COSMIC

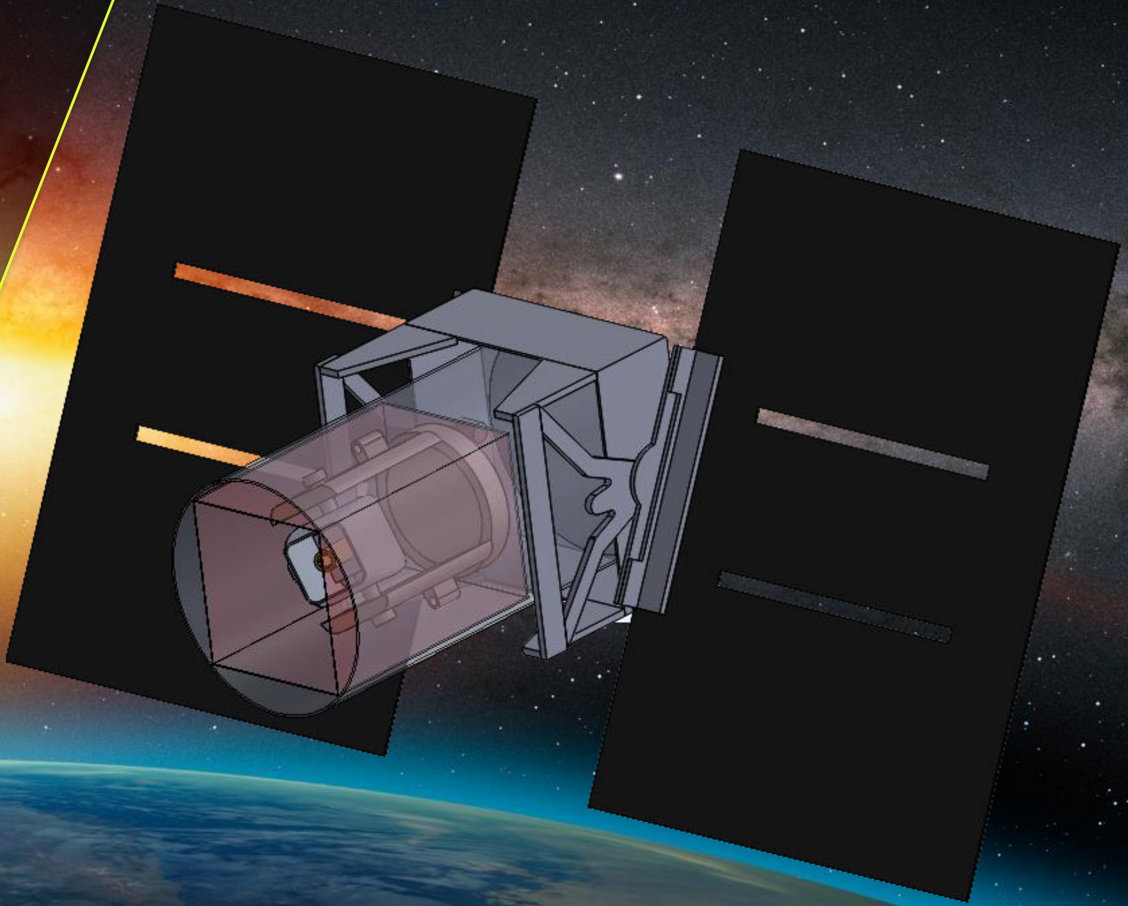
THE POWER OF COLLABORATION

COSMIC Capstone Challenge: Final Briefing

Starforge, Ohio State University
Debris Mitigation Device

Students: Dustin Mosteller, Chip Orban, Shreya Sandurkar, Jainesh Kothari
Advisor: Bob Rhoads, Dr. Lynn Hall
Mentor: Dr. Andrew O'Connor

April 16th, 2025



THE OHIO STATE UNIVERSITY

Team Overview

12 Members, 1 Team

From left to right: Hadley Arch (FABE), Sarah Halstead (BSF), Prachi Patel (AE), Camden Allen (ME), Jainesh Kothari (ECE), Dustin Mostoller (AE), Luke Lagando (BME), Shreya Sandurkar (ECE), Sarah Spatz (HS), Junaid Ashraf (BME), Collin Carrol (AE), Chipper Orban (ID)

Executive Summary

Space Debris Surveyor

- Area of inquiry: using ISAM to handle the growing number of small space debris in LEO
- Starforge is proposing a satellite concept that detects, tracks, and eliminates space debris smaller than 10 cm.
- The team created a technical paper alongside a small prototype that showcases the concept's basic functions.

