MARSRAM

Team 22: NASA Robotic Mining Competition

Team Members

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Sponsor

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AGENDA

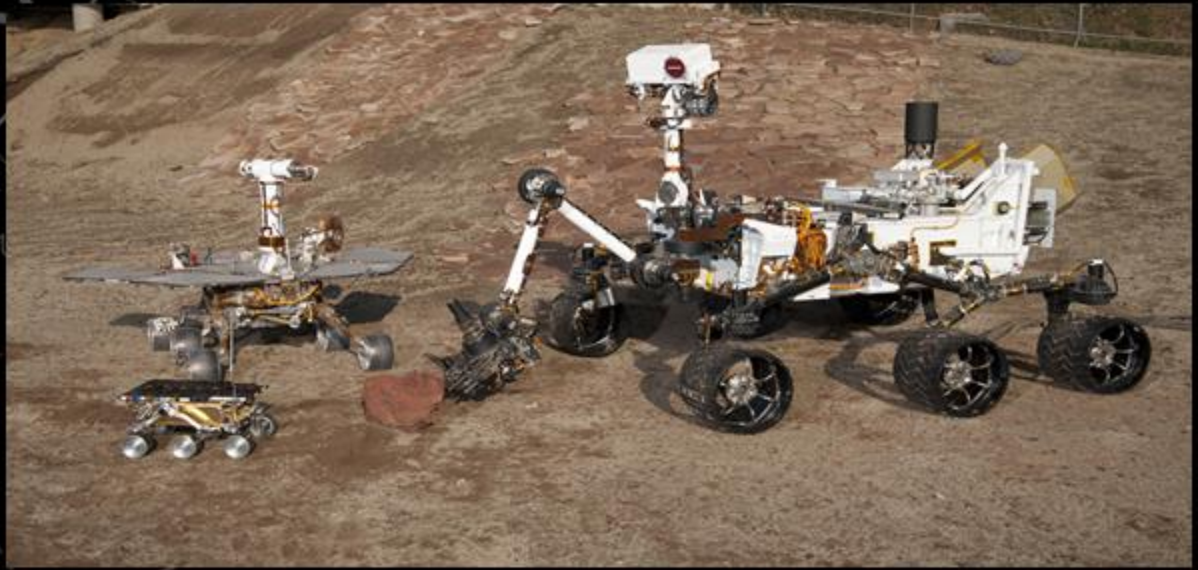
1. Project Scope
2. Significance
3. Constraints
4. Research
5. House of Quality
6. Prototype
7. Future Goals

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

Problem Statement: "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."



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Reports and Outreach

Systems Engineering Paper

- Discuss the design philosophy
- Optimization
- Schedules
- Operations Concept
- Systems Hierarchy

Slide Presentation

- Discuss the spirit, intent, and technical outcome

Outreach Project Report

- Detail type of STEM outreach
- Activities Provided
- Number of attendees
- K-12 Schools Represented
- Estimated Impact

Social Media & Public Engagement

- Creatively engage the public in robotics and STEM related topics

WHY MARS?

Why should we go to Mars?

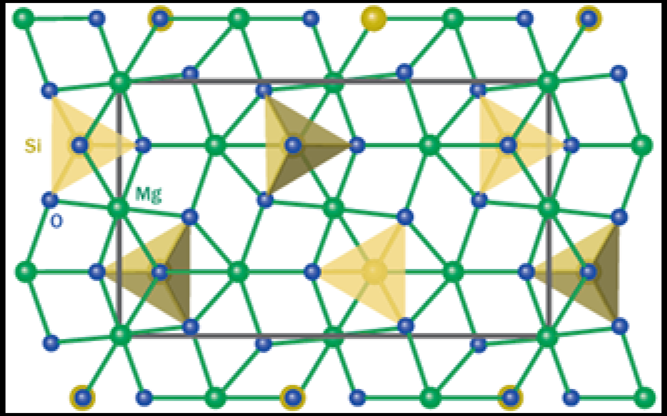
Past, Present, Future

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?

