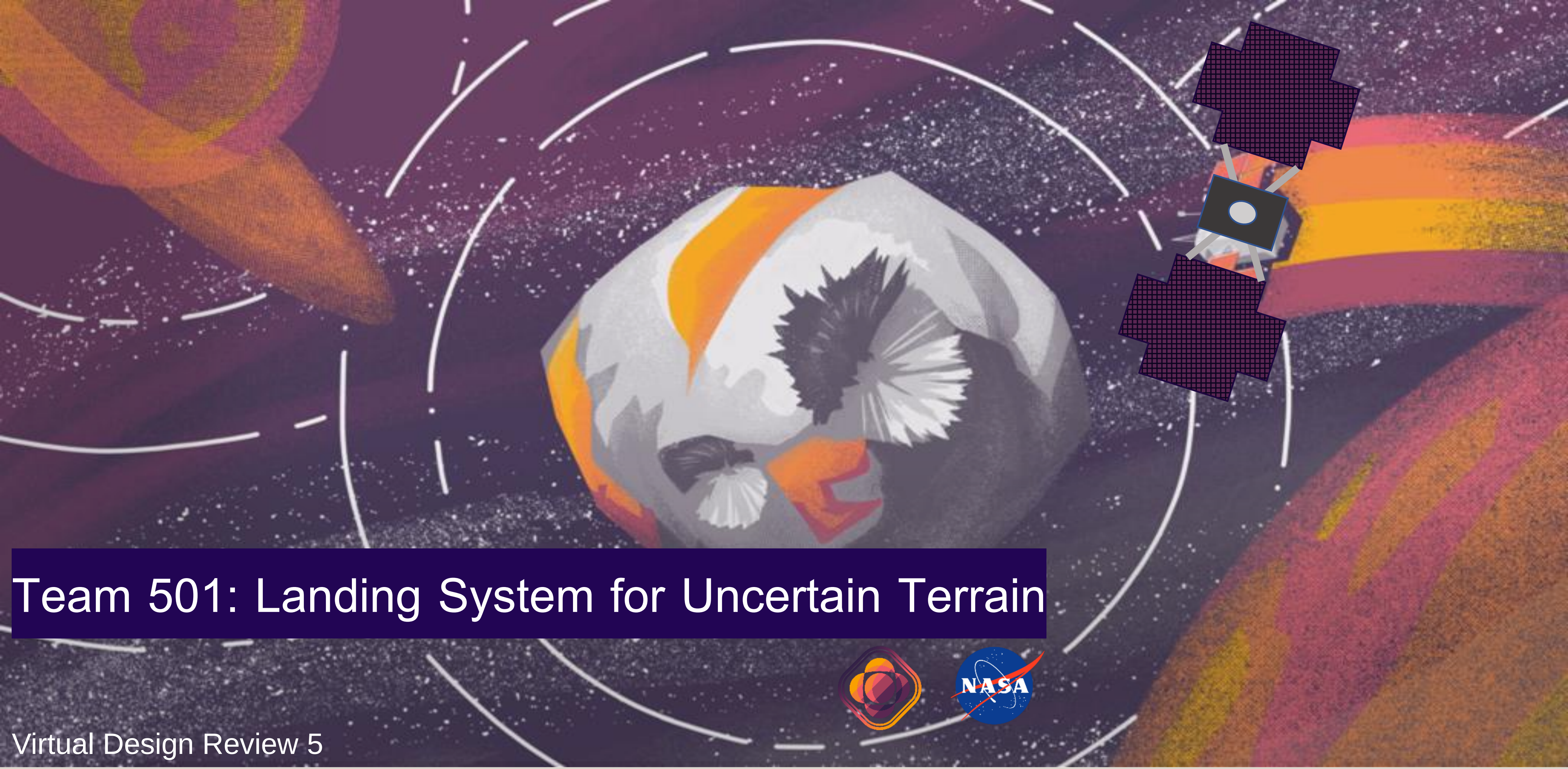


Team 501: Landing System for Uncertain Terrain

Virtual Design Review 5

Team Introductions

Saralyn Jenkins
Mechanical Systems Engineer

Elzbieta Krekora
Materials Engineer

Andrew Sak
Controls Engineer

Julio Velasquez
Mechanical Engineer

Julio Velasquez

Sponsor and Advisor

<u>Engineering Mentor</u>
Cassie Bowman, Ed.D.
Associate Research Professor, ASU

<u>Academic Advisor</u>
Camilo Ordóñez, Ph.D.
ME Teaching Faculty

Julio Velasquez

Objective

The objective of this project is to design a landing system capable of safely landing on the range of hypothesized surfaces and terrains of 16 Psyche.

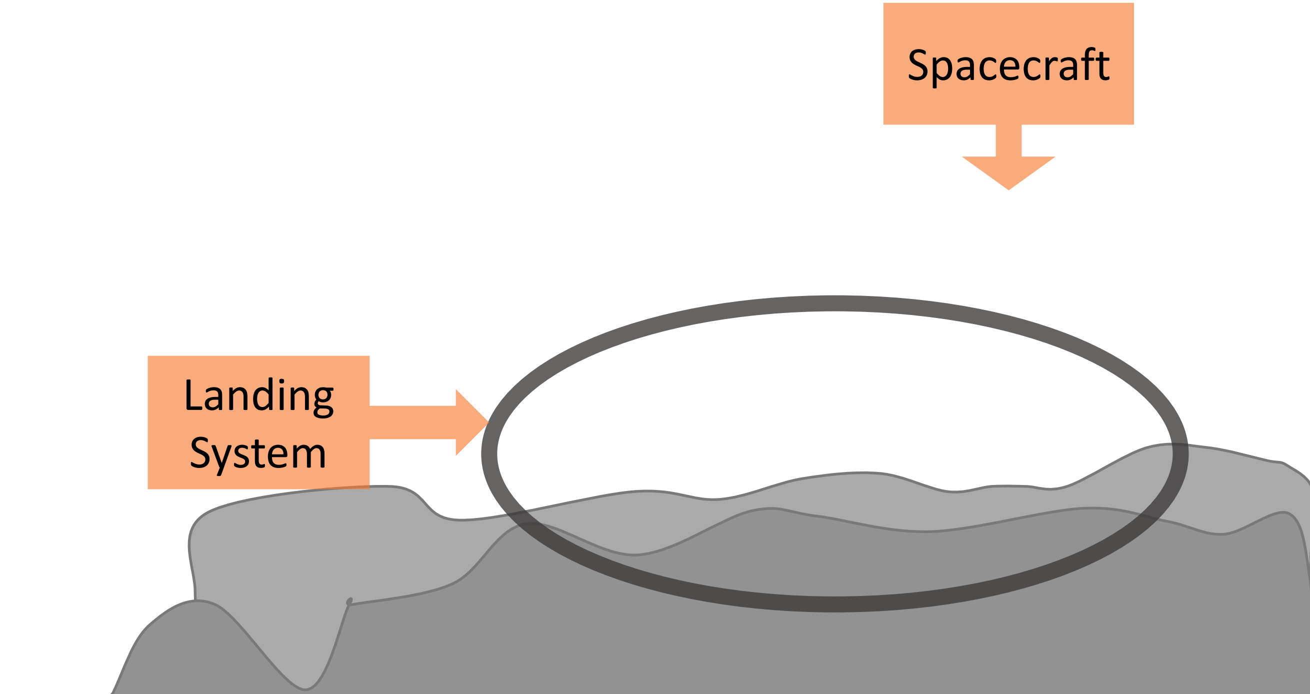
Julio Velasquez

Project Overview

Psyche: Believed to be an exposed core of an early planetesimal that lost its rocky outer layers due to violent collisions billions of years ago

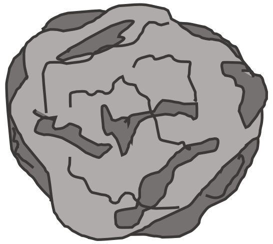
Our Mission:
To design the landing system (i.e. what lands/supports the spacecraft)

Terrain:
Psyche has hypothesized uncertain terrain (i.e. rocky, uneven and metallic)



Julio Velasquez

Assumptions



Attaches to future spacecraft without issue

Operated in minimal gravity, space like temperatures and conditions

Perform a soft landing on Psyche

Spacecraft approaches perpendicular to surface

Controlled Autonomously

Power supplied by spacecraft

Test model and forces are analogous to Psyche mission variables

Testing terrain resembles assumed surface of Psyche

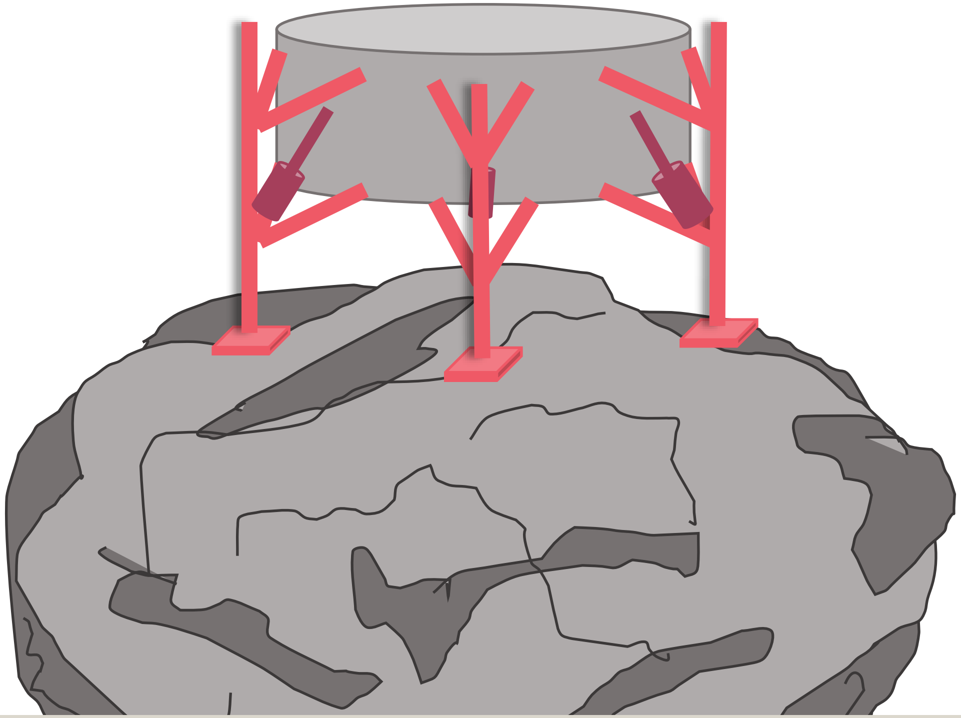
Julio Velasquez

Critical Targets

Dampens impact energy

Prevent lander from tipping

The system can support the weight of the lander

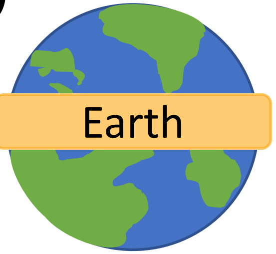


Lander can accommodate for any of the hypothesized surfaces

The lander is stable on Psyche’s surface

Julio Velasquez

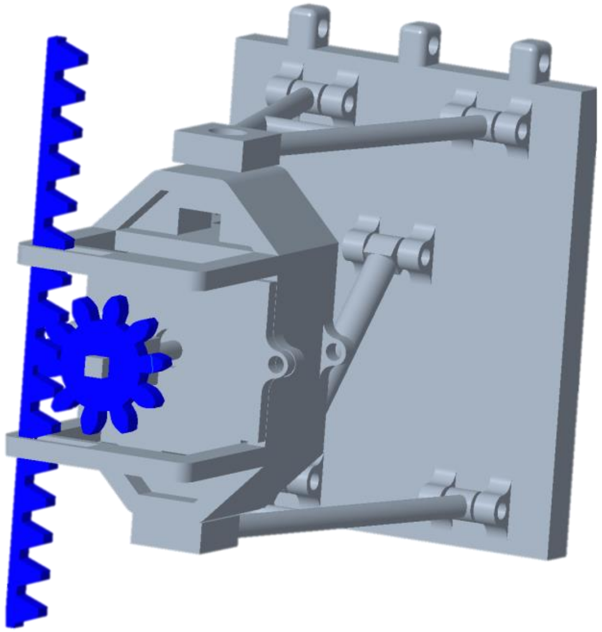
Validation of Targets



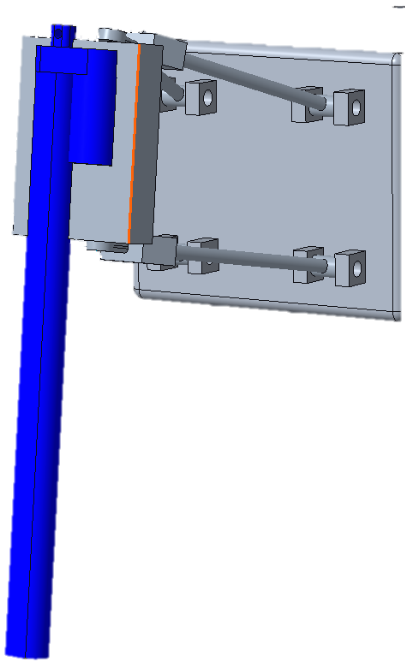
<u>Constraints</u>: Mass of Lander and Gravity	Psyche: 150 kg $0.144\ \frac{m}{s^2}$	Earth: 23 kg $9.81\ \frac{m}{s^2}$	Measure mass with appropriate scale to ensure following values are valid
Max Impact Velocity	Psyche: 6 m/s	Earth: 0.92 m/s	Read from sensors
Supports Weight	Psyche: 21.6 N	Earth: 225.63 N	All components in prototype specked to support weight based on this value