System Engineering Milestones

Defining Specifications to Guide Design and Ensure Effective Functionality

6th September 2024
- **Identify Project Manager**

12th October 2024
- **Initialized Operation Capabilities**

10th November 2024
- **Defined System Requirements**

13th January 2025
- **Completed Trade Studies**

3rd March 2025
- **Initialized Conceptual Design**

1st April 2025
- **Developed a Path to Preliminary Design Review**

Establishing Clear System Requirements is Crucial for Project Success

Impact

Why does space exploration matter ?

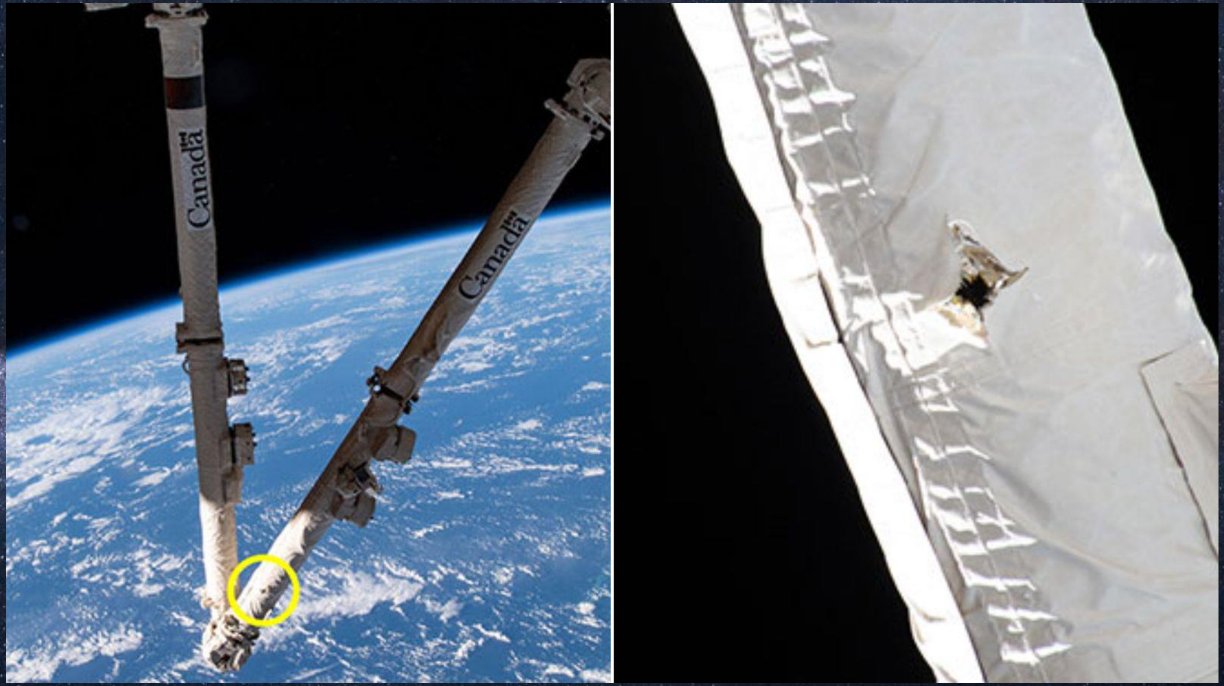
- Scientific discovery
- Climate research
- Defense initiatives
- Expansion of space economy

As of May 2024:

99,000 Active Satellites

670,000 Debris pieces < 10cm

- ISAM can mitigate the risk of debris collision



Source: NASA/Canadian Space Agency, CNN, June 21st 2021

Feasibility

Conceptualizing a solution

- Integration of new data collection tools

Conceptual Model:

- All the features and functions of a market ready product.
- Est. $102,110 in addition to the Venus Class Bus

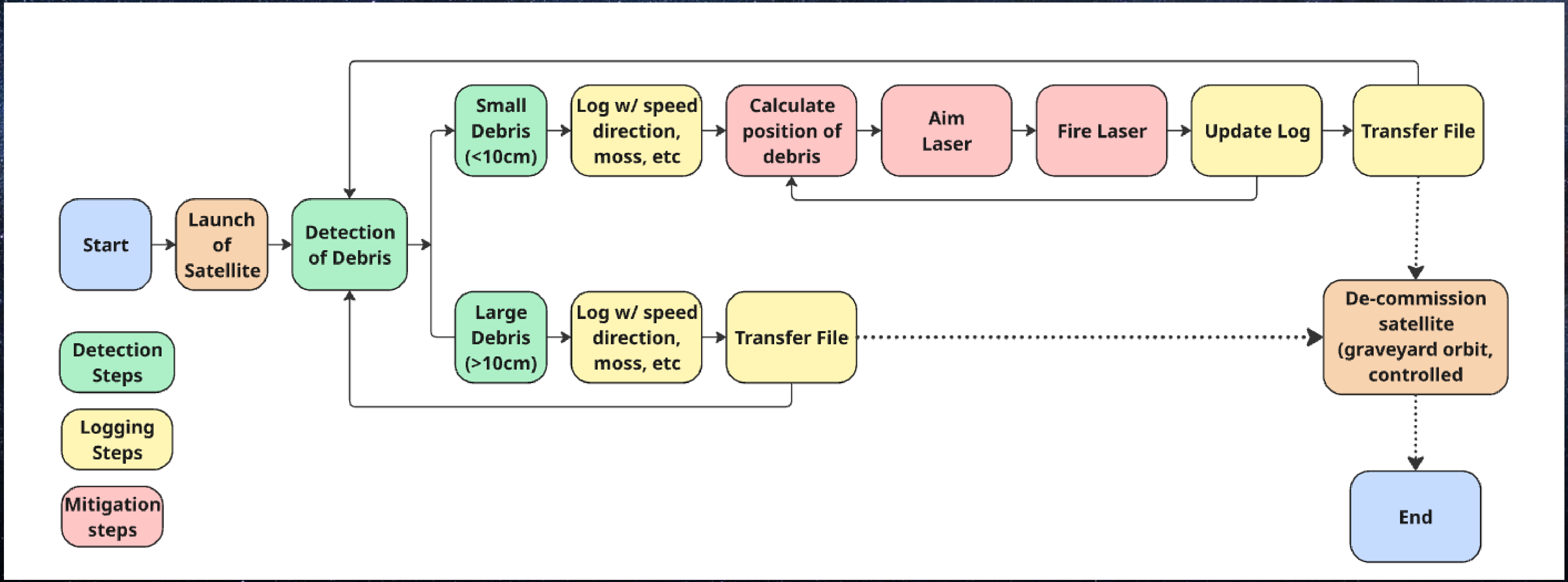
Prototype Model:

- Perform basic functions to validate the concept
- Est. $204.64 to build

Innovation

How can we do things differently?

- On board Light Detection and Ranging (LIDAR) to detect debris during satellite flight path
- Debris path generated based on speed / direction



Required Elements

Project and User needs

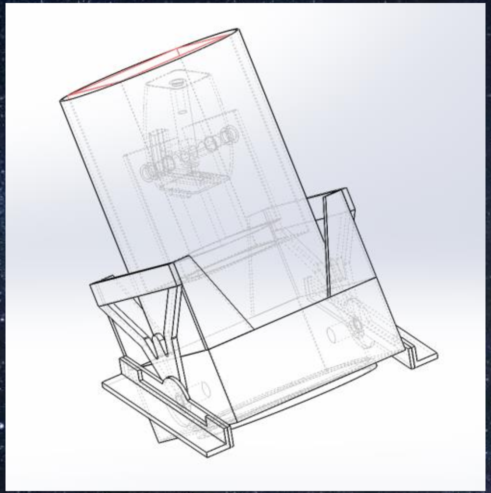
- (semi) Autonomous operations
- Four functions working together
- Payload volume: 17” X 16.4” X 27” payload volume

