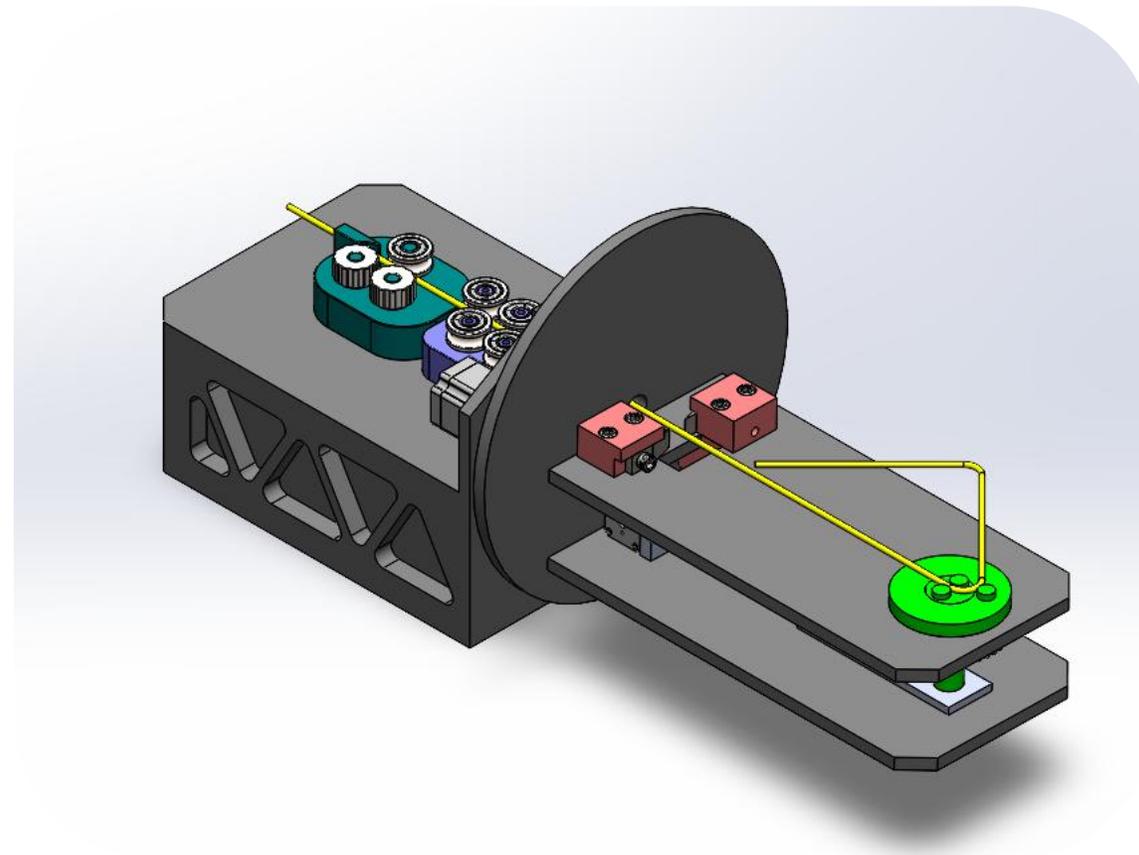


In Space Wire Bender Flash Talk

Team:

Jimmy
Garrett
Randy
Brandon



Instructor:

Professor Thorburn

Advisors from

Aerospace Corporation:

Horace Lee
Antonella S. Pinola

Team 102 Introduction



Randy Quintero Alvarado

Role: Project Lead

*Body Structure, Produced Structures,
Fastening*

Mechanical Engineering Student



Brandon Blue

Role: Manufacturing & Integration

Material Selection, Prototyping

Engineering Technology Student



Garrett Mullen

Role: Design & Integration

Straightening, Feed, Fastening

Mechanical Engineering Student



Saldivar, Jimmy

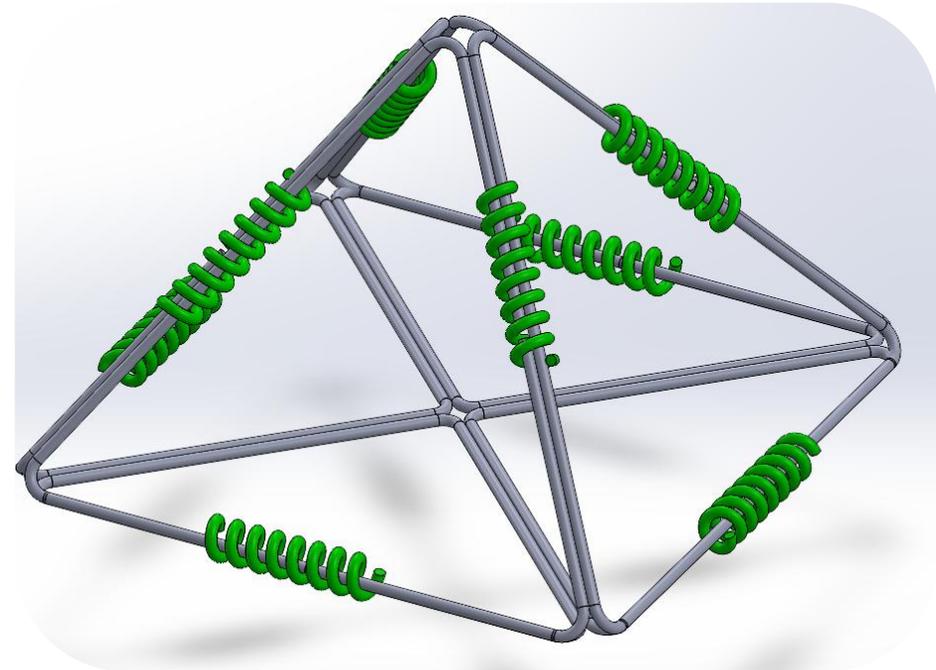
Role: Analysis & Design

Thermal, Bending, Cutting, Fastening

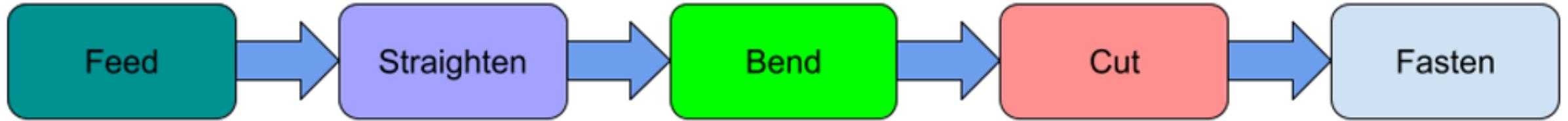
Mechanical Engineering Student

COSMIC Challenge Objective

- Our objective is to develop a wire-bending system capable of feeding, straightening, bending, and cutting wire to generate trusses, lattices, or frames.



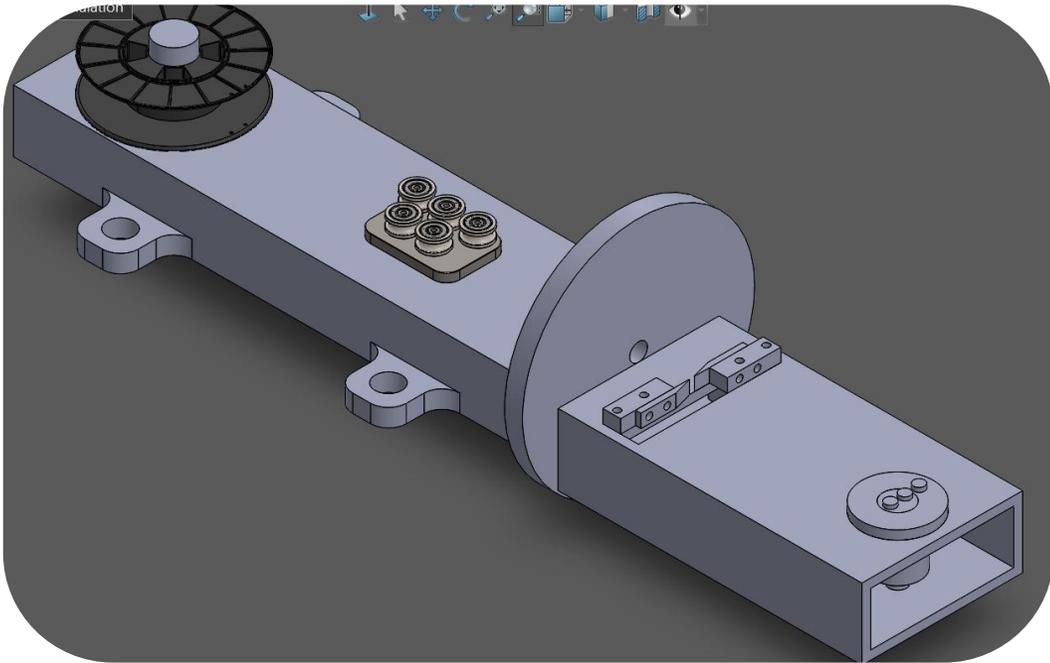
Operation Overview



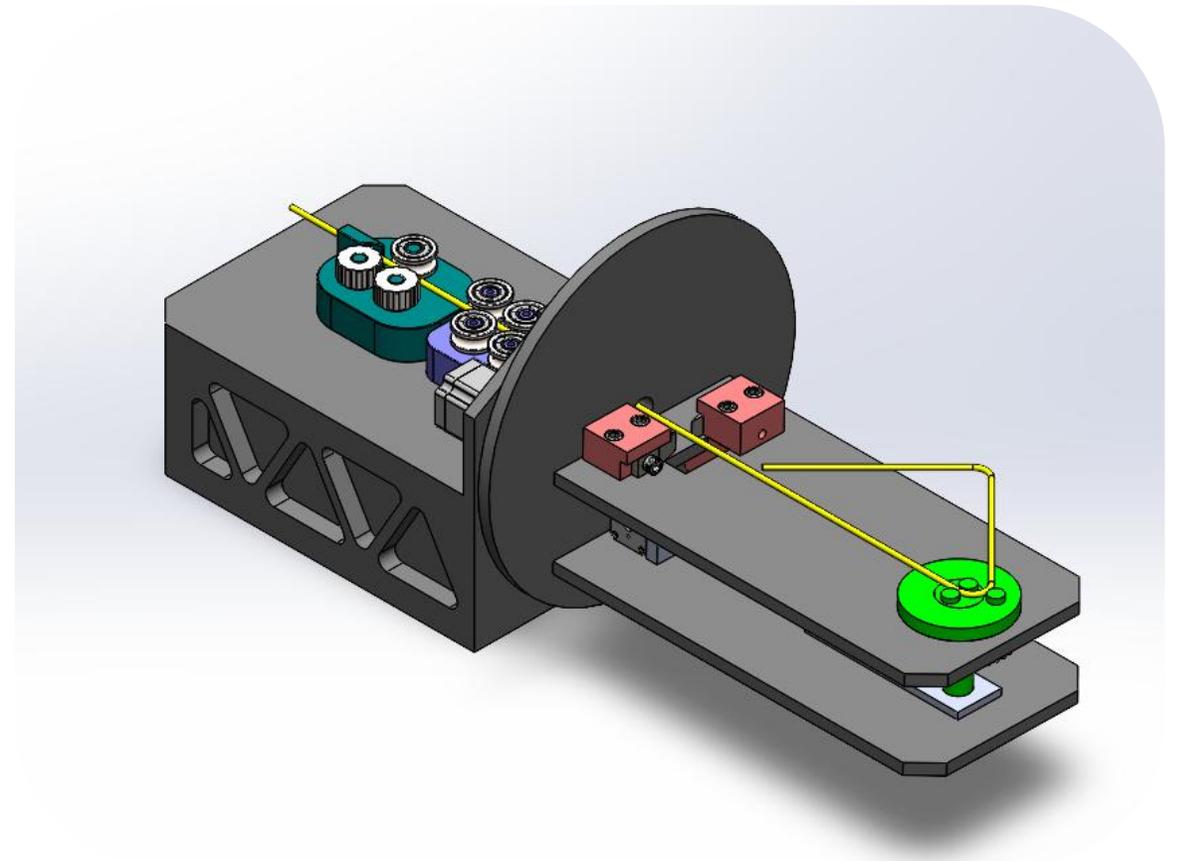
- Wire feed: Wire must be fed from the spool.
- Straightening: Preprocess the wire remove curvature from being spooled.
- Bending: Form the wire into the desired module.
- Cutting: Separate the feedstock wire from the produced module.
- Fastening: Close the module i.e. join the open ends and join connecting points.

Wire Bender Isometric View

Design 1.0

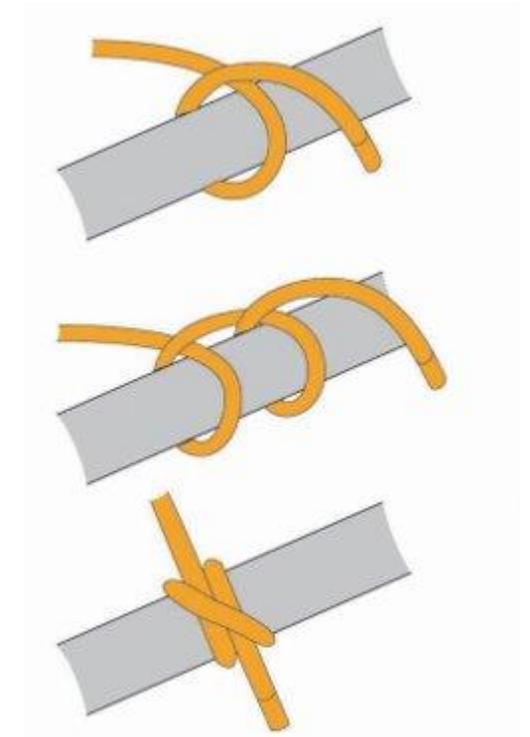
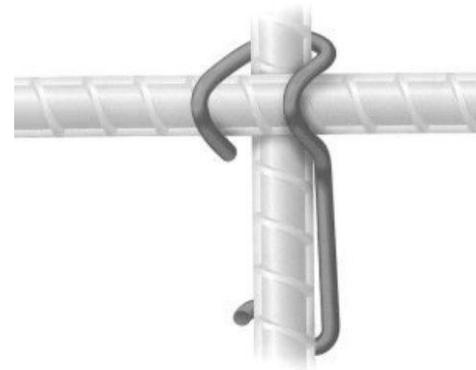
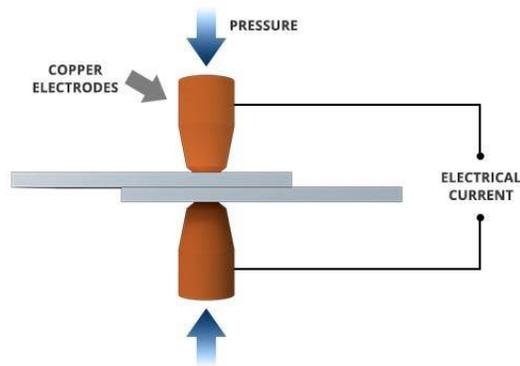
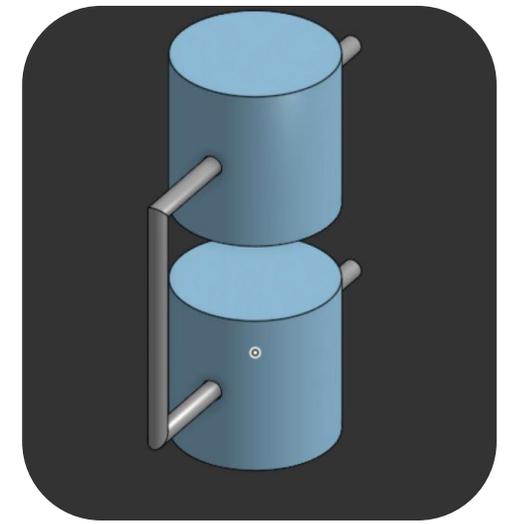
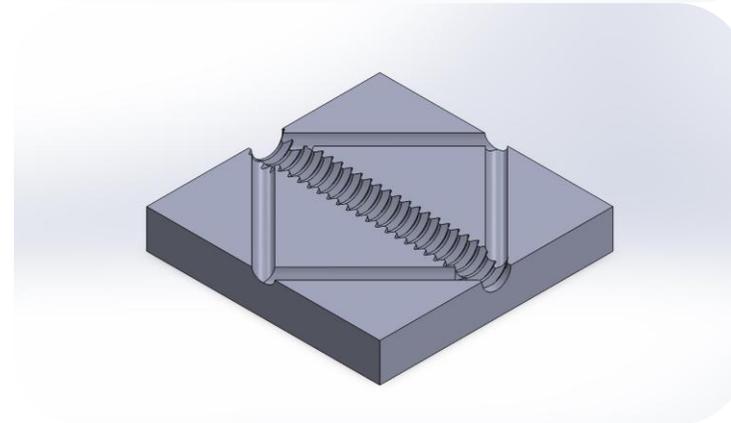
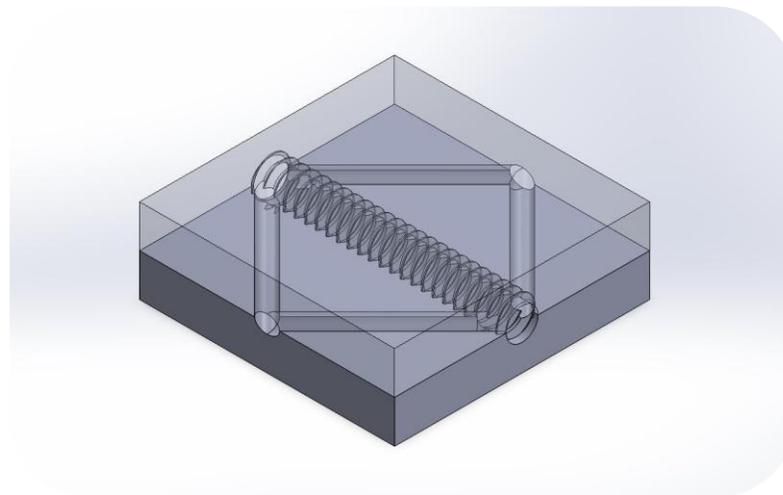


Design 2.0

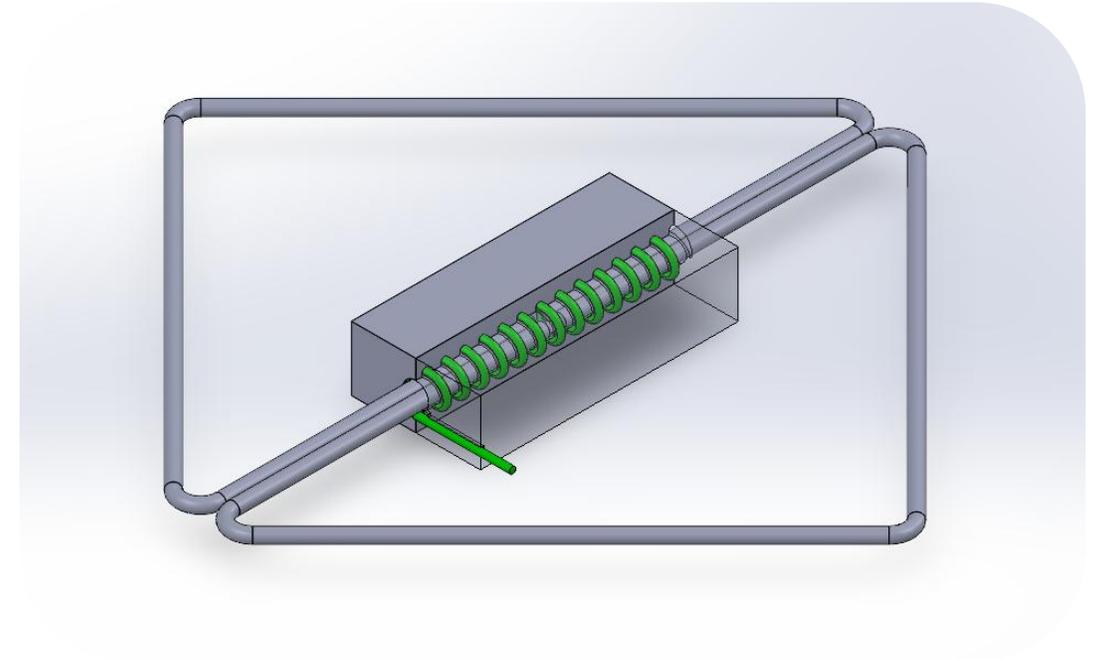


Fastening Considerations

- Integrated Staple
- Spot Welding
- Wire Knot
- Fastening Die
- Rebar twist



- A standalone wire-die system capable of coil-wrapping two produced modules
- The system can wrap around multiple geometries, no limited to triangular designs

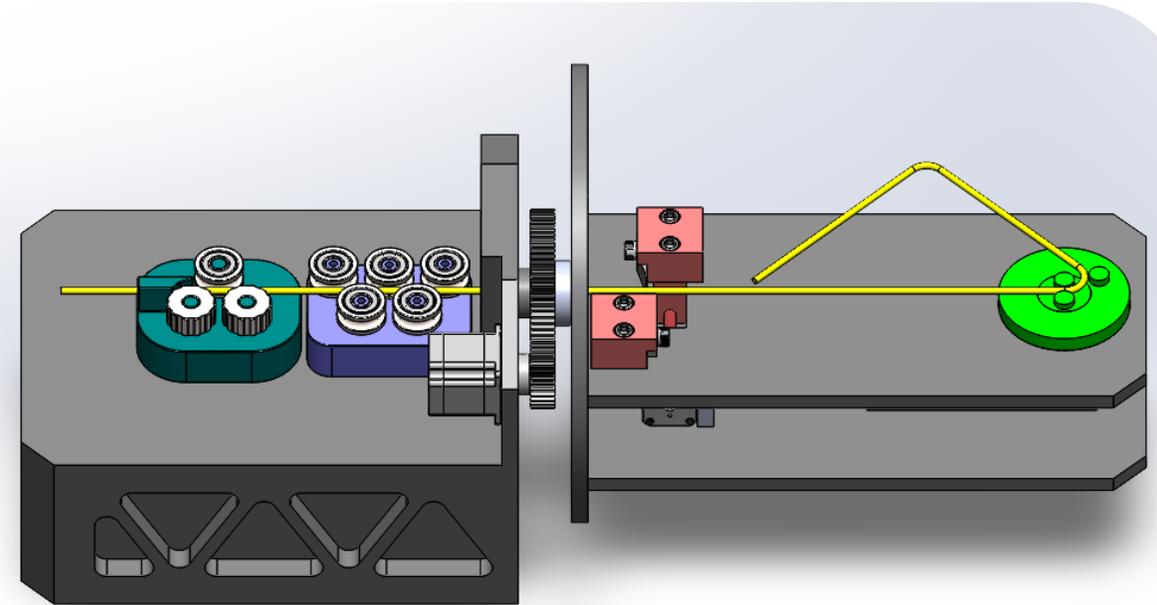


- **316 Stainless Steel | 4 AWG (0.204")**
 - **Pros**
 - High corrosion & thermal resistance
 - Ductility for bending operations
 - **Cons**
 - Higher mass than 304 SS
 - Larger power consumption

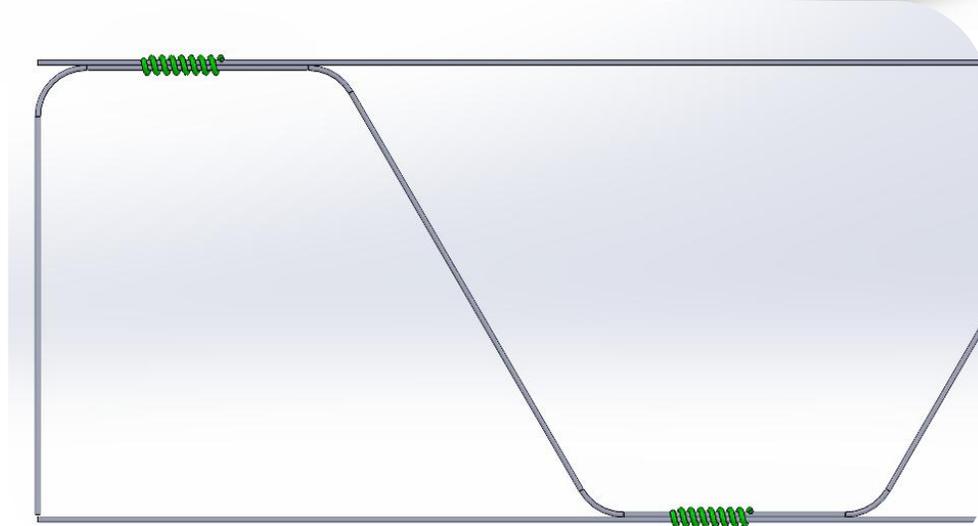
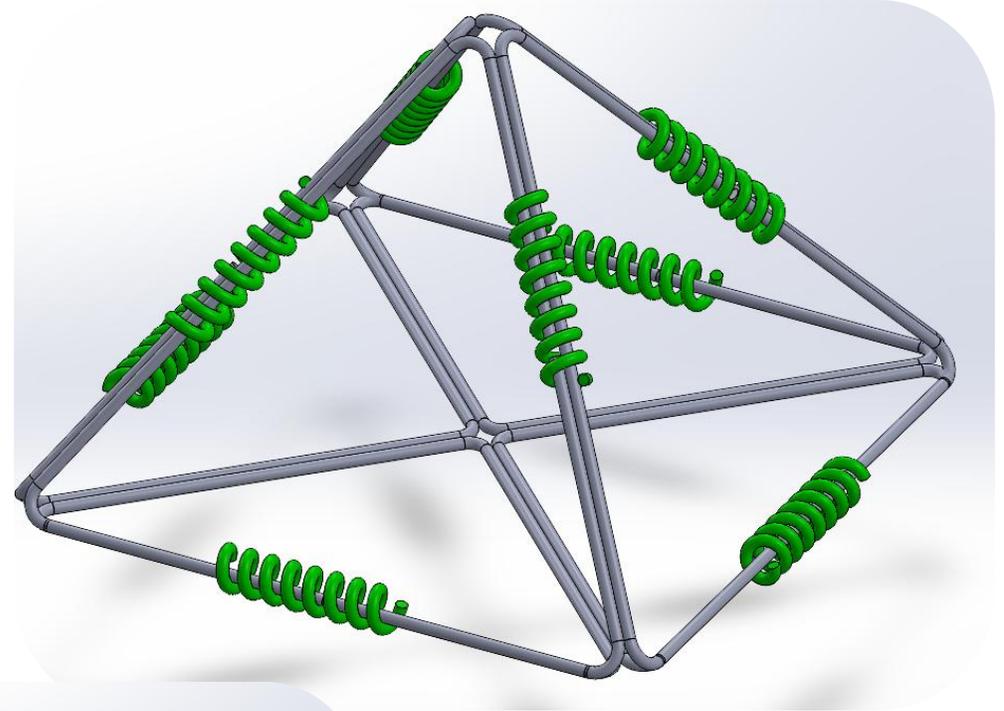
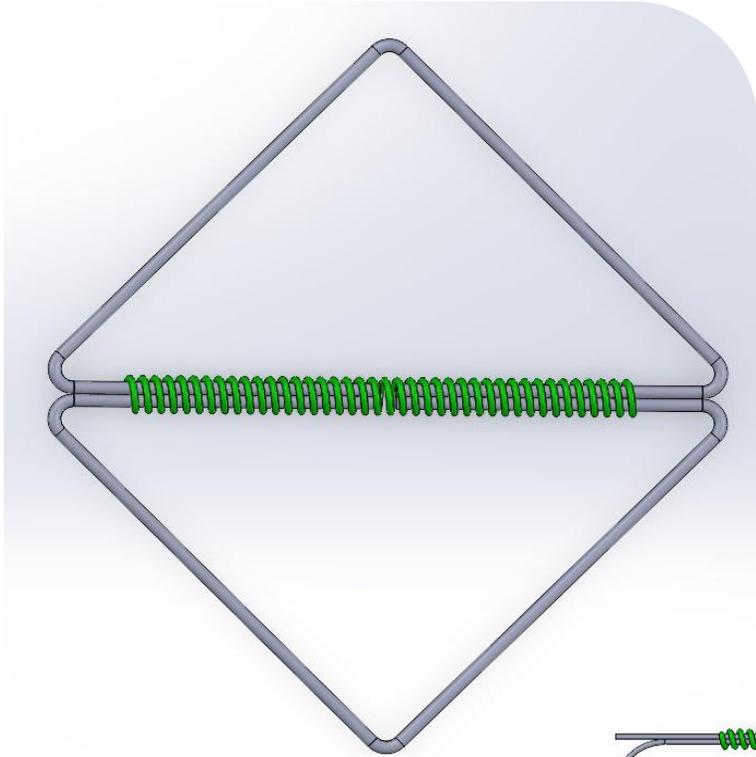


Challenges with the design:

- Spool is left unintegrated.
- Feed mechanism is unactuated.
- Bending implement is translationally fixed.
- Fastening absent.

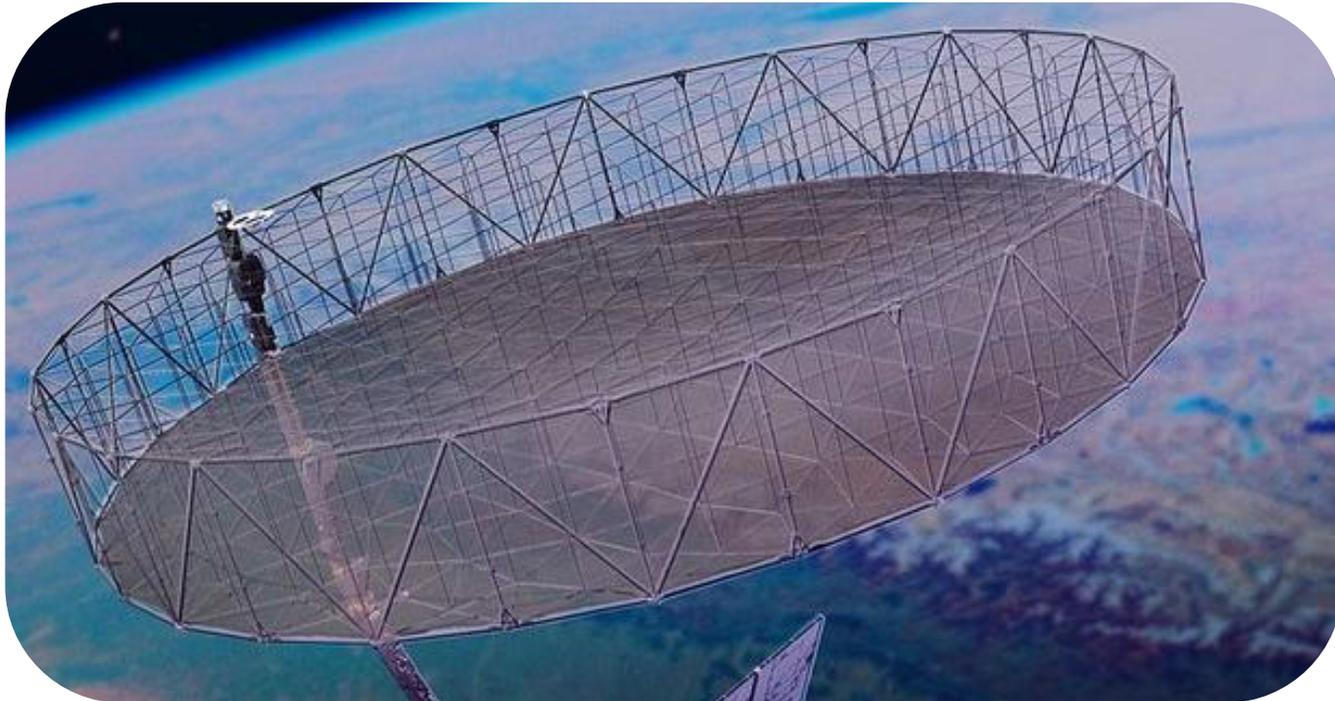


Produced Modules

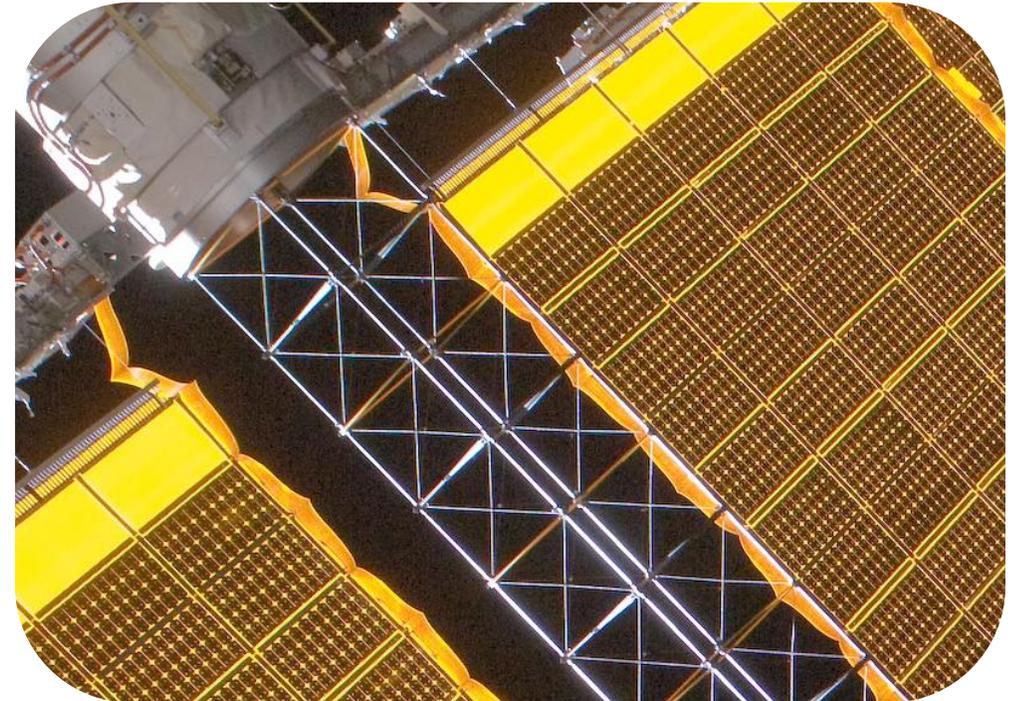


- The wire bender is ideal for large space structures.

Communication satellite reflectors.



Solar array:



Thank You!