Julio Velasquez

Adjustment of Design: Legs



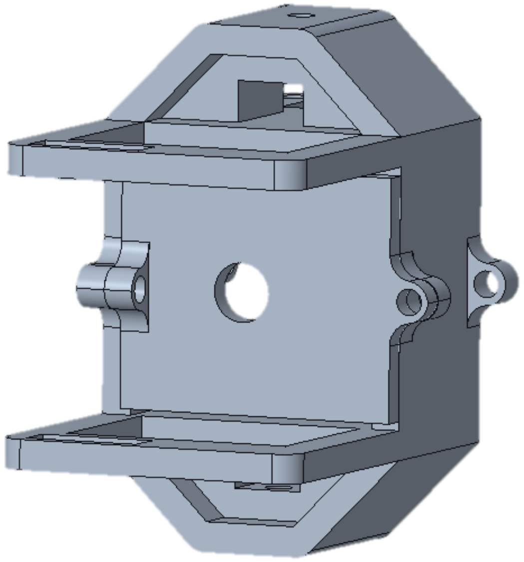
Rack and Pinion



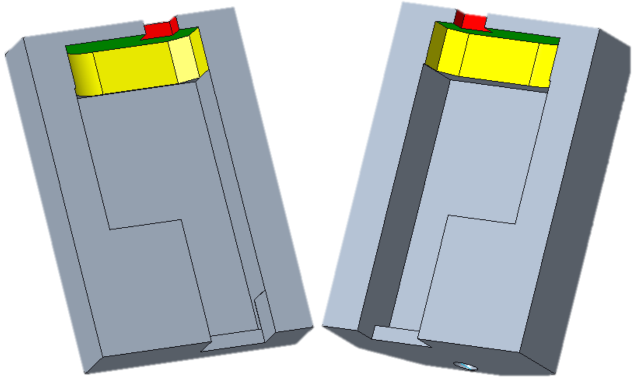
Linear Actuator

Julio Velasquez

Adjustment of Design: Knuckle



Knuckle

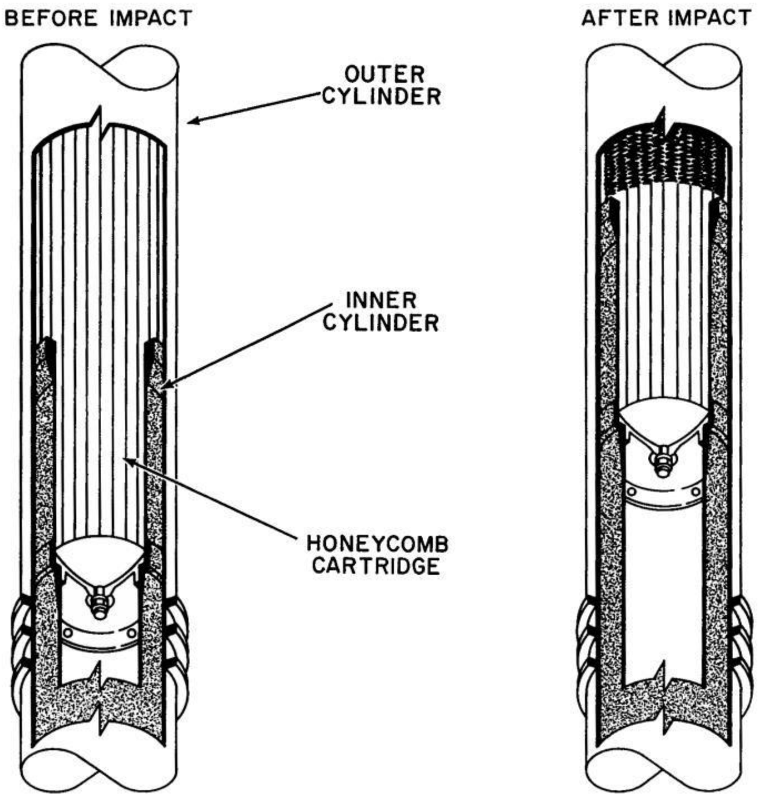


Knuckle Clamp

Julio Velasquez

Adjustment of Design: Damping

Psyche Model



Crushable Honeycomb Damper

Earth Prototype

Gas Shock Absorber

Julio Velasquez

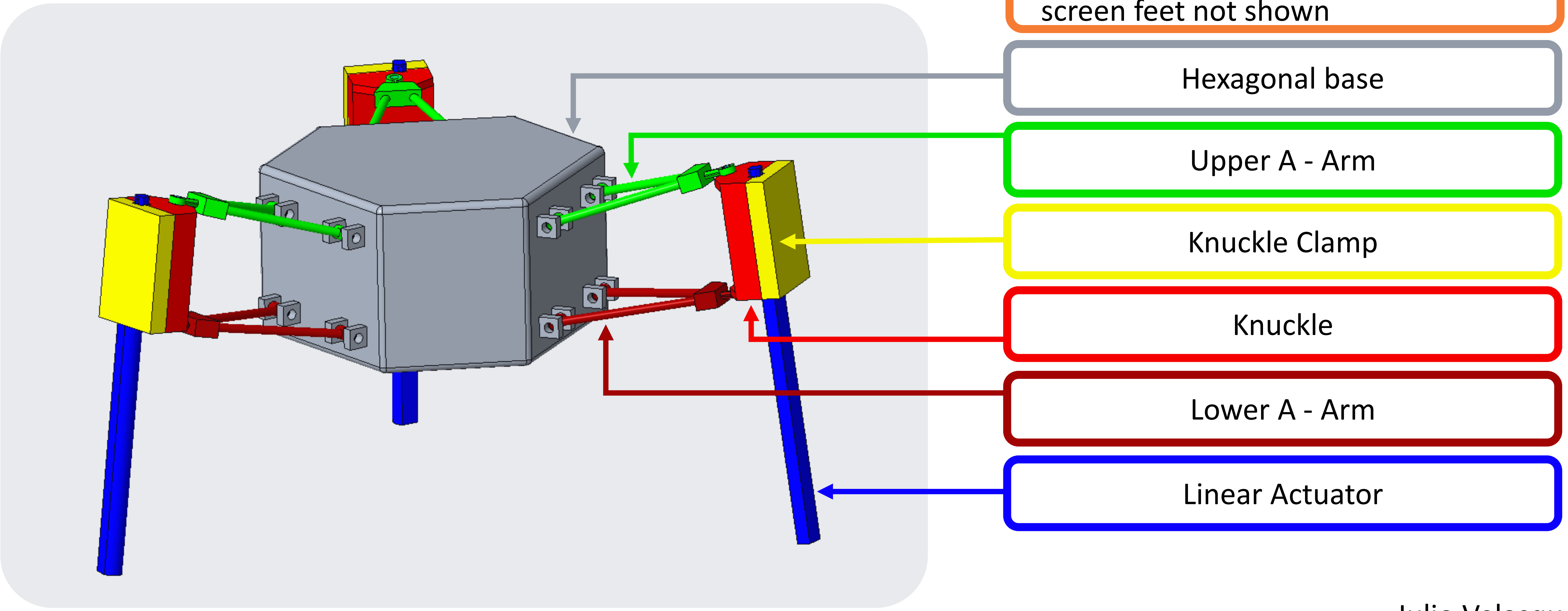
Prototyping Process

- 3D Printing
- Sizing of Prototype
- Testing and Reinforcing of Feet
- Experimentation of Sensors and Legs

