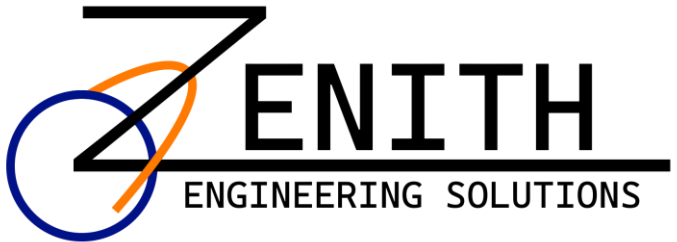
COSMIC Capstone Project Final Briefing

Zenith Engineering Solutions, University of Texas at Arlington: Autonomous In-Space Truss Assembly Robot (AITAR)

Students: Ethan Cross, Spencer Cornwell, Juan Rodriguez, Nicholas Hermes, Nevin Puthenpurackal
Advisor: Dr. Paul Davidson, UTA
Mentor: Dr. Jacob Rome, Aerospace Corp

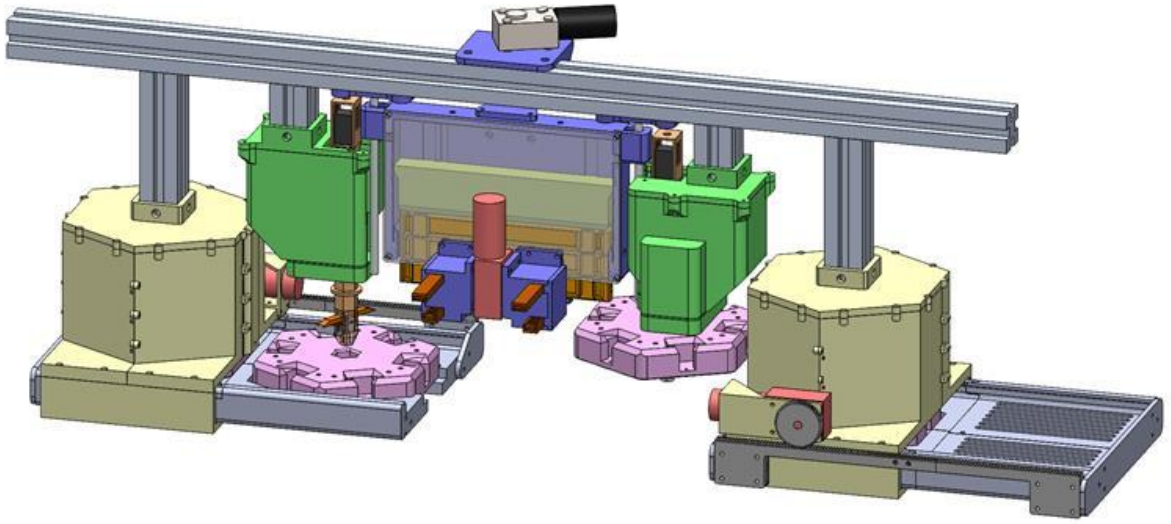
April 15, 2025



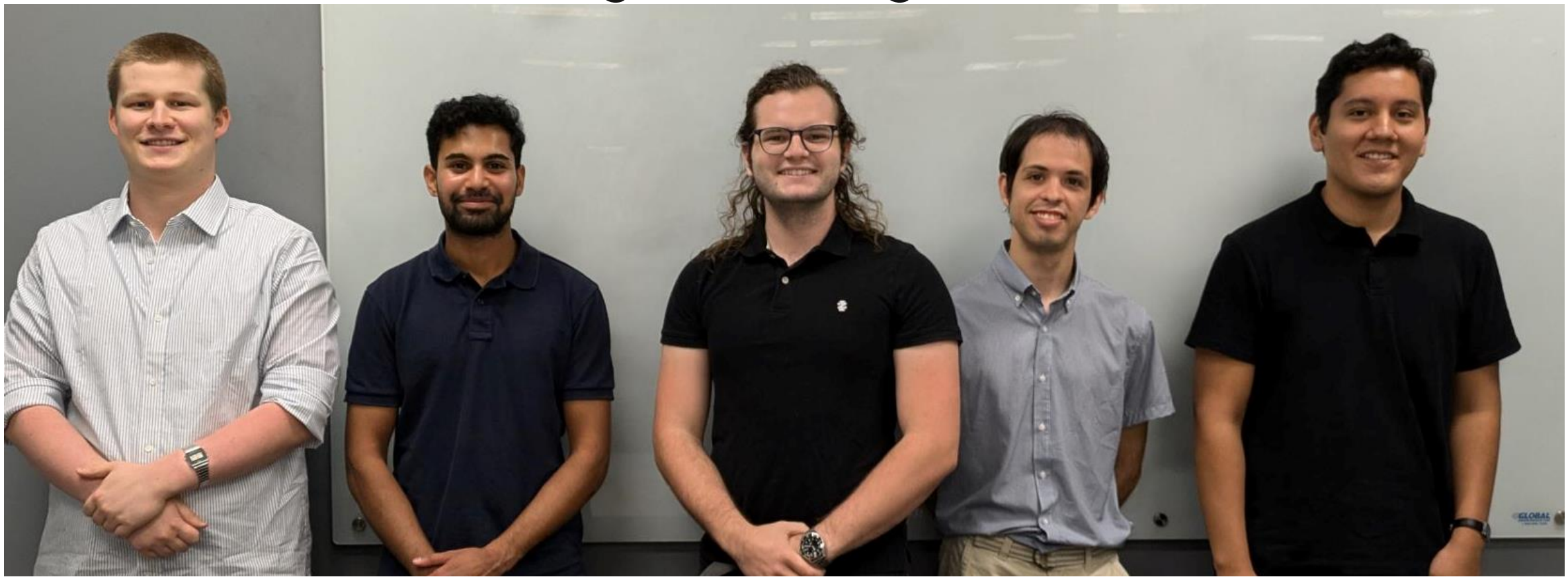
Executive Summary

Autonomous In-Space Truss Assembly Robot (AITAR)

- Motivation
  - Limited operational life of space systems
  - Need larger payloads
  - Trusses assembled by humans
- Modular
- How does it solve the problem?
  - Enables larger and more capable spacecrafts
  - Automates truss assembly in space
- Prototype phase



Team Overview – Undergraduate Engineers



Spencer Cornwell
Beam Magazine
Beam & Node
CAD & Manufacturing

Nevin Puthenpurackal
Beam & Node
Documentation

Ethan Cross
Team Lead
Programming
Mechatronics

Nicholas Hermes
Node Magazine
Animation

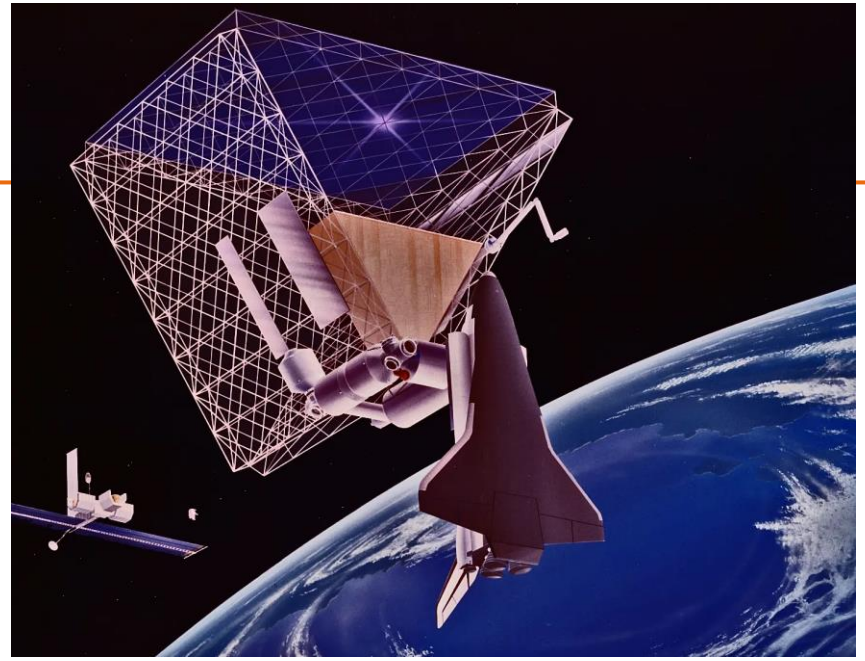
Juan D. Rodriguez
Torque Arm
Node Magazine
CAD & Manufacturing

2.4 Systems Engineering Milestones

Milestone	Date
Select program manager	10-10-2024
Chose operations/capability	10-17-2024
Defined system requirements	11-12-2024
Completed trade studies	10-31-2024
Finalized conceptual design	11-21-2024
Developed a path to Preliminary Design review	04-05-2025
Generated prototype specifications	02-05-2025
Prototype sub-assemblies functional	04-03-2025
Prototype assembled	04-07-2025

1.1 Impact

- Enables in-space structures larger than payload volume
- Serve as a support structure for repair and assembly
- Platform to enable technologies in space infrastructure
  - Structural
  - Fuel

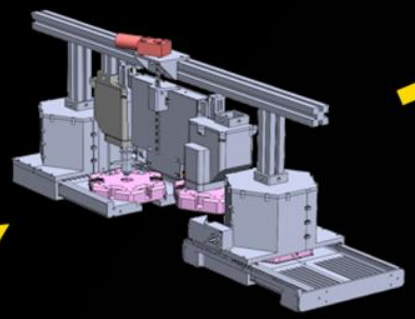


AITAR

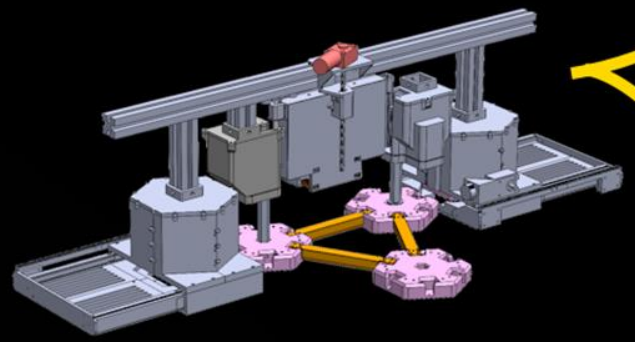
Autonomous In-space Truss Assembly Robot

