THE UNIVERSITY OF TEXAS AT EL PASO

Assembly of Space Structures

Northrop Grumman

Prepared for:
Dr. Andrew Kwas

Team Roles

Adrian Nunez

Team Lead

Planning Manager

Abraham Azaeta

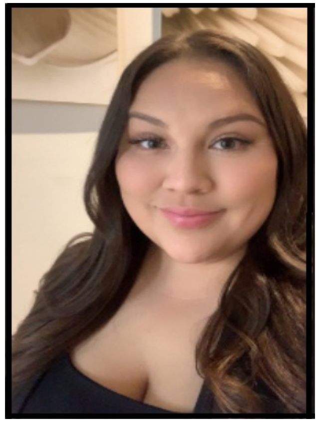
Design

Quality Manager

Hande Yetis

Scope Manager

Research



Melony Rodriguez

Coordinator

Research

Dr. Oliveira, Amanda

Dr. Smith, Erick

Mr. Rosa, Marco

Project Outline

- **Introduction**
    - International Space Station
    - Requirements
- Preliminary Research
    - Robotic Servicing of Geosynchronous Satellites (RSGS)
    - NASA’s Restore-L
    - James Webb Space Telescope (JWST)
    - DARPA’s Orbital Express
- Project Candidates
    - Candidate Requirements
    - Spider
    - Canadarm2
- Conclusion
    - Designs
    - Simulation
- References

Project Objective

Our primary aim is to develop a candidate space robotics system optimized for assisting in the construction of the new International Space Station (ISS). Our approach involves comprehensive research into historical, ongoing, and prospective space missions as well as robotic technologies. Through this research, we will not only construct the proposed candidate system but also identify and select the most suitable robotic candidates for integration into the ISS construction planning phase.

Project Stakeholders

Northrop Grumman

U.S. Government Agencies

Project Team and Engineers

Space Agencies

Opposing Companies

International Space Station 1998

The ISS is a collaborative project

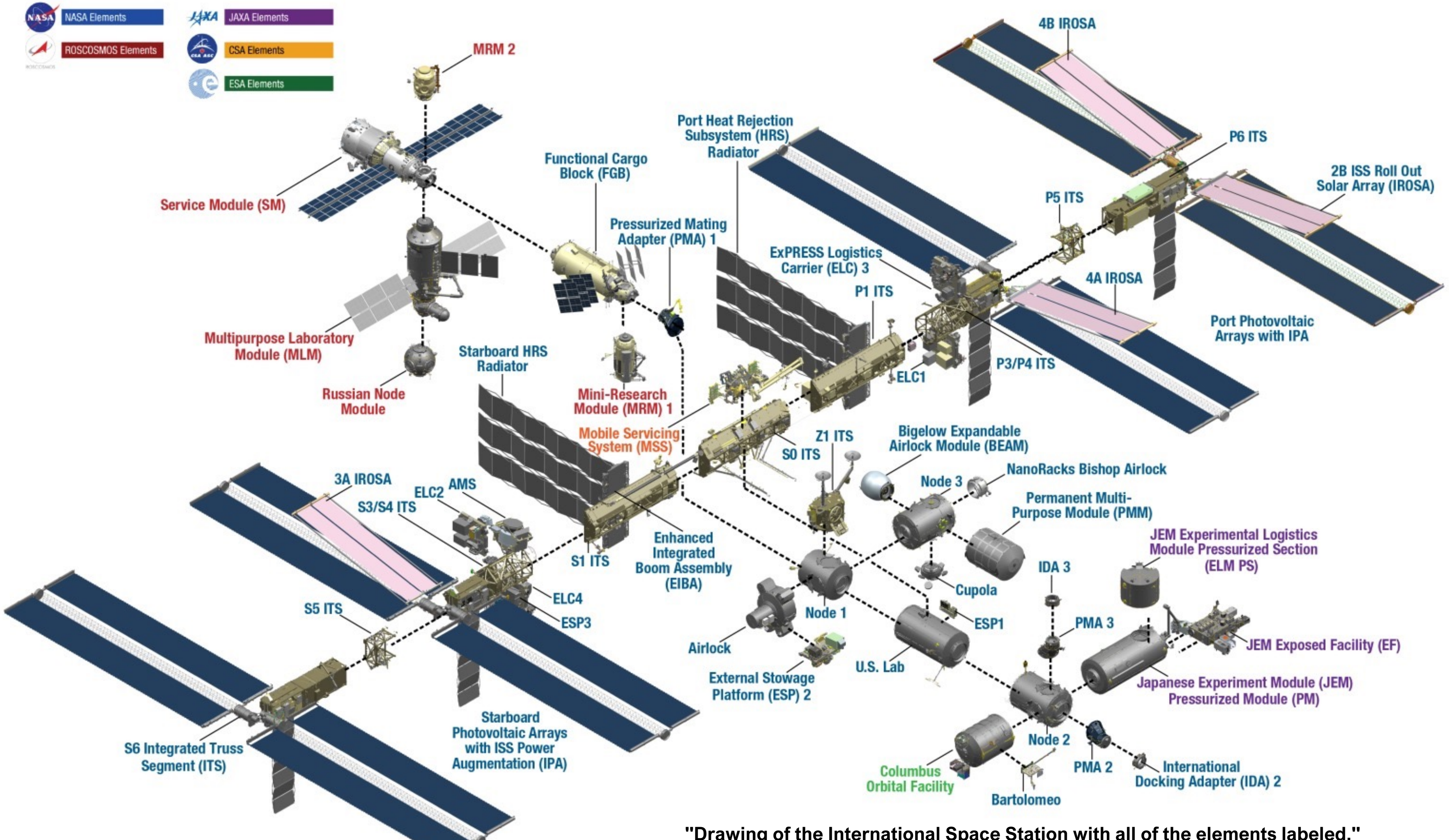
It has been continuously occupied since 2000.

The cost of assembling the ISS was $150 billion (USD).

More than 40 assembly flights were required to build the station.

