

COSMIC Capstone Challenge Final Briefing

Team OSCAR@VT, Virginia Tech: Project OSCAR

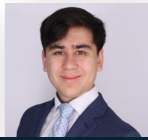
Students: Matthew Bahnsen, Alexander Barnes, Ryan Cruz, Alexandra Croley, Alexander Filip, Dawn Forrest, Elise Gage, Angela Dojcak, Yaman Saran, Emily Slater, Zachary Smith, Pisit Tantisuwanna, Sean Waddell

Advisor: Dr. Kevin Shinpaugh

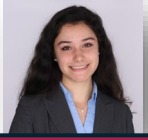
Mentors: Mathis Shinnick, Dr. Randy Spicer

April 16, 2026

Team Organization Chart



Chief Engineer: Sean Waddell



Team Lead: Dawn Forrest



Chief Engineer: Yaman Saran

Command, Communications, & Environment (CCE)

CCDH Lead: Allie Croley

Emily Slater

Power, Thermal & Propulsion (PTP)

PTP Lead: Matthew Bahnsen

Alex Barnes

Pisit Tantisuwanna

Sean Waddell

Yaman Saran

Payload

Payload Lead: Zach Smith

Alex Barnes

Matthew Bahnsen

Alex Filip

Angela Dojcsak

Allie Croley

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Elise Gage

Sean Waddell

Structures & Launch Vehicle (SLV)

SLV Lead: Elise Gage

Allie Croley

Angela Dojcsak

Ryan Cruz

Zach Smith

Yaman Saran

Guidance, Navigation, & Control (GNC)

GNC Lead: Emily Slater

Alex Filip

Yaman Saran

Ryan Cruz

Angela Dojcsak

Faculty Advisor: Dr. Kevin Shinpaugh

COSMIC Team Mentor: Mathis Shinnick

Technical Advisor: Dr. Randy Spicer



1. Executive Summary

- OSCAR impact on ISAM

2. Mission Design

- Operations and Architecture

3. Conclusion

- Lessons, Project Milestones, and Path to Preliminary Design Review (PDR)



Project OSCAR (Orbital Servicing Capture and Repair)

Problem Identified

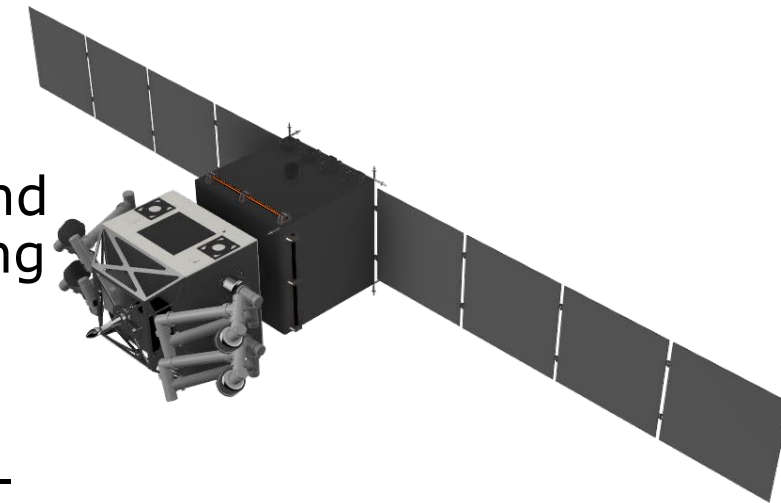
- Components on satellites decay overtime. Sensitive external instruments and batteries have ended multiple scientific missions before fuel depletion

Capability OSCAR Proposes to Solve Problem

- Life extending vehicle that can inspect and replace damaged and deprecated components for high value client satellites to prolong their lifespan and scientific value

Status of Project OSCAR

- Conceptual Mission Design: *Completed* (Tied to COSMIC's high-value missions: 2, 6, 10, 13 [1])
- Majority of trade studies have been completed, presented SRR, high-level component selection and design has been completed
- Higher-fidelity down-selections and testing/analysis are left before advancing to PDR



CAD Model of
OSCAR Spacecraft

The technology and capabilities required to perform component replacement and close-in inspection of high value satellites could provide low-cost revival and extension options for hundreds of existing and future missions

Selected Clients For Demonstration:

- Component Replacement: NOAA-18
 - Battery and transmitter replacement
 - Battery degradation caused EOL, no loss if client damaged
 - Similar missions available: NOAA-15, 19, etc.
- Inspection: Landsat 8 & 9
 - Close proximity to primary client NOAA-18
 - High value targets: ~ \$1B [2]
 - Comparing condition of older hardware

Innovation:

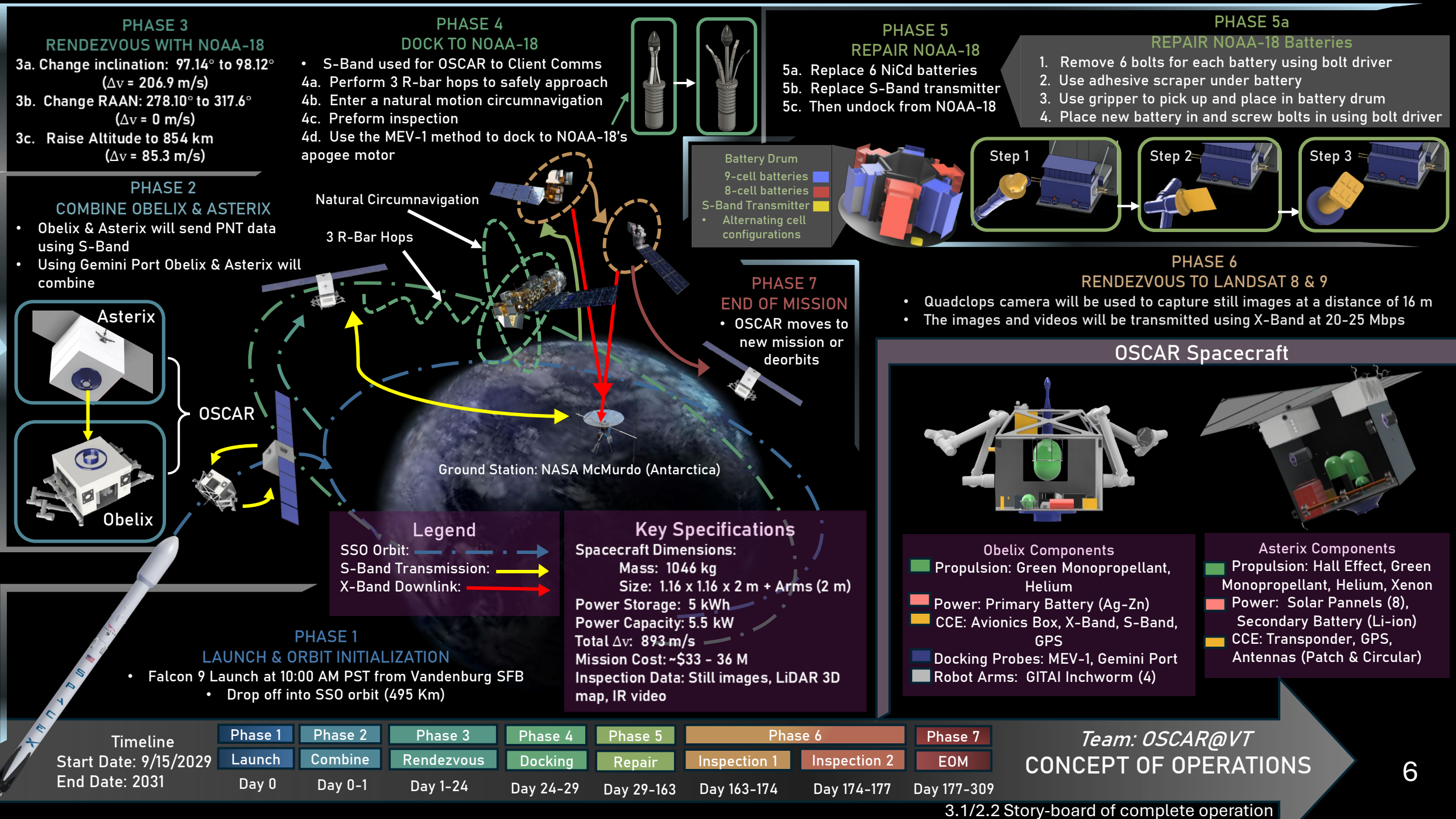
- Autonomous component replacement
- Autonomous rendezvous and docking in orbit

Proof Of Concept Rational:

- Required capabilities for battery replacement applicable for most external components
 - MLI Cutting
 - Wire Handling
 - Component Handling
 - Bolt Removal
- Systems in similar cost range (\$500M – \$1B) ideal for OSCAR missions
 - OSCAR service ~ \$20M for NOAA-18
 - Margin for OSCAR to profit (110% ROI, 52% PM)

Feasibility:

- External components are accessible
- Robotic arms tested and space rated



PHASE 3

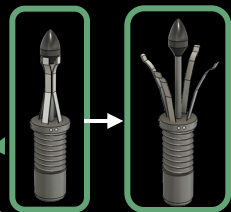
RENDEZVOUS WITH NOAA-18

- 3a. Change inclination: 97.14° to 98.12° ($\Delta v = 206.9$ m/s)
- 3b. Change RAAN: 278.10° to 317.6° ($\Delta v = 0$ m/s)
- 3c. Raise Altitude to 854 km ($\Delta v = 85.3$ m/s)

PHASE 4

DOCK TO NOAA-18

- S-Band used for OSCAR to Client Comms
- 4a. Perform 3 R-bar hops to safely approach
- 4b. Enter a natural motion circumnavigation
- 4c. Perform inspection
- 4d. Use the MEV-1 method to dock to NOAA-18's apogee motor



PHASE 5

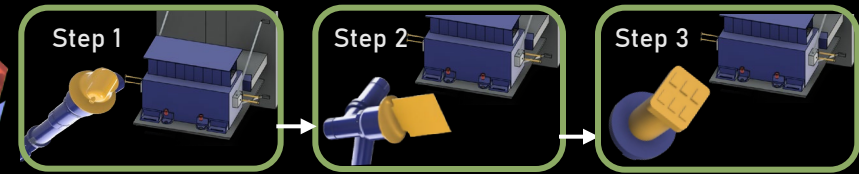
REPAIR NOAA-18

- 5a. Replace 6 NiCd batteries
- 5b. Replace S-Band transmitter
- 5c. Then undock from NOAA-18

PHASE 5a

REPAIR NOAA-18 Batteries

1. Remove 6 bolts for each battery using bolt driver
2. Use adhesive scraper under battery
3. Use gripper to pick up and place in battery drum
4. Place new battery in and screw bolts in using bolt driver