User Need	Importance	Existing Solution	Gaps in Solution
Autonomous Operation	High	Limited autonomous ISAM systems	Systems are still experimental
In-Orbit Servicing Capabilities	High	Manual and ground-based servicing	High costs, time delays
Modular Design for Scalability	Medium	Limited modular designs	Lack of flexible systems
Minimal Remote Commands	High	Remote-controlled systems	Frequent human intervention needed

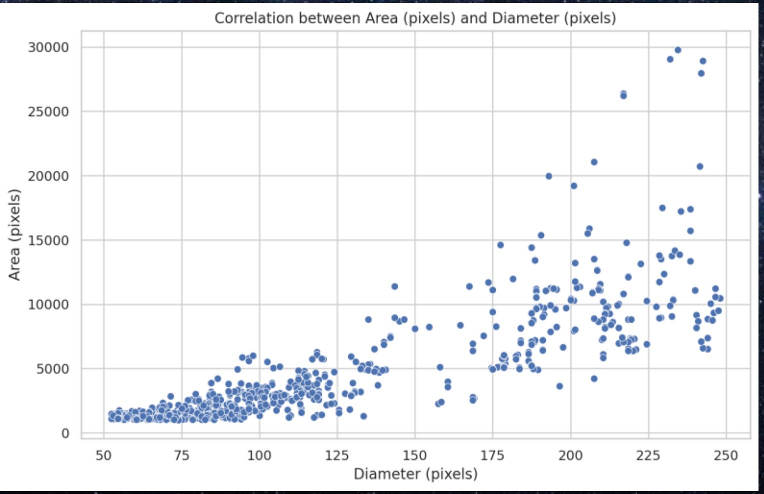
Trade Studies

The team is divided into 3 sub-teams:

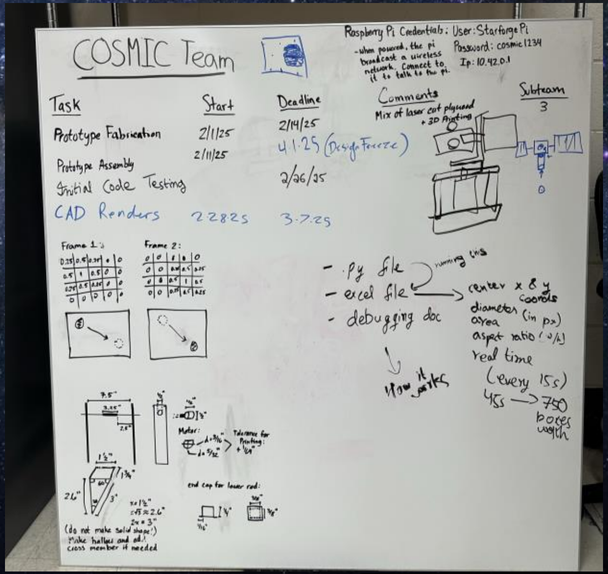
Sub-team 1
-Coding
-Testing
-Data Analysis