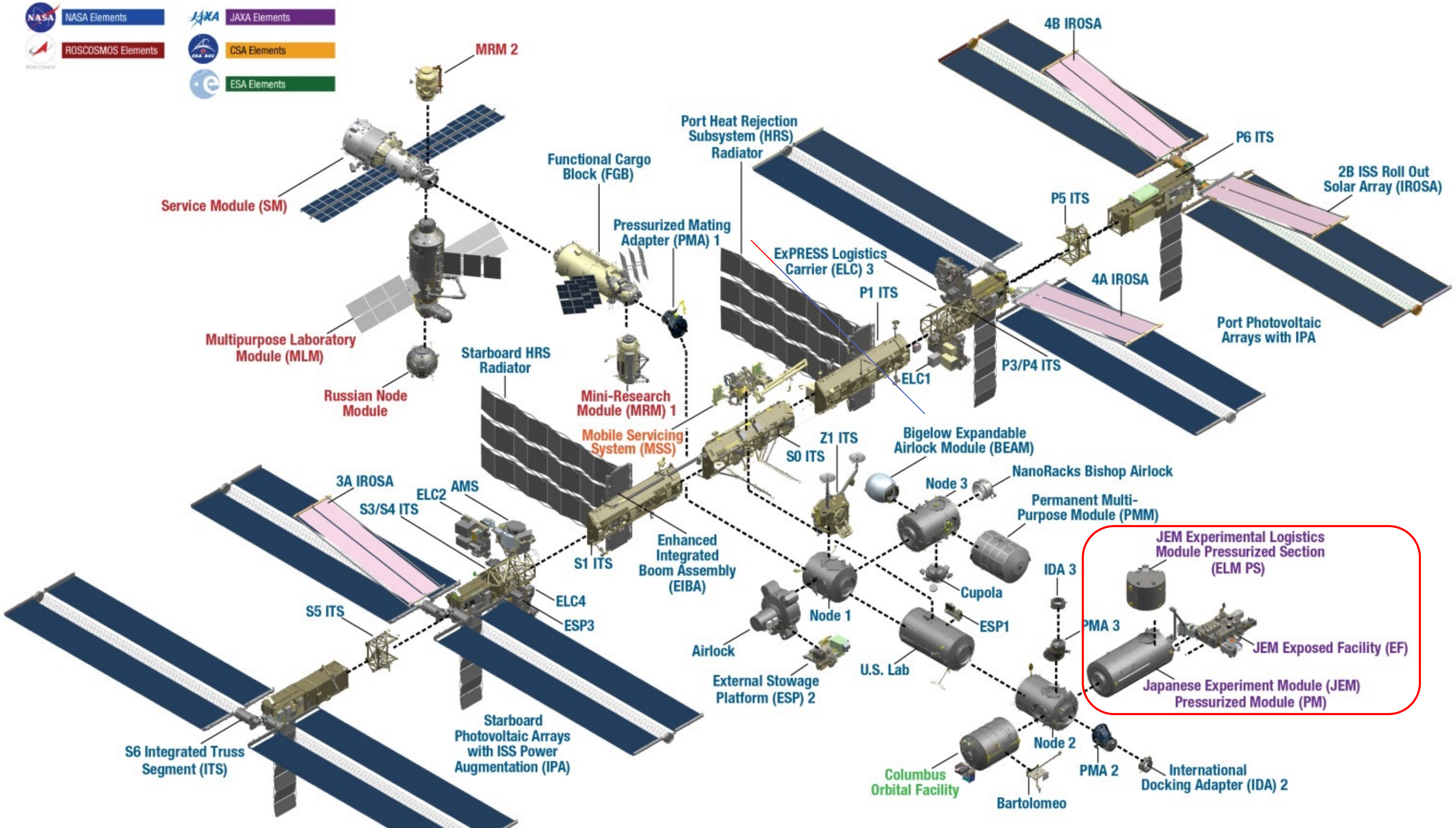
Symbol of international cooperation and a testament to engineering and technology capabilities.

ISS Modules



"Drawing of the International Space Station with all of the elements labeled."
Source: https://www.nasa.gov/international-space-station/space-station-facts-and-figures/

ISS Modules-*Japanese Experiment Module, Kibo*



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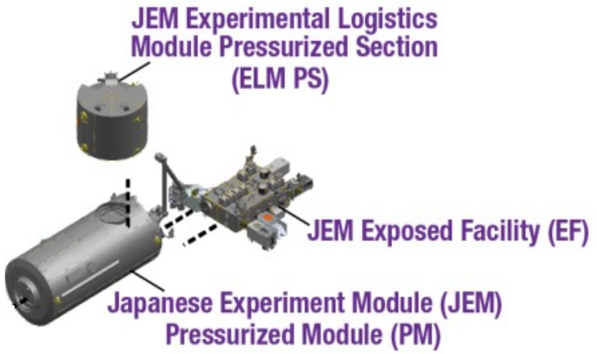

