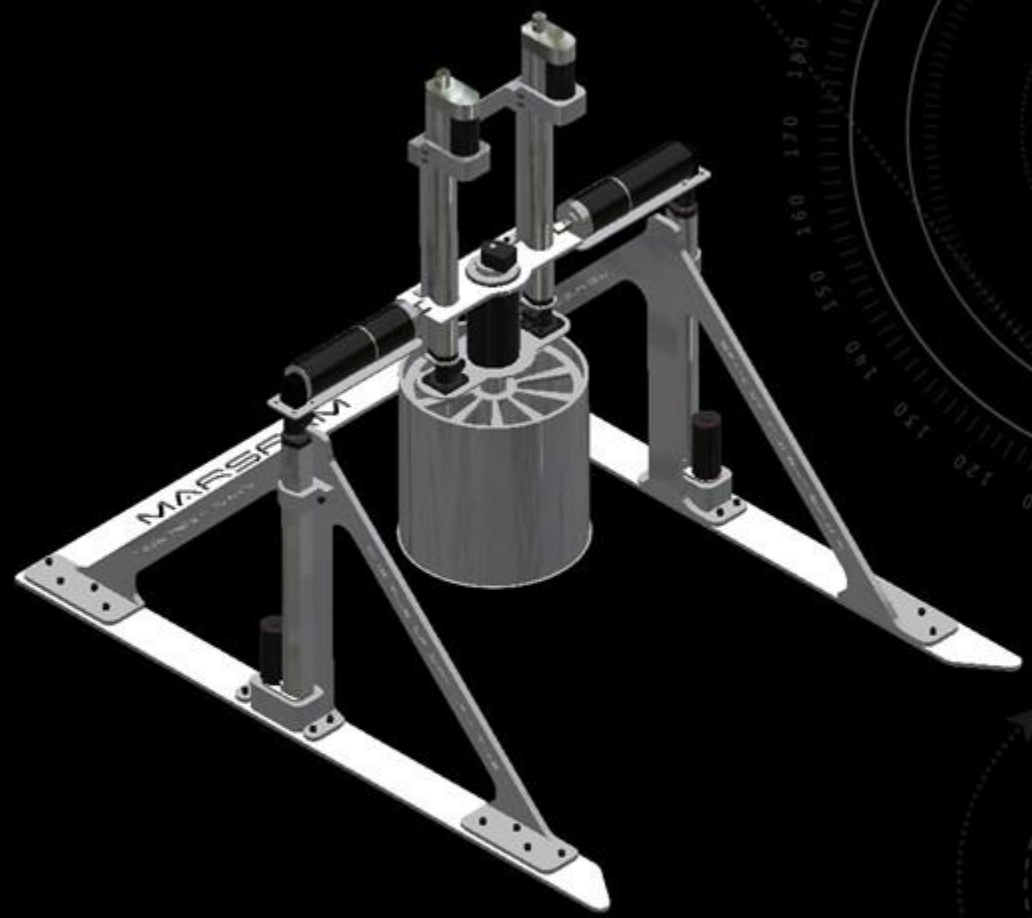
Relationships:
- •• Strongest= 10
- • Strong= 7
- ⊙ Fair= 4
- ○ Weak= 1

Customer Requirements	Customer Importance (0-5)	Weight ↓	Size ↑	Ease of Manufacturing ↑	Speed ↑	Material Properties ↑	Cost ↓	Controls ↑
Amount of Mined Regolith Simulant(BP -1)	4		••		•			⊙
Amount of Mined Ice Simulant (Gravel)	5		•		•			⊙
Maneuverability	2	•	⊙		•		○	•
Reliability	3			••		••	⊙	
Energy Consumption	2	••	○		••		••	••
Data Transfer	1				○			○
Dust Prevention	2		⊙		⊙	•	○	
Autonomy	2						•	•
Importance Rating →		34	99	30	106	24	50	85
Σ(Priority X Relationship)		8	23	7	25	6	11	20
% Relative Importance →								
Rank of E. C. →		5	2	6	1	7	4	3