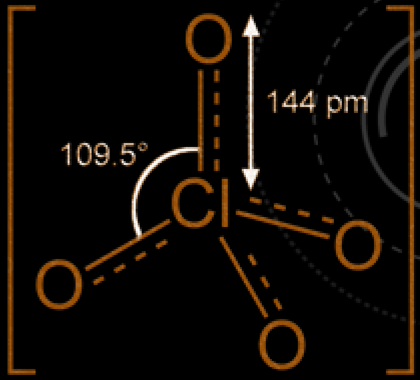
Olivine $(Mg_2Fe_2)SiO_4$

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



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Scoring Rubric

Application	Subsection	Points	Conditions
Technical Inspection and Communications Check	Competition	1000 Mining points	Awarded Required to Compete
Mining BP-1 Simulant	Mining	3 Mining Points/kg (over 10kg)	Awarded based on overall mass
Mining Icy Regolith Simulant	Mining	15 Mining Points / kg	Awarded based on overall mass
Dust Tolerance	Mining	30 Mining Points MAX.	Awarded at Judge's discretion
Dust Free Operation	Mining	70 Mining Points MAX.	Awarded at Judge's discretion
Autonomous Operation	Mining	500 Mining Points MAX.	4 Levels of Autonomy
Data Transfer	Data	1 Point / 50 kb/s	Minimize data transfer
Situational Awareness Penalty	Data	4 Points per Situational Awareness Camera	Penalized, Added to total Data Transfer
Vehicle Weight	Size	8 Points / kg	Penalized
Power Consumption	Energy	1 Point / Watt-hour	Penalized

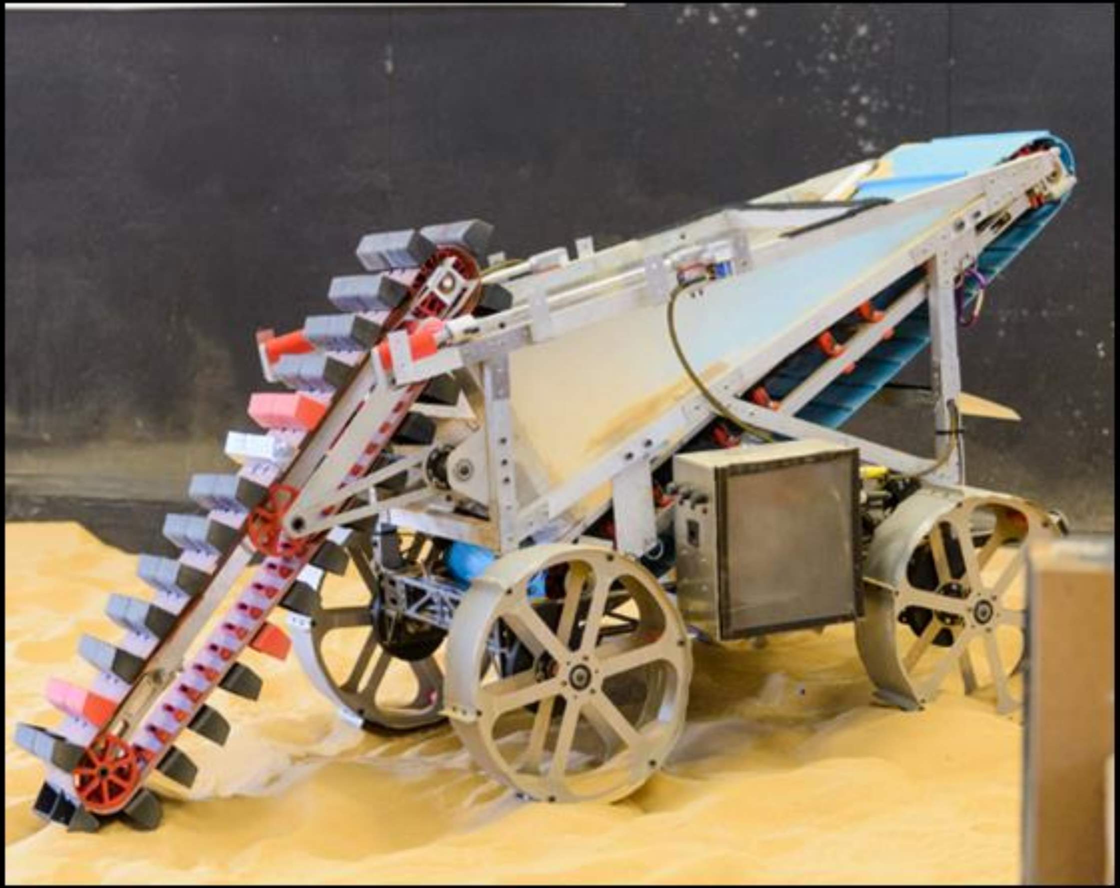
Table 1. Competition evaluation rubric.