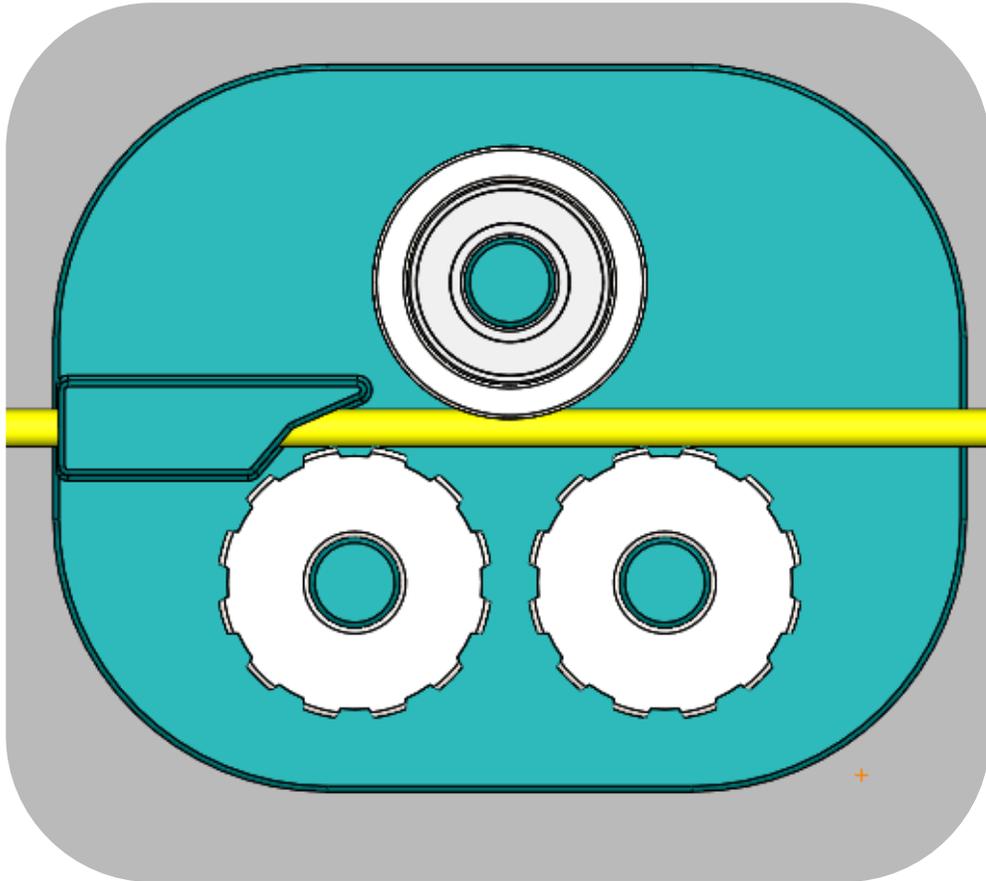
Appendix

Evaluation Approach

- Concept Alternatives numerical scoring (1-3).
- Criteria are assigned a weight percentage.
- Raw scoring is multiplied by the corresponding weight percentages and summed for the total score for each alternative.

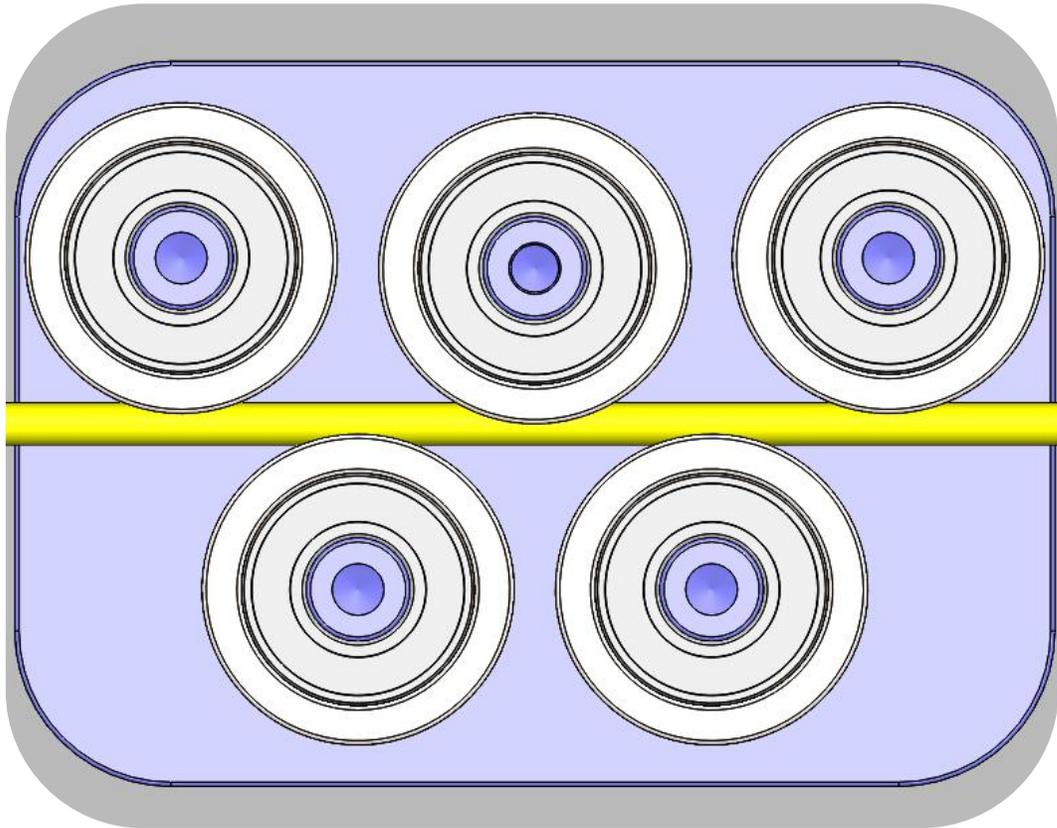
Scoring Method	
Score	Meaning
1	Poor / Unacceptable
2	Acceptable
3	Optimial

Key Trades – Feed



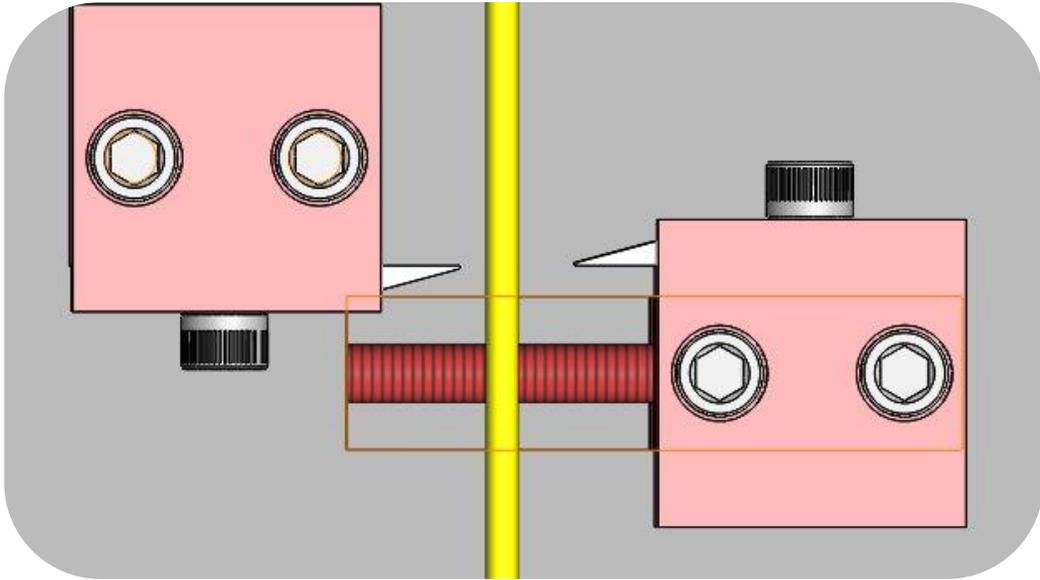
Operation: Feed				
Criteria	Weight	3 Roller Feed System	Mig Welder Feed System	2 Roller Feed System
Size	10%	2	1	3
Mass	10%	2	1	3
Power Consumption	20%	2	2	2
Thermal Resistance	10%	3	2	2
Reliability	20%	3	3	2
Accuracy	25%	3	3	1
Complexity	5%	2	1	3
Total Score	100%	2.55	2.20	2.00

Key Trades – Straightening



Operation: Straightening				
Criteria	Weight	Drawing Die	Multi Axis Series Rollers	5 linear Rollers
Size	10%	3	1	2
Mass	10%	3	2	2
Power Consumption	15%	1	2	2
Thermal Resistance	10%	2	2	2
Reliability	20%	2	3	3
Accuracy	25%	1	3	3
Complexity	10%	3	2	2
Total Score	100%	1.90	2.35	2.45

Key Trades – Cutting



Operation: Cutting			
Criteria	Weight	Shear Cutter	Rotary Cutting
Size	10%	2	1
Mass	10%	2	1
Power Consumption	20%	2	2
Thermal Resistance	10%	2	1
Reliability	15%	3	2
Accuracy	25%	3	3
Complexity	10%	3	1
Total Score	100%	2.50	1.85

Key Trades – Materials

- **316 Stainless Steel | 4 AWG (0.204") (Winner)**

- **Pros**

- High corrosion & thermal resistance
- Ductility for bending operations

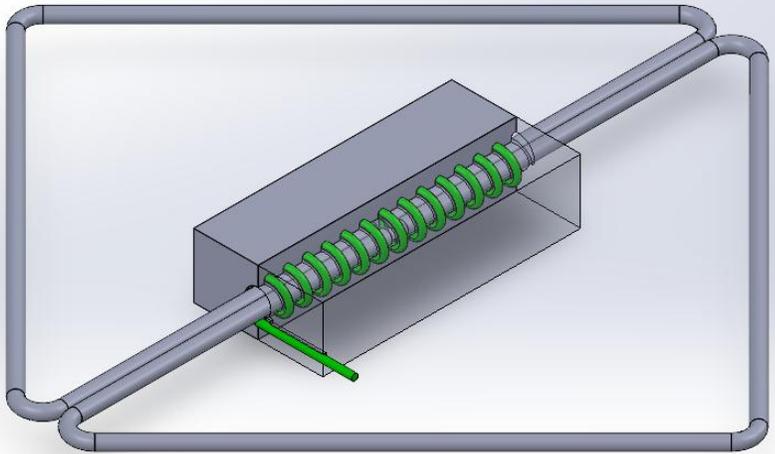
- **Cons**

- Higher mass than 304 SS
- Larger power consumption



Feed Material				
Criteria	Weight	304 SS	316 SS	410 SS
Size	N/A	N/A	N/A	N/A
Mass	20%	3	2	1
Power Consumption	25%	3	2	1
Thermal Resistance	15%	2	3	1
Reliability	20%	2	3	1
Accuracy	20%	2	3	1
Complexity	N/A	N/A	N/A	N/A
Total Score	100%	2.25	2.75	1.00

Key Trades – Fastening



Operation: Fastening				
Criteria	Weight	Wire Wrap Die	Knot Forming	Integrated Staple
Size	10%	2	3	1
Mass	15%	2	3	1
Power Consumption	20%	3	1	2
Thermal Resistance	15%	3	3	3
Reliability	15%	3	2	2
Accuracy	20%	3	1	2
Complexity	5%	2	2	1
Total Score	100%	2.70	2.00	1.85



THE FUTURE IS NOW

The Droids

Solar Optical Lithography and Assembly Research Industrial System
(S.O.L.A.R.I.S.)

Georgia State University

Students: Chisom Maxwell, Kubra Sag, Enedelia
Garcia-Romero, Varun Ahlwatt, Stephanie Hayden,
Jose Clutterbuck, Butoyi Aline

Advisor: Ashwin Ashok

Mentor: David Bodkin, Bo Varga

December 8, 2025

Team Overview

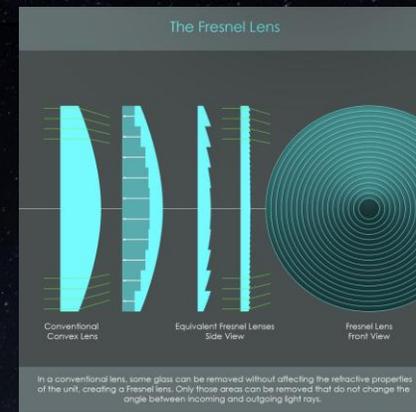
S.O.L.A.R.I.S.

- We are an undergraduate research group from the GSU Robotics Club
- Chips on the moon!



Executive Summary

S.O.L.A.R.I.S.



What are we trying to solve?

- There have been efforts to explore manufacturing microchips in outer space due to how important they are for space systems; however, this process can be expensive, and we are seeking to find ways to improve current methods.

What are we trying to Implement?

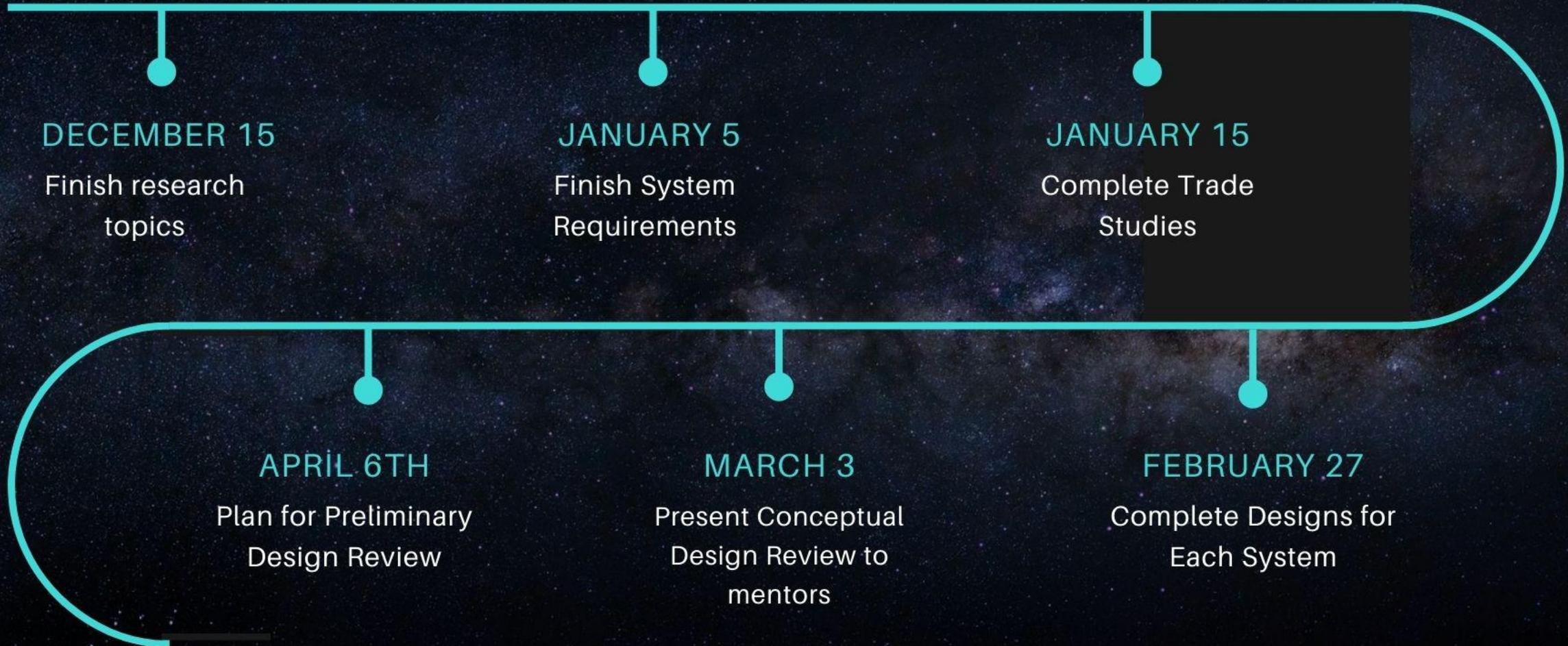
- We are proposing to use a Fresnel lenses to help capture the heat from the sun to treat the microchip. This method could save a lot of energy as producing the temperatures for the epitaxy can be hard on onboard power-supply.

Our Solution:

- This method, if done correctly, could save lots of money since we could manufacture microchips on mass without worrying to much about power resource management.

Projected Path

S.O.L.A.R.I.S.





THANK YOU



COSMIC Capstone Challenge:
Flash Talks

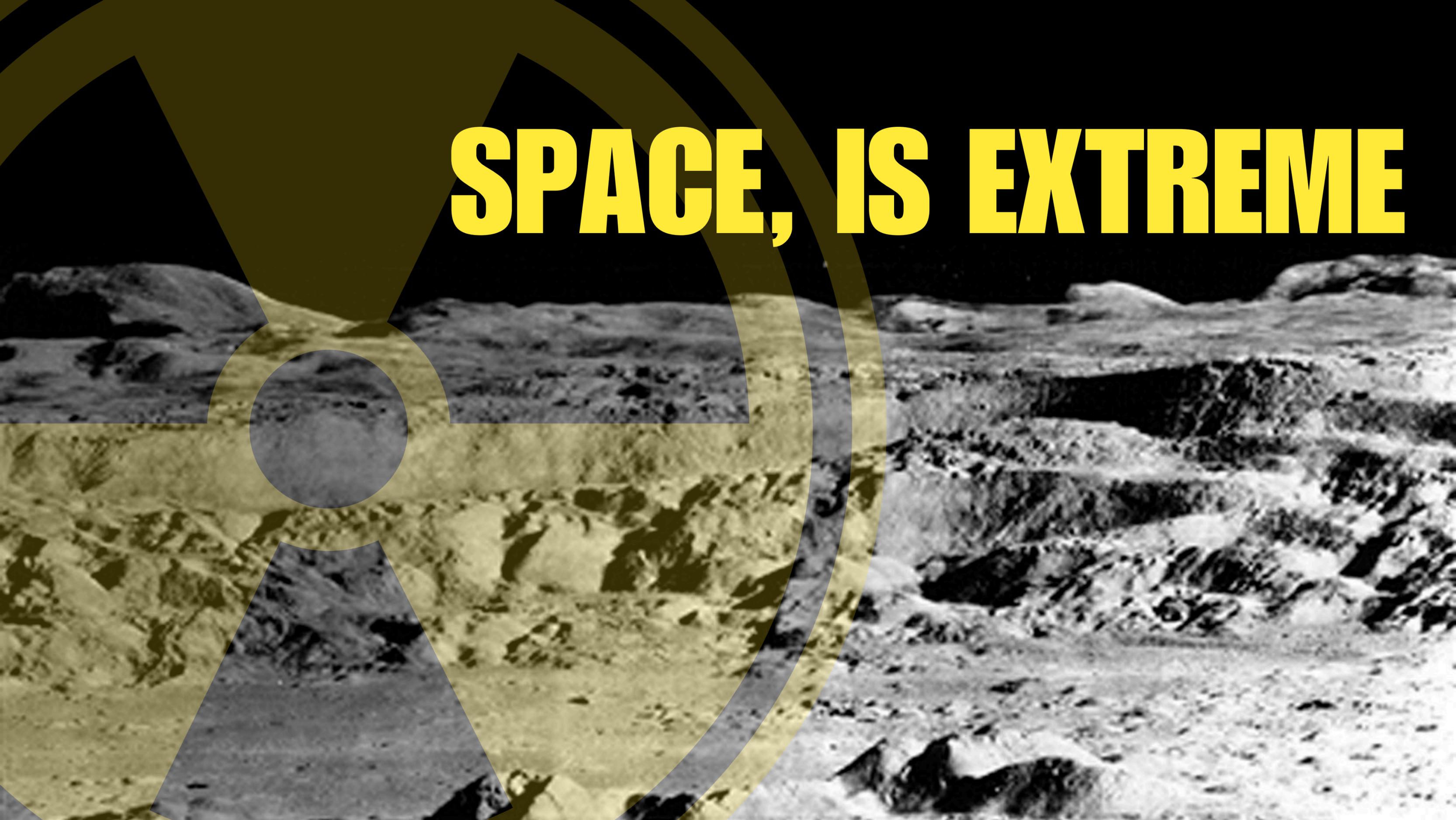
Project Starch Shield, University of Hawai'i at Mānoa:
In-Space Manufacturing of Aerogels
Using a Starch Simulant Lunar Regolith Composite

Students: Avi Rubin, Diarmuid Higgins, Kai Kennedy, Nick
McTurnan, Elizabeth Young, Andrew Lin
Advisor: Dr. Peter Englert
Mentor: Steven Floyd

December 8th, 2025



SPACE, IS EXTREME





***Isolation.
To Scale***

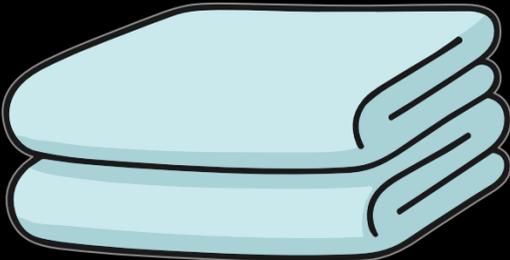


Humanity needs shielding that is:

Resilient



Maneuverable



Cost effective



Accessible





Team Overview

From The University of Hawai'i at Mānoa:

PROJECT STARCH SHIELD:

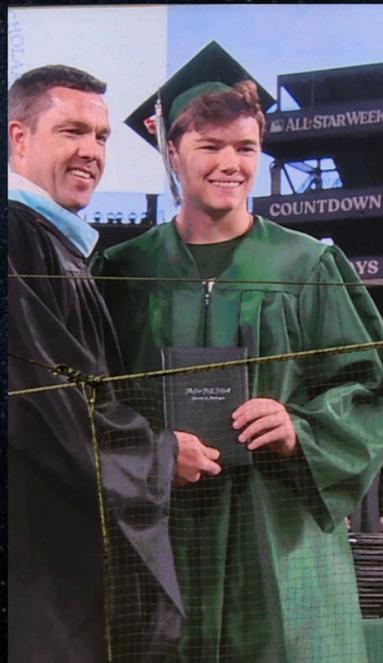
"Keeping Your Space Settlements Safe and Warm."

Co-Lead
(Science Lead)



Avi Rubin

Co-Lead
(Material Eng.)



Diarmuid Higgins

Mechanical Eng.



Elizabeth Young

Electrical Eng.



**Nicholas
McTurnan**

Thermal Eng.



Kai Kennedy

Computer Eng.



Andrew Lin

Executive Summary

PROJECT STARCH SHIELD

- **The Problem:**

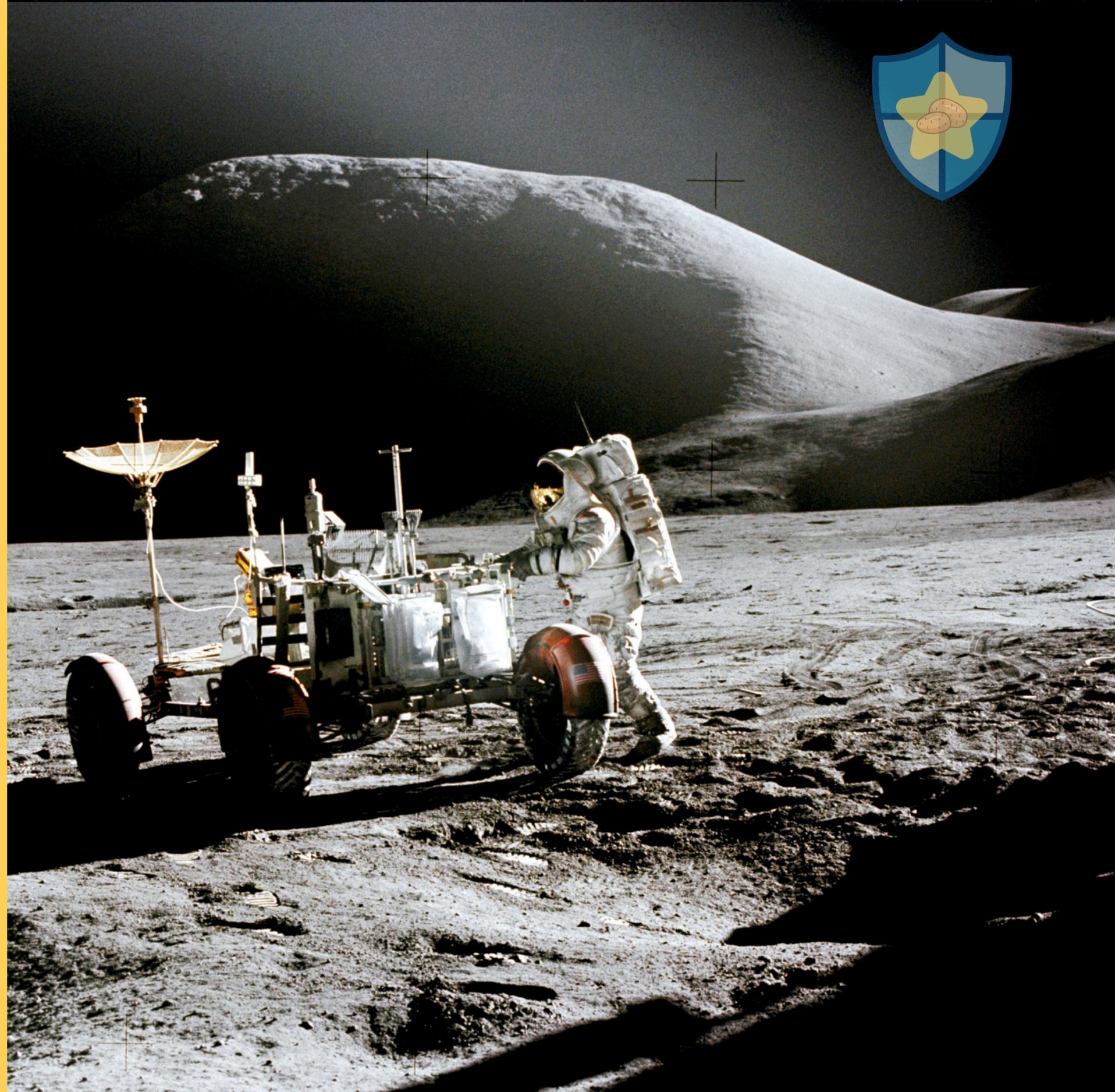
Space is Extreme.
We need extremely robust solutions in order to **survive the thermal and radiation environment.**

- **Our Solution:**

Produce cutting edge starch-regolith composite Aerogel bricks for use as mass-efficient, effective passive heat and radiation shielding.

- **How It Works:**

Leveraging automated In-Situ Resource Utilization & renewable starch for demonstrably effective **high quality shielding**, ready for use on site.



What Is Aerogel?

- One of the lightest solid materials
- Made from a polymer gel with the liquid removed leaving behind nano bubbles
- These bubbles prevent heat transfer creating an extremely effective insulation while also leveraging extraordinary mass efficiency

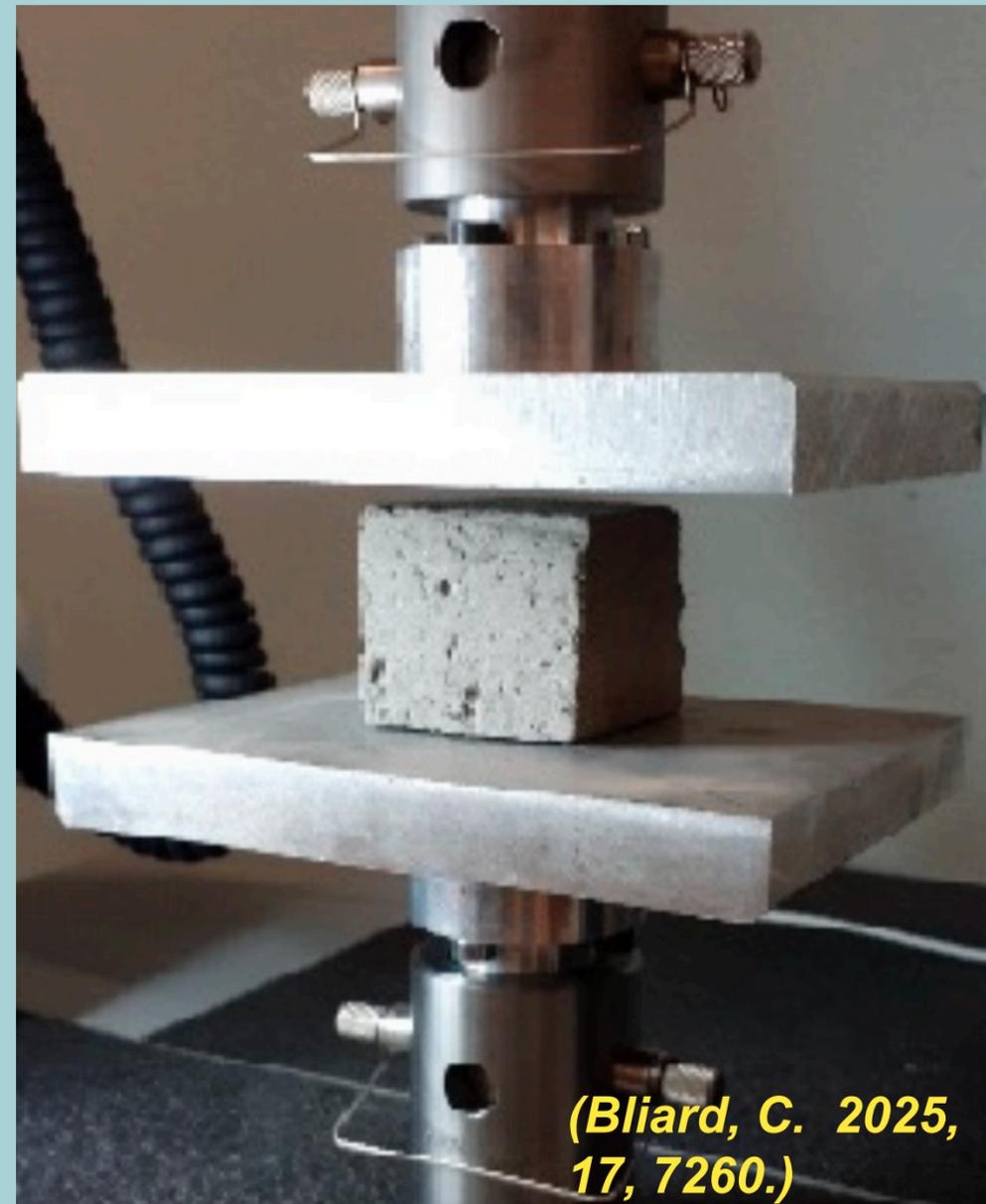
Pure Lunar Regolith



Abundant in lunar environment but is a comparatively poor insulator and can require significant energy to form pure solid bricks

V.S.

Lunar Regolith Simulant Starch, Composite Aerogel



(Bliard, C. 2025, 17, 7260.)

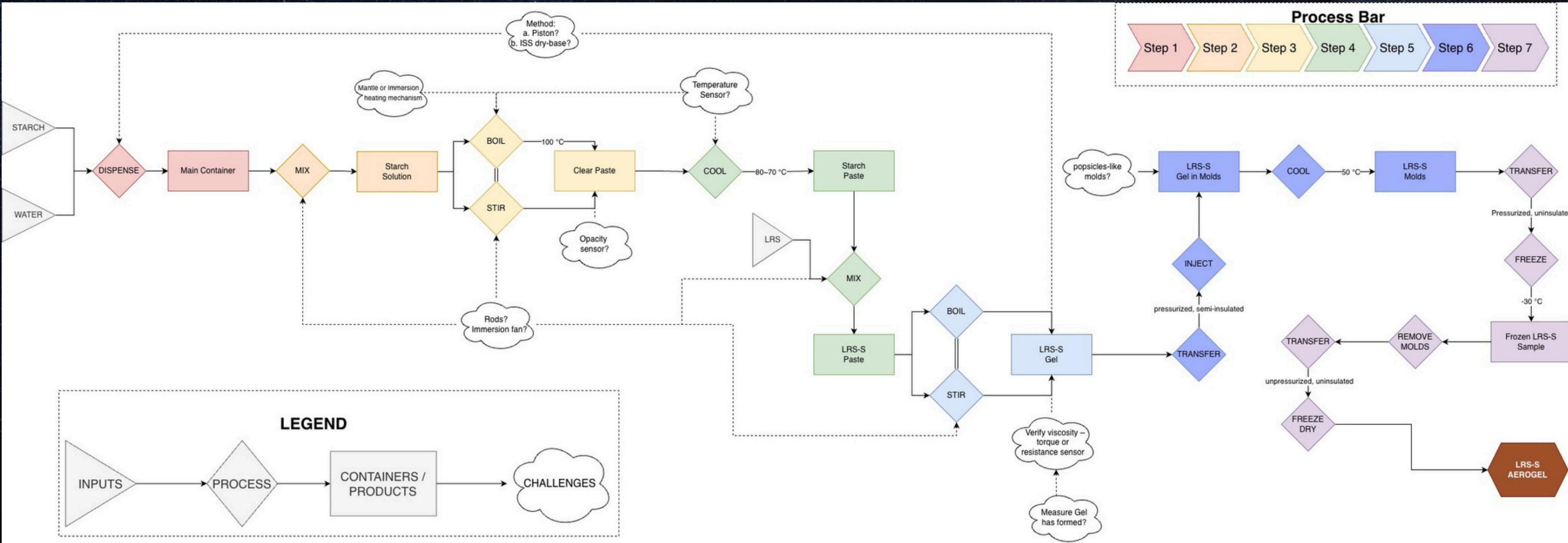
V.S.

Requires starch, but offers vastly improved insulatory properties, and energy efficient production while still taking advantage of ISRU

Process Flow Diagram - "7-Phase Plan"

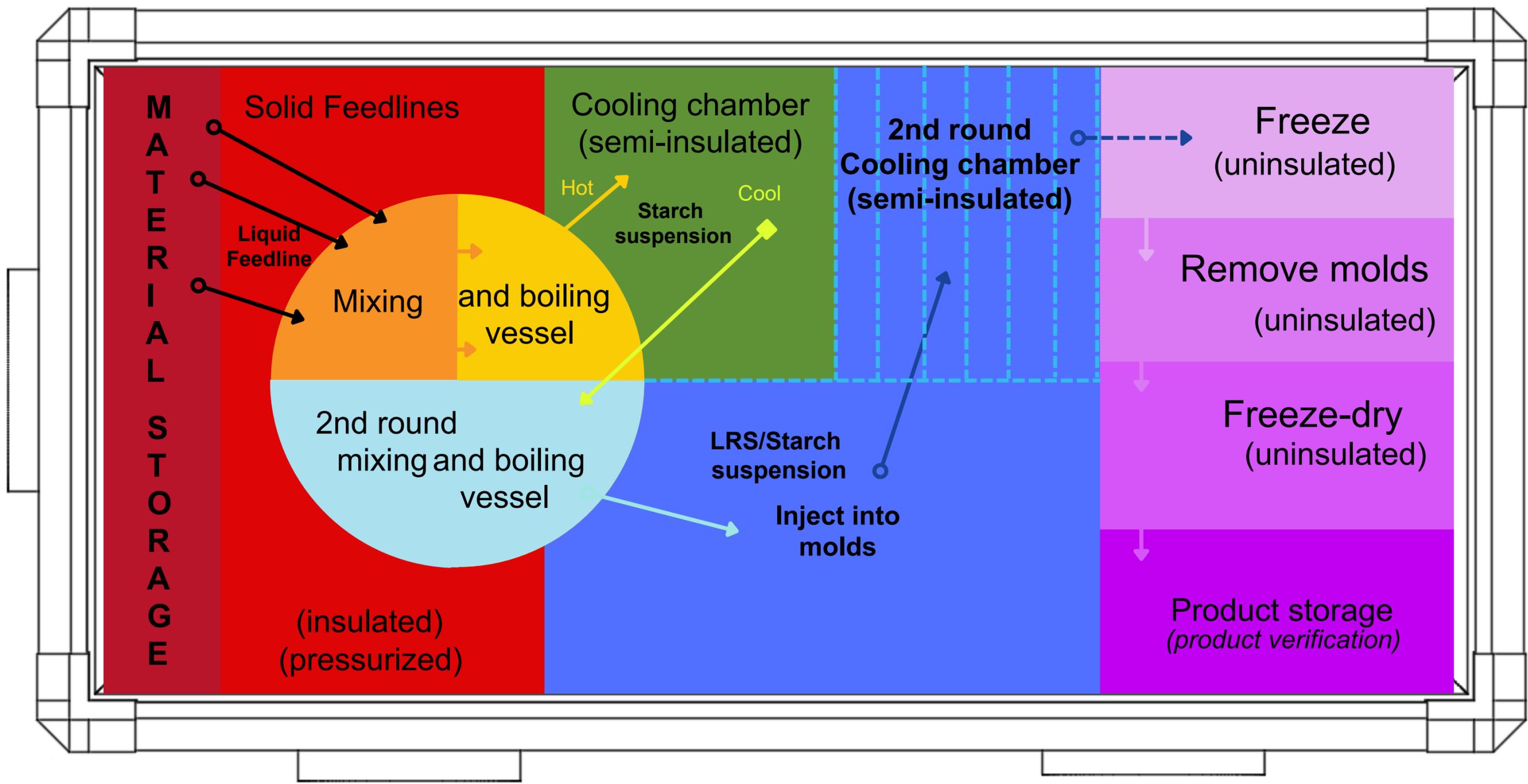
The *operations* that will facilitate our *capability*

Aerogel Manufacturing Steps



Preliminary Layout Diagram

- Taking advantage of natural cooling, and vacuum (with consistent easy access to power)



Meeting The Constraints

“Thinking outside the box, building inside the parameters of the locker”

- Pressurized portion of the locker, allowing for heating and cooling liquids.
- Utilizing the natural vacuum and temp of LEO, to drastically reduce energy consumption for the freeze and freeze-drying processes.
- Employing induction heating, to effectively heat and cool-down mixtures.