Direction of Improvement

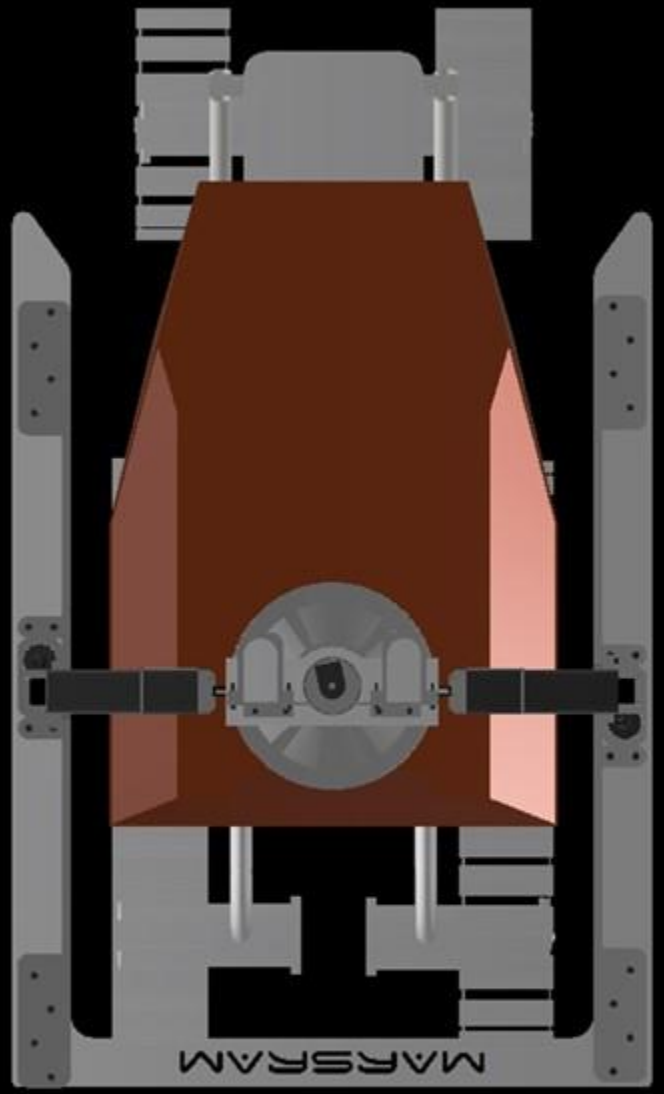
CHASSIS & MINING SYSTEMS

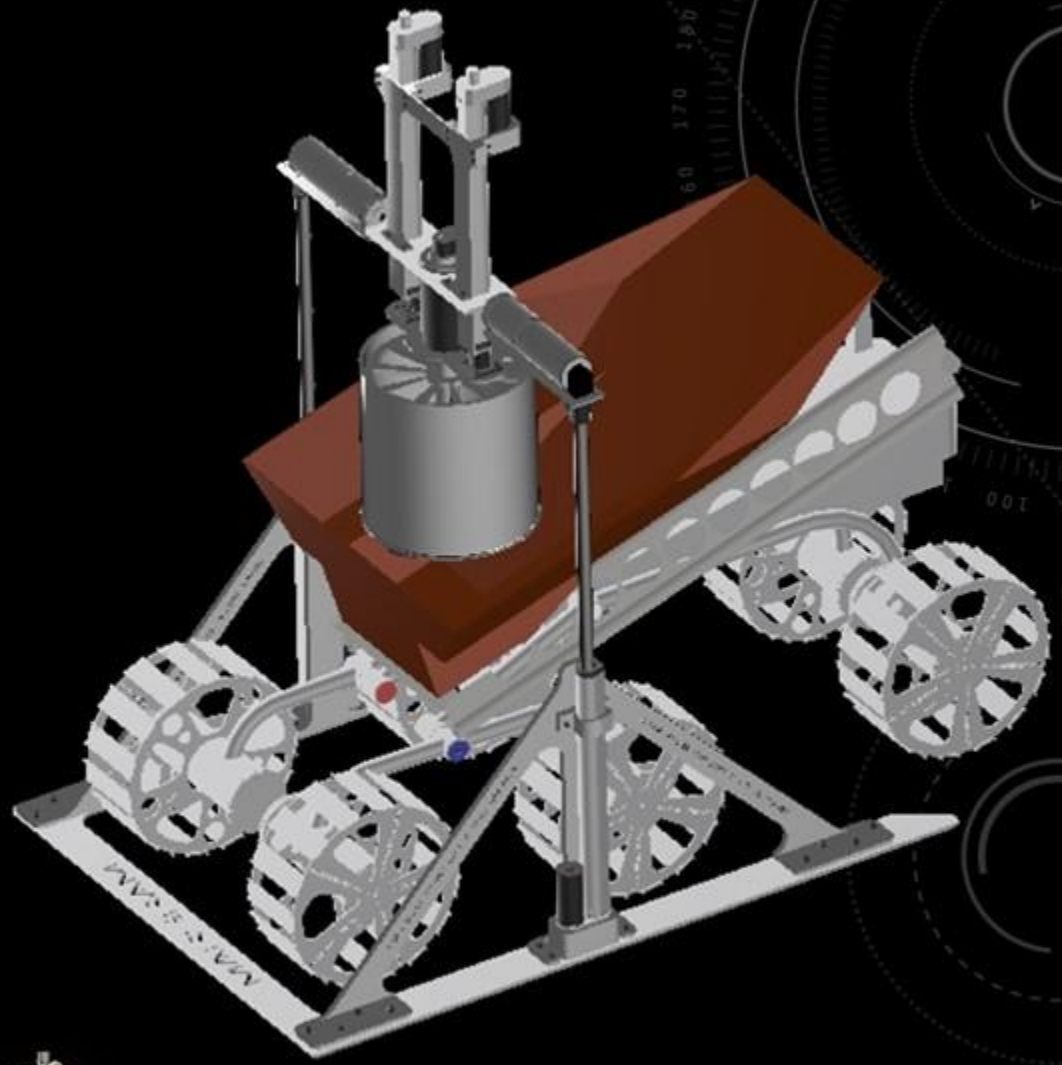




- Two Independent Designs
- Engineering Characteristics

CHASSIS & MINING SYSTEMS

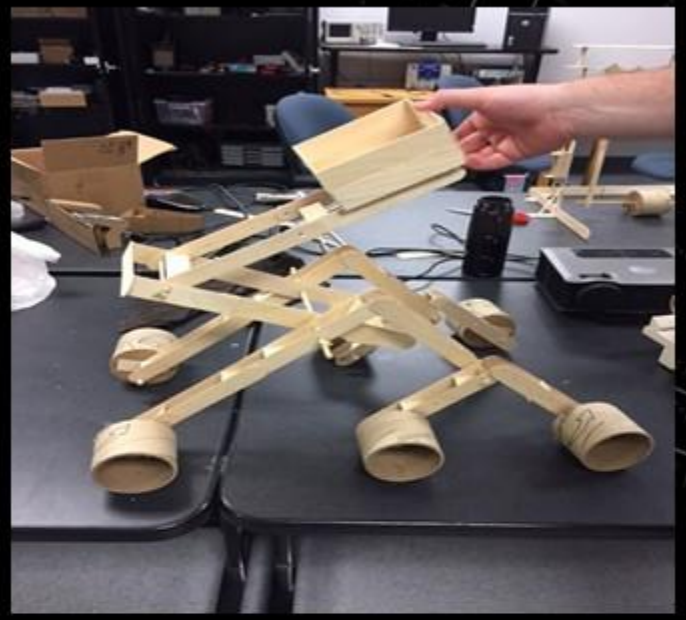




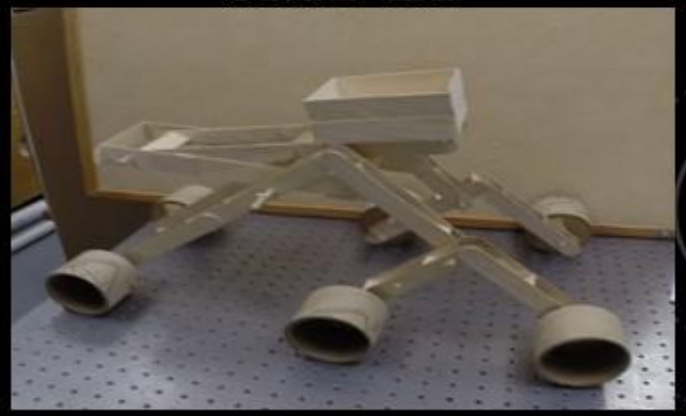