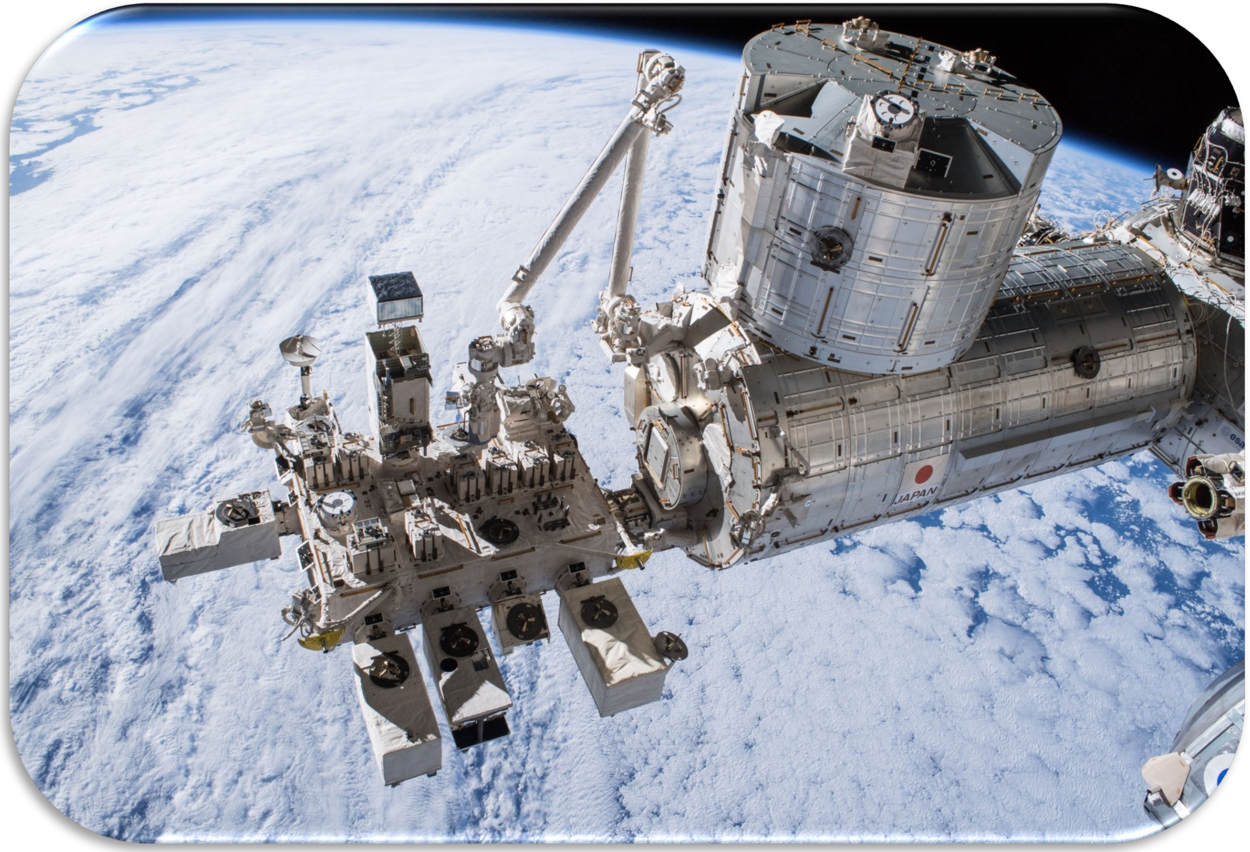

"The Japanese Kibo laboratory module with its Exposed Facility, Pressurized Module, Logistics Module, and robotic arm is pictured as the International Space Station orbited over the southern Pacific Ocean."
Source: https://www.nasa.gov/international-space-station/japanese-experiment-module-kibo/

Candidate Requirements

Candidate Requirements			
	Functional Requirments		
	1.1	Human Intervention	The candidates shall be controlled remotely with minimal human physical interaction
	1.2	Compatitibility	The candidates shall be compatible with modules from all Space Agencies
	1.3	Accessability	The candidates shall be able to move easily and have access to every location on the new ISS
	1.4	Compatitibility	The candidates shall collaborate to berth/stage new modules as well as dock these modules with ease
	1.5	Safety	Candidate shall insure safe interaction if humans are present
	1.6	Autonomy	The candidate shall be capable of precise and dexterous manipulation
	1.7	Autonomy	The Candidate shall be able to handle sensor faillure or communication disruptions
	1.8	Communication	The candidate shall communicate with ground station or other spacecraft
	Physical Requirements		
	2.1	Payload Handling	The robot Should accomodate Various Payloads (e.g., Cameras, sensors, tools)
	2.2	Mass Payload	The candidate shall have a minimum payload capacity of at least 36,000lbs
	2.3	Maximum Length	The candidate shall be able to manipulate a payload with the maximum length of at least 37ft
	2.4	Maximum Diameter	The candidate shall be able to manipulate a payload with the maximum diameter of at least 15ft
	2.5	Environmental adaptability	The candidates shall withstand temperatures ranging from -250°F to 250°F

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Robotic Servicing of Geosynchronous Satellites (RSGS)

Artist's Concept

Dexterous Robotic Arms & Supporting Technology(DARPA)

→

Designed to:

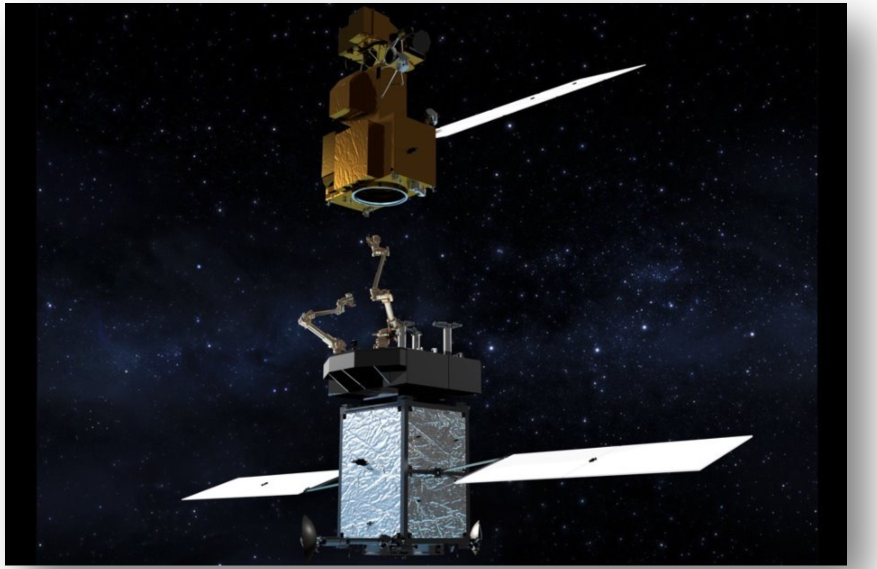
- ❖ Repair
- ❖ Refuel

Its operation :