(1) Launch

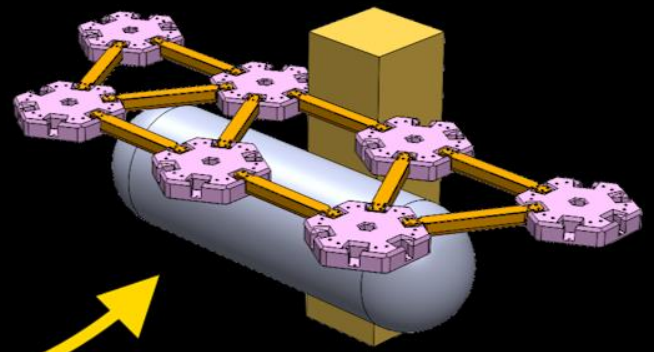
(2) Deploy from Bus



(3) Truss Construction

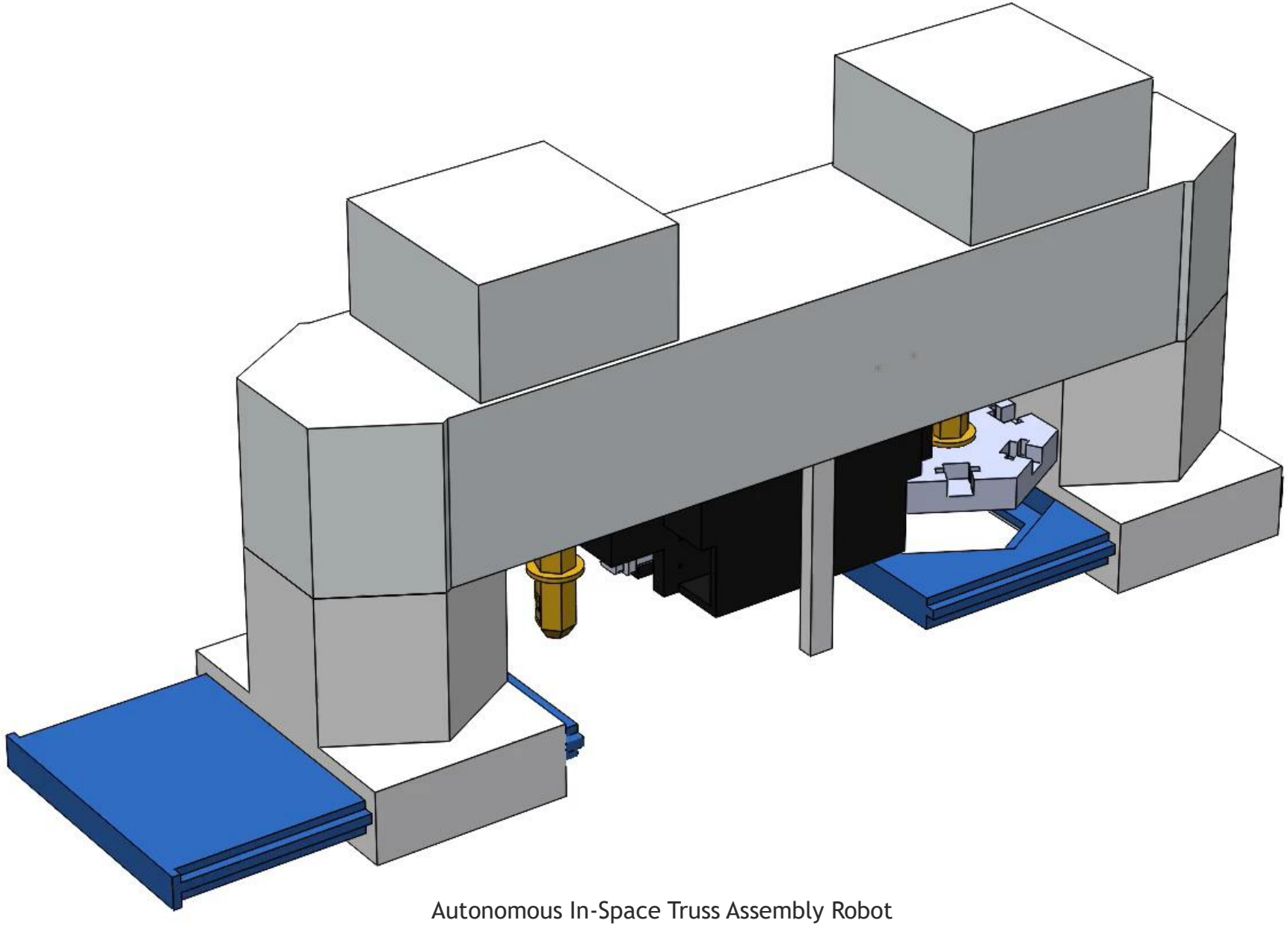


(4) Truss Utilization

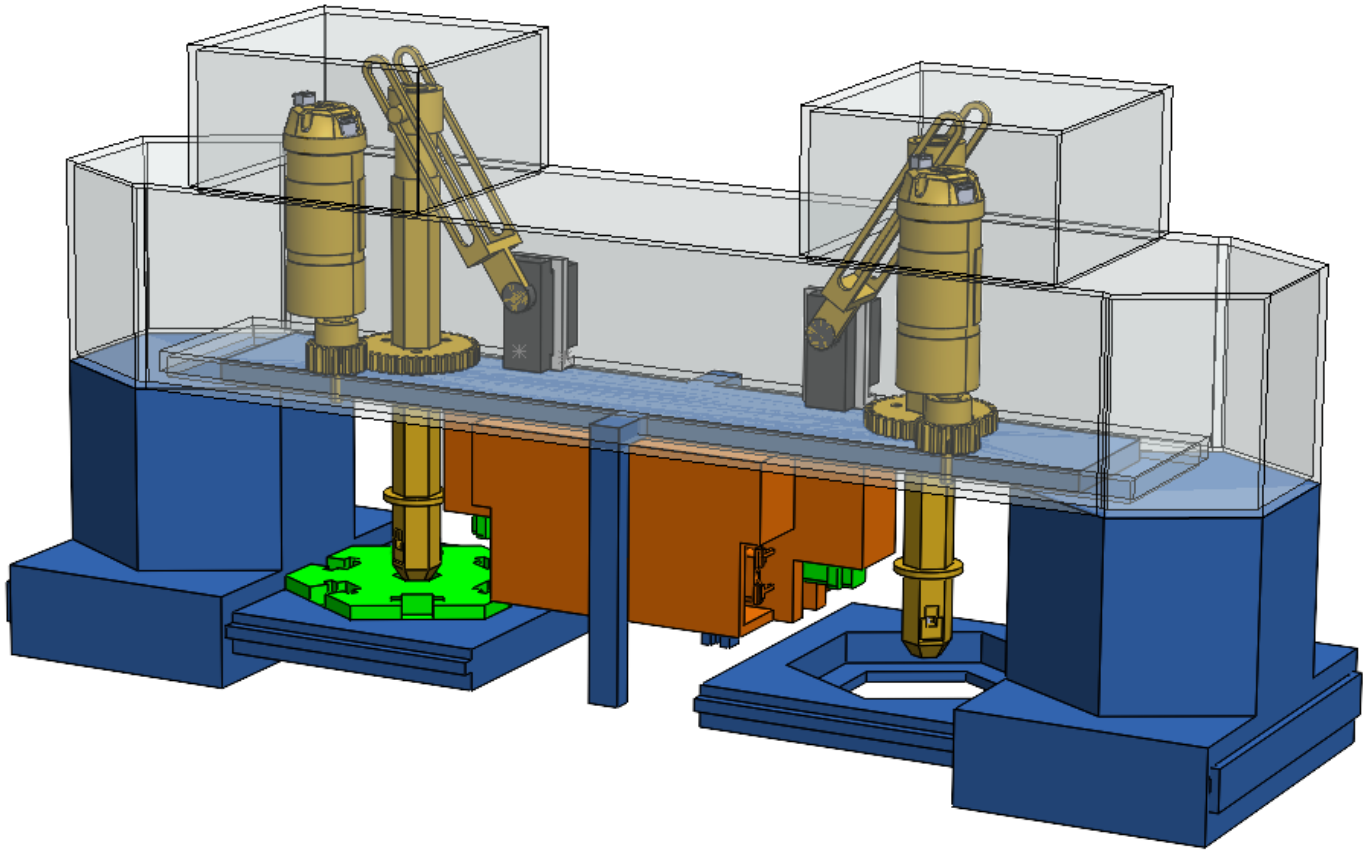


(5) Deorbit

2.1 Animation of Key Operating Sequence



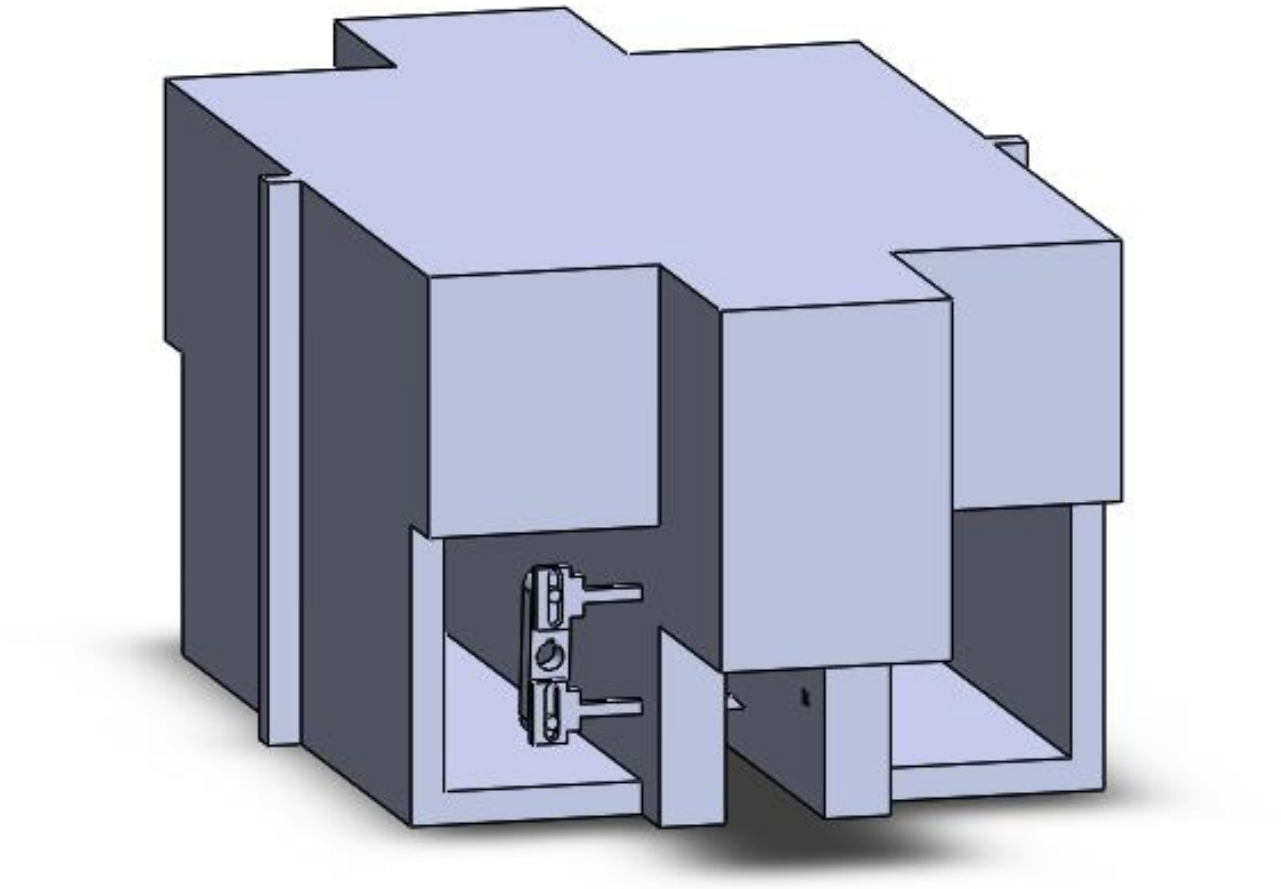
Subassemblies – Conceptual Design



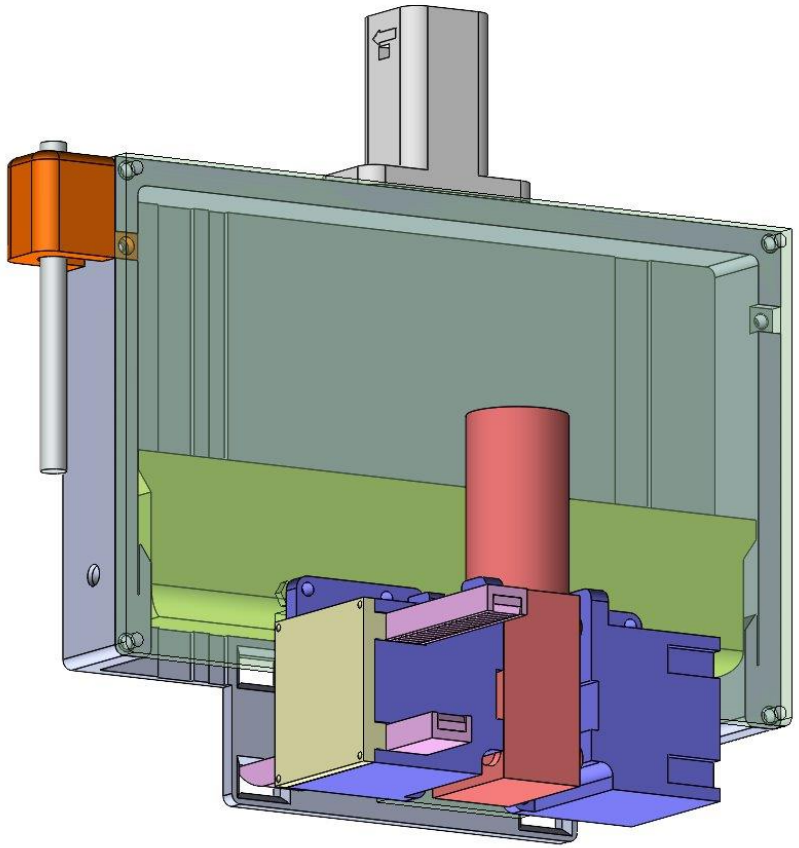
Node Magazine Torque Arm Beam Magazine Beam & Node

