EML4551-2

CLPS MOBILITY TOOL

TEAM: 516

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CLPS Mobility Tool
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Kyle Nulty

Project Scope

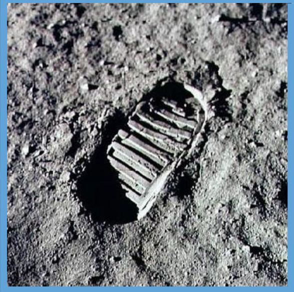
Commercial Lunar Mission for the 2026 Timeline

Loading:

- **300 kg** Payload
- **3 m** Height

Motion:

- Traverse **1.5 km**
- Negotiate **15°** incline



Environmental Conditions:

- Regolith
- Extreme Temperatures

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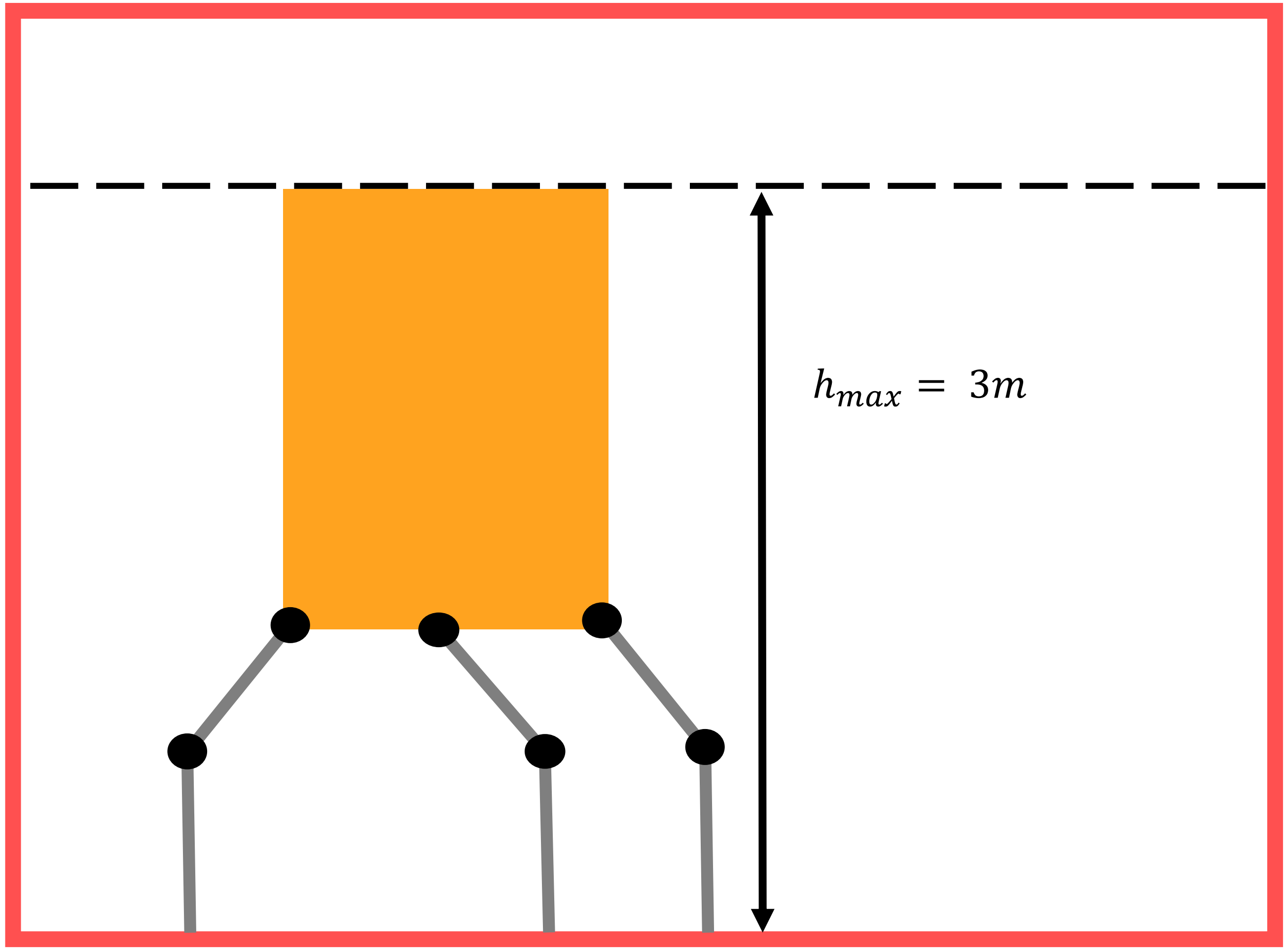
CLPS Lander

