Free Flyer Grapple System

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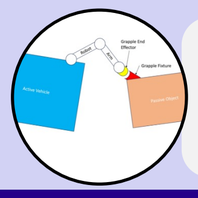
Project Background

Motivation

We can extend the lifespan of decommissioned satellites through ISAM, instead of letting them become space debris.

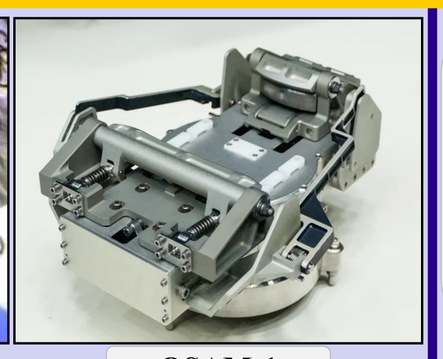
Using grappling systems, ISAM enables repair, refueling, and assembly for extended service life.



Grappling connects two free flying space craft, enabling servicing and re-supplying in-space.

Current Benchmark

Canadarm2

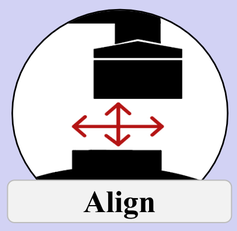


OSAM-1

Current end effectors use human-operated cooperative fixtures like Snares or Marman ring grippers, while newer missions work toward autonomous capture of unprepared targets.

Objective

Design, develop, and demonstrate an autonomous grapple system, hosted aboard the BCT X-Sat Venus Class spacecraft, that can execute a chain of three or more on-orbit operations to support In-space Servicing, Assembly, and Manufacturing (ISAM) activities.



