The Role of ISAM Capability as We Look Towards the Future of Space Nuclear Propulsion

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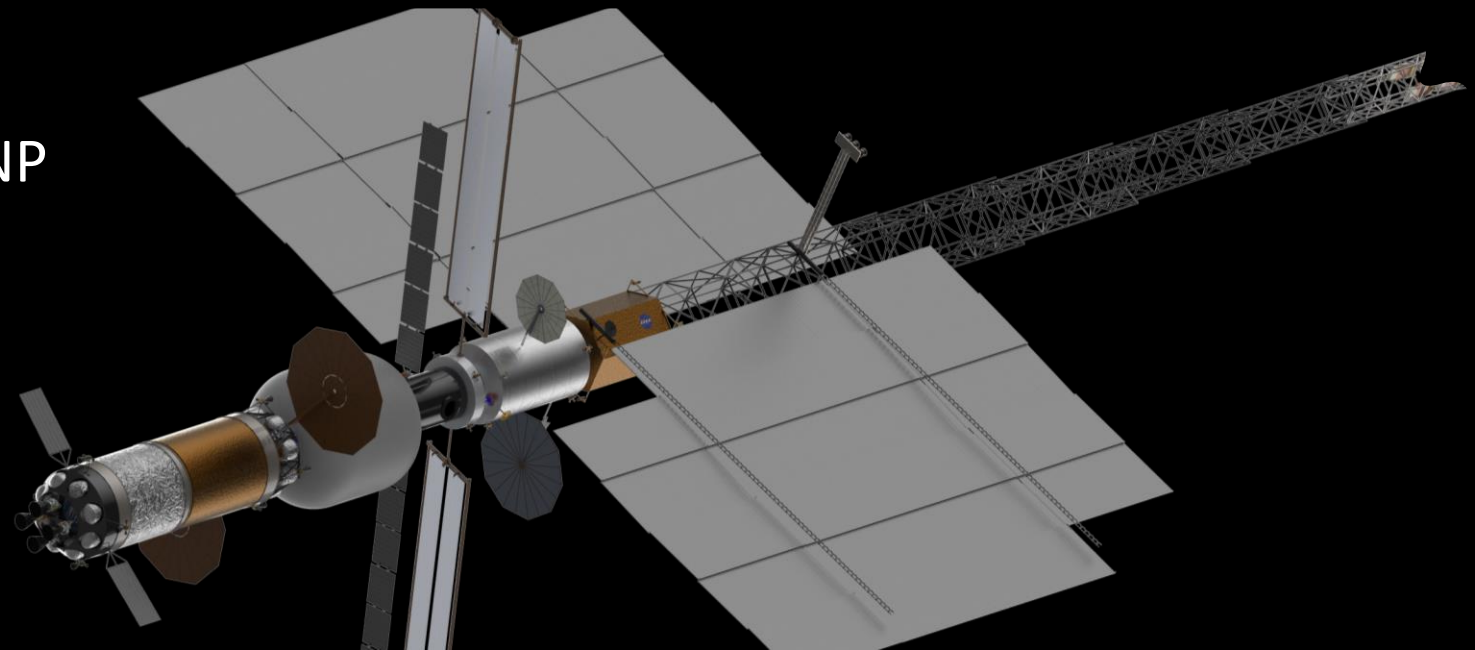
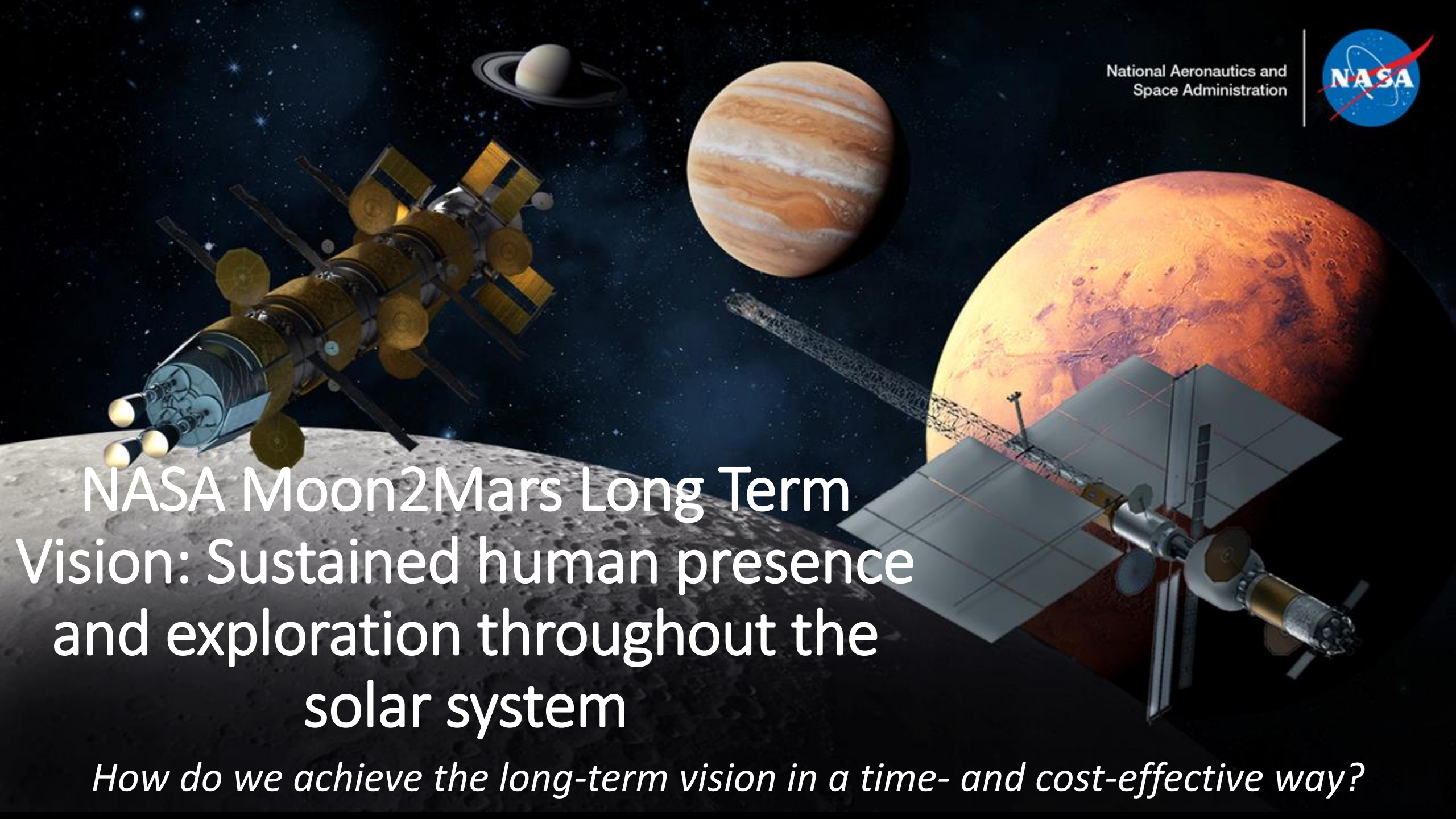
Agenda