Commercial Lunar Payload Services Landers

- NASA working with several companies
  - Required to reach Moon and carry payload(s)
  - No specific size requirements
- Minimum 13 different lander designs as of January 2020
  - Avg Height: 2 ± 1.01 m

Project Requirements

- Design for possibility of different landers
- Reach all possible locations of payload storage
- Place payload on ground upon return to base



Hannah Rodgers

Overall Design

Robotic Actuated Payload Transport Rover (RAPTR)

- Titanium chassis
- Full suspension
- Four aluminum mesh wheels
- Height of 1.3 m
- Image Processing for securing payload
- Arm to retrieve payload
    - Capable of 6 DoF
- Mass: 1116 kg
- Validation through Simulation
- Dynamically scaled for various length factors

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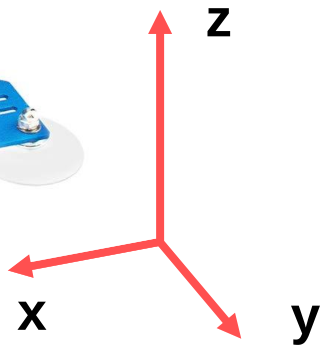
Robotic Arm

Robotic Arm and End Effector

- 6 DoF to ensure workspace is entire range of payload placement
    - CLPS payloads inconsistently placed
- End effector (gripper) will rotate about X,Y,Z and translate in Z
- Gripper will move over payload, locate handle, and secure the payload

Lewan Soul xArm Robot



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Suspension & Wheels

Suspension System

- Double A-Arm Suspension
  - Independent wheel travel
- Spring suspension
  - Reduce ride height change when loaded
- 0.75 m suspension travel
  - Traverse over rough terrain
- Titanium arms with steel springs

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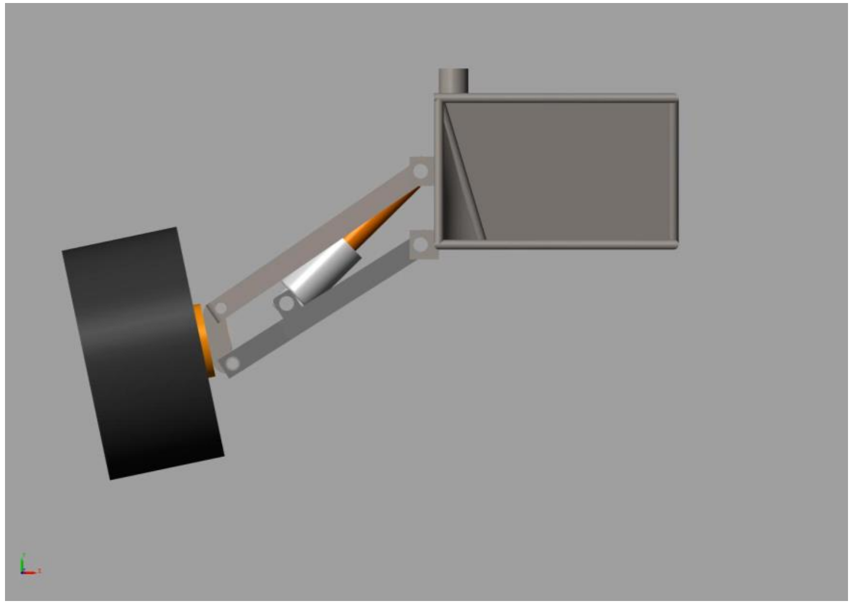

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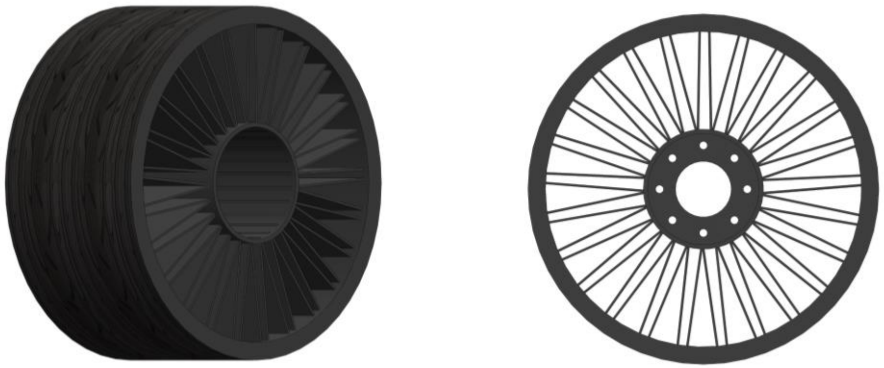
Suspension & Wheels