Align

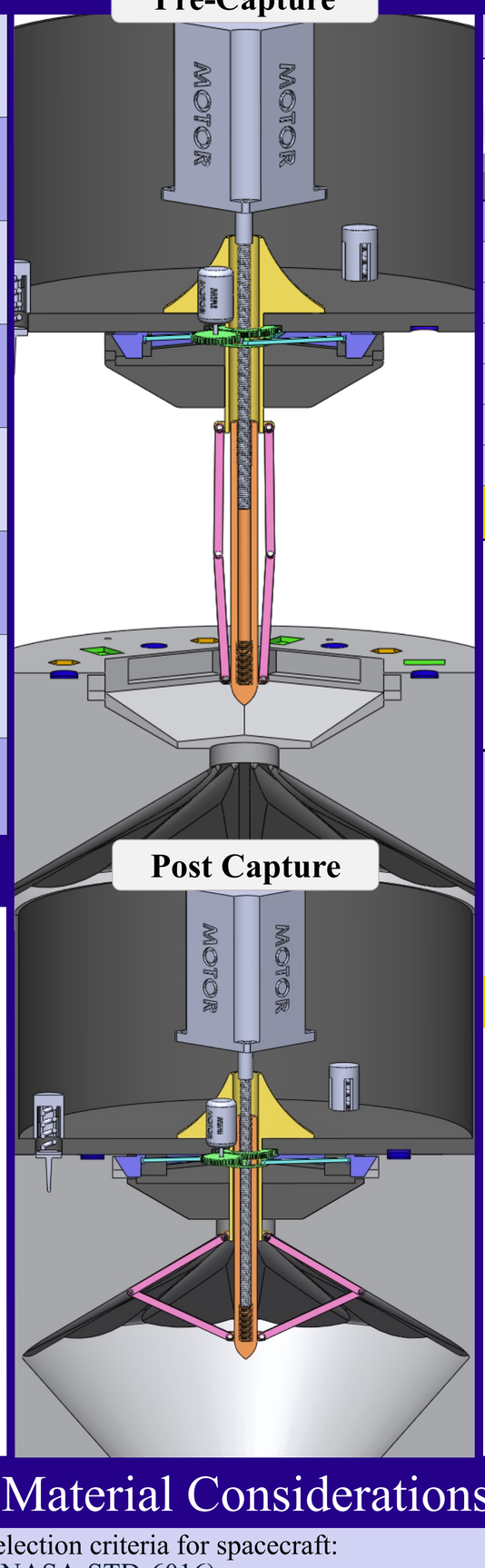
Capture

Release

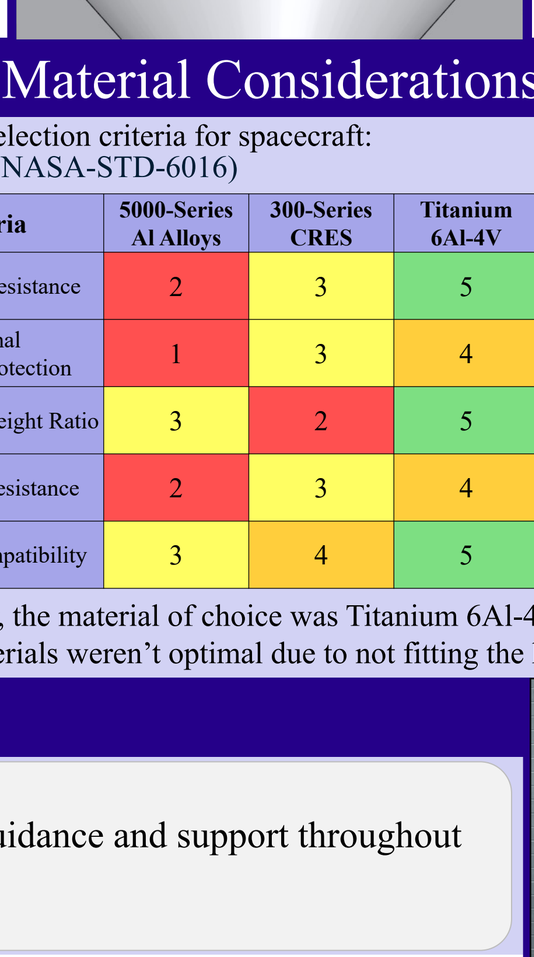
Requirements

Requirement	Objective	Verification Method
Contact to Capture	The grapple system shall have alignment features from initial contact to capture	Design
Attaching	The grapple system shall mate the service vehicle and the client vehicle	Design
Locking Mechanism	The grapple system shall have a locking mechanism after grapple extension	Design
Release	The grapple system shall be capable of releasing after the capture phase	Design and Test
Push-off	The grapple system shall have a push-off mechanism	Design
Fiducial	The interface shall provide a fiducial for identification or tracking	Test
Autonomous	The grapple system shall mate autonomously	Analysis or Design

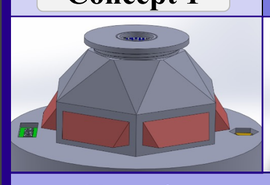
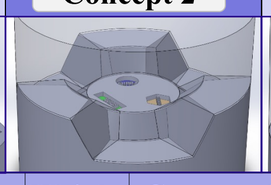
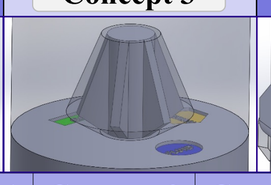
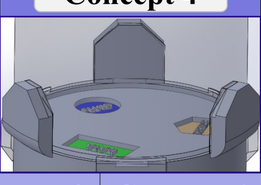
Pre-Capture



Post Capture

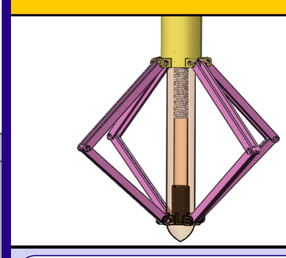


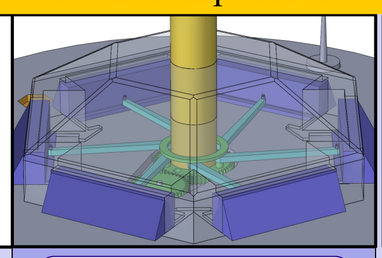
Design

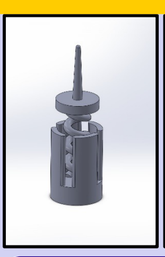
Concept 1	Concept 2	Concept 3	Concept 4
			

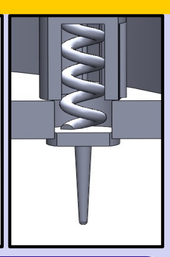
Function	Weight	Concept 1	Concept 2	Concept 3	Concept 4
6D Constraint	15	15	15	7.5	15
Alignment Geometry	10	10	5	7.5	7.5
Capture Envelope	7.5	3.75	0	7.5	5
Complexity	5	3	2.5	0	1.25
Load Capability	12.5	8	12.5	6.25	10
Zero Force Capture	5	2.5	0	2.5	5

