

Space Loom

Team Buckeyes

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Team Overview



Tyler Smith
Mechanical and
Electrical
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Hayden Morrison
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Matt Fisher
Engineering
Physics with
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Ben Dobo
Mechanical
Engineering

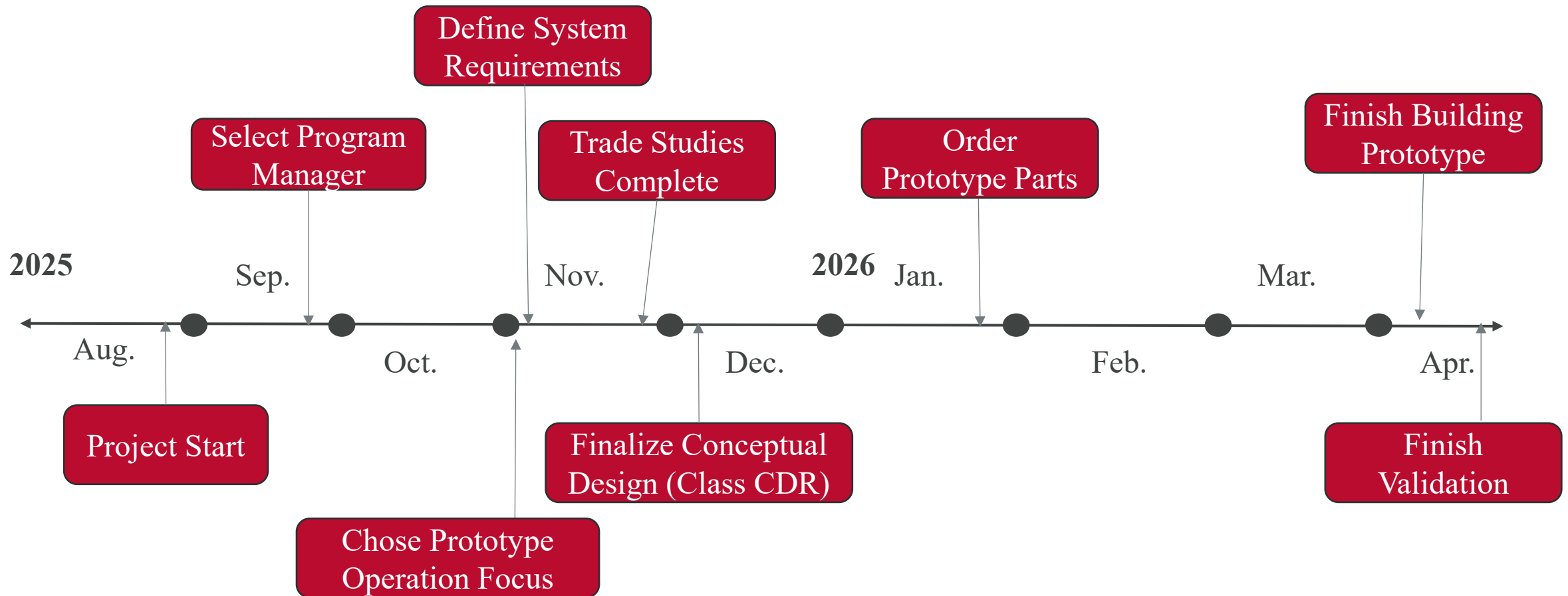


**Isaac Appiah-
Boateng**
Information
Security



**Varsha
Venkateshwaran**
Electrical and
Computer
Engineering

Milestones



Executive Summary

Problem:

- Long duration missions cannot rely on Earth resupply.
- Textile based materials can tear.

Solution:

- Produce textiles in microgravity on-demand

Impact:

- Enables in-space repair
- Independence from Earth resupplies

Status:

- Initial Prototype finished with validation





Problem

- Longer duration space missions lead to wear and tear of all components, including textiles
- High number of textiles-based components (spacesuit beta cloth, heat shield)
- Textiles are expensive to launch into orbit
- Need to make textiles / fabric on demand

Method	Description	Pros	Cons
Rapier Weaving	Interlaces warp with linear mechanical weft insertion	Centuries of proven success, strong textiles output	High mechanical complexity control
Nonwoven	Fibers bonded with heat/pressure	Low mechanical complexity	Weak fabric, heat and fluid control in sensitive environment
3D Printing	Prints flexible, pre-weaved textiles	Automated and proven to work in space	Slow, high power, and produces few textile types
Linear Electromagnet Weaving	Moves thread with linear guided electromagnet	Efficient, suited for microgravity environments	Low technology readiness, high EM production

Figure 1: Manufacturing Methods Considered

Criteria	Why It Matters
Reliability	Must work for long missions
Autonomy	Minimize crew time spent repairing
Safety	Must not interfere with other payloads and spaceship equipment
Power	Limited ISS power allocation
Fabric Quality	Must be usable for repair of various components
TRL	Must be buildable with current technology
Mass Volume	Must fit in Bosuns locker and not exceed mass limits
Microgravity Compatibility	Must work in space