CHASSIS SCRAPS

SCRAP 1.0

Scaled
Configuration
Regolith
Acquisition
Prototype

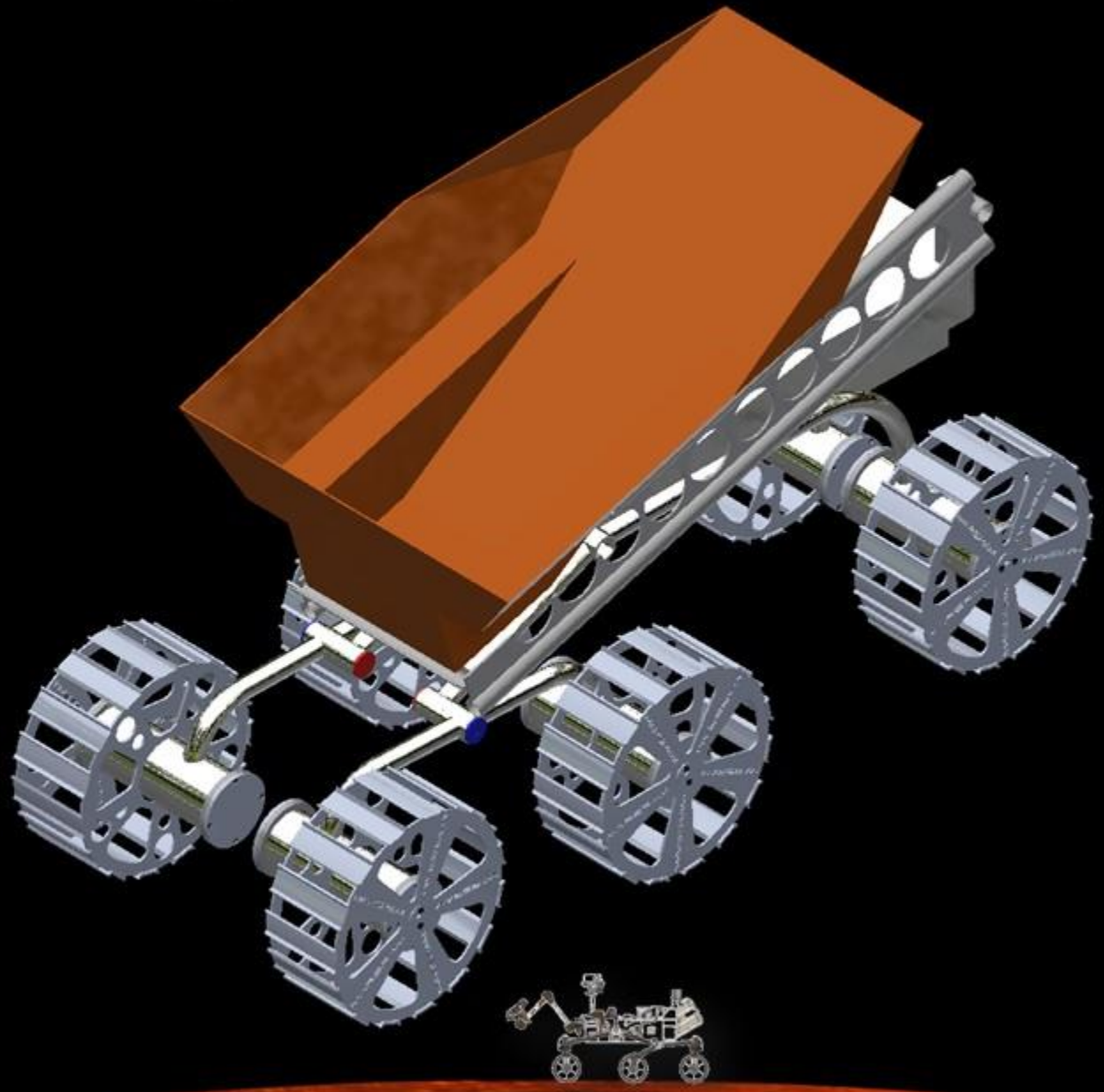


SCRAP 1.1

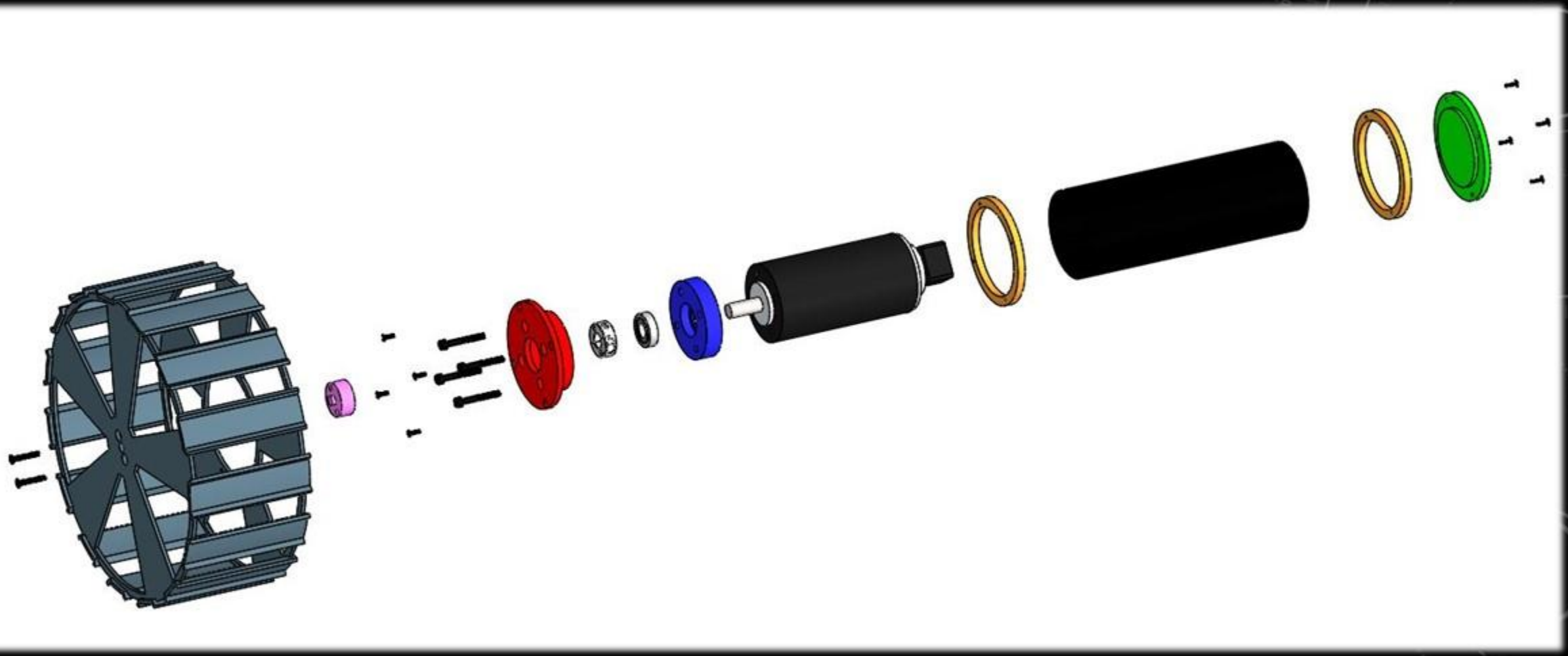


ROCKER-BOGIE CHASSIS

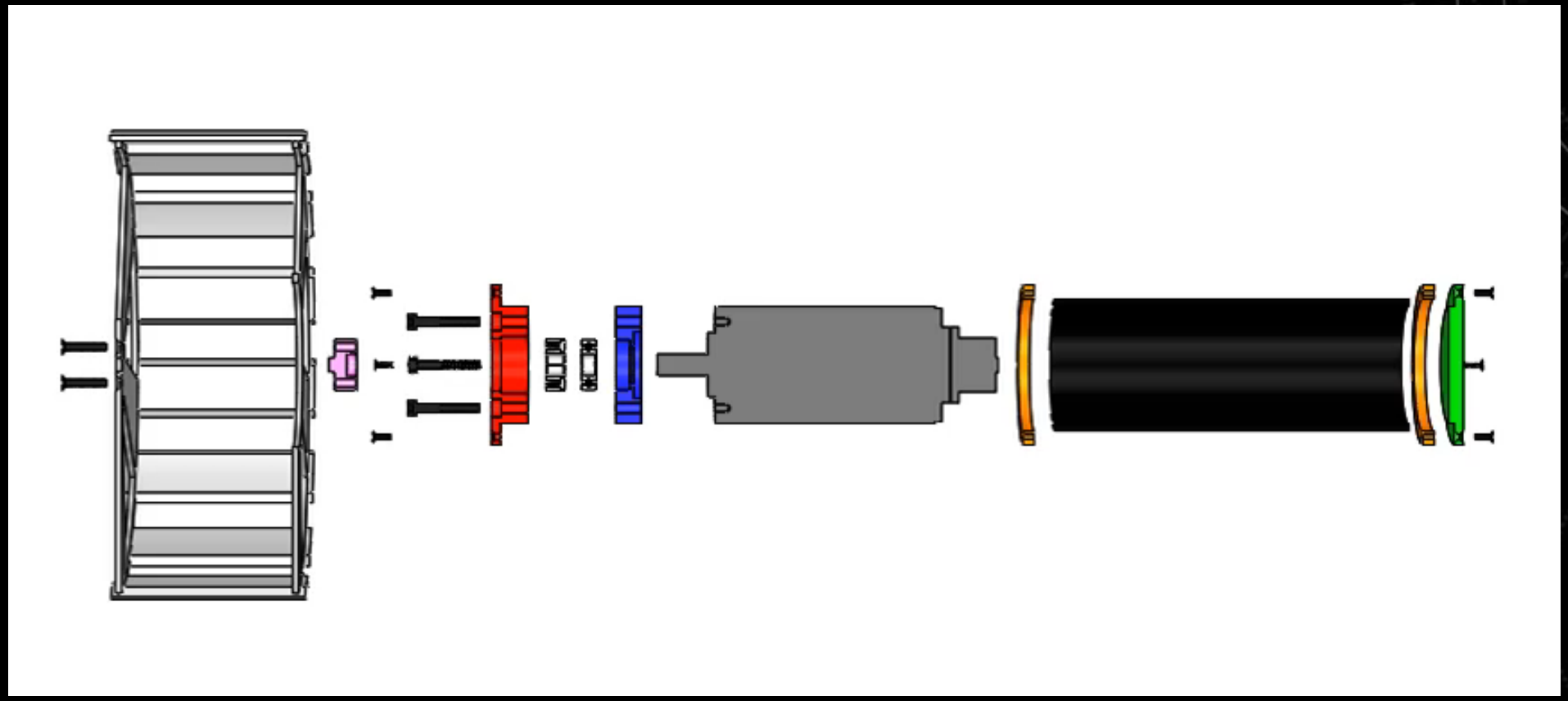
Height: 26 in
Width: 20 in
Weight: 82 lb