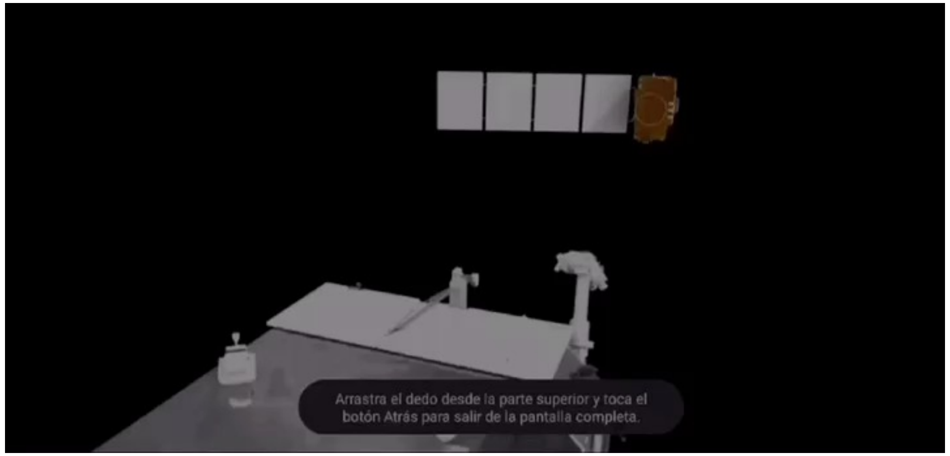
- ❖ Arms
- ❖ Tools

NASA Restore-L

- Autonomous navigation.
- Refueling Landsat 7 satellite.
- Robotic arms.
- Autonomous test capabilities

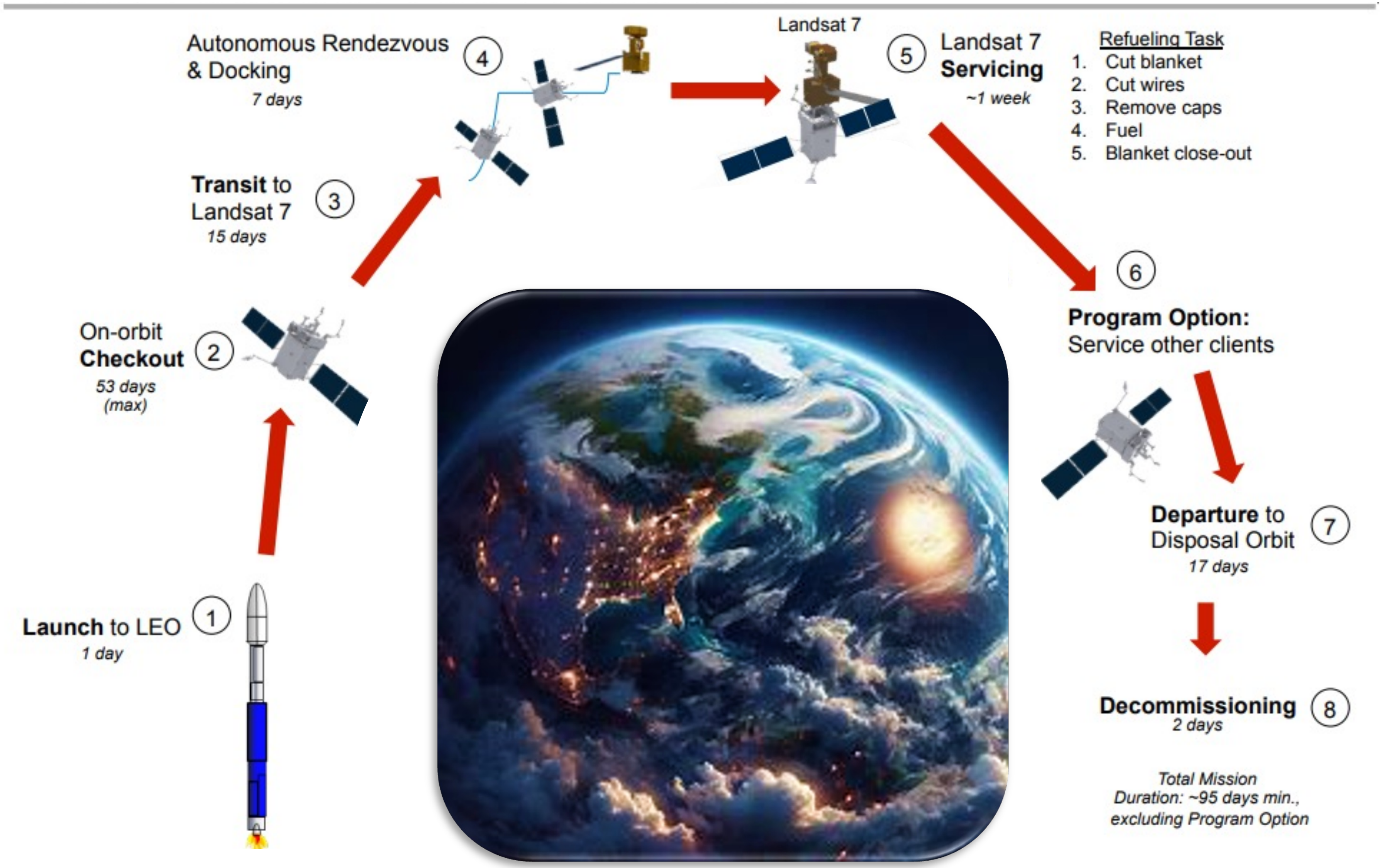


OSAM-1 preparing to refuel Landsat 7



OSAM-1 utilizing Spider to complete refueling mission.