Figure 2: Trade Study Evaluation Criteria

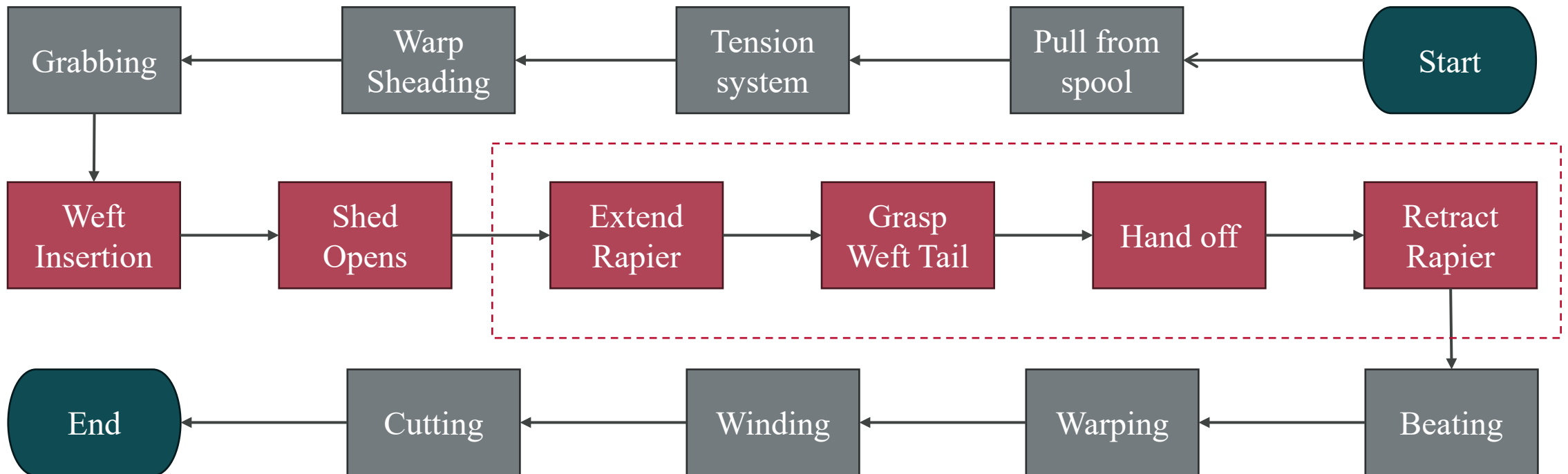
Criteria	Weight	Rapier Weaving	Nonwoven	3D Printing	Linear EM Weaving
Reliability	0.15	5	4	3	2
Autonomy	0.10	4	4	5	3
Crew Safety	0.15	4	5	4	3
Power Consumption	0.15	4	3	2	2
Mechanical Complexity	0.1	3	4	3	2
Fabric Quality	0.15	5	2	3	4
TRL	0.1	5	4	3	2
Mass and Volume	0.05	3	4	3	2
Microgravity Compatibility	0.05	4	3	3	2
Total Score	1.00	4.25	3.65	3.05	2.35

3.1 Required Elements

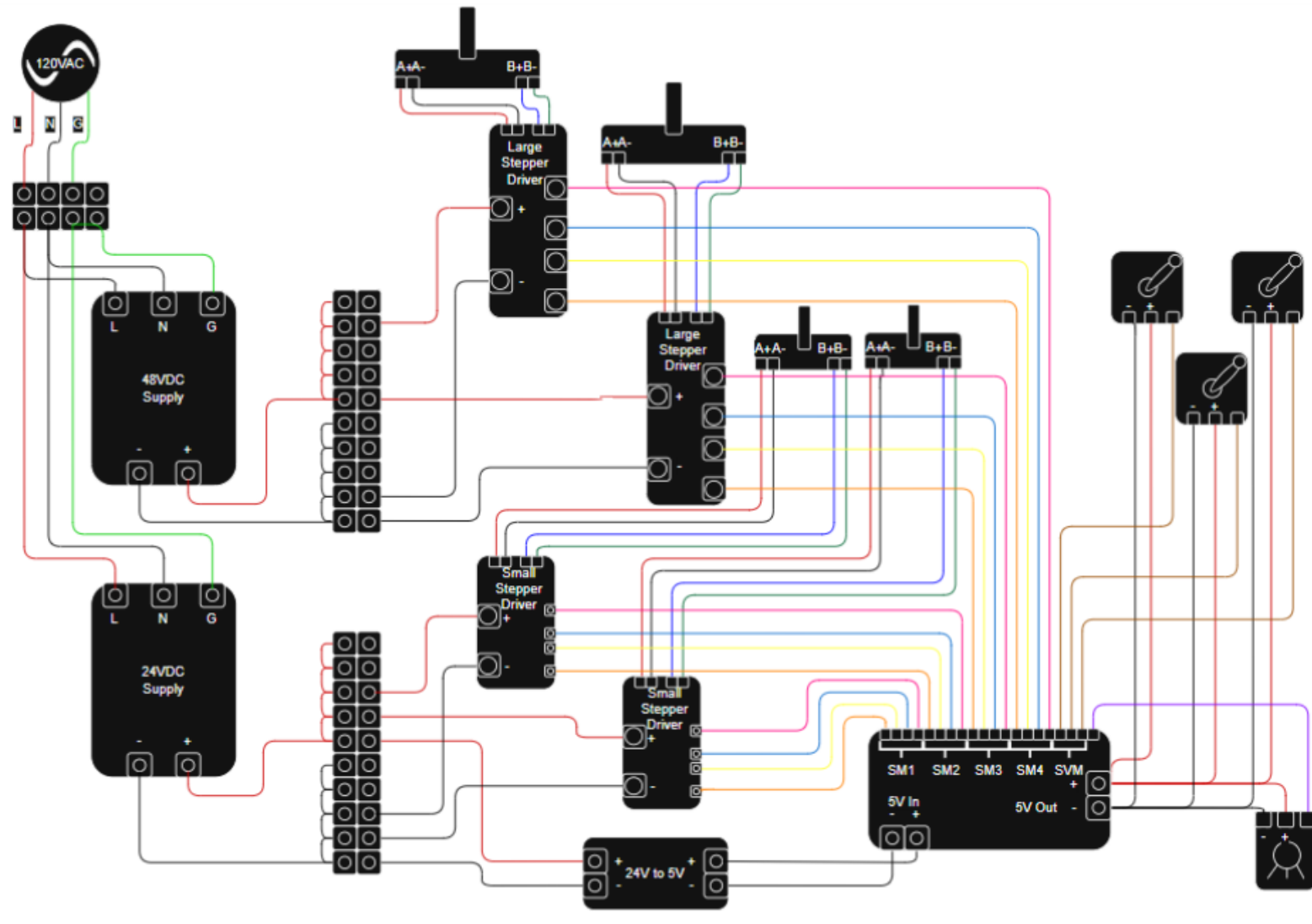
Major Subsystem	Parts
Material Feed System	Thread spools and guides, tension control system
Weaving Mechanism	Rapier head system, linear actuator, and guide rails thread handoff mechanism
Fabric Handling System	Take-up roller, fabric alignment and cutting
Electrical and Control System	Stepper driver/motors, servo motors, logic controllers, wireless connection modules
Power System	Power supplies and converter