Wheels

- Tweel inspired design
  - Capable of deformations without any suspension travel
- Aluminum mesh wheels
  - Greater wear resistance than rubber
- Airless tire design
- 20in diameter (508 mm)
- 400mm Width (15.75in)



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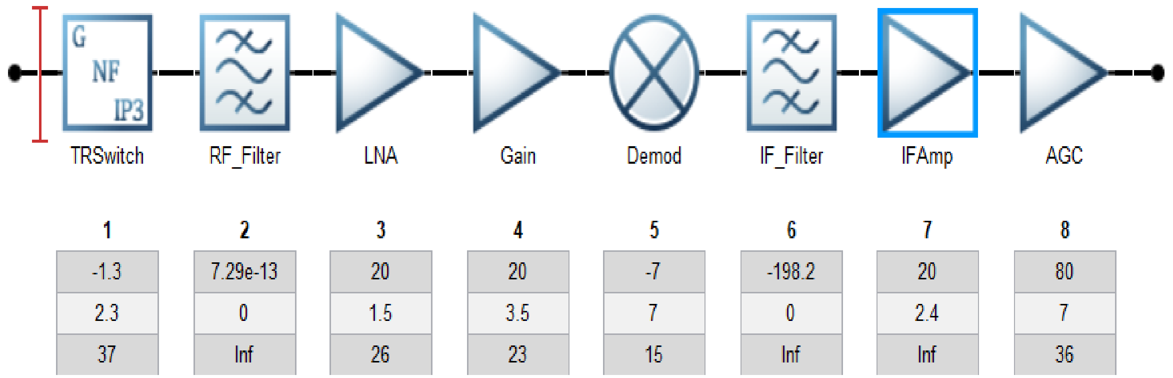
Communication System

Transmission and Reception

- 1.5 km Maximum Transmission Distance, X-Band Signals
- Goal to implement using Deep Space Network (DSN) for quick and easy integration
- Prototype will use a prefabricated RF receiver and transmitter pair



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Logic System

- Using multiple Arduino Mega 256 R3 Microcontrollers.
  - One Arduino used for motor control
  - One Arduino used for control of the robotic arm
- Using MATLAB and the Arduino Library to properly model and simulate logic for the full-scale Simulink model.