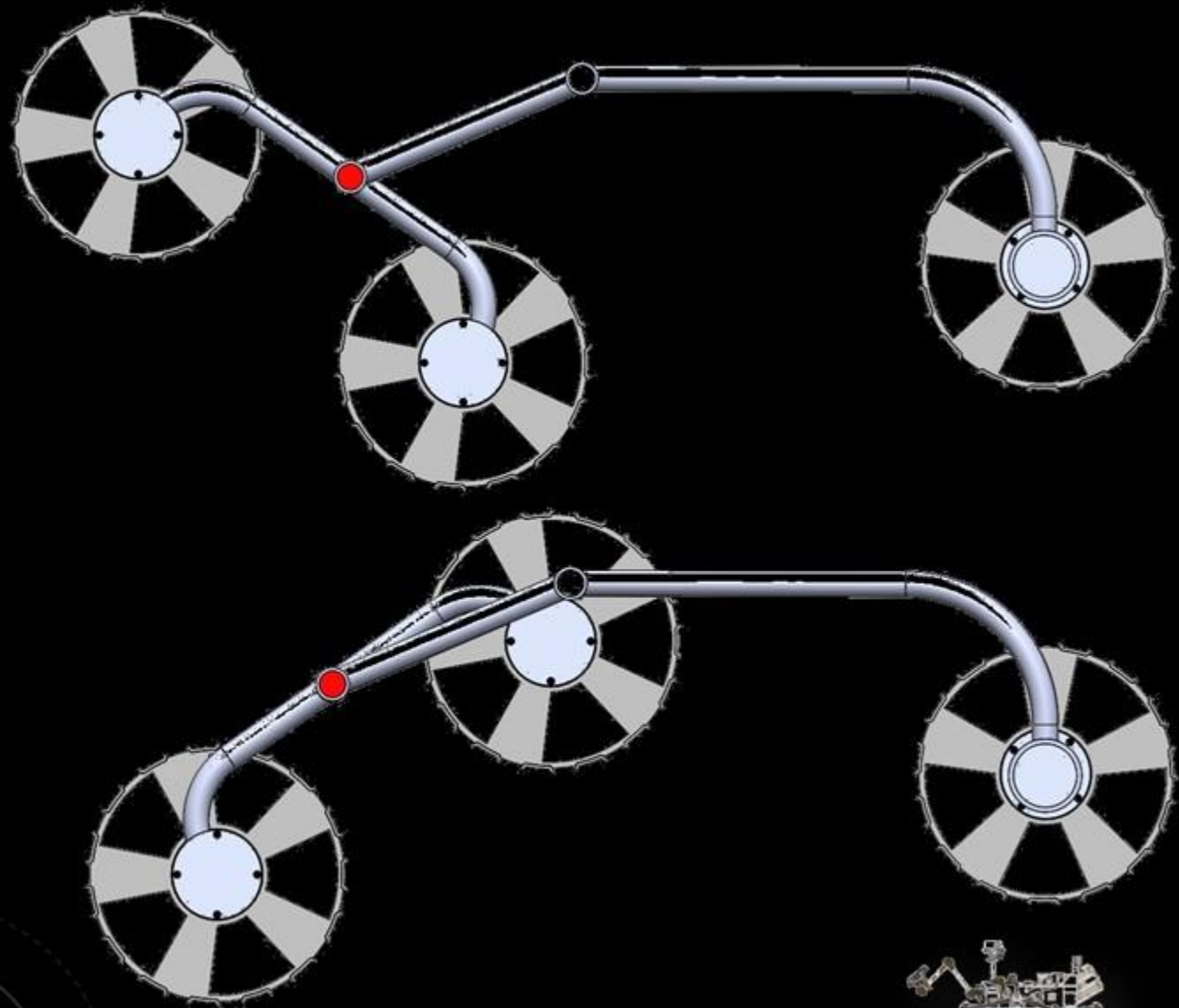
WHEEL MOTOR HOUSING



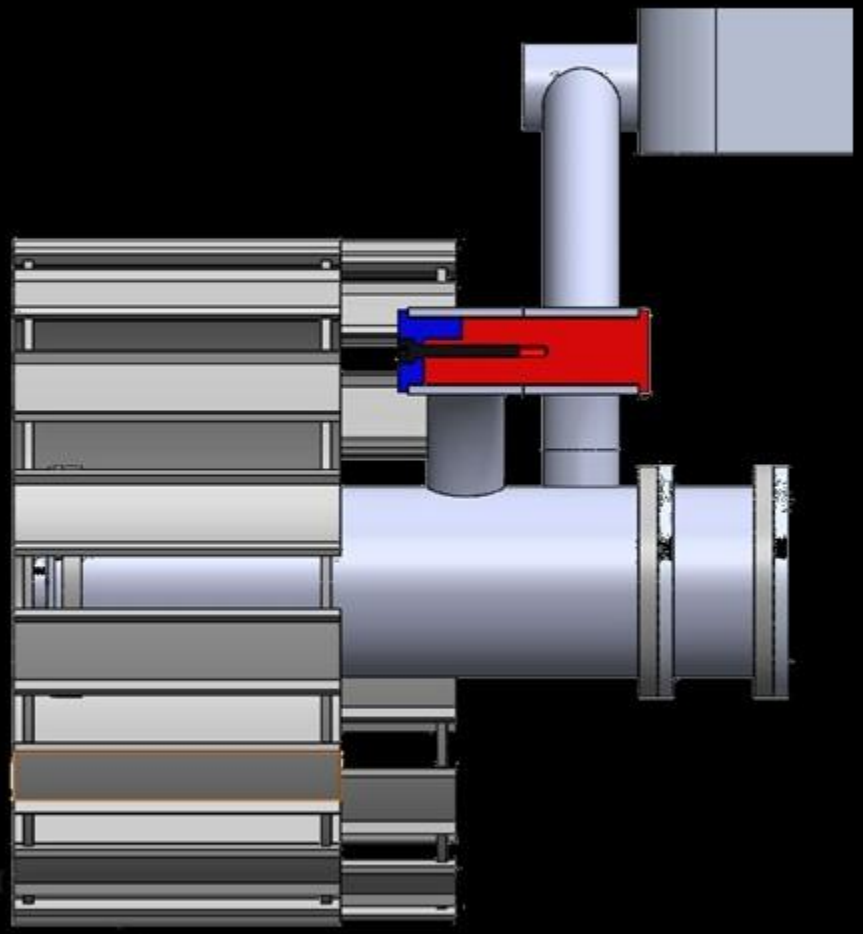
WHEEL MOTOR HOUSING

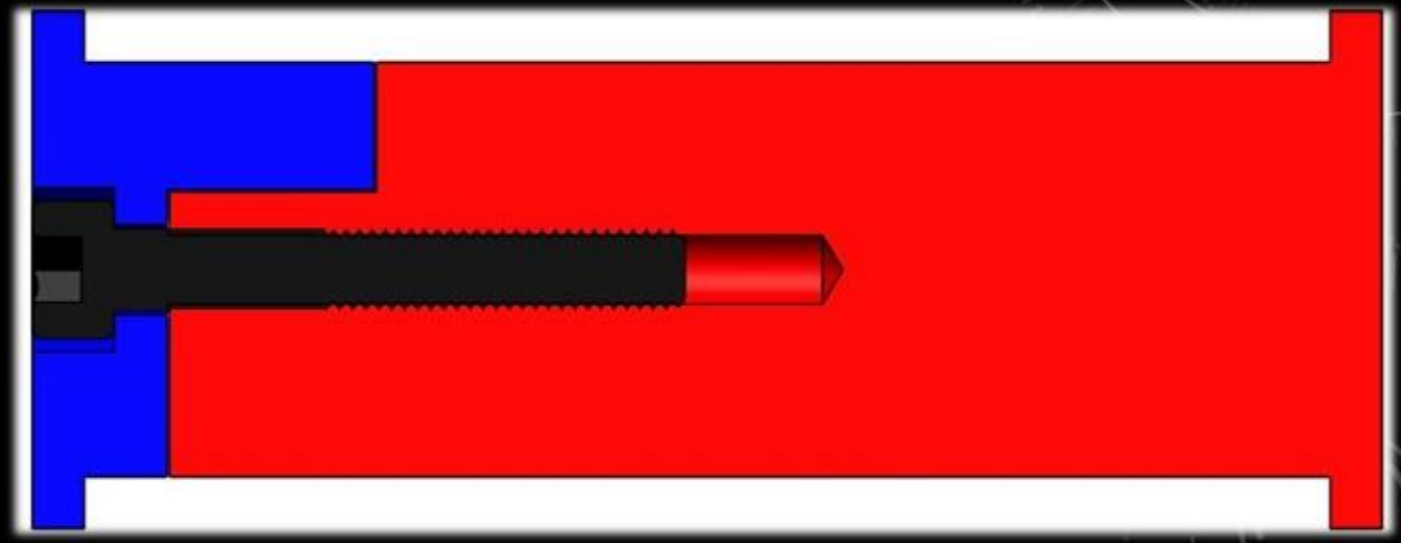


BOGIE ROTATION LIMIT



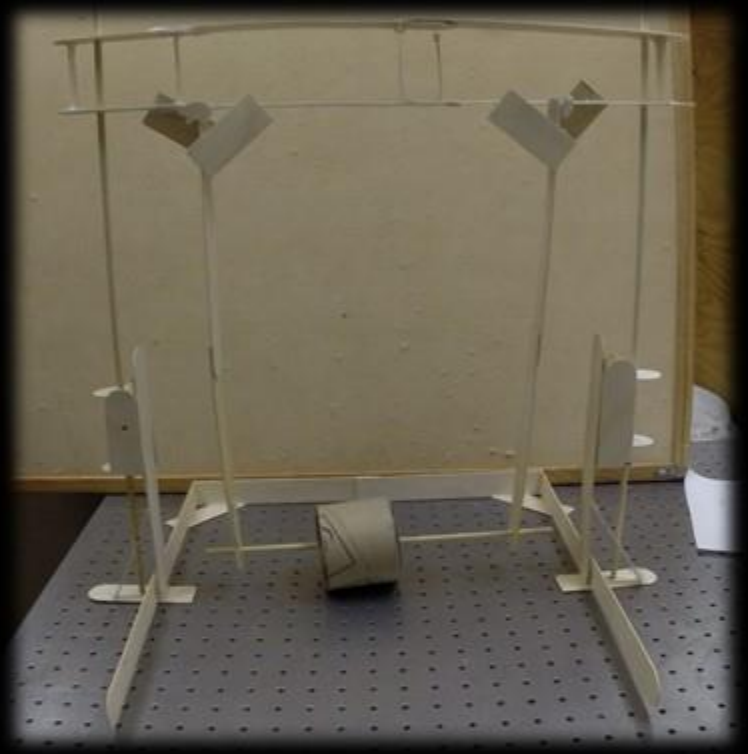