Operation Sequence

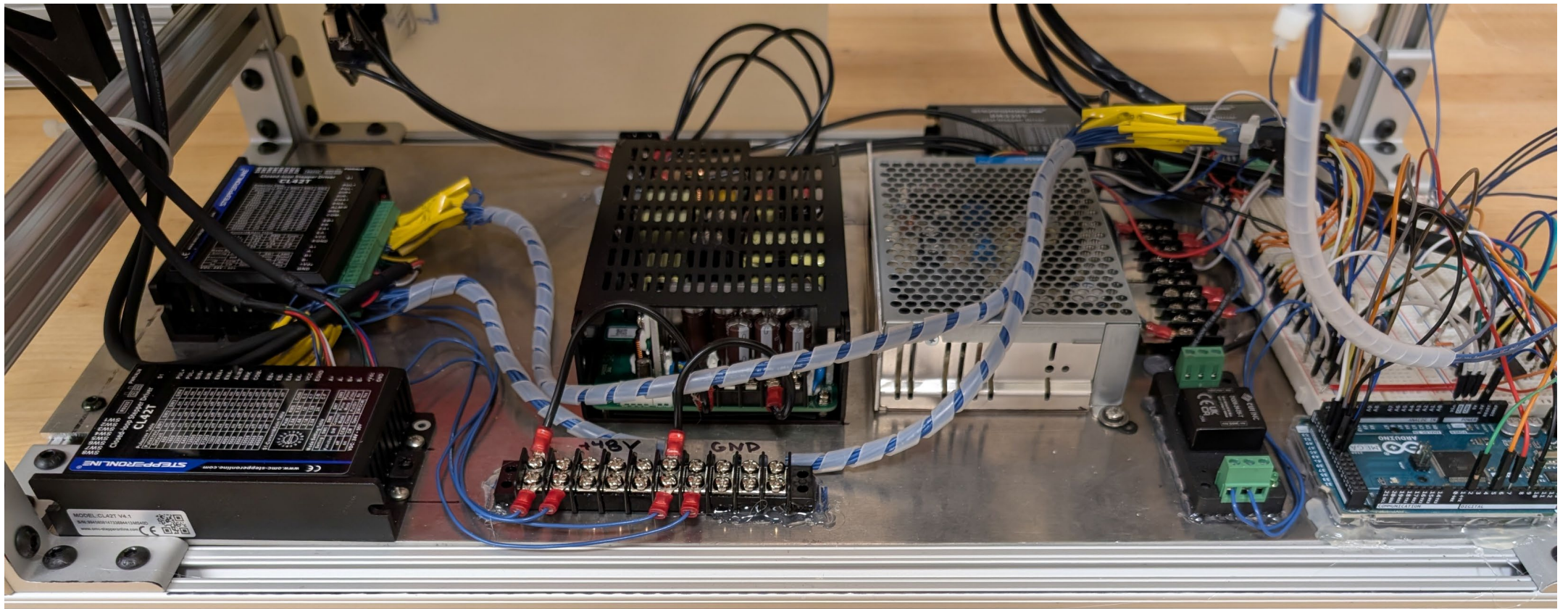
**Prototype Focus Highlighted*



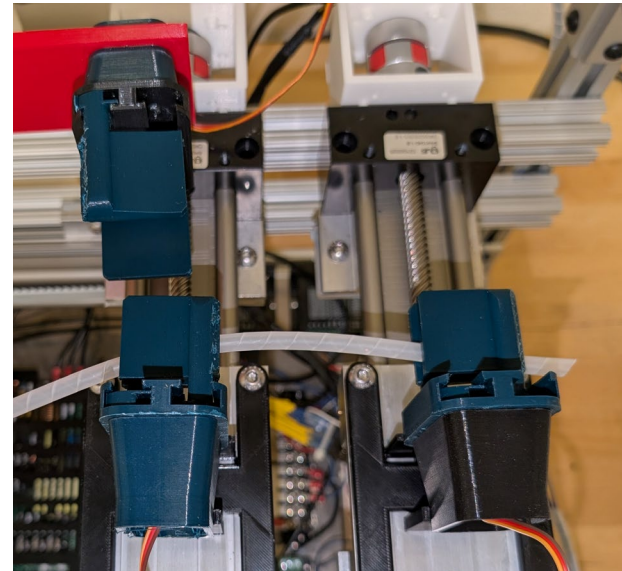
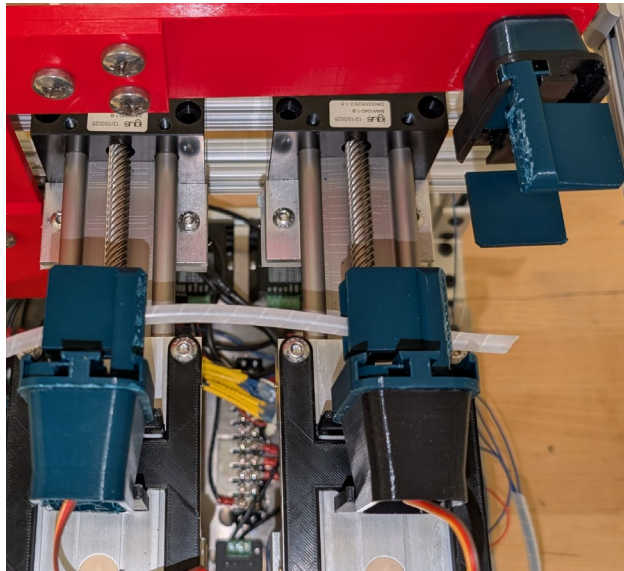