Sub-team 3
-Planning
-Documenting
Communications



Sub-team 2
-CAD
-Design
-Prototyping



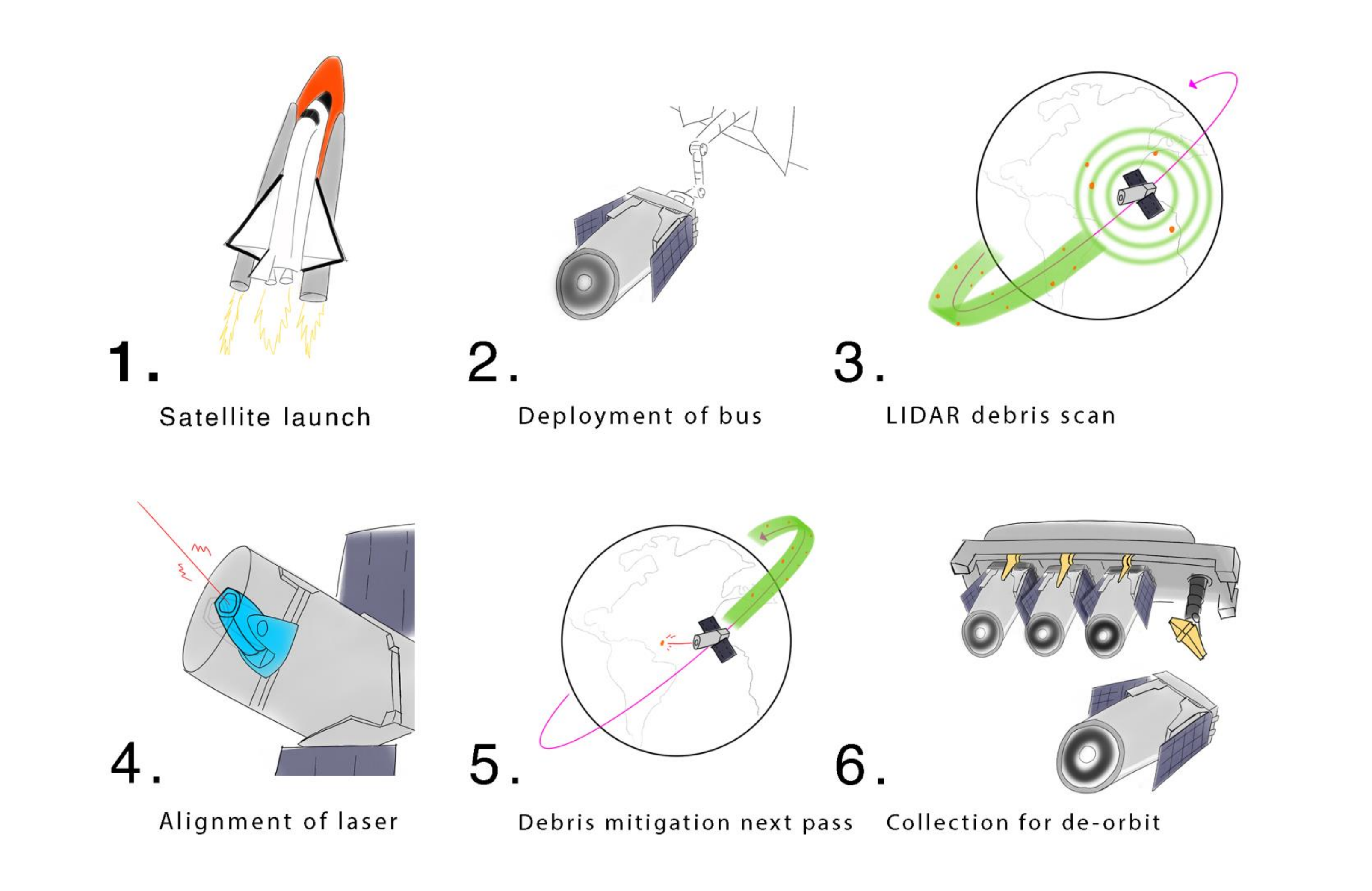
Risks

Risks and Mitigation Plan

- Highlighted critical risks and direct stakeholders with the design steps involved.
- Likelihood or frequency on a scale from 0 to 1 (0 being the least, 1 being the most likely)
- Scaled consequence on a scale from 0 to 10 (0 being the smallest, 10 being the most consequential)