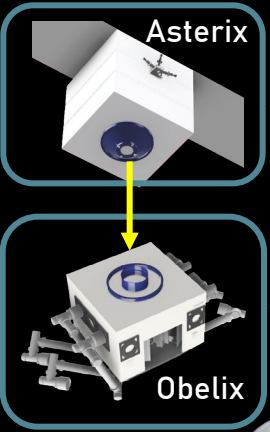
Battery Drum

- 9-cell batteries
- 8-cell batteries
- S-Band Transmitter
- Alternating cell configurations

PHASE 2

COMBINE OBELIX & ASTERIX

- Obelix & Asterix will send PNT data using S-Band
- Using Gemini Port Obelix & Asterix will combine



Natural Circumnavigation

3 R-Bar Hops

PHASE 7

END OF MISSION

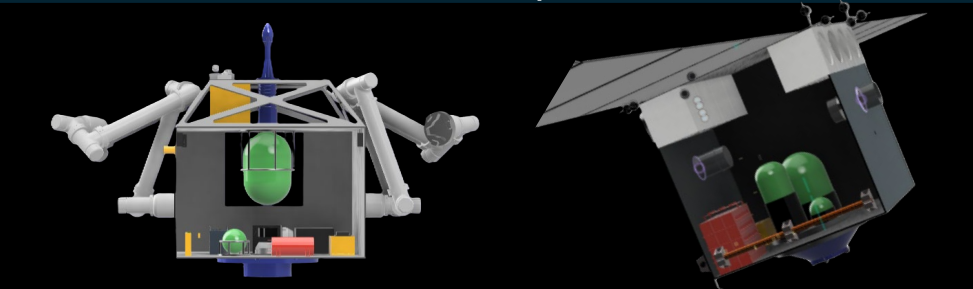
- OSCAR moves to new mission or deorbits

PHASE 6

RENDEZVOUS TO LANDSAT 8 & 9

- Quadclops camera will be used to capture still images at a distance of 16 m
- The images and videos will be transmitted using X-Band at 20-25 Mbps

OSCAR Spacecraft



Obelix Components

- Propulsion: Green Monopropellant, Helium
- Power: Primary Battery (Ag-Zn)
- CCE: Avionics Box, X-Band, S-Band, GPS
- Docking Probes: MEV-1, Gemini Port
- Robot Arms: GITAI Inchworm (4)

Asterix Components

- Propulsion: Hall Effect, Green Monopropellant, Helium, Xenon
- Power: Solar Pannels (8), Secondary Battery (Li-ion)
- CCE: Transponder, GPS, Antennas (Patch & Circular)

Legend

- SSO Orbit:
- S-Band Transmission:
- X-Band Downlink:

Key Specifications

Spacecraft Dimensions:
 Mass: 1046 kg
 Size: 1.16 x 1.16 x 2 m + Arms (2 m)
 Power Storage: 5 kWh
 Power Capacity: 5.5 kW
 Total Δv : 893 m/s
 Mission Cost: ~\$33 - 36 M
 Inspection Data: Still images, LiDAR 3D map, IR video

PHASE 1

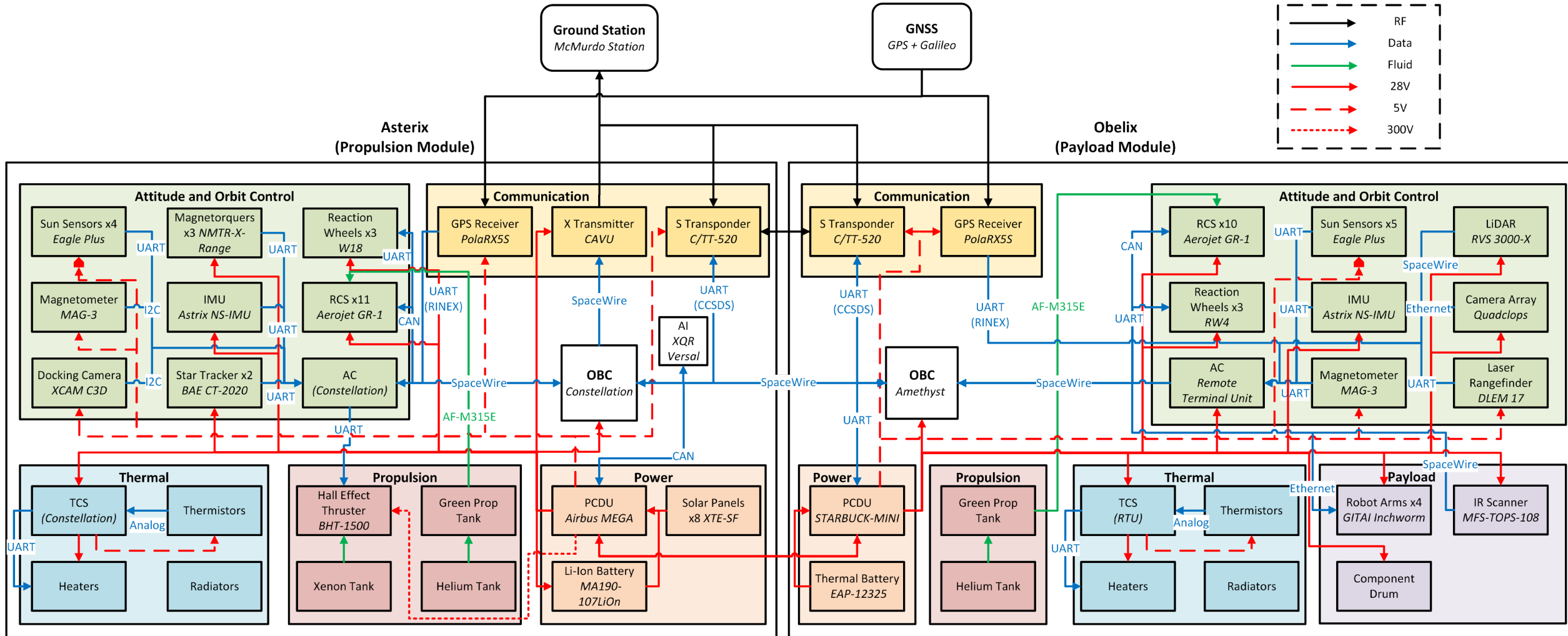
LAUNCH & ORBIT INITIALIZATION

- Falcon 9 Launch at 10:00 AM PST from Vandenberg SFB
- Drop off into SSO orbit (495 Km)

Timeline	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6	Phase 7
Start Date: 9/15/2029	Launch	Combine	Rendezvous	Docking	Repair	Inspection 1	Inspection 2
End Date: 2031	Day 0	Day 0-1	Day 1-24	Day 24-29	Day 29-163	Day 163-174	Day 174-177
						Day 177-309	EOM

Team: OSCAR@VT
CONCEPT OF OPERATIONS

OSCAR Block Diagram



SpaceX Rideshare Program

- Launches on a Falcon 9 on Sept. 15, 2029
- Uses two XL Plates for separate modules, which unify after launch vehicle separation
- Main criteria were cost and reliability, characterized by success rate with smoothing factor

Criteria	Weights
Cost	46%
Reliability	27%
Allowable Mass	16%
Orbital Placement	6%
Available Volume	5%

	Maximize			Minimize		Score
	Mass (kg)	Volume (m ³)	Orbital Placement (T/F)	Reliability (rate)	Price (\$M)	
SpaceX Rideshare [3]	1662	2.25	0	0.94	7.3	0.37
SpaceX Cake Topper	2500	50	0	0.94	25	0.32
ESPAStar-D	960	25536	1	0.83	20	0.31

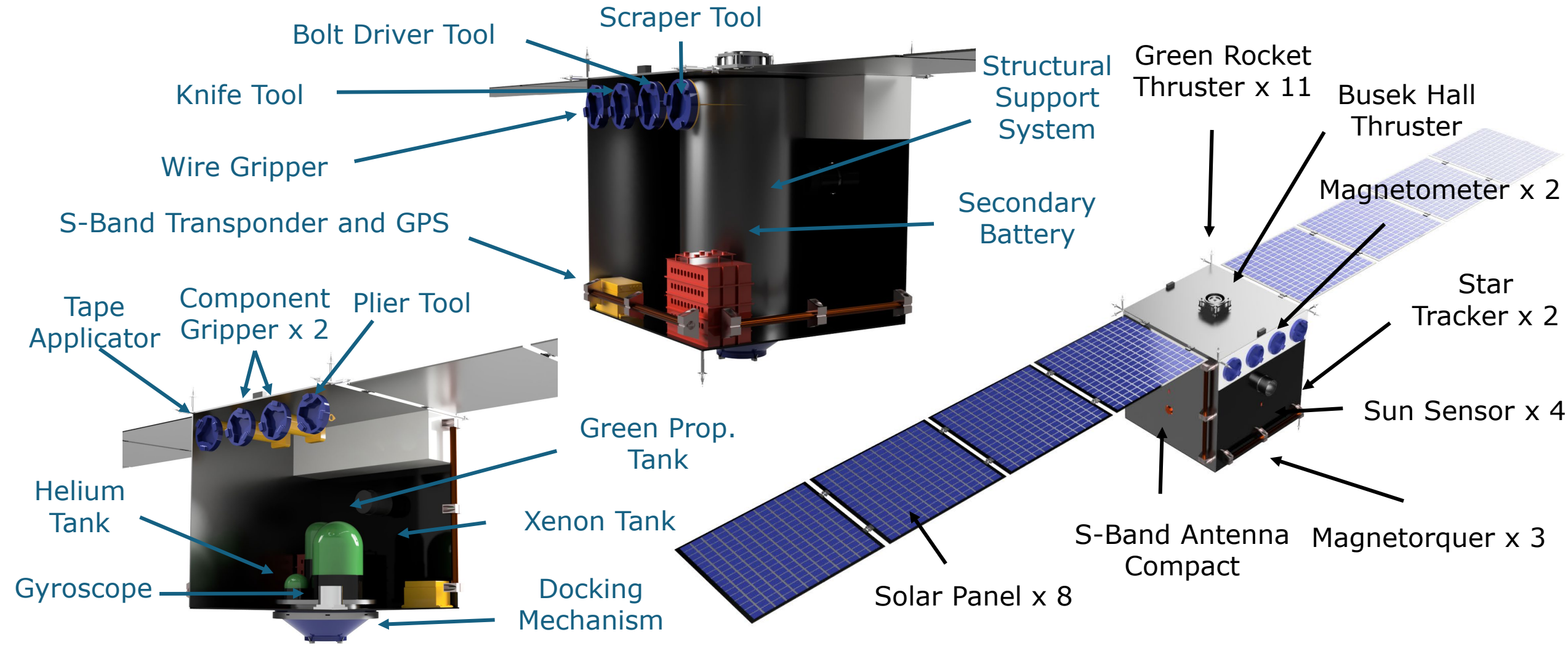
S-1.1 Each module shall be no more than 831 kg individually.