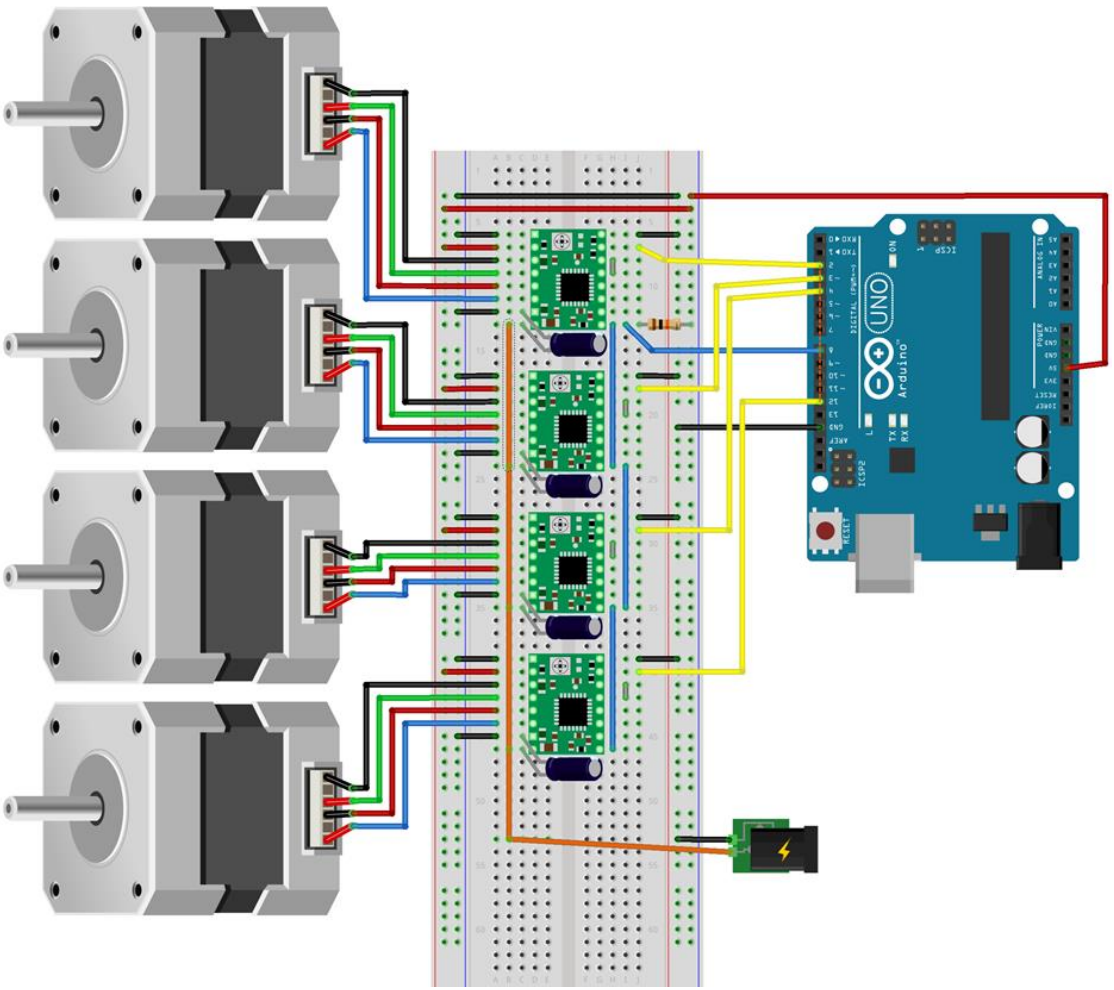

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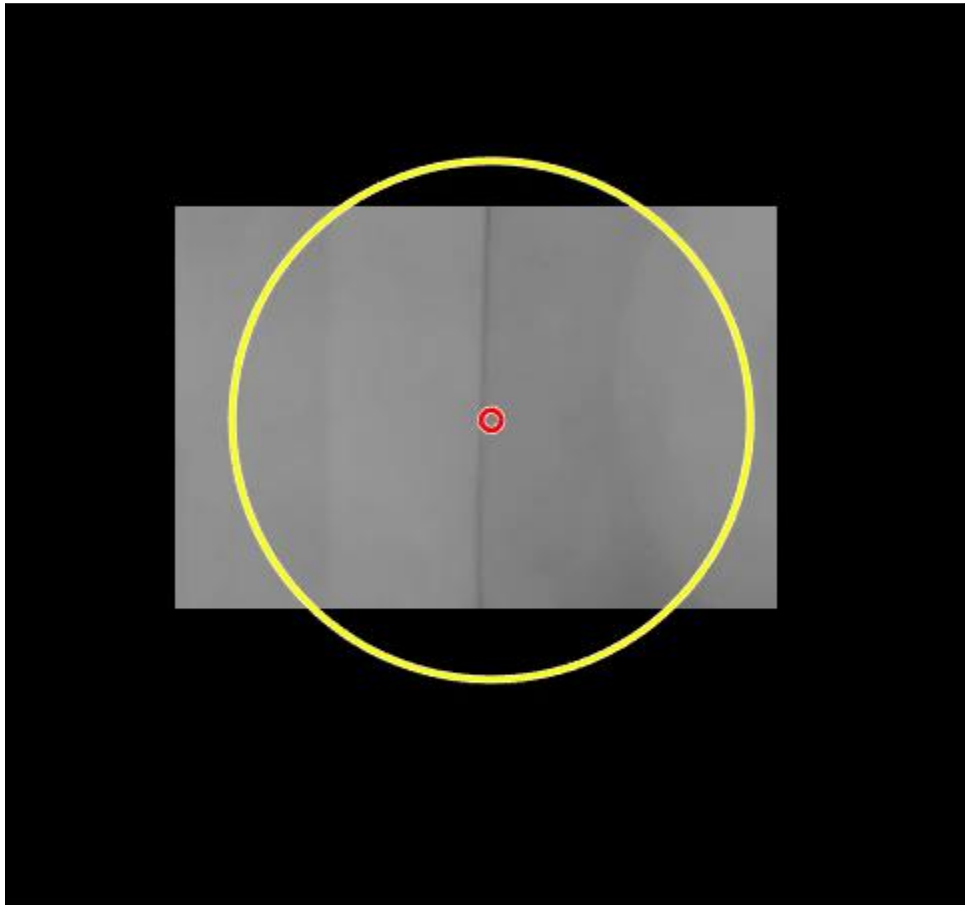
Image Processing