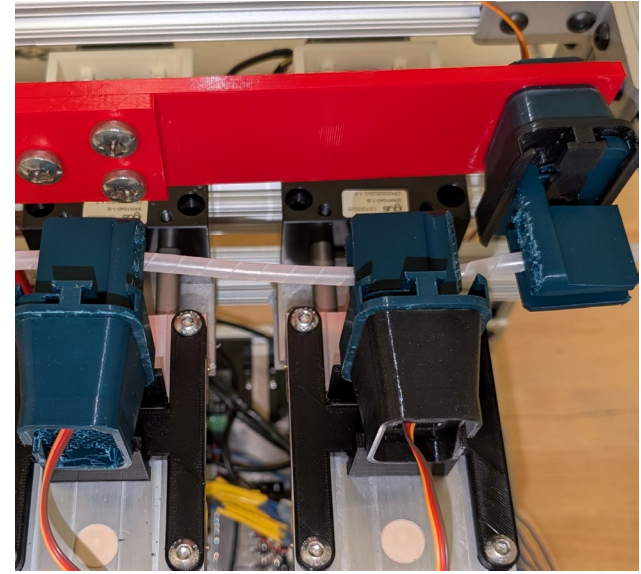
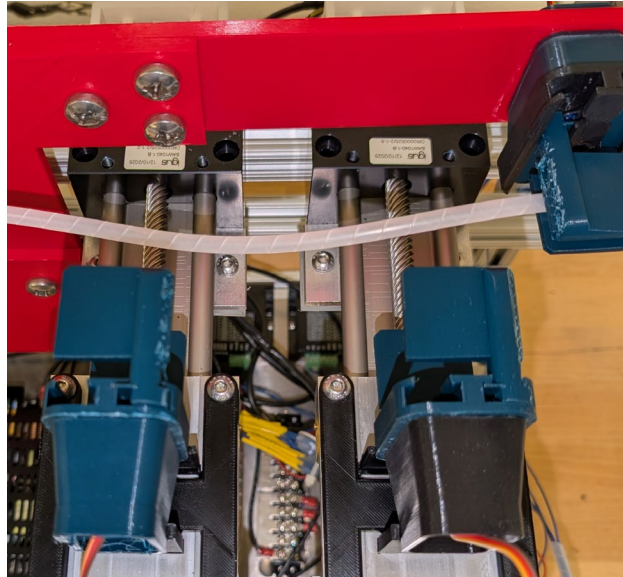
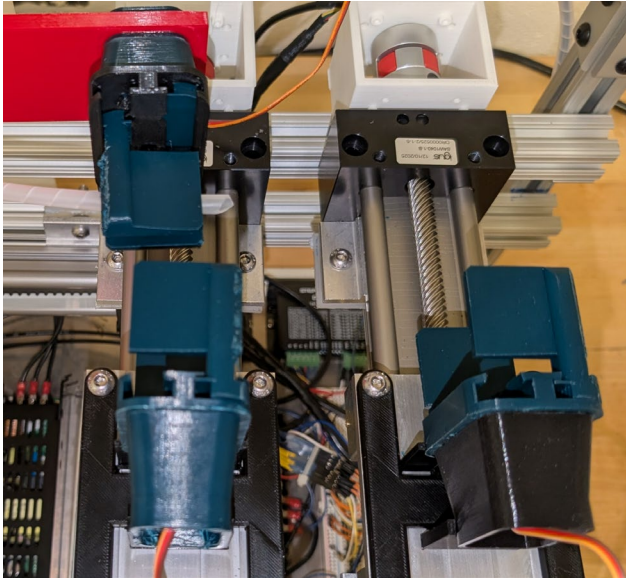
Electrical and System Diagram