S-1.2 The structure shall mechanically interface with the launch vehicle using a 24" diameter standard mechanical interface.

S-2.1 The structure shall have no elastic natural frequencies below 40 Hz in the launch configuration.

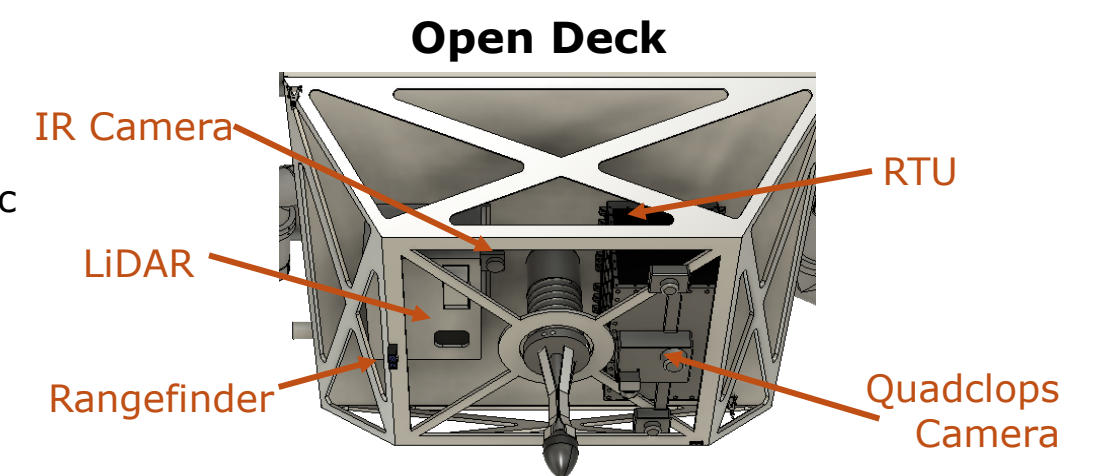
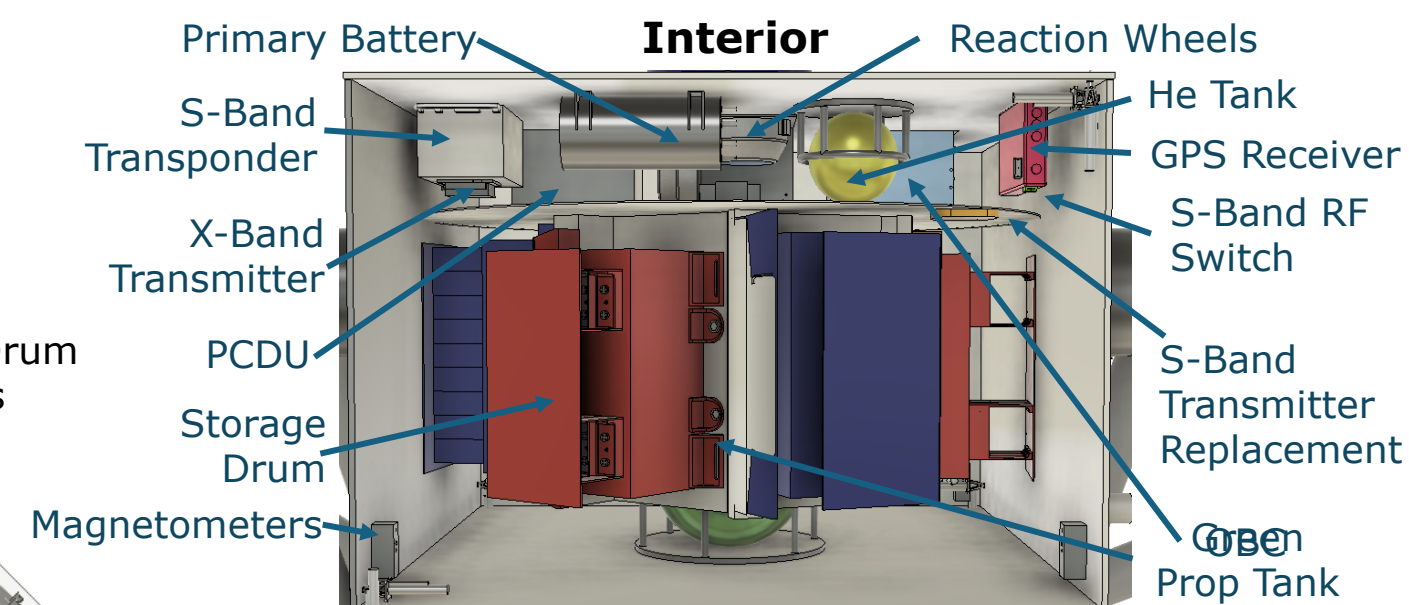
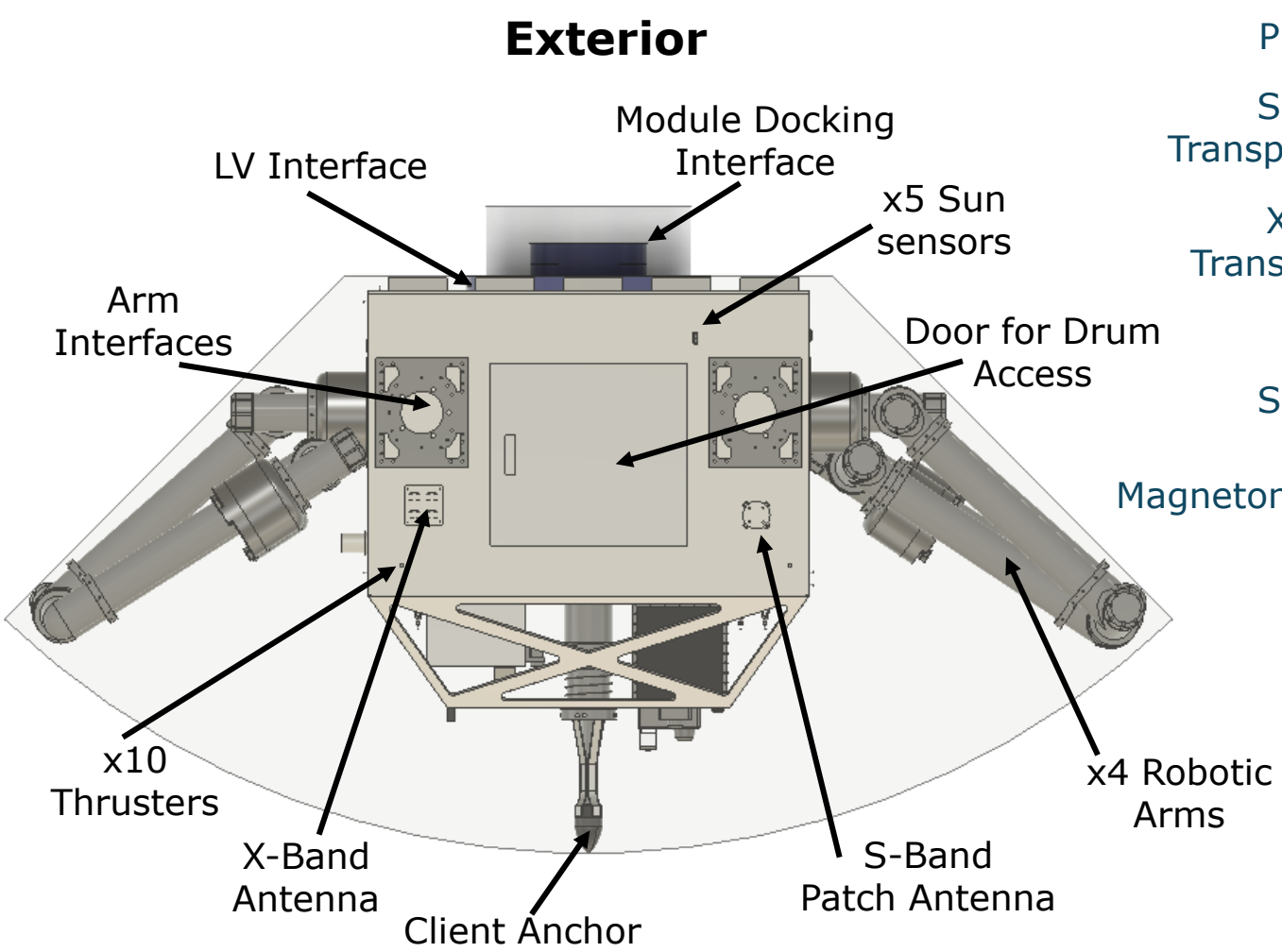
S-2.5 The structure shall conform to the center of mass table provided by the SpaceX Rideshare User's Guide.

Asterix: Propulsion Module



S-1 The structure of the spacecraft shall provide a robust framework that protects and integrates all subsystems for the mission life-cycle.