Julio Velasquez

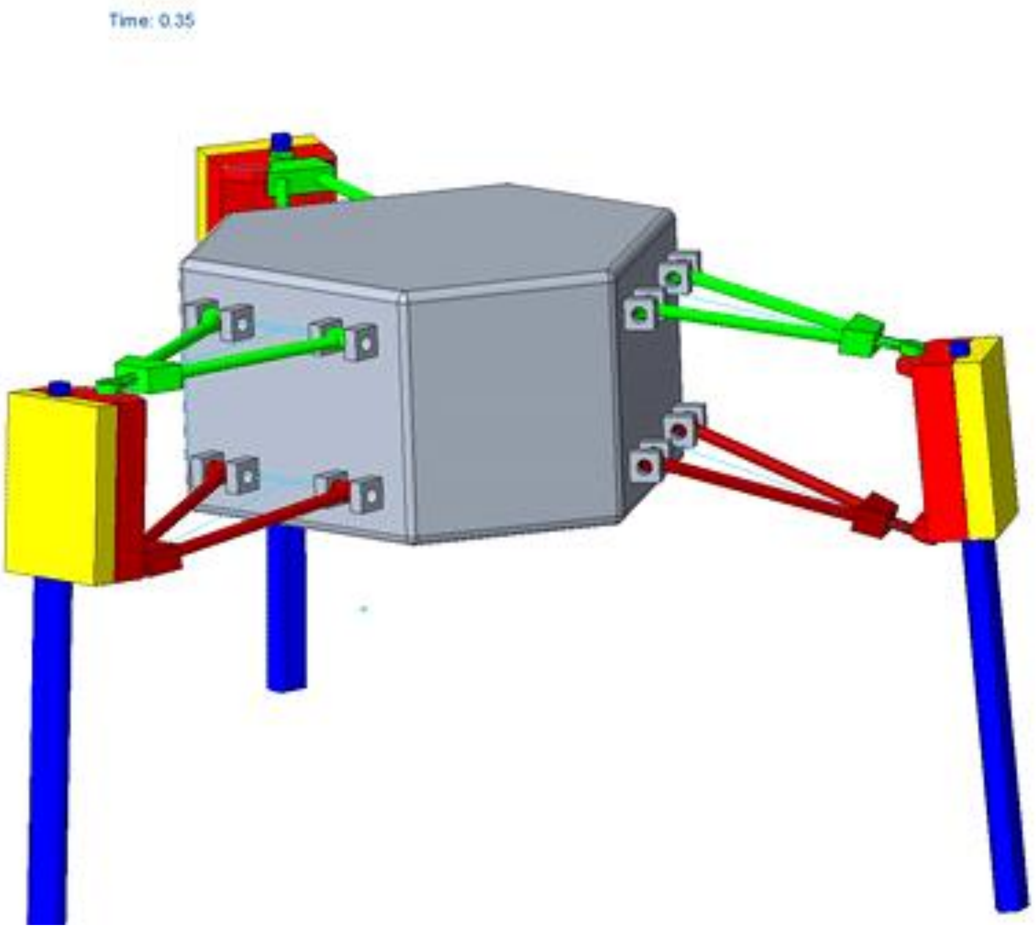
Prototype Model

Note: Shock absorber/damper and pin screen feet not shown



Julio Velasquez

Prototype Model



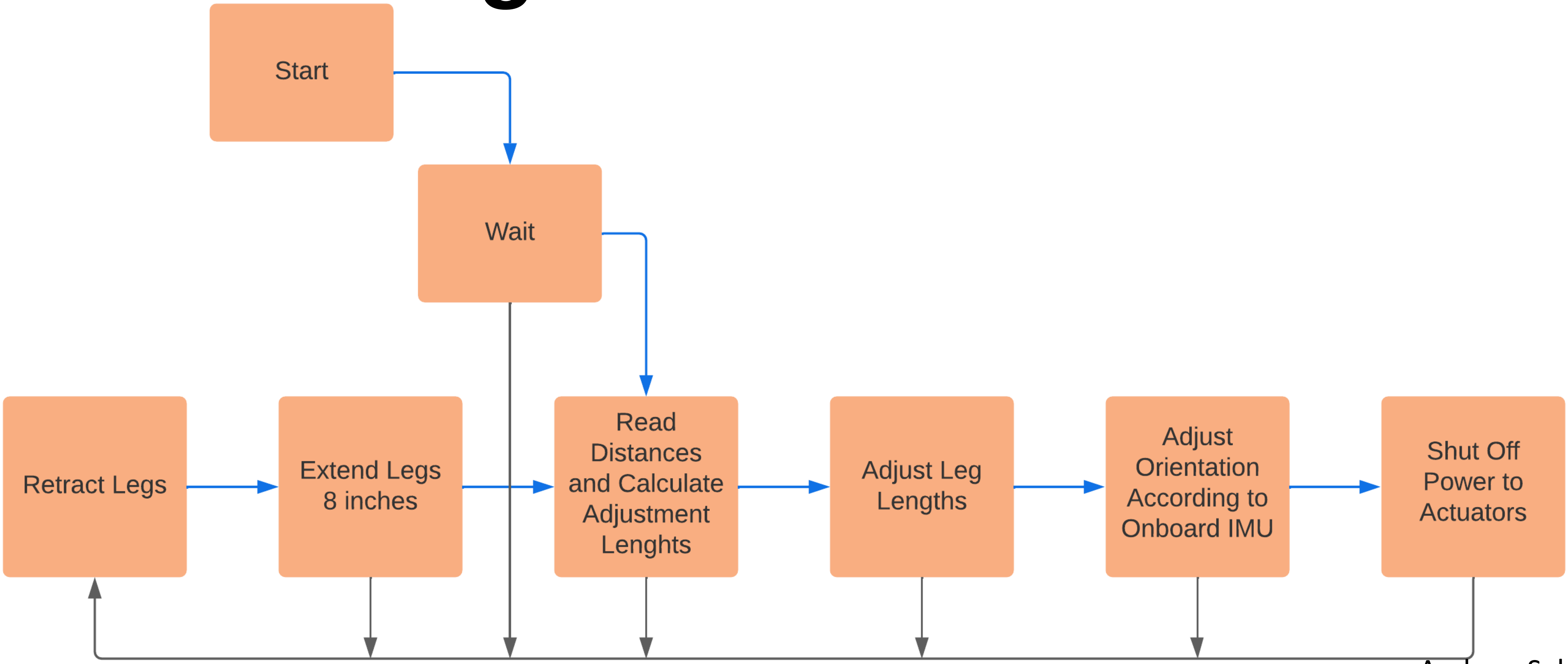
Julio Velasquez

Landing Feet Reinforcement and Testing

Reinforced with metal screws and metal plate to support up to ~880 N

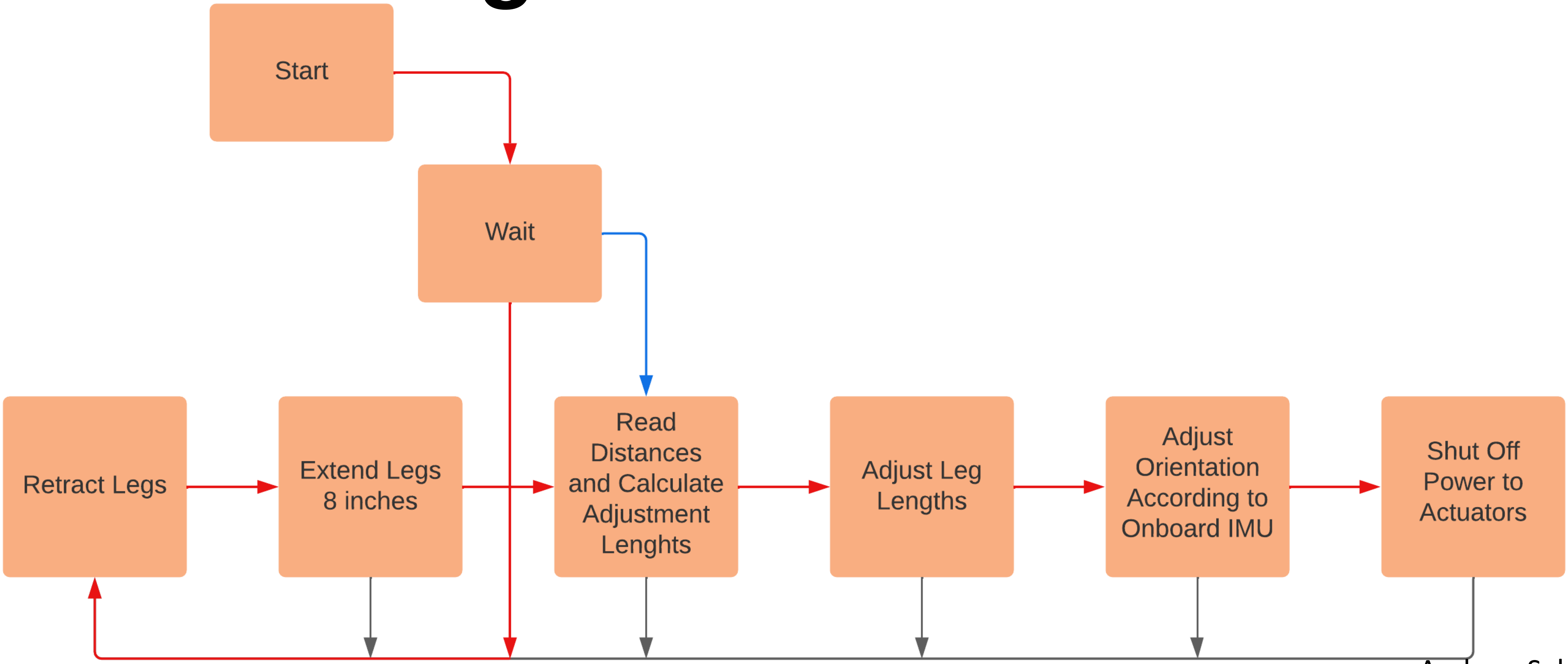
Julio Velasquez

Lander Algorithm



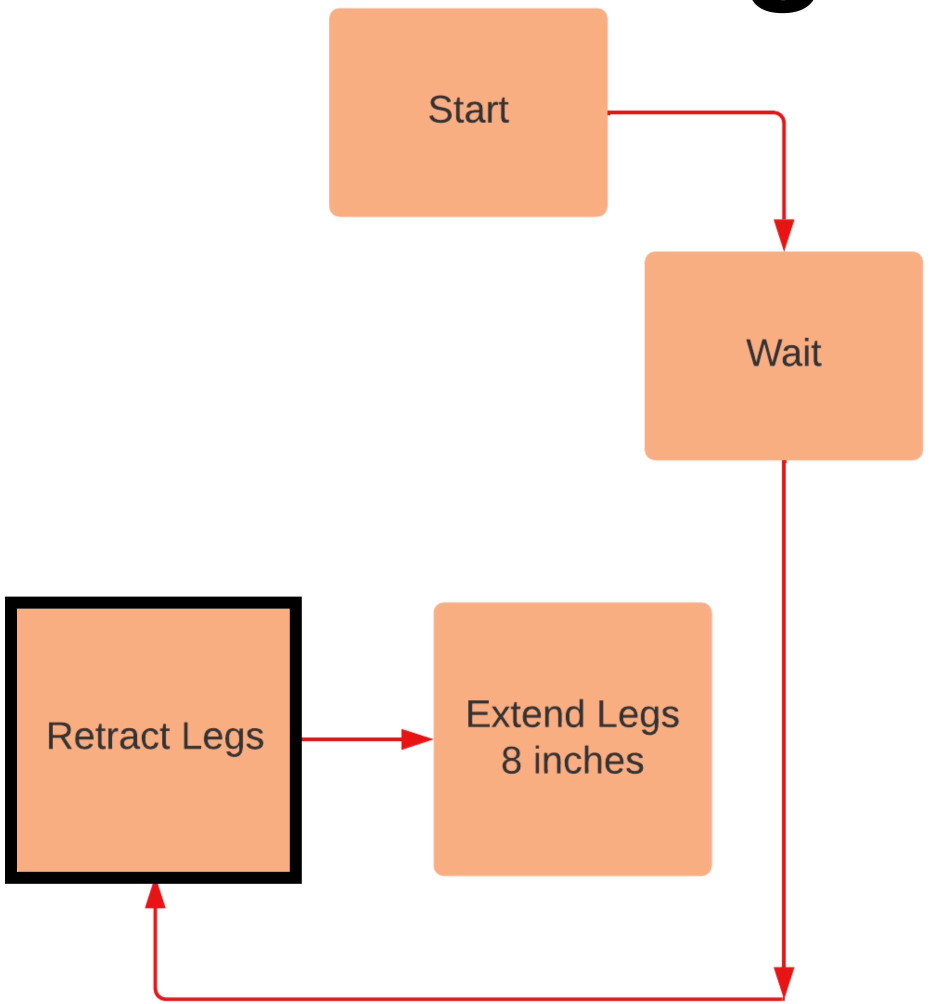
Andrew Sak

Lander Algorithm



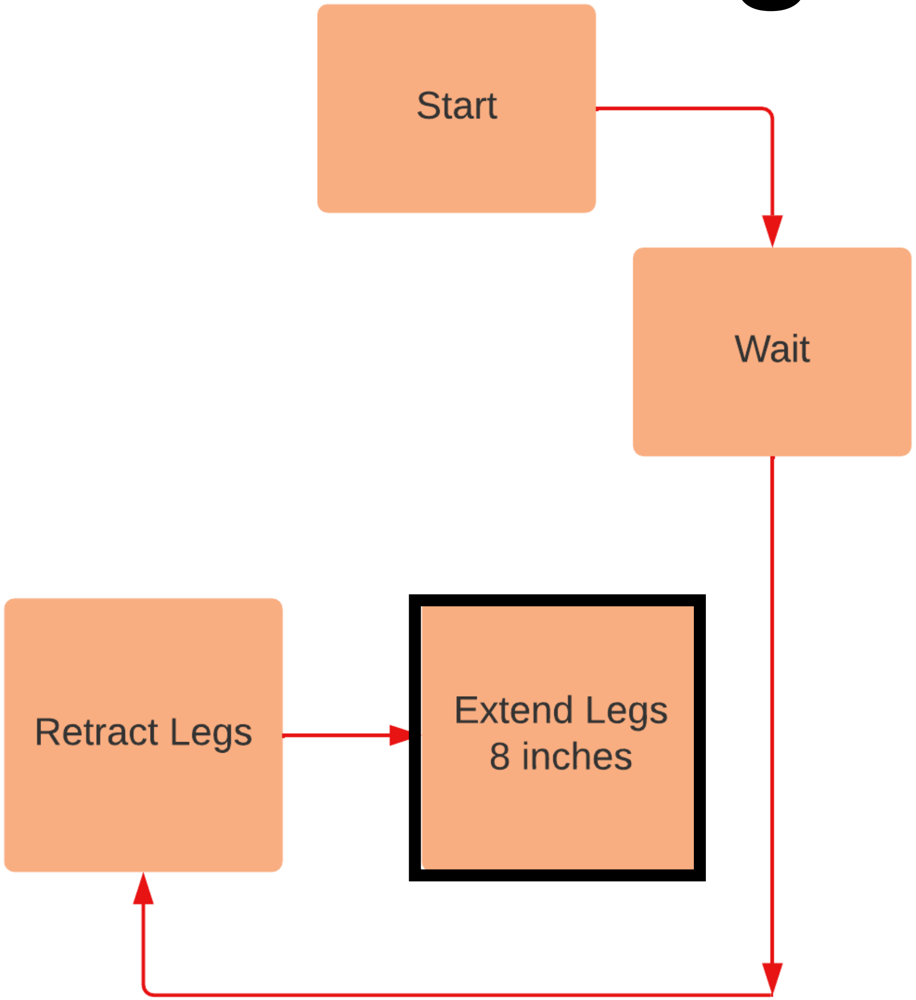
Andrew Sak

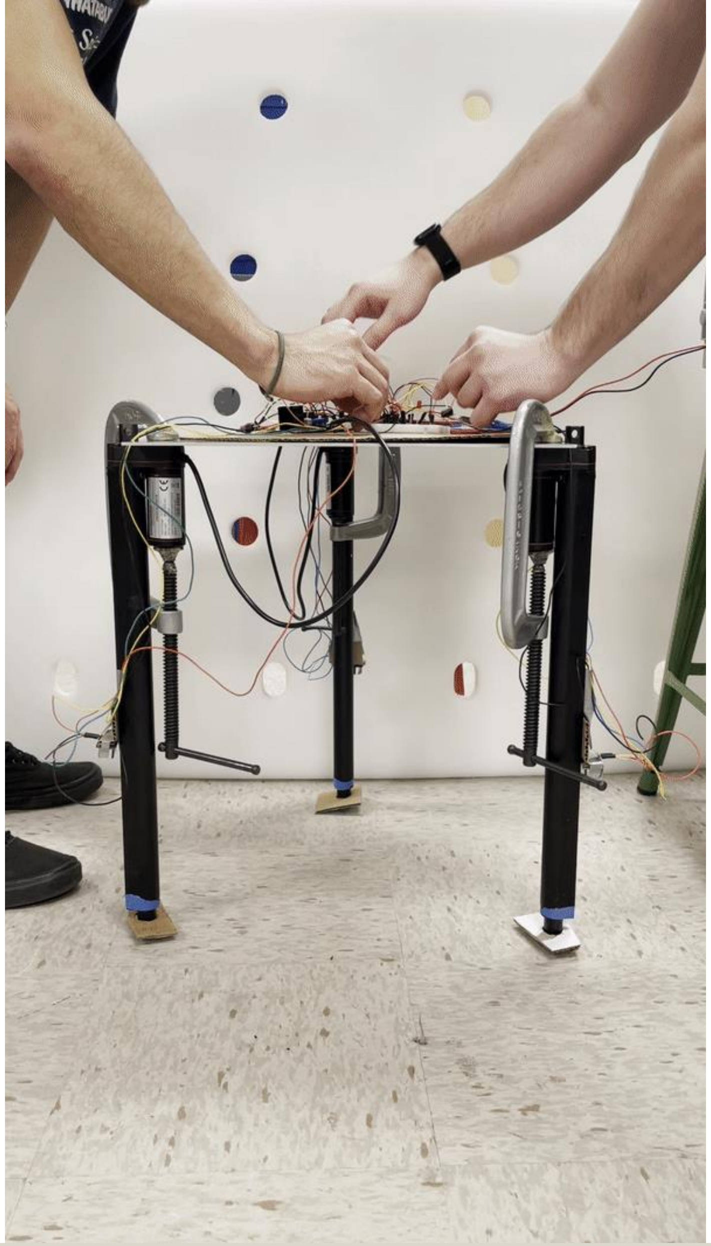
Lander Algorithm



Andrew Sak

Lander Algorithm





Andrew Sak

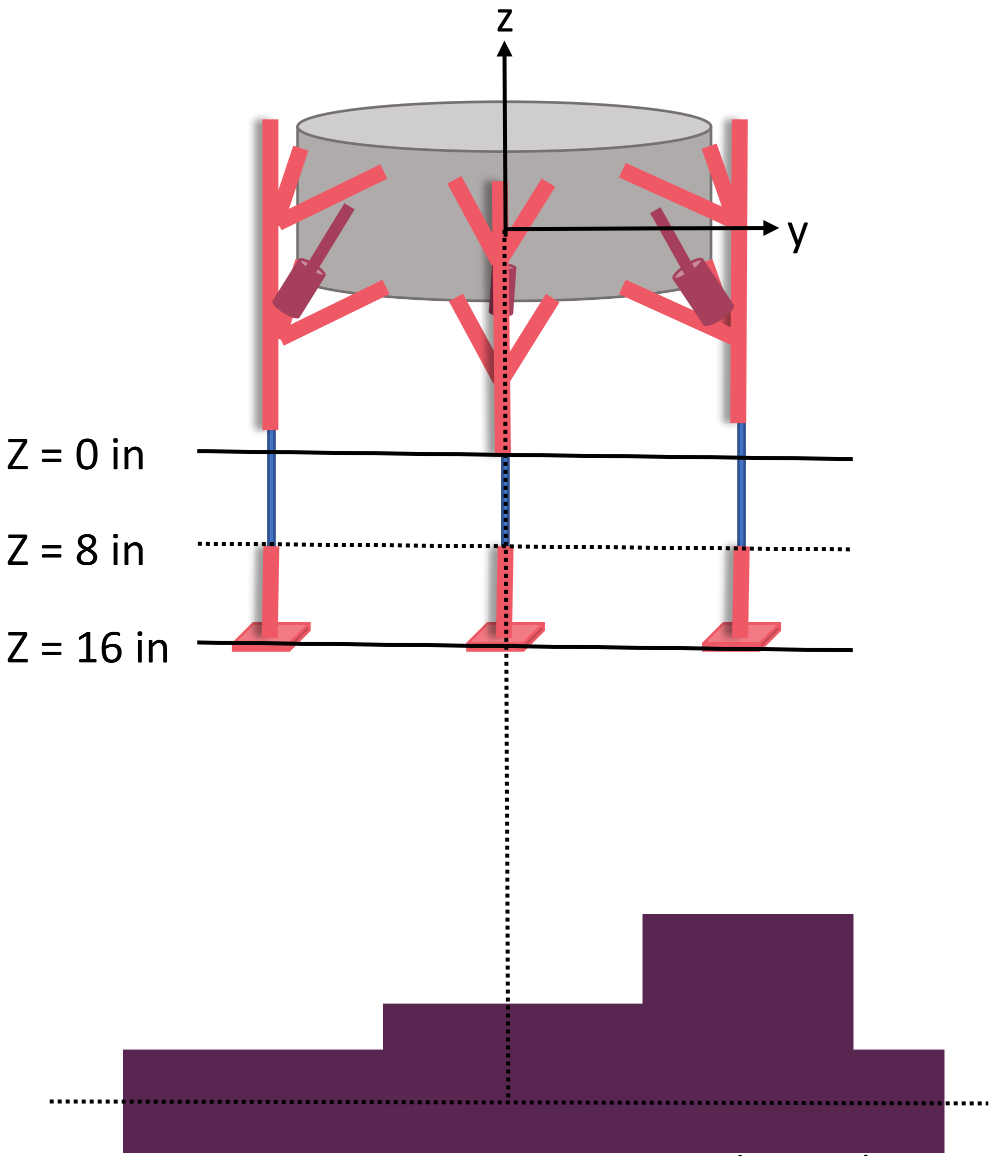
Lander Algorithm

Extend Legs 8 inches

Read Distances and Calculate Adjustment Lenghts

Linear actuators are extended halfway

Lander approach is perpendicular to a predetermined plane

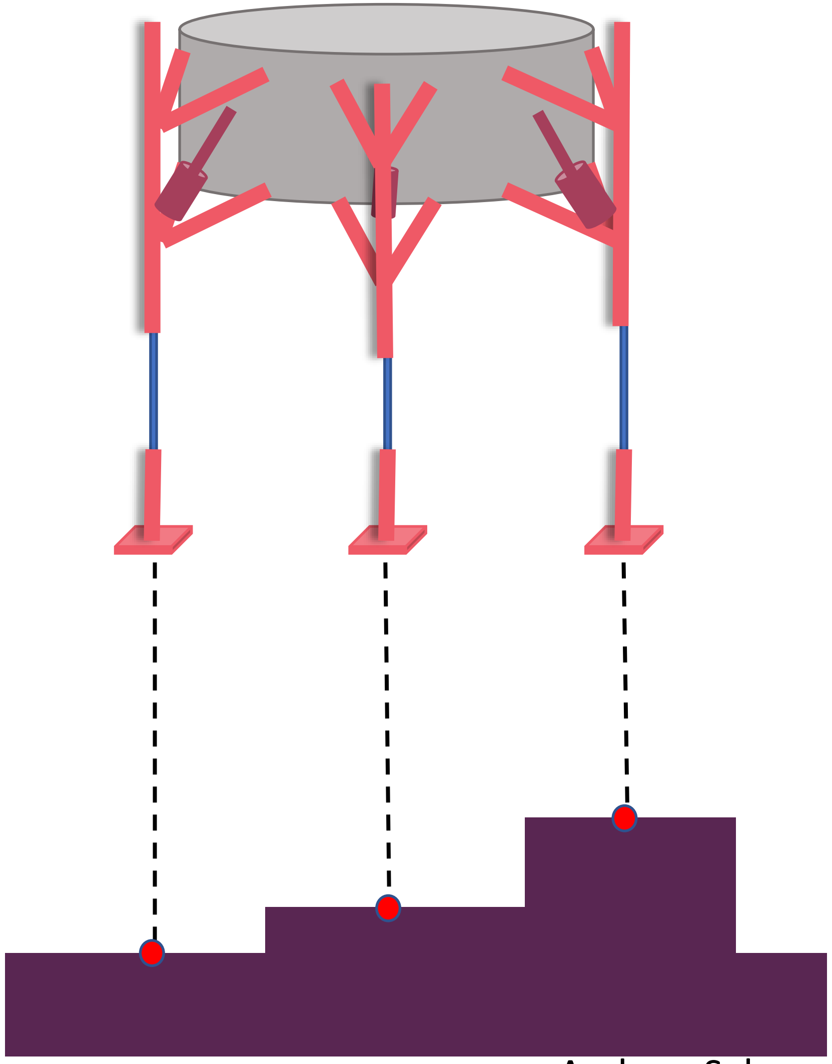


Andrew Sak

Lander Algorithm

Extend Legs 8 inches → Read Distances and Calculate Adjustment Lenghts

1. Read distance from sensor to terrain below



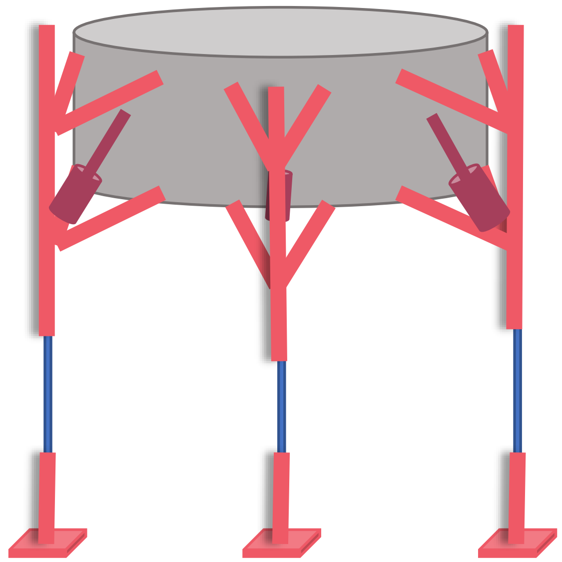
Andrew Sak

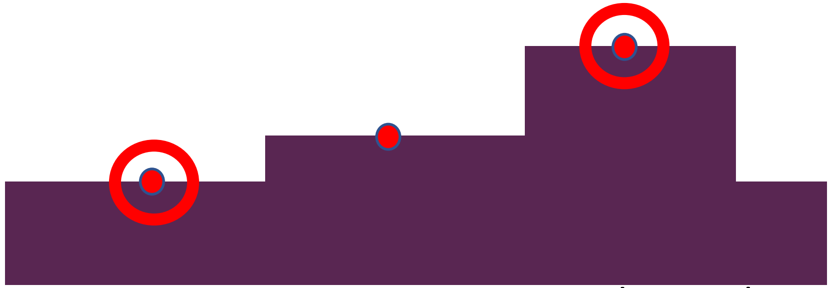
Lander Algorithm

Extend Legs 8 inches → Read Distances and Calculate Adjustment Lenghts

1. Read distance from sensor to terrain below

2. Find the closest point and farthest point on surface





Andrew Sak

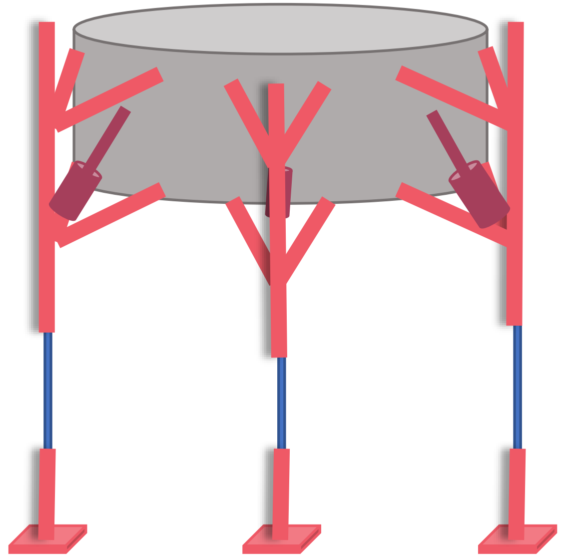
Lander Algorithm

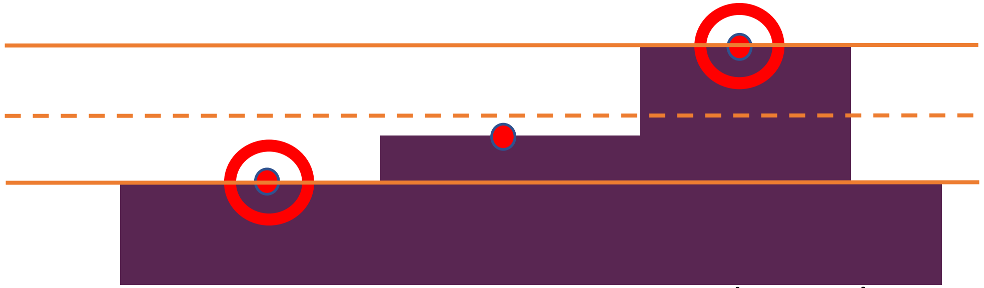
Extend Legs 8 inches → Read Distances and Calculate Adjustment Lenghts

1. Read distance from sensor to terrain below

2. Find the closest point and farthest point on surface