Electrical Prototype Setup



Rapier Insertion Mechanism



2.1 Prototype Video



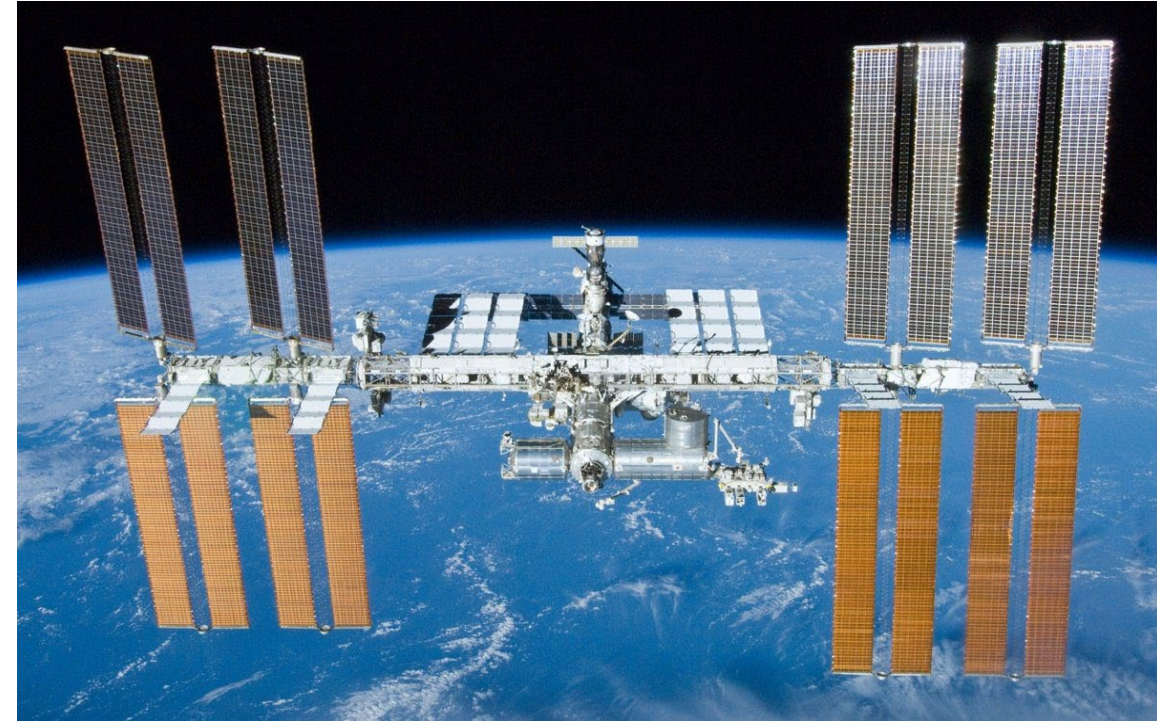
1.1 Impact

Enables Long Missions:

- Repair damaged soft goods (insulation, suits).
- Reduces dependence on Earth resupply
- Replaces initial load of backup textiles with raw materials that can be wove into desired size

Scalable for Future Missions:

- Can be adapted for larger manufacturing systems
- Supports future space stations and surface habitats



1.2 Feasibility

Proven Technology:

- Rapier weft insertion has been used and improved for hundreds of years
- Commercial production method
- No untested manufacturing methods

Meets Size and Power Constraints:

- Estimated mass < 50kg
- Estimated power: 250W
- Fits within Bosuns locker volume requirements

Realistic Path to Flight:

- Can be prototyped and tested on Earth
- Uses COTS components



1.3 Innovation

- No existing system for woven textile manufacturing in space
- Modified rapier insertion weaving to function independent of gravity (No gravity or microgravity)
- Shifts mission architecture from storage to manufacturing
- Technology can expand to larger textile manufacturing systems.

1.4 Advancing High Value Mission

- Supports In-Space Assembly and Manufacturing (ISAM)
 - Introduces gravity independent textile manufacturing
- Increases mission self-sufficiency and sustainability
- Allows repair of damaged fabric equipment instead of replacement

Fabrics in Space:

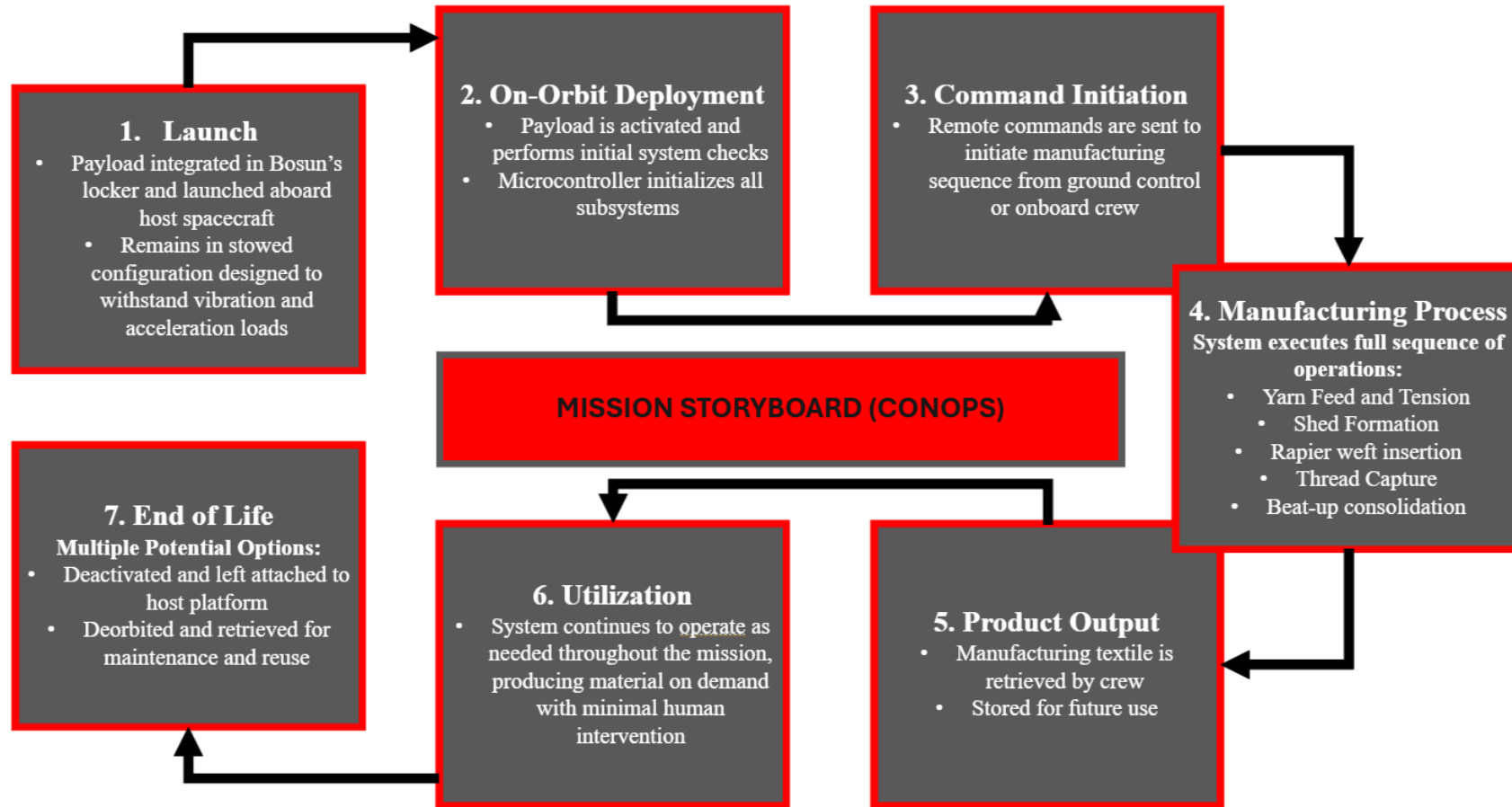
EVA Suit patch repair

Thermal Blanket repair

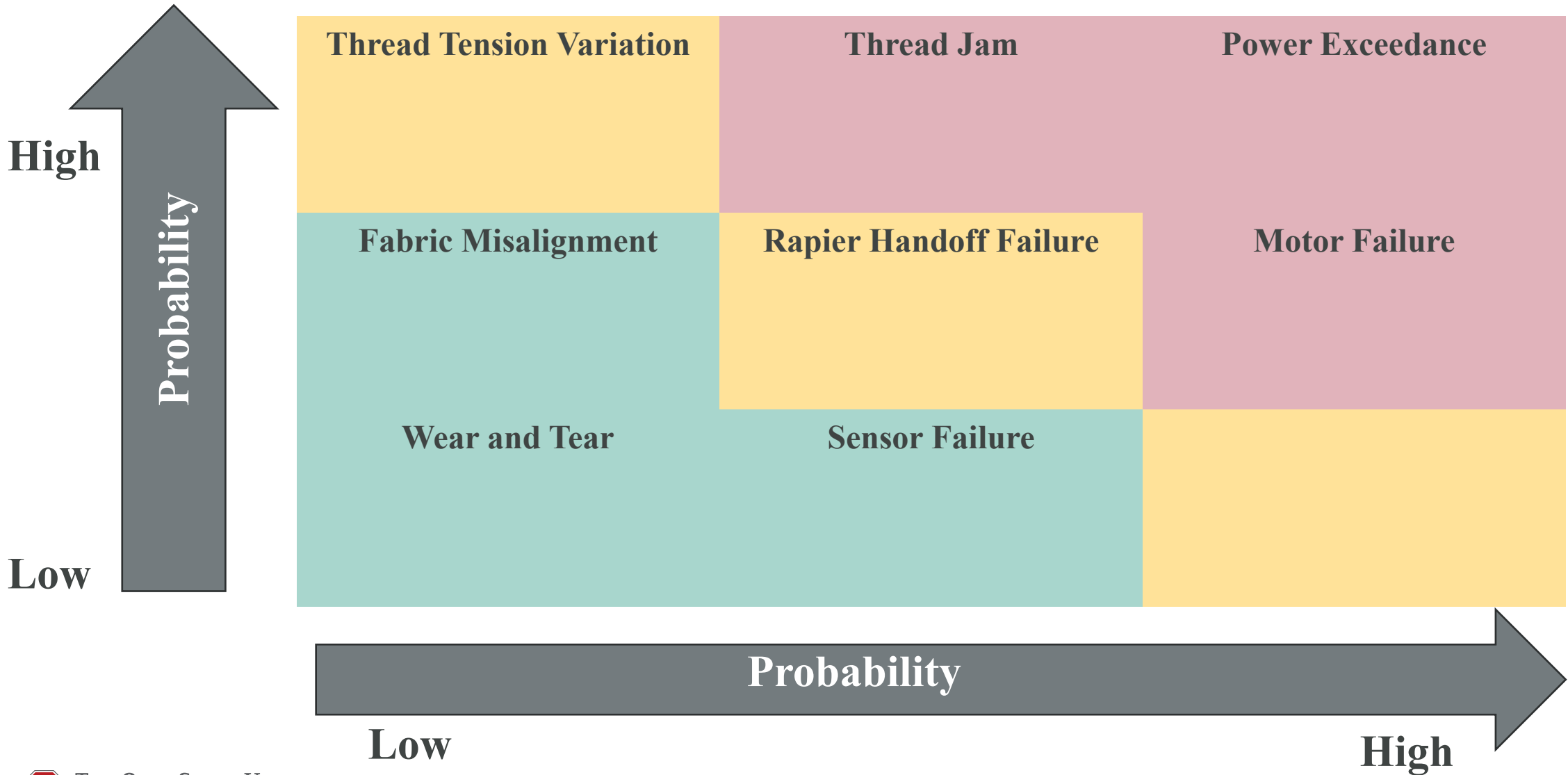
Cargo bag repair

Filters and mesh materials

2.2 Storyboard



3.2 Risks Matrix



3.2 Risk Table (cont.)

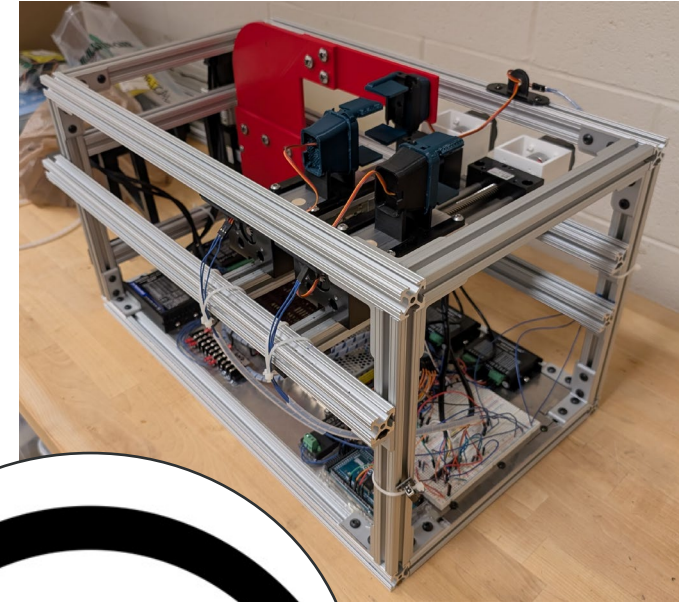
Risk Chance	Risk	Description	Mitigation
Low	Wear and Tear	Components wear over time	Use space-rated bearings and schedule maintenance
Low	Sensor Failure	Sensor provides incorrect readings	Sensor and fault detection
Low	Fabric Misalignment	Fabric not aligned correctly	Guide rollers and alignment sensors
Moderate	Thread Tension Variation	Tension causes poor fabric	Closed-loop tension control
Moderate	Rapier Handoff Failure	Rapier does not transfer thread	Detect failure and retry cycle
Moderate	Thread Jam	Thread jams in mechanism	Auto-stop and reverse motor
High	Motor Failure	Motor stops working	Manual override
High	Power Exceedance	System draws too much power	Keep design under 300W

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3.3 Data Handling and Communications

- System will be wirelessly controlled and run autonomously outside of start, stop, material insertion, and product retrieval
- Communication to device via Wi-Fi using on station server
- Receive data from device based on success and failures with specific fail modes
- For prototype, IR remote and receiver used to imitate wireless control



4.1 Innovative Concepts

Concept	Lesson Learned
Microgravity-adapted double-rapier weaving system	Earth based mechanisms cannot be directly translated to space; core behaviors must be redesigned for microgravity conditions.
Enclosed thread guidance	Unconstrained materials behave unpredictable in microgravity; they require fully guided paths
Modular textile manufacturing subsystem design	Splitting weaving system into separate blocks makes it easier to design and test independently





4.2 Technology Gap Assessment

1. Little research on textile manufacturing in microgravity.
 - More research would improve performance and reliability of system
2. Automated Tension Control in Microgravity
 - Reduce jams and increase fabric quality
3. In-Space Inspection of Fabric
 - Increase reliability of system

4.3 Biggest Challenges

- Flexible materials (like yarn) require tension control in gravity independent environments
- Precise alignment and synchronization are CRITICAL for textile manufacturing
- System requires a compact and efficient design

Idea	Challenge	Mitigation
Thread Control in Microgravity	Loose fibers can float and tangle in the mechanism	Influenced decision to use rapier system. Tension control feedback implementation
Volume Constraint	System had to fit within a small launch volume	Required compact mechanical layout
Traditional Double Rapier Handoff	Requires very precise timing and alignment	Pivoted to new single rapier insertion design