Obelix: Payload Module



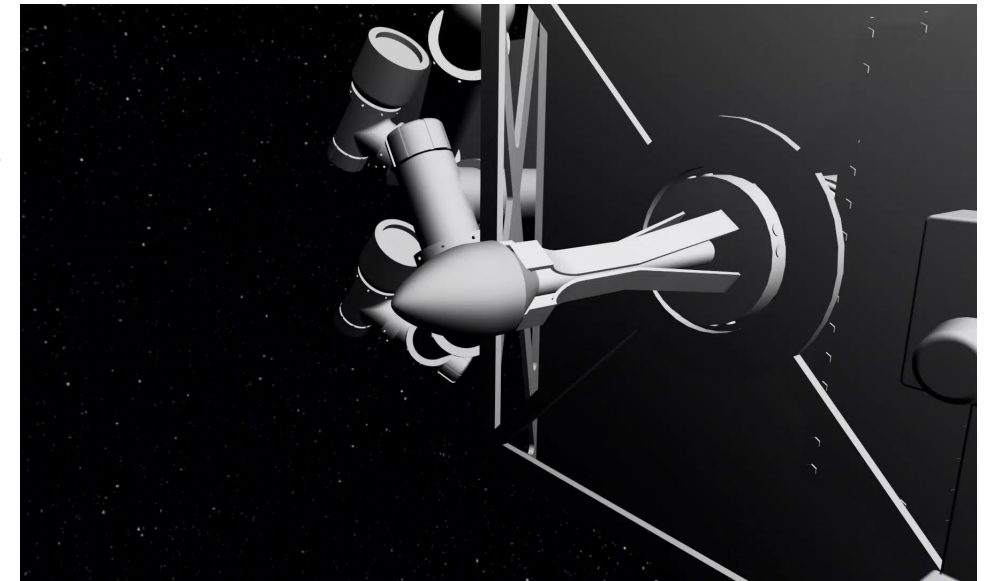
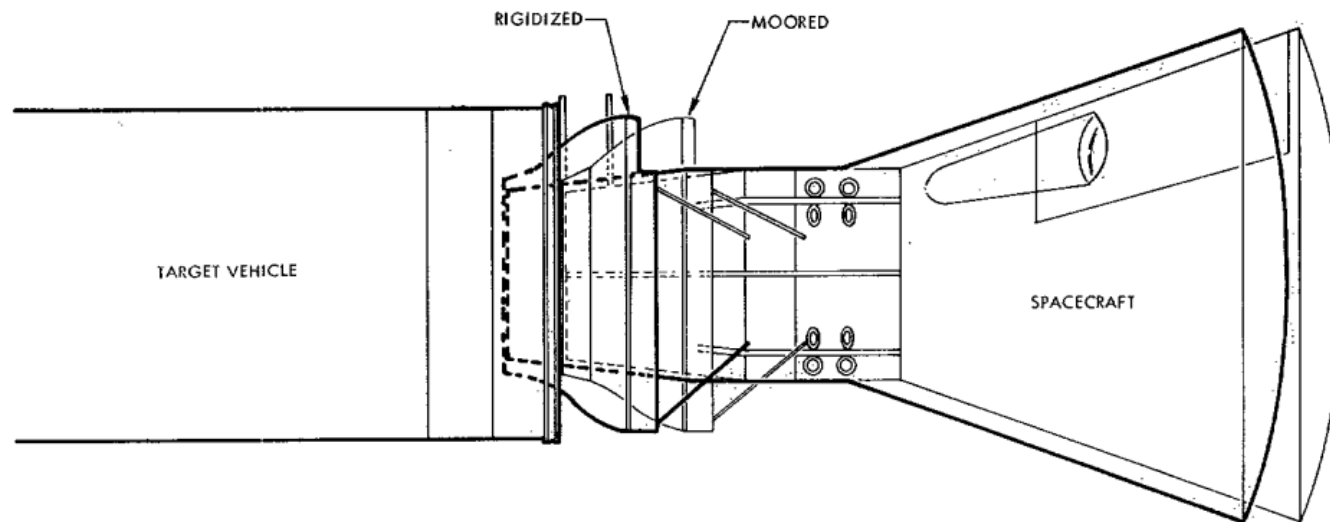
S-1 The structure of the spacecraft shall provide a robust framework that protects and integrates all subsystems for the mission life-cycle.

Permanent Module Dock

- Uses Gemini-Agena style rigid dock
- Power and data connection made via four contact points

Client Anchor Mechanism

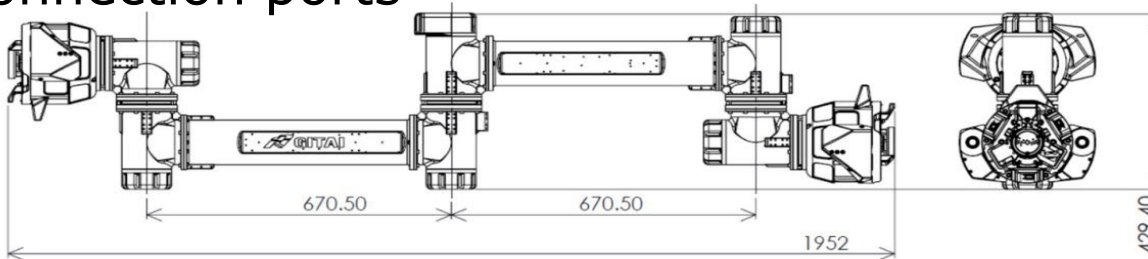
- Anchors to client Apogee Kick Motor nozzle
- LiDAR aligns mechanical probe
- Heritage includes Northrop Grumman's MEV-1 servicing vehicle



S-1.3 The structure shall provide secure, stable, and properly aligned mounting interfaces for all spacecraft equipment.

Robotic Arm

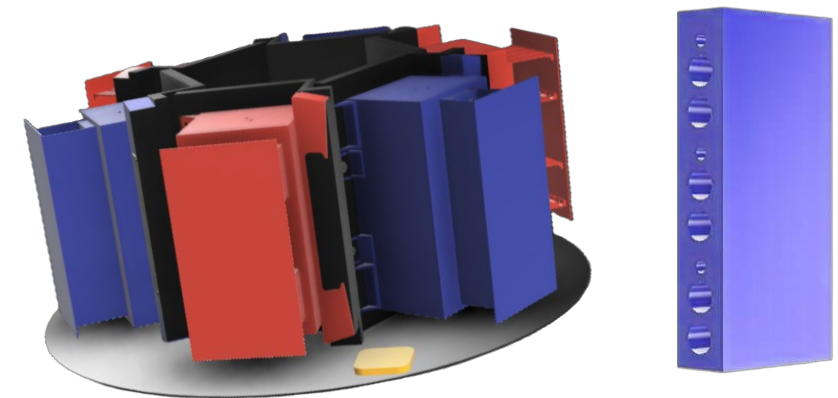
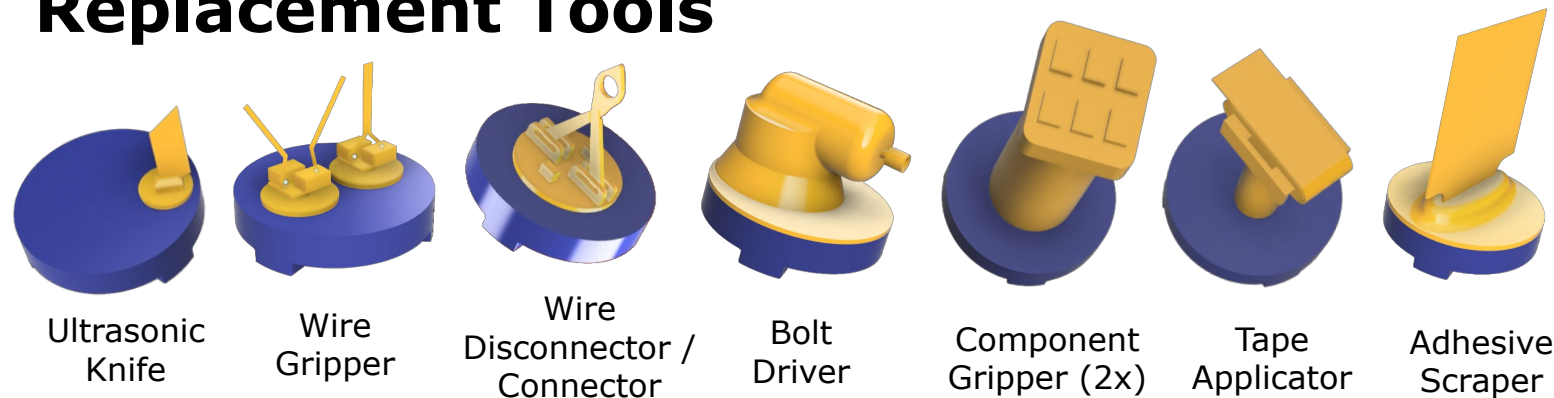
- COTS, space rated, GITAI Inchworm Robotic Arm
- Arm mobility achieved through multiple available connection ports



Component Storage

- Components (such as batteries) are stored in a rotating, thermally insulated internal drum (left)
- Includes threaded holes beneath components for bolt storage (right)
- Holds S-band transmitter replacement (shown in yellow)

Replacement Tools



- PL-1 The system payload shall be capable of accessing and manipulating mechanical and electrical connections between the client satellite and its external components.
- PL-2 The system payload shall be capable of safely storing and transporting replacement components, tools, and dead components that have been removed from the client satellite.

G-1.3 OSCAR shall autonomously correct navigation and control errors using sensor feedback during proximity operations and docking.

G-1.1 OSCAR shall estimate relative position, velocity, and relative attitude with respect to the client spacecraft using sensors to autonomously support rendezvous, proximity operations, and docking.

G-1.1.1 OSCAR shall maintain an attitude accuracy of 0.1 deg, 3 sigma, in any direction.

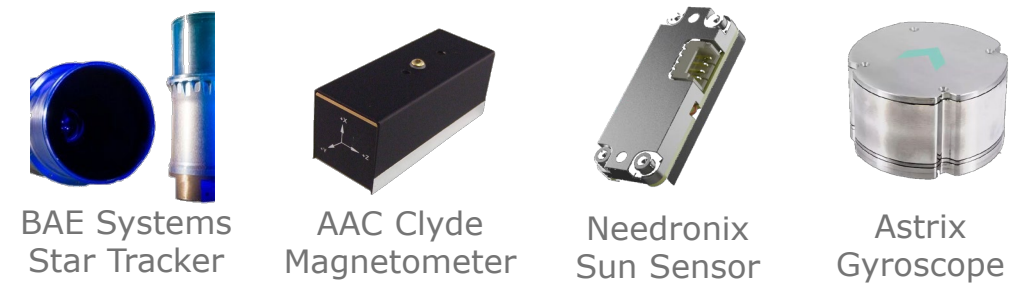
Navigation Sensor and Location	Brand and Type	Momentum ($N \cdot m \cdot s$)
3 Reaction Wheels on Obelix	Blue Canyon RW4	4
3 Reaction Wheels on Asterix	Bradford W18	18
Navigation Sensor and Location	Brand and Type	Moment ($Am^2 B$)
3 Magnetorquers on Asterix	Taurus NMTR-X-Range	55