- Space Nuclear Propulsion (SNP)
- In-Space Servicing Assembly and Manufacturing (ISAM)
- ISAM's Current Role with SNP
- In-Space Assembled Telescope: An analogous story
- A path to architecting future SNP vehicles incorporating ISAM



Space Nuclear Propulsion Enhances Mission Efficiency for:

- Crewed and cargo missions to Mars
- Science missions in deep space
- Agile movement in cis-lunar space



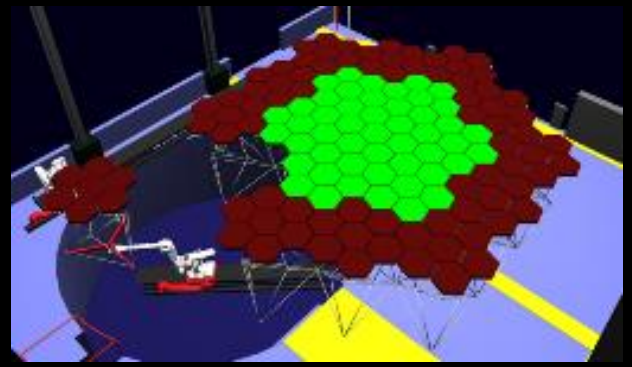
NASA Moon2Mars Long Term Vision: Sustained human presence and exploration throughout the solar system

How do we achieve the long-term vision in a time- and cost-effective way?