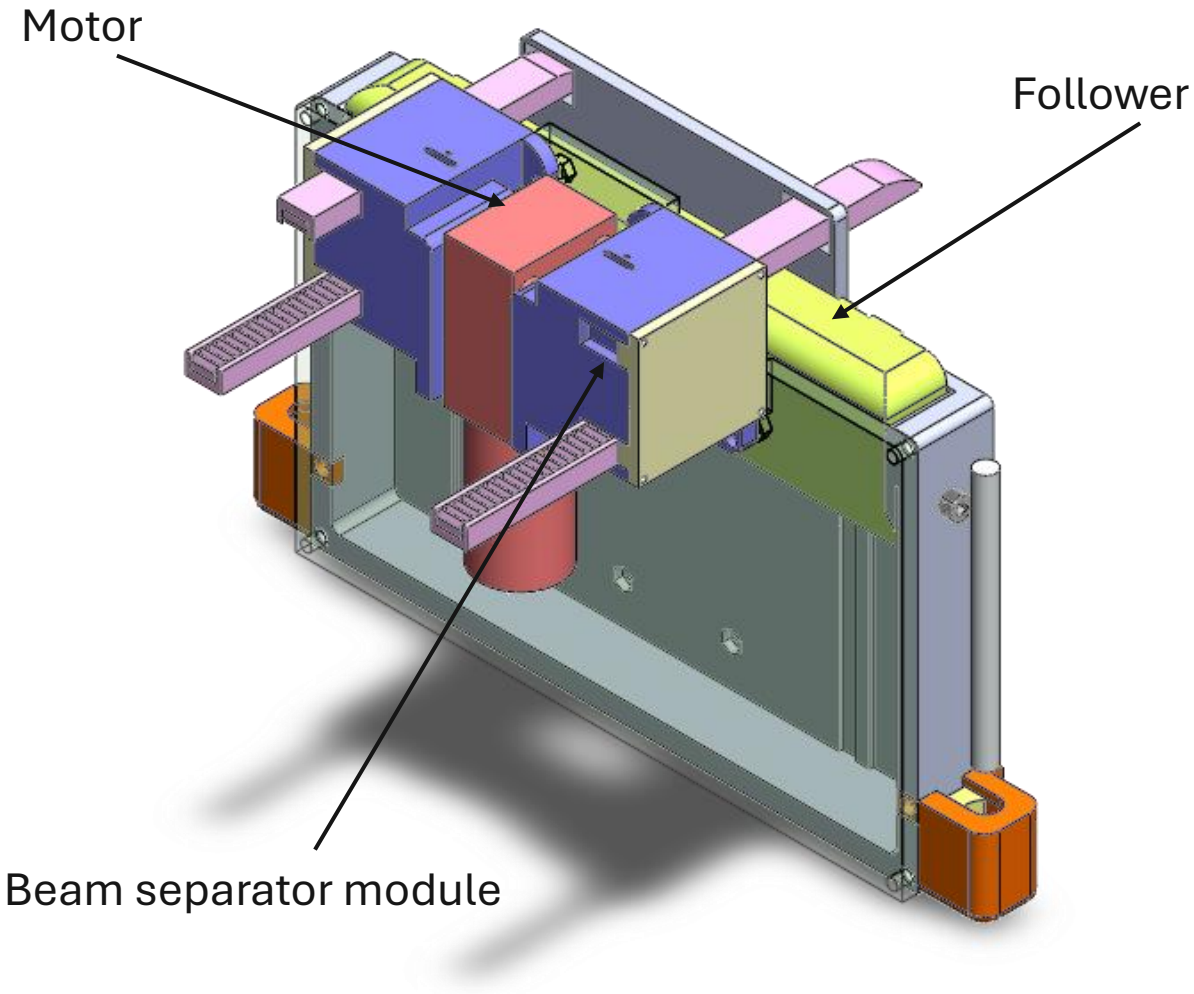
Beam Magazine – Conceptual

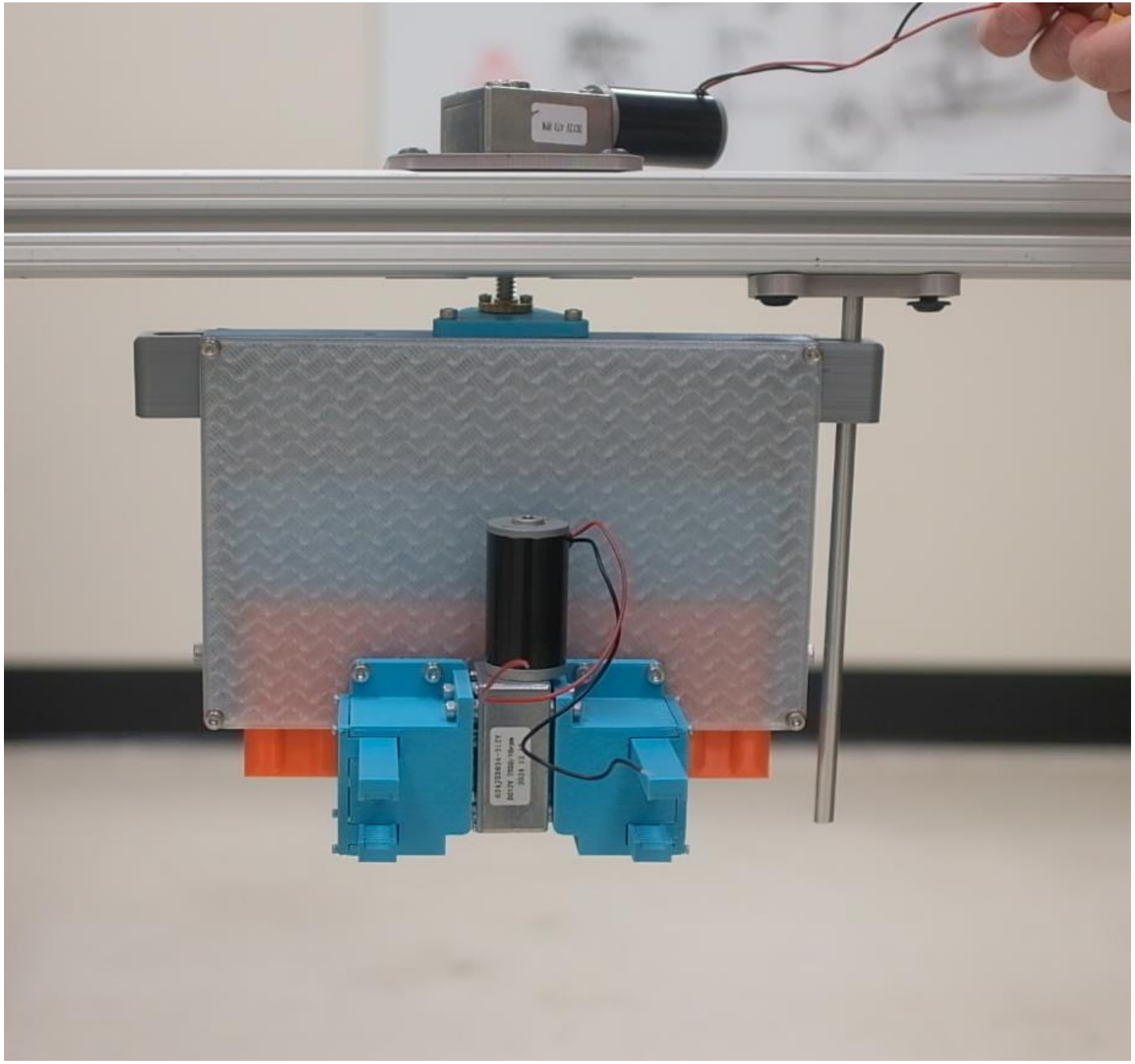
- Store
- Dispense
  - Spring and follower
- Isolate
  - Servomotor
- Translate
  - Ball Screw
  - DC motor