(As well as for its suitability for rapid, precise heating of liquids in sealed containers)

- Use of Raspberry Pi and Arduino Micro-controller units for efficient and precise processes, keeping cost and space to a minimum.

Projected Path

- Finalize Budgets (Power, Mass, Thermal etc.).

To refine the details of the project, we are in active correspondence with the lead author of our primary source paper: Senior CNRS Researcher, Dr. Christophe Bliard.
(UMR 7312/URCA Reims, since 1990).

- System Requirements Review (SSR)

- Formalize mechanical processes, communication, and data systems.

Develop a flowchart for data handling & comms

- Continue to refine details of design through consultation with advisors.

We have interacted with a systems engineer specialist in the past, and plan to reach out to see if he would be willing to help refine the project's system interaction points.

- Submit Preliminary Design Review (PDR)



Dr. Christophe Bliard



**WHAT'S THE ONLY THING MORE
EXTREME THAN SPACE?**

**WHAT'S THE ONLY THING MORE
EXTREME THAN SPACE?**

PROJECT STARCH SHIELD:





Thank you for your
consideration.

Any questions?

SPACE LOOM

Team Buckeyes



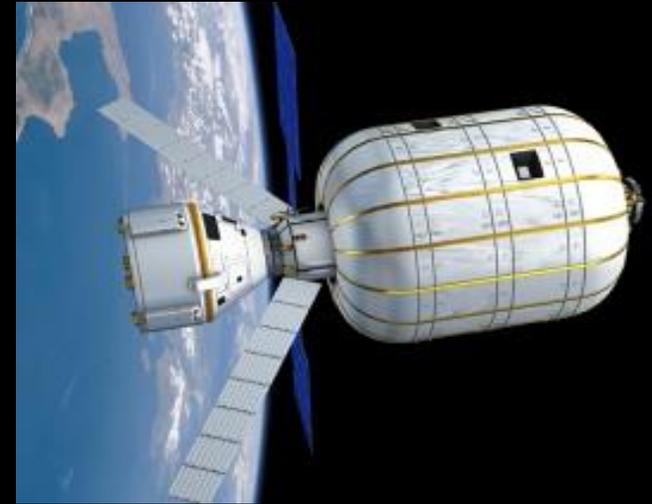




Spacesuits



MLI Blankets



Inflatable Habitats



Cargo Straps



Restraint Harness



MMOD Shielding Fabrics

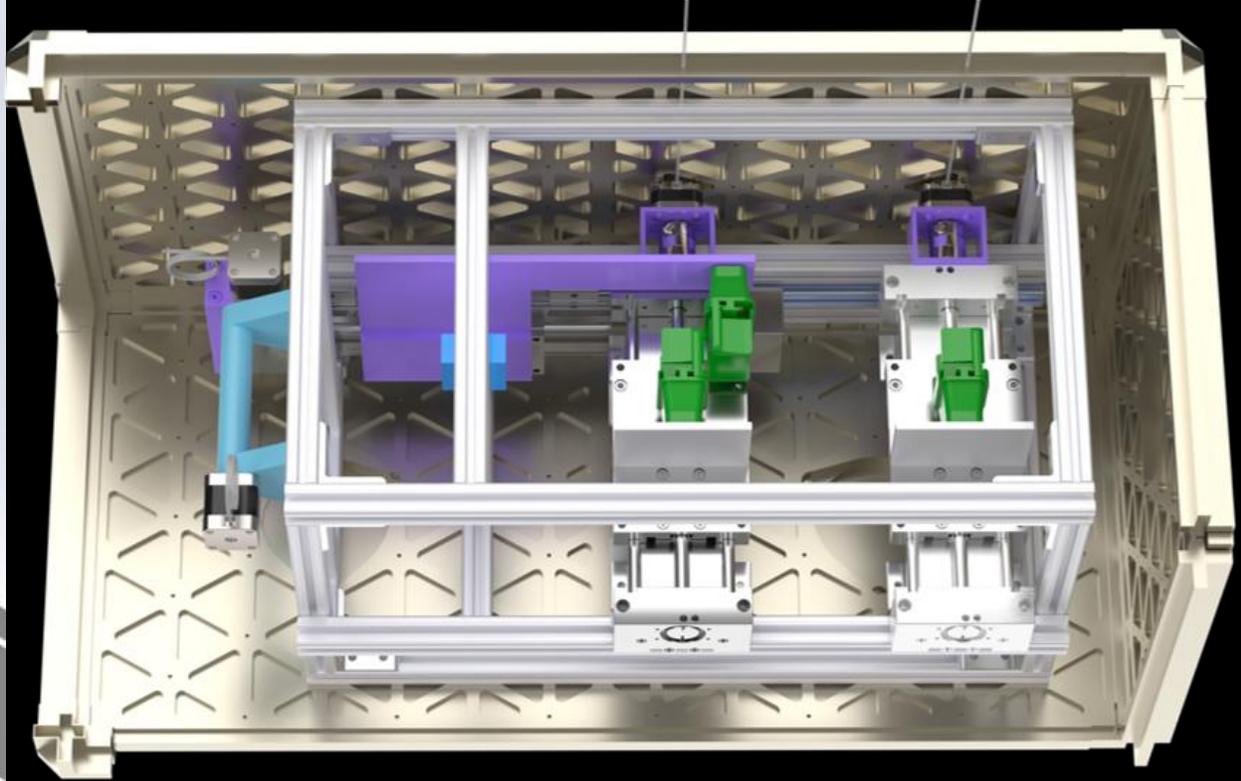
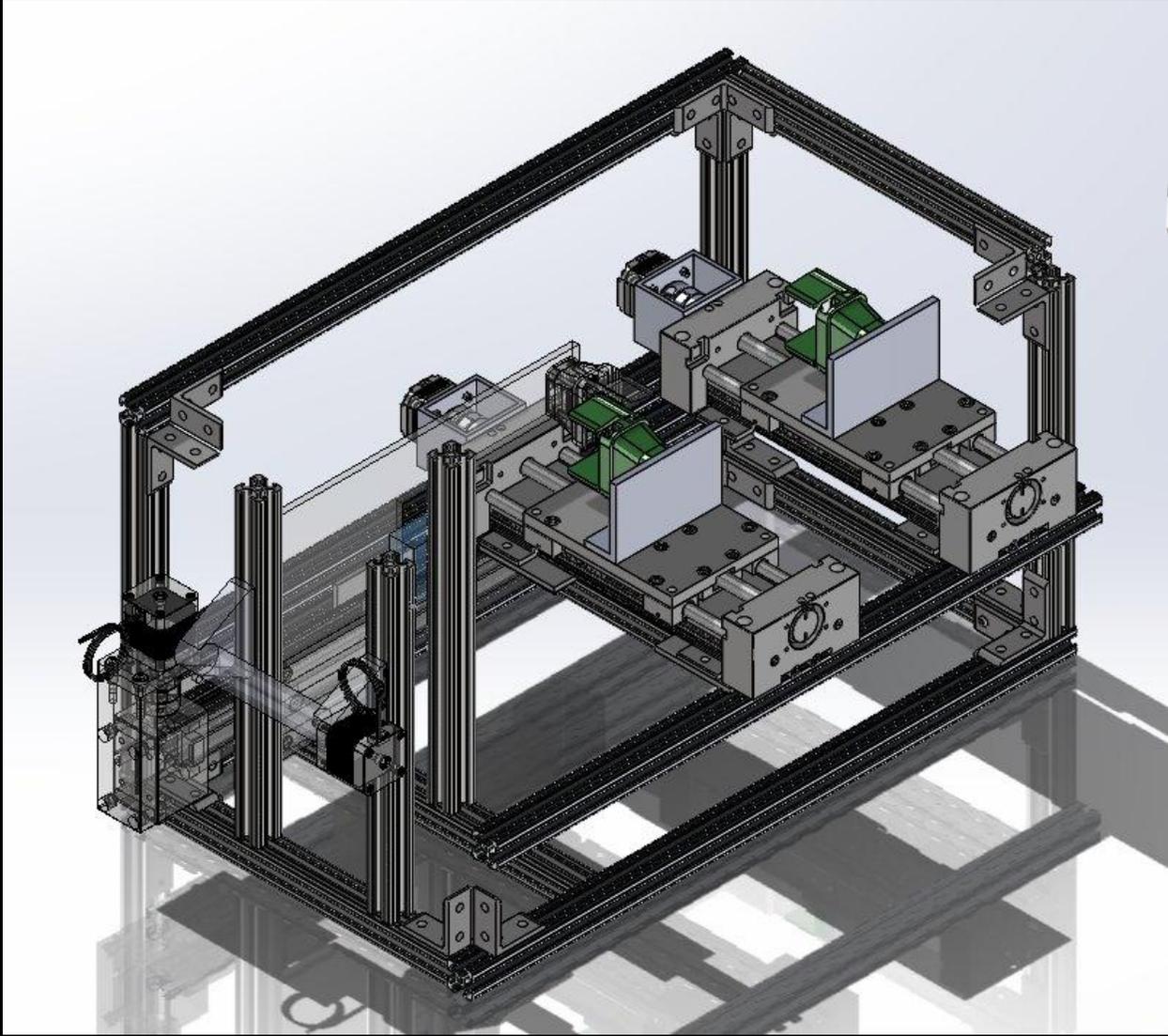
PROJECT GOALS

- Design a fully automated, space cable weft insertion system

System:

- Rotating Disc tension control mechanism
- Motorized feed and take-up units
- Rapier weft insertion
- Closed-loop microcontroller control





WHY THIS MATTERS

- Enables on-demand textile production in orbit
- Reduces dependence on Earth resupply
- Foundation for future autonomous space manufacturing







UNITED STATES
AIR FORCE
ACADEMY

Flashtalk for SPAMM

Space Printer for Autonomous Manufacture of Mega-Structures

Team Lead: C1C Nicholas Realuyo
C2C Gavin Ehrich

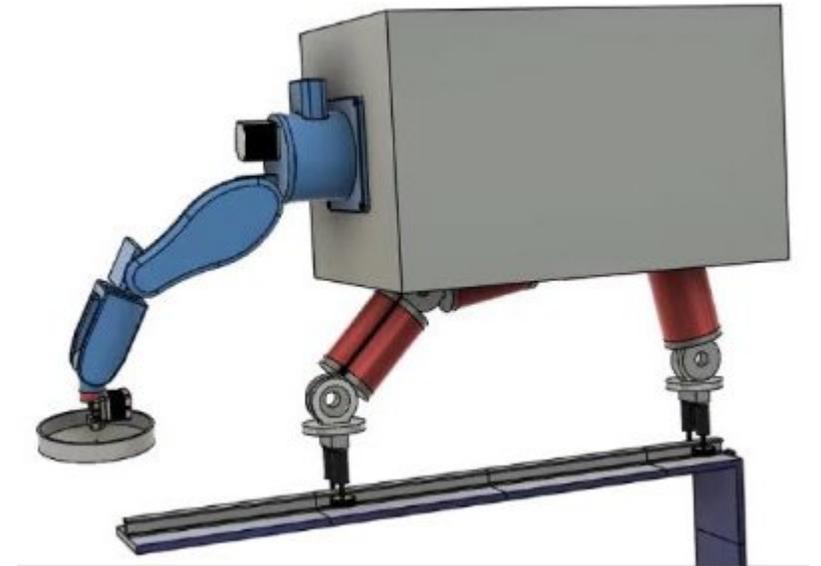
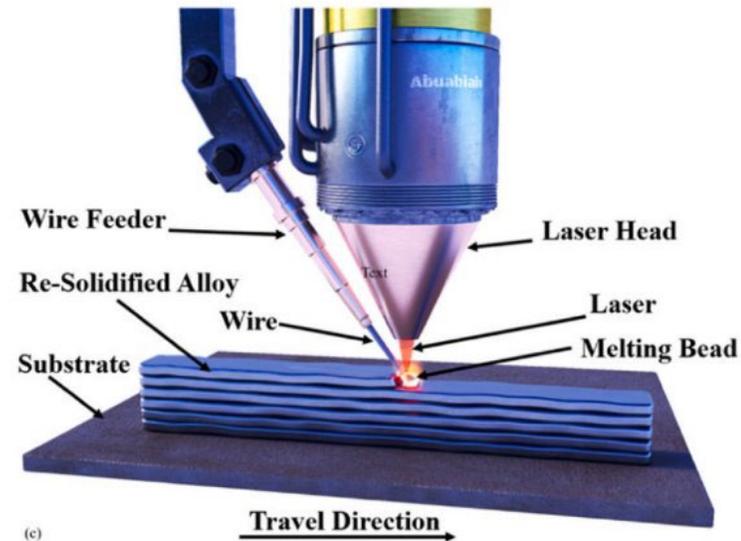
Last semester contributors:
C1C Giorgio Simoncioni, C1C Ashley Spear, C1C Benjamin Yan,
C1C Stephen Timperly, C2C Grant Stec

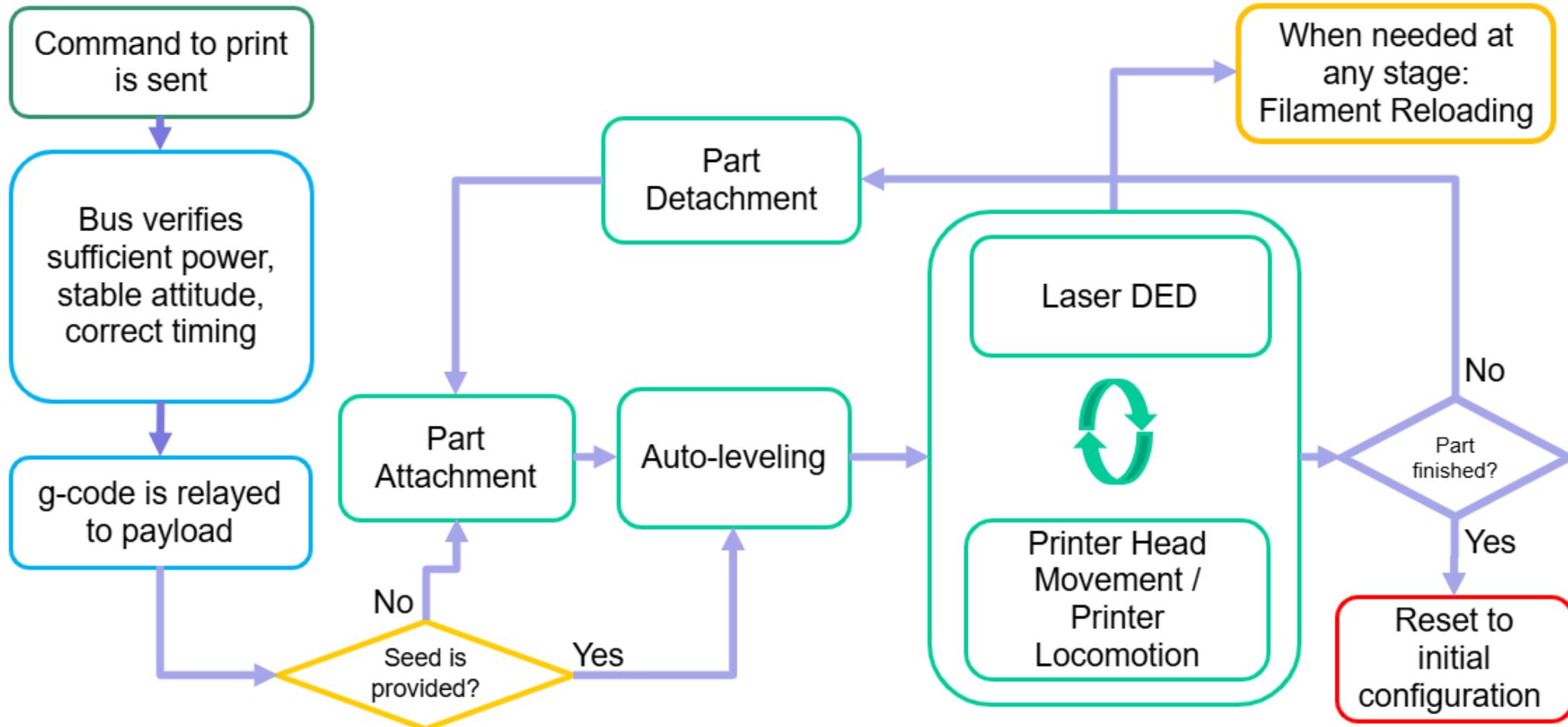
What does the future of space look like?

- What's stopping us?
 - Launch Constraints!
- What if we easily build in space instead of putting each part on a rocket?
- How are we going to do this?



- **Space Printer for Autonomous Manufacture of Mega-Structures (SPAMM)**
 - Wire Fed Laser Direct Energy Deposit (DED)
 - Mobility across manufactured parts
 - Enable the printer to print structures larger than itself
 - Autonomous operation
 - Send and print
 - Aluminum Alloy
 - Reload Capability
 - No limit to structure size





- Please direct any questions to c26nicholas.realuyo@afacademy.af.edu





COSMIC Capstone Challenge:
Mid Design Brief

AIAA University of South Florida: Telescoping Robotic Arm Manipulator (TRAM)

Students: Ethan DeWild, Harshitha Madabhushani, Lucas Birnbrook-
Palm, Matthew Hernandez, Yavuzalp Gulyurdu, Dulce Melendez
Advisor: Dr. Stephanie Carey
Mentor: Richard Nederlander, Molly Sullivan

December 8, 2025

Team Overview



Telescoping Robotic Arm Manipulator (TRAM)

- University of South Florida – American Institute of Aeronautics and Astronautics Student Section



Ethan DeWild



Harshitha Madabhushani



Lucas Birnbrook-Palm



Matthew Hernandez



Yavuzalp Gulyurdu



Dulce Melendez

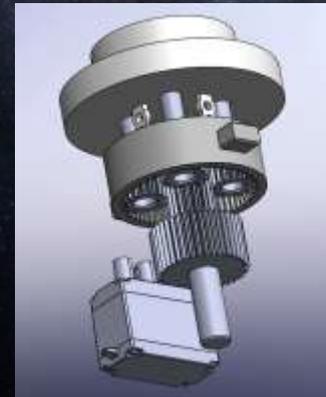
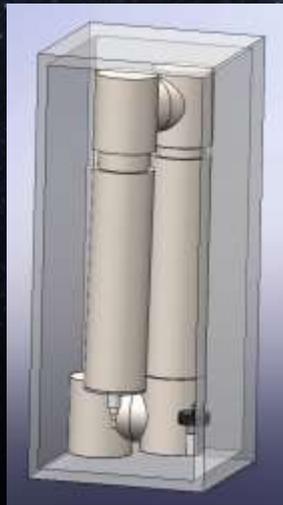
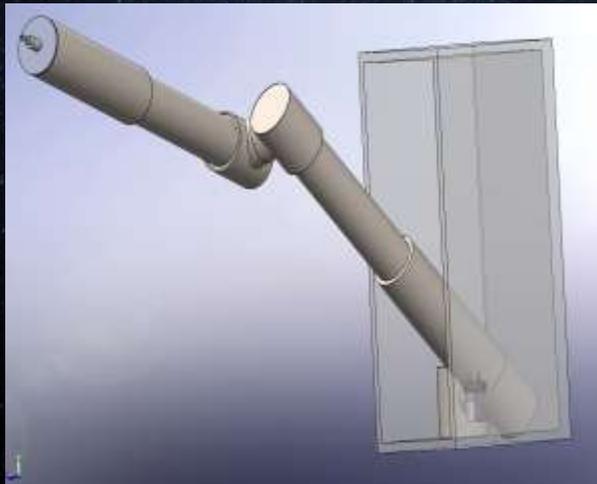
- A compact, extendable robotic arm designed to perform autonomous drilling, screwing, and bolting operations essential for future in-space servicing and assembly.

Executive Summary

Telescoping Robotic Arm Manipulator (TRAM)



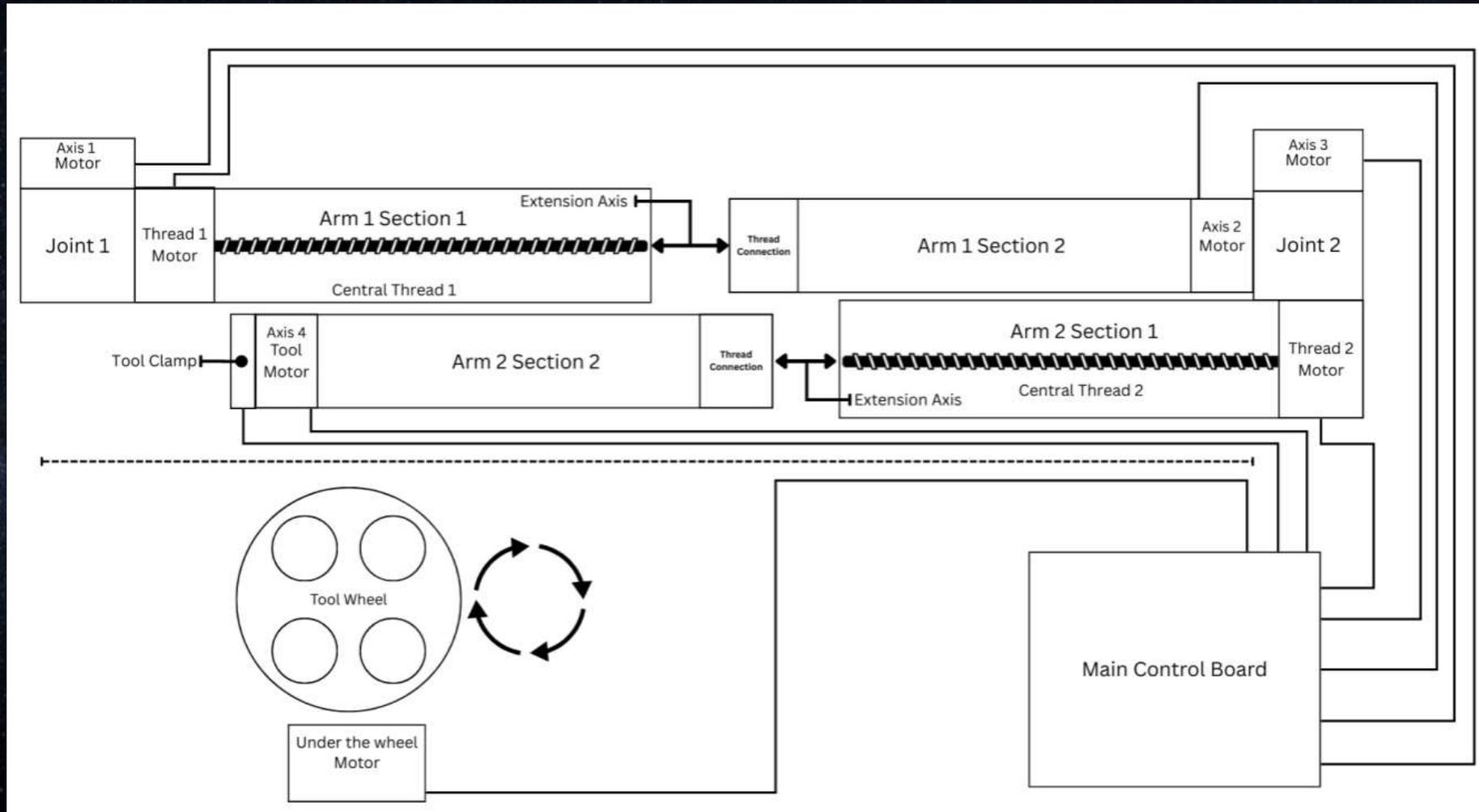
Task	Our Solution	Function
<p>Our team has designed a payload meant to fit in an Arkisys Bosons Locker with the goal of aiding developers with in-space manipulation, manufacturing and assembly.</p>	<p>A flexible, telescopic robotic arm designed to perform three major autonomous operations: hardware drilling, screwing, and bolting. The system will also be supplied with a rotating tool holder containing a drill bit, screw bit, and a socket for the arm to utilize during manufacturing performances.</p>	<p>The functions of the robotic arm are driven by. The tool holder will use a gear mechanism, powered by a motor, to allow for the rotation of the bits.</p>



Telescoping Robotic Arm Manipulator

Electrical Diagram

Telescoping Robotic Arm Manipulator (TRAM)



Projected Path



- January – February
 - Fabricate a small-scale telescoping arm prototype to evaluate compactness, extension ratio, rigidity, and structural strength.
 - Begin subsystem tests on axis control, deployment stability, and preliminary tool-changer mechanics.
- March
 - Conduct full prototype testing: extension reliability, stiffness, operational accuracy, and simplified drilling/fastening demonstrations.
 - Refine mechanical design using test data and mentor feedback.
- Late March – Early April
 - Finalize prototype performance report, CAD updates, and engineering analysis.
 - Prepare demonstration materials for the COSMIC Showcase.
- April 13–17
 - Present prototype, findings, and validated design approach.
 - Demonstrate deployment sequence and multi-tool functionality at the Showcase.



University of Michigan

Michigan In-Space Servicing Orbiter

C3 Midpoint Flash Talk

December 8th, 2025

Serabi Francis, Ethan Landt, Armita Marpu, Devin Mroz, Jina Patel, Ayush Pujara, Tao Sevigny, Calvin Wong

Advisor: Prof. Aaron Johnson **Mentor:** Dr. Ed Tate

MISO Team Overview

Michigan In-Space Servicing Orbiter



Devin Mroz



Serabi Francis



Tao Sevigny



Ethan Landt



Prof. Aaron Johnson



Ayush Pujara



Armita Marpu



Jina Patel



Calvin Wong

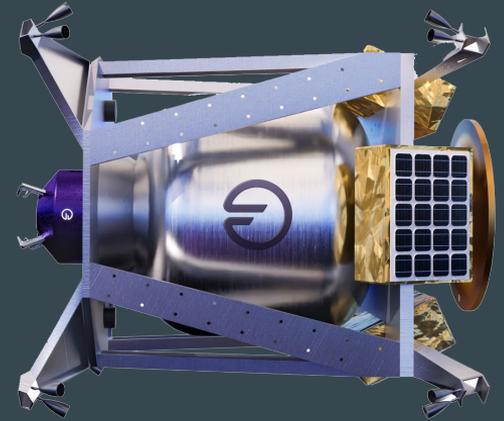


Dr. Ed Tate

“Everything You Need, All in One Place.”

Current Situation

- Motivation:
 - Enable long term ISAM operations
 - Support future cislunar + Mars infrastructure
 - Ensures sustainable operations, minimizing space debris
- Current Industry:
 - GEO servicers focused on life extension
 - All servicing vehicles rely on resources launched from Earth
- Industry Gaps:
 - No refuel/resupply pathway for other servicers
 - New GEO servicers are costly + slow to launch



Orbit Fab fuel shuttle spacecraft

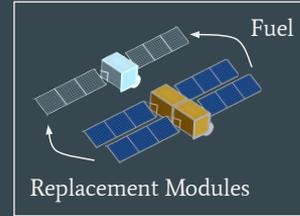


Orbit Fab fuel depot

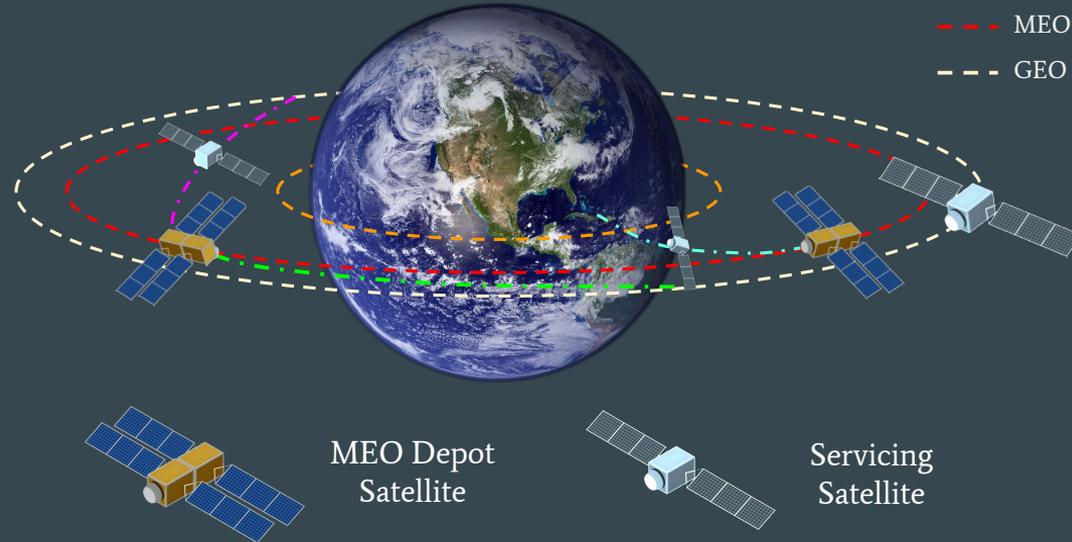
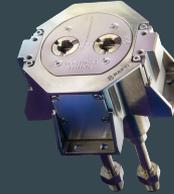
CONOPS

- MEO orbiting depot to resupply other servicers
- Targeting GEO servicers
- In combined constellation, store:
 - 15,000 kg of fuel
 - 1,300 kg of replacement modules and components
- From one depot at 21,000 km, servicers can reach:*
 - 50% of GEO satellites in 22 hrs
 - 90% of GEO satellites in 43 hrs
- Multi-depot constellation:
 - At least 2 depots:
 - Servicers can reach 99% of GEO within 24 hrs of leaving a depot
 - For defense clients
 - At least one depot:
 - Stationed for optimized delta-v
 - For commercial clients

Delivery to Servicer Satellite



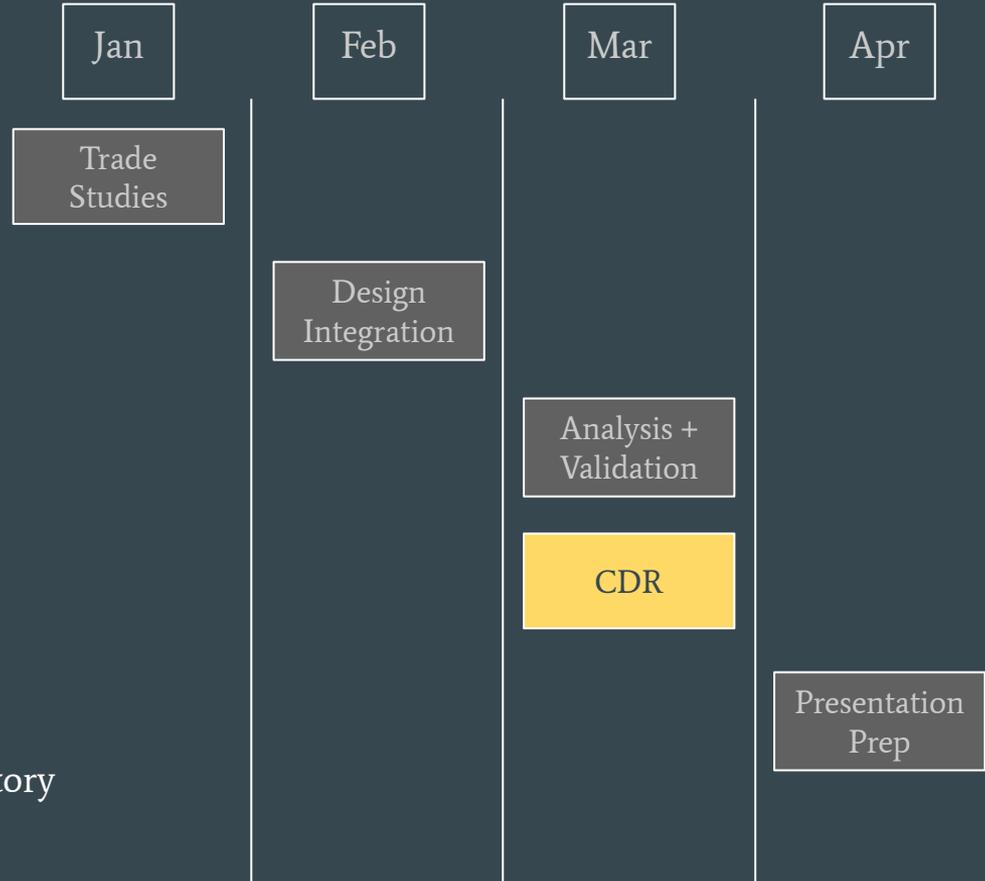
Orbit Fab RAFTI Interface



*Assumptions in Appendix

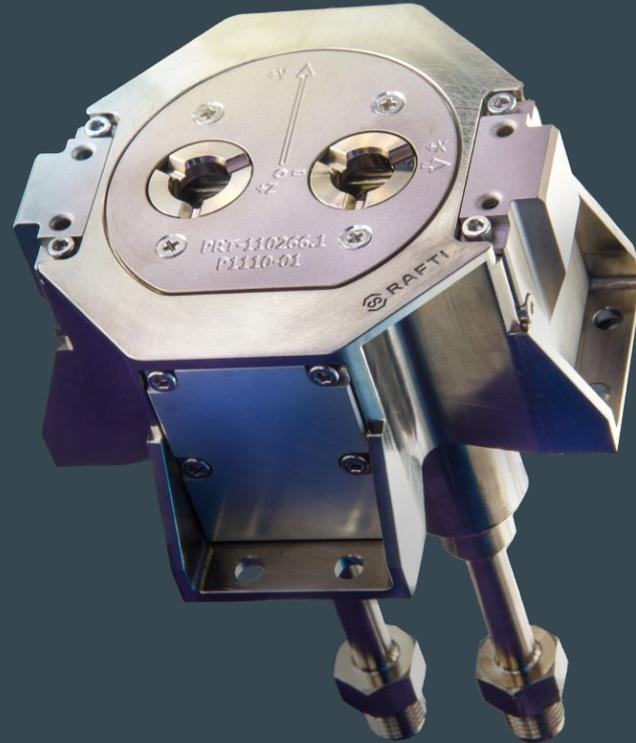
Projected Path

- Trade studies:
 - Fuel storage & transfer
 - Robotic arm integration
 - Module storage
 - Docking ports
- Design Integration:
 - Subsystem interfaces defined
 - CAD model of system
- Analysis + Validation:
 - Final SWaP estimates
 - Bill of materials
 - Software simulations of desired trajectory
- Conceptual Design Review (CDR)

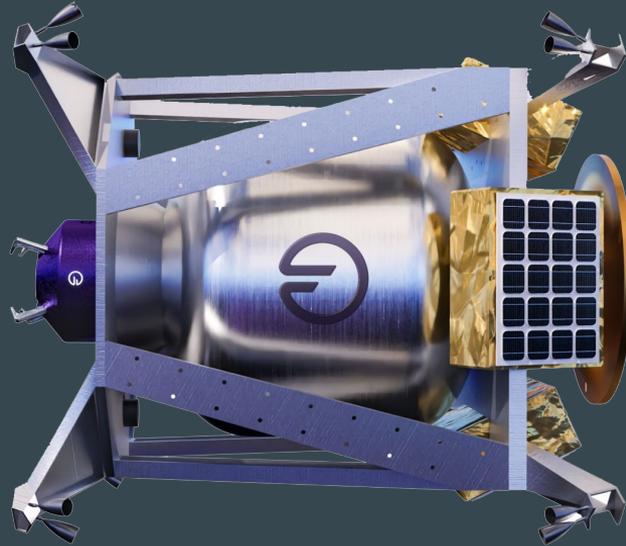


Thank you! Questions?