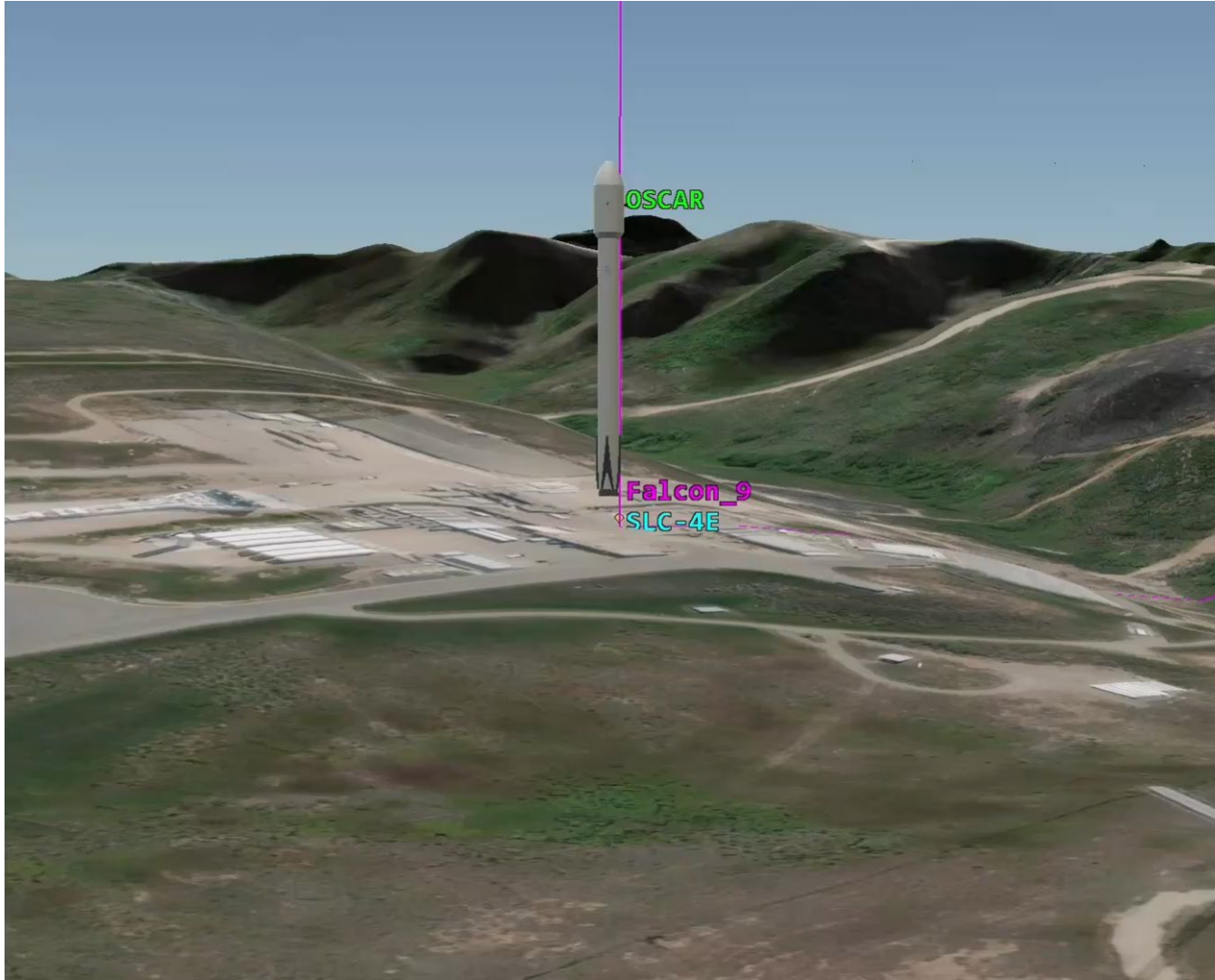


ADACS Sensor and Location	Brand and Type	Accuracy	Dimensions (mm)
2 Star Trackers on Asterix	BAE Systems CT-2020	1" twist accuracy 1.5" cross accuracy	147 diameter x 305 tall
4 Sun Sensors on Asterix and 5 on Obelix	Needronix Eagle Plus	$< \pm 0.1^\circ$	29.5 x 11.5 x 6.5
2 Magnetometers on Asterix and Obelix	AAC Clyde Space MAG-3	$\pm 65 \mu T$	35.1 x 32.3 x 82.6
1 Gyroscope on Asterix and 1 on Obelix	Astrix NS-IMU	$< 0.005^\circ/h$ Bias $0.0025^\circ/\sqrt{h}$ ARW	130 x 130 x 117

- On Board Computers:**
- Asterix: Constellation OBC**
 - 3600 DIMPS
 - Obelix: Amethyst OBC**
 - 215 DIMPS
 - Obelix: Remote Terminal Unit**
 - Interface between OBC and all subsystems

- PCDU:**
- Asterix: Airbus Mega**
 - 5,28,75 V lines with 4 kW peak
 - Obelix: Starbuck Mini**
 - 5,28 V lines with 1.5 kW peak





Mission Overview

- $\Delta i = 0.98^\circ$ and coast until RAAN aligns with NOAA-18. Increase altitude by 360 km to match NOAA-18 for inspection and servicing
- Enter natural motion circumnavigation for inspection
- Radial Bar approach at 3.6 cm/s to dock with NOAA-18
- After servicing increase altitude by 200 km to change RAAN and inspect Landsat 8
- Adjust altitude by 50 km to align RAAN and inspect Landsat 9
- Far out inspections are performed on all client satellites to ensure safety before close inspections

G-1.2 OSCAR shall use predefined approach corridors during proximity operations to ensure safe relative motion with the client spacecraft.

PM-1 Mission will be ready to launch at the end of the decade.



Propulsion

Constraints: • Min $\Delta v \sim 891$ m/s • Min Rendezvous Thrust ~ 29 mN • Min Prox-Ops Thrust ~ 2 N

Component Type	Component Chosen	Performance	Output	Mass	Power	Source
Hall Effect Thruster	Busek BHT-1500 (Xe)	1865 s	0.179 N	6.6 kg	2700 W	[4]
RCS Thruster	Aerojet Rocketdyne GR-1 (AF-M315E)	235 s 8 mN-s	1.1 N	0.33 kg	22 W	[5]
Xenon Tank	96 L Capsule COPV Tank & Xenon	---	---	114 kg	---	[6]
AF-M315E Tank	2 x 25 L Capsule COPV Tank & AF-M315E	---	---	35.5 kg	---	[6]
Helium Tank	2 x 3 L Spherical COPV Tank & Helium	---	---	1.3 kg	---	[6]

Power

Constraints: • Power Requirement ~ 3450 W • Max Transient Mode (Maneuvering) ~ 2905 W

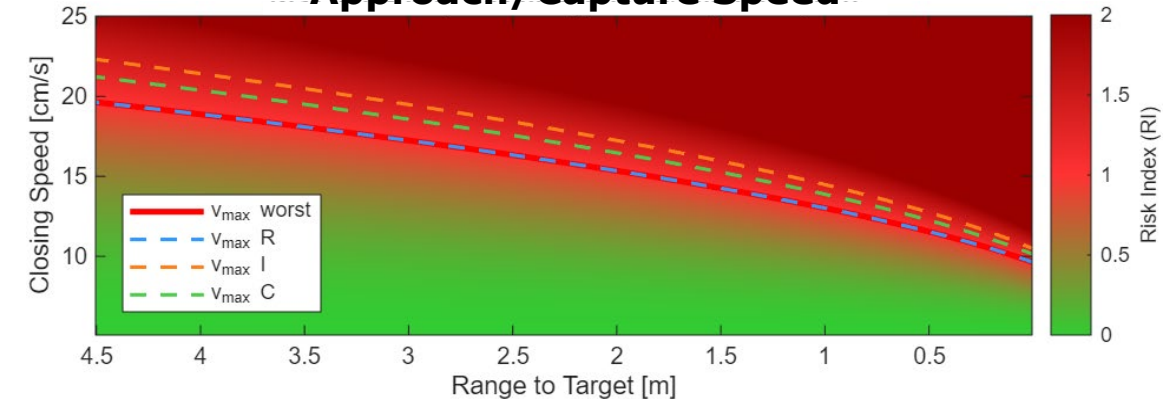
Component Type	Component Chosen	Performance	Output	Mass	Footprint	Source
Primary Battery	Eagle Picher EAP-12325 Ag-Zn	353 Wh	920 W	5.6 kg	45 in ³ (737 cm ³)	[7]
Secondary Battery	GS Yuasa MA190-107 LiOn	5001 Wh	2950 W	37 kg	1850 in ³ (30316 cm ³)	[8]
Solar Panel	Spectrolab XTE-SF (8.25 m ²)	435 W/m ²	3590 W	1.76 kg/m ²	22 mm	[9]

Prox-ops Risks

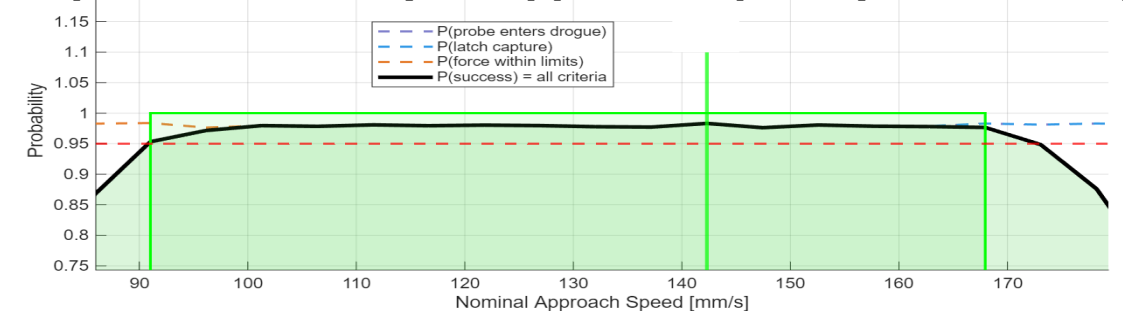
- **Inspection position uncertainty:** Our ability to realize the impact trajectory
- **Thruster response time:** Our ability to change the impact trajectory in time during close inspection

Docking failure: Monte Carlo simulation using reaction control and impact threshold parameters to derive unification approach/capture speed of 14.2 cm/s and client dock capture speed of 5 cm/s

Risk Index Map: Non-Cooperative Client Approach/Capture Speed



Capture Probability vs Approach Speed (Monte Carlo)

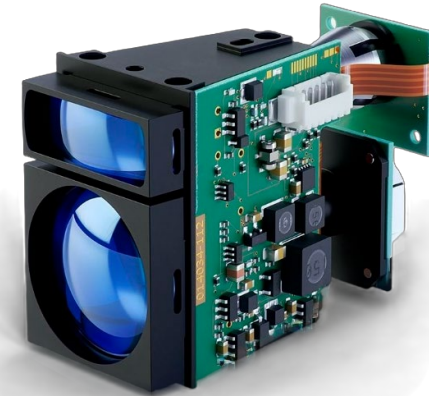


Risk Sigma (Inspection)	Radial (m)	Along Track (m)	Cross Track (m)
5- σ ($6 \times 10^{-5}\%$)	16	16	15
3- σ (0.25%)	9	9	8
2- σ (4.5%)	6	6	6
1- σ (31%)	3	3	3

- Instruments selection driven by the 16 m distance dictated by 5- σ risk and requirement for space rated components



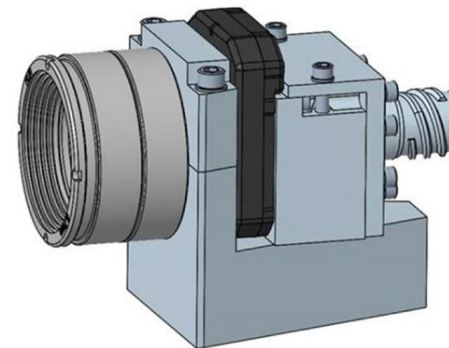
- Visual Inspection (Quadclops)
 - Still images of the client from multiple angles



- Laser Range Finding (DLEM 17)
 - Allows maintainable safe distance during inspection