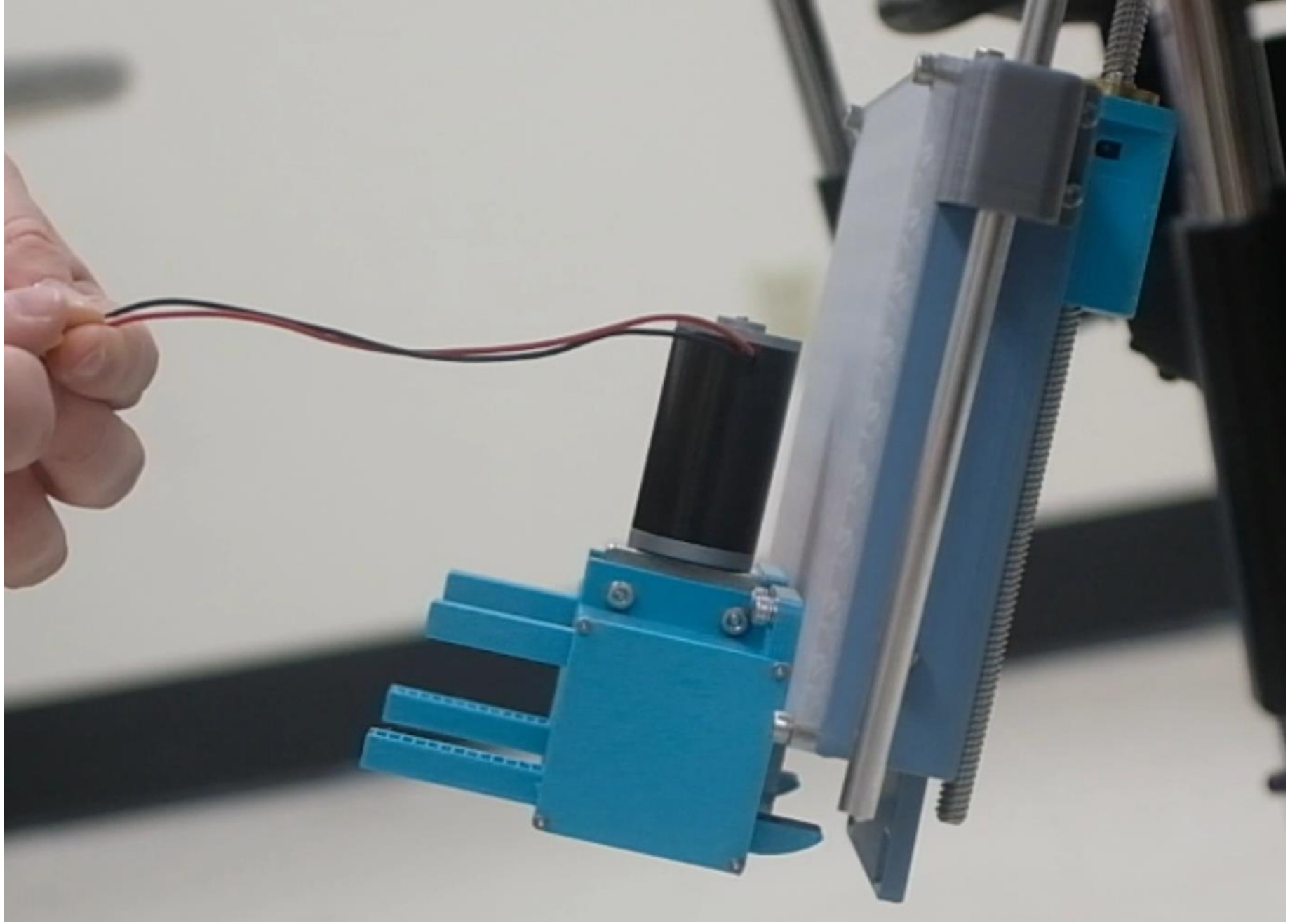


Beam Magazine – Prototype



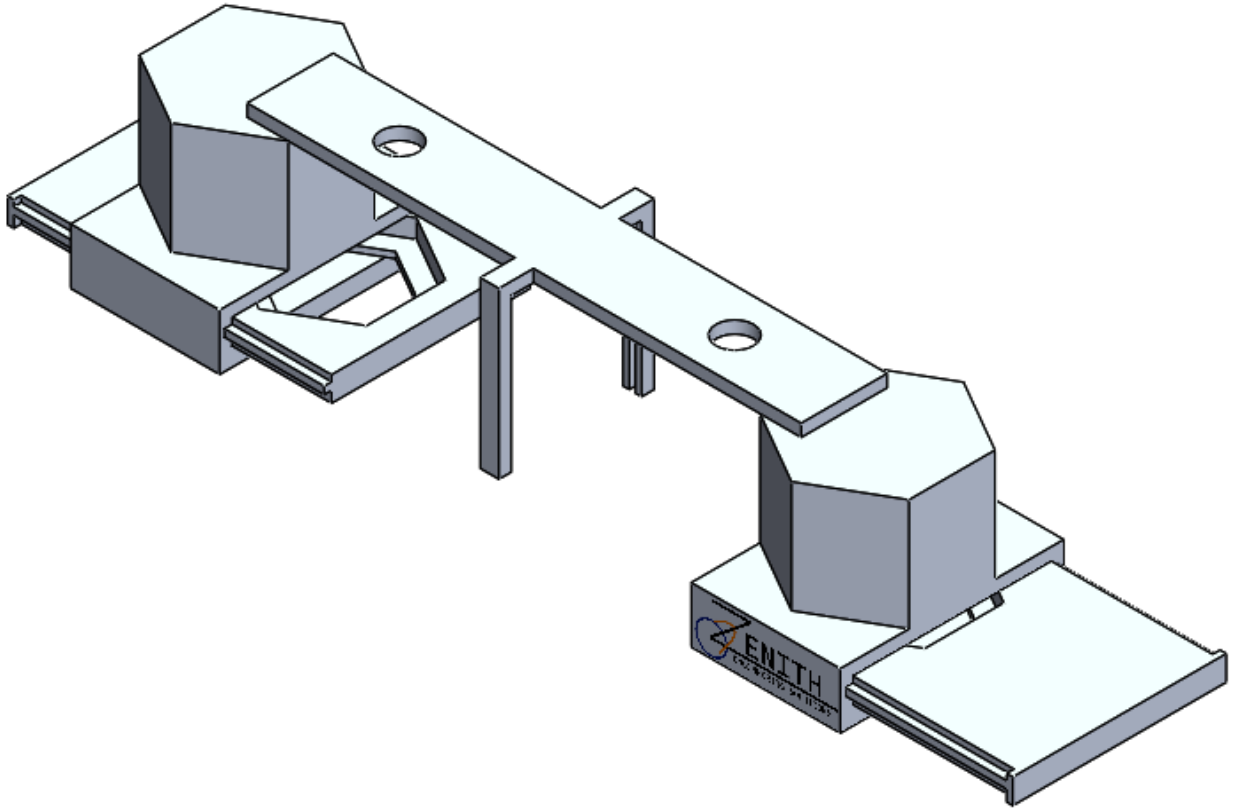




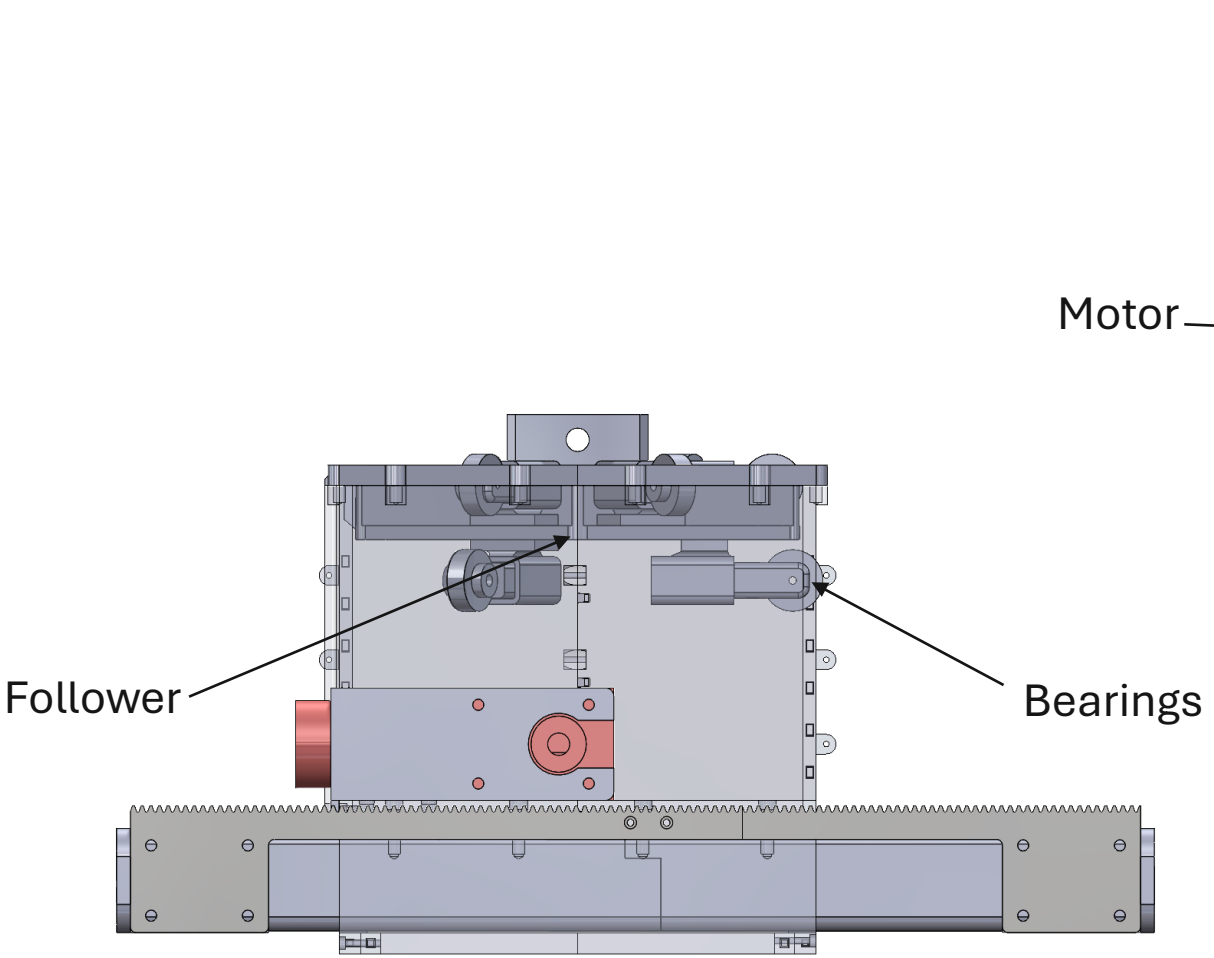


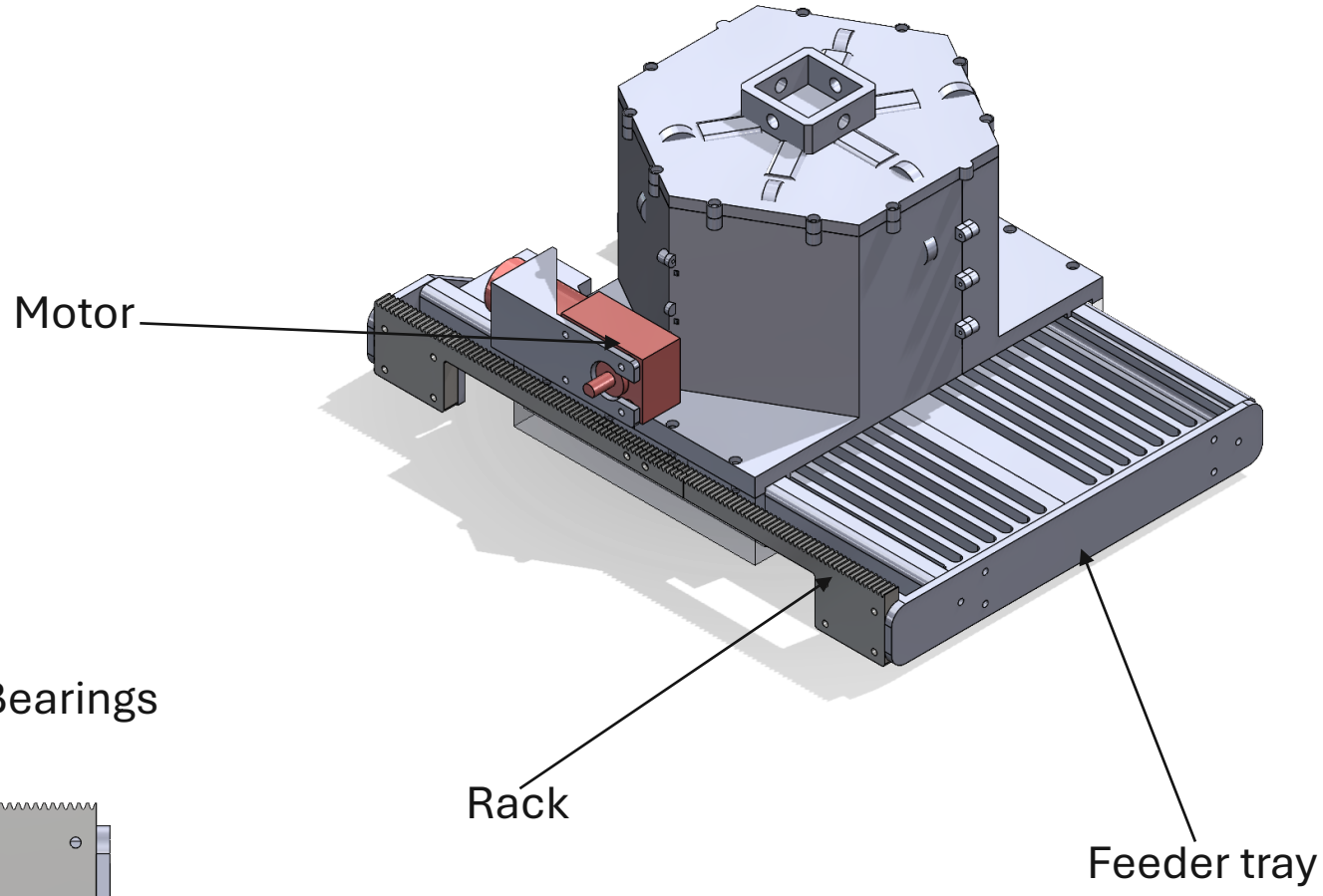
Node Magazine - Conceptual

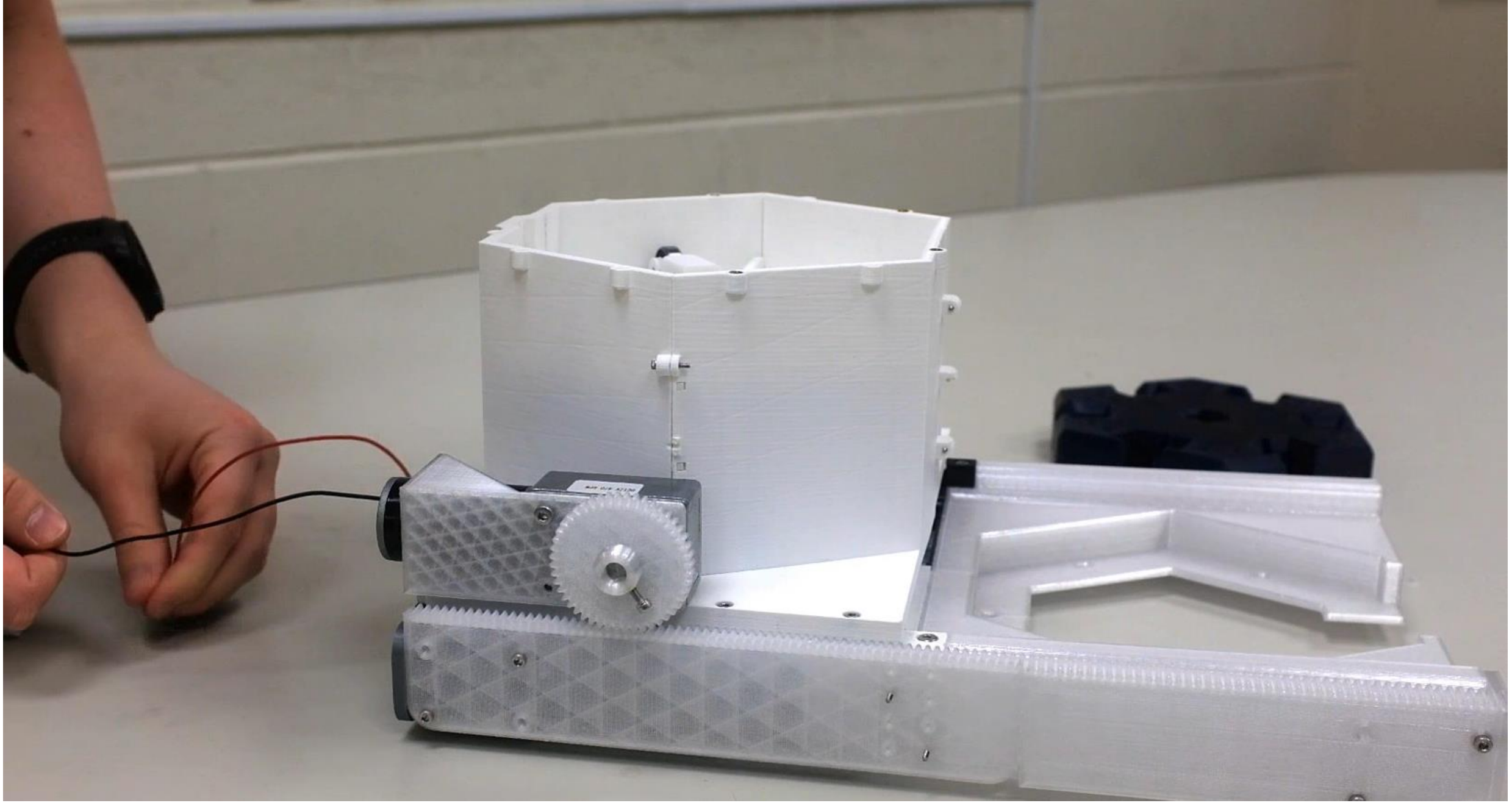
- Store
- Dispense
  - Ball Screw