OrbitFab RAFTI Refueling Interface



Orbit Fab Fuel Shuttle Spacecraft



<https://www.cnn.com/world/orbit-fab-gas-stations-in-space-scن-spc-intl>

Orbit Fab Fuel Depot



<https://www.orbitfab.com/news/fuel-geo/>

Depot to Asset Time Calculations and Assumptions

- Calculation:
 - Impulsive maneuver
 - Response time = phasing time + time of flight
 - Delta-v use calculated with Lambert's problem for a given time of flight to use in as a penalty value
 - Perigee calculated to use as a penalty value
 - Response time + delta-v penalty + perigee penalty is optimized
 - Monte Carlo of uniform randomized depot true anomaly and target orbital elements ran to calculated min, max, mean, and percentiles of response time for a given depot altitude
- Assumptions
 - Depot:
 - Non-eccentric
 - Inclination = 0°
 - Delta-v constrained to 1.4km/s
 - Based on Firefly Elytra delta-v for 100kg payload (<https://fireflyspace.com/elytra/>)
 - Perigee constrained to 100 km
 - GEO satellites
 - In ranges
 - Altitude: [35776, 35796] km
 - Eccentricity: [0,0.84]*
 - Inclination: [0,1] degrees**
 - RAAN: [0,360] degrees
 - Argument of periapsis: [0,360] degrees
 - True anomaly: [0,360] degrees
 - * Based on publicly available satellite catalogue from <https://www.ucs.org/resources/satellite-database>
 - ** Constrained for problem simplification, further exploration required



COSMIC Capstone Challenge:
Mid Design Brief

H2Probe, University of Pittsburgh: Geosynchronous Xenon Refueling Spacecraft (GXRS).

Students: Aidan Kleinhenz, Nathan Belcufine, Camden Smith, Alex Adams, Arin Magesh, and Mat Tannenbaum
Advisor: Dr. Matthew Barry
Mentor: Anjit Fageria

December 8, 2025

Team Overview



Geosynchronous Xenon Refueling Platform

Six-member team from the University of Pittsburgh.

- Aidan Kleinhenz – Program Director
- Nathan Belculfine – Refueling Lead
- Camden Smith – Docking Lead
- Arin Magesh – Chassis Lead
- Alex Adams – GN&C Lead
- Mat Tanenbaum – Power Lead



Aidan Kleinhenz



Nathan Belculfine



Camden Smith



Mat Tanenbaum



Alex Adams



Arin Magesh



Executive Summary



Geosynchronous Xenon Refueling Spacecraft

- Spacecraft are often discarded once their fuel supply runs out, polluting highly used orbits and wasting launch resources.
- Satellites should be designed to be refuellable, rather than relying on launching replacements or costly mission extension vehicles which can only service one client at a time.
- We propose an autonomous refueling spacecraft capable of supplying supercritical Xenon to satellites that utilize electric propulsion systems. The system will employ a custom tank interface designed by our team to enable docking and propellant transfer. Xenon will be stored as a supercritical fluid to eliminate active cooling and cryogenic complications while maximizing storage density.

Projected Path

Docking

- Design 2-part soft-capture system (GXRS & Client Tank) which extends and retracts to guide and stabilize the target satellite. Once satellites are sufficiently aligned, the docking assembly performs a controlled “lunge,” allowing the soft-capture mechanism to engage and interlock with the corresponding ring on the client satellite.
- After the two soft-capture rings connect, an onboard fluid transfer mechanism extends and connects to the client’s fuel tank interface. This mechanism will be a large focus of the design, with both a Simulink and practical model likely.
- A mockup of the chassis will be created, currently undergoing research into whether existing platforms could suit project needs. Stress and vibrational analysis will be performed to ensure systems are protected during launch and docking, and a CAD model to draft the placement of components like the refueling mechanism and power systems.

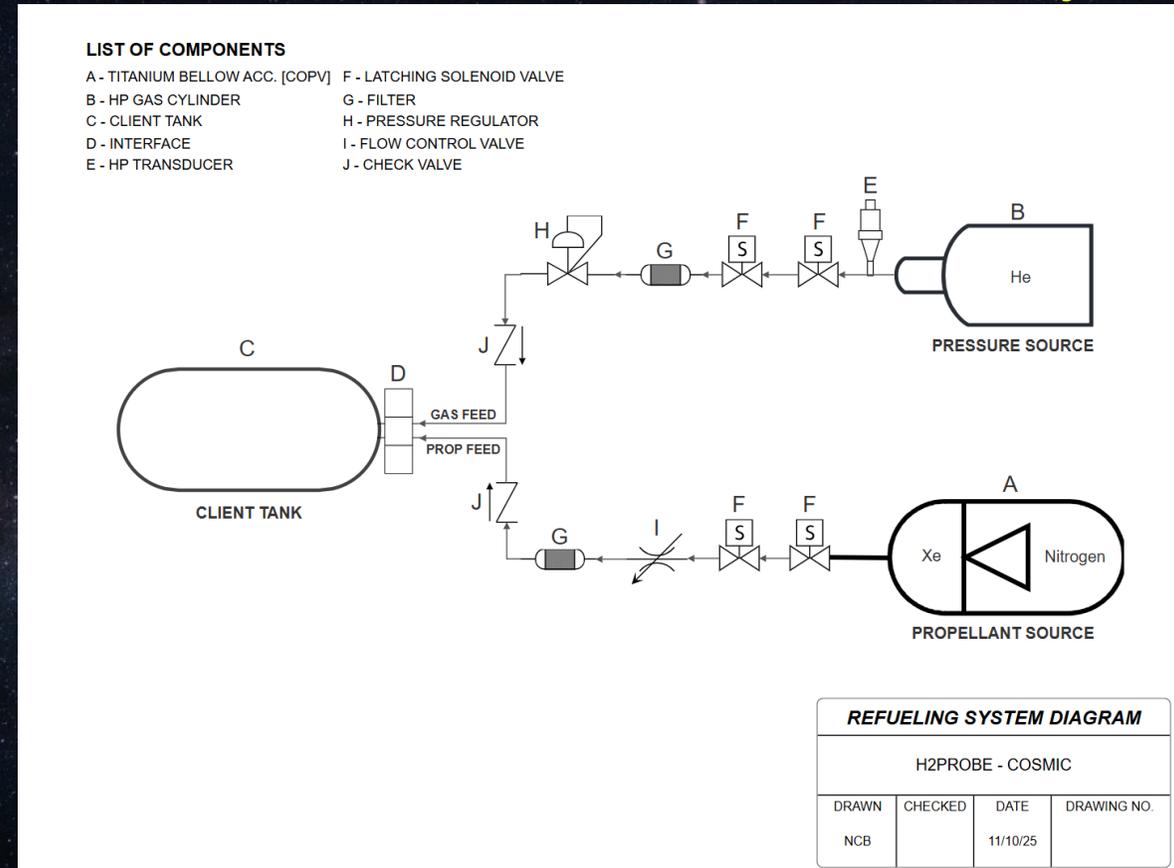
Design interface and fuel system, then supporting chassis and fuel systems.

System Overview

Refueling

- Looking into in-orbit propellant transfer methods, accumulators can be used with a nitrogen pre-charge within a metal bellow for driving pressure.
- To maintain Xenon at a supercritical state, the client tank must be pressurized before prop transfer. Helium can be used for pre-pressurization as an inert gas, avoiding hindrance of Xenon fuel efficiency.
- Methodology (Formulating within Excel):
 1. Identify target mass transfer (150kg)
 2. Utilize Van der Waals EOS Equations to actively determine pressure
 3. Sizing Metal Bellow Accumulator (Xe propellant & Pre-charge Nitrogen)
 4. Calculating final equilibrium Pressure from ideal gas mixing equation

P&ID of Interfaced Refuel System





THE POWER OF COLLABORATION

COSMIC Capstone Challenge:
Mid Design Brief

Questions?

OSCAR@VT

Project S.H.I.E.L.D

COSMIC Capstone Challenge: Orbital Servicing

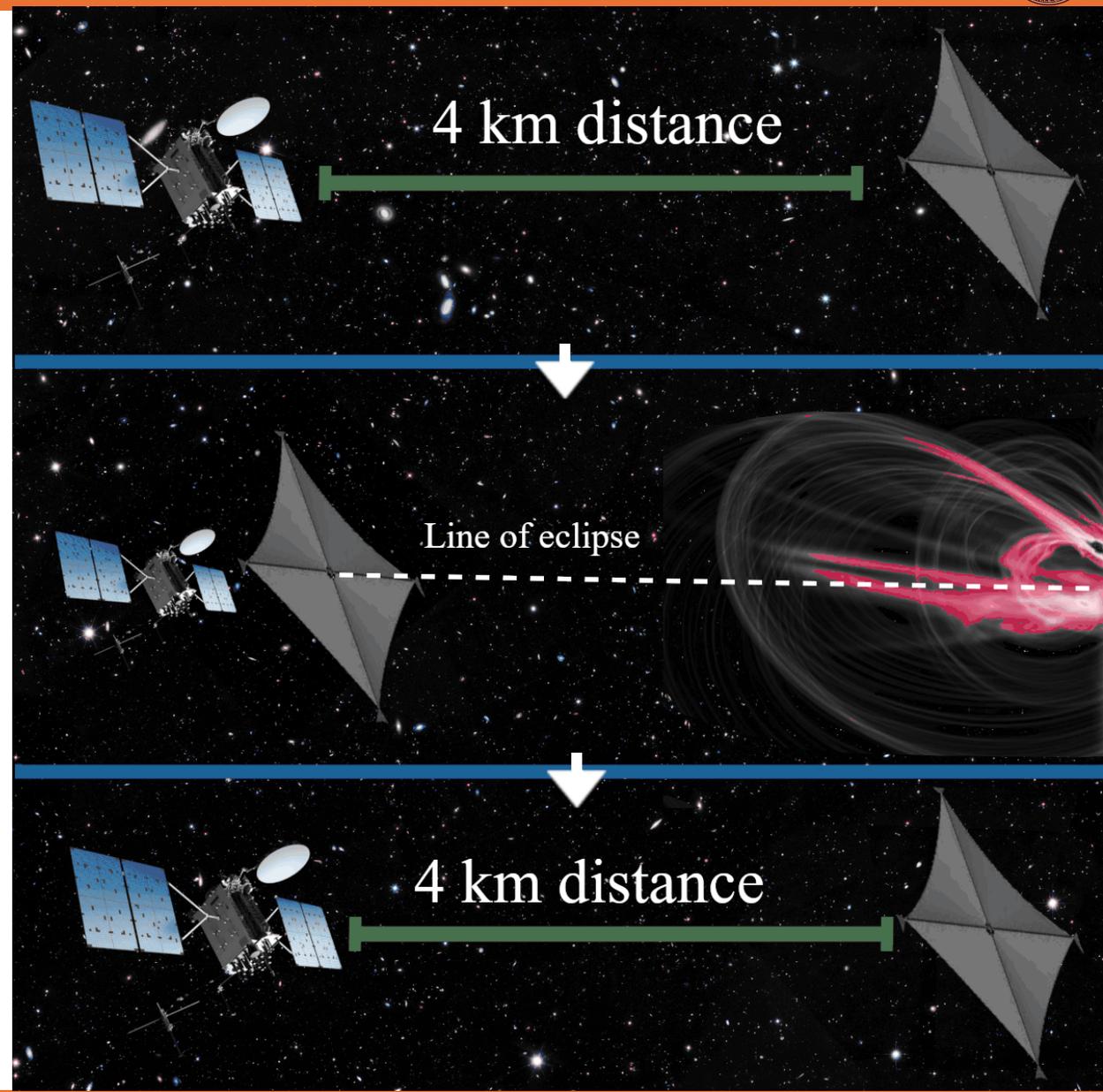
A modular GEO servicing spacecraft designed to protect high-value satellites during extreme CME events.





Mission Overview

- S.H.I.E.L.D will be contracted by clients to shield GEO satellites during CME events.
- For duration of the contract, S.H.I.E.L.D maintains 4 km distance during dormancy.
- S.H.I.E.L.D will close the distance and maintain line of eclipse at a 5m distance while the CME event is active, then return to a 4 km distance.





1

1- Launch ESPASat-D bus into GTO orbit via Falcon Heavy

2

2- Use ESPASat bus to insert into GEO orbit at client sat's neighborhood

3

3- Rendezvous with client's orbit

4

4- Maintain 4 km distance from client

5

5- Receive advanced CME warning from NOAA and other associated entities

6

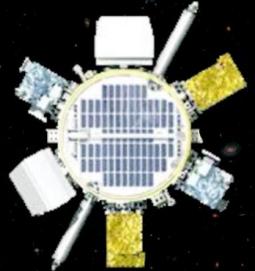
6- Move into position near client

7

7- Maintain line of eclipse between client satellite and the sun for the duration of the CME

CME threats consist of high energy protons and electrons, as well as sparse high energy particles

OSCAR@VT S.H.I.E.L.D CONCEPT OF OPERATIONS





Significance of Problem:

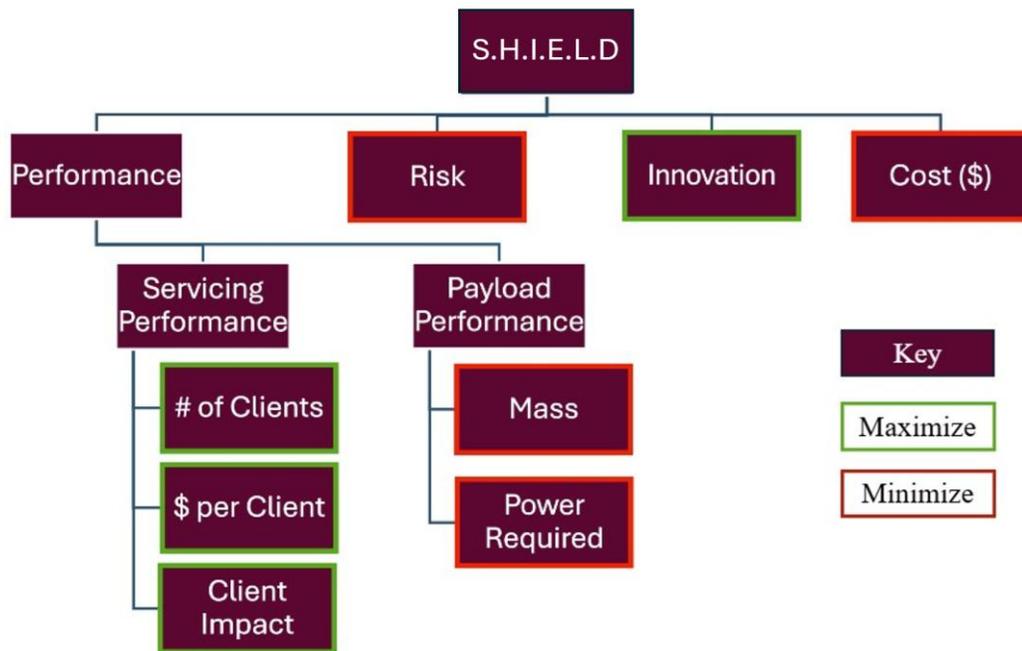
- GEO satellites cost **~\$200M** and operate for **10–15 years**.
- CMEs cause: **SEUs, latchups, dielectric charging, surface charging, failure of electronics**.
- In **2023, 47 satellites** experienced anomalies in a single storm.
- Historical failures (ANIK E1/E2, TDF-1, Telecom-2A) led to **months-long outages**.

Purpose of S.H.I.E.L.D

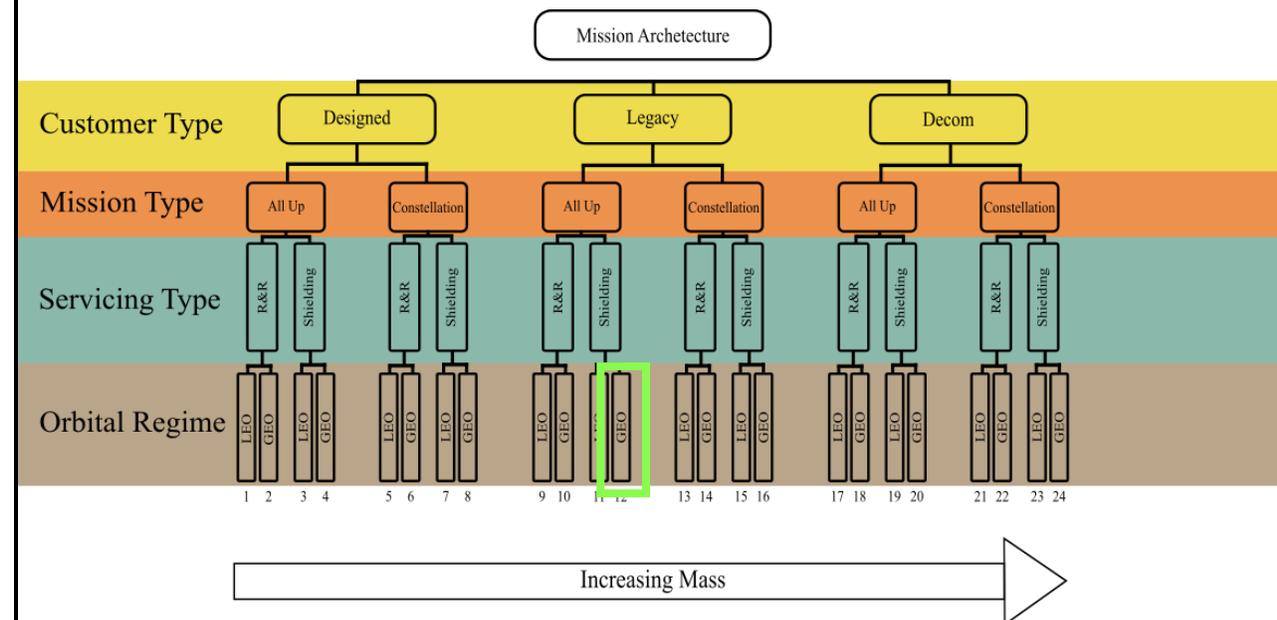
- Many GEO sats were launched decades ago, **not designed for today's extreme cycles**.
- S.H.I.E.L.D intends to serve as a life extension for GEO satellites by shielding against protons, electrons, and high energy particles that would contribute to the degradation of its components.



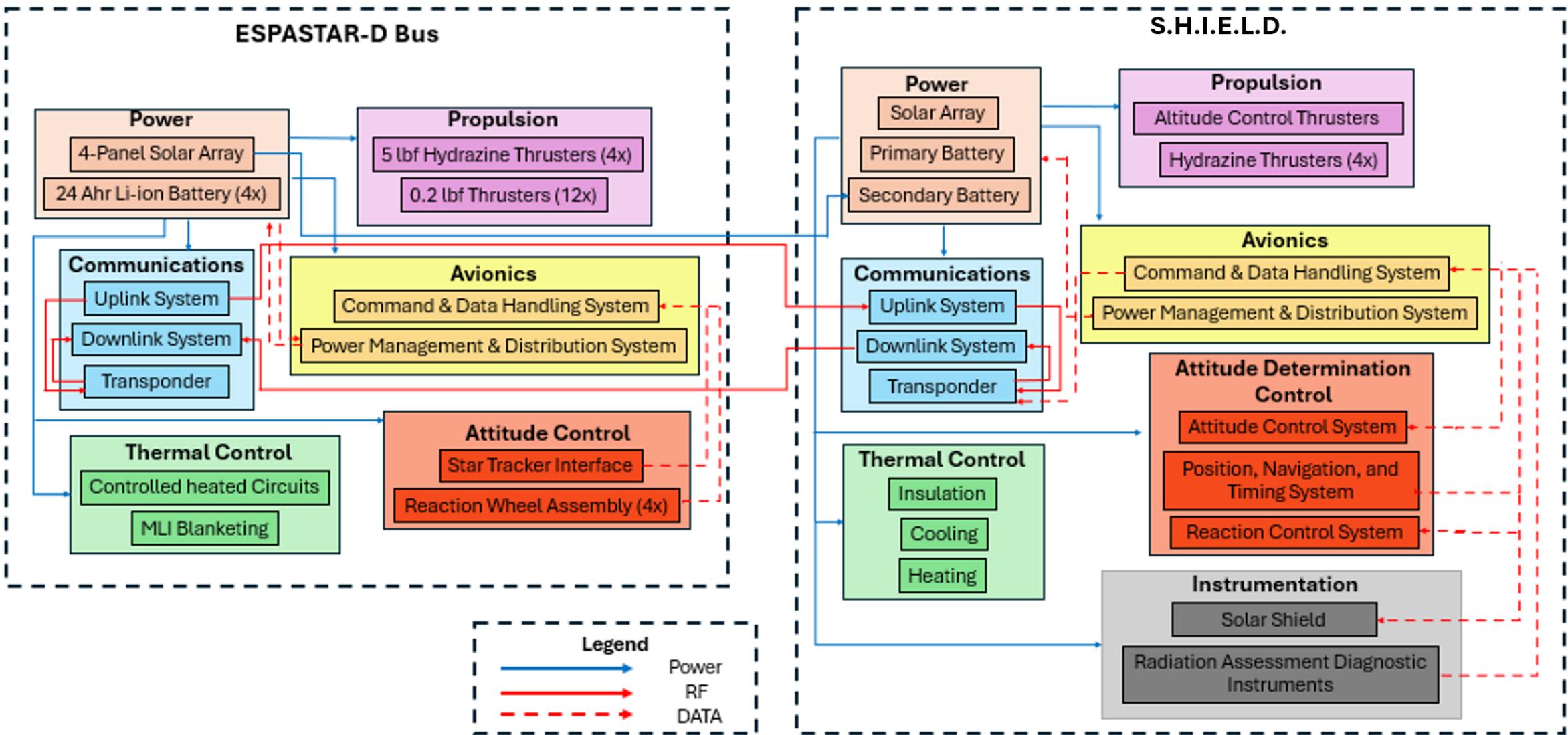
Objective Hierarchy



Mission Architecture



S.H.I.E.L.D Preliminary Block Diagram





- 5 Shielding Concepts Identified and researched
 1. Graded-Z
 2. H-BNNT
 3. H-CNT
 4. Electrostatic
 5. Magnetic
- Trade Studies are still being refined for down-selection with the following criteria weights:

Shielding Options	Minimize				Maximize		Score
	Mass (kg)	Power (W)	Cost (\$)	Secondary (Rad)	TRL	Stopping Power (MeV/cm)	
Criteria Weight	0.0594	0.0284	0.0229	0.1395	0.4111	0.3356	



- Finalize shielding material selection (Graded-Z vs. electrostatic).
- Complete subsystem component trades (power, thermal, comms, propulsion).
- Refine orbital trajectories & proximity-operations profile for CME response.
- Begin structure + component placement within ESPASat-D envelope.
- Validate design against mission-level and derived requirements.
- Develop updated mass & power budgets based on selected components.
- Integrate shielding design with CONOPS for deployment + station-keeping.

Thank you!

Questions?





COSMIC Capstone Challenge:
Mid Design Brief

AULUNA, Auburn University: Laser Sintering Robotic Hexapod (LSRH)

Students: Laith Bader, Claire Brandon, Jacob Bui,
Cade May, Justin Wade
Advisor: Dr. Davide Guzzetti
Mentor: Matt Anderson

December 8, 2025

Meet the Team



Dr. Davide Guzzetti



Matt Anderson



Cade May
BAE/MEM



Laith Bader
BAE



Claire Brandon
BAE



Jacob Bui
BAE



Justin Wade
BAE/MEM

Project Overview

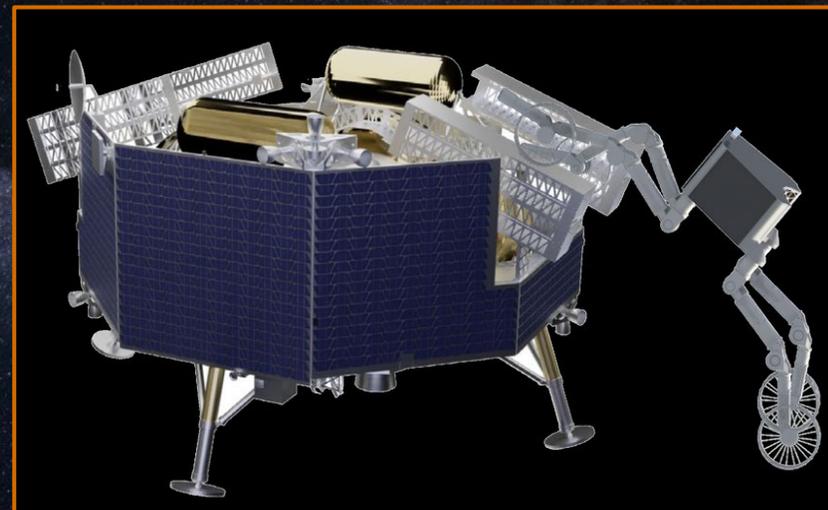
Laser Sintering Robotic Hexapod



Team AULUNA at Auburn University is designing a hexapod rover that will autonomously use a laser sintering device to create lunar landing pads.



Sample rendering of an LSRH design



Astrobotic's Griffin Lunar Lander

Executive Summary

Laser Sintering Robotic Hexapod (LSRH)



- Problem: Dust plumes generated by lunar landers can damage structures and vehicles on the Moon
- Solution: Build dust mitigating landing pads to reduce plume size and provide stable launch and landing sites
- How it Solves the Problem: The autonomous rover will utilize lunar regolith to create launch and landing pads (LLPs), while being able to navigate the harsh lunar surface



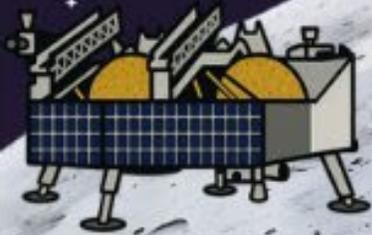
Concept Art of LSRH - Not Final Design



1. Arrive from Earth



2. Deploy from the Griffin



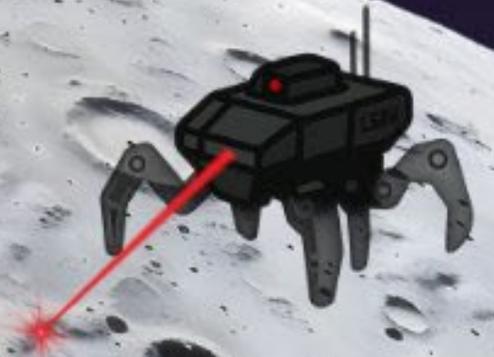
3. Maneuver to construction site



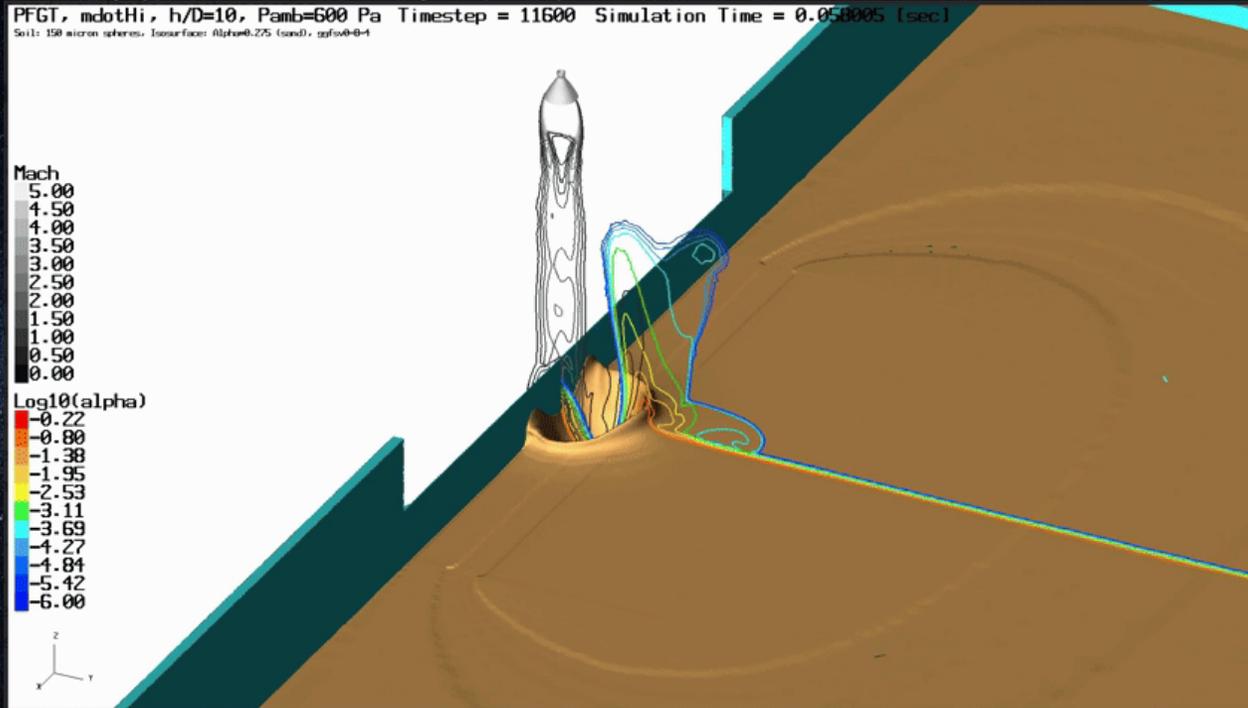
4. Perform Site Survey



5. Carry out Sintering Process



Dust Plumes Could Create “Ultra-FOD”



NASA Gas Granular Flow Solver (GGFS) Dust Plume Simulation

- Regolith particles come in many sizes, and porous/jagged grains lead to high abrasion
- Lack of atmosphere allows regolith to be launched across planetary surface
- Oxidized iron within the regolith can give electrostatic charges (Cohesion effect) and could potentially damage electronic components

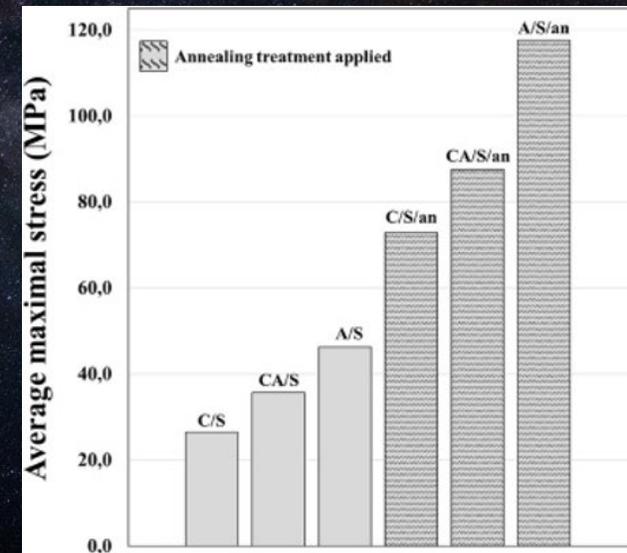
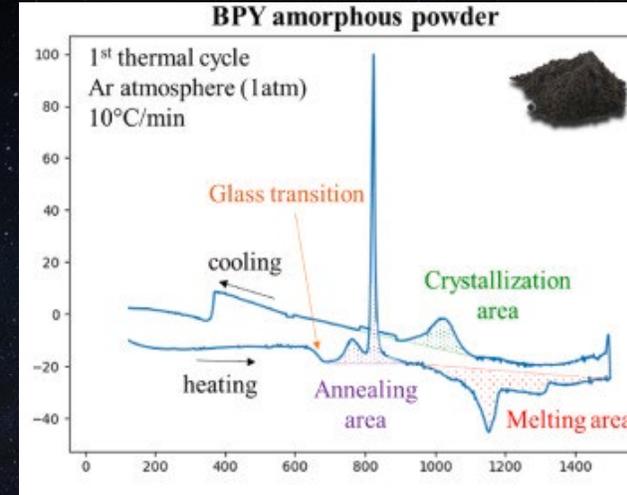
[1] Lunar sourcebook : a user's guide to the Moon

[2] NASA@SC22: Rocket Plume-Surface Interaction Simulations for Moon and Mars Landings

Laser Sintering



- A fiber optic laser with tunable power settings will be used to uniformly sinter regolith until annealing temperatures are met (820 - 850 °C) [3]
- Annealing treatment allows for the compressive strength of processed regolith to be increased considerably



[3] www.sciencedirect.com/science/article/pii/S0094576524005988

The Hexapod is Innovative, Resilient, and Adaptable



- Future lunar and planetary missions will be required to traverse steeper, rougher terrain where wheels will reach their limits
- Inspired by the movement of spiders, the hexapod will be well-suited to mount the obstacles of these future missions [6]
- The hexapod's point-foot contacts create less drag and abrasion compared to wheels or tracks, improving its reliability and resilience in regolith
- We intend to prove hexapod feasibility on a mission with simple mobility requirements



Hexapod Gait Demonstration [4]



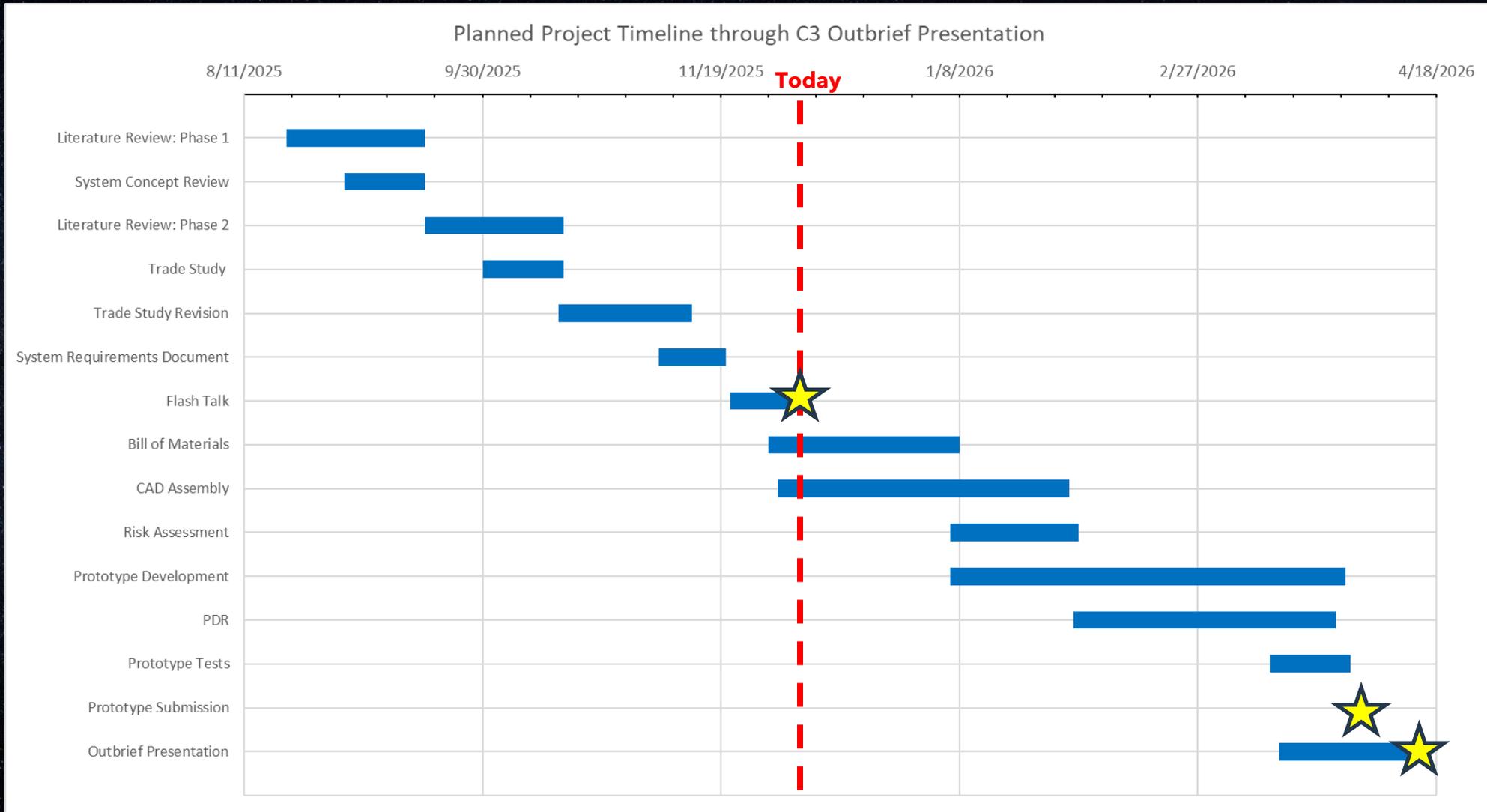
Curiosity Rover Wheel Damage [5]

[4] [youtube.com/watch?v=6T8NDrmyjwc](https://www.youtube.com/watch?v=6T8NDrmyjwc)

[5] robotics.jpl.nasa.gov/media/documents/fmwi-rankin-2022-0225-final.pdf

[6] ieeexplore.ieee.org/document/7536027/

What's Next?