Main Components







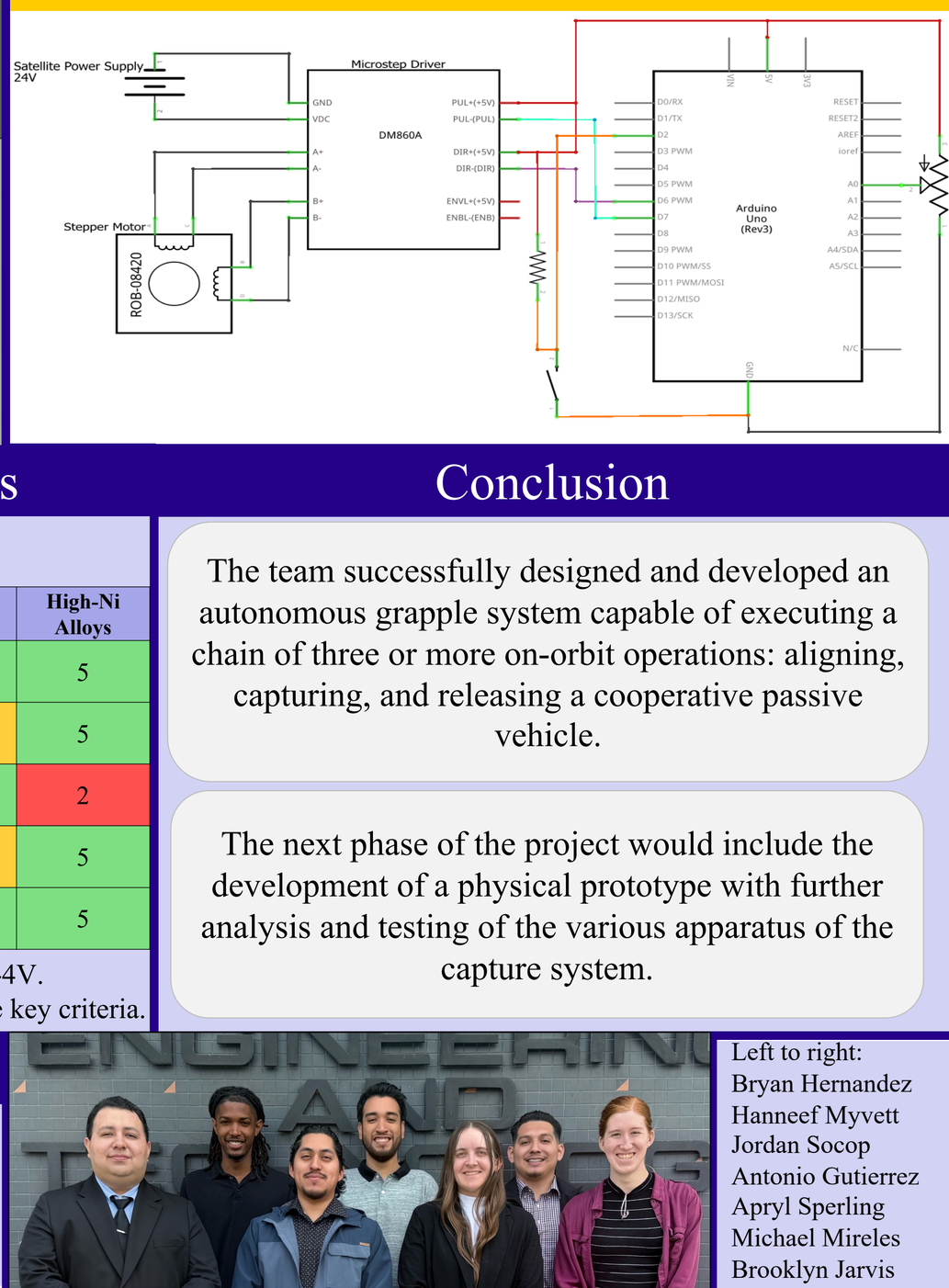


Umbrella System
- Captures passive craft
- Helps align end effectors
- Driven by main motor