BOGIE ROTATION LIMIT





MINING SCRAP ITERATIONS

"Scaled-Configuration Regolith Acquisition Prototype"



SCRAP 2.0

SCRAP 2.1

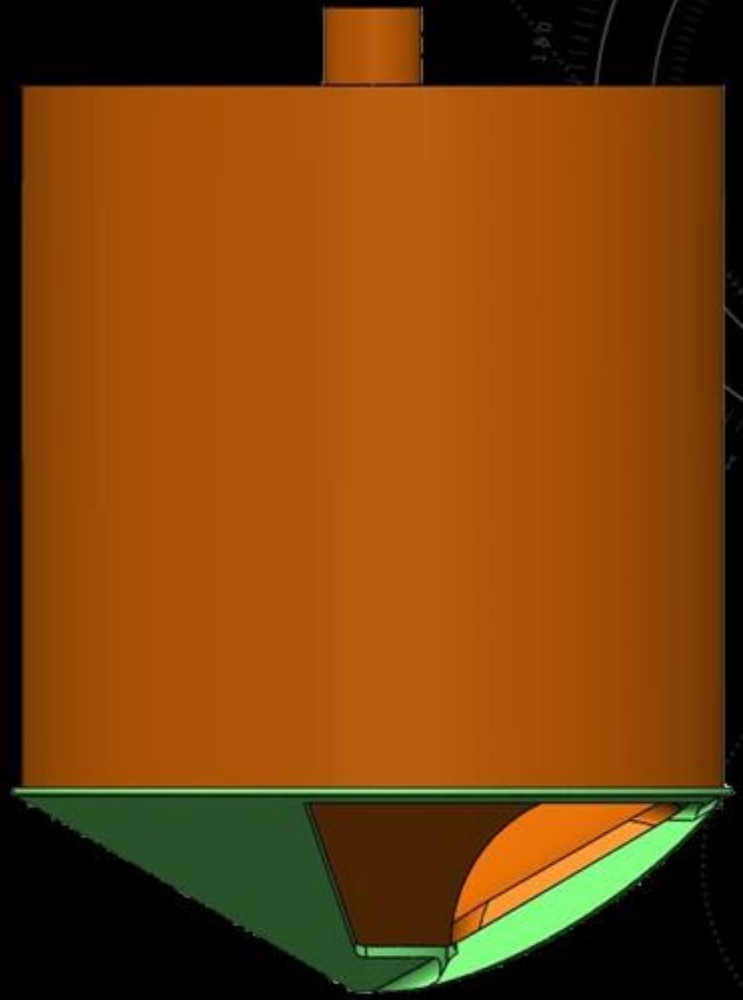
MINING SCRAP ITERATIONS

"Scaled-Configuration Regolith Acquisition Prototype"