ISAM is a paradigm shift for space operations

In-Space	Refers to the suite of capabilities which are used on-orbit, on the surface of celestial bodies, and in transit between these regimes
Servicing	Inspection, life extension, repair, or alteration of a spacecraft after initial launch
Assembly	The construction of space systems using discrete components
Manufacturing	The transformation of raw or recycled materials into components, products, or infrastructure

Servicing



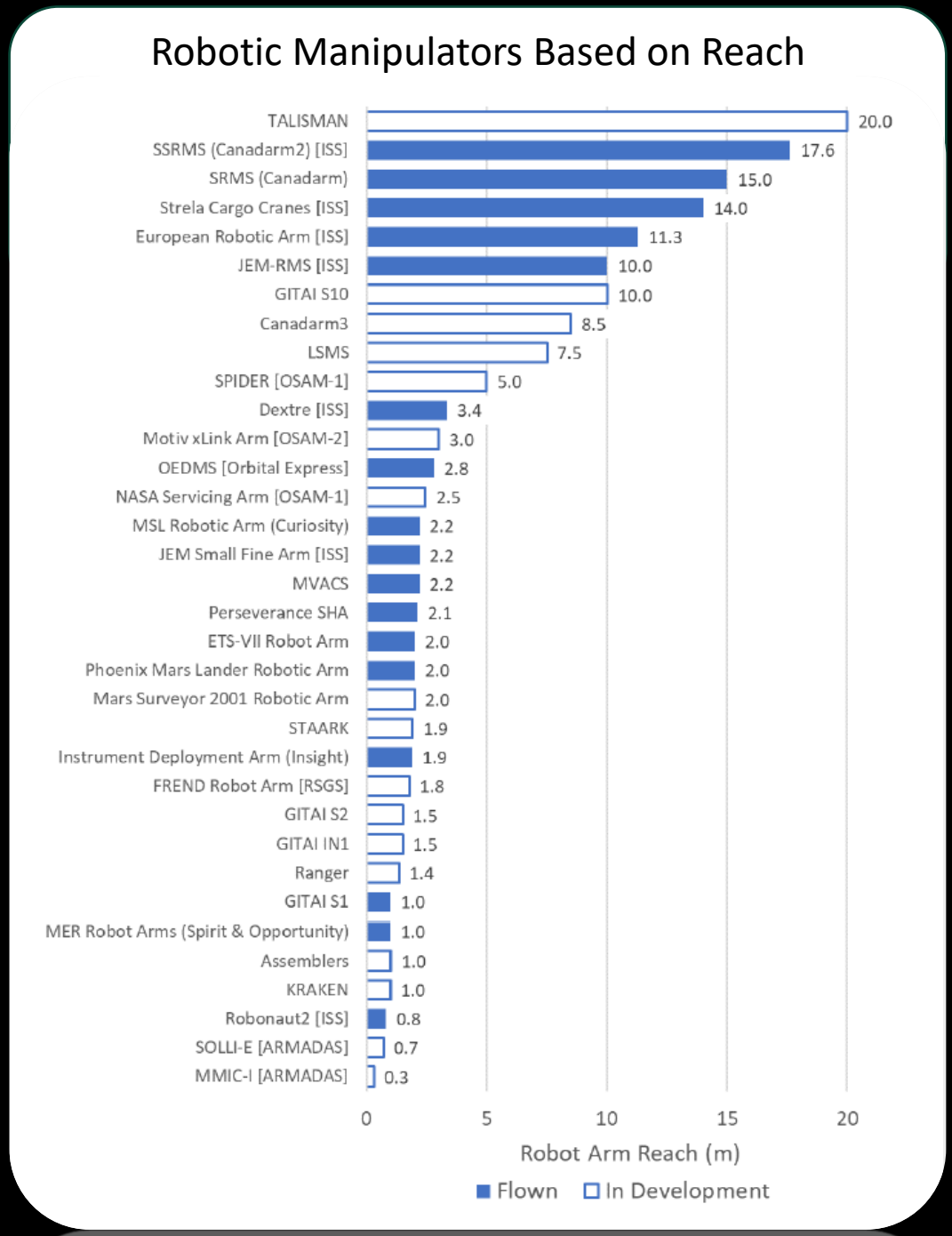
Assembly

Manufacturing

All ISAM Technologies are Rapidly Maturing

- The **ISAM State of Play** is an annual review that characterizes the current state of ISAM capabilities
- Assesses 11 capability areas:

1. Robotic Manipulation
2. Rendezvous and Proximity Operations, Docking and Mating
3. Relocation
4. Planned Repair, Upgrade, Maintenance and Installation
5. Unplanned or Legacy Repair and Maintenance
6. Refueling and Fluid Transfer
7. Structural Manufacturing and Assembly
8. Recycling, Reuse and Repurposing
9. Parts and Goods Manufacturing
10. Surface Construction
11. Inspection and Metrology



Although SNP is planning 15+ years ahead, architectures are relying on current technology

Mars Transportation Assessment Study (MTAS, 2019, report released March 2023) - The study's objectives were to: 1) Establish the feasibility of transportation systems for a ~2-year human Mars mission in the 2030s with **acceptable risk** and **minimal development**, and 2) Provide the agency with necessary knowledge and insights to inform future architectures, concept of operations (ConOps), campaigns, and development of the required capabilities.

NASA Utilization of Space Nuclear Systems (SNS) for Robotic and Human Exploration Missions Response to Executive Order 13972: Promoting Small Nuclear Reactors for National Defense and Space Exploration (July 2022) – "This report examines NASA-envisioned mission applications and associated performance needs for SNS over the next twenty years leading to 2040 along with the unique technical considerations posed by space nuclear technology development……. Integrated, high-power density SNS capable of being packaged in a single vehicle is a key consideration for NASA. Due to concerns for complexity and reliability, in-space reactor assembly and reactor refueling are not current design considerations."

ISAM is not being considered because of perceived cost, schedule, and risk concerns

ISAM should not be neglected or an afterthought

The role of ISAM is not defined for SNP mission and vehicle architectures……..yet

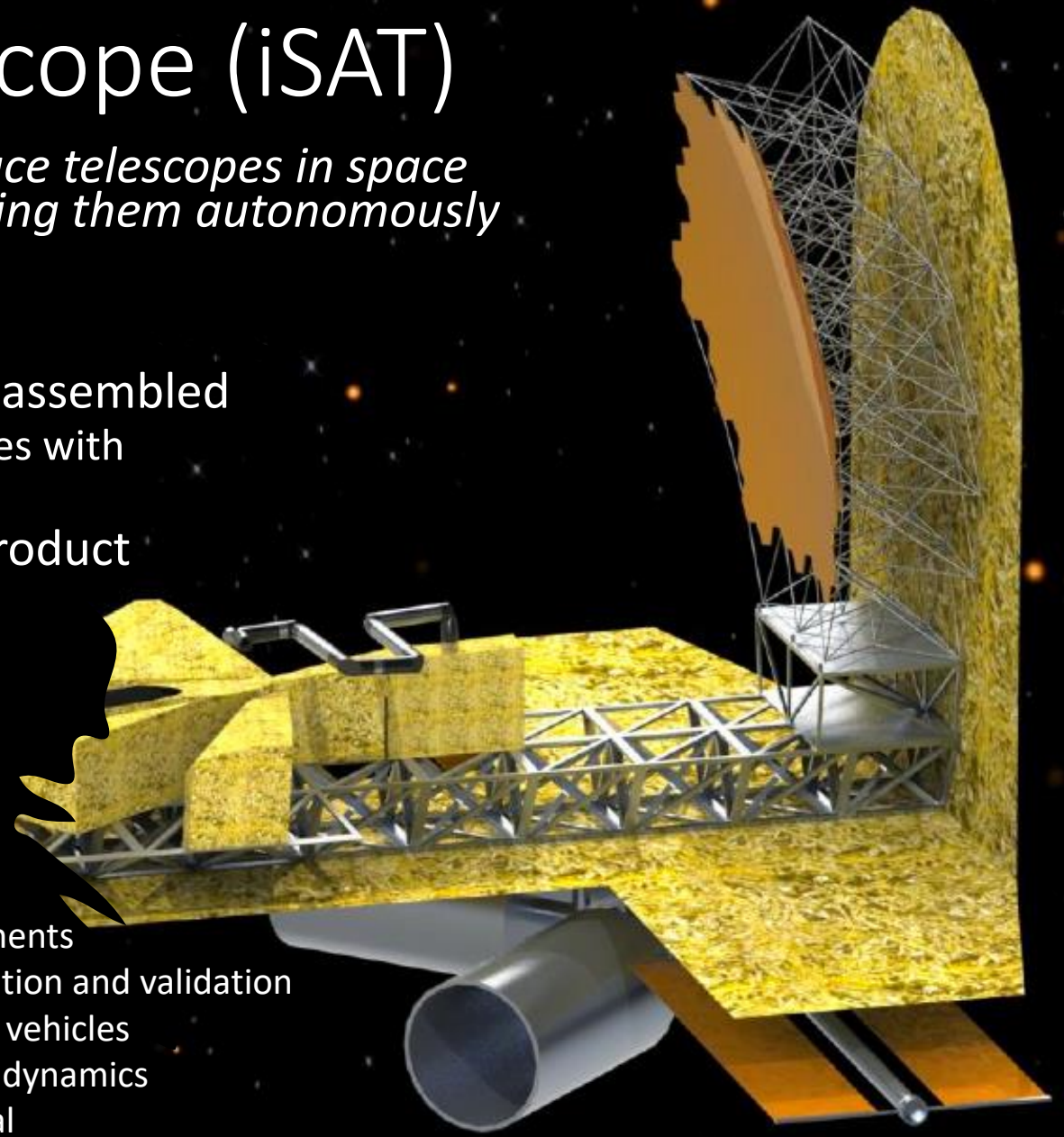
So how do we define it?