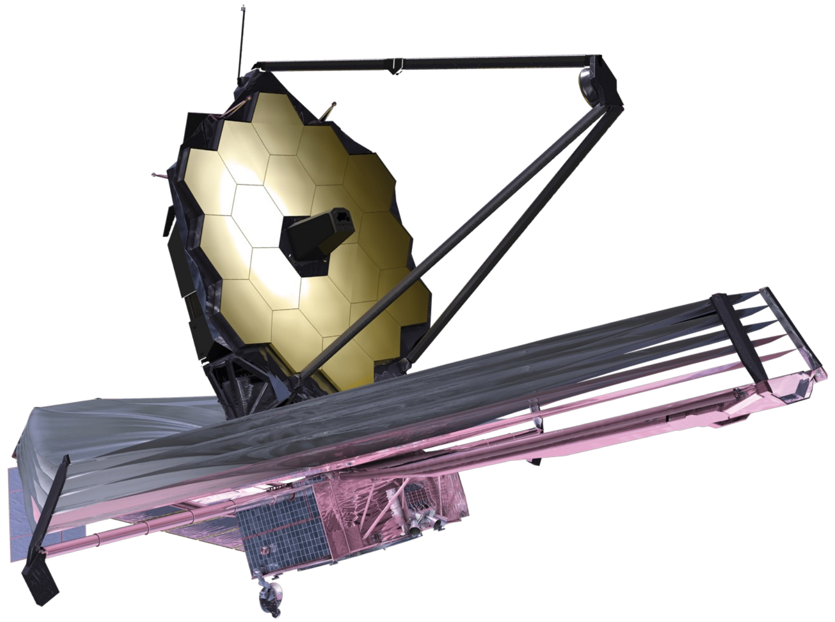
Source: "https://www.nasa.gov/mission/on-orbit-servicing-assembly-and-manufacturing-1/"



Source:https://www.nasa.gov/wp-content/uploads/2015/05/restore-l-info_nnh15heomd001_r7.pdf?emrc=e131ba

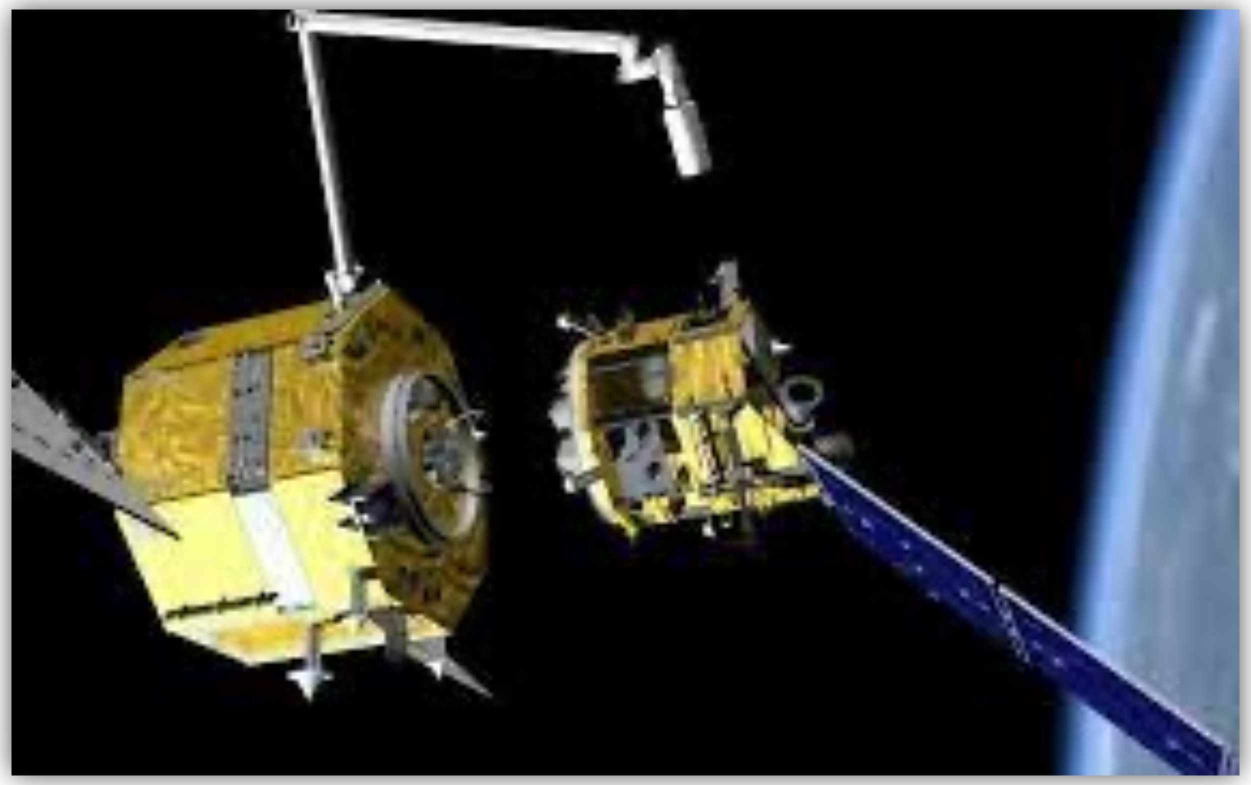
James Webb Space Telescope (JWST)

- Project by NASA, ESA, & CSA with NGC acting as the primary contractor.
- Launched December 25, 2021
- Launched on Ariane 5 rocket from Kourou in French Guiana.
- Specifications- 18 hexagonal polished mirrors, 6.5 meters in diameter.
- Total Polished Area-26.3 meters squared, with .9 meters square obstructed by support struts
- Launched on Ariane 5, with payload of 4.57 meters in diameter and 16.19 meters in length



DARPA: Orbital Express

The Orbital Express mission, led by DARPA in 2007, featured the ASTRO service vehicle as a pioneering example of autonomous orbital capabilities.