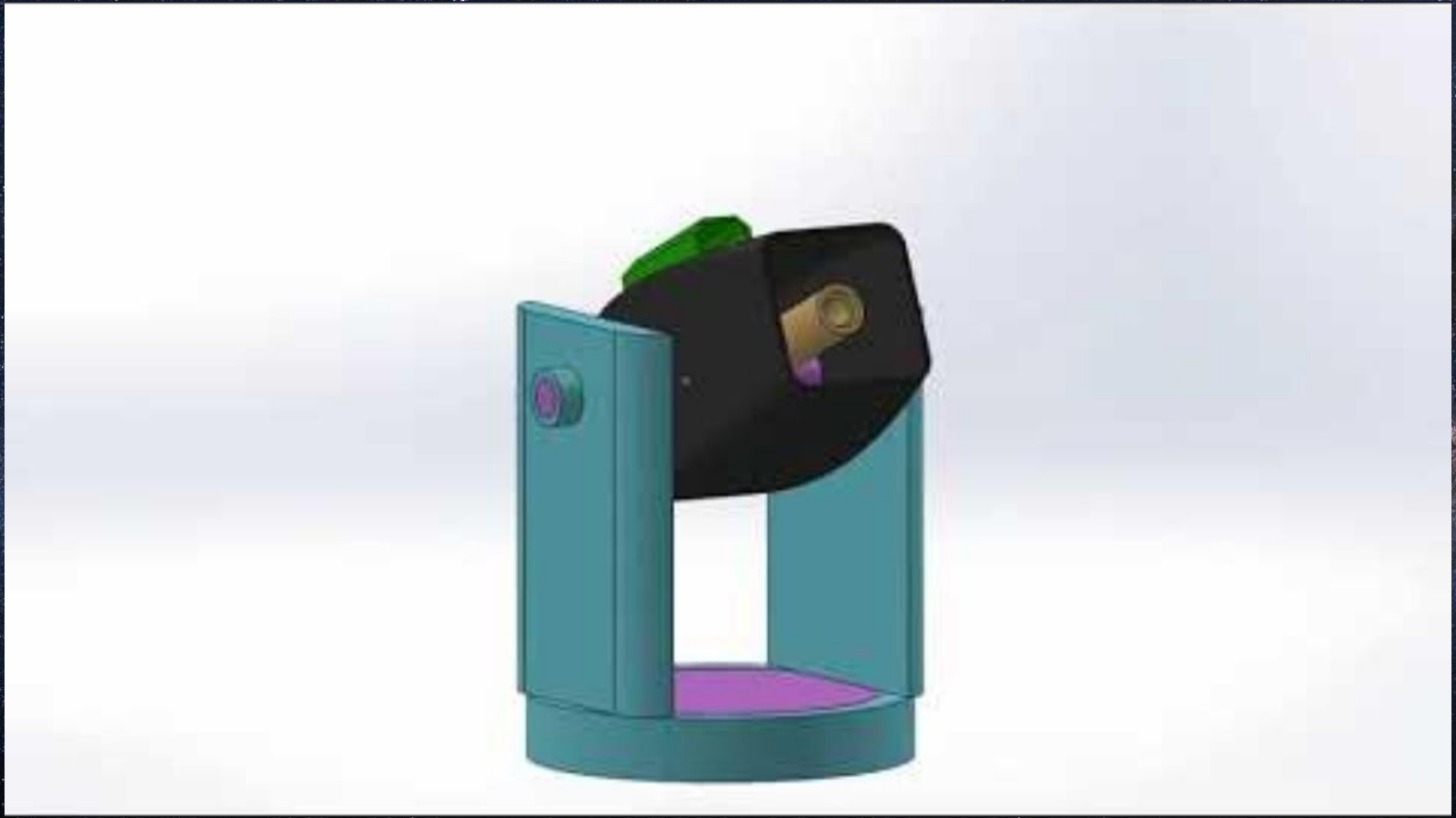
Design Step	Risk Critical Point	Stakeholders	Likelihood	Scaled Consequence
All	Scheduling on a Large Team	• Team Members • Advisors	95%	3
All	Communicating Assignment Status	• Sub Teams • MDC team	50%	6
All stages but specifically in prototyping	Budget Allocation	• Sponsors • MDC team	10%	9
Prototyping Phase	Prototype Quality	• Sub Teams • MDC team • Lab/shop managers	30%	6
Problem Definition Step	Defining User Needs	• Team Members • Sponsors • End Users	70%	8

Concept of Operations



Animation of Key Operating Sequence

Motion graphics and CAD



Data Handling and Communications

- **Real-Time Downlinks:**
  - Enables immediate transmission of collected data to ground stations
  - Critical for timely debris analysis and decision-making
- **Observer Consideration:**
  - Not explicitly required, but beneficial for data validation and anomaly resolution
  - Enhances oversight and operational accuracy in complex scenarios
- **Operator Involvement:**
  - System designed for autonomous operation with minimal human input
  - Optional operator presence recommended for critical tasks or emergencies
- **Data Bitrate Requirements:**
  - Not specifically defined; must support debris characteristics and ephemerides updates
  - Bitrate should align with expected data volume and update frequency