In-Space Assembled Telescope (iSAT)

Study Objective: "When is it worth assembling space telescopes in space rather than building them on the Earth and deploying them autonomously from single launch vehicles?"

Outcome:

- Telescopes with aperture > 15 m will need to be assembled
  - ISAM is a viable approach to achieve larger apertures with benefits for even 5-m class telescopes
- Servicing, repair, and upgrading are natural by-product of designing with ISAM
- Risk posture potentially more manageable than relying on single-launch approach
- Technology gaps identified



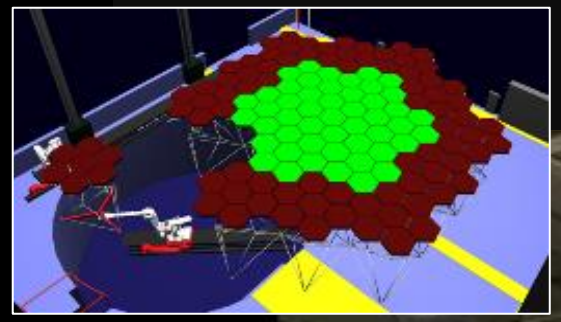
Study involvement:

- 72 participants
- 6 NASA Centers
- 14 private companies
- 2 government agencies
- 5 universities

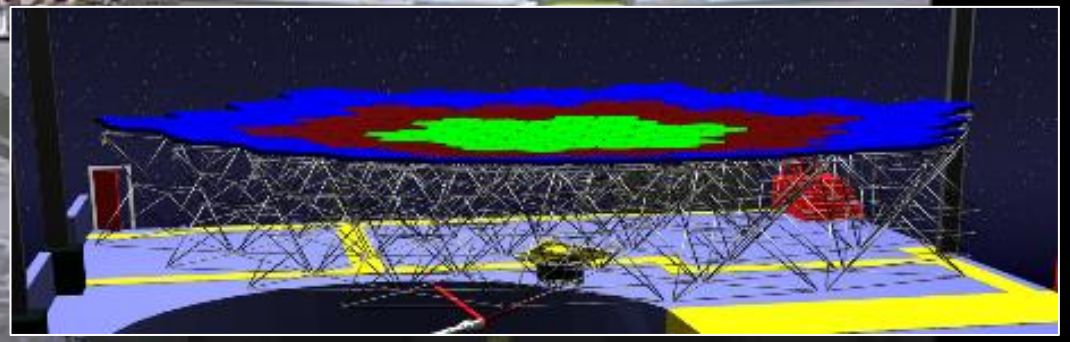
Disciplines:

- Rendezvous and proximity operations
- Telescope optics
- Robotics
- Structures
- Sunshade
- Instruments
- Verification and validation
- Launch vehicles
- Orbital dynamics
- Thermal
- Astrophysics