- Uses symbol recognition
- Tracks the center of a target for orientation of the RAPTR
- Would be a live demonstration as a proof on concept, separate from the full-scale Simulink model
- Using Matlab's Image Processing Toolbox for image reading and processing



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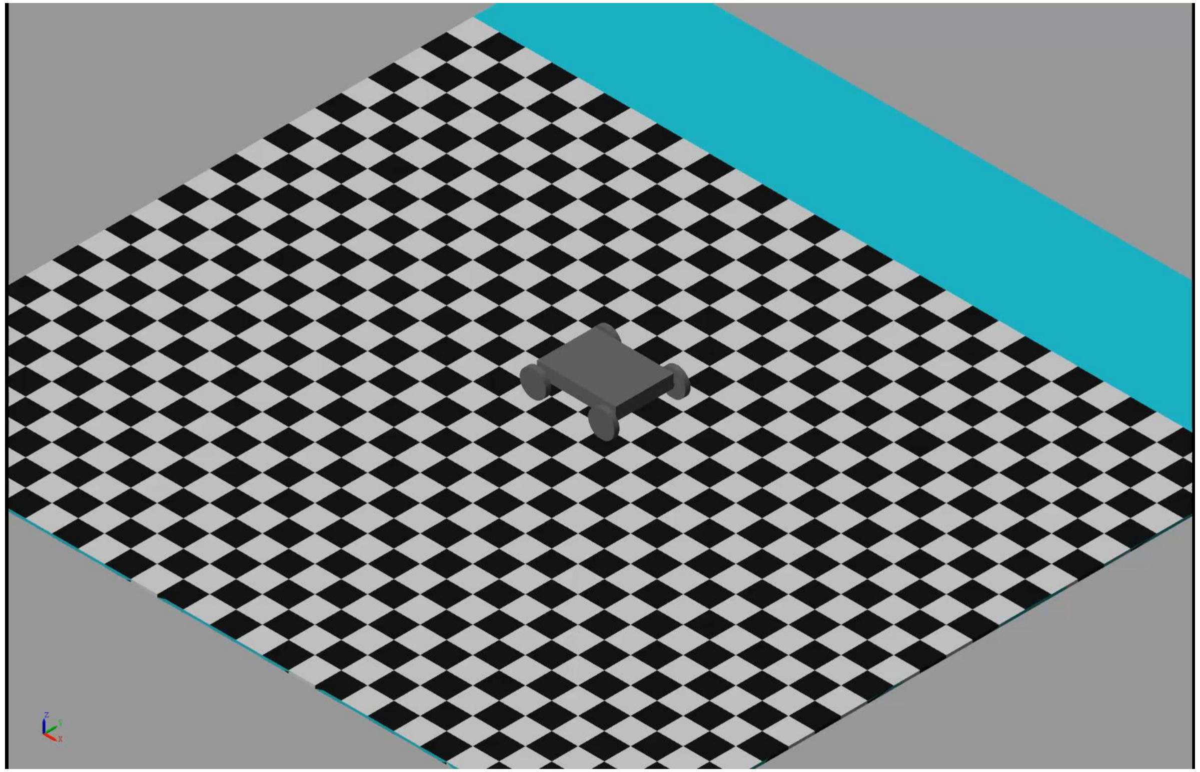
Simulation

Current Work

- Refining CAD model into Simscape
- Restricting trivial solutions for inverse kinematics of robot arm

Design Restrictions

- Wheels will not have deformation modeling
- Regolith will be modeled as a flat plane with an effective coefficient of sliding friction of 0.67[4]