COMPETITION ARENA

Competition Requirements	Value	Description
Arena Size	~10 m x 20 m	Total traversable terrain for vehicle
Deposit Trough	1.575m Length 0.457m Depth 0.550m Height	Sole location to deposit mined material from rover
Competition Time Limit	10 min	2 Competition Runs
Mining BP-1 Simulant	0 – 30 cm	Majority of material contained in mining arena
Mining Icy Regolith Simulant	~30 cm	Mixed with BP-1, Concentrated at 30 cm depth
Subterranean Obstacles	Random	Randomly mixed throughout arena
Surface Obstacles	up to 30 cm Width	Large rocks and craters will be placed randomly
Robot Size Limits	1.50 m length 0.75 m width 0.75 m height	Maximum allowable size of robot

Table 2. Competition Arena Specifications.

COMPETITOR DESIGNS



University of Alabama

- Four Wheel Fixed Frame
- Large Diameter Wheels
- Dust Build-Up Problems

Oakton Community College

- Four Wheel Fixed Frame
- Light-Weight Frame
- Wheel Slippage Issues

COMPETITOR DESIGNS

Iowa State University
- Track Design
- Slow Movement
- Autonomy Failures

Embry Riddle Aeronautical University
- Four Wheel Fixed Frame
- Slow Movement
- Minimal Dust Issues

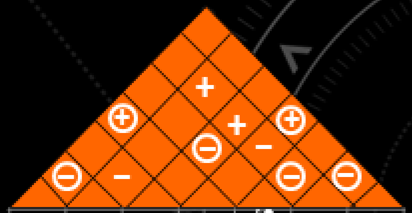
HOUSE OF QUALITY

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
Direction of Improvement		↓	↑	↑	↑	↑	↓	↑
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 Σ(Priority X Relationship)		34	99	30	106	24	50	85
% Relative Importance		8	23	7	25	6	11	20
Rank of E. C.		5	2	6	1	7	4	3

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MORPHOLOGICAL CHART

Functions	Options		
Boards	Raspberry Pi	Arduino	BeagleBone Black
Chassis Design	Rocker-Bogie	Four Wheel Fixed Frame	Fixed Frame Skid
Chassis Material	Aluminum	Stainless Steel	Carbon Fiber
Controls	Joystick/Keypad	Gaming Controller	Autonomous
Wheel type	Rubber	Aluminum	Track
Mining Apparatus	Auger	Conveyer Belt	Rotating Drum