Evolution of the Mining Drill

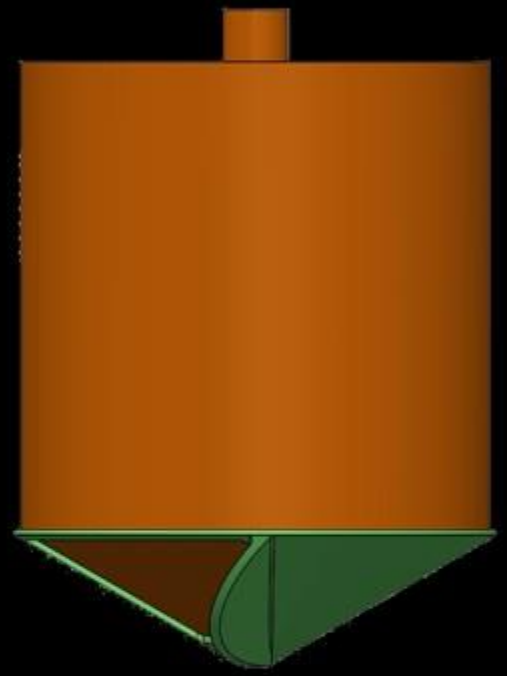
MINING DRILL

Rock Drilling Bucket

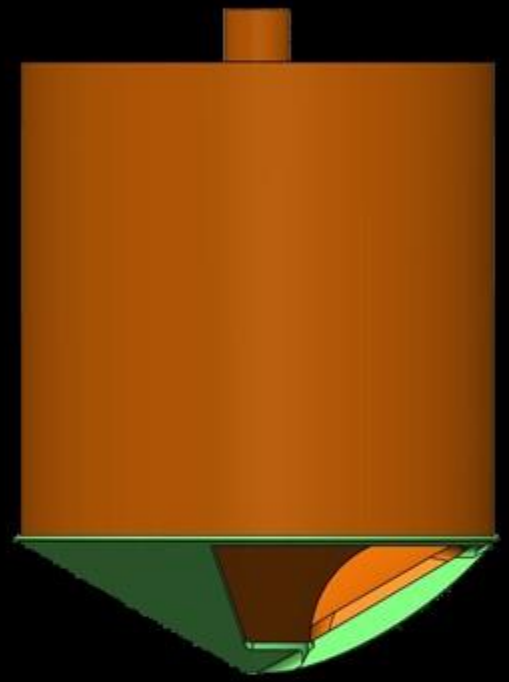


MINING DRILL

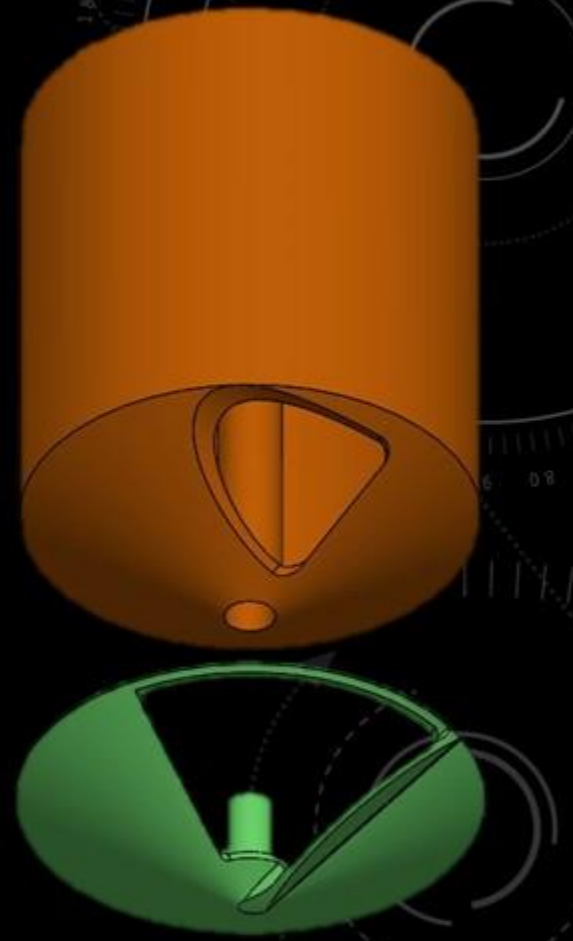
Outer Diameter: 8 in
Height: 12 in
Volume: 529 in^3
Filled Mass: 26 lb