3. Find midplane between closest and farthest point





Andrew Sak

Lander Algorithm

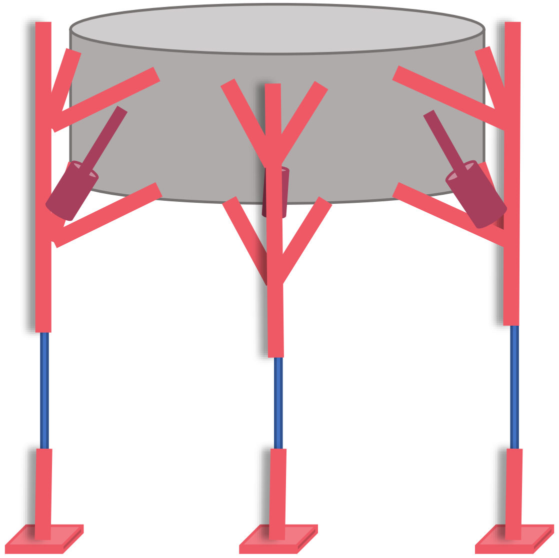
Extend Legs 8 inches → Read Distances and Calculate Adjustment Lenghts

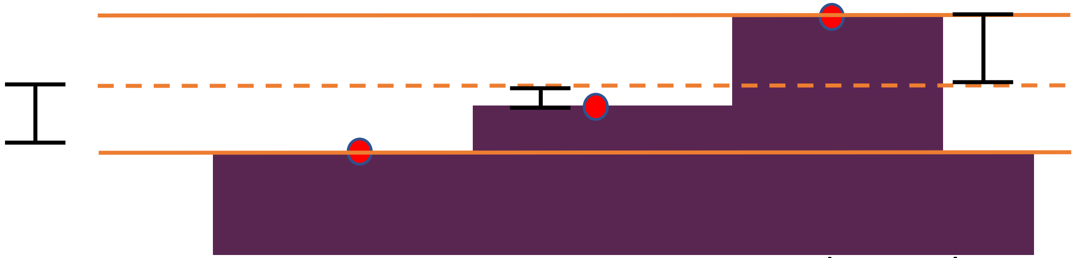
1. Read distance from sensor to terrain below

2. Find the closest point and farthest point on surface

3. Find midplane between closest and farthest point

4. Find distance from midplane to each point on surface



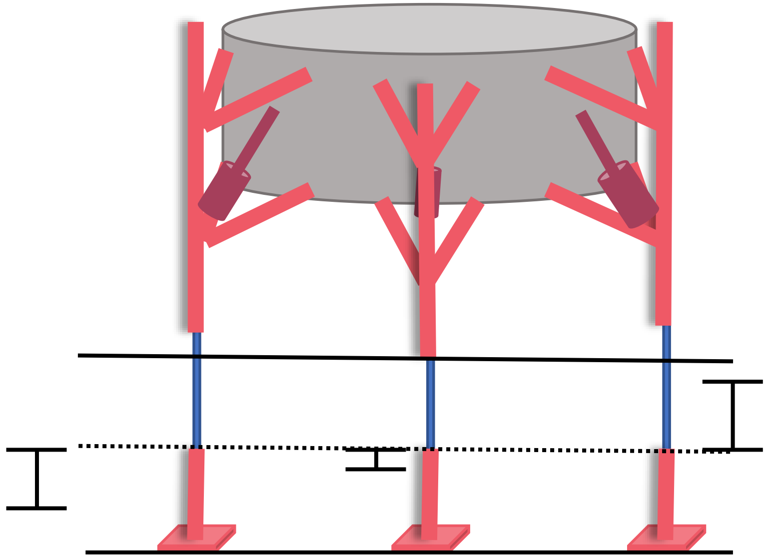


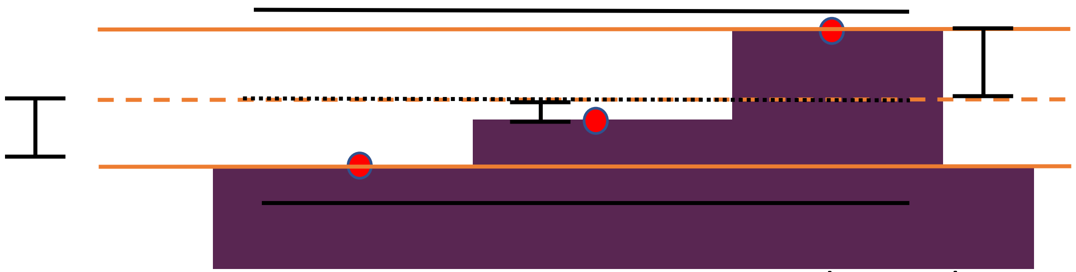
Andrew Sak

Lander Algorithm

Extend Legs 8 inches → Read Distances and Calculate Adjustment Lenghts

1. Read distance from sensor to terrain below
2. Find the closest point and farthest point on surface
3. Find midplane between closest and farthest point
4. Find distance from midplane to each point on surface
5. Overlay distances on lander leg frame





Andrew Sak

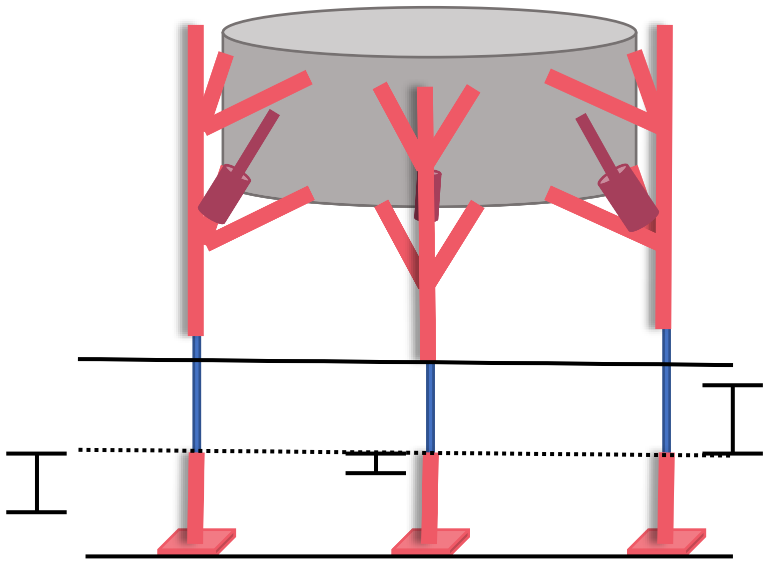
Lander Algorithm

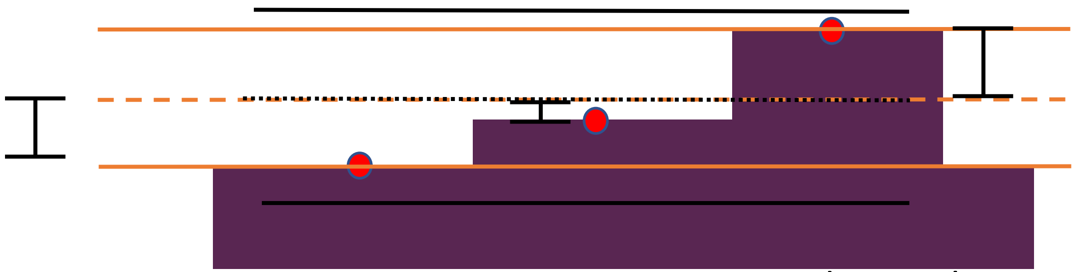
Read Distances and Calculate Adjustment Lenghts → **Adjust Leg Lengths**

Calculated adjustment lengths used to control actuators

Points below the midplane cause actuators to extend

Points above the midplane cause actuators to retract





Andrew Sak

Lander Algorithm

Read Distances and Calculate Adjustment Lenghts → Adjust Leg Lengths

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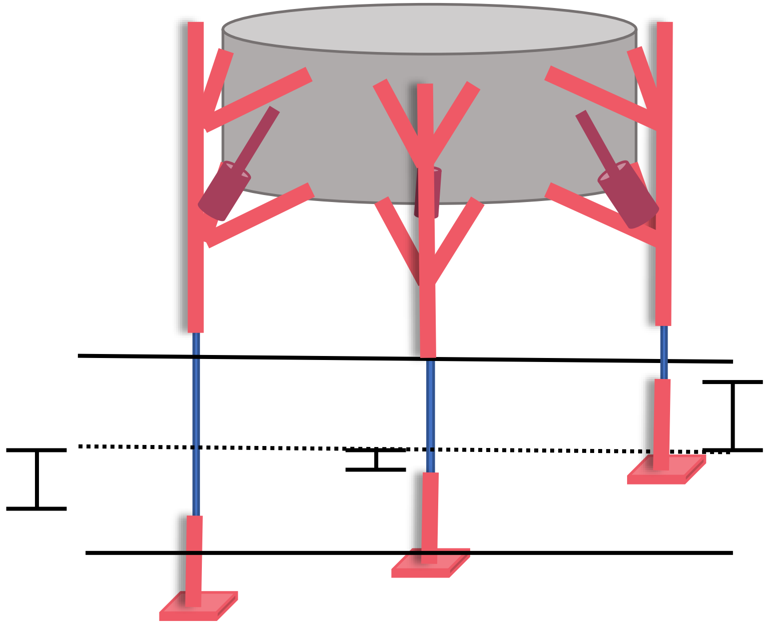

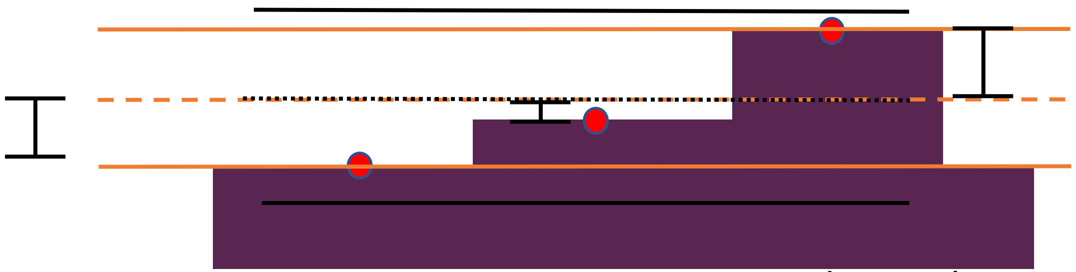

Andrew Sak

Lander Algorithm

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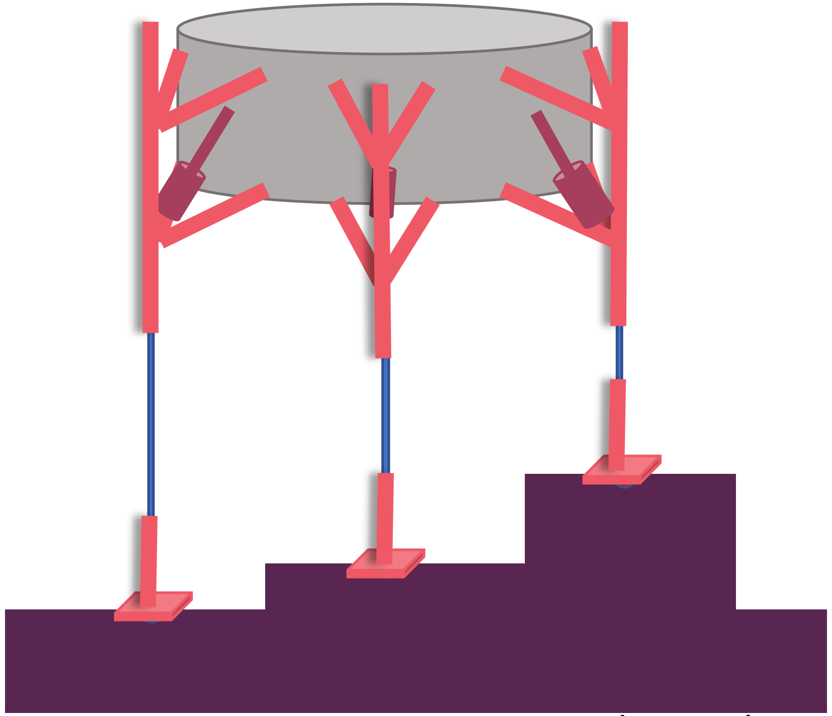