References



- [1] Dishongh, Lora. “Lunar Surface Data Book.” *NASA Technical Reports Server (NTRS)*, ACD-50044/Revision A, 25 May 2023, https://ntrs.nasa.gov/api/citations/20220015275/downloads/ACD-50044%20Lunar%20Surface%20Data%20Book_100622.pdf
- [2] “Rocket Plume–Surface Interaction Simulations for Moon and Mars Landings.” *NASA@SC22 Research Projects*, NASA Advanced Supercomputing (NAS) Division, 8 Nov. 2022, www.nas.nasa.gov/SC22/research/project12.html.
- [3] Granier, Julien, Thierry Cutard, Patrick Pinet, Yannick Le Maout, Serge Chevrel, Thierry Sentenac, and Jean-Jacques Favier. “Selective Laser Melting of Partially Amorphous Regolith Analog for ISRU Lunar Applications.” *Acta Astronautica*, vol. 226, 2025, www.sciencedirect.com/science/article/pii/S0094576524005988.
- [4] “Demonstration Video.” *YouTube*, n.d., youtube.com/watch?v=6T8NDrmyjwc.
- [5] Rink, Kimberly, Jiun-Kai Freddy Wang, Evan Graser, Nikunj Patel, and Arturo Rankin. “Assessing Mars Curiosity Rover Wheel Damage.” *JPL Robotics*, Jet Propulsion Laboratory, National Aeronautics and Space Administration, 5 Mar. 2022, robotics.jpl.nasa.gov/media/documents/fmwi-rankin-2022-0225-final.pdf.
- [6] Roditis, Ioannis. “Maintaining Static Stability and Continuous Motion in Rough Terrain” Hexapod Locomotion without Terrain Mapping | IEEE Conference Publication | IEEE Xplore.” *IEEE Explore*, IEEE, 8 Aug. 2016, ieeexplore.ieee.org/document/7536027/.



COSMIC Capstone Challenge:
Mid Design Brief

Questions?



COSMIC Capstone Challenge:
Mid Design Brief

War Eagle Lunar Team, Institute: Auburn University
Auburn University

Students: Kai Reid, Thomas Markun, Emily Headley, Sarah
Barnhart, Evans Bishop
Advisor: Davide Guzzetti
Mentor: John McHale, Matt Andersen

December 8, 2025



Meet the Team, Advisors and Mentors

Converting Lunar Environment for Access and Residence

C·L·E·A·R



WAR EAGLE
LUNAR TEAM

Advisor, Dr. Davide Guzzetti



Mentor, Dr. John McHale



Mentor, Matt Andersen





Meet the Team, Team Members

Converting Lunar Environment for Access and Residence

Kai Reid



Thomas Markun



Sarah Barnhart



Emily Headley



Evans Bishop





Executive Summary

Converting Lunar Environment for Access and Residence

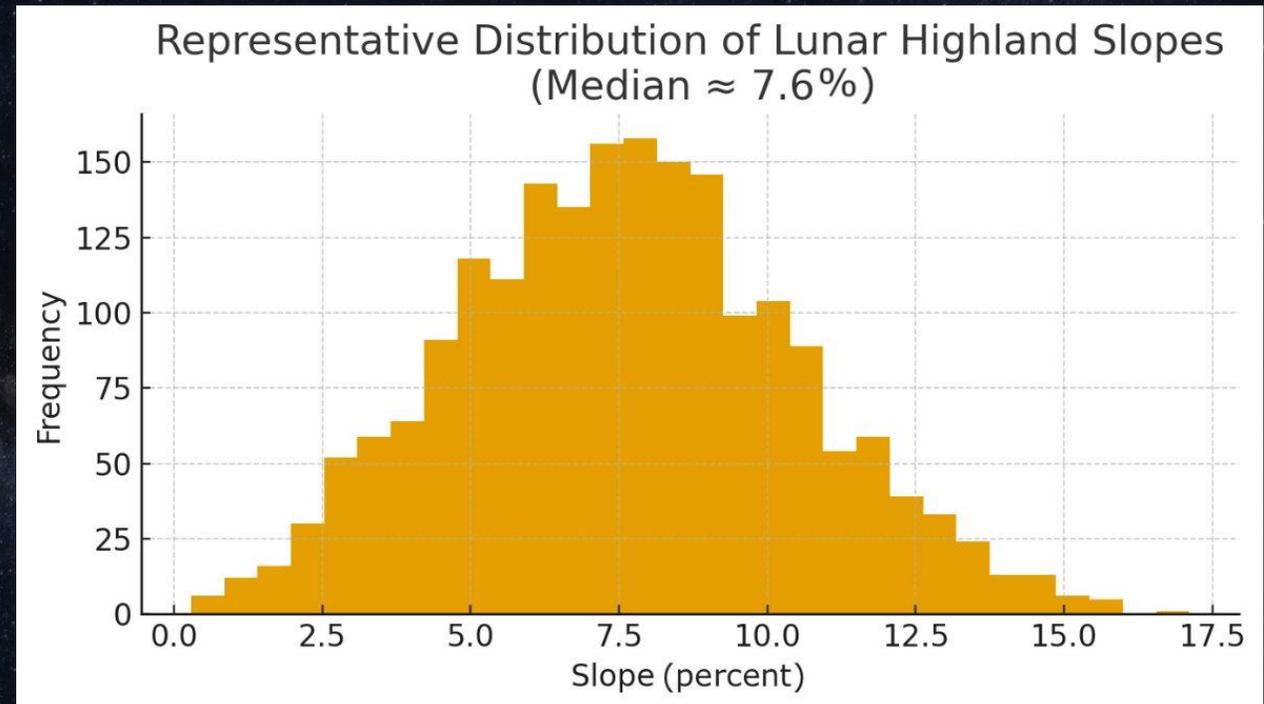
- Lunar South Pole has slopes emblematic of the Highlands terrain with roughly 0.2% harsher grades.
- An Autonomous Rover that utilizes an updated version of Bettemir's [4] algorithm to grade ahead of other Lunar Missions.
- Allows Lunar Bases to have groundwork laid and minimize future mission payload sizes



Overarching Objective

Converting Lunar Environment for Access and Residence

- Device(s) that establish a favorable geography for a future permanent lunar base.
- Previous Auburn projects have produced remote controlled rovers [1][2]

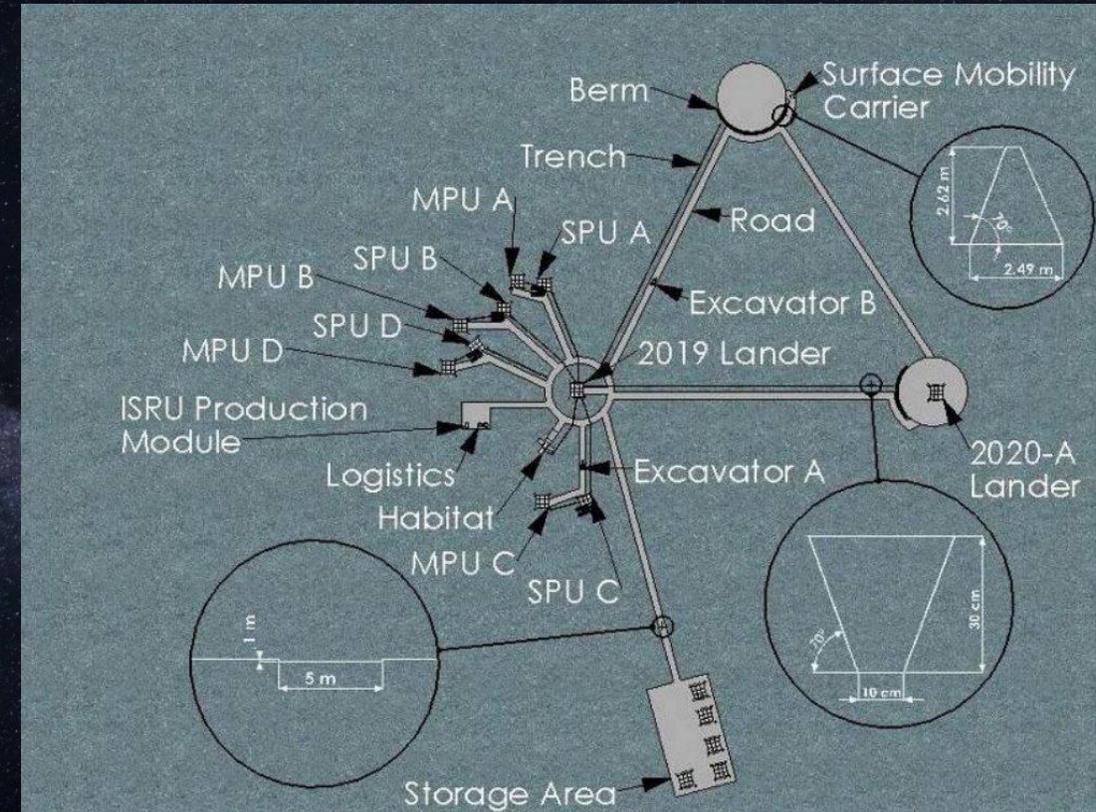




Executive Summary

Converting Lunar Environment for Access and Residence

- Lunar Structures such as Landing Pads, Roads and Berms will need a certain grade level to begin *construction*.
- Good Site choice can mitigate level of grading required, but not all.



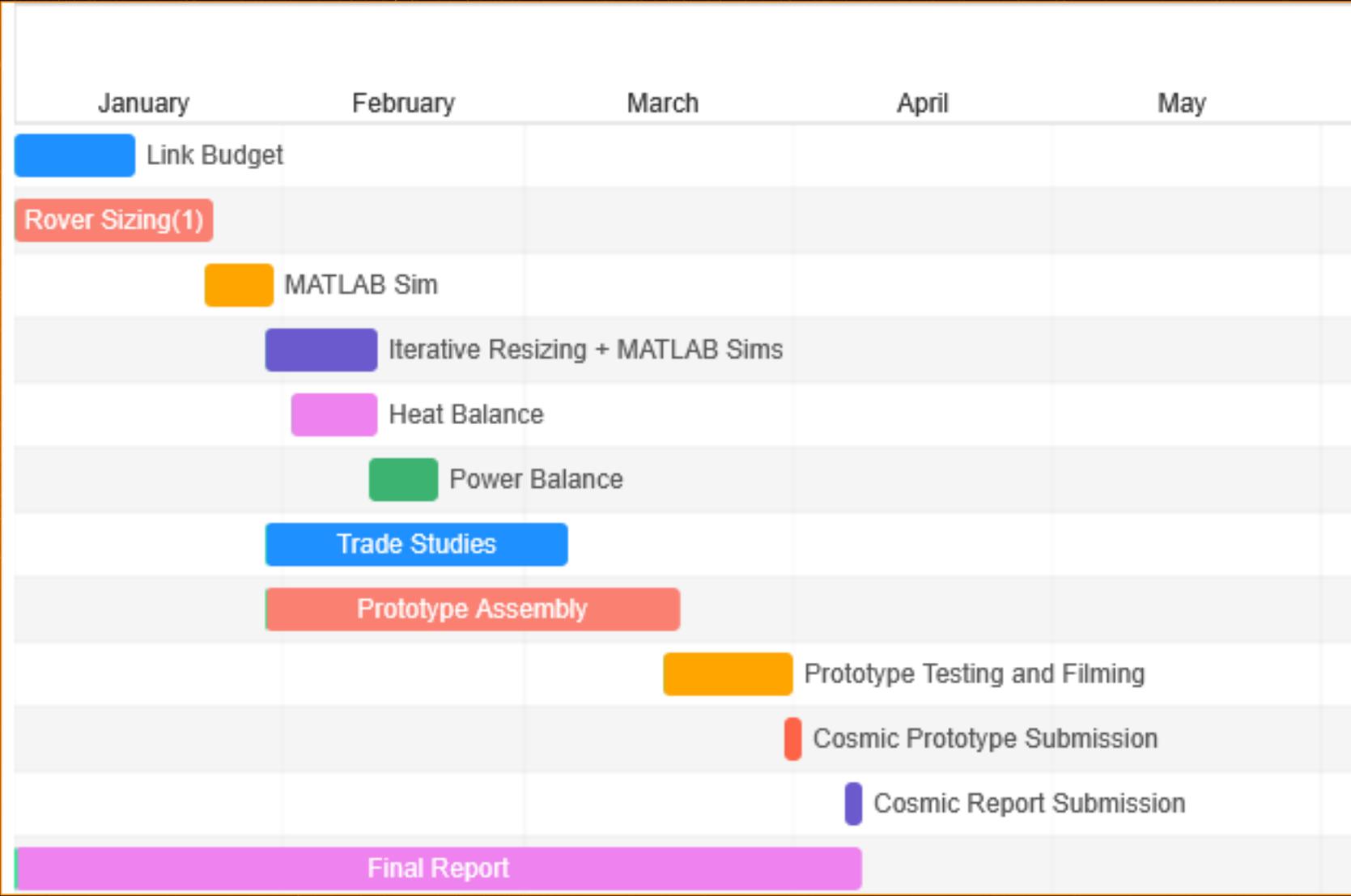
[3]

Grading will be required in order to construct a Lunar Base.



Gantt Chart of Remaining Work

Converting Lunar Environment for Access and Residence





References

Converting Lunar Environment for Access and Residence

- [1] Bender, N., Craven, A., Daniels, J., Lambert, C., & Wingo, T. (2008). *Final Design Report: Lunar Excavator, NASA – Corp 1*. Auburn University. <https://www.eng.auburn.edu/~dbeale/MECH424050/Projects/Excavator/Excavator4240FinalReportSpring08.pdf>.
- [2] Harlos, R., Davis, H., Iddawela, G., & Braxton, D. (2009). *Lunar Regolith Excavator, NASA – Corporation 2: “Critical Design Review.”* Auburn University. https://www.eng.auburn.edu/~dbeale/MECH4240-50/reports/Excavator_4240_FinalReport_Summer09.pdf.
- [3] Mueller, R. P. (2022). *Lunar Base Construction Planning (v2 RPM)*. NASA Swamp Works, Exploration & Research Technologies, Kennedy Space Center. <https://ntrs.nasa.gov/api/citations/20220005192/downloads/Lunar%20Construction%20Planning%20v2%20RPM.pdf>
- [4] O. H. Bettemir, "Simulation of Autonomous Grading of Lunar Surface," 2023 10th International Conference on Recent Advances in Air and Space Technologies (RAST), Istanbul, Turkiye, 2023, pp. 1-6, doi: 10.1109/RAST57548.2023.10197888.

Flexion

Team Members

- William Dortch
- Matthew Loi
- Jonathan Sanchez
- Kin Tsang

Mentor

- Horace Lee
- Antonella S. Pinola

Overview

- NASA currently wants a power grid with a justification being "Allows for the deployment of future science loads that do not need to carry their own power generation".
- Need for charging infrastructure to support future devices
- Lunar dust and harsh conditions creates problems with traditional physical charging methods

Statement of Work

- Utilizing Armadas Voxels as a base, we will design a modular and scalable rover charging infrastructure that will generate power, store power, and charge exploration rovers at mission critical sites such as ISRU excavation at the Shackelton Crater
- We will be outlining robotic assembly process of charging station.

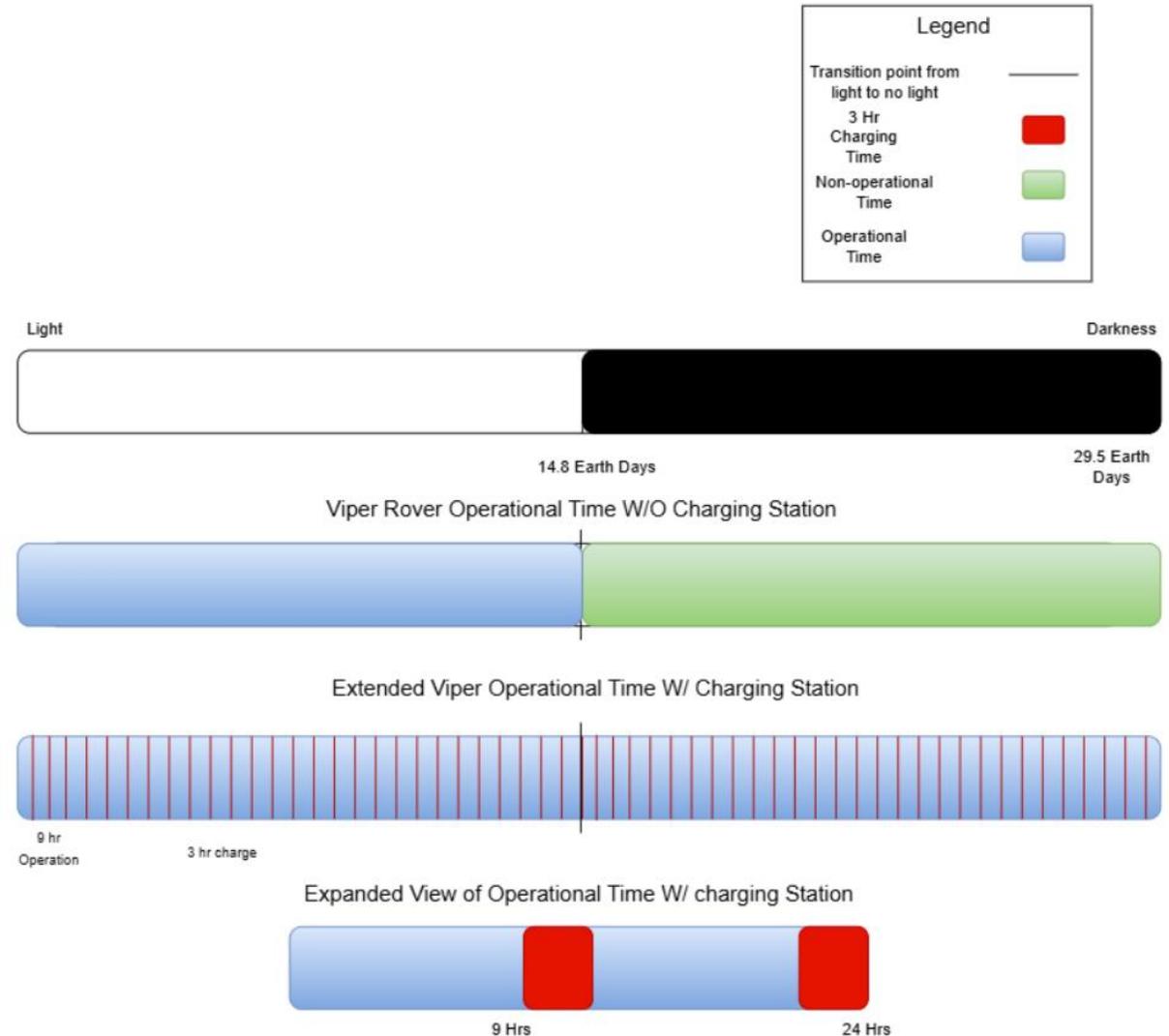
Roles

William Dortch	Matthew Loi	Jonathan Sanchez	Kin Tsang
Power Flow	Battery	Thermal Management	Outfitting
Inductive Resonance Charger	Overall Structural Design	Visual illustrator	Robotic Assembler Operations
	Energy/Power Requirement		
	Power Generation		

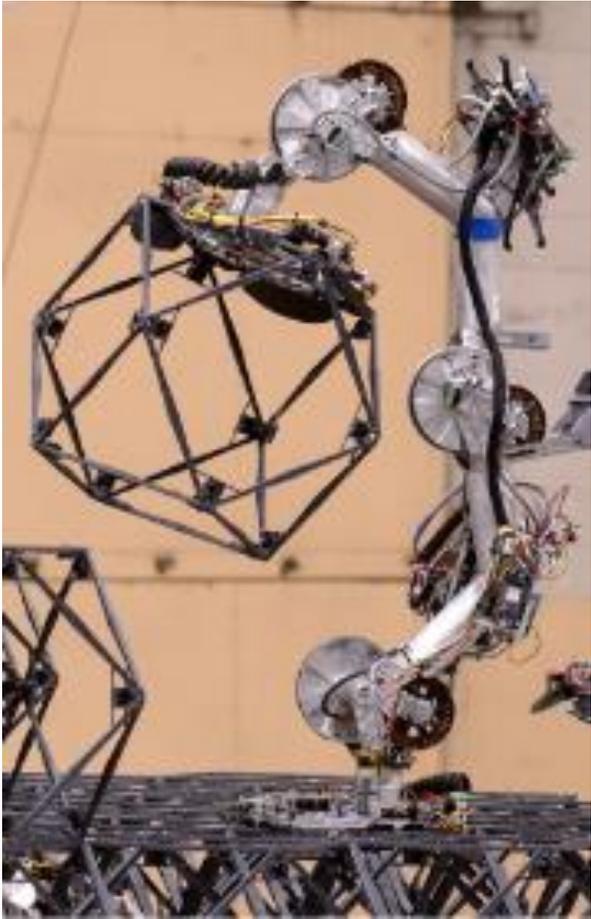
Operational Time Comparison

- Timeline to compare benefits of charging station to current rover operational cycle
- Viper can only function when light is present to charge its battery
- Charging station stores energy for viper to charge from during darkness
- Per day Rover uptime is 18hrs (75%)

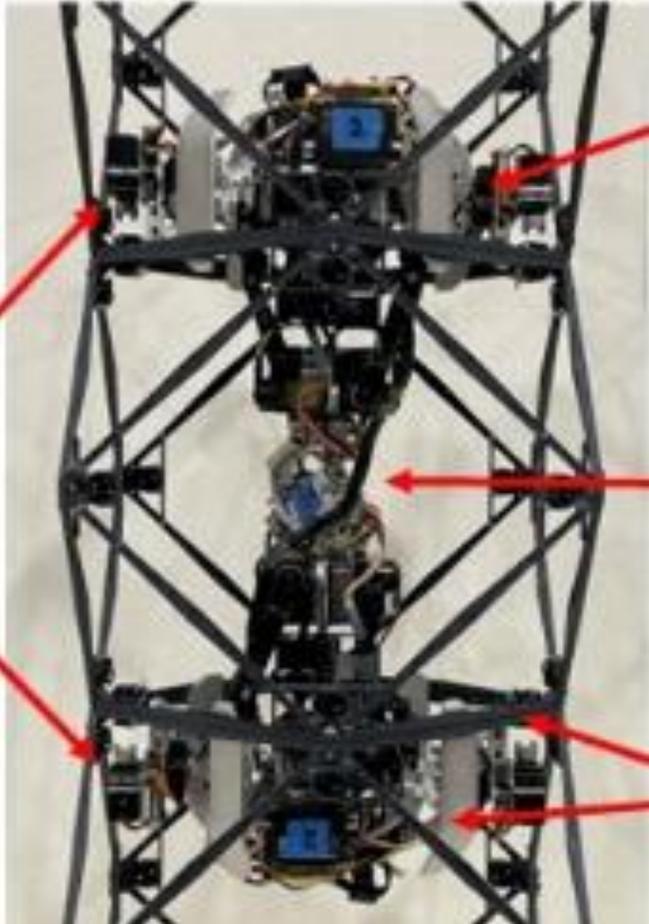
	Operational Time
Viper W/O Charging Station	355.2 hrs per cycle
Viper W/ Charging Station	531 hrs per cycle



ARMADAS Voxel and Assemblers



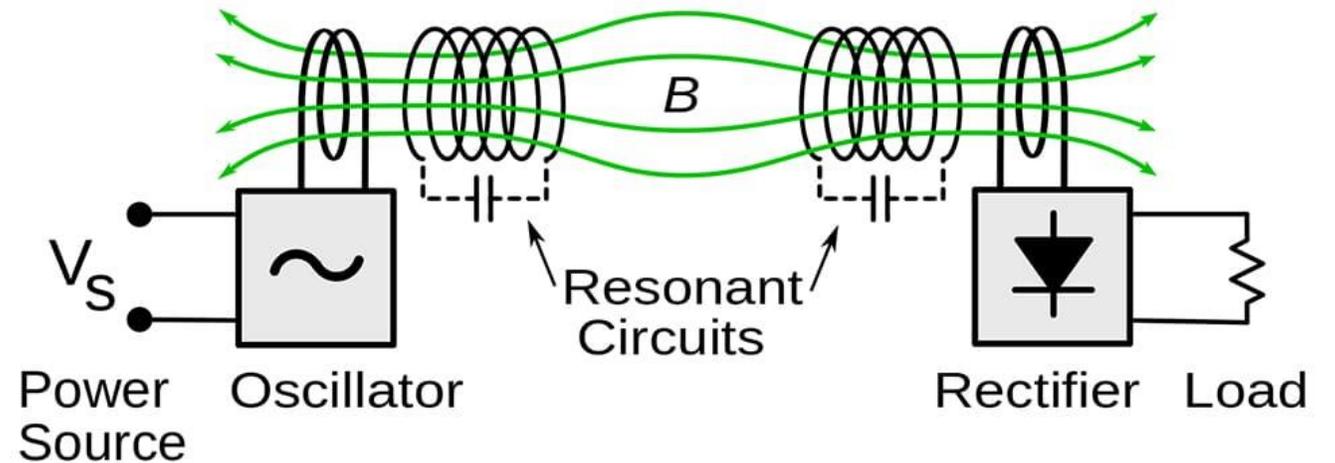
SOLL-E transports and places ARMADAS Voxel



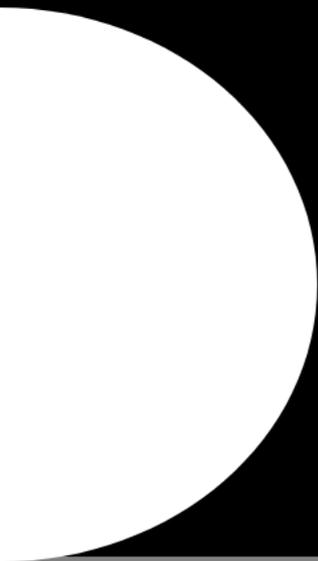
MMIC-I traverses ARMADAS voxel and bolts them together

Inductive Resonance Charging

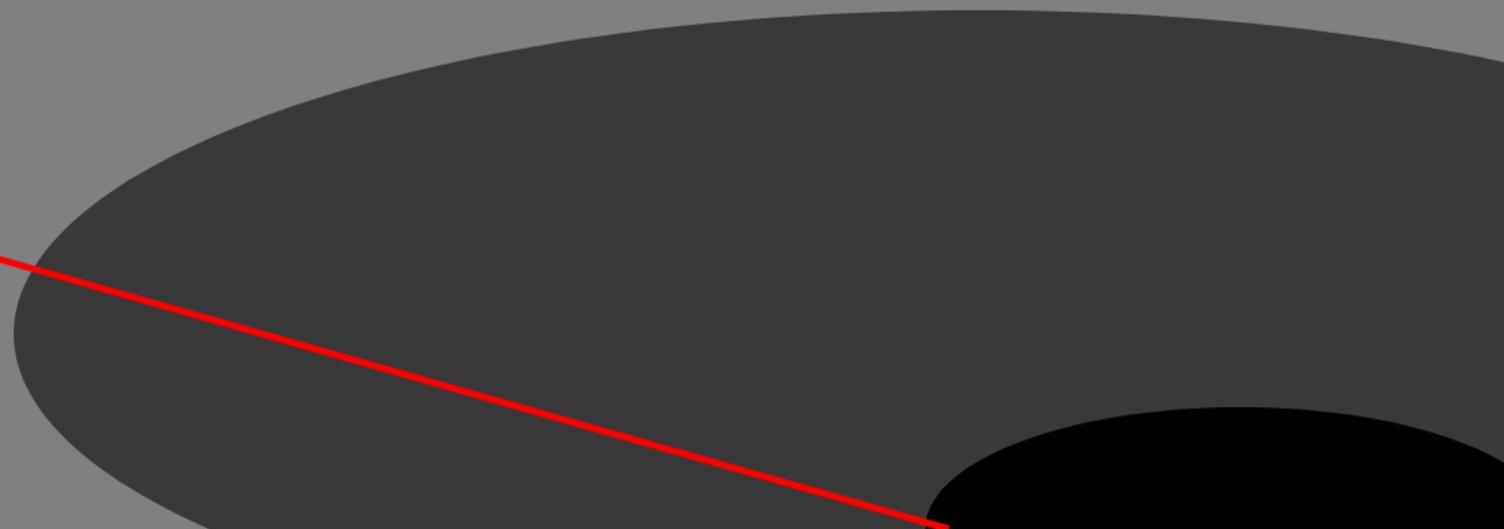
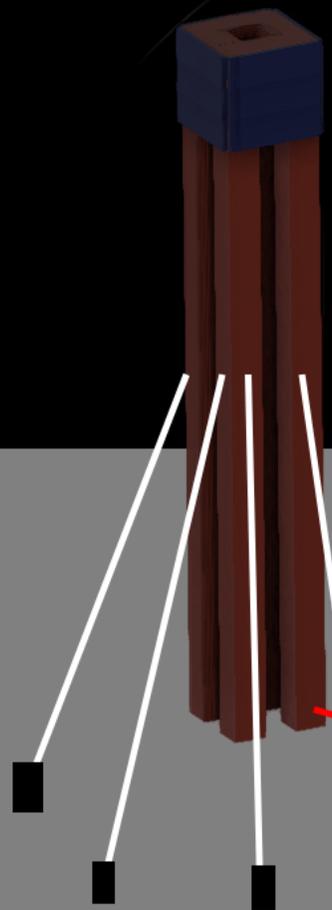
- Inductive Resonance Coupling is using an oscillating magnetic field via transmission coil and receiver coil.
- This coupling is called a inductive resonance circuit where power is transferred similarly to the effect of a transformer.
- Power is transferred through AC then rectified to charge the rover.



Block Design

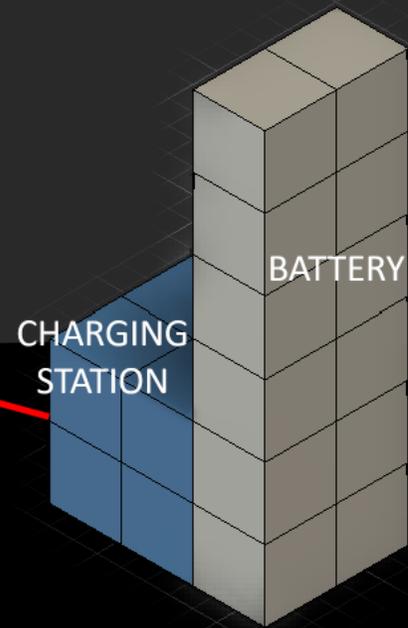


Solar Tower



Block Design

WIRE



Wormhole - Mini Flash Talk

A Soft-Robotic End-Effector for Orbital Debris Capture

C3: COSMIC Capstone Challenge

December 8, 2025

Presentation by:

Sabby Clemmons

Sarah Remeis

Track 4 Alignment — In-Space Assembly / Orbital Servicing:

Wormhole directly supports Track 4 by enabling safe, compliant capture and stabilization of uncooperative objects, a core requirement for future in-space servicing, assembly, and debris-handling architectures.