Source: https://images.app.goo.gl/TocnSgorSMygXSETA

Main Objectives

Autonomous spacecraft

Safe Maneuvers

On-Orbit Servicing

Modular Design

In-Space testing

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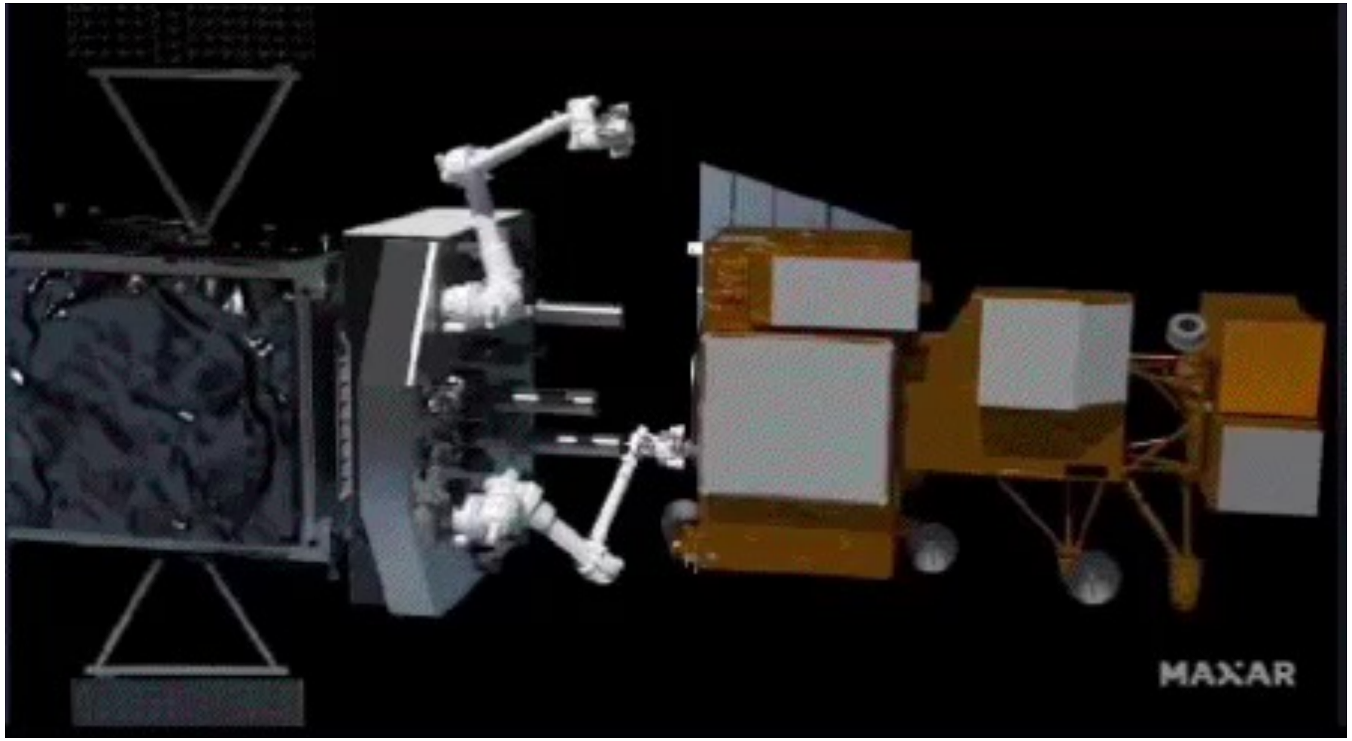
SPIDER

- **Components:**
- Communications antenna
- Lightweight composite beam

- **Investigation:**
- Maxar Technologies
- Additional Information:
- Restore-L and OSAM 1



Spider (mounted on OSAM-1) refuels satellite.
Source: https://www.youtube.com/watch?v=gverl0Ypf0k

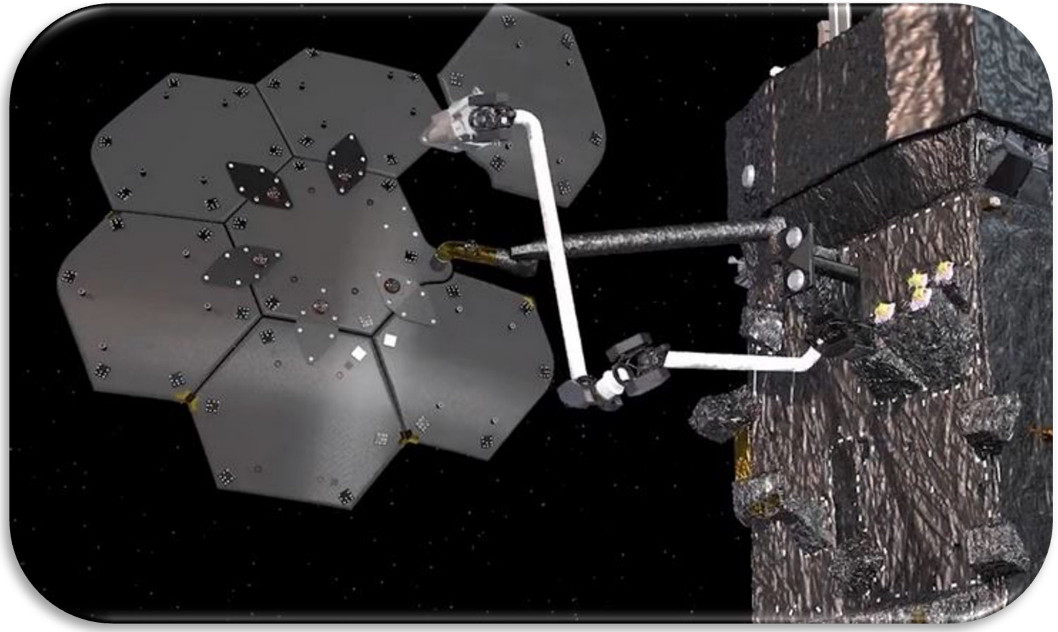
SPIDER

Pros

- Infrastructure for human exploration
- Design complexity and system mass
- Reduce need for multiple launch vehicles

Cons

- Technology for space missions
- Space assembly



Source:NASA Funds Demonstration of Assembly and Manufacturing in Space - NASA

Canadarm

- April 1981-July 2011

  Capable of lifting 29,000lbs
- 50ft reach capability
- 5 Joints with 5 Degrees of Freedom
- Stationary, Fixed to Space Shuttle Columbia