Concept #1
Concept #2
Alabama
Oakton
Iowa State
Embry Riddle

Table 3. Morphological Chart

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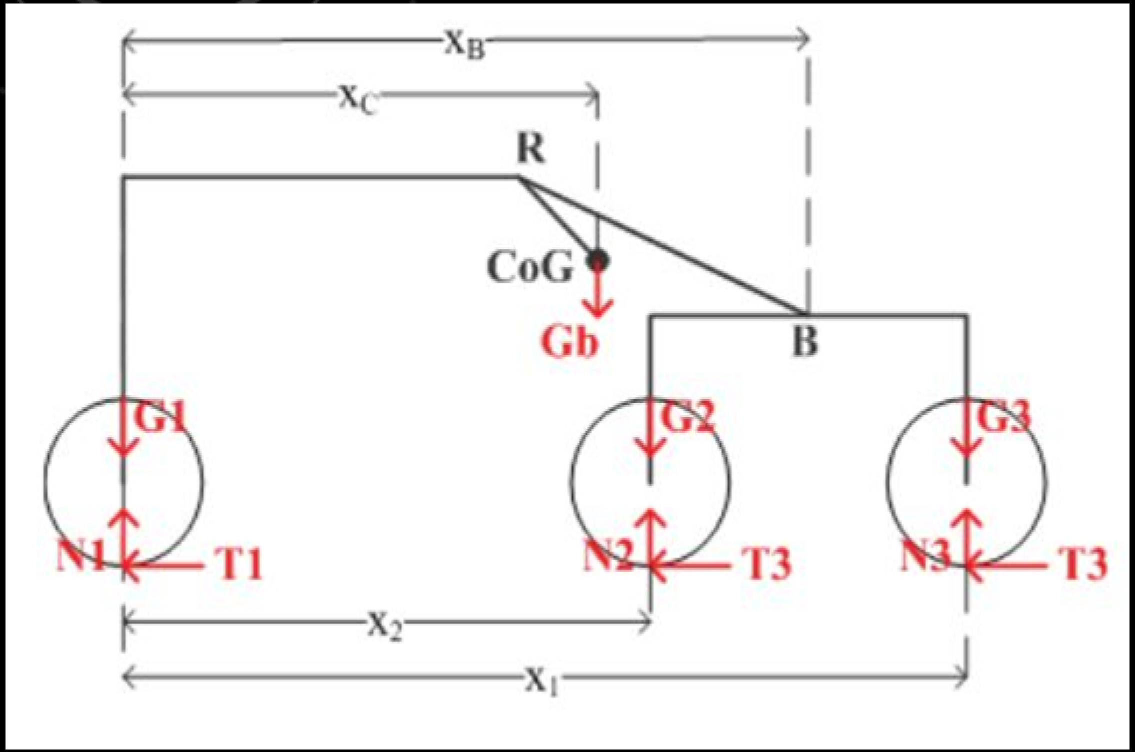
Chassis Design - Functional Relationships

Rocker-Bogie Suspension Design [1]

- No spring systems required
- Continuous 6 wheel contact
- Differential between rockers
- Ratio between wheel distances



Rocker-Bogie wheel distances with equations

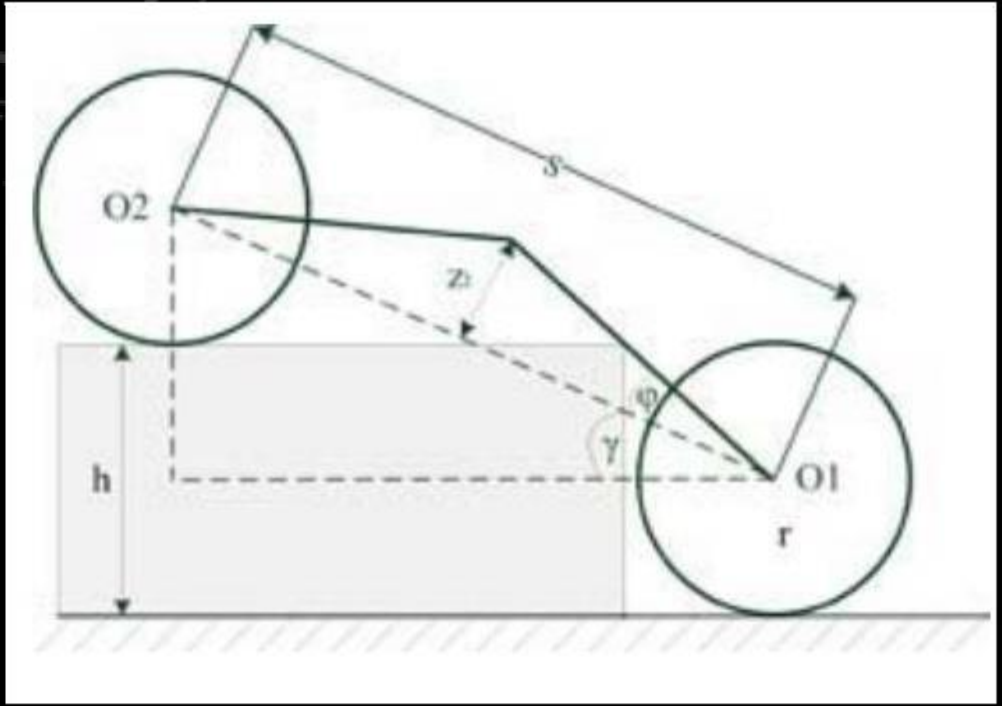
$$X_B = \frac{3}{2} X_C$$

$$X_B = \frac{1}{2}(X_1 + X_2)$$

CHASSIS DESIGN - MAXIMUM OBSTACLE HEIGHT

WHEEL AND BOGIE SELECTION [1]