  - DC motor



Node Magazine – Prototype

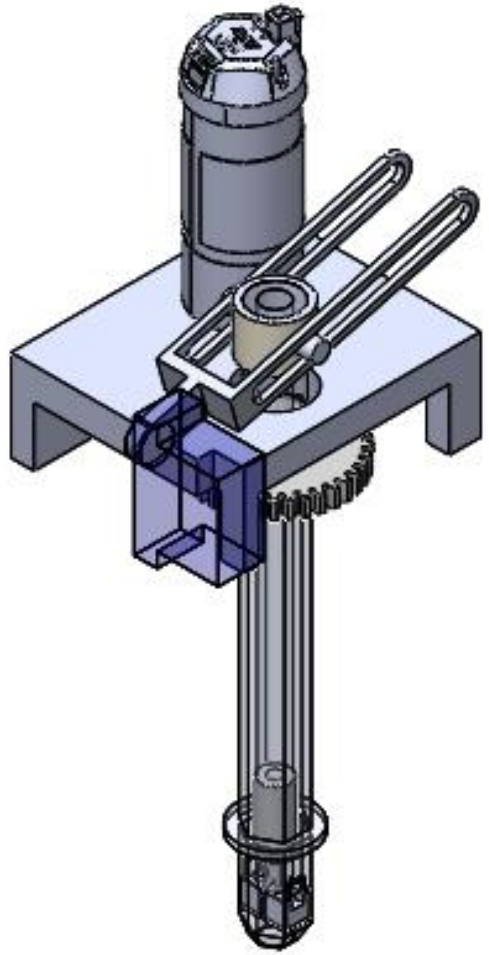




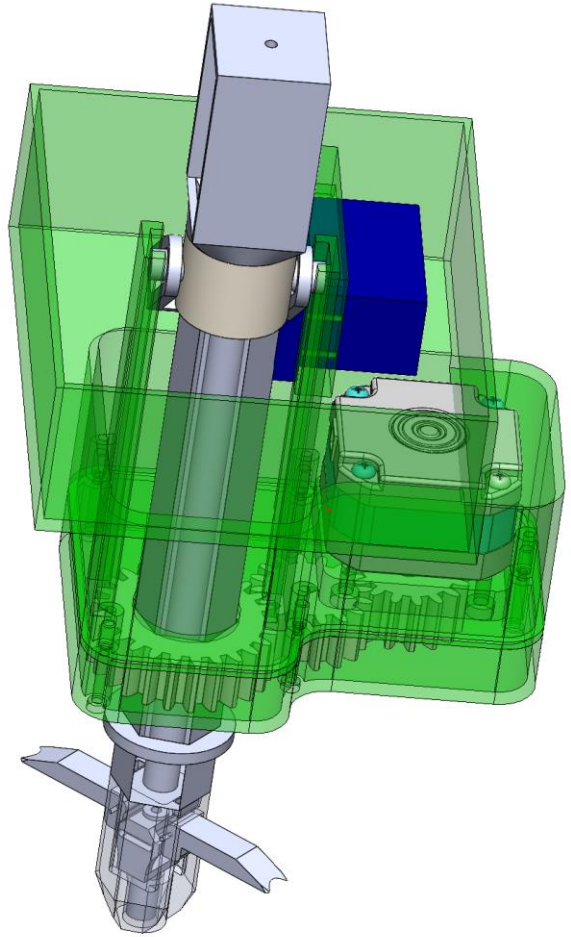


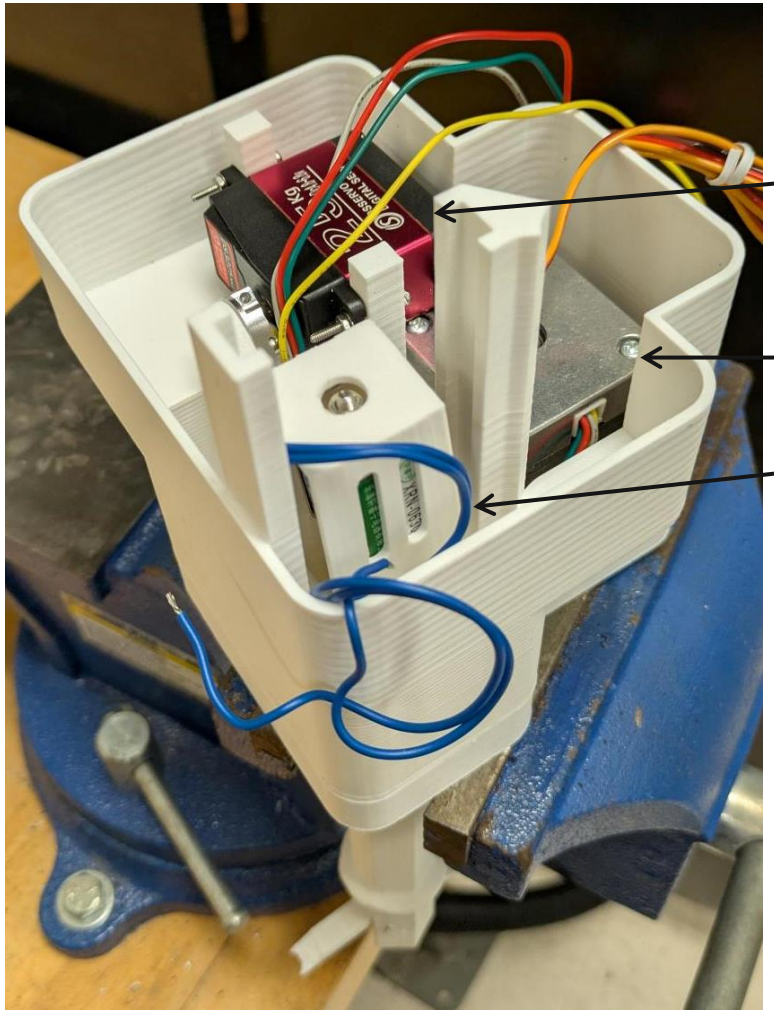
Torque Arm - Conceptual

- Constrain
  - Flanges
  - Servo motor
- Translate
  - Servo motor
- Rotate
  - Stepper motor
  - Gears