Canadarm I

Canadarm2

- Installed April 2001
- Capable of lifting 255,000lbs
- 57.7ft reach capability
- 7 Joints with 7 Degrees of Freedom
- Permanently fixed on ISS

"Canadarm2 catching SpaceX’s Dragon resupply ship as it arrives at the ISS in 2016"

Photos Source: "https://thewalrus.ca/canadarm/"

Canadarm2

Pros:

- Increased Mobility
- Increased Strength
- Space Repairability

Cons:

- Slower Operational Speed
- Increased Vulnerability
- Increased Complexity in Maintenance

Candarm2
Source: https://www.nasa.gov/wp-content/uploads/2015/05/design_iss_systems_engineering_case_study.pdf

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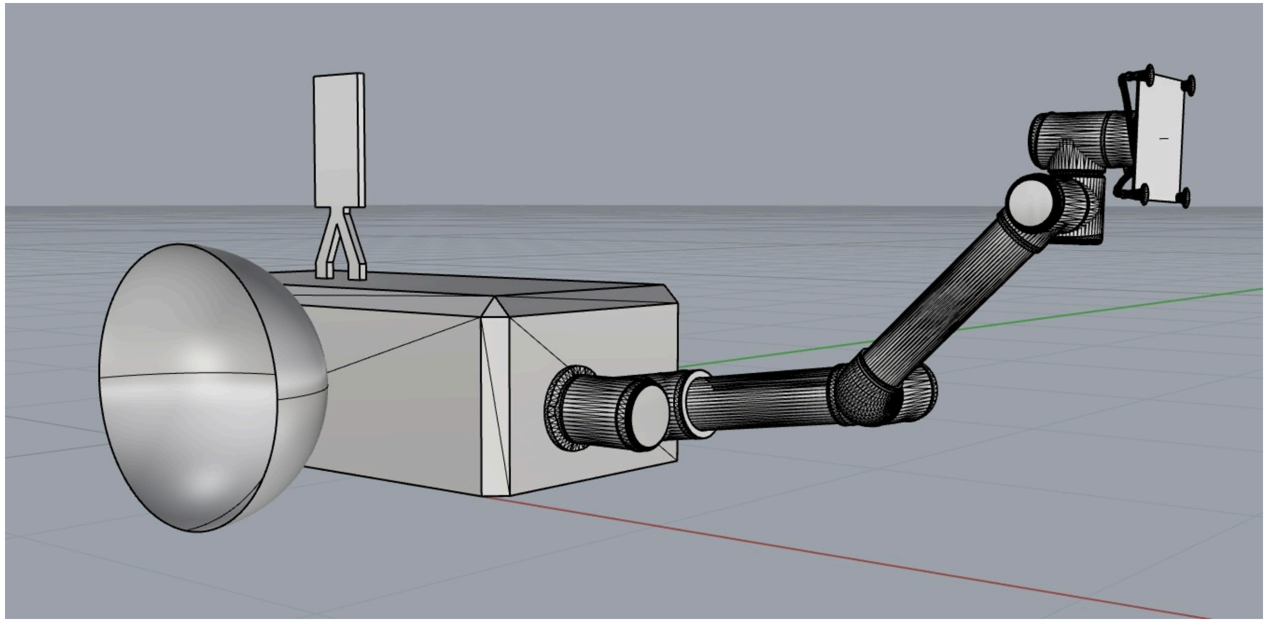
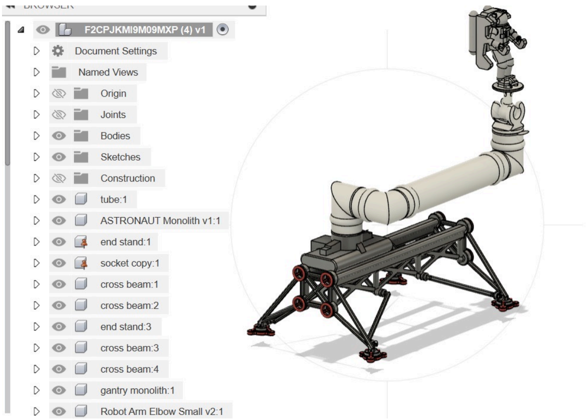
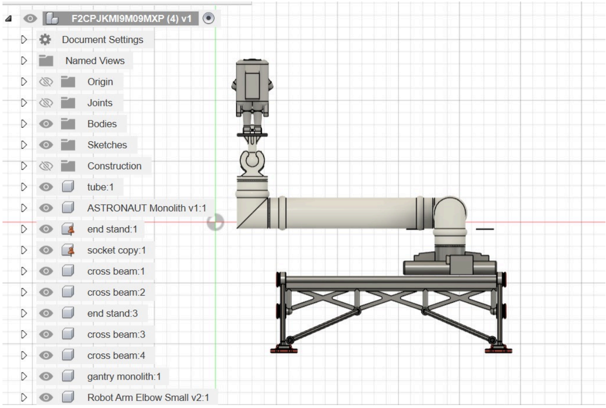
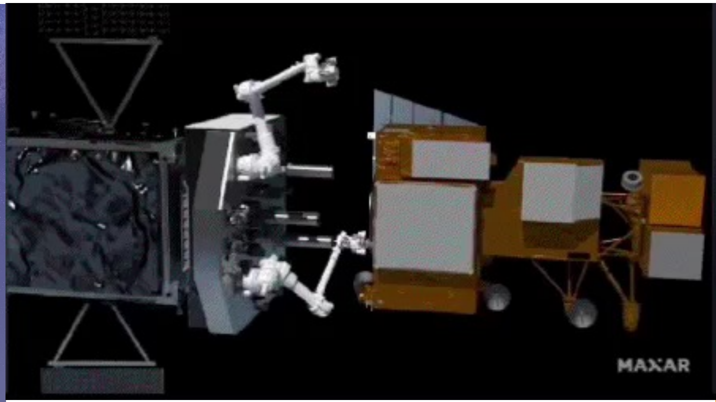
Candidate Designs