Andrew Sak

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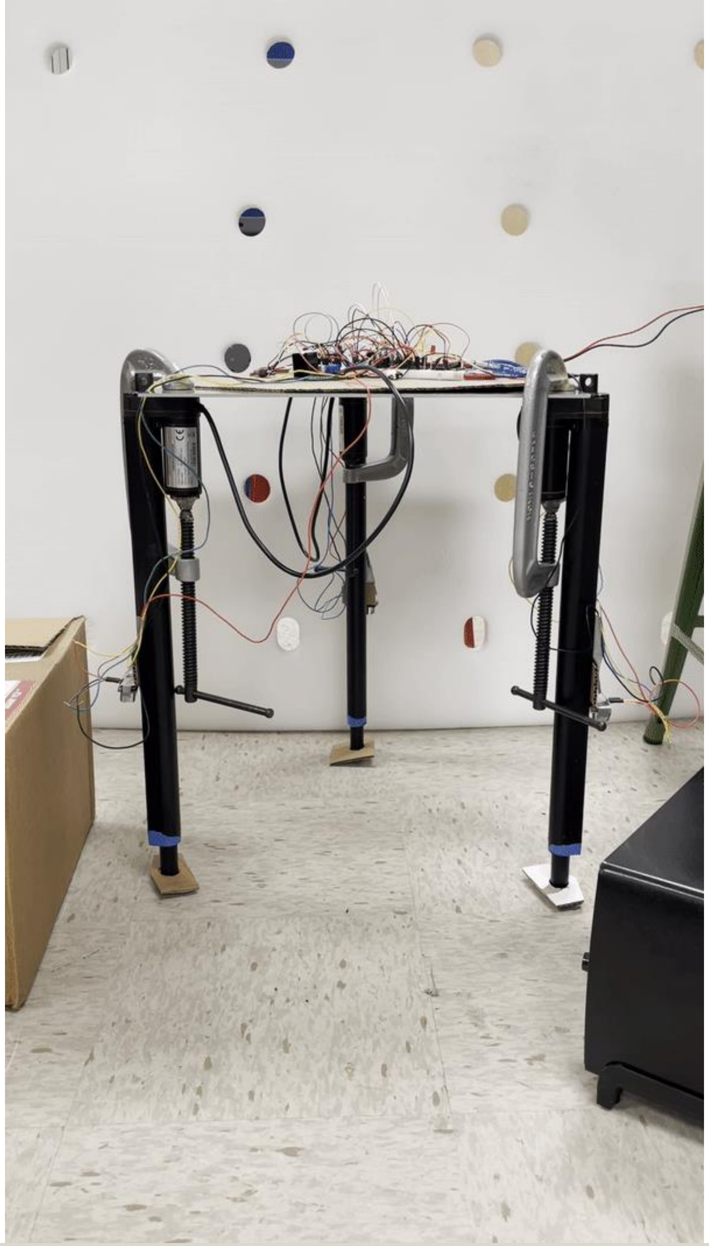

Andrew Sak

Lander Algorithm

Read Distances and Calculate Adjustment Lenghts → Adjust Leg Lengths

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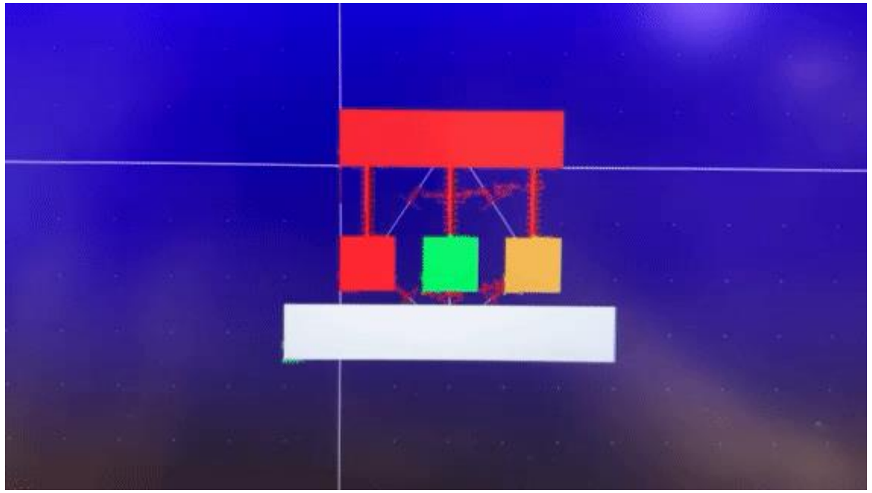
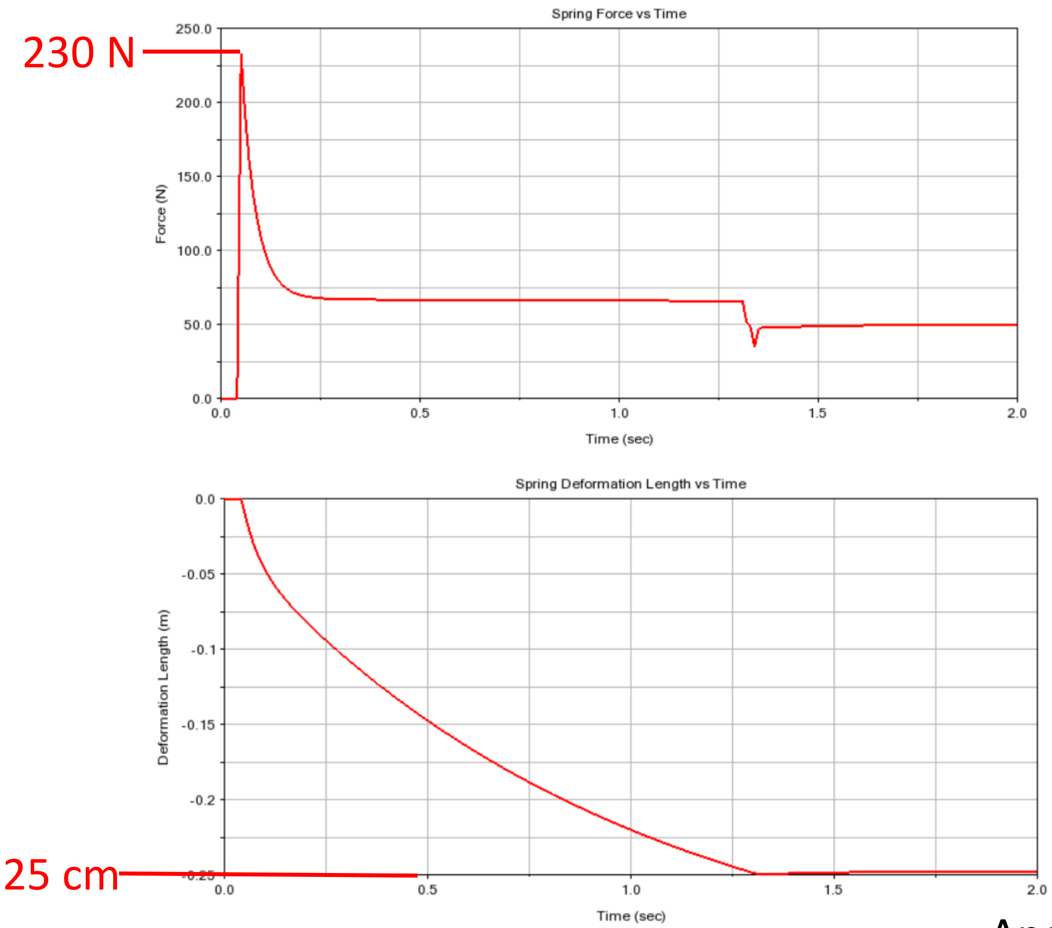
Andrew Sak

Simple Adams Simulation

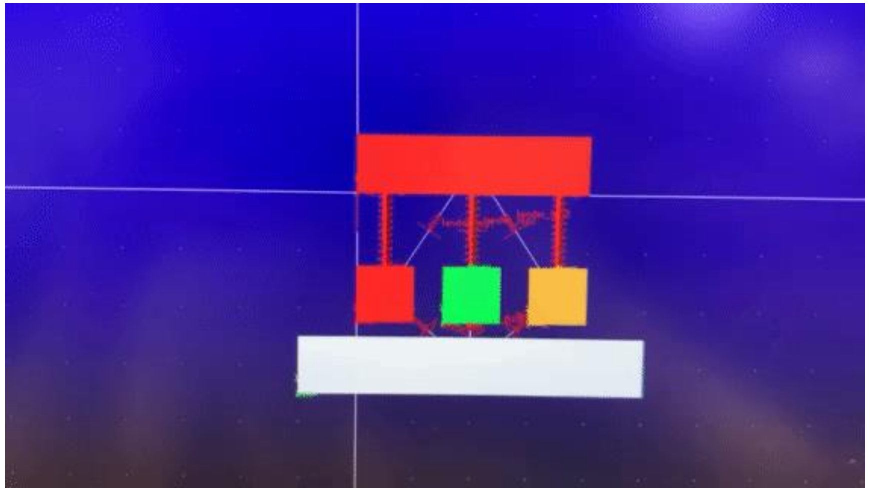


Failed Dampers

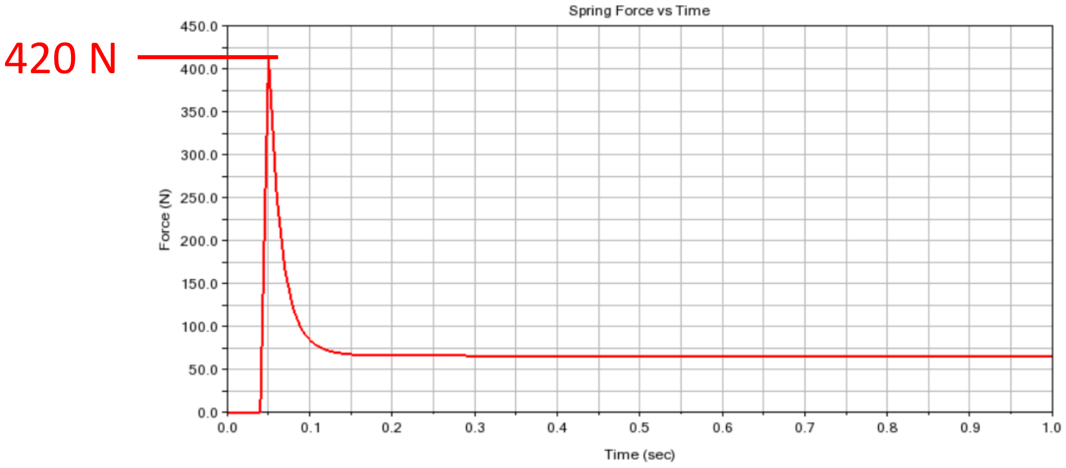


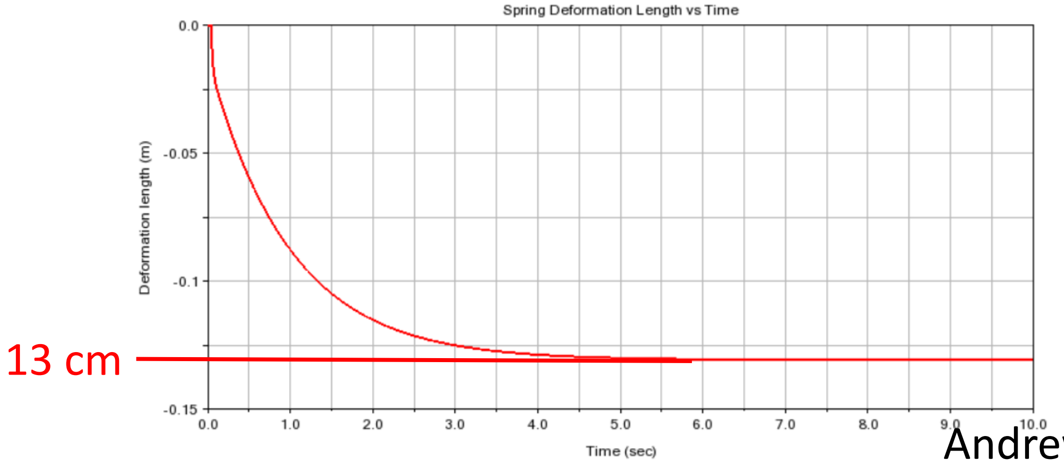
Andrew Sak

Simple Adams Simulation



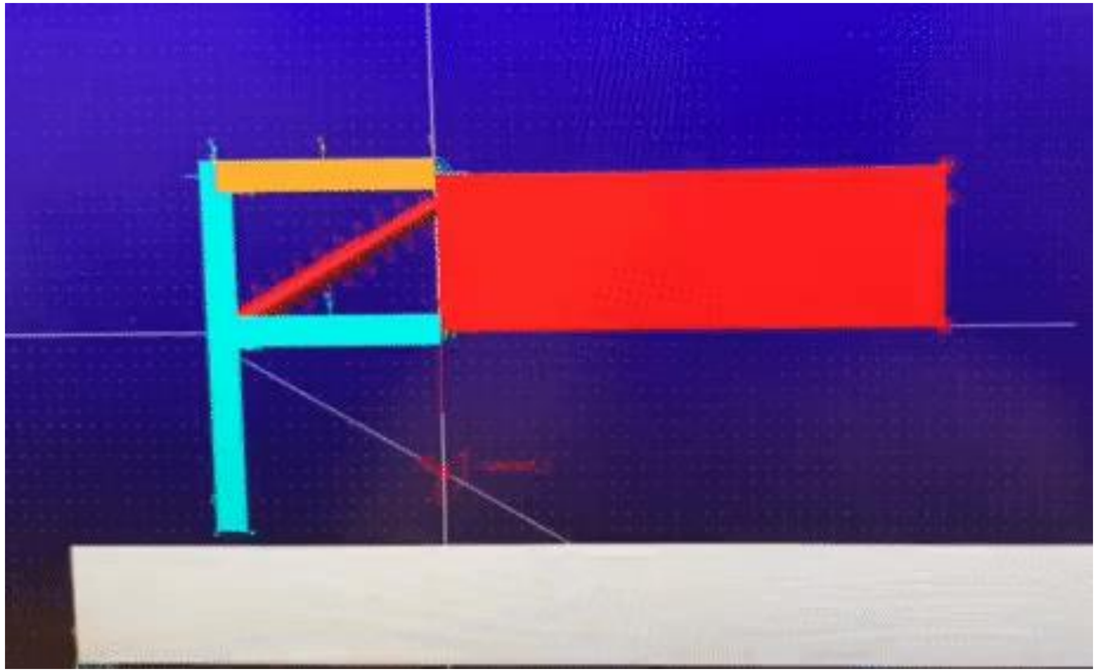
Successful Dampers



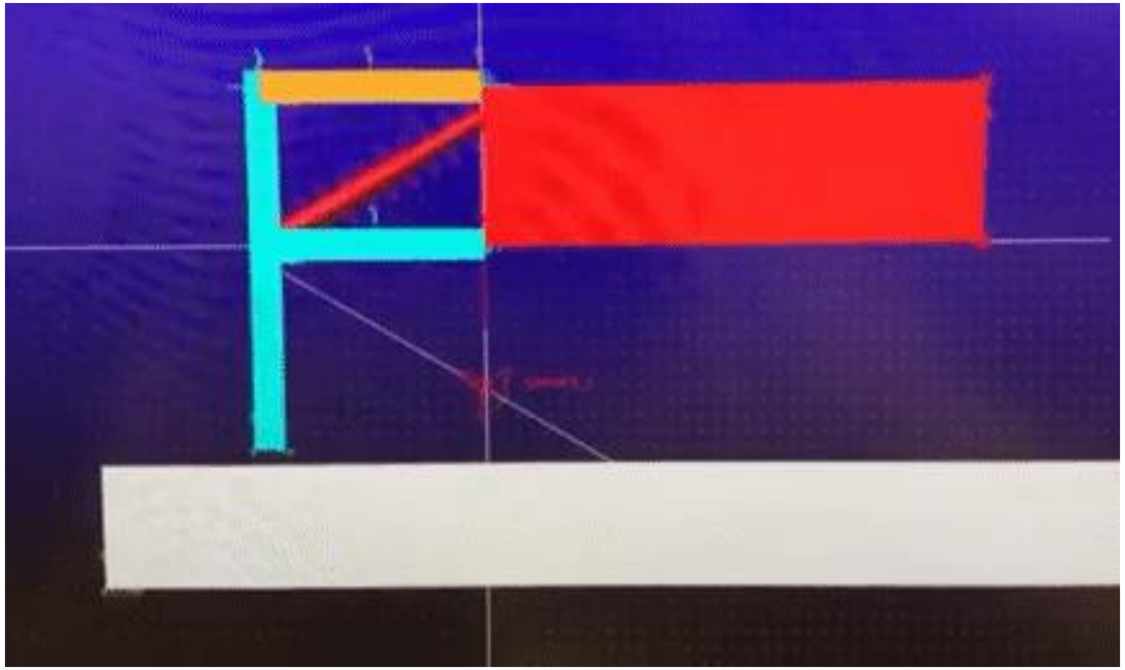


Andrew Sak

Complex Adams Simulation



Low Damping Coefficient



High Damping Coefficient

Andrew Sak

Continuing/Future Work

Continue Ordering Parts

Continue Experimentation with Sensors

Continue Constructing Prototype and Begin Building Test Rig

Physical Testing and Verification

Andrew Sak

Contact Information

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Connect on LinkedIn:

Andrew Sak
Email: avs15b@my.fsu.edu
Connect on LinkedIn:

Julio Velasquez
Email: jav19e@my.fsu.edu
Connect on LinkedIn:

Assumptions

Test model and forces are analogous to Psyche mission variables

Attaches to future spacecraft without issue

Controlled Autonomously

Operated in minimal gravity, space like temperatures and conditions

Perform a soft landing on Psyche

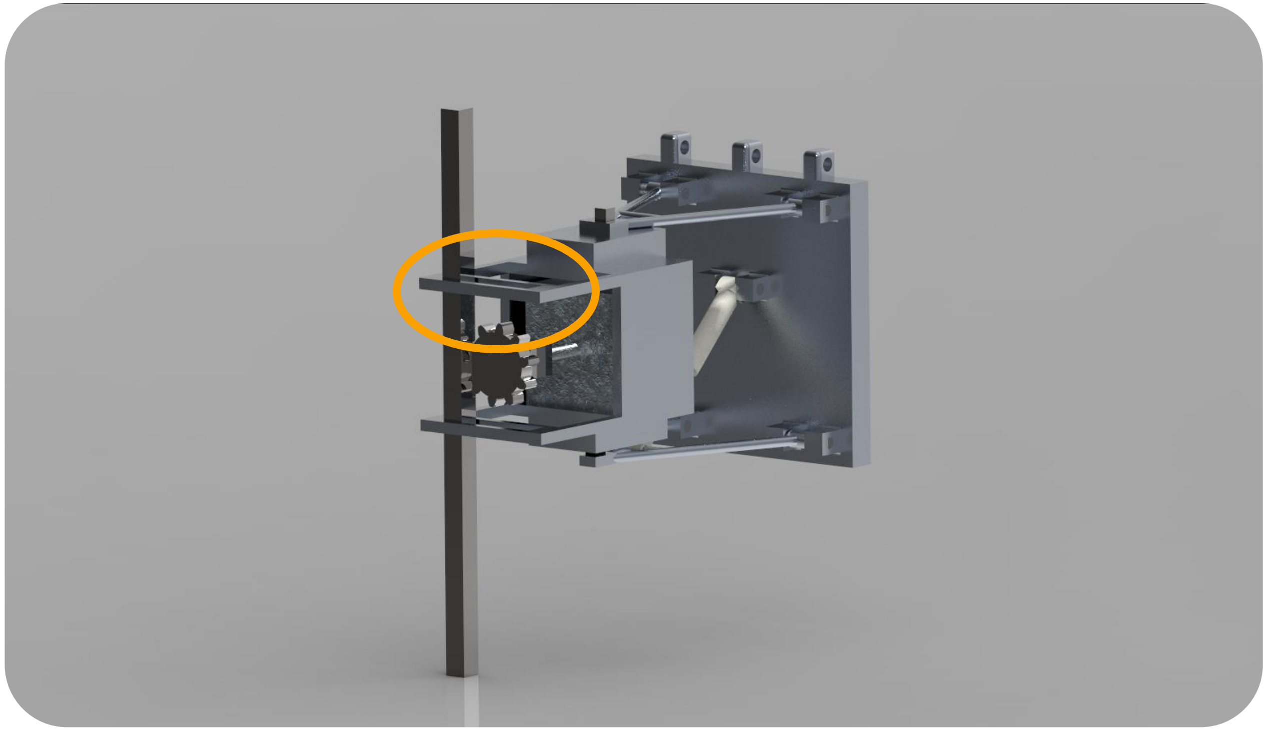
Power supplied by spacecraft

Elzbieta Krekora

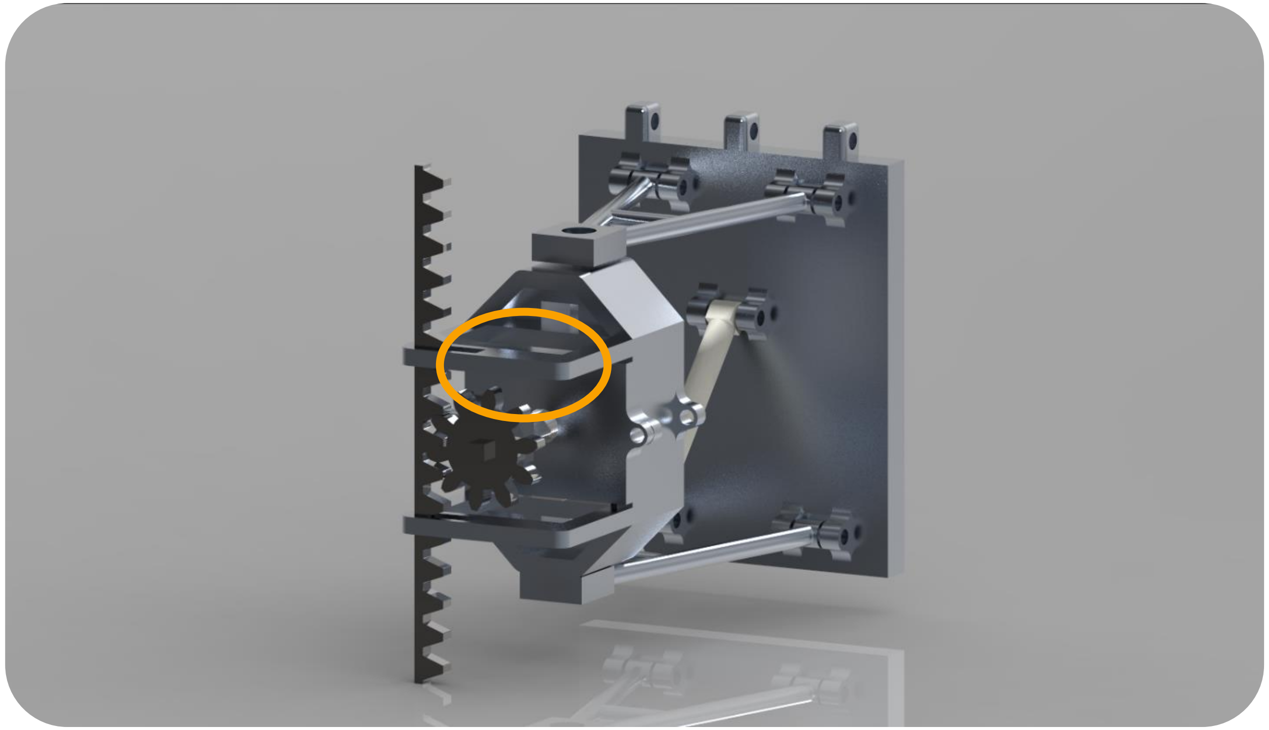
Prototype/Testing Planning

Elzbieta Krekora

Adjustment of Design: Knuckle



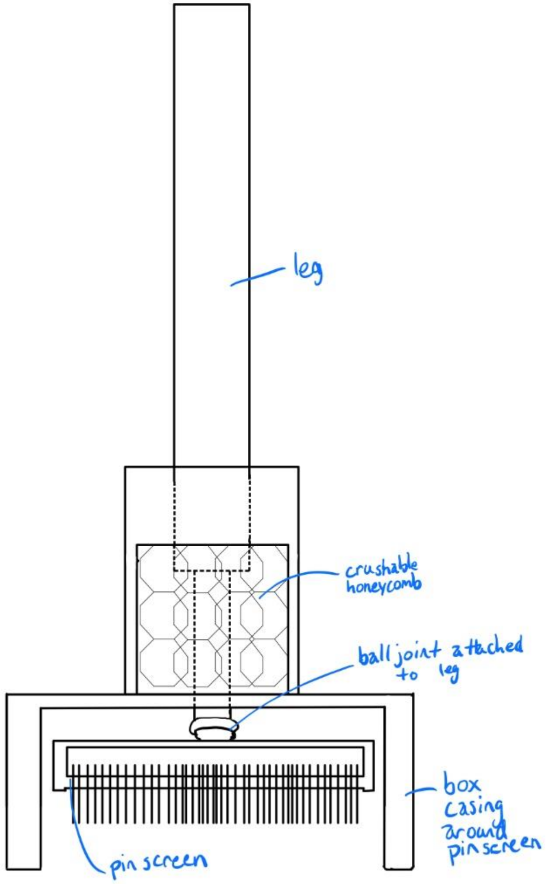
Original Design of Knuckle



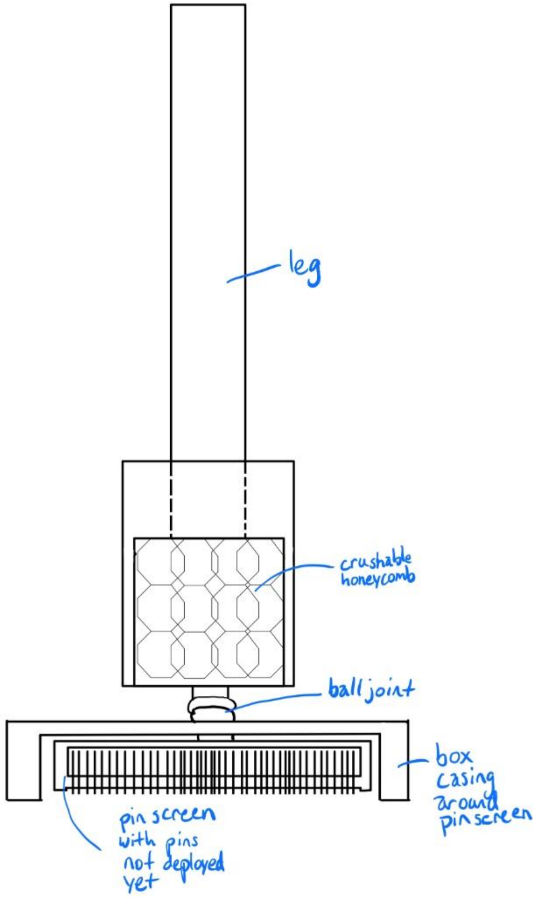
Modified Design of Knuckle

Elzbieta Krekora

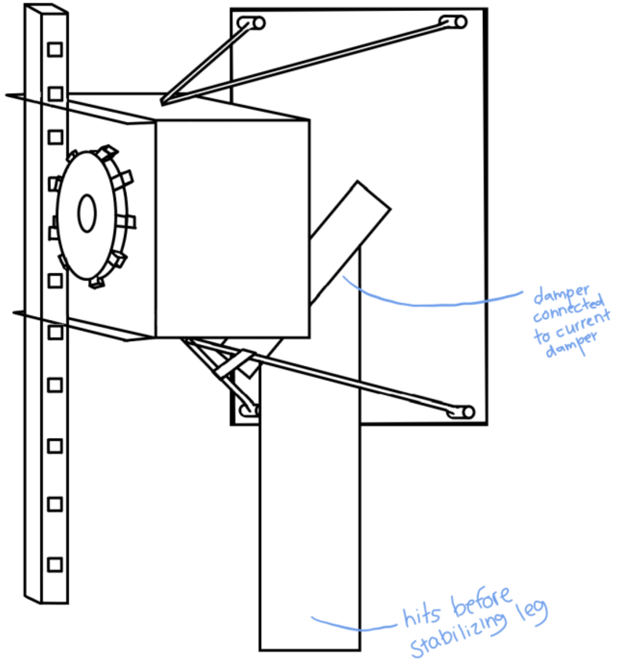
Adjustment of Design: Additional Damping



Design 1: Damping Attached to Foot (Attachment 1)



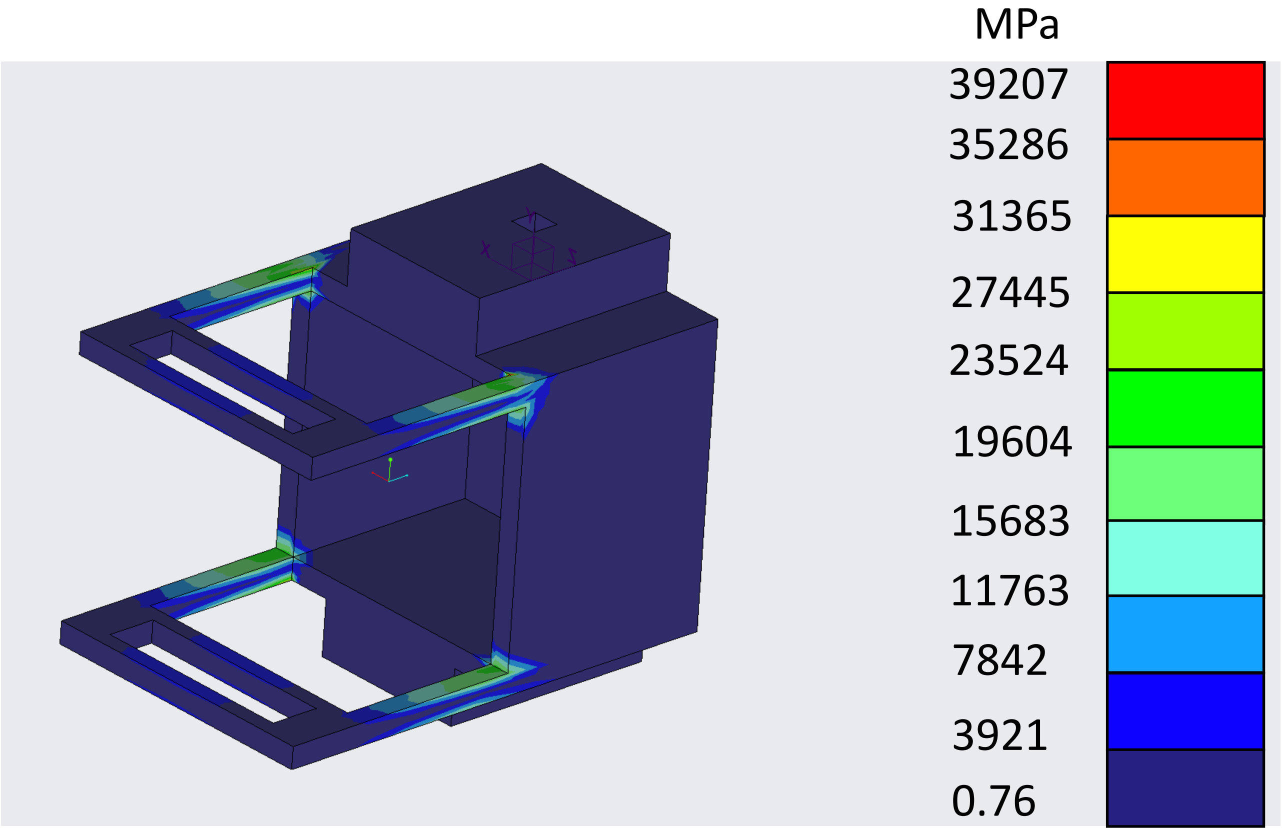
Design 2: Damping Attached to Foot (Attachment 2)