5.2 Paper

- Title: Orbital Weaving System for In-Space Manufacturing (ISAM)
- Abstract Length: approx. 200 words (summary of design concepts, objectives, and feasibility)
- Paper Length – 18 pages (includes design, modeling, prototype, and analysis)
- Key Sections: Introduction/ISAM relevance, design concept/trade study, prototype development and testing, packaging within Bosun's locker, control systems architecture, and analysis of performance
- Potential Publication Venues
 - Aerospace/ISAM-focused journals
 - Conference Submissions (AIAA, NASA-related forums)
 - University or capstone research showcases

2.3 Path to PDR

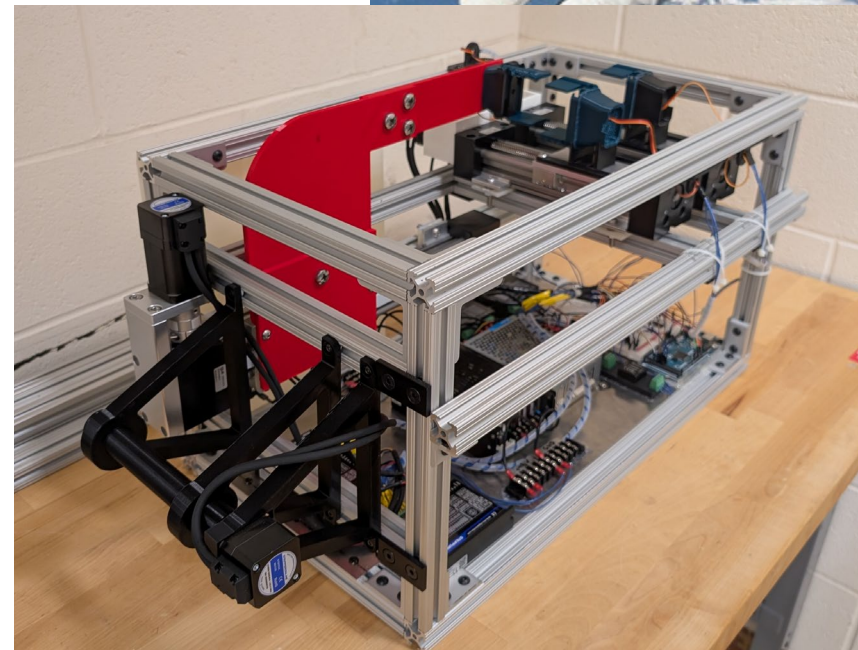
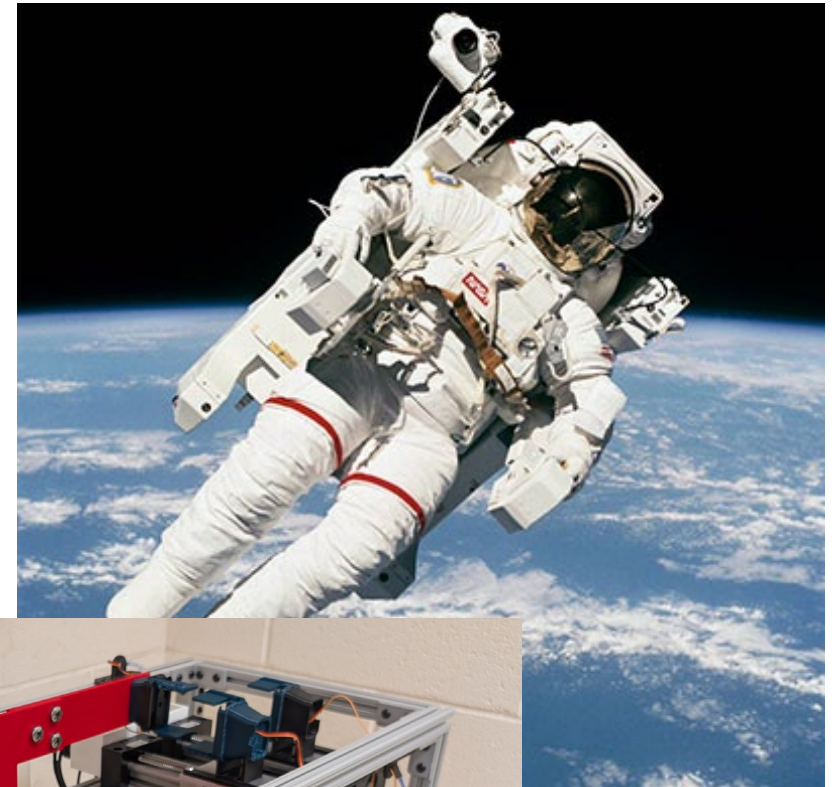
- Integrate rapier insertion mechanism with spool system, tension control and fabric take-up system
- Structural and vibration analysis (from launch)
- Refine rapier mechanism, optimize alignment and synchronization
- NASA safety compliance

2.3 Path to PDR (cont.)

Timeline	Task
0-2 Months	Prototype Refinement (Rapier hand off reliability, and tension control)
2-4 Months	Full System Integration (Add spool system, rollers, and frame)
4-6 Months	Testing and Validation (speed, fabric quality)
6-9 Months	Microgravity Testing (Parabolic flight)
9-12 Months	Finalize design documentation and internal design review

Conclusion

- Enables on-demand textile manufacturing in-space
- Reduces mission mass and coordination burden
- Improves crew safety and mission reliability



Questions