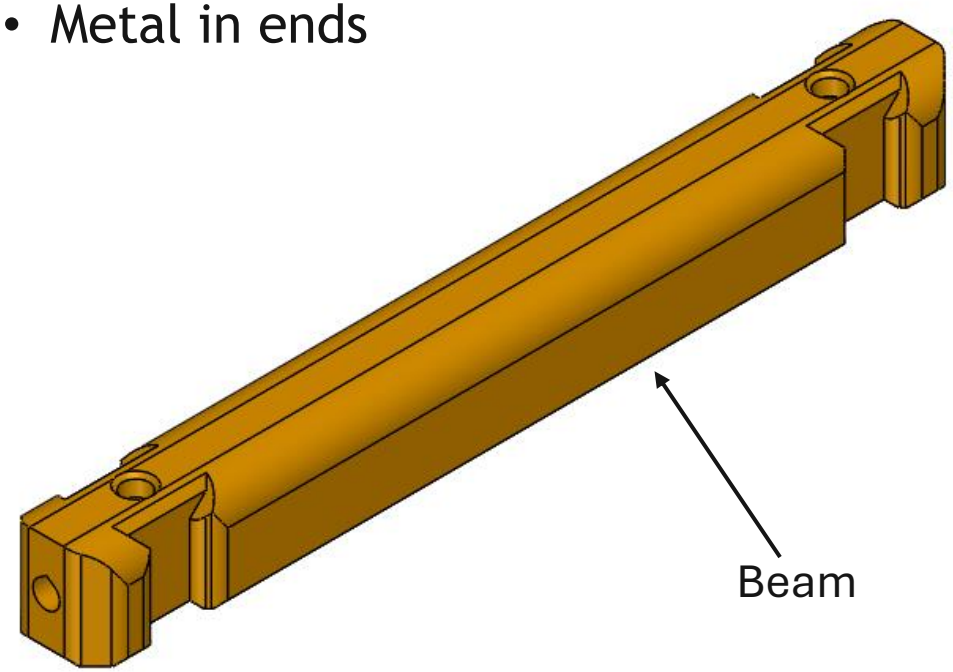
Torque Arm – Prototype

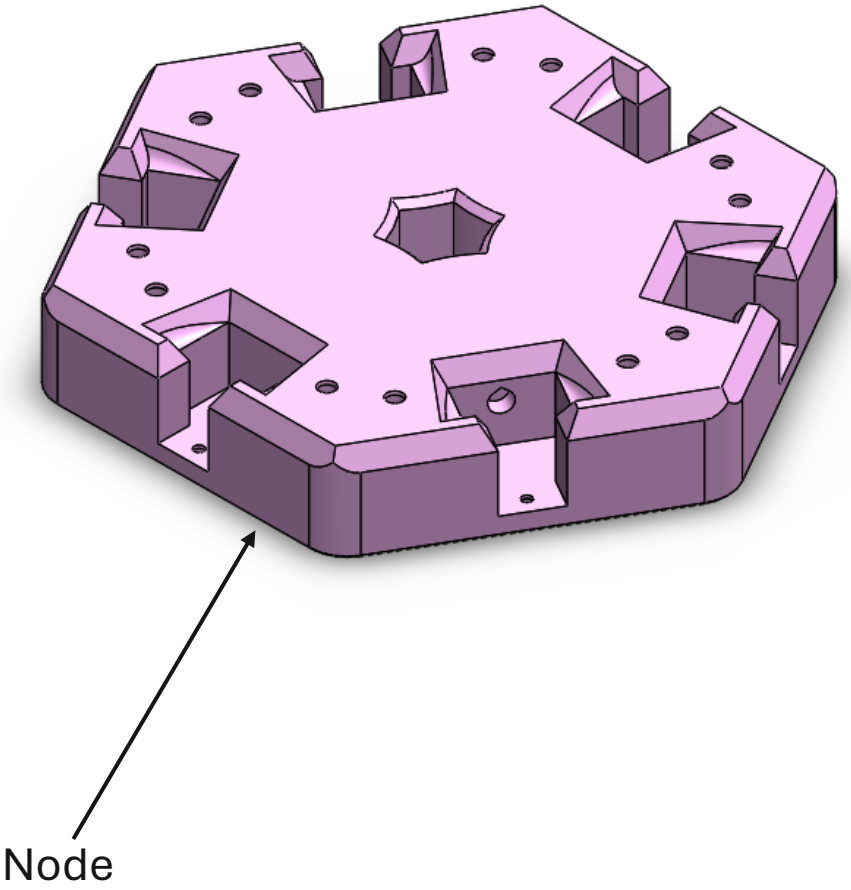


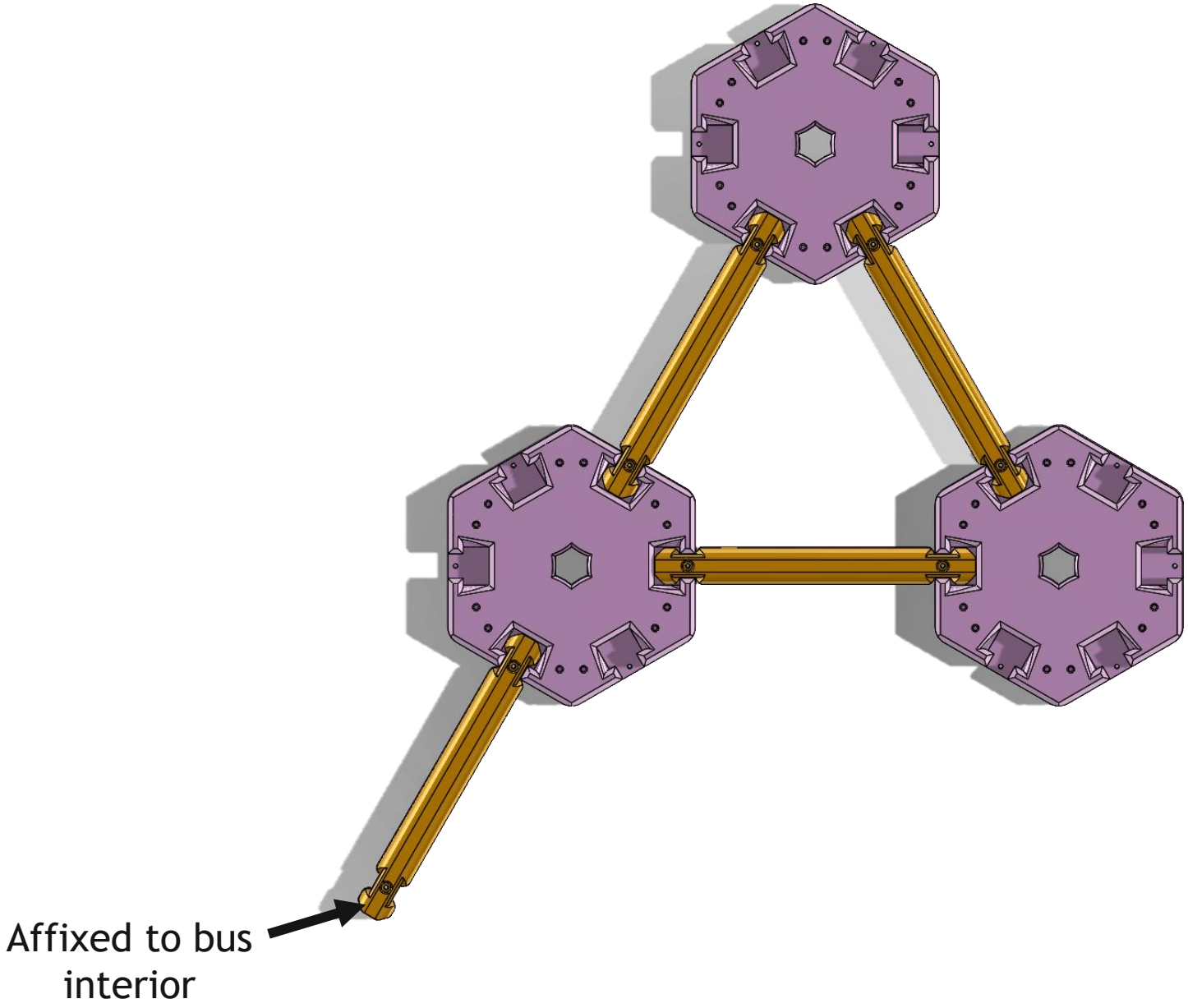


Truss Elements

- Induction welding
- PEEK/CF beam
  - Metal in ends

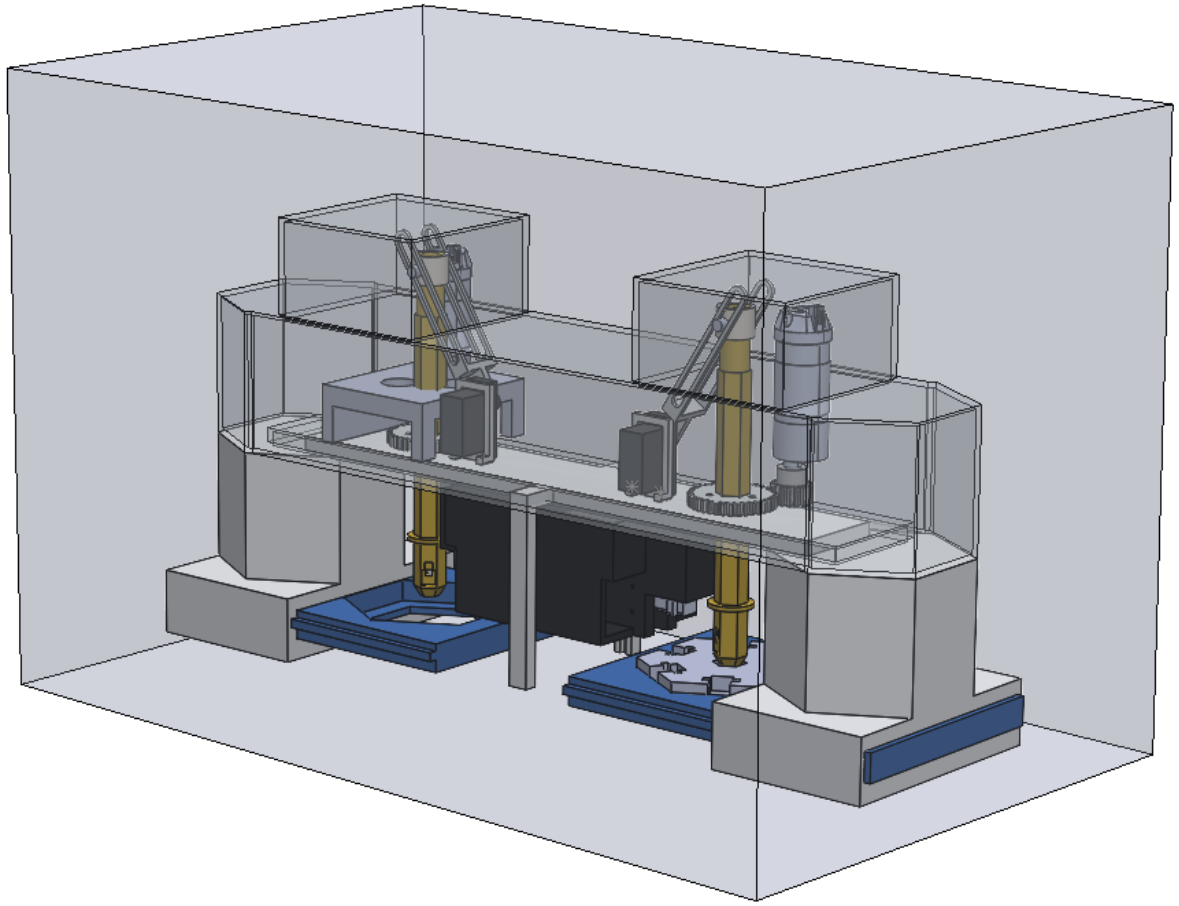





Affixed to bus
interior

Completion of Required Elements

- Mass: 17 kg
- Power
  - >222W welding power draw
- Max Launch stress of 13 MPa at 6 G's
- Operations
  - Dispensing/Alignment
  - Joining
  - Locomotion



1.2 Feasibility

- Kinematics proven
- Automation
- BOM Critical components:
  - Stepper motors
  - Servo motors
  - Ball screws
  - Induction coil
  - Composite beams

Feasible within a decade

3.2 Technology Gap Assessment

- Thermoplastic induction welding not subject of recent research for space applications
- Capability to inspect welded joints would ensure the stability of the truss
- Streamlining reloading would decrease build time and failure rate

- No technology gap which is insurmountable

1.7 Trade Studies - Joining

- Fasteners
- Ultrasonic welding
- Adhesives
- Snap fits
- Induction welding

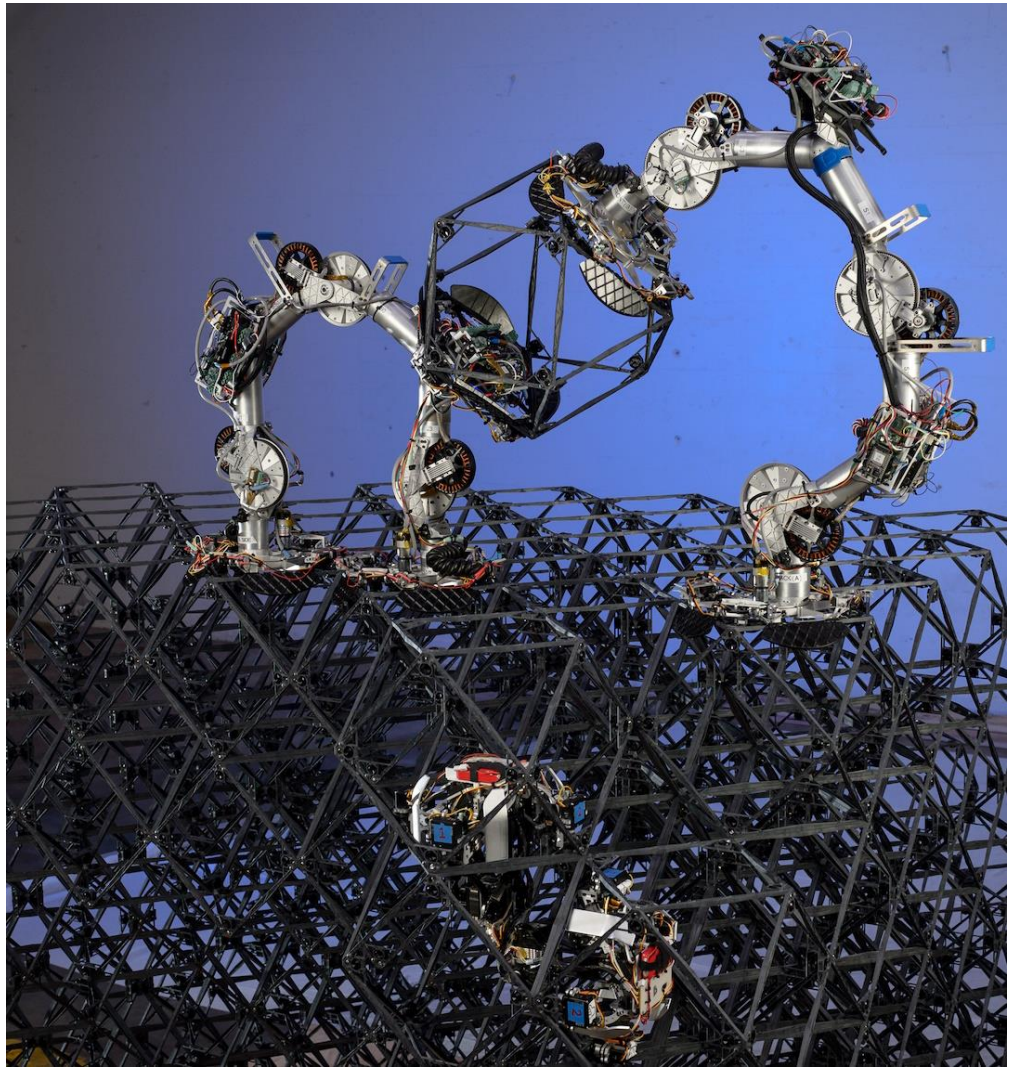
1.7 Trade Studies – Linear Actuation

- Lead screw
  - Rely on sliding friction
- Ball screw
  - Reduced friction
  - Used in space applications