- LiDAR Inspection (RVS 3000-X)
 - LiDAR 3D map of client



- Thermal Imaging (Boson 640)
 - IR video of client satellite

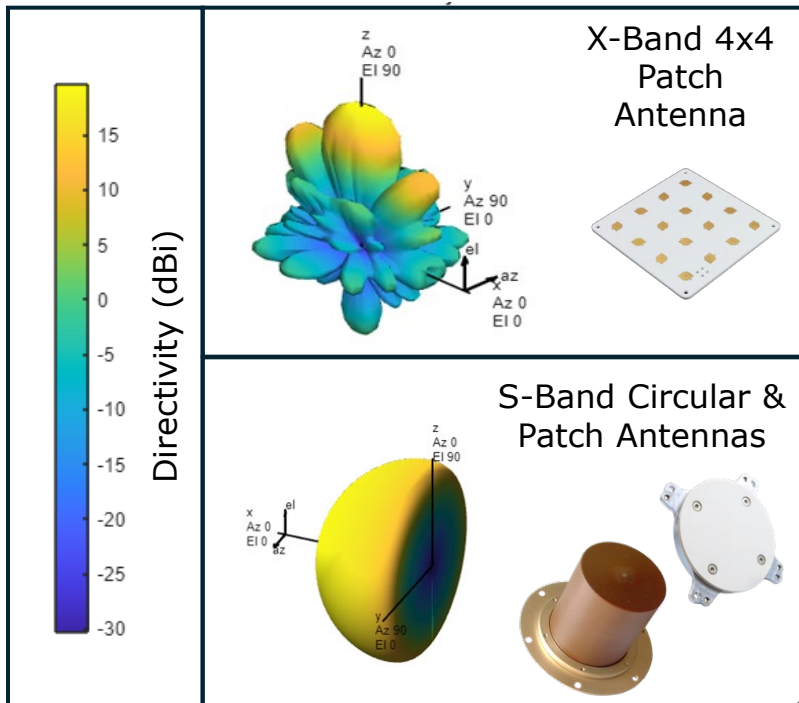
PL-3 The system must be capable of providing visual inspection and diagnostics of the client satellite from a safe and consistent range.



Communication System:

- S-Band:** Transponder (≤ 2290 MHz)
 - OSCAR \leftrightarrow Client
 - OSCAR \leftrightarrow Ground Station
- X-Band:** Transmitter (8025-8400 MHz)
 - OSCAR Inspection Data \rightarrow Ground Station
- GPS:** Position, Navigation, & Timing Data
 - Ground Station \rightarrow OSCAR

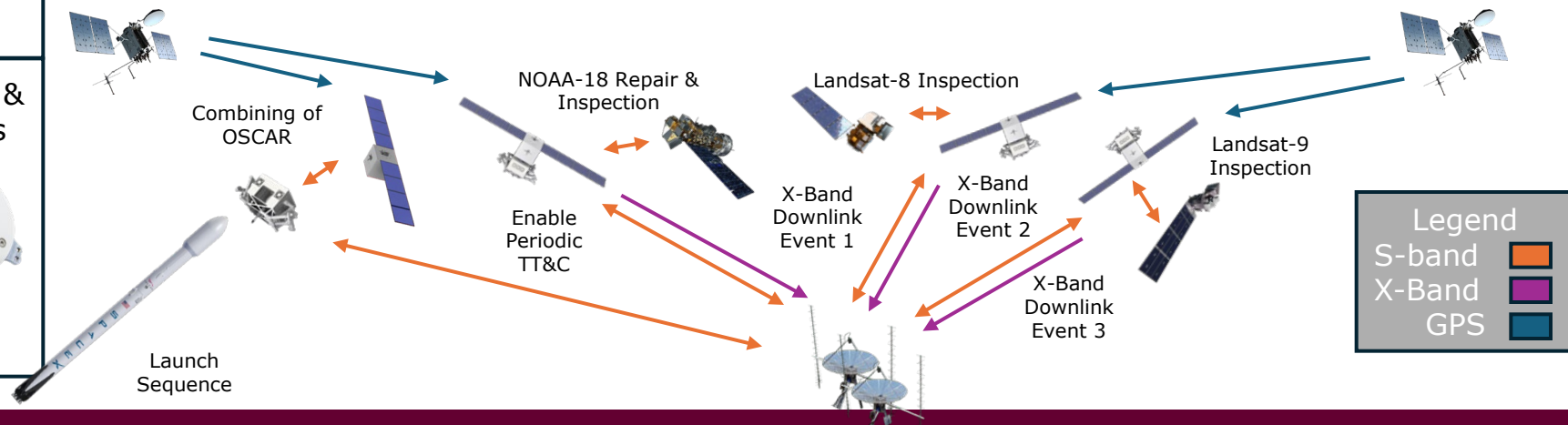
Antenna Coverage Representation



- C-3 The system must be capable of communicating with McMurdo ground station throughout entire mission using S-Band and at inspection events using X-Band .
- C-5 The antenna's maximum allowable pointing offset angel must be at a maximum $\pm 3^\circ$.

Mission Data Rates for Supervised Autonomy

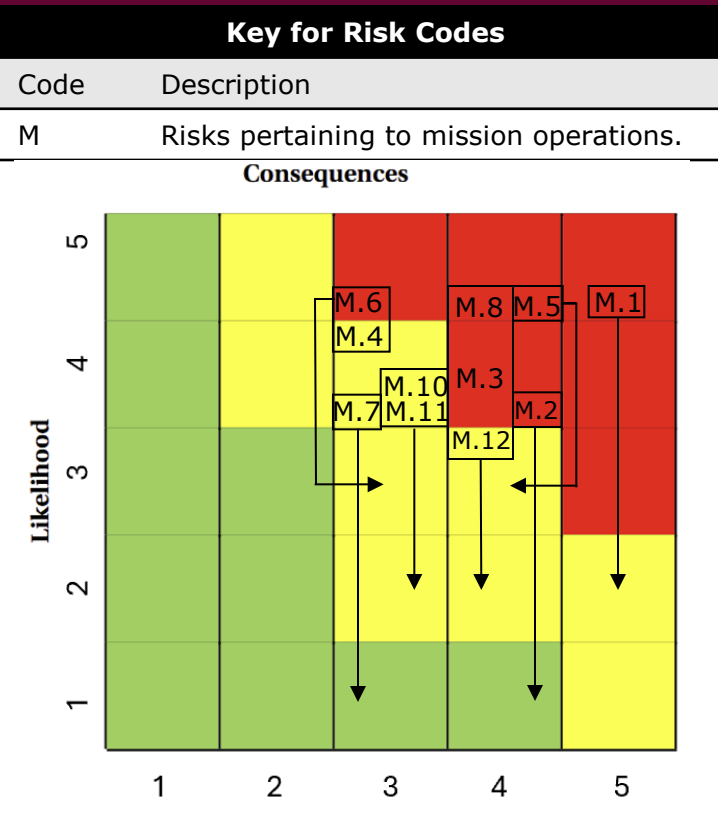
Data Generating Activities	Data Rate	Content	Timing
TT&C	Uplink: 4 kbps Downlink: 8 kbps	Command, health & status telemetry, & tracking	Every 1-5 seconds throughout the entire mission timeline
PNT	Uplink: 8 kbps	Position & navigation	Every 1 second throughout the entire mission timeline
OSCAR \leftrightarrow Client	Crosslink: 8 kbps	Navigation, repair health report, laser range finding	During inspection of NOAA-18 on 03/11/30-03/15/30 and inspections of Landsat 8 on 10/04/30 and Landsat 9 on 10/15/2030
Inspection Imagery	Downlink: 20-25 Mbps	Visual inspection imagery, LiDAR, IR video	During inspections of Landsat 8 on 10/04/30 and Landsat 9 on 10/15/2030



Risks

Code	Risk Statement	Preliminary Mitigation
M.1	If the OSCAR enters the client satellite's trajectory to service them, then OSCAR could crash into the client.	Perform an Rbar approach instead of a Vbar approach so that OSCAR is never in the trajectory of the satellite.
M.2	If an ADACS sensor fails, then OSCAR will not know its position or be able to complete the mission.	A GPS system is added to OSCAR as a secondary position tracking sensor. Additionally, there are 4 different types of sensors on the satellite for redundancy.
M.3	If OSCAR misses the maneuver window for J2 RAAN precession, then the mission can fail or spend excessive Δv .	A buffer is given in the wait period to make sure to make RAAN changes.
M.4	If the probe's level spreaders that grip the walls of the AKM's chamber and prevent the probe from exiting the nozzle, then it may cold-weld the walls of the chamber.	Adapt level spreader curvature to reduce contact pressure, coat spreaders, use material unlikely to cold-weld.
M.5	If the Propulsion and Payload Modules are unable to unify, then the spacecraft will be unable to maneuver its payload and complete the mission.	Fine tuning approach and capture speed to minimize risk of failure and minimize physical damage from accidental impact by staying well below the aluminum frame's yield strength.
M.6	If the spacecraft is unable to anchor to the client, then it cannot provide any replacement services and may damage the client.	Fine tuning approach and capture speed to minimize risk of failure and minimize physical damage from accidental impact by staying well below the aluminum frame's yield strength.
M.7	If the robotic arm collides with the client, it may damage itself or the client.	Robotic arms have integrated camera systems.
M.8	If the replacement batteries (or other replacement components) degrade en route to the client, there will be no components to replace, resulting in a mission failure.	Replacement components will have a thermally insulated storage system.
M.9	If the catalyst preheat is insufficient, the green monopropellant may not ignite and will perform poorly.	Add thermal margin, closed-loop heater control, pre-burn warmup timelines, and ground test validation of cold-start and hot-start cases.
M.10	If AF-M315E plume or decomposition products land on the client's surface, then contamination may damage sensitive components.	Enforce keep-out zones, can't thrusters away from the client, and validate plume geometry in analysis.
M.11	If there is uneven depletion or tank geometry effects, then the spacecraft's balance, attitude control, and precision burns will be difficult to operate.	Use diaphragm/bladder/managed tank design where appropriate, model depletion cases, and include control authority margin in ADACS design.

Likelihood of Failure Metric
Very High 50-100% (5)
High 25-50% (4)
Medium 12-25% (3)
Low 5-12% (2)
Very Low 0-5% (1)



Consequence	Consequence of Failure Description
Catastrophic (5)	Total Mission Failure; failure to satisfy mission requirements.
Critical (4)	Failure to satisfy multiple mission requirements.
Moderate (3)	Failure to satisfy a mission requirement.
Minor (2)	Mission requirements are met. Disruption to mission timeline.
Negligible (1)	Minimal to no impact on mission outcome.