One-Sentence Mission Summary:

Wormhole is a soft-robotic end-effector designed for orbital servicing missions to safely capture and stabilize uncooperative debris or inactive satellites.

Meet the team

the students

the advisors



Sabby Clemmons
Senior EE at UNH



Sarah Remeis
Senior EE at UNH



Se Young Yoon (Pablo)
ECE Professor @ UNH
ECE Project Advisor



Brad Kinsey
ME Professor @ UNH
Co-Advisor & C3 Advisor



Jerry Fuller
Senior Engineer @ The
Aerospace Corporation
Mentor & Pioneer of AFCs



MD Shaad Mahmud
ECE Professor @ UNH
Unofficial Advisor
(on sabbatical)

Problem

LEO is increasingly congested with debris.

- Even small fragments travel >7 km/s and threaten satellites.
- Existing rigid capture systems (arms, nets, harpoons) are heavy, high-risk, and require predictable target motion.

Key Technologies

AFC — Autodynamic Flexible Circuits

- Flexible PCBs that bend with the structure
- Carry power + sensor signals through soft robotic fingers
- Enable lightweight, embedded sensing → “nervous system” of Wormhole

SMA — Shape Memory Alloy (Nitinol)

- Wire “muscle” that contracts when electrically heated
- Provides 3–5% strain → curls fingers with no motors

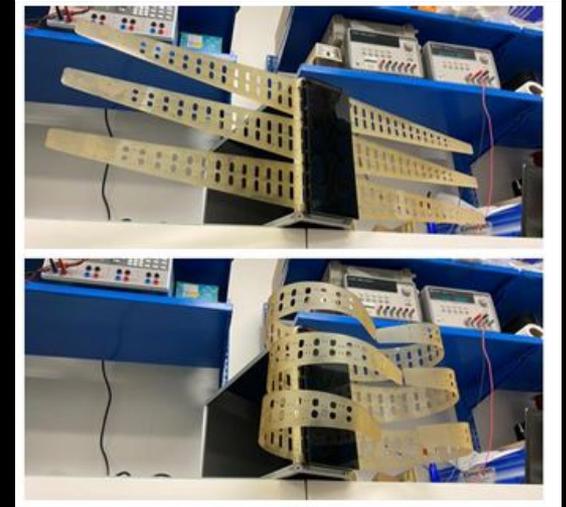
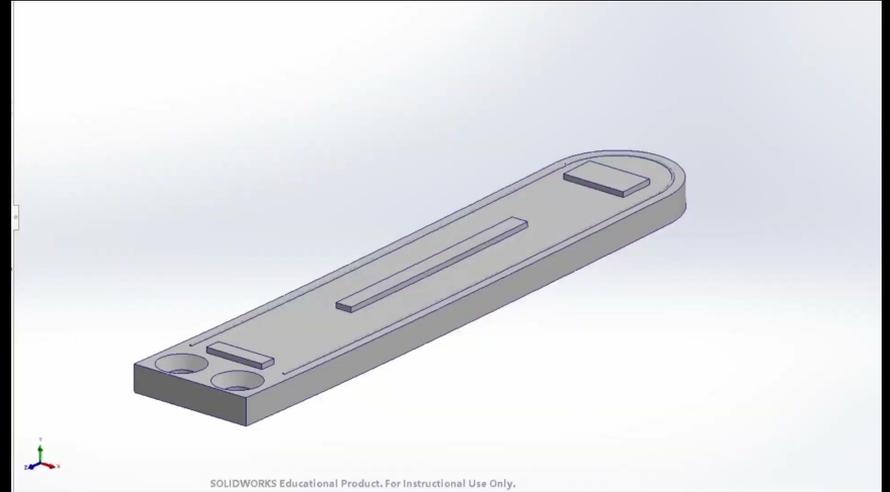


Figure 1 SmallSat 2024 demo system

How Wormhole Works

Soft-Robotic Capture Mechanism:

- **SMA-actuated PEI/Kapton fingers** curl around objects
- **Embedded IMUs + flex sensors** measure motion and curvature in real time
- **Central electronics bay** controls SMA drivers & sensor fusion
- **Vision system** triggers the capture sequence



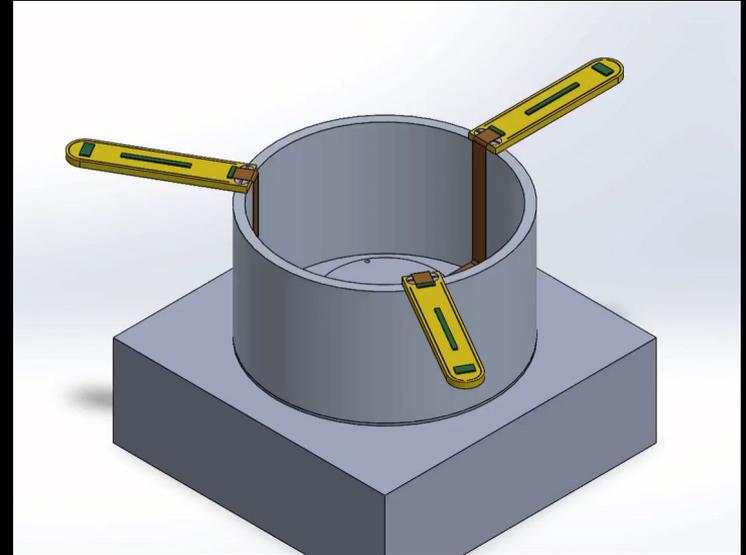
Autonomous Toss and Catch Prototype Demo

Proof-of-Concept Demonstration (2026):

- Detect a free-floating object using embedded vision
- Estimate trajectory + trigger SMA actuation
- Fingers close around a 5-inch balloon
- Demonstrates **adaptive grasping, impact damping, and stabilization**

Validates the core mechanics of orbital servicing →

a **scalable, low-risk approach** to capturing uncooperative debris





THE POWER OF COLLABORATION

COSMIC Capstone Challenge:
Mid Design Brief

Rats in Space, TAMU: In-space Manufacturing of Carbon Fiber Tubing

Students: J. Glenn, H. Kakiuchi, A. MacKay, L. Mikulas,
O. Roberg-Perez, A. Timofte
Advisor: Dr. Manoranjan Majji
Mentor: Dr. Jacob Rome

December 8, 2025

Team Overview

In-space Manufacturing of Carbon Fiber Tubing

- We are Rats in Space, a team from Texas A&M University
- Our team consists of 6 undergraduates of aerospace engineering:
 - James Glenn, Hirokuni Kakiuchi, Alison MacKay, Lily Mikulas, Oliver Roberg-Perez, and Aidan Timofte
- We wish to create a conceptual design for an in-space manufacturing process for carbon fiber tubing



Executive Summary

In-space Manufacturing of Carbon Fiber Tubing

- Carbon Fiber Reinforced Polymers (CFRPs) are increasingly prevalent in spacecraft structures
 - Superior stiffness-to-weight ratio is ideal for ISAM
- Simple CFRP beams can be used to construct complex truss structures
- We propose a small-scale system capable of manufacturing carbon fiber tubing from constituent components
- In-space manufacturing of CFRP components would allow for larger, more efficient, and more complex in-space assemblies

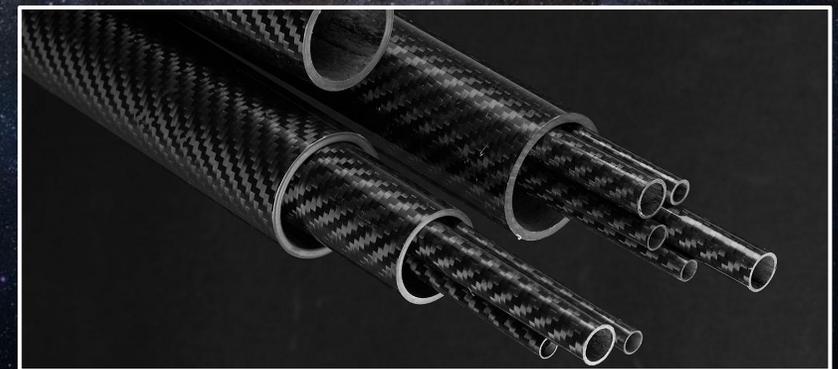
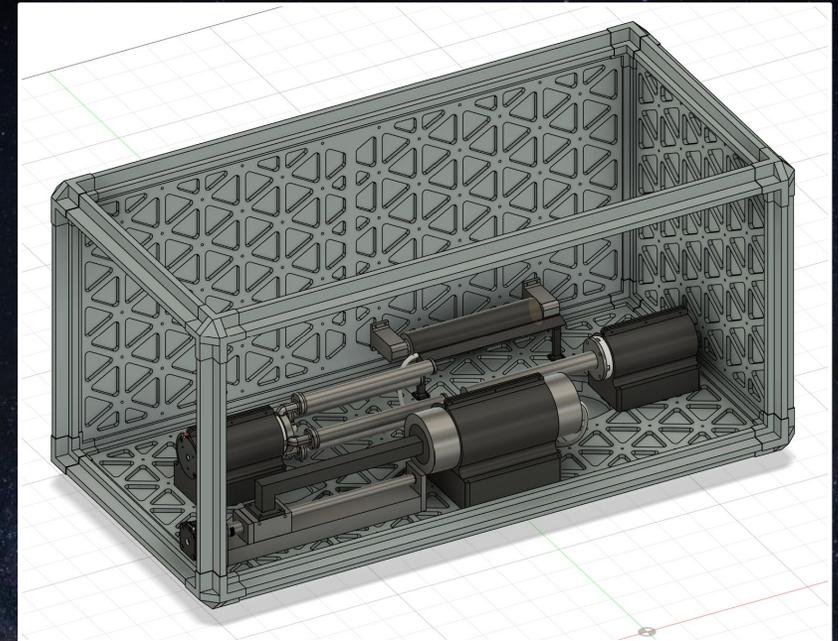


Image Source:
<https://www.nitrocomposites.com/blog/carbon-fiber-tubes-advantages-disadvantages-and-applications>

Projected Path

In-space Manufacturing of Carbon Fiber Tubing

- We have begun a conceptual design that satisfies the constraints and goals of C3 Cosmic Track 1
- Moving into next year, we plan to finish our CAD design in January, 2026
- Under the Texas A&M Capstone design class, we plan to select components and assemble a physical prototype by March

COSMIC Capstone Challenge Track 3 - Space Pirates



TEXAS A&M UNIVERSITY
Engineering



Meet the Crew

Structures - Jacob Bustamante, Dominic Escamilla, David Limbert

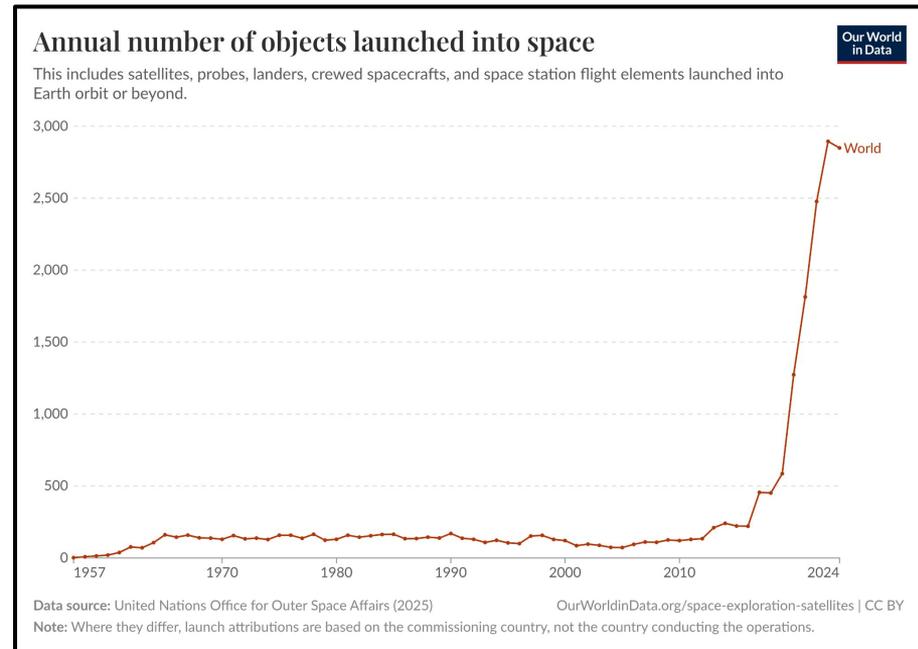
PP&T - Eliud Garcia, Shawn Lattner, Luke Logan

Computer Systems - Calvin Schroeder

ADCS/GNC - Carson Capps, Juan Pena, Nate Rodriguez

Background and Motivation

- Exponentially increasing satellite population in LEO
 - Starlink, Kuiper, etc.
- No current/past way to service satellites in orbit efficiently
 - NASA OSAM-1 cancelled
- Projected 50,000+ in LEO
- SPARROW (Spacecraft Platform for Autonomous Repair Refuel and Orbital Work)
- **Inclination Target: [50, 71.6]°**
- **Altitude Target: [500, 650] km**



“Annual Number of Objects Launched into Space.” *Our World in Data*, ourworldindata.org/grapher/yearly-number-of-objects-launched-into-outer-space?country=~OWID_WRL. Accessed 27 Oct. 2025.

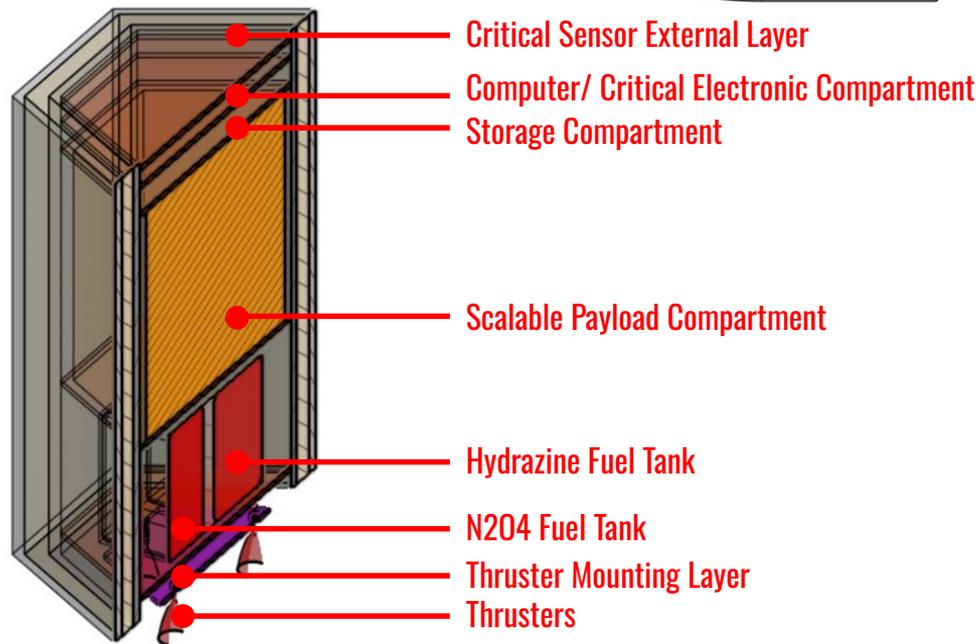
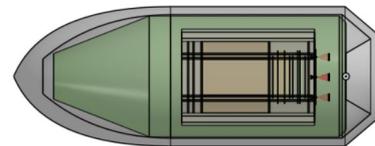
Main Payload - Robotic Arm

- Rendezvous grappling
- Modular end effectors
- Universal Robots UR8 Long
 - 44.7 kg
 - 1.75 m reach
 - Modified for in-space use

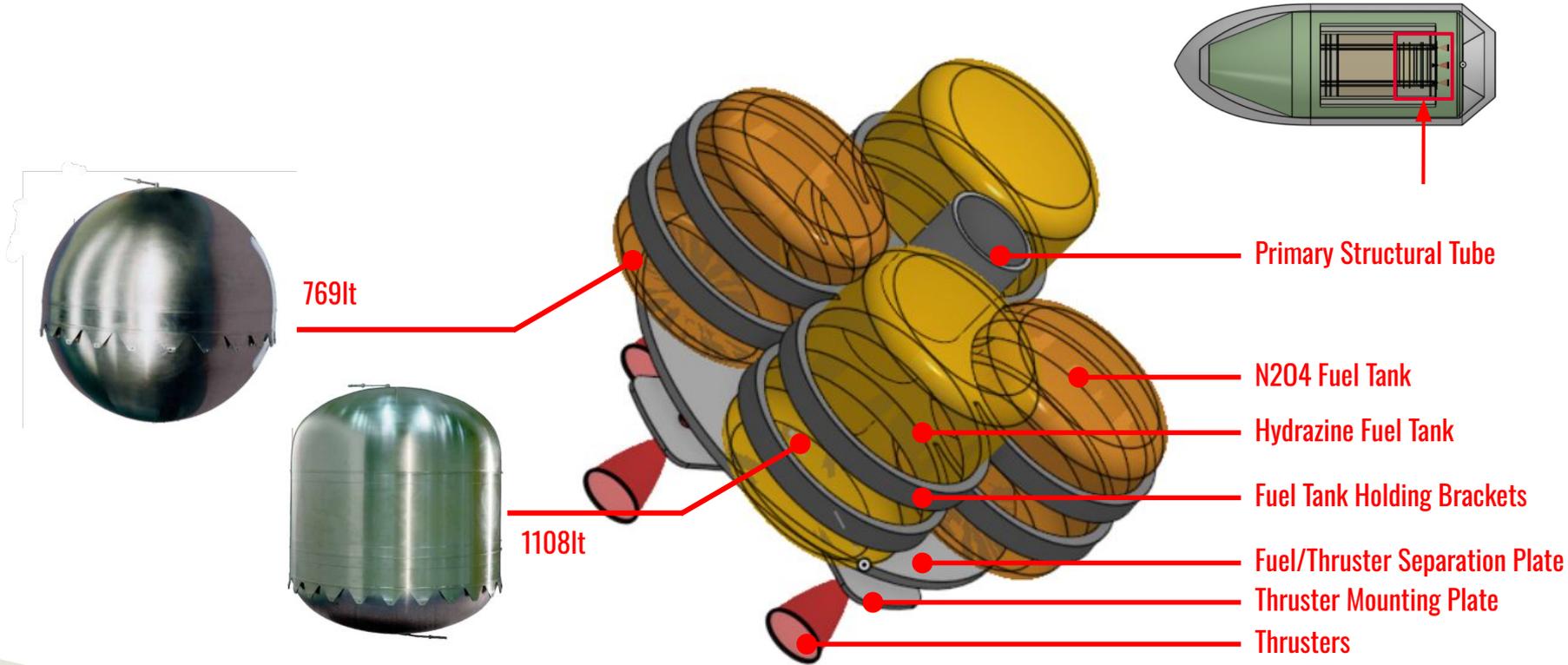


Volume Block Preliminary Structure

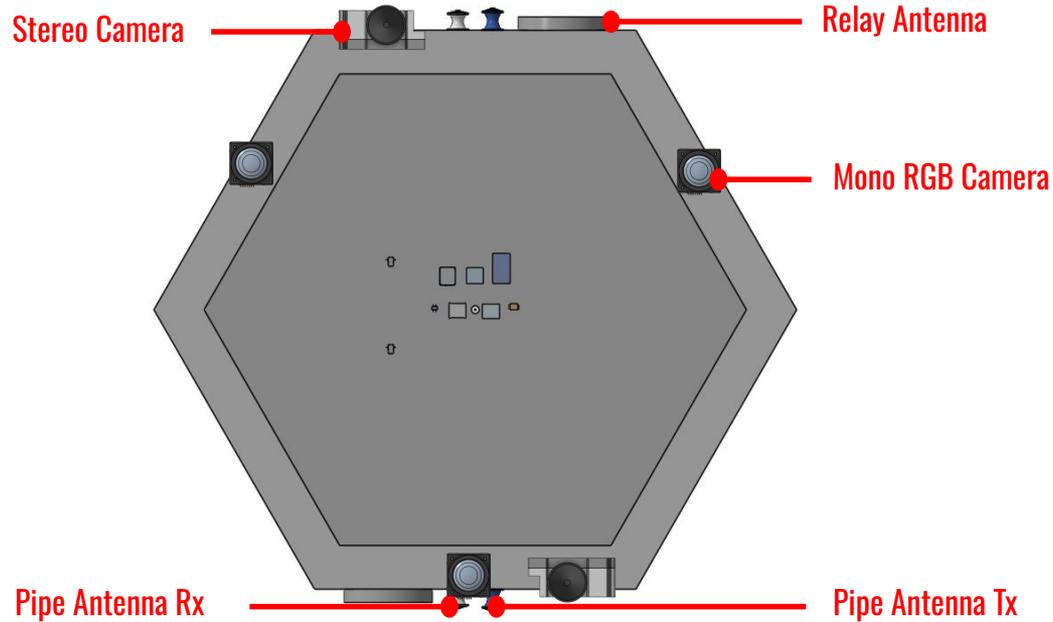
- Payload compartment is scalable; structure is designed as such.
- Payload configurable to client needs.
- Rough estimate of sub-assemblies.



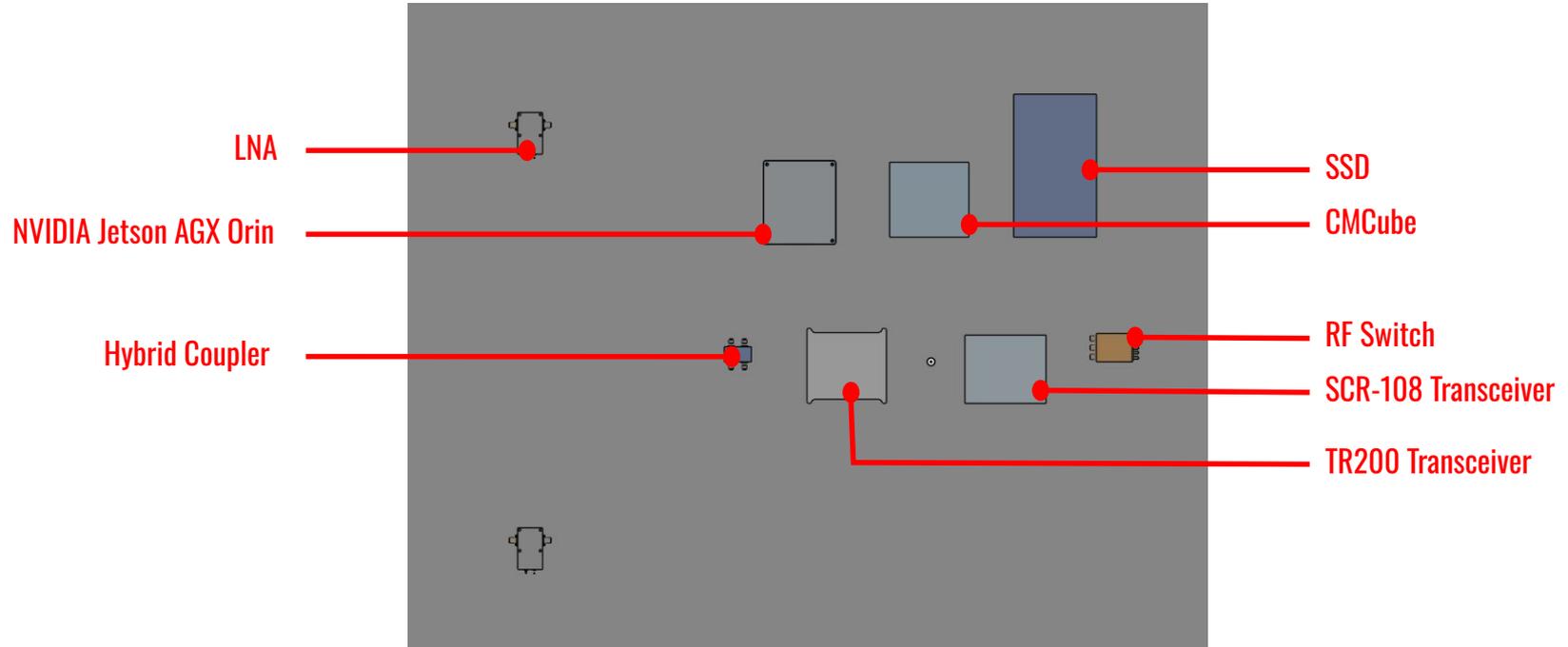
Propulsions Structure Concept



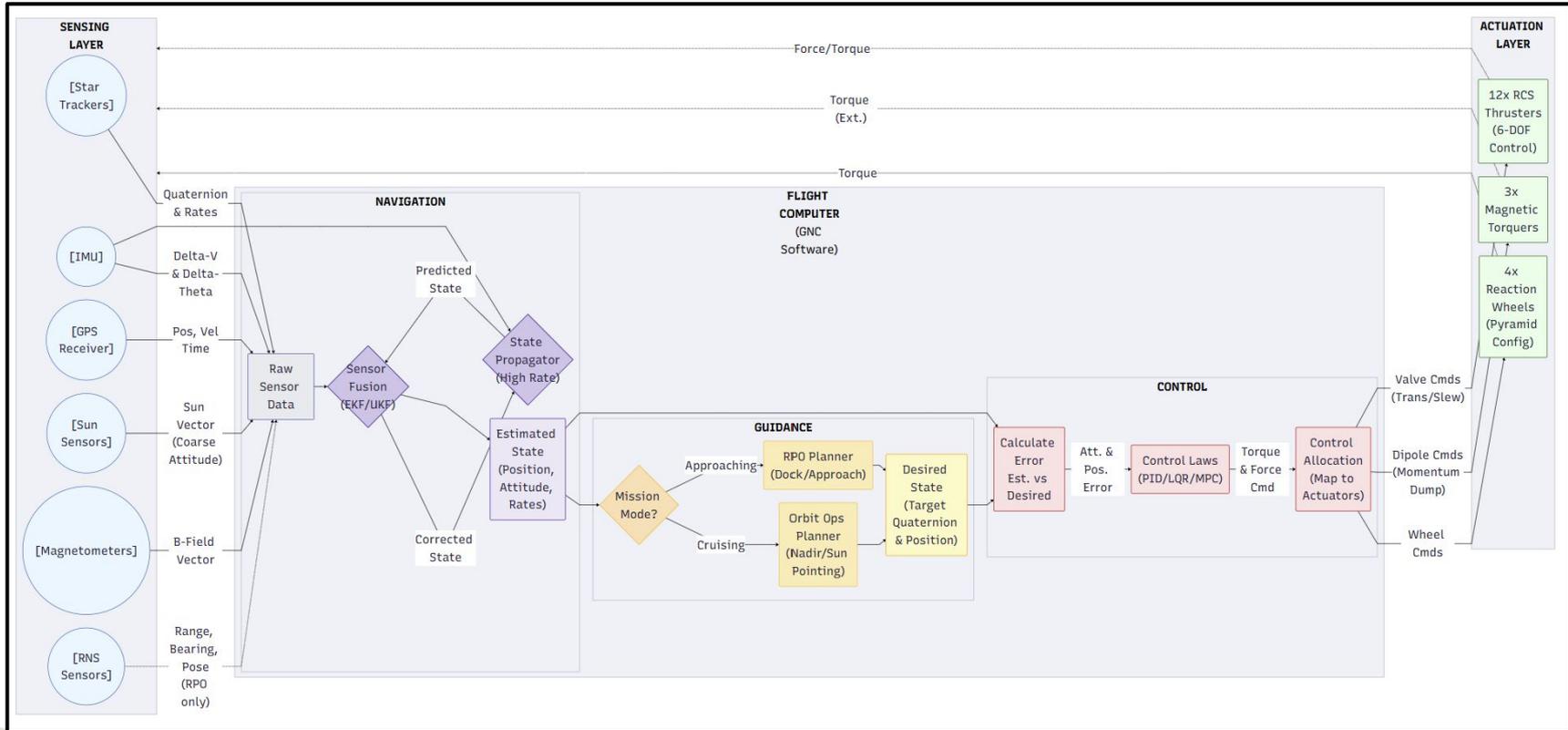
Comms. & GNC Structures Concept



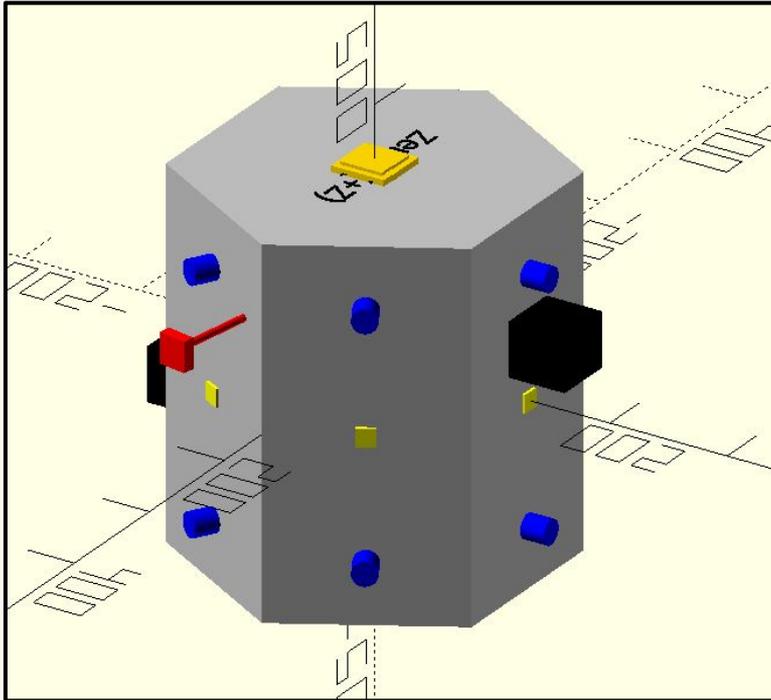
Comms. & GNC Structures Zoomed



GNC Diagram



Basic External ADCS Architecture



Sensor Legend:

- Star Tracker
- Sun Sensor
- Magnetometer
- GPS Receiver
- RCS Thruster

Notes:

- Scale exaggerated for visualization
- Internal components (IMU, Reaction Wheels, Magnetic Torquers) not visualized



Estimated Cost Table (Pt 1)

- Leverage (old) SMAD Table 20-4
- X parameters based on estimates + known component masses

Cost Component	Parameter, X (Unit)	Input Data Range	RDT&E CER* (FY00\$K)	SE (%)
1. Payload				
1.1 IR Sensor	aperture dia. (m)	0.2–1.2	356,851 $X^{0.562}$	53,559†
1.2 Visible Light Sensor	aperture dia. (m)	0.2–1.2	128,827 $X^{0.562}$	19,336†
1.3 Communications	comm. subsystem wt. (kg)	65–395	353.3 X	51
2. Spacecraft	spacecraft dry wt. (kg)	235–1,153	101 X	33
2.1 Structure	structure wt. (kg)	54–392	157 $X^{0.83}$	38
2.2 Thermal	X_1 = thermal wt. (kg)	3–48	394 $X_1^{0.635}$	45
	X_2 = spacecraft wt. + payload wt. (kg)	210–404	1.1 $X_1^{0.610} X_2^{0.943}$	32
2.3 Electrical Power System (EPS)	X_1 = EPS wt. (kg)	31–491	62.7 X_1	57
	X_2 = BOL power (W)	100–2,400	2.63 ($X_1 X_2$) ^{0.712}	36
2.4 Telemetry, Tracking & Command (TT&C)/DH†	TT&C/DH wt. (kg)	12–65	545 $X^{0.761}$	57
2.5 Attitude Determination & Control Sys. (ADCS)	ADCS wt. (kg)	20–160	464 $X^{0.867}$	48
2.6 Apogee Kick Motor (AKM)	AKM wt. (kg)	81–966	17.8 $X^{0.75}$	—
3. Integration, Assembly & Test (IA&T)	spacecraft bus + payload total RDT&E cost (FY00\$K)	2,703 – 395,529	989 + 0.215 X	46
4. Program Level	spacecraft bus + payload total RDT&E cost (FY00\$K)	4,607 – 523,757	1,963 $X^{0.841}$	36
5. Ground Support Equipment (GSE)	spacecraft bus + payload total RDT&E cost (FY00\$K)	24,485 – 581,637	9,262 $X^{0.842}$	34
6. Launch & Orbital Operations Support (LOOS)	N/A			11

Estimated Cost Table (Pt 2)

- ~32 million in RDT&E costs
- COTS increased by 20% for integration costs
- Falcon 9 launch cost not factored in
 - Adds ~\$70 million per launch

Cost Component	Parameter X (unit)	X Input	RDT&E CER (FY25 \$K)	RDT&E Cost (FY25 \$K)
1. Payload				
1.1 UR8 Long (x2)	COTS cost (\$)	65517	2 * 1.2 X	157.24
2. Spacecraft				
2.1 STR	weight (kg)	150	157 X [^] .83	15071.16
2.2 PROP	LAE wt. (kg)	19.04	17.8 X [^] .75	0.97
2.3 POW	X1 = POW wt. (kg)	150	62.7 X	14.11
	X2 = BOL power (W)	7500	2.63(X1 X2) [^] .712	80.25
2.3 THM	X1 = thermal wt. (kg)	75	394 X1 [^] .635	9.17
	X2 = spacecraft wt. + payload wt. (kg)	65517	1.1 X1 [^] .610 X2 [^] .943	800.01
2.5 CDH	COTS cost (\$)	76198	1.2 X	91.44
2.6 COMM	weight (kg)	35.994	353.3 X	12.72
2.7 ADCS + GNC	COTS cost (\$)	1,841,970	1.2 X	2210.36
3. IA&T	Spacecraft bus + payload total RDT&E cost	18447.43	989 + .215 X	1483.82
4. Mission Ops	Spacecraft bus + payload total RDT&E cost	19931.25	1.963 X [^] .841	12159.62
			TOTAL	32090.87



TEXAS A&M UNIVERSITY
Engineering

THANK YOU



A large, spreading oak tree with a paved path leading through its branches towards a building. The tree's thick, gnarled branches arch over the path, creating a natural canopy. The ground is covered in fallen leaves, and a few people can be seen walking in the distance. A large, classical-style building is visible on the left side of the frame. The sun is shining brightly in the upper right corner, creating a lens flare effect.