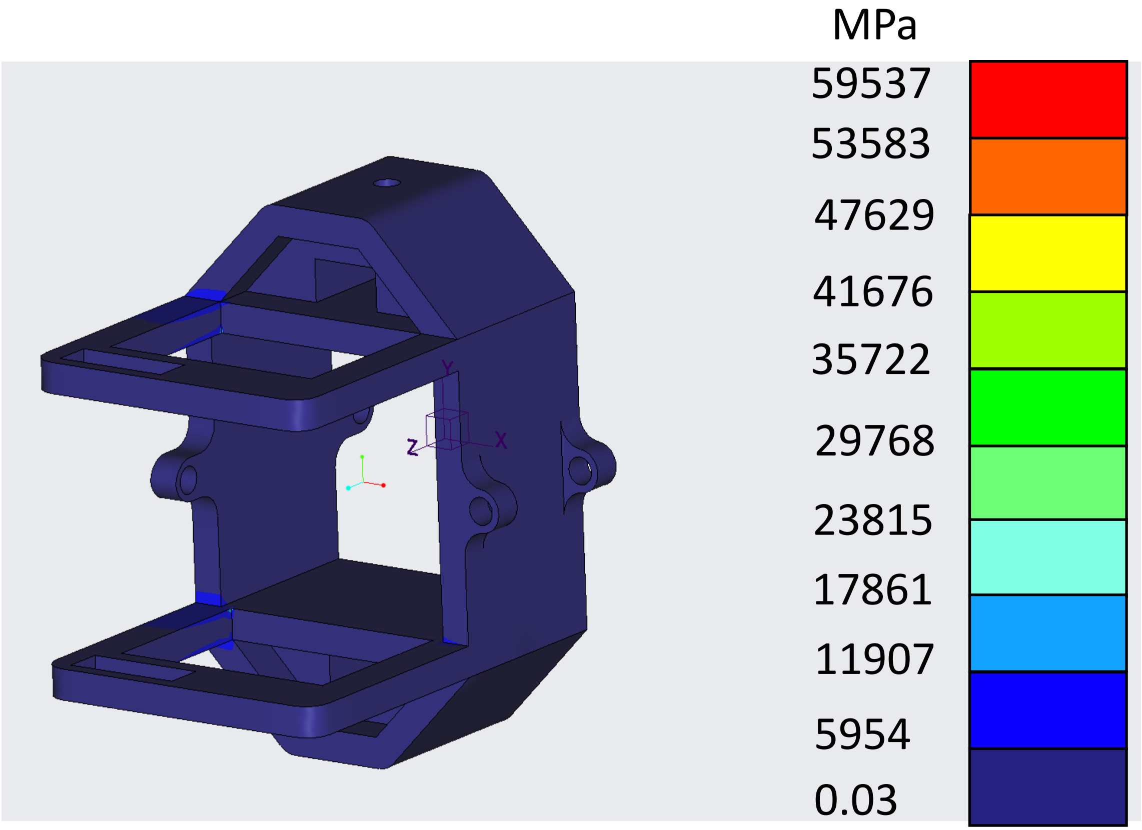
Design 3: Damping Attached to Separate Component