Mass Budget

Subsystem		Mass (kg)	Growth Allowance	Upper Bound (kg)
Structure		240	20%	288
Power/Thermal		74	15%	85
Propulsion		102	20%	122
Propellant	Xenon	76	20%	91
	AF-M315E	55	20%	66
Communications		8	20%	10
Control & Command		43	20%	52
ADACS		21	20%	25
Payload		370	6%	392
Total		954	---	1046

Power Modes: Average Power Draw (W) and Average Duty Cycle

Subsystem

	Maneuver		ProxOps		Diagnostics		R&R		Eclipse	
Thermal	40	100%	40	100%	40	100%	40	100%	40	100%
Propulsion	2700	100%	610	20%	35	9%	35	9%	0	0%
Communications	2	10%	4	20%	10	50%	10	50%	2	10%
ADACS	88	95%	94	100%	94	100%	94	100%	88	95%
Control & Command	25	100%	25	100%	25	100%	25	100%	25	100%
Payload	0	---	47	6%	120	15%	690	90%	0	---
Parasitic	15	---	10	---	10	---	2.5	---	20	---
Total	2870	---	825	---	330	---	900	---	175	---

Mission Overview Animation



Program Milestones

Program Manager Selection

The team was organized by a trifecta leadership style with multiple sub-teams.

September 2025

System Requirements Definition

System Requirements were refined with component selection.

February 2026

Trade Studies Completion

Majority of conceptual design trade studies have been defined. More will be completed as a higher fidelity design develops during PDR.

March 2026

April 2026

Operations and Capabilities Selection

OSCAR's mission was re-selected during winter break from "Space Weather Shielding Service" to "Repair and Replace Service" after implementing feedback.

Finalized Conceptual Design

The repair and replace mission architecture was down selected for specific NOAA/Landsat clients.

AIAA Paper and Developed Path to PDR

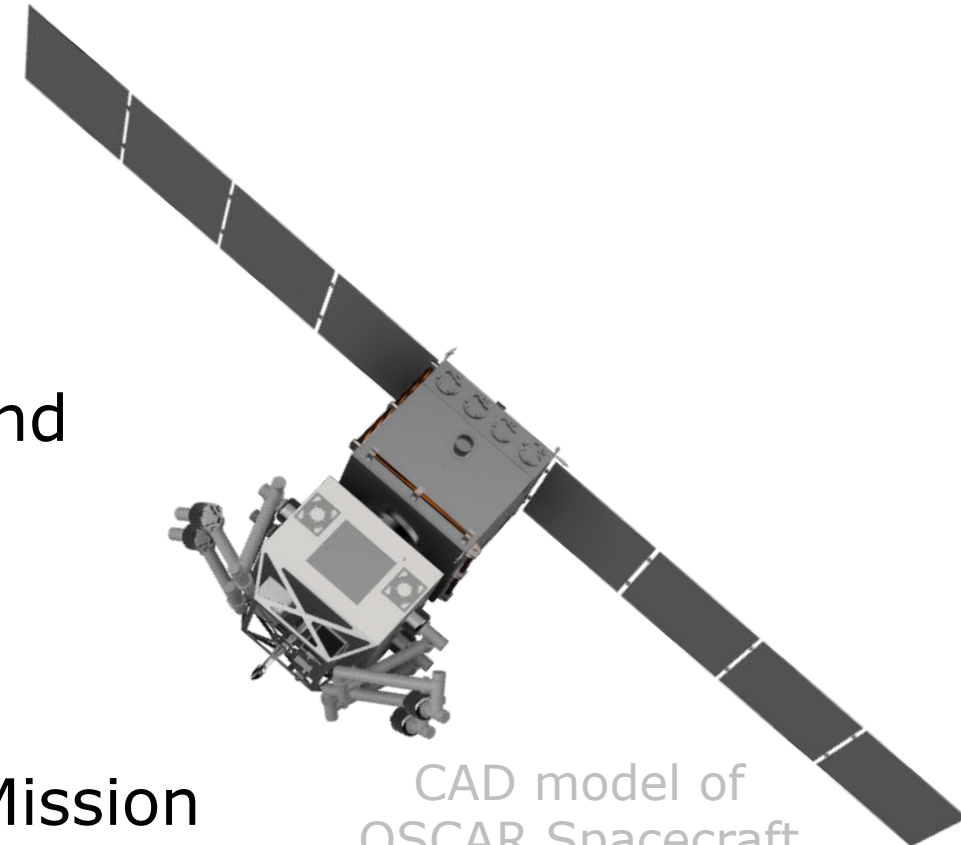
Completed 10-20 page AIAA paper. Refer to next slide for PDR.

Completed:

- Requirements Flow Down and General Work Breakdown System
- Preliminary Program Cost
- OSCAR Block Diagram
- Docking and Anchoring Safety Analysis

To Do:

- Low-Level Software/Autonomy Requirements and Technology Development Plan
- Safe Approach Simulation
- Thermal and Mechanical Response Analysis
- Integrated Master Schedule
- Mission Extension, Maintainability, and End of Mission Design
- Stakeholder Contract Analysis and Assumptions [10][11]



CAD model of
OSCAR Spacecraft

Innovative Concepts	Technology Needed to Further Develop OSCAR	Biggest Challenges in the Design Process
<ol style="list-style-type: none">1. Using custom-designed tools to perform component replacement2. Solar-shielding satellite3. Use light-weight, low-cost satellites to de-orbit at EOL	<ol style="list-style-type: none">1. Space-rated AI computers for improving autonomy2. Prepare to send new Asterix to increase maintainability3. Improve validity of space-rated tools being used	<ol style="list-style-type: none">1. Accessing information for potential clients2. Returning components (MLI, adhesive, bolts) after invasive surgery3. Limiting number of servicing tools

What we learned:

- Business case matters as much as the engineering
- Importance of working together as one project and not as separate sub-teams
- Initial research before committing an idea to the conceptual-design-cycle
- Radiation shielding and importance of prox-ops

A **modular life extension spacecraft** capable of inspection, replacement, and spot repair.

INNOVATIVE

- **Modular architecture** enables in-space resupply via Asterix module replacement
- **Interchangeable end-effectors** support multi-functioning servicing
- Integrated unique tool and storage system enables full **component replacement**
- Combines **inspection, repair, and replacement** in one platform



High-Value Missions

- 2: Upgrade/**Replacement** of Instruments
- 6: Autonomous **Payload Swap** on Persistent Platforms
- 10: Upgrade/Replacement/**Repair** of Spacecraft Systems, Subsystems, or Components
- 13: **Inspection** of Satellites for Failure Assessment

Key Specifications

- Mass:** 1046 kg
- Cost:** \$33-36 M
- Power Supply:** 5.5 kW
- Launching:** 09/15/2029

FEASIBILITY

- Uses **commercially available**, space-rated components where possible
- Design is driven by **rigorous requirements**
- **Trade studies** informed key system selections
- Δv , Mass, and more **technical analyses** validate mission viability

Thank you!

Questions?



- [1] <https://cosmicspace.org/wp-content/uploads/2025/09/COSMIC-Prioritized-Use-Cases-List.pdf>
- [2] <https://newsletter.terrawatchspace.com/the-future-of-landsat-and-civilian-earth-observation/>
- [3] <https://www.spacex.com/rideshare/>
- [4] https://static1.squarespace.com/static/60df2bfb6db9752ed1d79d44/t/61292a6a6a852874bb123c23/1630087786826/BHT_1500_v1.0.pdf
- [5] <https://ntrs.nasa.gov/api/citations/20140012587/downloads/20140012587.pdf>
- [6] <https://ntrs.nasa.gov/api/citations/20170003928/downloads/20170003928.pdf>
- [7] <https://www.eaglepicher.com/sites/default/files/EAP%2012325.pdf>
- [8] <https://gsyuasa-lp.com/SpecSheets/MA190.pdf>
- [9] https://www.spectrolab.com/photovoltaics/XTE-SF_Data_Sheet.pdf
- [10] https://nodis3.gsfc.nasa.gov/npg_img/N_PR_7123_001D_/NPR7123_001D_.pdf
- [11] https://www.nasa.gov/wp-content/uploads/2018/09/nasa_systems_engineering_handbook_0.pdf

Backup Slides



Mass Budget

Subsystem	Component	Part Number	Lower Bound (kg)	Allowable Growth		Upper Bound	Total Subsystem Mass
				%	kg		
Structures	Frame	Custom	240	20	48	288	85
Power	Solar Panels	XTE-SF	32	10	3	35	
	Batteries	MA190-107 + EAP12325	42	9	4	46	
	PCDU	Terma_PCU	8.3	10	0.8	9	
Propulsion	Primary Thruster	BHT-6000	13.5	5	0.5	14	280
	RCS Thrusters	GR-1	6	10	0.6	6.5	
	Tanks	Custom	21	20	4	25	
	Propellant	Xenon + AF-M315E	200	20	40	240	
	Pressurant	Helium	3	50	1.5	4.5	
Communications	Comms	Various	8	40	2	10	10

Mass Budget (Cont.)

Subsystem	Component	Part Number	Lower Bound (kg)	Allowable Growth		Upper Bound	Total Subsystem Mass
				%	kg		
ADACS	Reaction Wheels	BCT-RW4	13	15	2	15	20.5
	Sensors	Various	4	10	0.4	4.5	
	GPS Receiver	PolaRx5	1	10	0.1	1	
Payload	LIDAR	GSFL-4K	15	10	1.5	16.5	392
	Rangefinder	FLARE MDA	1.6	10	0.2	1.8	
	Cameras	Quadclops+ORION12 MP	3.5	30	1	4.5	
	IR Scanner	HYPERION-IR MWIR	3	15	0.5	3.5	
	Waldo	HG9900	200	5	10	210	
	Storage	Custom	2.5	50	1.5	4	
	R&R Replacements	Client Dependent	125	5	6	131	

Power Modes: Power Draw (W) and Duty Cycle

Component	Item	V										
			Maneuver	ProxOps	Diagnostics	R&R	Eclipse					
HE Thruster	Busek BHT-6000	400	2700	100%	500	20%	0	0%	0	0%	0	0%
Green Thruster	Aerojet GR-1 (x18)	28	35	9%	107	27%	35	9%	35	9%	0	0%
Star Tracker	BAE CT-2020	28	8	10%	8	10%	8	10%	8	10%	8	10%
Sun Sensor	RWS FPSS	28	0.5	100%	0.5	100%	0.5	100%	0.5	100%	0	0%
Magnetometer	AAC Clyde Space MM200 (x4)	5	0.2	100%	0.2	100%	0.2	100%	0.2	100%	0.2	100%
IMU	Honeywell HG9900	5	10	100%	10	100%	10	100%	10	100%	10	100%
Reaction Wheels	0	28	75	100%	75	100%	75	100%	75	100%	75	100%

Power Budget (Cont.)