Appendix

References

- <https://www.universal-robots.com/products/ur8-long/>
- <https://rbtx.com/en-US/components/robots/universal-robots-ur8-long-6dof-1750-mm-8kg>
- [State-of-the-Art of Small Spacecraft Technology - NASA](#)
- <https://www.spacex.com/assets/media/falcon-users-guide-2025-05-09.pdf>
- <https://www.satcatalog.com/>
- <https://www.endurosat.com/products/small-satellite-eps/>
- <https://www.nasa.gov/smallsat-institute/sst-soa/power-subsystems/>
- <https://www.satnow.com/products/solar-panels/redwire-space/102-1191-roll-out-solar-array-rosa->
- <https://www.elconprecision.com/material-showdown-analyzing-titanium-steel-and-aluminum-in-precision-manufacturing/>
- <https://www.osti.gov/biblio/7369177>

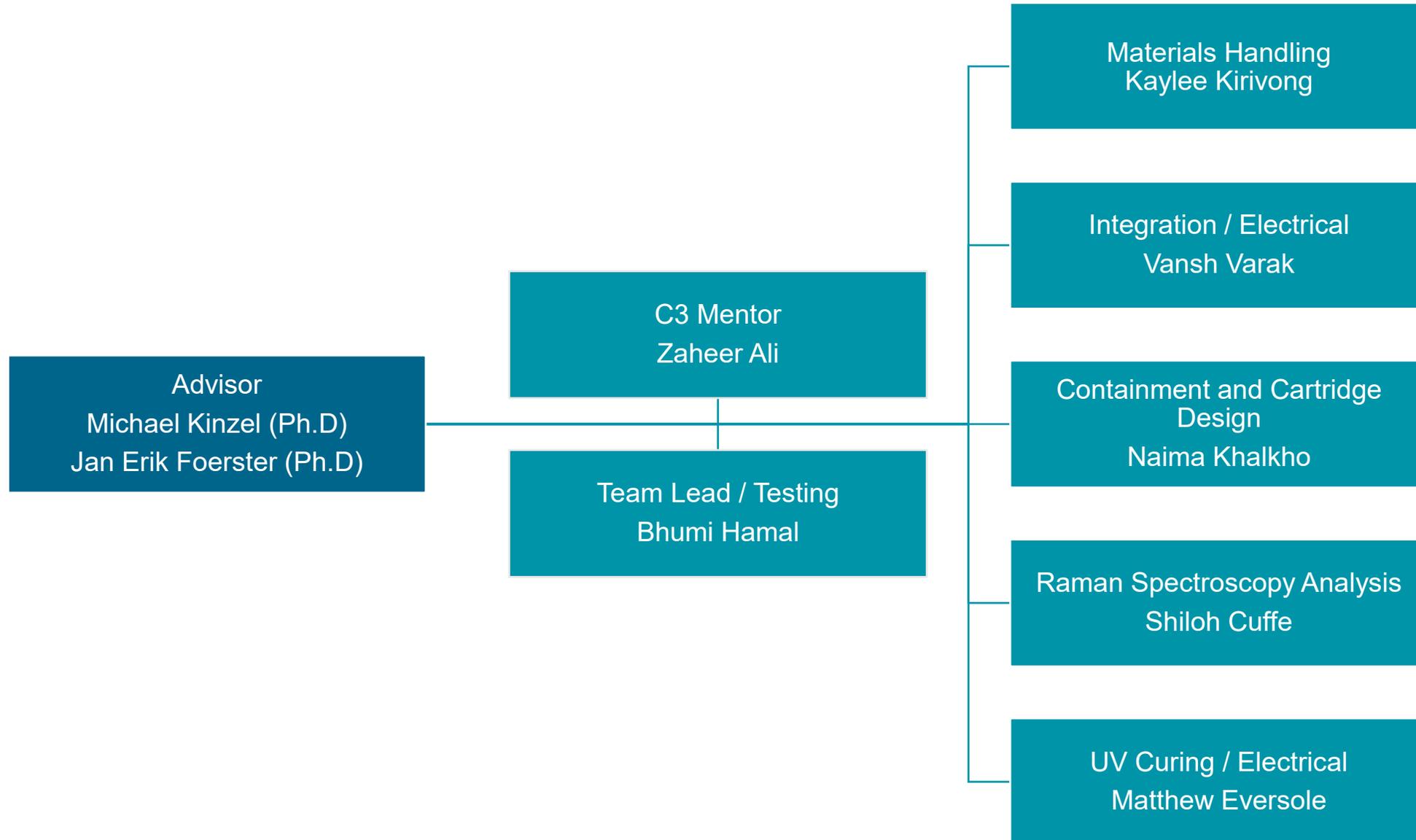
DIRECT INK WRITING SYSTEM WITH IN-SITU CURING AND ANALYSIS FOR IN-SPACE MANUFACTURING

C3 Mid-Point Brief

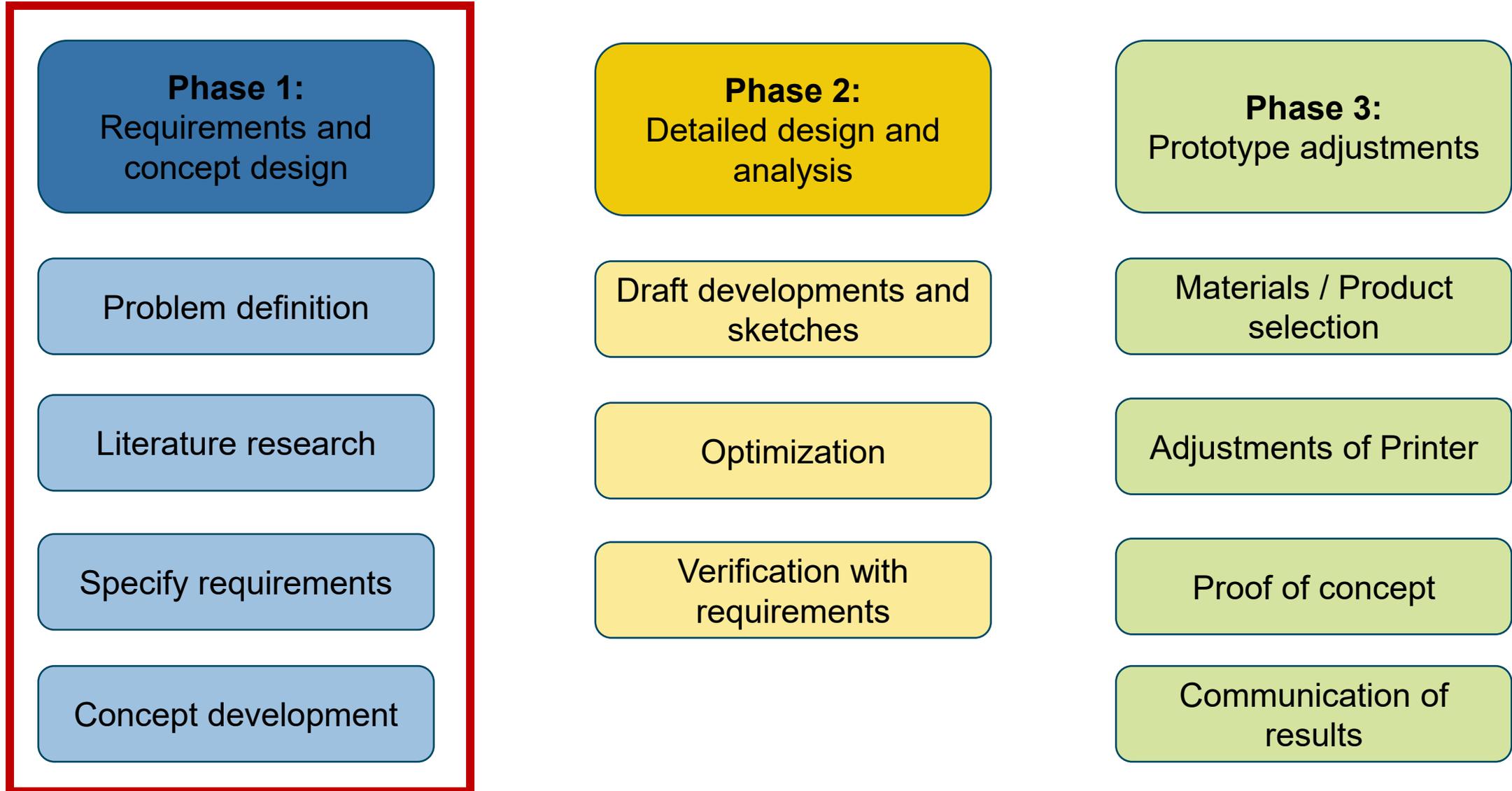
Team InStellis

Embry-Riddle Aeronautical University | Daytona Beach, FL

InStellis | Work Organization



InStellis | Work Organization





Current Situation

Earth to Space Supply Chain

- Cost inefficient logistic system
- On-demand supply of products not possible

Need for In-Space manufacturing to support long term space missions with mandatory products



The Future

In-Space Manufacturing

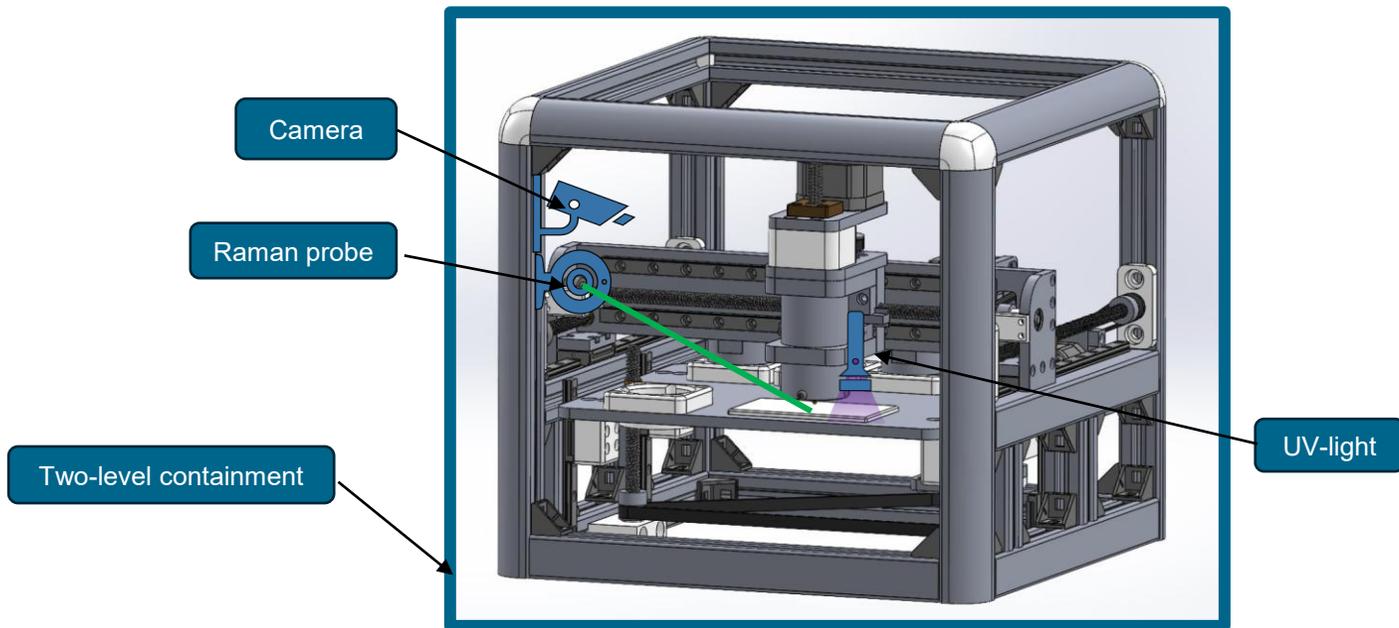
However...

- Limited resources in space
- Unknown effects on material processing and end-product quality

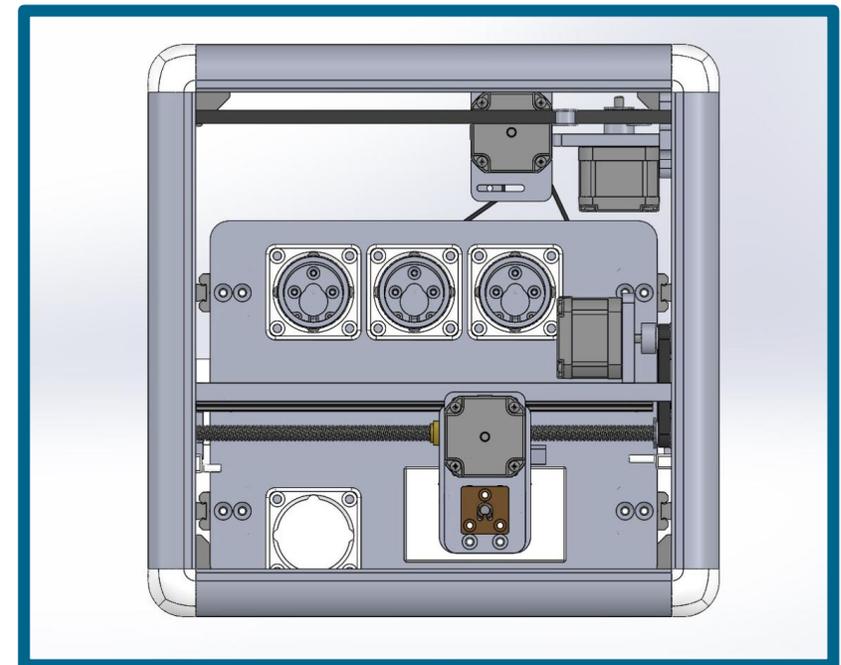
InStellis | Concept for Solution



- Utilization of in-situ space resources such as lunar regolith to produce products during long term space missions
- Direct Ink Writing (DIW) of UV-curable polymer-based inks as an additive manufacturing methods for ISAM
 - Low temperature process
 - Low energy consumption
 - Contact-based process
 - Processing of various slurries / inks



DIW printer (Prototype), Isometric View



DIW printer (Prototype), Top View

InStellis | Constraints

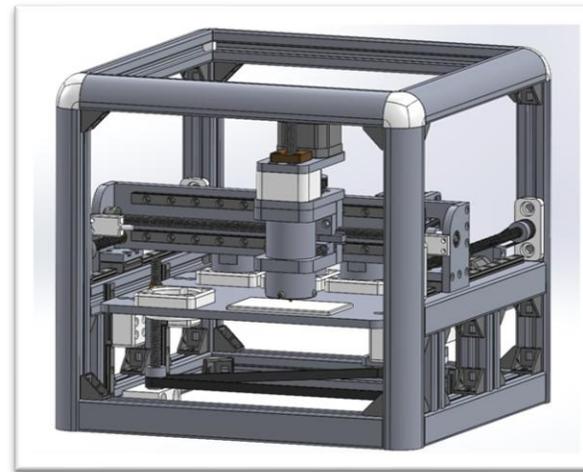


Bosun's Locker



- Available volume:
 - 15.75" x 15.75" x 35.45"
- Payload mass limitation:
 - 400 kg
- Peak available power:
 - 1000 W
- Sustained available power:
 - 300 W

DIW Printer Prototype

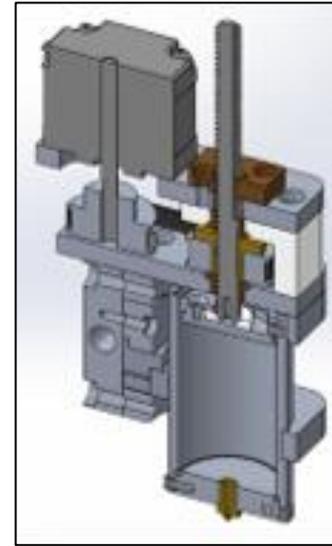


- Printer volume:
 - 12" x 12" x 12"
- Control unit volume:
 - 8" x 10" x 4"
- Expected payload mass:
 - 10 kg
- Power supply:
 - 500 W

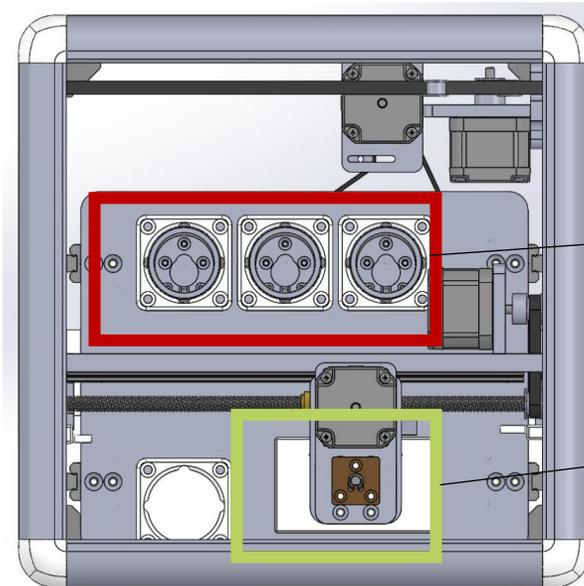
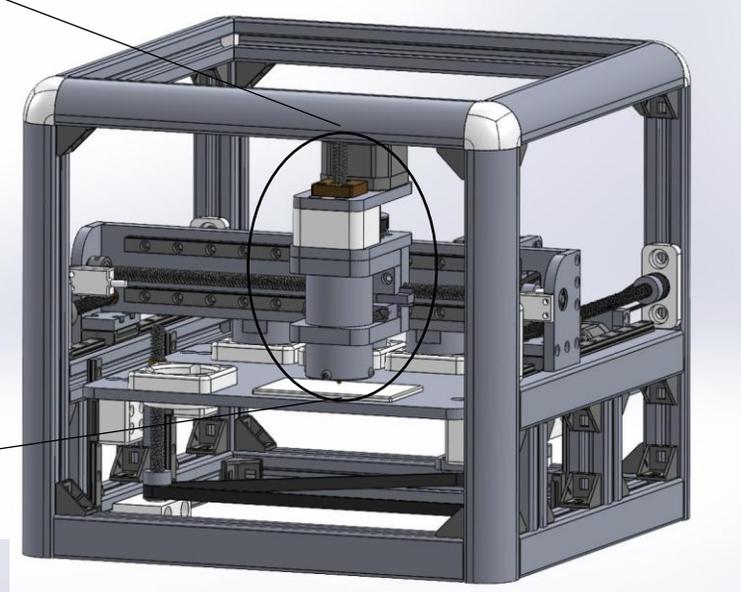
InStellis | Concept of Operations and Capabilities



- Cartridge preparation
 - Implement tank for regolith slurry into the system
 - Connect to cartridge filling system
 - Begin mixing to ensure homogeneous slurry
- Printing
 - Adjust desired print settings (if needed)
 - Move printing bed into the printing section
 - Grab and lift the cartridge
 - Move the cartridge to the printing bed
 - Dispense regolith slurry out of the cartridge through mixing nozzle
 - Move back used cartridge into cartridge storage
 - Drop the cartridge
- Curing and Analysis
 - Start and stop UV light / curing
 - Adjust the UV light intensity
 - Start Raman spectra analysis
 - Quality inspection acc. to Raman data
 - Exchange print bed with processed product



Cross-section of dispensing unit



Cartridge storage

Manufacturing area
(Print, cure, analysis)

InStellis | Design Requirements



#	Subsystem	Requirement	Verification Artifact
1	Material Handling	The slurry shall maintain sufficient viscosity to prevent layer slumping or spreading.	Viscosity tests
2	Material Handling	The slurry shall remain homogeneous with no visible particle settling or agglomeration during operation.	Visual Inspection, Operational Quality, Print Quality
3	Material Handling	The extrusion system shall minimize nozzle clogging and provide consistent printing line width through adequate clearances, filtration, or design features.	Nozzle Testing, Operational Quality, Print Quality
4	UV Curing	Curing shall achieve full polymerization without causing deformation of extruded features.	UV Safety Procedure, UV Testing, Print Quality
5	Mechanical	The system shall include mechanisms to effectively switch and manipulate cartridges and test beds	CAD, System Testing
6	Mechanical	The containment wall shall be able to protect the surrounding environment in case of material leakage.	CAD, Environmental Testing
7	Integration	All mechanical, electrical and software interfaces shall be compatible with one another and operate under defined universal constraints	CAD, FlatSat Testing, System Testing
8	Data Collection	All raw data from sensors, measurements, and observations shall be recorded	Exported Data Files

InStellis | Milestones



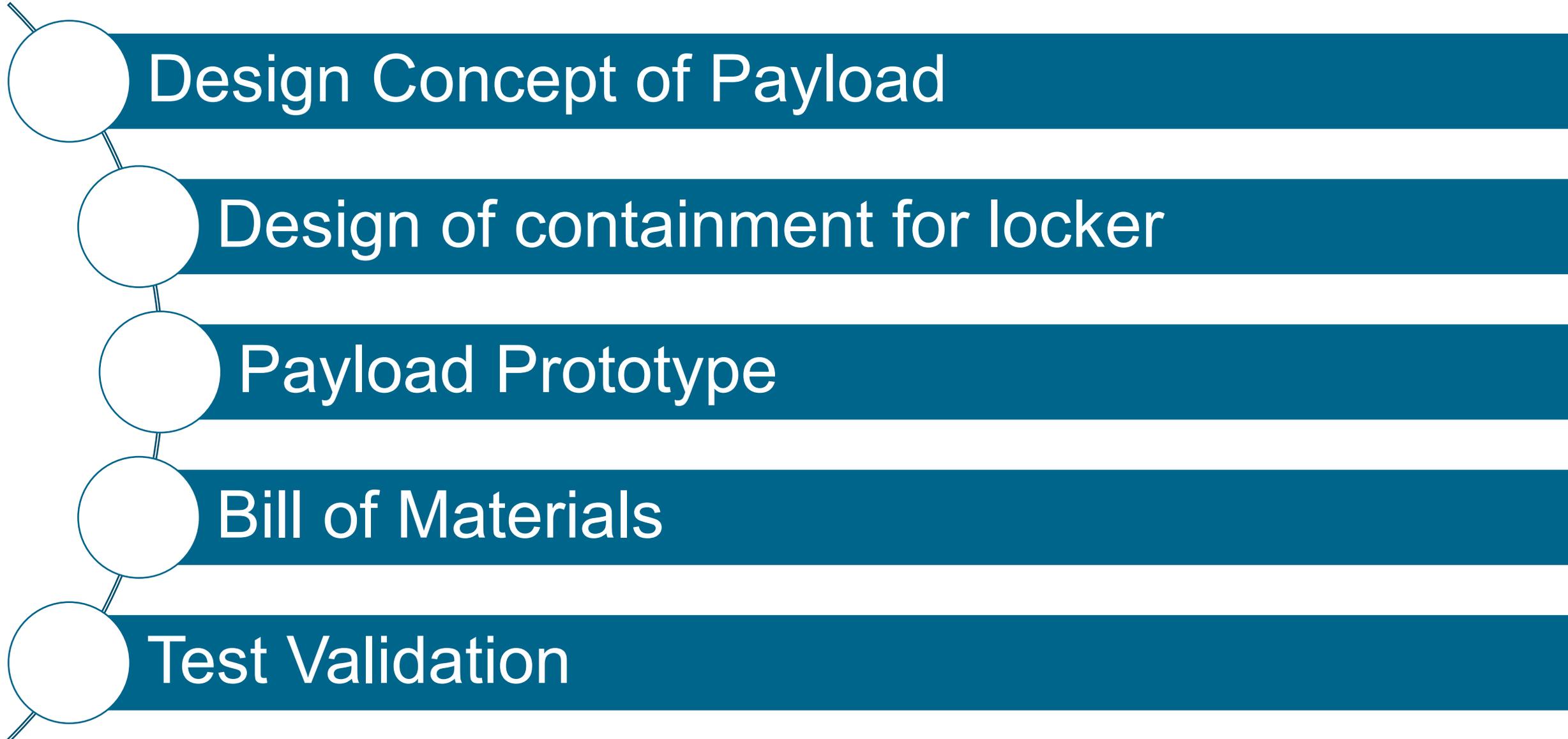
December: Milestones and Requirements Matrix

January: UV Light Finalization

February: Bill of Materials Finalization

March: Part Order and Installation

April: Final Presentation



Design Concept of Payload

Design of containment for locker

Payload Prototype

Bill of Materials

Test Validation

Cosmic Capstone Challenge 2025

The Miners-Track 1

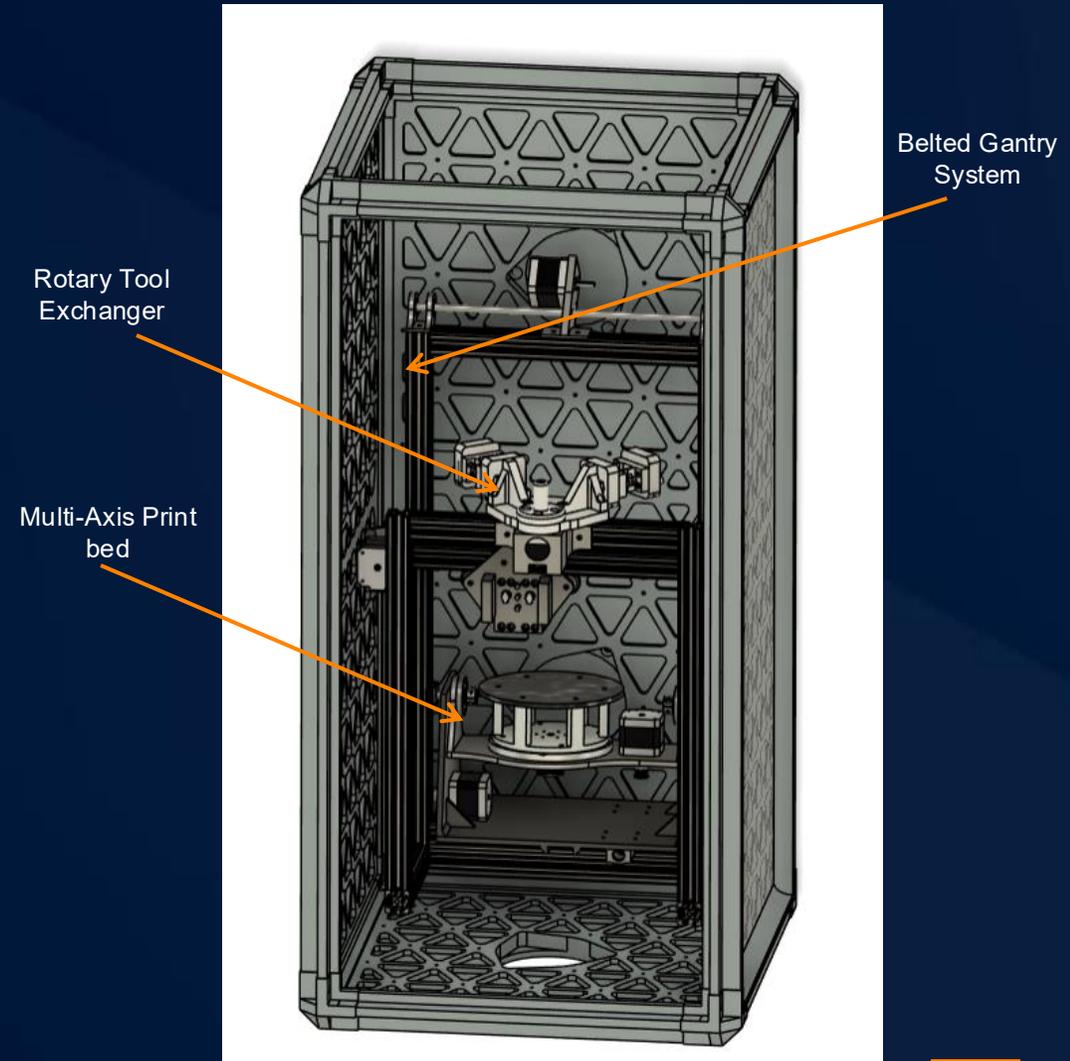


Objectives and Goals



Develop a compact, **autonomous** fabrication payload for the Bosun's Locker that integrates multi-functional manufacturing processes, including **3D printing**, **soldering**, and **wire embedding**. Ensure spaceflight-ready performance through compliant materials, **automated tool-changing**, advanced sensing and control, validated operation via modeling and subsystem testing.

The system was designed using **commercially available** parts for **maintainability and ease of assembly**.



Bosun Locker with integrated subsystems



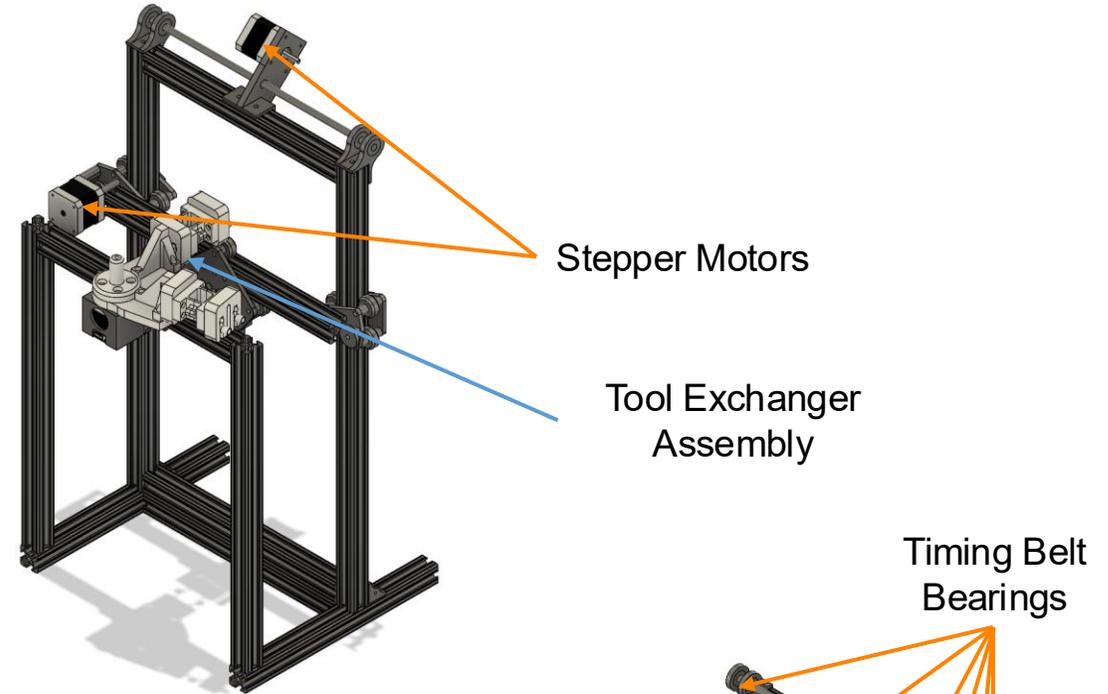
System Overview

A nighttime photograph of a university campus. In the foreground, a large, illuminated sculpture is the central focus. The sculpture is a tall, curved, abstract form, primarily red on the left side and blue on the right. It has a perforated or lattice-like texture, allowing light to pass through. The sculpture is set on a landscaped area with rocks and some plants. In the background, a multi-story building is visible, with the words "UNIVERSITY BOOKSTORE" clearly visible on its facade. The building is lit up, and its windows are glowing. The sky is dark with some clouds, and there are streetlights and other campus lights visible in the distance. The overall scene is a mix of natural and artificial light, creating a vibrant and modern atmosphere.