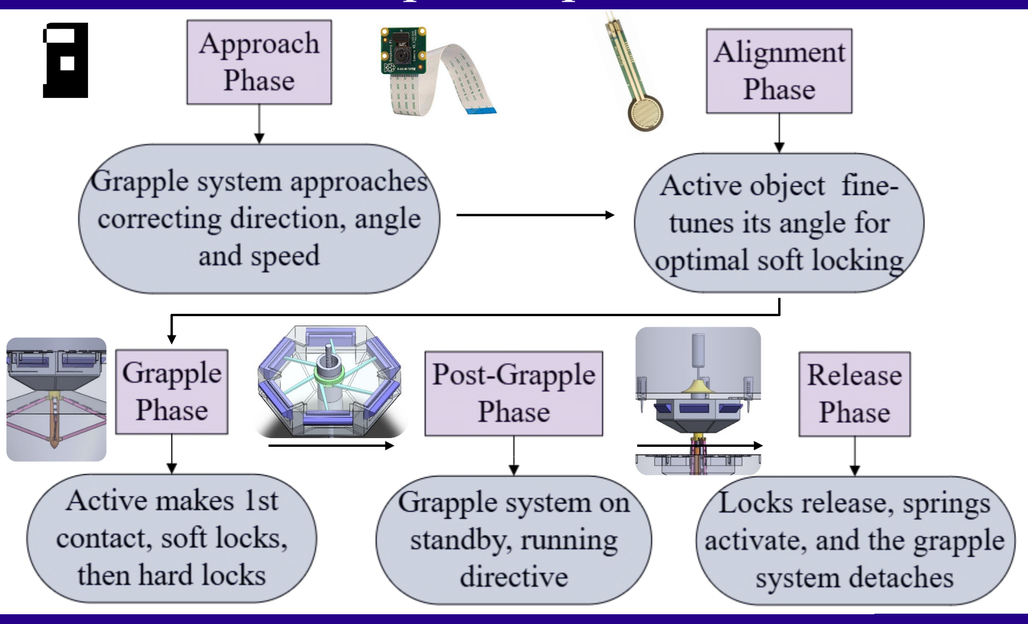
Locking Mechanism
- Completes capture, preventing backing off
- Driven by smaller motor

Release Method
- Encased springs
- Passively loaded upon capture
- Provide push-off force

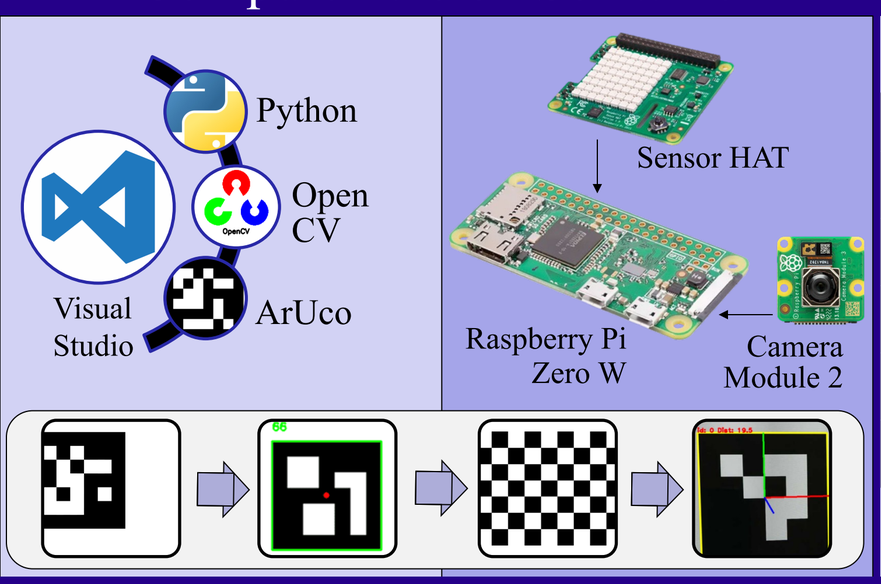
Electrical Schematic



Concept of Operations



Computer Vision Software



Material Considerations

Material selection criteria for spacecraft:
(Based on NASA-STD-6016)

Criteria	5000-Series Al Alloys	300-Series CRES	Titanium 6Al-4V	High-Ni Alloys
Corrosion Resistance	2	3	5	5
Thermal Stability/Protection	1	3	4	5
Strength-to-Weight Ratio	3	2	5	2
Radiation Resistance	2	3	4	5
Vacuum Compatibility	3	4	5	5

Ultimately, the material of choice was Titanium 6Al-4V.
Other materials weren't optimal due to not fitting the key criteria.

Conclusion

The team successfully designed and developed an autonomous grapple system capable of executing a chain of three or more on-orbit operations: aligning, capturing, and releasing a cooperative passive vehicle.

The next phase of the project would include the development of a physical prototype with further analysis and testing of the various apparatus of the capture system.

Acknowledgments

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