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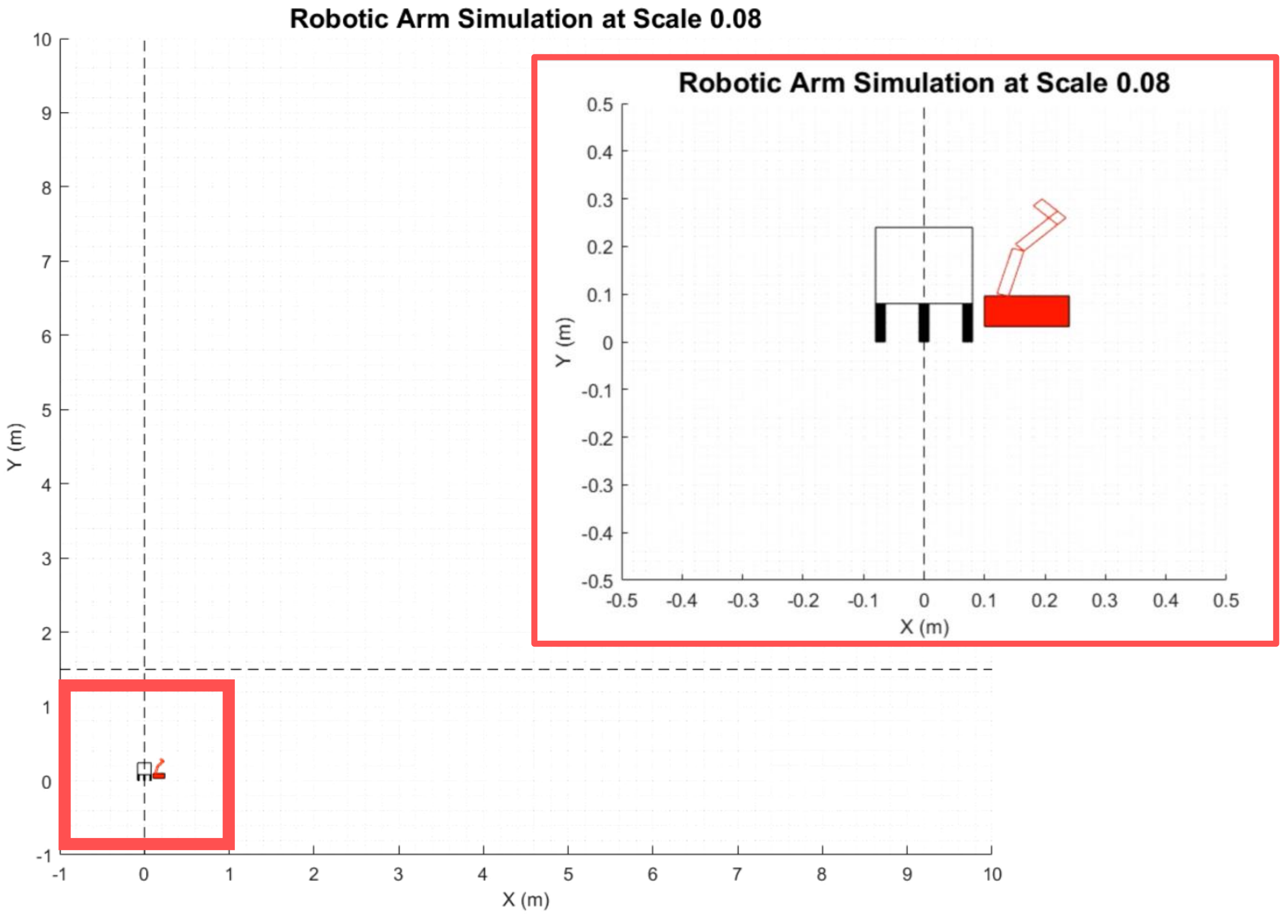
Scaling GUI

Current Work

- Determining critical parameters to scale:
  - End effector to payload handle
  - Vehicle height
- Developing structures to store dimensions to send to CAD and simulation

Scaling Factor

- 0.08 <= Scale Factor <= 1
  - Lunar Design Scale = 1
  - Prototype Scale = 0.08