CLOSED



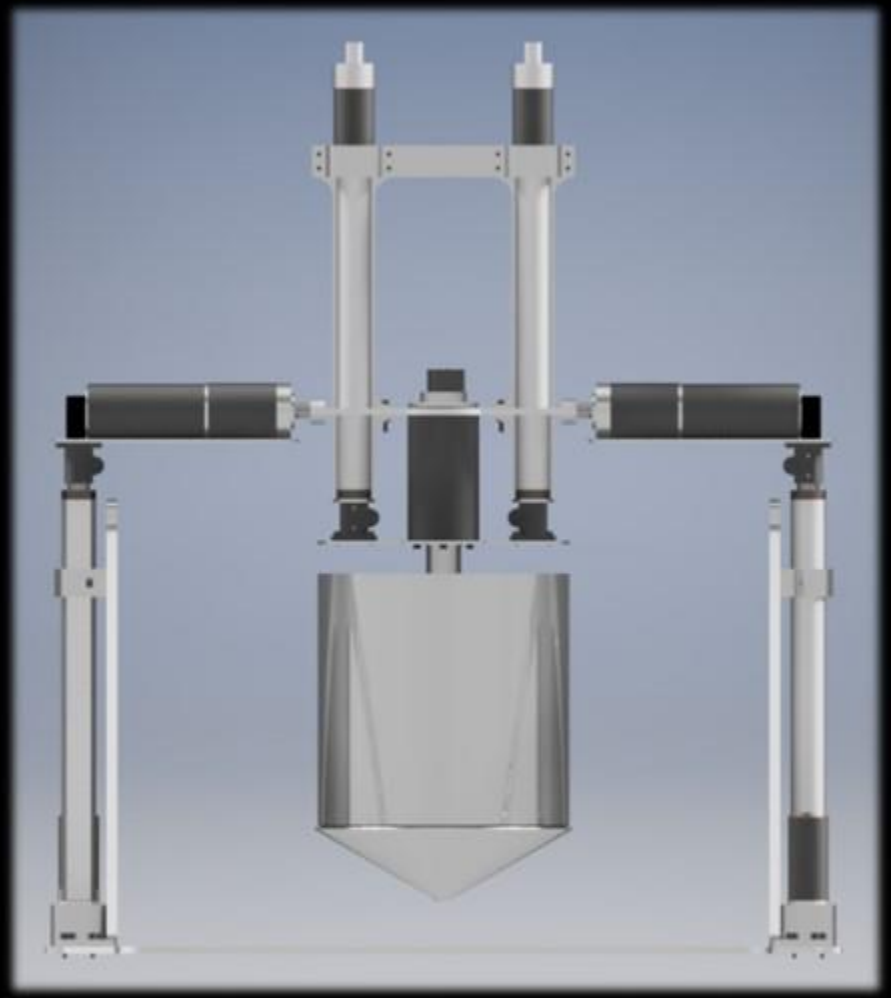
OPENED



MINING APPARATUS

Height: 28 in
Width: 28 in
Weight: 58 lb

MINING DESIGN

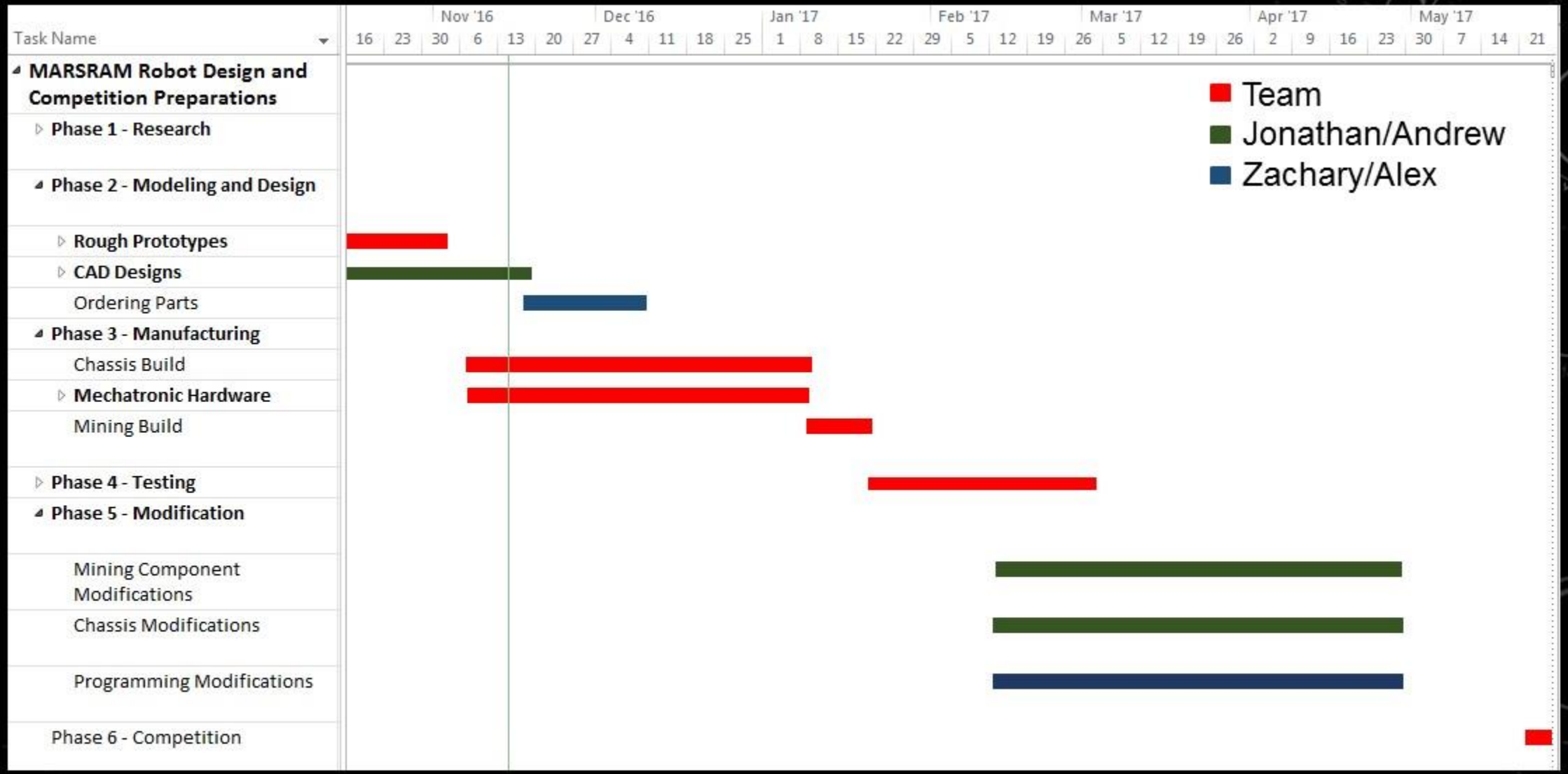


BUDGET ALLOCATION

Budget Provided: $2,000

Items	Projected Costs ($)
Raw Materials	535.00
Hardware	677.82
Total	1212.82

FUTURE PLANS



REFERENCES

- Ullrich, Franziska, Ali Hayder Goktogan, and Salah SUkkarieh. "Design Optimization of a Mars Rover's Rocker-Bogie Mechanism Using Genetic Algorithms." *Design Optimization of a Mars Rover's Rocker-Bogie Mechanism Using Genetic Algorithms* (2006): n. pag. Print.
- NASA. "Rules and Rubrics." (n.d.): n. pag. *NASA Robotic Mining Competition 2017*. Web. <http://www.nasa.gov/sites/default/files/atoms/files/00_rmc2017_rulesrubrics.pdf>.
- NASA. "Overview & Introduction." *NASA Robotic Mining Competition* (n.d.): n. pag. Web. <http://www.nasa.gov/sites/default/files/atoms/files/01_rmc2017_overviewintro.pdf>.
- NASA. "The Competition Events." *NASA Robotic Mining Competition 2017* (n.d.): n. pag. Web. <http://www.nasa.gov/sites/default/files/atoms/files/03_rmc2017_competitionevents_rev02_2c_10042016.pdf>.

MARSRAM

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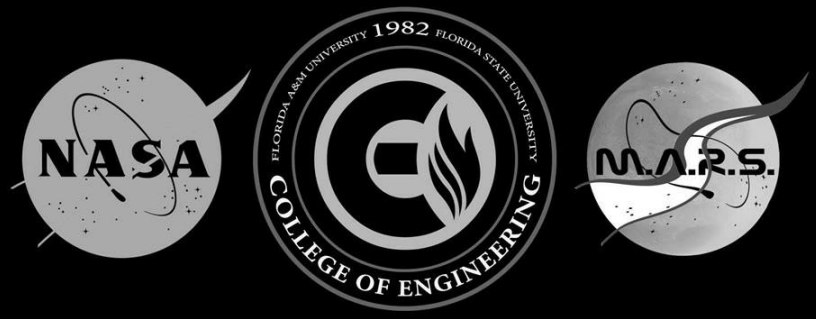
MINING TOOLING



MARSRAM

TEAM_MARSRAM TEAM MARSRAM

BUDGET ALLOCATION RAW MATERIALS

Budget Provided: $2,000

Raw Materials	Maximum Estimated Costs ($)
Aluminum Sheet 12”x12”– ¼”Thick	40
Aluminum Sheets 4’x8’ - 1/8” Thick	150
Aluminum Tubing 1”OD -1/16” Wall	100
Aluminum Pipe 1” SCH40	30
Aluminum Pipe 2.5” SCH40	100
Aluminum Round Rod 1”	15
Aluminum Tubing 8”OD	100
TOTAL	535