1.3 Innovation

- Similar projects under development
  - ARMADAS
  - NASA Assemblers
  - SAMURAI

- What makes ours unique?
  - Simple
  - Modular
  - On-orbit
  - Scalable
  - Plastic welding



1.5 Risk Assessment

Probability	Severity			
	4	3	2	1
4			Electronic interruptions	
3	Misalignment of nodes and beams	Welded joint breaks	Robot loses communication	
2	Follower motion impeded		Actuator failure	Insufficient power generation
1	Impact with space debris	Beam and node discharge		Regular wear and tear

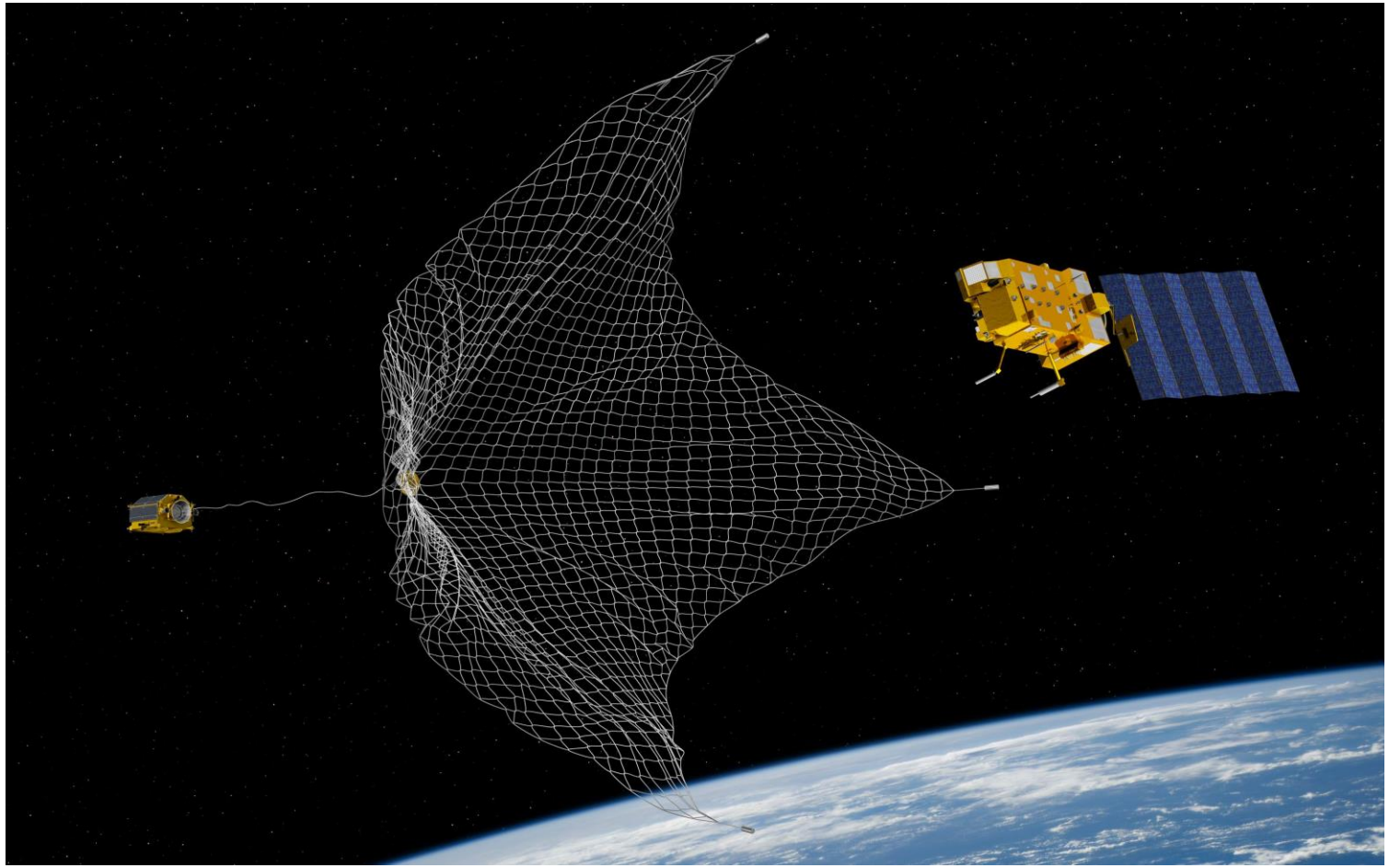
2.3 Data Handling and Comms

- No-need for real time
- Could be constantly observed, or piece-wise
- Operator only needed for initialization and updates if desired
- Low bitrate

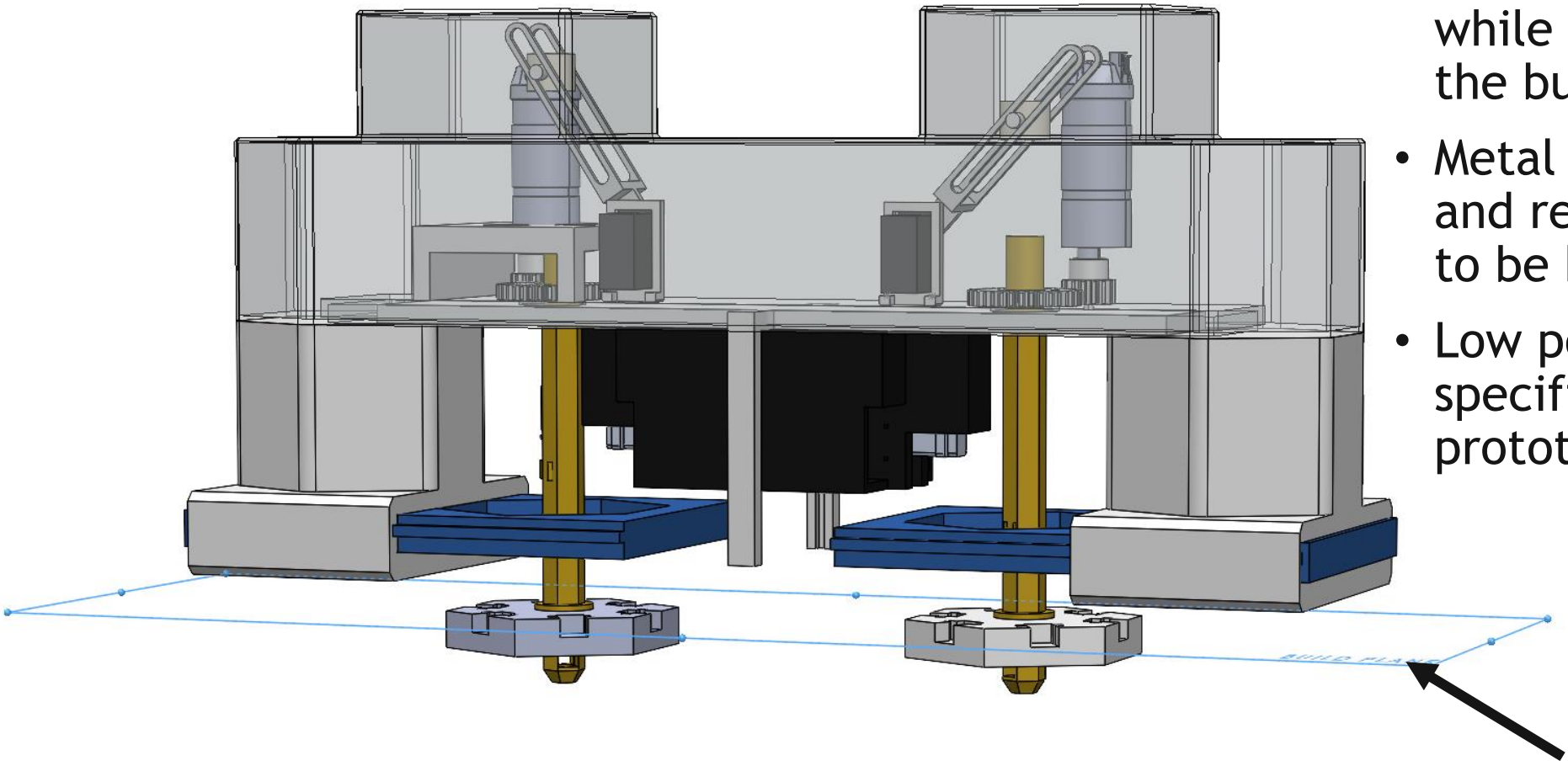
- **Brief** skimming of systems brought us to: Astrodev Lithium-1
  - 9.8 Kbps
  - 48g
  - 0.25-4W Tx Power

3.1 Most Innovative Concepts Considered

- Satellite commandeering
- Solar panel repair
- Induction welded composite trusses



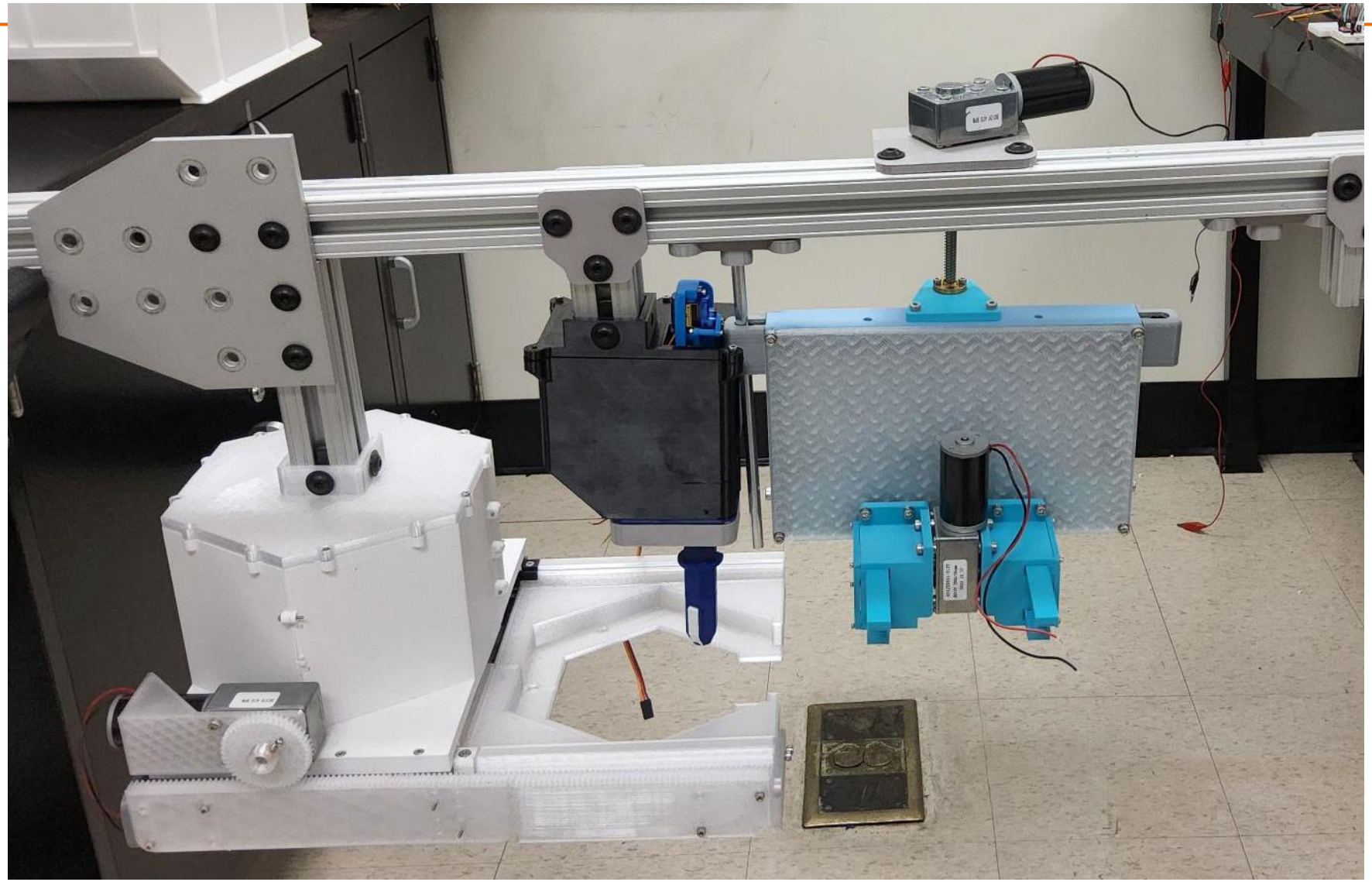
3.3 Biggest Challenges



- Assembling a truss while remaining outside the build plane
- Metal trusses are heavy and require high power to be heated
- Low power specifications of prototype actuators