- Obstacle clearance dictated by wheel diameter and height of bogie
- 170:75 wheel diameter to thickness ratio



Bogie wheel distances and angle with equations

$$z_t = \frac{s}{\sqrt{\left(\frac{r\sqrt{s^2-h^2}+(h-r)h}{(h-r)\sqrt{s^2-h^s}-hr}\right)^2+1}}$$

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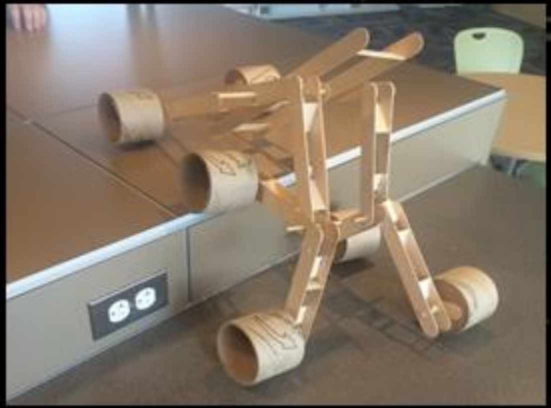
"SCRAP 1" PROTOTYPE

SCRAP: "Scaled-Configuration Regolith Acquisition Prototype"

- Made from consumable materials: wood dowels, cardboard tube, popsicle sticks, and hot glue



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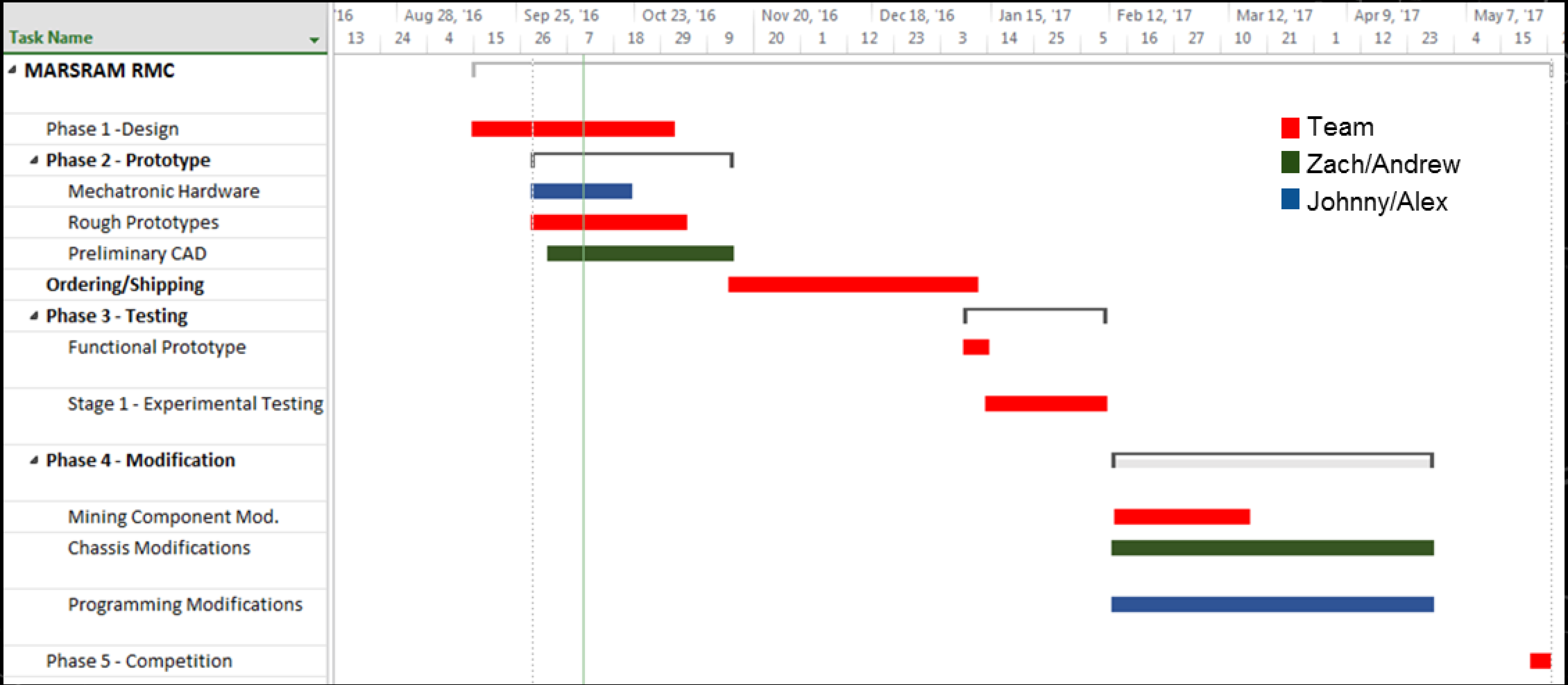
FUTURE PLANS