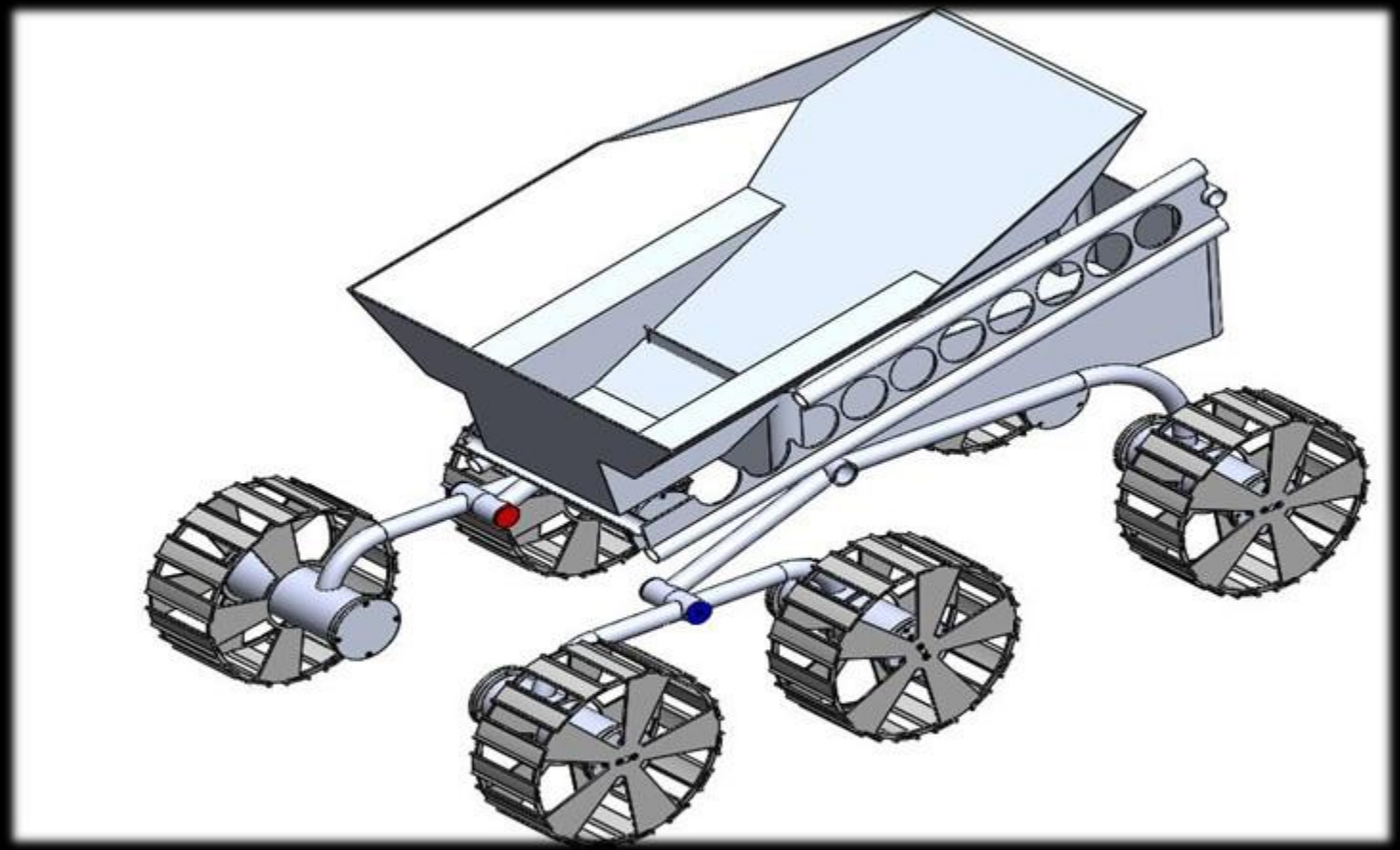
BUDGET ALLOCATION
MOTOR CONTROL

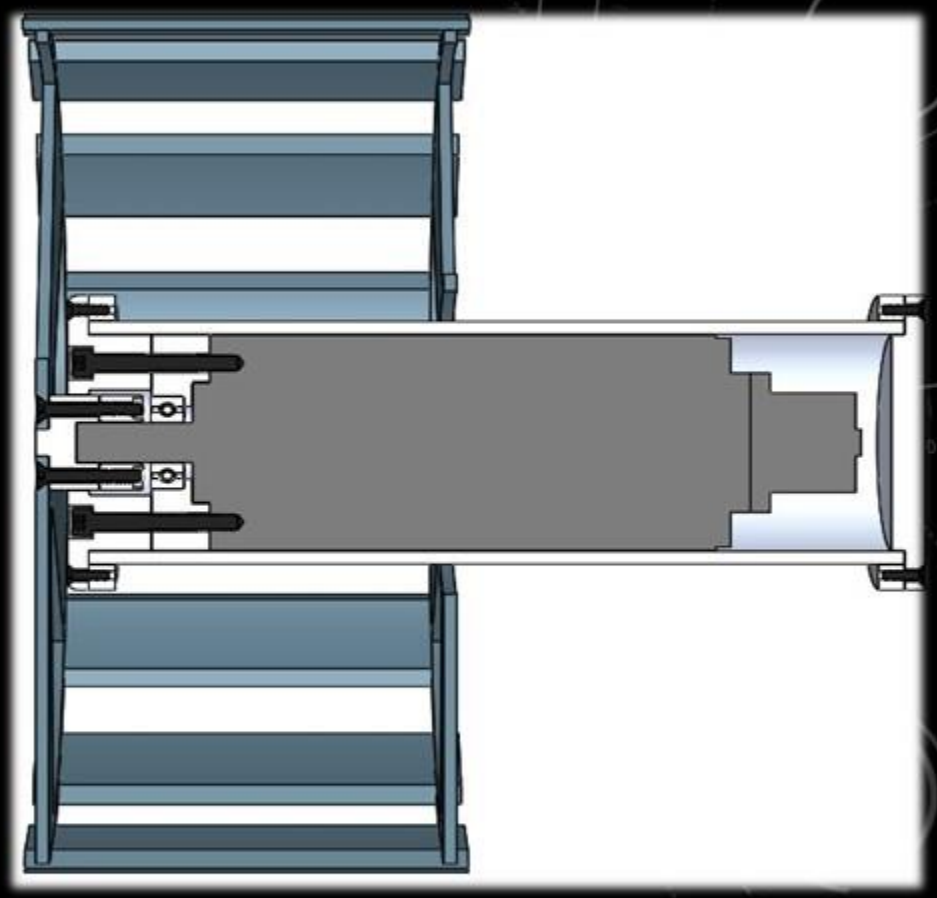
Budget Provided: $2,000

Item	Quantity	Unit Price($)	Estimated Costs ($)
12mm Shaft Collar-Face Mount Tap	6	19.60	117.60
12mm Double Shielded Press Fit Bearing	6	7.54	44.70
Linear Actuators 16” Stroke – 250lbf Cap.	4	73.00	292.00
18-8 SS FHSC 6-32X3/8” (100 pack)	1	4.30	4.30
18-8 SS SHC M5X0.8mm 35mm Long (25 pack)	1	5.47	5.47
18-8 SS FHSC M4X0.7mm 25mm Long (100 pack)	1	13.75	13.75
Maxon Motor Controller	4	50.00	200
Total			677.82

APPENDIX A

ROCKER-BOGIE CHASSIS CAD





DONATED MATERIALS