Build plane

Prototype



4.1 Paper

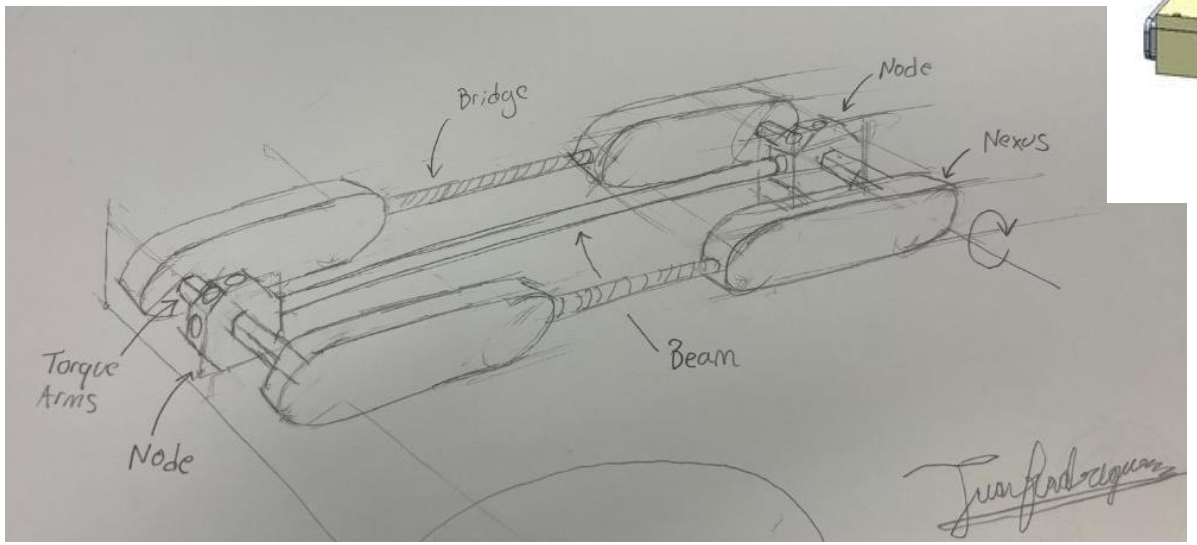
- Discusses Detailed decisions and motivations
- Abstract: 163 words
- Paper: 13 pages
- References: 26
- Can be published at: Journal of Spacecraft and Rockets

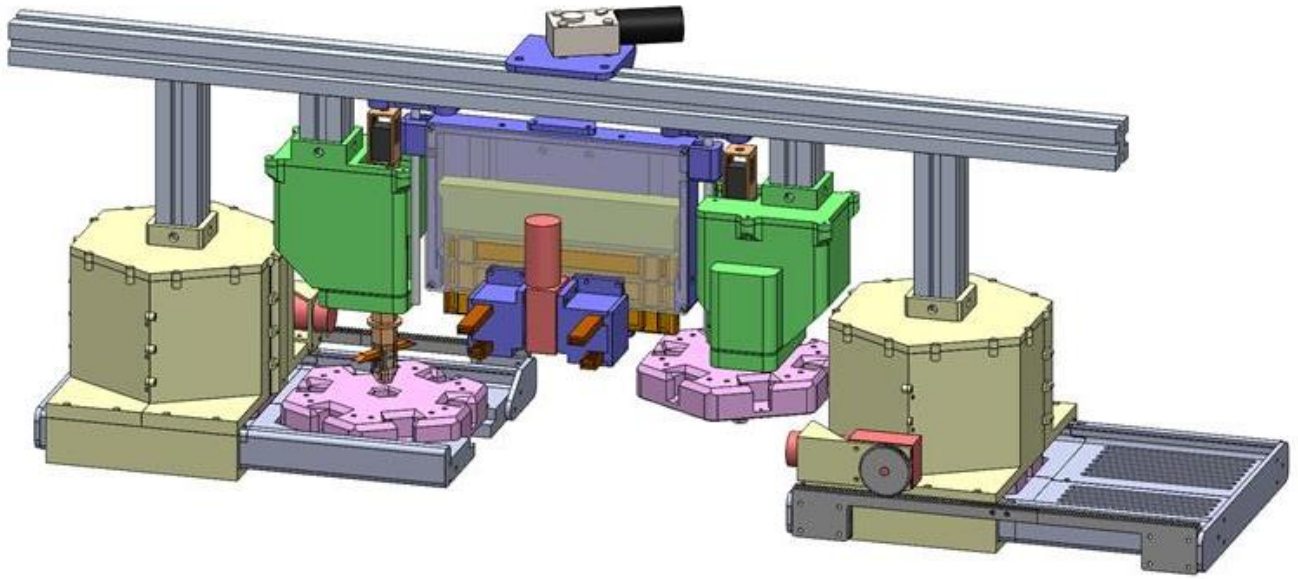
1.6 Path to PDR

- Design launch configuration and mounting structure to bus
- Design disassembly and reloading processes
- True environment testing
  - Resistance to rotation resulting from the robot’s locomotion
  - Control of thermal loading from welding and motion
- Rescale to fit bus
- Assignment of space-rated motors

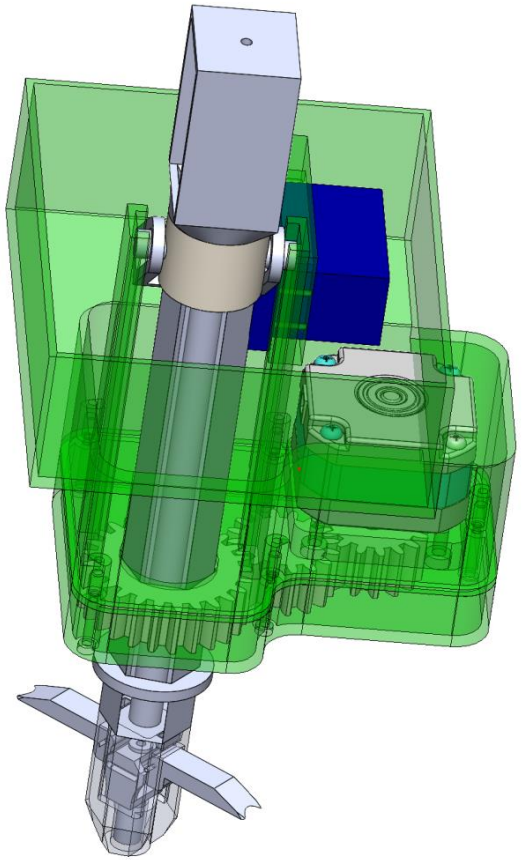
Summary/Conclusions/Highlights

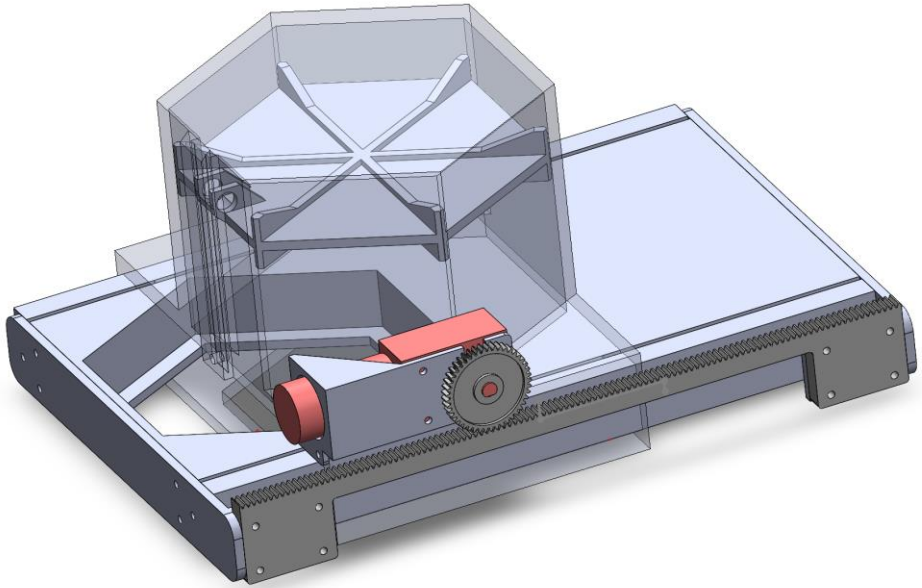
- Research
- Mission Selection
- Iterations
- Conceptual Design
- Prototype

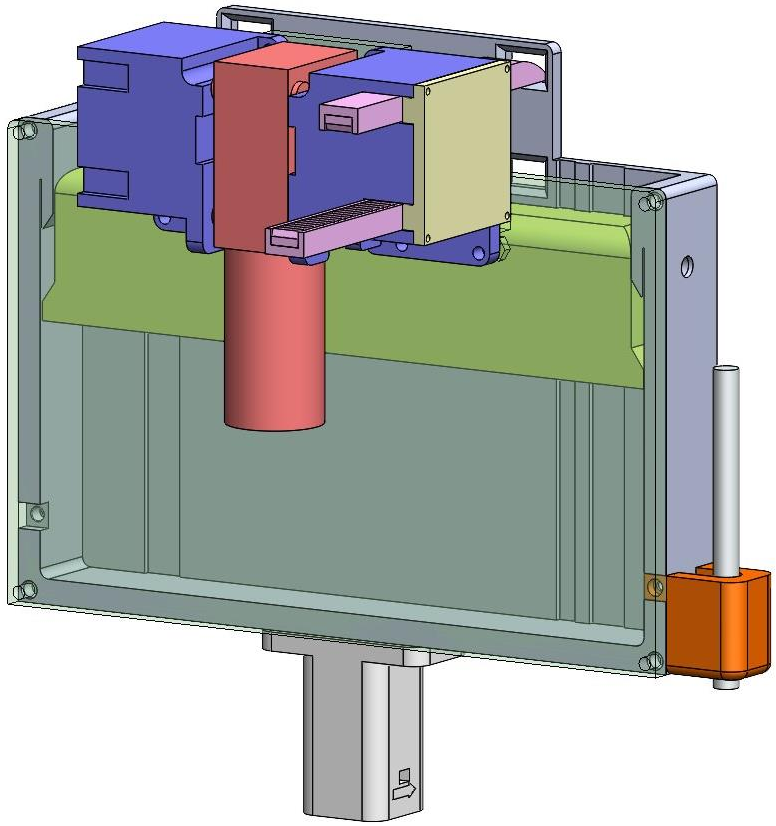




Questions?







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