Saralyn Jenkins

Creo Simulation: Knuckle



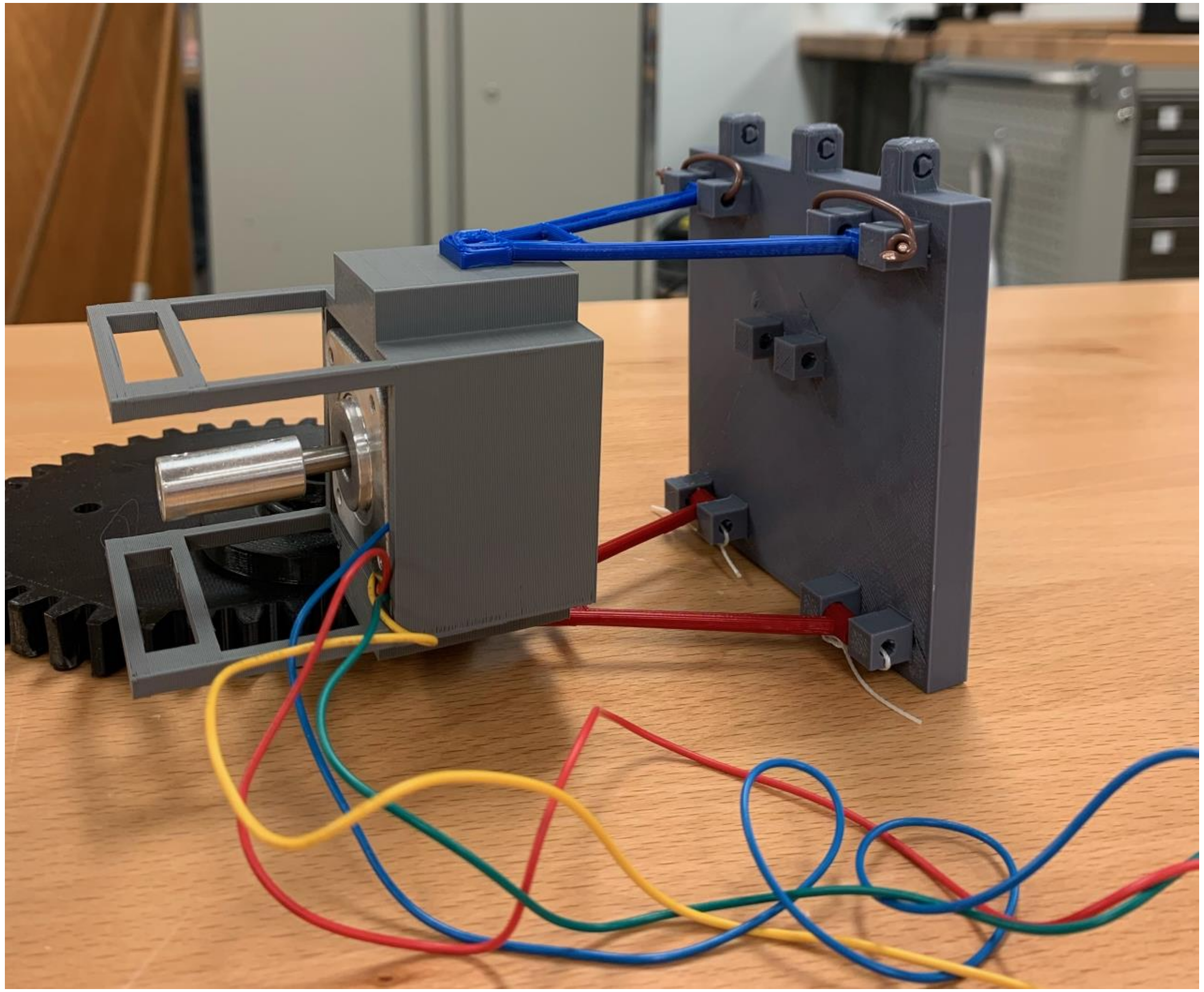
Original Design of Connector



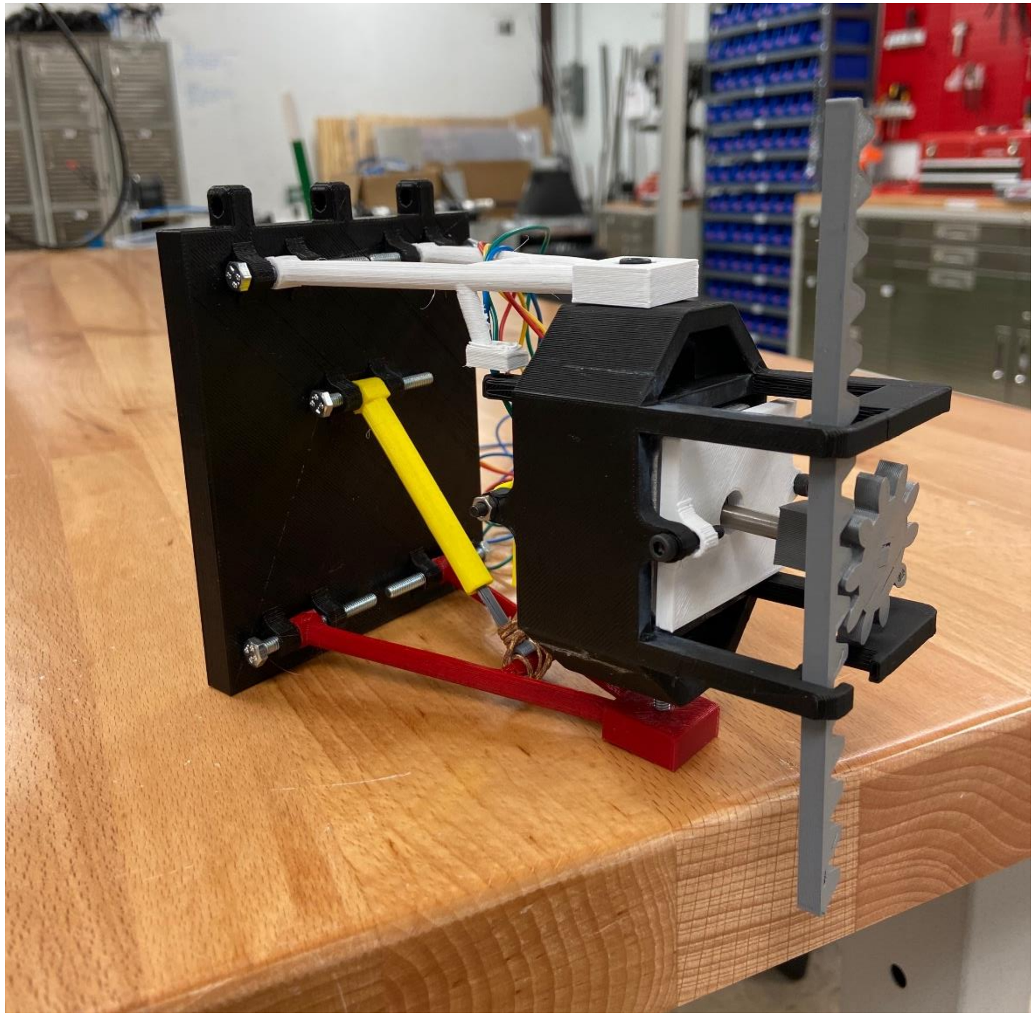
Modified Design of Connector

Saralyn Jenkins

3D Print of Model

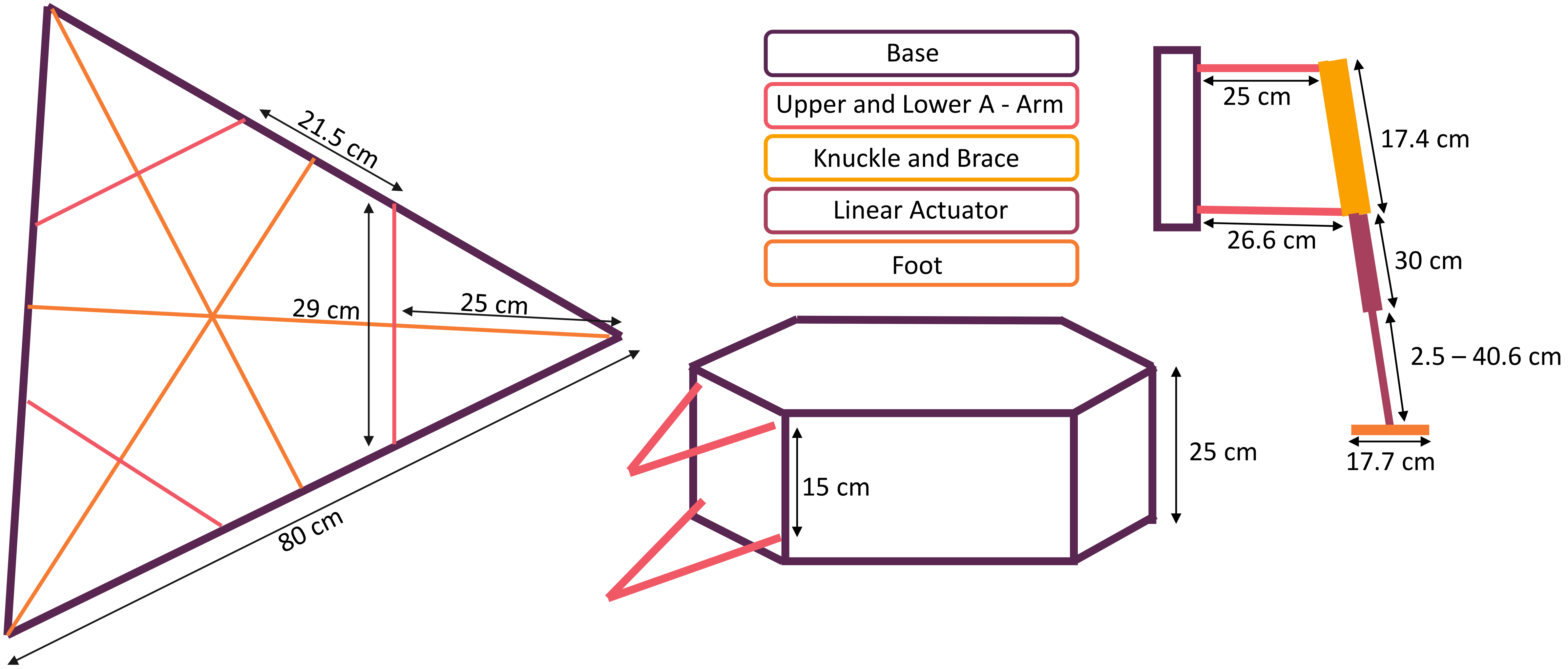


First Print

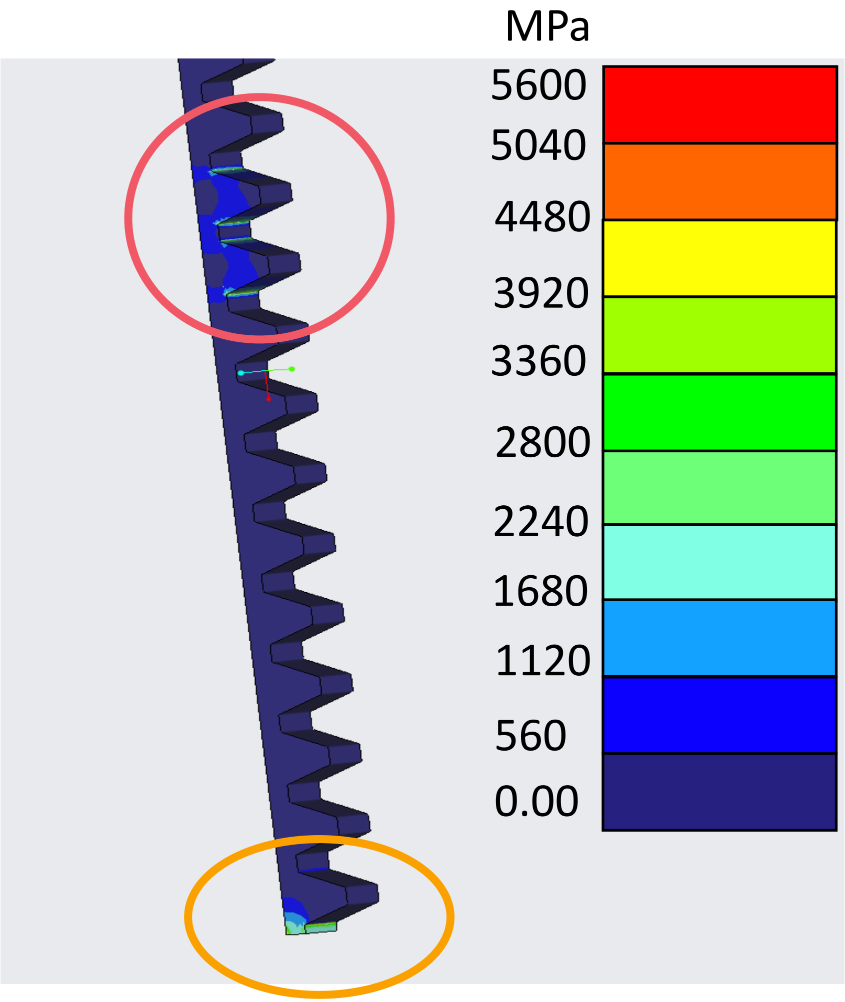


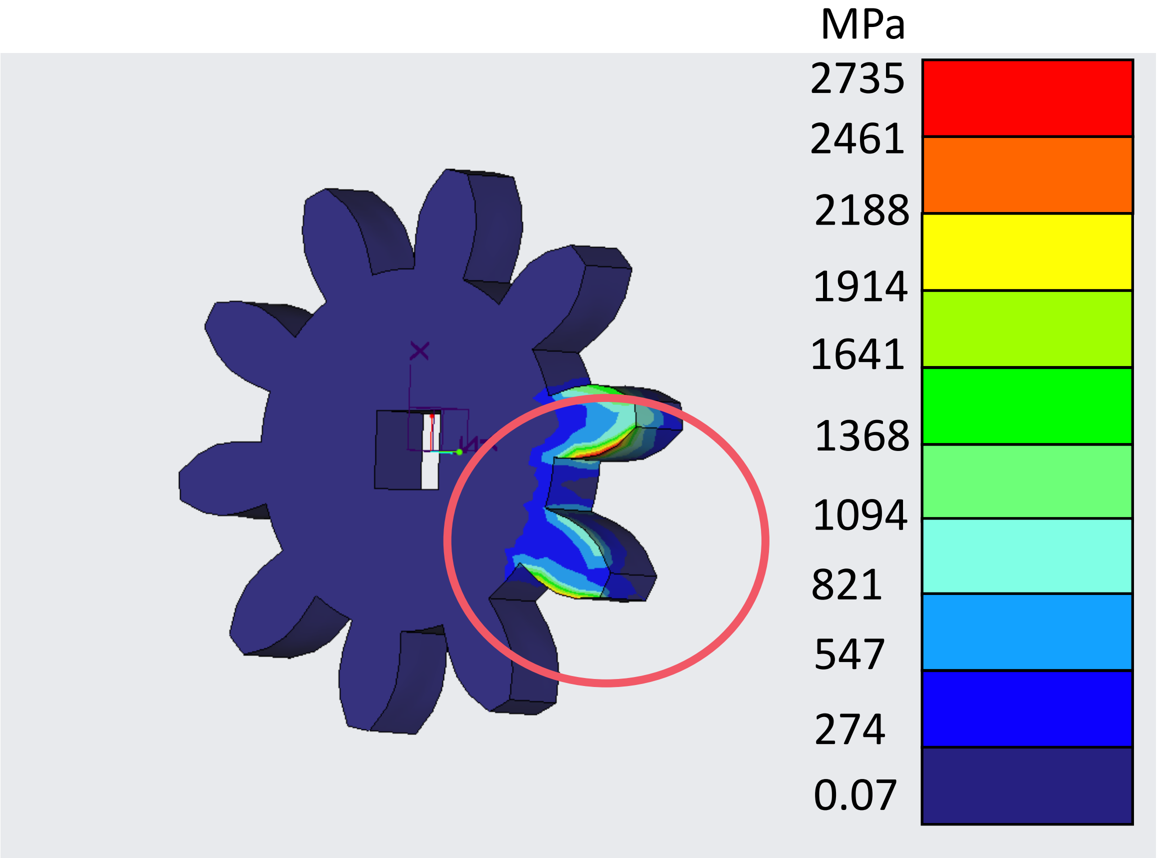
Second Print

Sizing of Prototype



Creo Simulation: Rack and Pinion



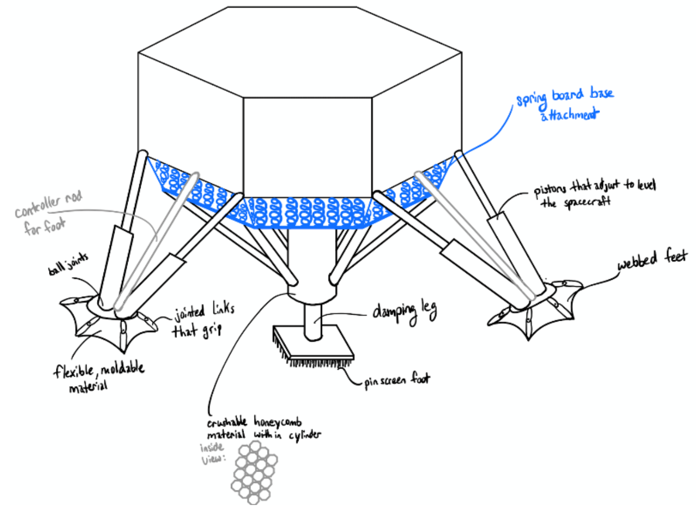


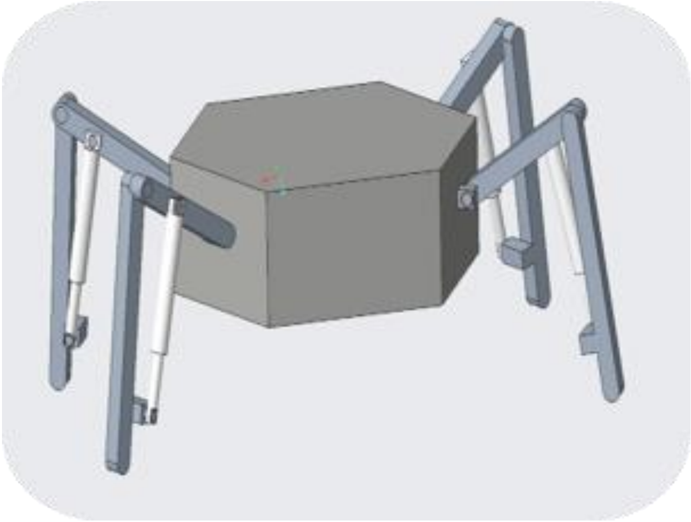
Contact Point with Ground

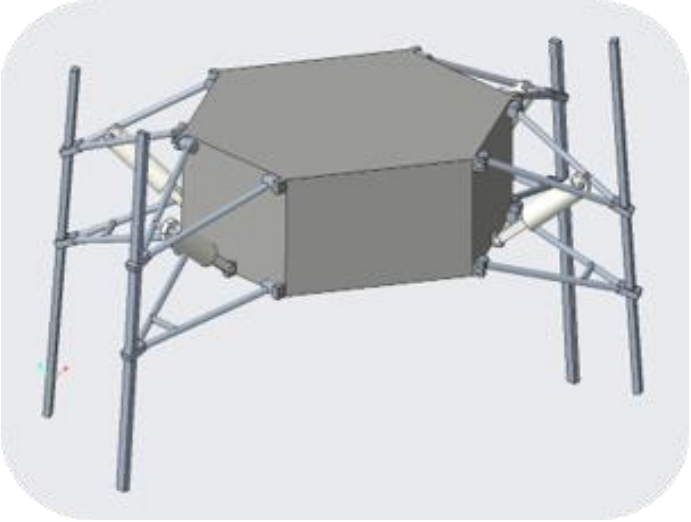
Contact Point Between Gears

Saralyn Jenkins

Concept Selection







Single Impact Leg, Springboard Base, 3 Stability Legs

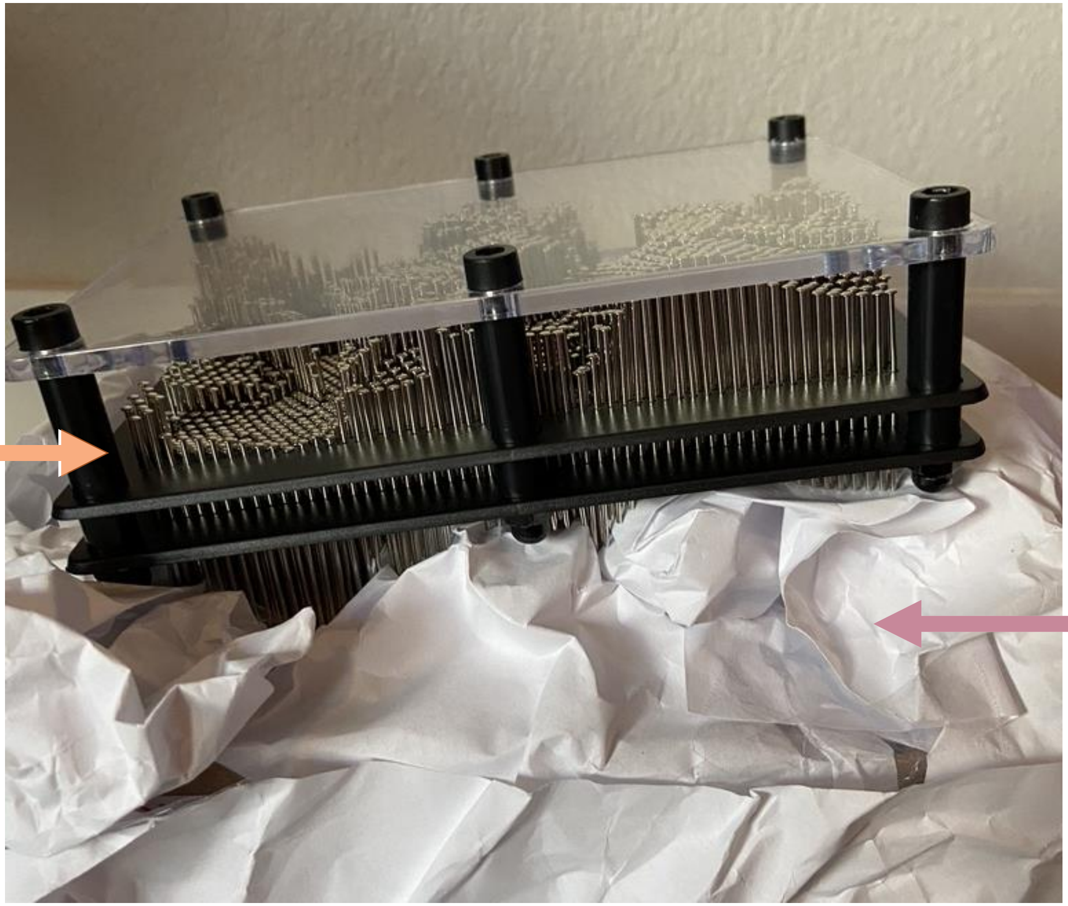
Grasshopper Suspension

Double A-arm Suspension

Saralyn Jenkins

Original Landing Feet Design

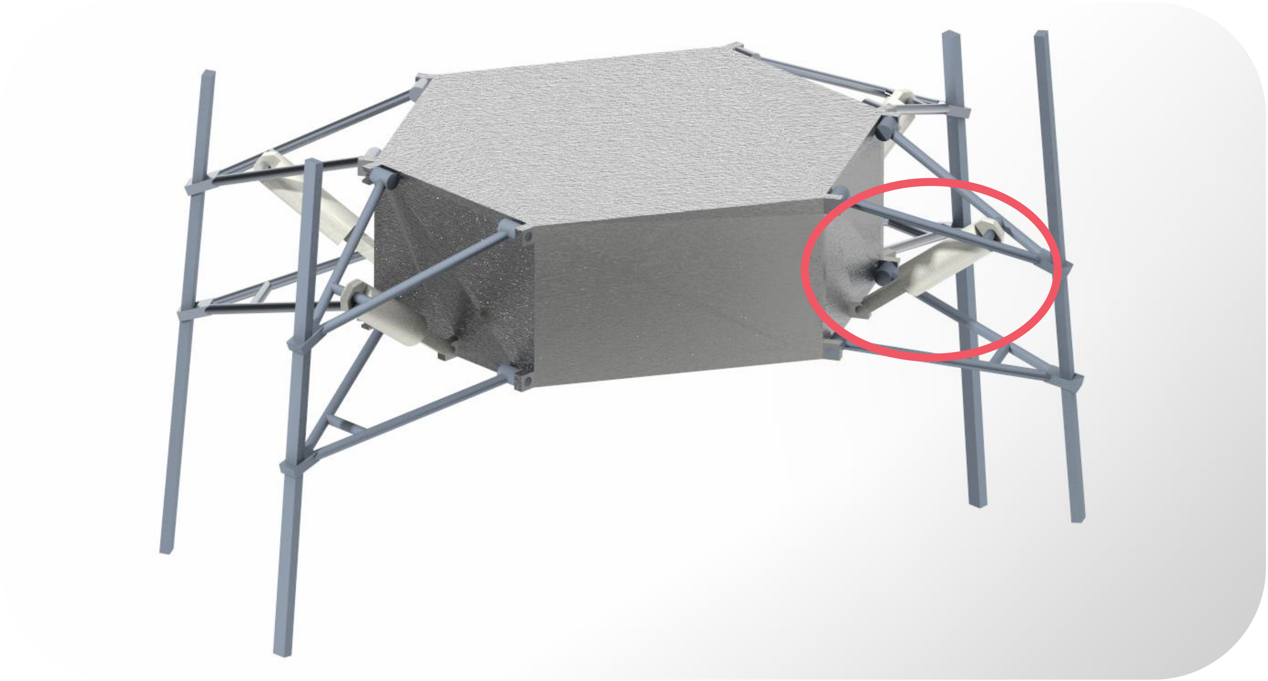
Pin screen with closely packed pins that conform to shape of surface it is placed on



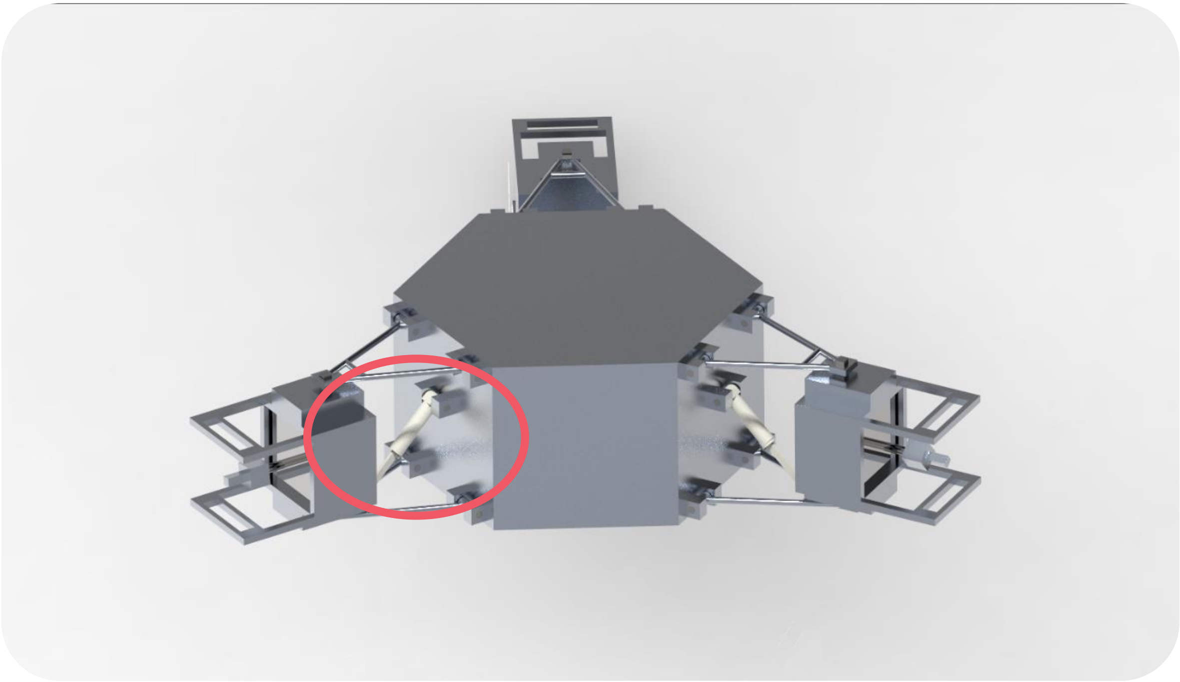
Uneven terrain made of paper

Saralyn Jenkins

Adjustment of Design: Suspension



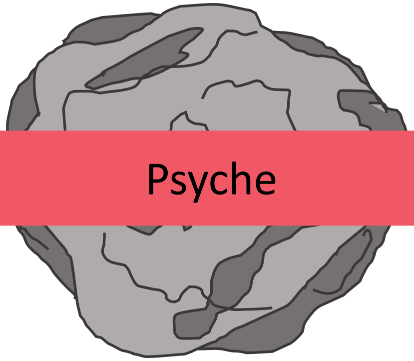
Original Design (Feet Not Shown)



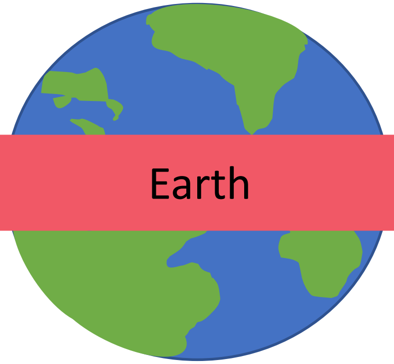
Modified Design (Legs and Feet Not Shown)

Elzbieta Krekora

Transfer of Design



Psyche



Earth

Idk if we need this,
But I made it just in case we
Want to clarify

Honey comb -→ shock absorber
Spacegrade materials --> aluminum and plastic