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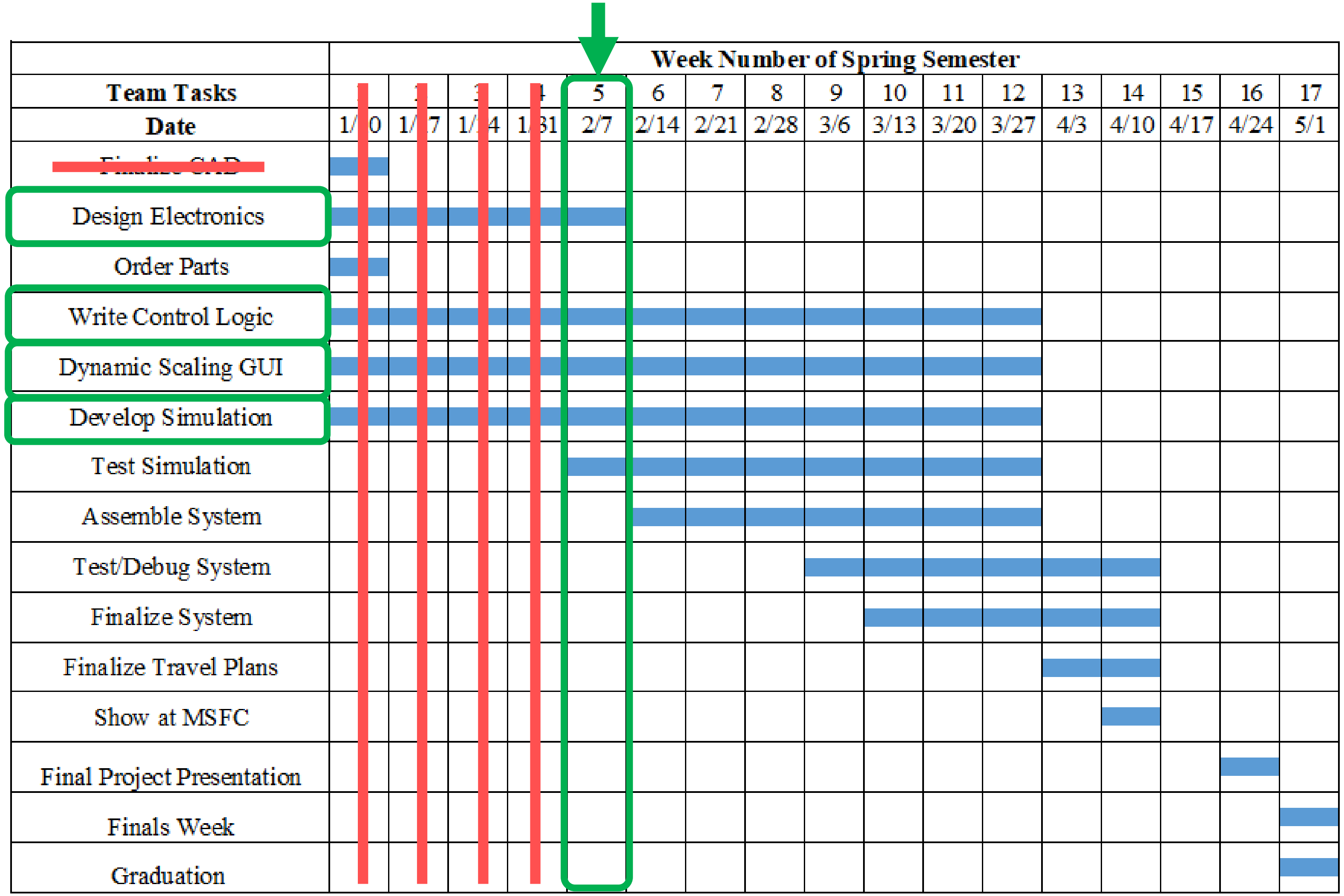
Schedule



We have not received our grant money as of 2/1/2020

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Expectations

Design Maturity and Risks

- Prototype design will be shown at MSFC
- Simulation will be delivered to NASA with solid mechanical and electrical designs
  - Power will remain undecided, based on sponsor recommendation
- Risks will be analyzed further into the design process