Source: Youngwonk

Most Innovative Concepts Considered

Our three most innovative concepts

1. Using LiDAR on the vessel to determine the position, speed, direction, size, and possibly material makeup of space debris
   – Most debris tracking is currently done from the ground rather than in space

2. Using laser technology to destroy or deorbit small to medium space debris
   – Deorbiting would allow for the small debris to burn up in Earth's atmosphere

3. Remove the need for large battery storage by using solar-pumped lasers or ion beams
   – These would rely on a buildup of solar energy before each firing of the laser

The Ohio State University

COSMIC
CONSORTIUM FOR SPACE MOBILITY AND ISAM CAPABILITIES

Most Important Technology Gaps

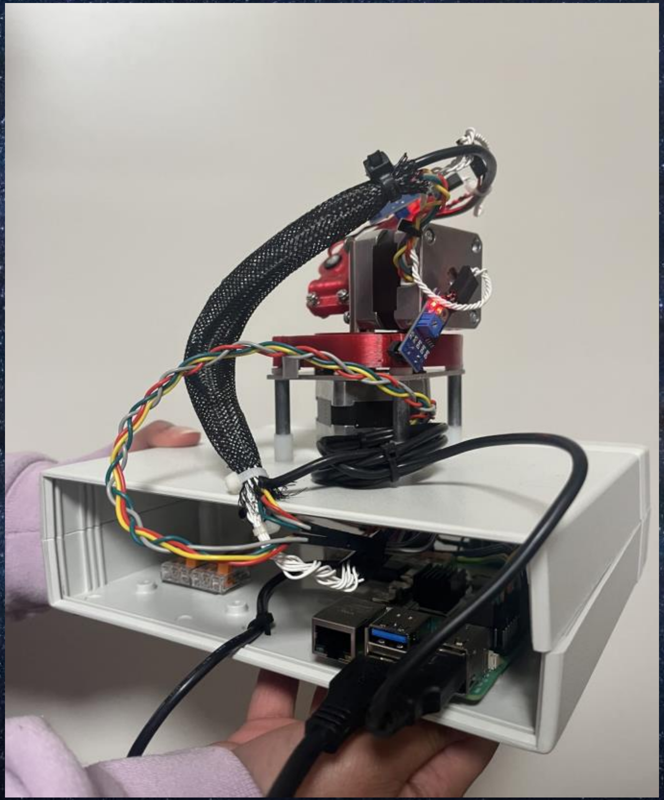
- ***High-Precision Sensing***
  - Current sensors struggle to accurately detect and classify small or fast-moving debris.
- ***Reliable On-Orbit Power***
  - Providing the required energy for a high-power laser in space is challenging due to limited solar availability and battery capacity.
- ***Safe Debris Capture***
  - No proven, small-scale capture system exists for tiny fragments that still pose a collision risk.

THE OHIO STATE UNIVERSITY
COSMIC
CONSORTIUM FOR SPACE MOBILITY AND ISAM CAPABILITIES

Prototype

- The prototype was developed to test the functionality of image detection.

- Results from testing will be used to develop the full scale prototype and identify key risks in the methods.



Biggest Challenges Encountered

Key obstacles and how we addressed them

- **Cost vs. Sensor Quality**
  High-end LiDAR was too expensive and power-hungry.
  → Started with low-cost sensors; deferred LiDAR to later phases.

- **Hardware-Software Integration**
  Calibration issues during data + control software integration.
  → Tested components individually before full system integration.

- **Space Environment Design**
  LEO conditions required more robust materials.
  → Revised design; added shielding and upgraded components.

Strategic compromises and iterative testing helped us overcome technical and environmental challenges in building a space-ready system.