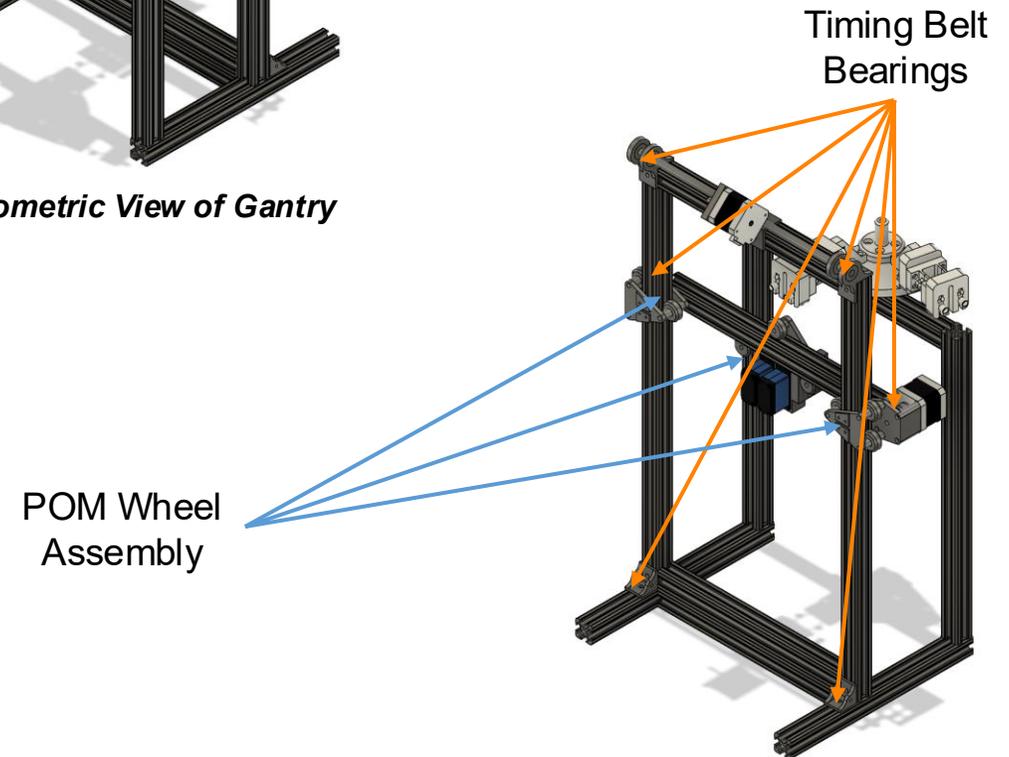
Gantry System

Belted Gantry System

- Belted vertical and horizontal axes allow for movement of the toolhead with one motor per translational axis
- The rotary tool swapper was positioned to reduce collision risk with locker and gantry

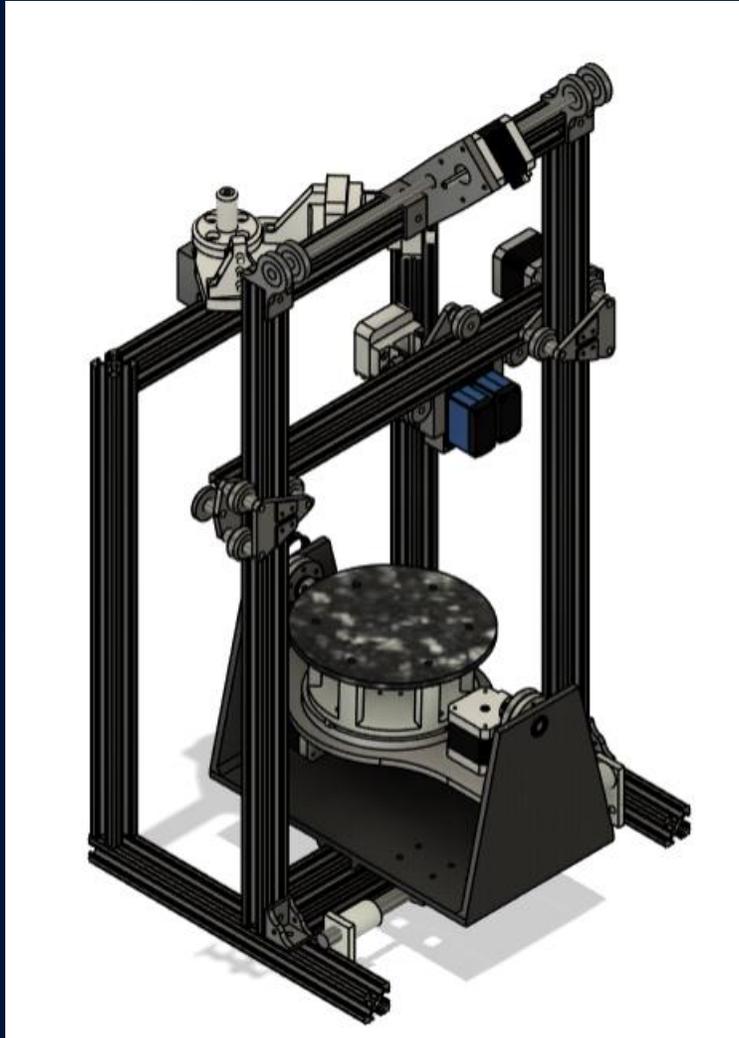


Front Isometric View of Gantry



Back Isometric View of Gantry

Animation of Working Components



Belted Gantry assembly

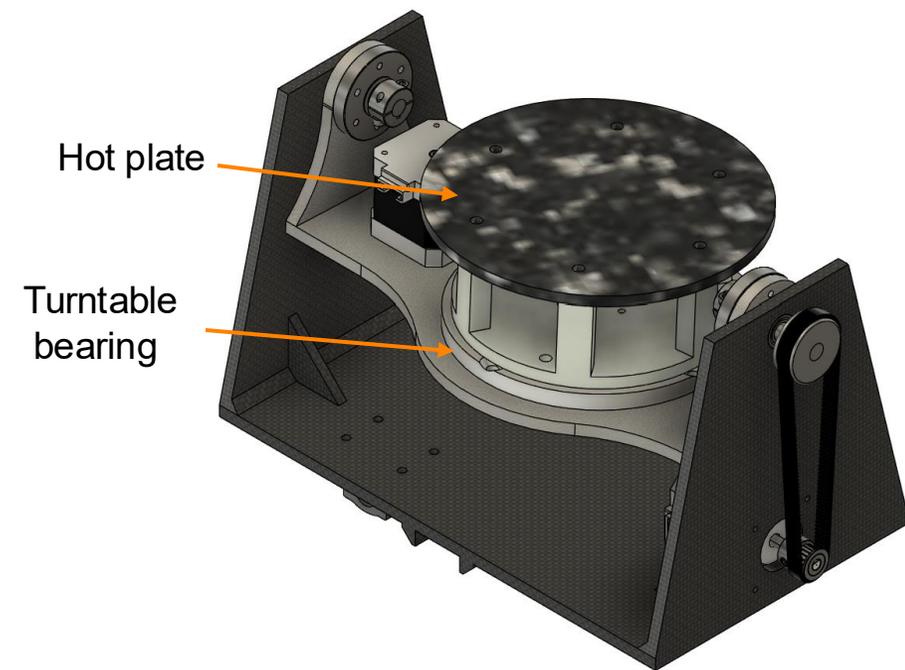


Belted Gantry with tool in motion

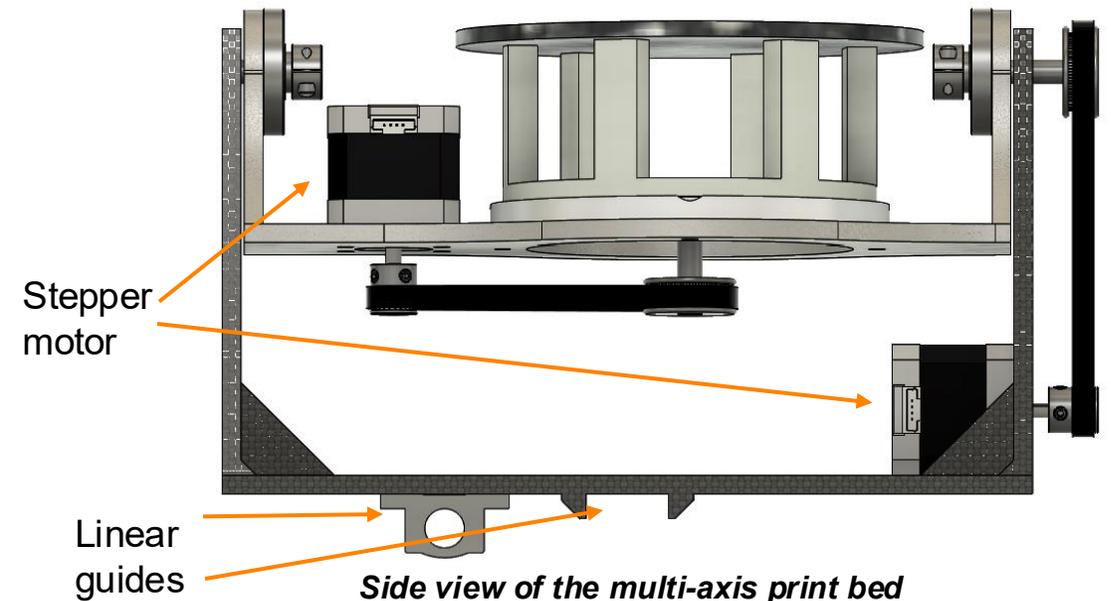


Multi-Axis Print Bed

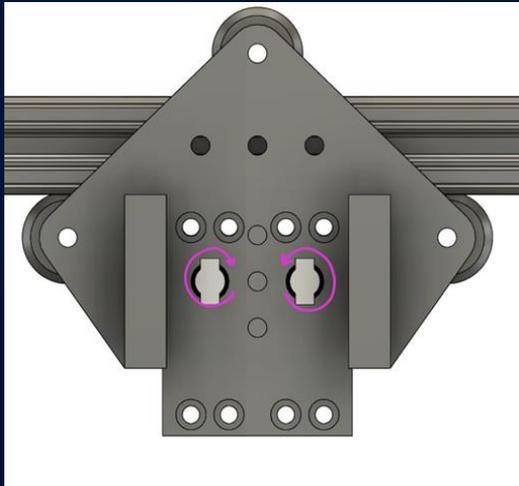
- The multi-axis print bed is designed to reduce or eliminate support material for overhangs
- Two pulley-driven stepper motors provide the bed with two rotational degrees of freedom
- Guide rails under the bed carriage add one translational degree of freedom
- Combined with the printer's existing X/Z motion, the system achieves **five total degrees of freedom**: three translational and two rotational



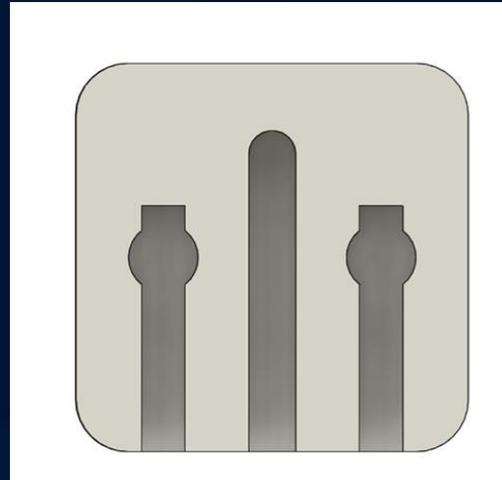
Isometric view of the multi-axis print bed



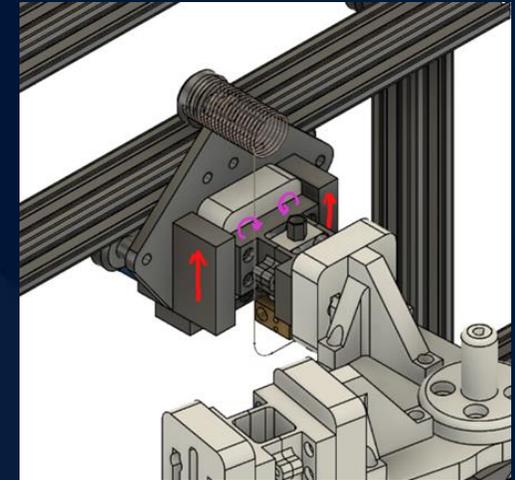
1. Rotate Keys



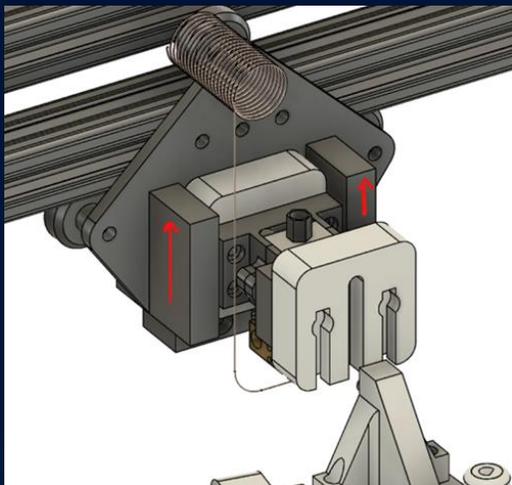
2. Align properly so it slides into holder



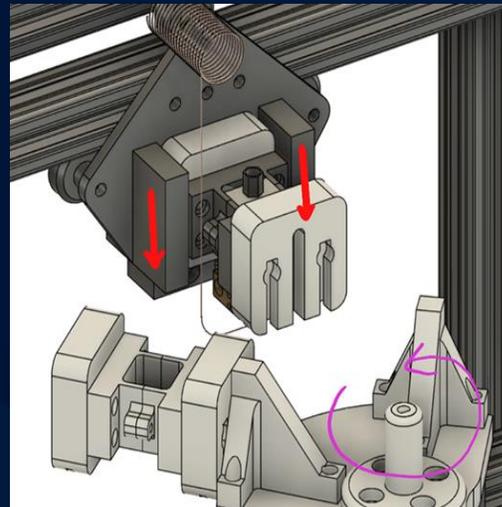
3. Move gantry to ready position and lock keys



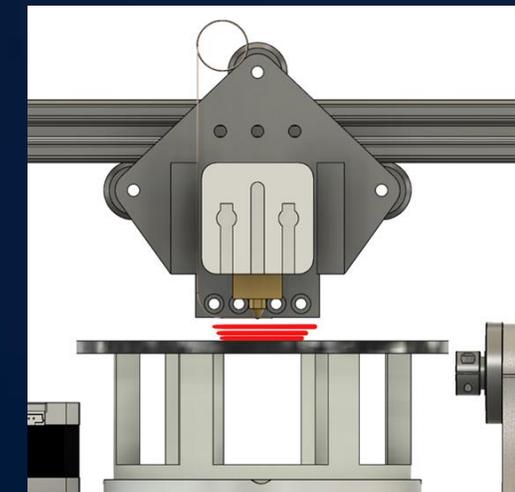
4. Move gantry upward to release from tool exchanger



5. Move gantry downward out of the way of tool exchanger



6. Begin desired tool actuation

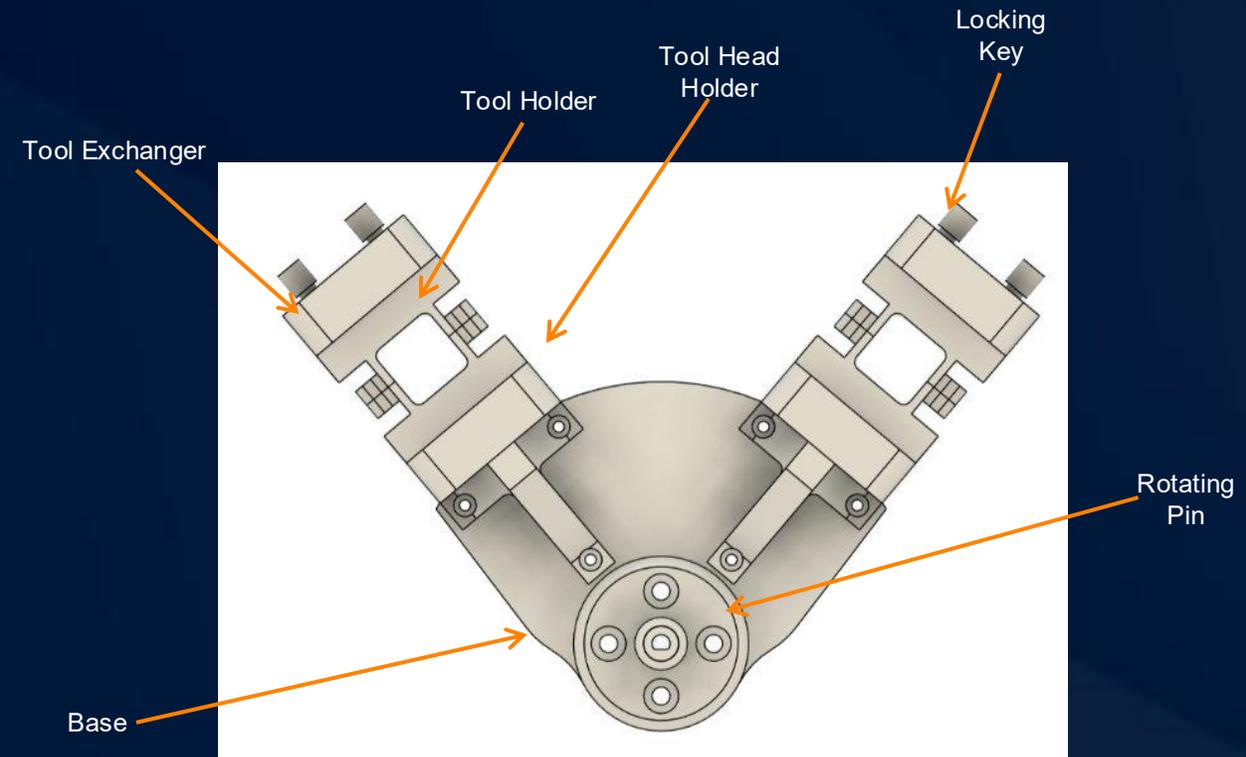


- **Bed Slinger 3D printer**
- **Wire Embedding Additive Manufacturing**
- **CNC Machine**
- **Polar 3D Printer Hotbeds**



Future Plans

- The project is still a work in progress
- Integration of the wire-embedding and soldering tools is ongoing as available methods are evaluated
- The rotatory tool exchanger is designed for future adaptability
- The spaces in the rotatory tool exchanger are intentionally designed to hold future tool designs.



Rotary Tool Exchanger with empty tool compartments



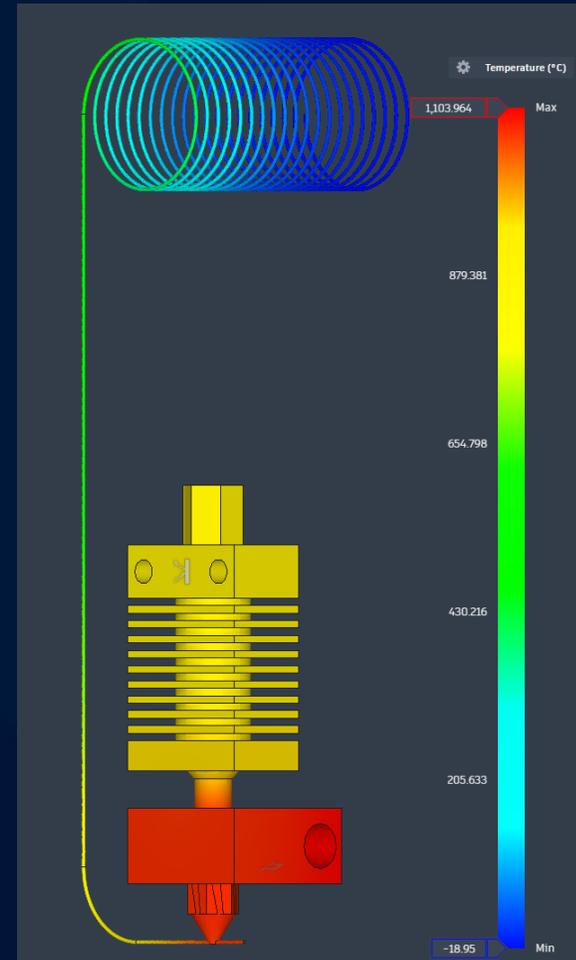
Results

Thermal Simulation, Power
Consumption, FEA

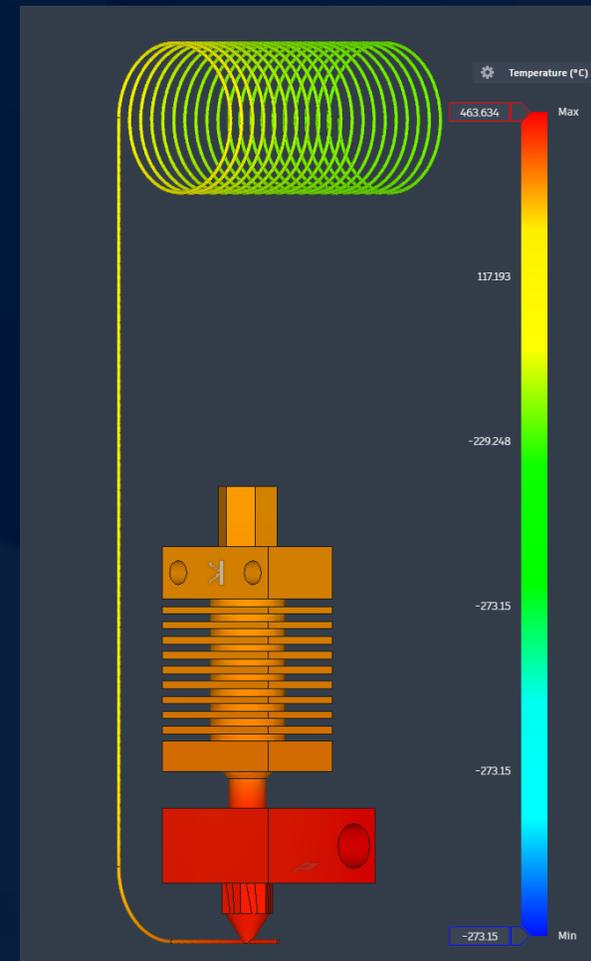


Thermal Simulations: Heated Printing Nozzle

- The thermal simulation was done to determine heat dissipation capability under max power
- The printing nozzle was assumed to operate with an applied load of 50W at the inner heat cartridge face
- The environment was assumed to be -270°C and convection-less to simulate low orbit conditions
- The low emissivity simulation had a max temperature of 1103°C and high heat creep
- The high emissivity simulation had a max temperature of 463°C and lower heat creep



Low Emissivity Simulation
 $\epsilon = 0.05$. e.g. Polished Metal



High Emissivity Simulation
 $\epsilon = 0.8$. e.g. Anodized Metal



Power Consumption

- To ensure the system operates within the maximum power limits of **1000 W peak** and **300 W continuous**, we calculated the total power consumption of the entire system.
- The operating torque for the motors was also calculated to ensure the selected motors could sustain the load imposed by the system's weight.
- The total maximum power calculated was **429.8 W**, with the general system power consumption at **150.8 W**.

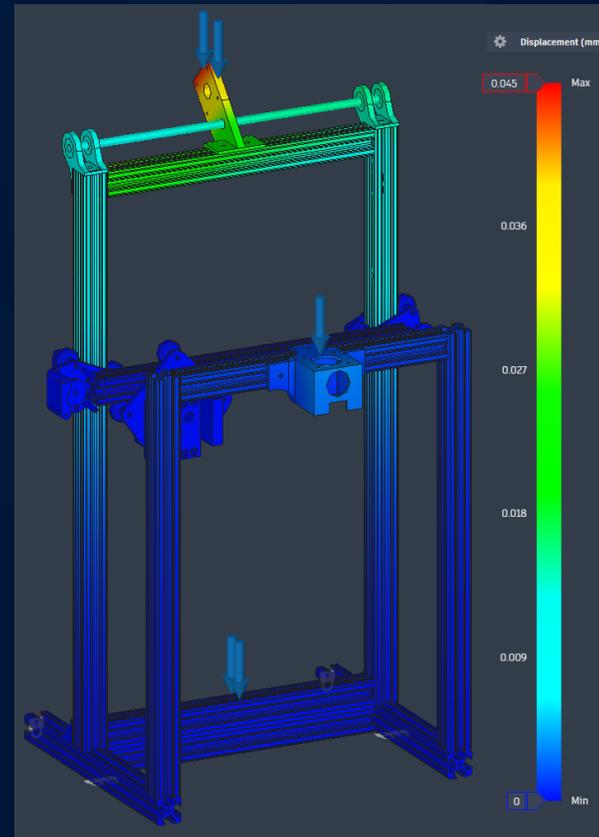
Component	Max Power (W)	General Operating Power (W)	Quantity	Total MAX	Total General
Stepper motor	9.6	2.4	8	76.8	19.2
Print Hot Bed	300	100	1	300	100
Nozzle heater	50	30	1	50	30
Servomotor	1.5	0.8	2	3	1.6

Total System Power (MAX)	Total System Power (General)
429.8 W	150.8 W

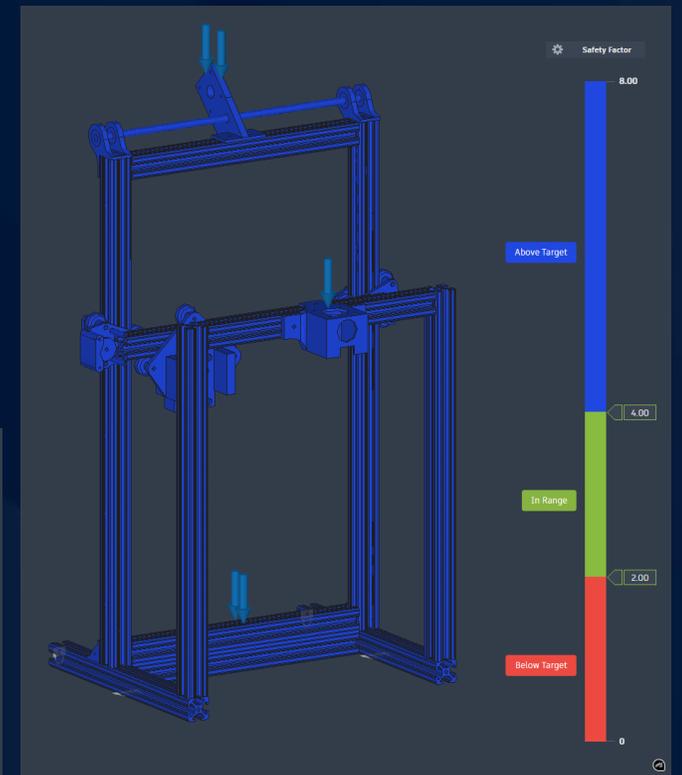


Structural Analysis - FEA

- To verify that the gantry could support the weight of the subsystems, we conducted some analysis on the frame
- The stress experienced by the gantry and the resulting displacement were minimal, demonstrating its structural integrity under the applied load
- The simulations assume Earth conditions and represent the subsystems' weights as point loads
- Simulations resulted with a **safety factor of 15** and a **maximum displacement of 0.045mm**, confirming the gantry's reliability under operating conditions



Max displacement simulation in Fusion360



Safety Factor simulation in Fusion360





THANK YOU

Members: *Manuel Ruiz De Esparza, Brian Gamboa, Jofiel Zapata, Estrella Martinez, Ingrid Nunez, Franciso Miranda, Mario Solis*

Collaborators: *Adrianna Villegas, Alexander Pustinger*

Advisor: *Dr. Angel Flores Abad*

References

- Arkisys, Inc. *Arkisys | Modular Spacecraft*. Arkisys, Inc., 2025, <https://www.arkisys.com/>
- “Arkisys and iBoss Team up to Enable Orbital Bosun’s Lockers for Students to Develop Payload Access for the Port.” *EIN Press Wire*, 9 Aug. 2023, <https://www.einpresswire.com/article/822743713/arkisys-and-iboss-team-up-to-enable-orbital-bosuns-lockers-for-students-to-develop-payload-access-for-the-port>
- COSMIC (Consortium for Space Mobility and ISAM Capabilities). *2025–26 COSMIC Capstone Challenge: Information Packet – Initial Release*. Revision A, Document No. COSMIC-E01-WD005-2025-A, Released 17 July 2025, COSMIC, www.cosmicspace.org/c3
- National Aeronautics and Space Administration. “Additive Manufacturing of PEEK and Fiber-Reinforced PEEK for NASA Applications and Custom Medical Devices.” *NASA TechPort*, Project No. 102286, techport.nasa.gov/projects/102286.
- Johnston, Mallory M., Mary J. Werkheiser, Kenneth G. Cooper, Michael P. Snyder, and Jennifer E. Edmunson. *3D Printing in Zero-G ISS Technology Demonstration*. NASA Marshall Space Flight Center, 4 Aug. 2014, doi:10.2514/6.2014-3881, ntrs.nasa.gov/api/citations/20140012888/downloads/20140012888.pdf.
- Prater, Tracie, Niki Werkheiser, Frank Ledbetter, and Alexander Jehle. *NASA’s In-Space Manufacturing Project: Toward a Multimaterial Fabrication Laboratory for the International Space Station*. Conference Paper (AIAA Space Forum), 17 Sept. 2018, NASA Marshall Space Flight Center, Document No. 20180006362, <https://ntrs.nasa.gov/api/citations/20180006362/downloads/20180006362.pdf>
- European Space Agency. “ESA Launches First Metal 3D Printer to ISS.” *ESA*, 31 Jan. 2024, https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/ESA_launches_first_metal_3D_printer_to_ISS.
- Saari, Matt, Bryan Cox, Edmond Richer, Paul S. Krueger, and Adam L. Cohen. “Fiber Encapsulation Additive Manufacturing: An Enabling Technology for 3D Printing of Electromechanical Devices and Robotic Components.” *3D Printing and Additive Manufacturing*, vol. 2, no. 1, Mar. 2015, pp. 32-39, doi:10.1089/3dp.2015.0003.
- Instructables. (2020, September 23). *DIY Automatic Tool Changer for MPCNC*. Instructables. <https://www.instructables.com/DIY-Automatic-Tool-Changer-for-MPCNC/>
- WEAM - Wire Encapsulating Additive Manufacturing - Fraunhofer IWU. (n.d.). Fraunhofer Institute for Machine Tools and Forming Technology. <https://www.iwu.fraunhofer.de/en/research/range-of-services/Competence-from-A-to-Z/functionalization-technologies/power-electronics/wire-encapsulating-additive-manufacturing.html>



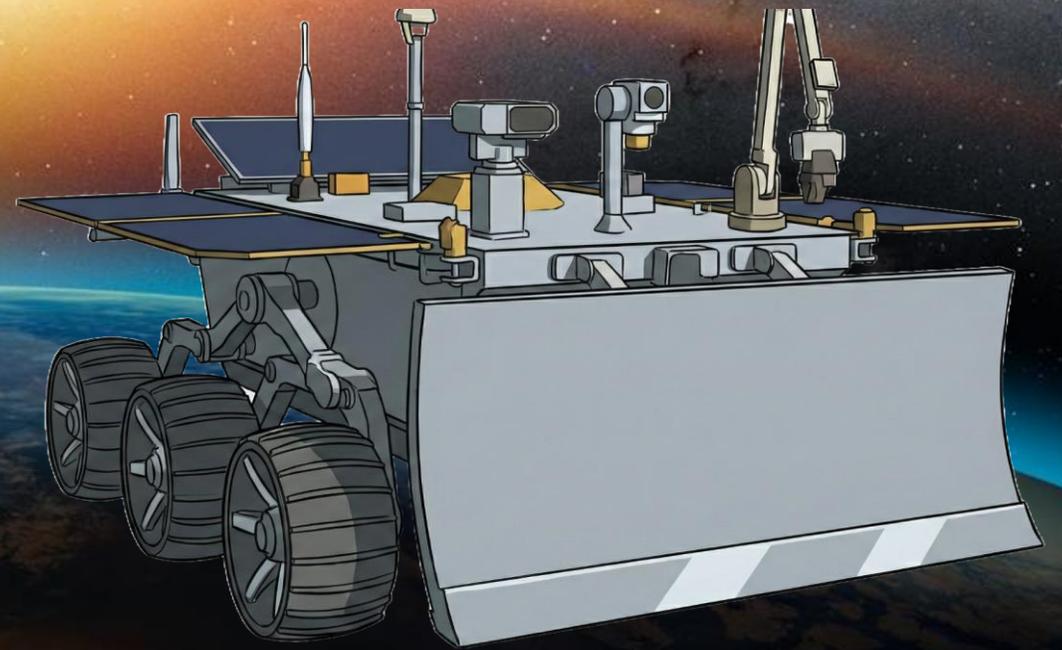


COSMIC Capstone Challenge:
Mid Design Brief

REV-LE, Texas A&M University:
Regolith Excavation Vehicle for Lunar Exploration
Track 2: Lunar Operations

Students: Joshua Cole, David Fumero, Miranda Kang, Evan McCuaig, Ram Vedula, Wayne Williams, Brooke Wolfram
Advisor: Manoranjan Majji
Mentor: Tim Kienberger

December 8, 2025



Mission Statement



Track 2 Challenge: Lunar Operations (C3-Lunar)

- Design a payload, to be delivered by the Griffin lunar lander, that can create infrastructure for a permanent lunar outpost.

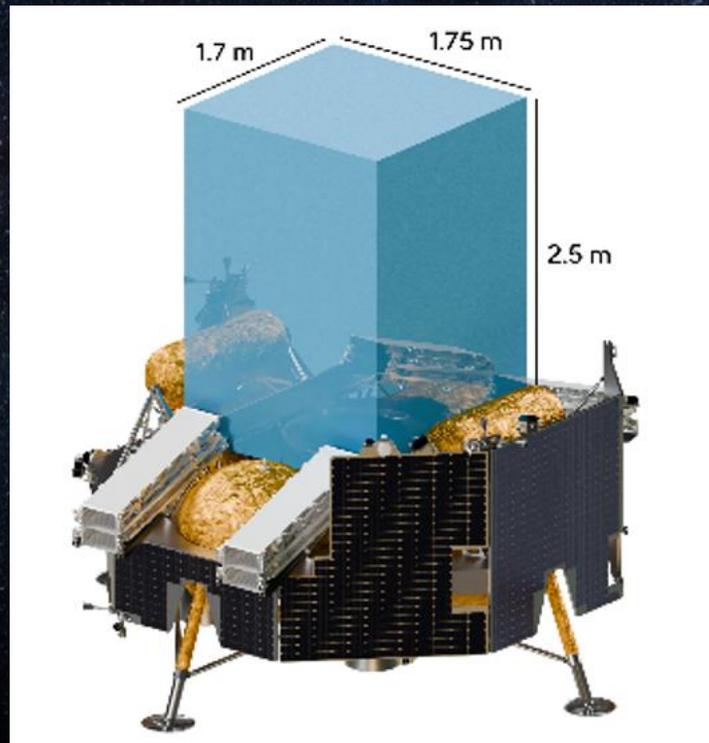


Fig 1. Astrobotic's Griffin Lunar Lander

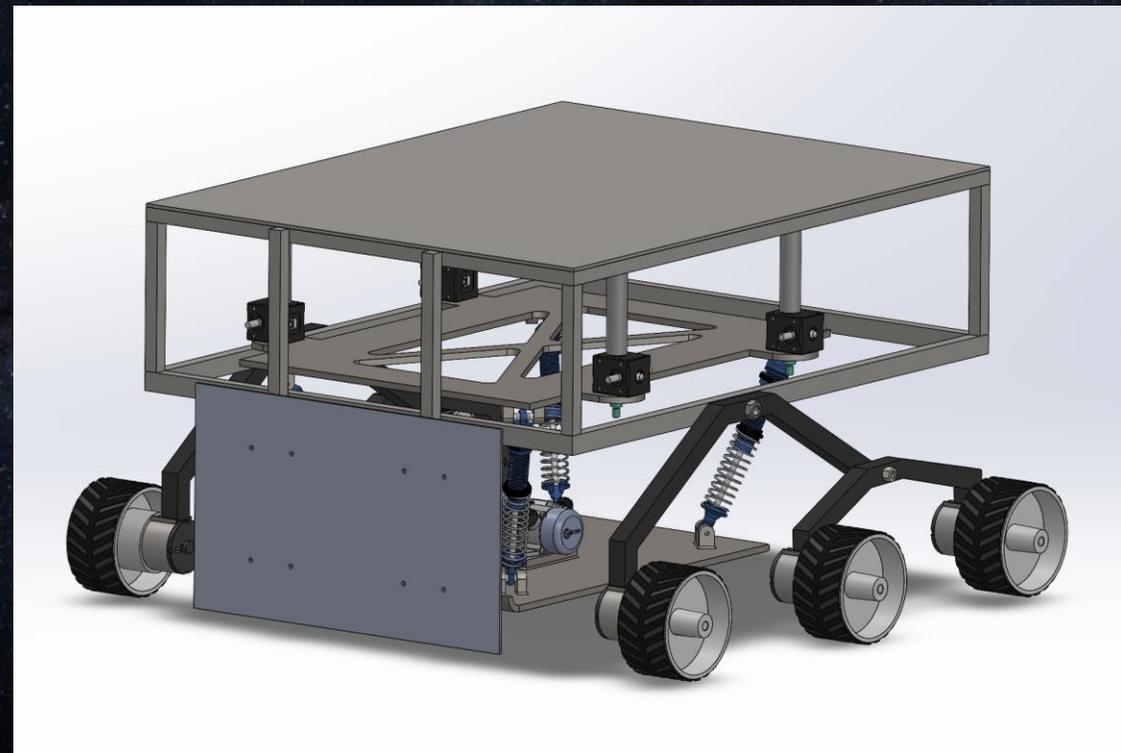


Fig 2. REV-LE CAD

Team Overview



- Senior capstone design aerospace design project
- Team REV-LE, Texas A&M University
- REV-LE makes the moon ready for touchdown and construction



Ram Vedula
Structures



Miranda Kang
Team Lead



Evan McCuaig
Software & Autonomy



Dr. Manoranjan Majji
Advisor



Joshua Cole
Compaction



Wayne Williams
Robotics and
Manufacturing



Brooke Wolfram
Systems



David Fumero
Electronics/Power



Tim Kienberger
Cosmic Mentor

Executive Summary



- Lunar regolith is fine, abrasive, electrostatically adhesive, and easily erodes causing unstable landing conditions, dust plume kickup, erosion, and hardware damage
- REV-LE is an autonomous rover that identifies suitable compaction sites, levels terrain, compacts regolith, and verifies surface stability and density to support safe landings and lunar surface infrastructure construction
- NASA identifies landing site preparation as a critical unmet need
 - Currently no CLPS/Artemis missions include autonomous leveling and compaction
- Regolith Strength increases 2-4x with moderate compaction, greatly reducing plume kick-up and increases building site stability

Projected Path



TASK TITLE	November		December		January			February				March			April						
	10-11/6-11/13-11/13	11/30-12/6	12/7-12/13	12-11-12/8-1-1	1/11-1/17	1/18-1/24	1/25-1/31	2/1-2/7	2/8-2/14	2/15-2/21	2/22-2/28	3/1-3/7	3/8-3/14	3/15-3/21	3/22-3/28	3/29-4/4	4/5-4/11	4/12-4/18	4/19-4/25	4/26-5/2	5/3-5/9
PDR																					
Presentation Submittal																					
Prepare to Present PDR in Class																					
PDR Report Due																					
COSMIC																					
Submit Midpoint Flash Talk Chart																					
REV-LE Midpoint Flash Talk																					
C3 Final Showcase Briefing																					
Prototype Entry Video																					
COSMIC Technical Paper																					
24 Minute Briefing																					
Next Semester																					
Finalize IDD for GLL																					
Order Parts for Prototype																					
Prototype Assembly																					
Prototype Testing																					
Interim Progress Review Report IDR																					
Interim Progress Review IPR																					
CDR Presentation																					
CDR Report																					



Thank you!

Any Questions?