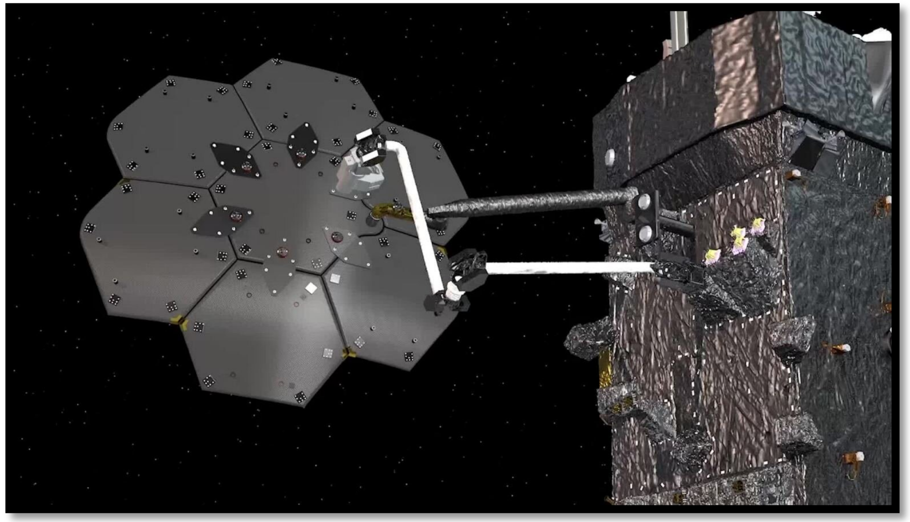
Simulation



Conclusion

In summary, our project aims to identify the optimal compatibility among our candidate systems, specifically focusing on the collaborative capabilities of the **Canadarm 2 and the Spider**, to effectively achieve the assembly of new space structures.

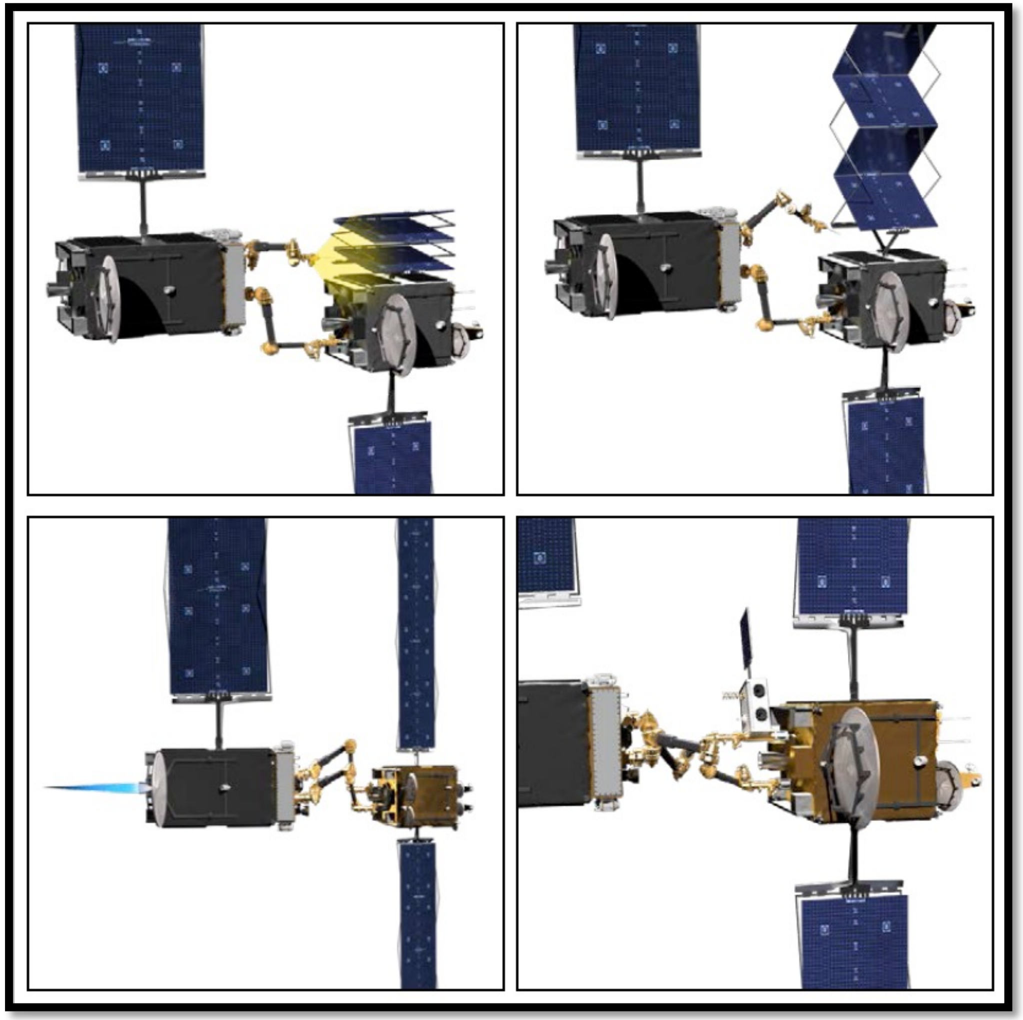
Source: https://apod.nasa.gov/apod/ap060522.html



Source:NASA Funds Demonstration of Assembly and Manufacturing in Space - NASA

Conclusion Continued...

Furthermore, despite these two systems being excellent for the example we provided; they are particularly suitable for large structures. For medium-sized structures, the **RSGS satellite** (Robotic Servicing of Geosynchronous Satellites) may be more efficient. This system offers an innovative and effective alternative for maintenance and servicing tasks in geostationary orbit, showcasing the versatility and adaptability of space technologies.



Source: https://images.app.goo.gl/Juc8rM3k7fcCvArA9

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