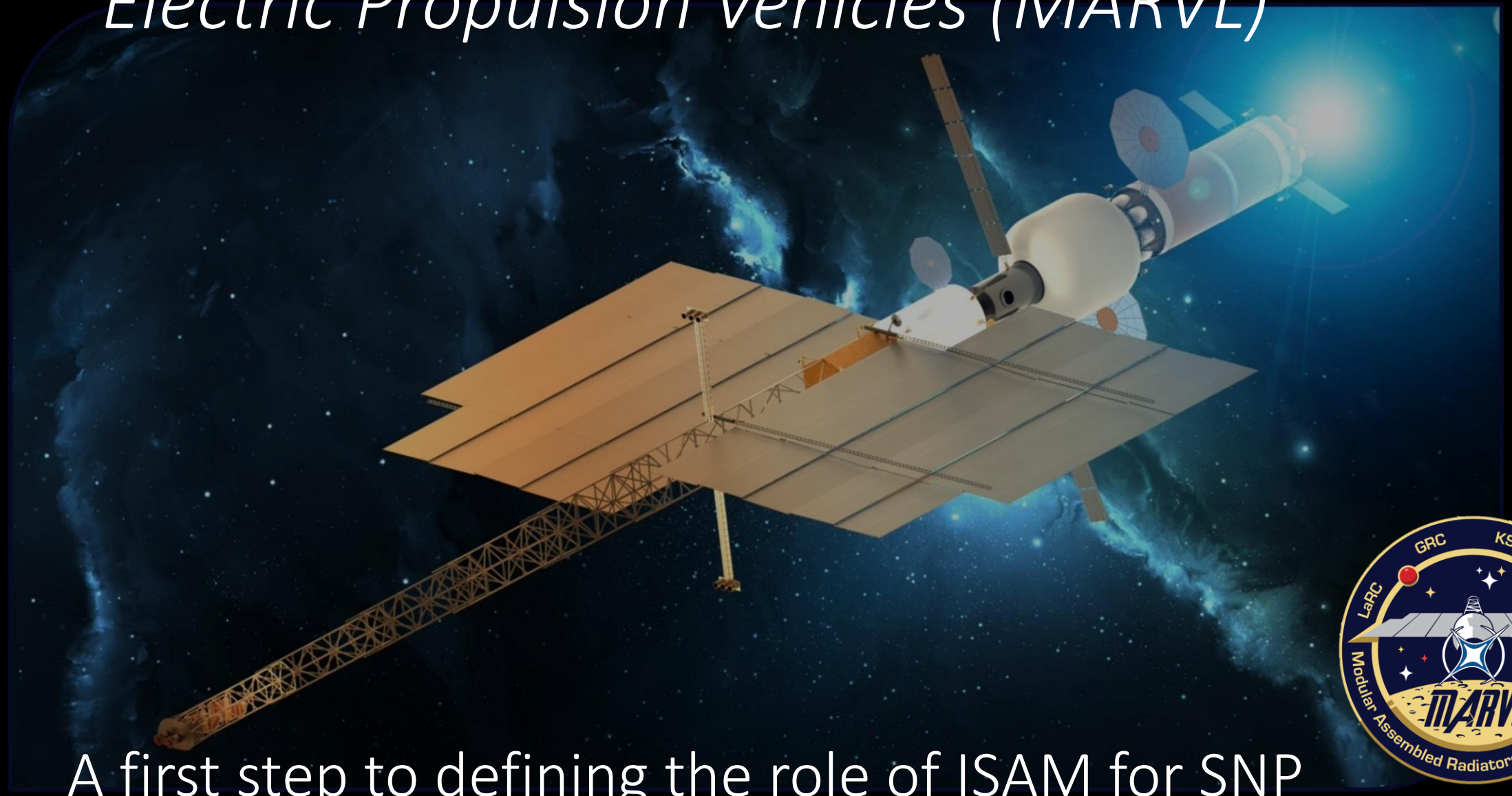
Identifying technology gaps allows research to focus on closing those gaps