Power Modes: Power Draw (W) and Duty Cycle

Component	Item	V										
			Maneuver	ProxOps	Diagnostics	R&R	Eclipse					
Thermal Heater	---	---										
GPS Reciever	PolaRx5	5	4.7	100%	4.7	100%	4.7	100%	4.7	100%	4.7	100%
Uplink	Pulsar STX (S-band)	5	0.5	10%	2.5	50%	2.5	50%	2.5	50%	0.5	10%
Downlink	DXB X-band Diplexer (X-band)	5	1.5	10%	7.5	50%	7.5	50%	7.5	50%	1.5	10%
LIDAR	GSFL-4K	5	0	0%	0	0%	71	73%	71	73%	0	0%
Manipulator	Honeywell HG9900	28	0	0%	0	0%	0	0%	600	75%	0	0%
Storage	Custom	28	0	0%	0	0%	0	0%	20	5%	0	0%
Rangefinder	FLARE MDA	28	0	0%	8	100%	8	100%	0	0%	0	0%

Power Budget (Cont.)

Power Modes: (Power Draw (W) and Duty Cycle)

Component	Item	V	Power Modes: (Power Draw (W) and Duty Cycle)									
			Maneuver		ProxOps		Diagnostics		R&R		Eclipse	
Wide Camera	Quadclops	28	0	0%	15	60%	15	60%	0	0%	0	0%
Narrow Camera	Orion12MP	28	0	0%	6	60%	6	60%	0	0%	0	0%
IR Scanner	HYPERION-IR MWIR	28	0	0%	18	60%	18	60%	0	0%	0	0%
OBC	Constellation OBC	28	9	40%	9	40%	23	100%	23	100%	6	26%
PCDU	Terma-PCU	---	15	100%	15	100%	15	100%	15	100%	15	100%
Parasitic	---	---	15	100%	10	100%	10	100%	2.5	100%	20	100%
Growth		---	5%		5%		5%		10%		10%	
Total		---	2875		800		2080		875		140	

Propulsion Selection

Criteria	Weight	Rendezvous	Score
Isp (s)	0.40	Hall Effect	0.454
Thrust (N)	0.25	Hydrazine Monoprop	0.361
Density (kg/L)	0.20	Cold Gas	0.184
Cost of Fuel (\$/kg)	0.15		

Criteria	Weight	Prox-Ops	Score
Thrust (N)	0.40	Green Monoprop	0.262
Isp (s)	0.25	Hot Gas	0.255
Density (kg/L)	0.20	Hydrazine Monoprop	0.250
Cost of Fuel (\$/kg)	0.15	Cold gas	0.233

Prop-1 The propulsion system shall be capable of providing the total mission delta-v required for rendezvous, phasing, inspection flybys, proximity operations, and safe departure from the client satellite.

Criteria	Weight
Isp (s)	0.15
Thrust (N)	0.15
Power (W)	0.3
Mass (kg)	0.15
Xe prop for ΔV (kg)	0.15
Burn Time (days)	0.1

Criteria	Weight
Isp (s)	0.25
Min impulse bit (n-s)	0.2
Power (W)	0.15
Mass (kg)	0.15
Mass for ΔV (kg)	0.15
Heritage	0.1

Option	Score
Busek BHT-1500	0.206
Busek BHT-6000	0.204
Safran PPS®5000	0.198
OKB Fakel SPT-140	0.198
Aerojet Rocketdyne XR-5	0.193

Green Prop Thruster	Score
Aerojet GR-1	0.247
ECAPS HPGP 1N	0.206
ECAPS HPGP 5N	0.198
Aerojet GR-22	0.185
Bradford/ECAPS HPGP 22N	0.163

Power Selection

Primary Battery	Score
Ag-Zn	0.301
Li-CFx	0.259
Li-SO2	0.231
Li-SOCl2	0.209

Secondary Battery	Score
GS Yuasa	0.350
Saft	0.219
EaglePicher	0.218
Airbus	0.213

Solar Panel	Score
Spectrolab	0.302
Lockheed	0.266
Mitsubishi	0.236
Airbus	0.195

Criteria	Weight
Energy Density (Wh/L)	0.35
Specific Power (W/kg)	0.35
Specific Energy (Wh/kg)	0.25
Capacity Loss (%/yr)	0.05

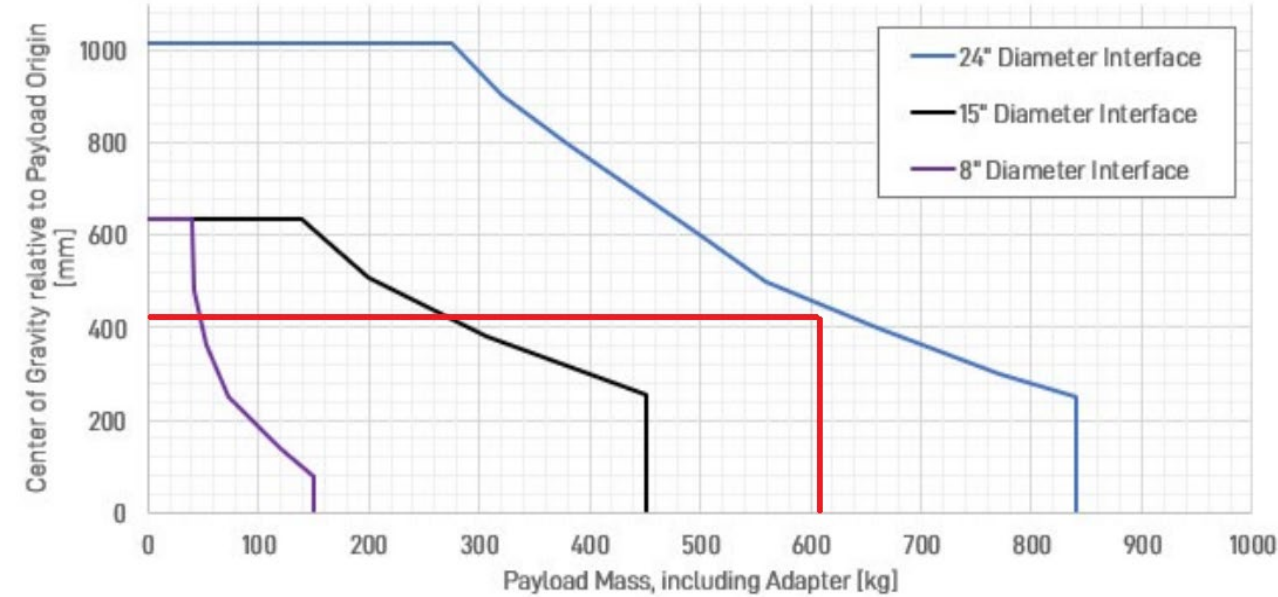
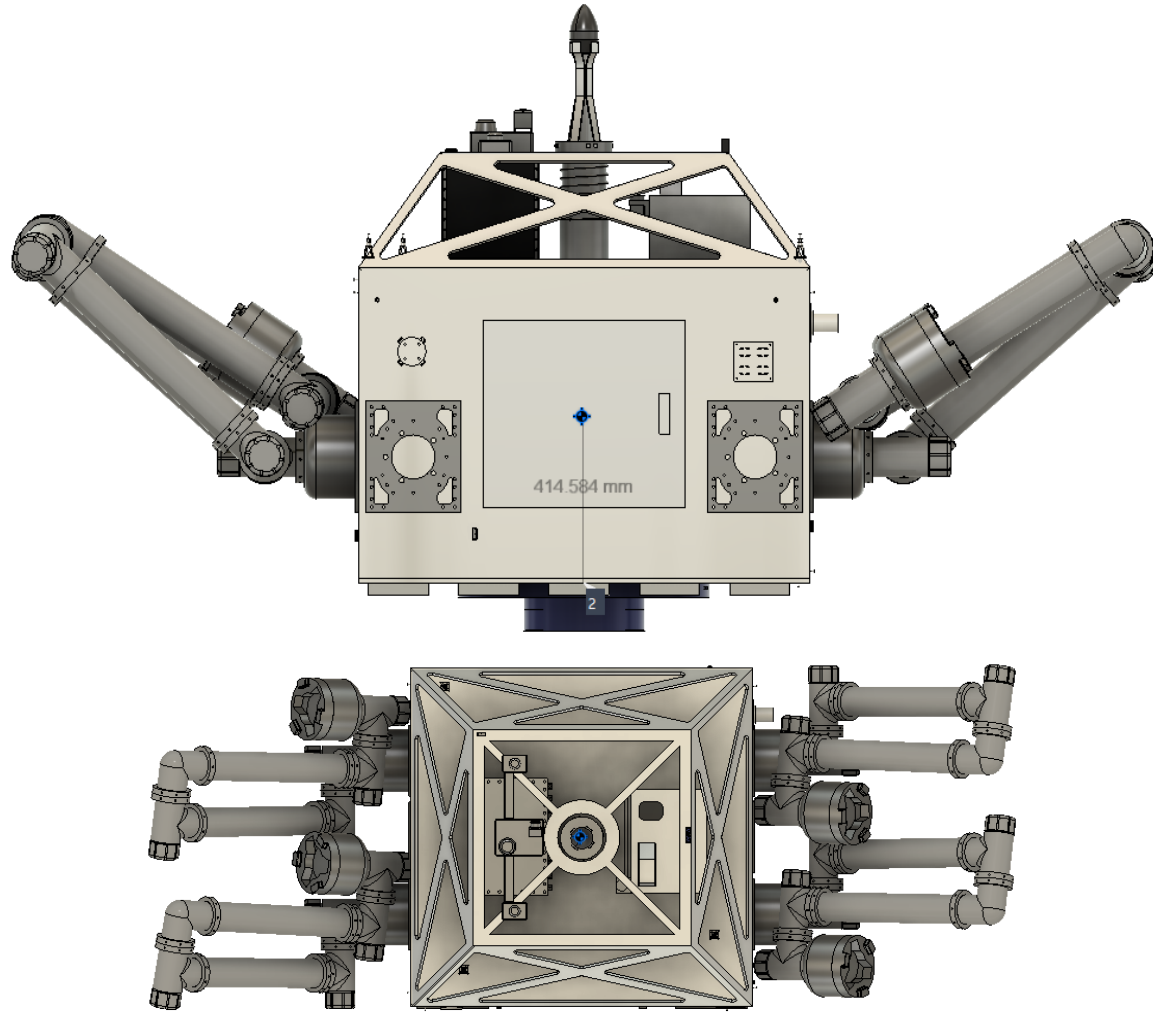
Criteria	Weight
Specific Density (Wh/L)	0.48
DoD	0.28
Cycle Life	0.14
Specific Energy (Wh/kg)	0.10

Criteria	Weight
Power (W/m ²)	0.43
Thickness (mm)	0.26
Mass (kg/m ²)	0.22
PA5/BOL	0.09

P-1 The power system shall be capable of generating, storing, conditioning, and distributing sufficient electrical power to support all spacecraft subsystems during all mission phases.

CG Analysis: Obelix

Obelix Center of Gravity = 414.58 mm



Center of Gravity Constraint provided by SpaceX Rideshare Program User's Guide

- Margins can be increased by looking into an arm reposition or looking into sizing down some of the computers located on the open deck

Modal Analysis