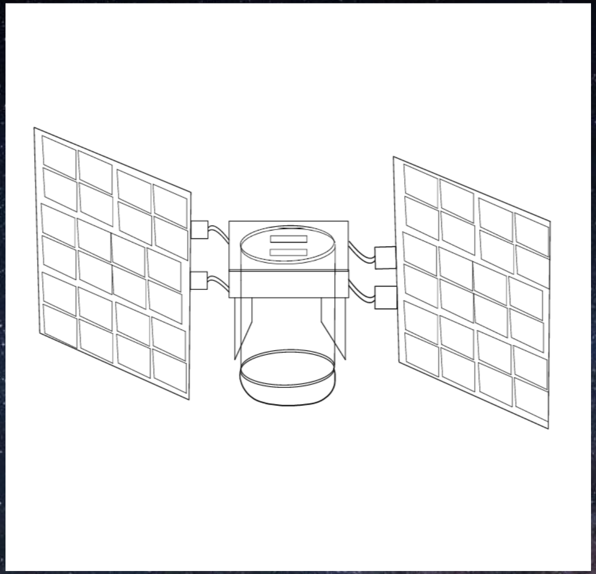
Path to PDR

Recommended steps for project completion

1. ***Refine*** the design and adjust for successful prototype integration

2. ***Test*** the prototype iterations. Make sure the design works as intended when deployed

3. ***Integrate*** with the host vehicle and perform full system testing



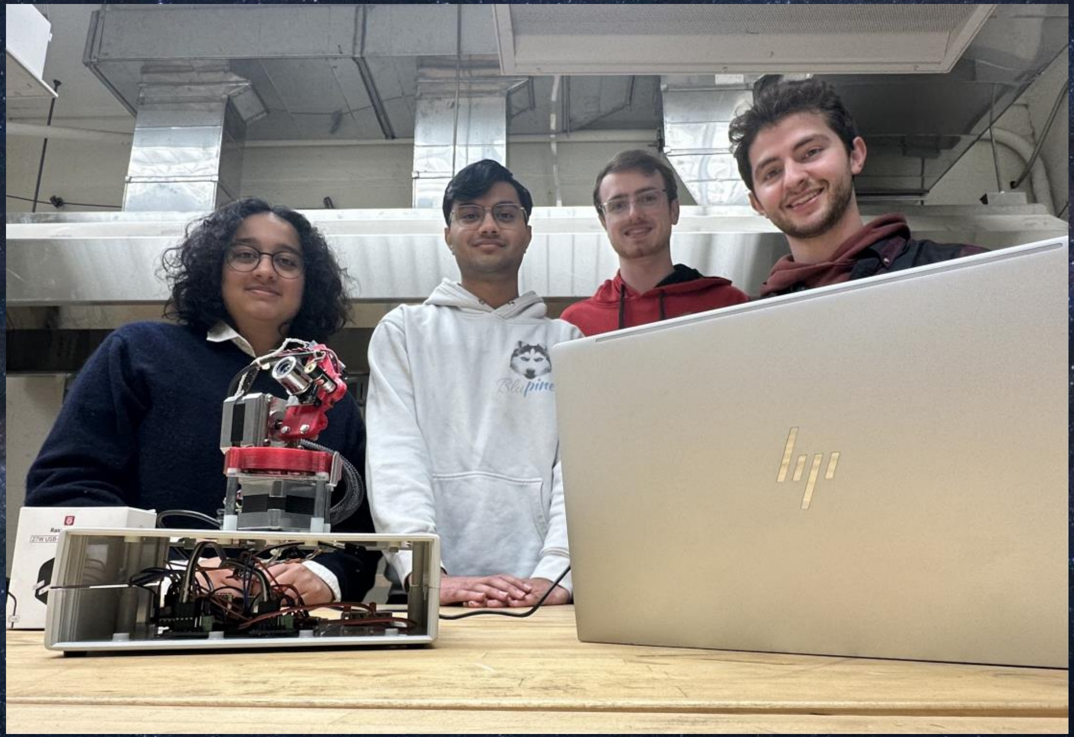
Conclusion and Highlights

Collaborative Solutions for a Safer, Sustainable Space Environment

- Multidisciplinary team effort, communication was key to project development

- Space debris is the most challenging obstacle for the future of the industry

- In-space mitigation technology may be necessary for debris smaller than 10cm



Questions

Questions?

Impact

Stakeholder Map