Gantt Chart

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QUESTIONS?

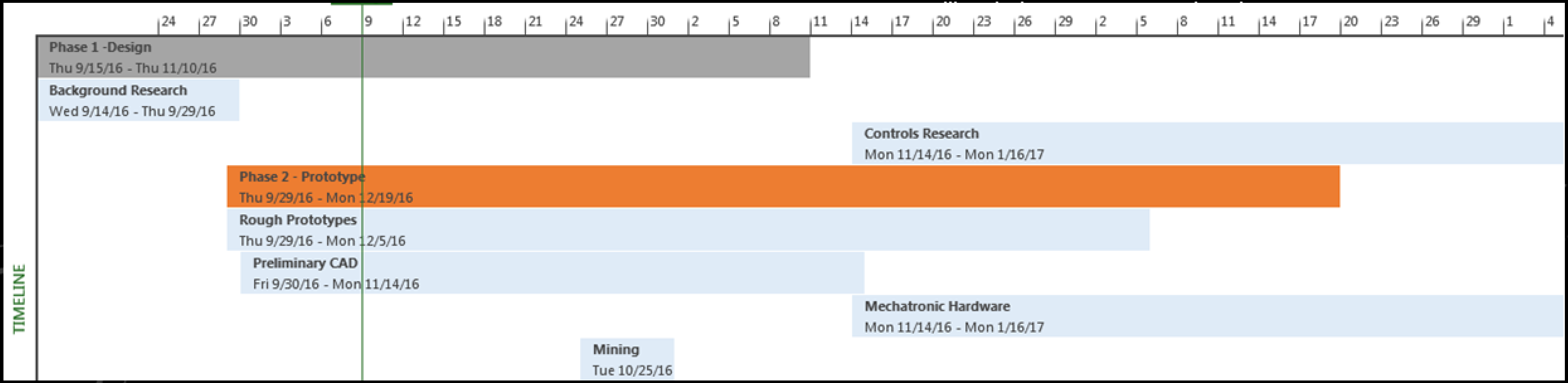
MARSRAAM

"Mining our own business on other planets."

APPENDIX: GANTT CHART

1. Phase 1: Design
   a. Background Research
      i. Rocker Bogie Suspension
      ii. Previous Years Robots
   b. Hardware Research
      i. Motor Drivers, Microcontrollers, Chassis Materials
   c. Controls Research
      i. Telecommunication Hardware

2. Phase 2: Prototype
   a. Rough Prototypes
      i. Rocker Bogie
      ii. Mining Hardware
   b. CAD
      i. Chassis
      ii. Mining Hardware
   c. Mechatronic Hardware
      i. Motor/Controls Testing
      ii. Telecommunication Testing



APPENDIX: GANTT CHART (CONT.)

3. Phase 3: Testing
   a. Functional Prototypes
      i. Develop Steel Frame for Prototype
      ii. Assemble Electronics Hardware
      iii. Route Wiring, Protect Components
   b. Stage 1: Experimental Testing
      i. Verify Mining Components
      ii. Collect BP-1 Simulant
      iii. Collect Icy-Regolith Simulant
      iv. Observe Dust Prevention
      v. Observe Potential Threats
4. Phase 4: Modifications
   a. Mining Component Modifications
   b. Chassis Modifications
   c. Programming Modifications
      i. Check Energy Consumption
      ii. Develop Code for Increased Accuracy