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References

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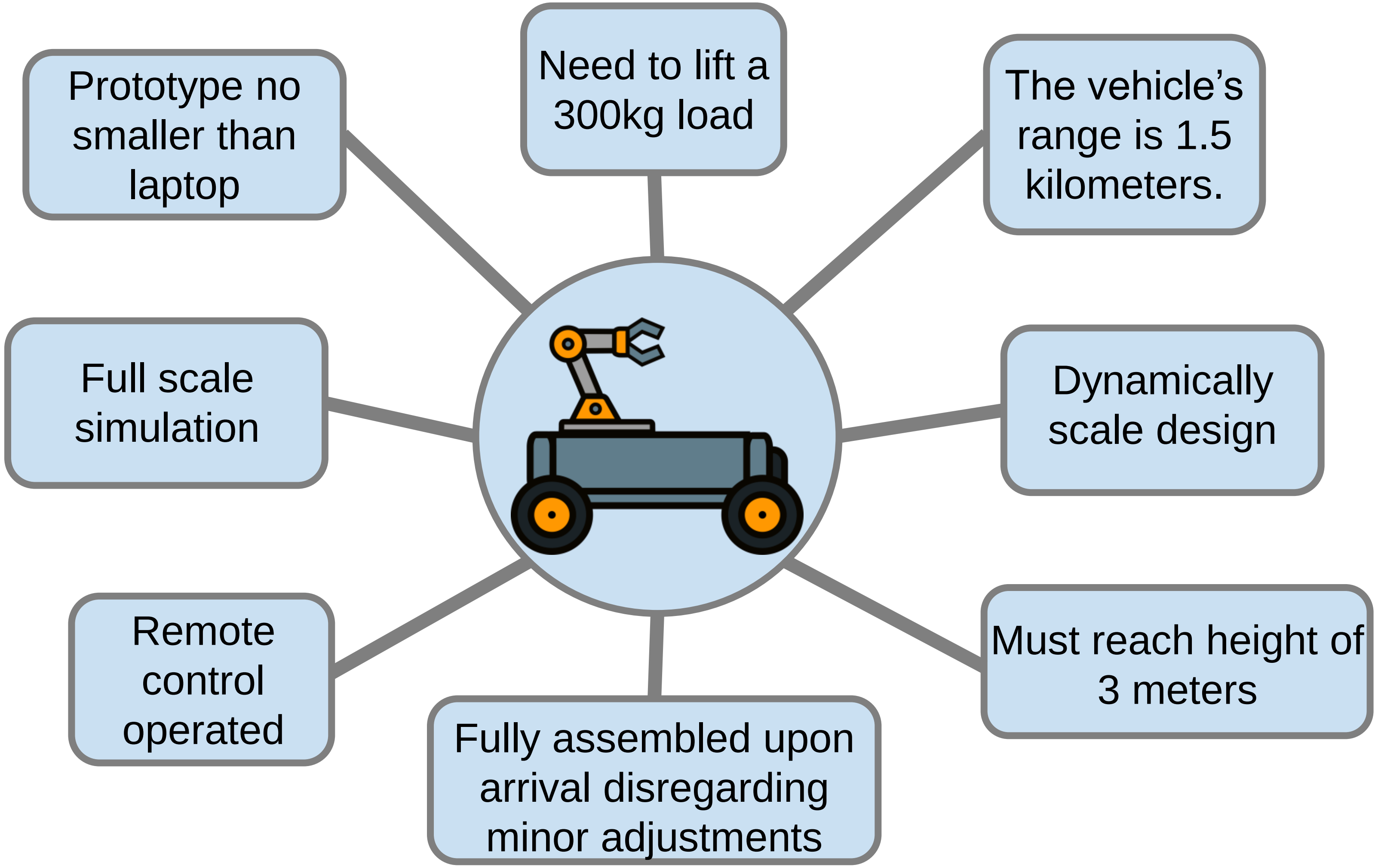
7. Lockheed Martin (2019, September) McCandless Lunar Lander: User's Guide. Retrieved from: https://www.lockheedmartin.com/en-us/products/mccandless-lunar-lander.html
8. NASA (2019, Nov. 20) Commercial Lunar Payload Services. Retrieved from: https://www.nasa.gov/content/commercial-lunar-payload-services

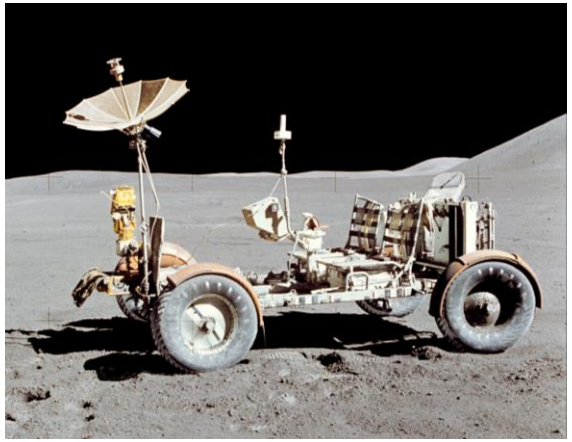
Project Requirements

Focus on securing and transporting LSS payload



Background Research

Existing technology



Lunar Rover Vehicle

- Travelled 19 kph
- Utilized wheels with chevron pattern to avoid sinking
- Carried LSS equipment and tools to different sites

ATHELE Rover

- 6 Degree of Freedom limbs with wheels at end
- 2 three-limbed robots that join to carry payload

Chariot Lunar Truck

- Pressurized cabin on wheeled chassis
- Wheels that can pivot for “crab like” motion
- Special tools can be attached to move cargo

Background Research

Challenges to engineering for the lunar surface

Regolith

- Sharp, will damage materials
- Electrostatic, can damage exposed electronics with EM radiation/static discharge
- Requires the use of specialized locomotion (wheels resistant to damage)

Little Atmosphere

- No combustion engines, must rely on electric motors
- Remote must be accessible to astronauts in suits

Cost of Transportation

- $10,000 to put a pound of payload in Earth orbit (2008)

Concept Generation