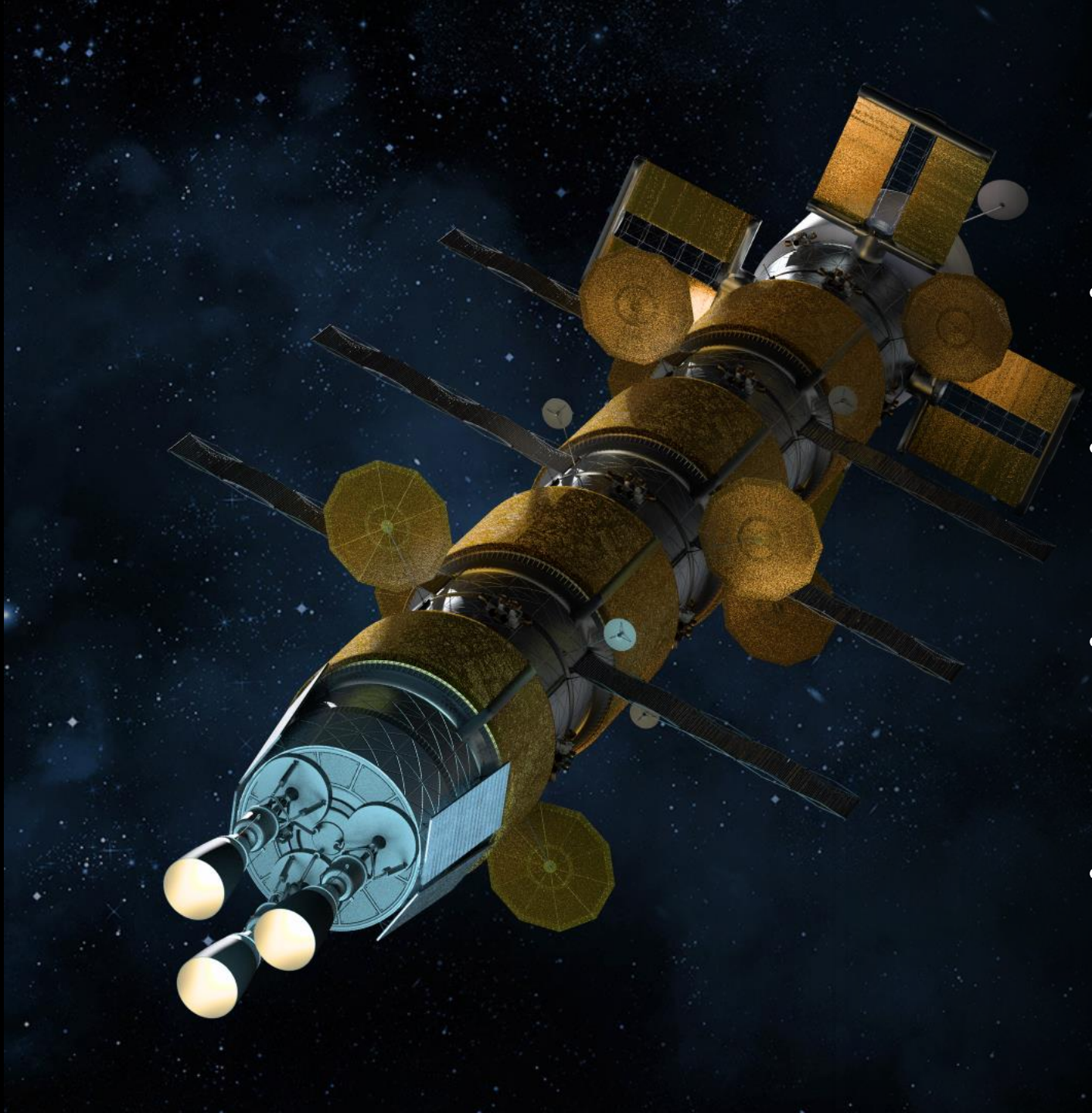
Precision Assembled Space Structures (PASS) Project



Modular Assembled Radiators for Nuclear Electric Propulsion Vehicles (MARVL)



A first step to defining the role of ISAM for SNP



Concluding Remarks

- The role of ISAM for SNP is currently undefined; lots of ideas but nothing codified
- ISAM is game changing for SNP, enabling reusable vehicles, and reducing cost/schedule risk in the long term
- ISAM enables designing a nuclear propelled vehicle for the mission, not design the vehicle to package “origami” style to a launch fairing
- A comprehensive study on incorporating ISAM into SNP architectures from the onset will address concerns raised about cost/schedule risks and identify technology gaps

Thank you. We welcome comments and further discussion.

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