NETS 2025

NUCLEAR and EMERGING TECHNOLOGIES for SPACE

The Case for Architecting Space Nuclear Propulsion Missions and Vehicles That Incorporate In-Space Servicing, Assembly and Manufacturing Principles

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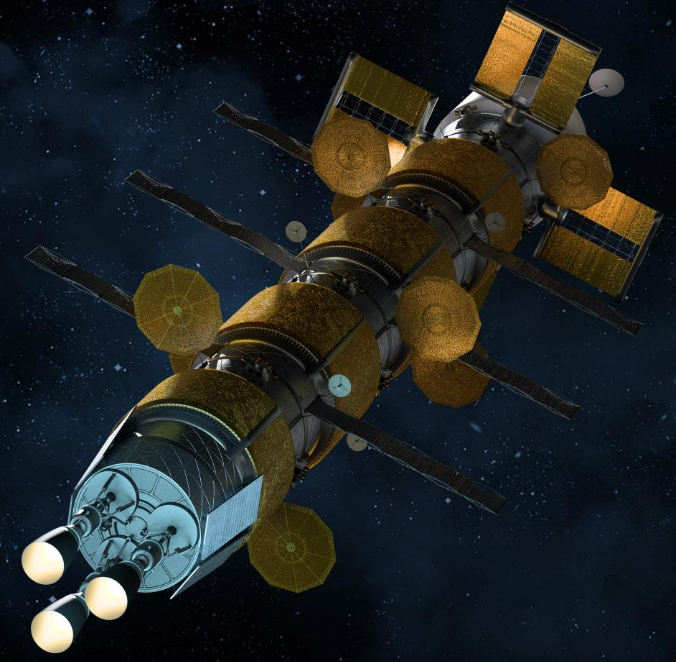
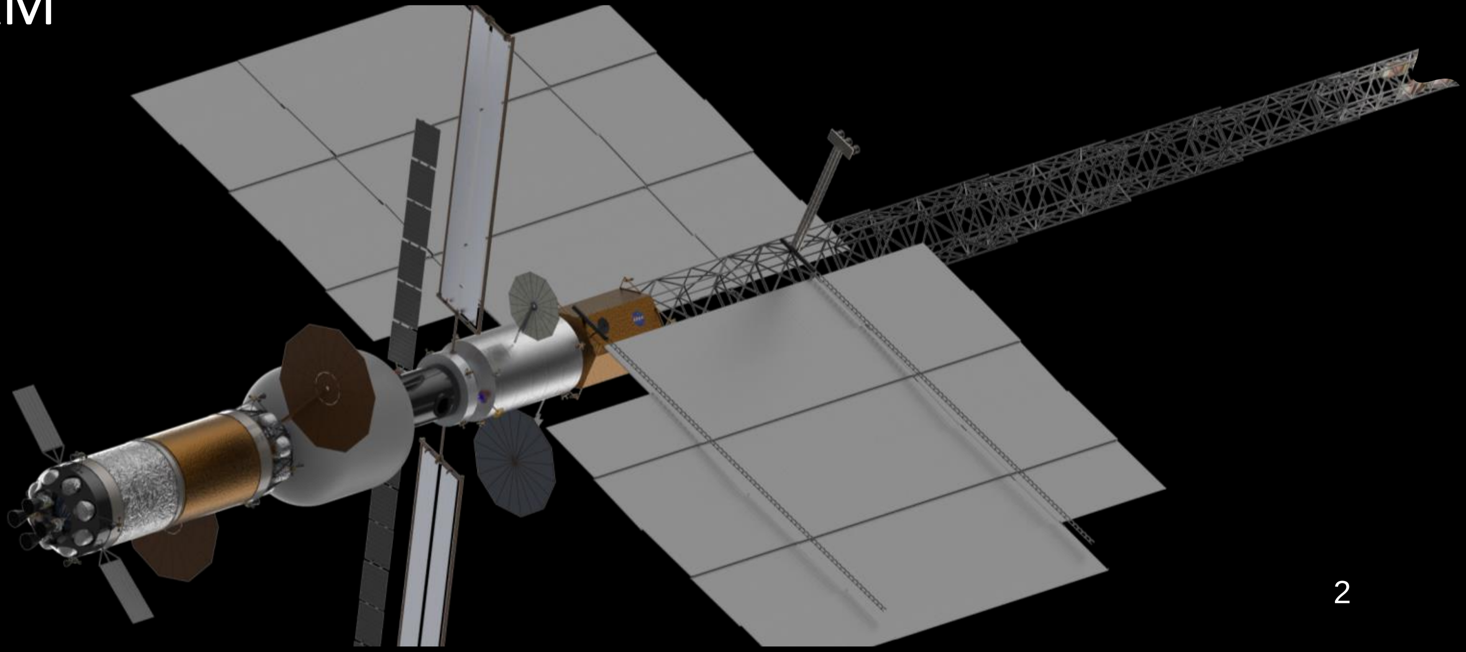
ANS American Nuclear Society

Agenda

- Space Nuclear Propulsion (SNP)
- In-Space Servicing Assembly and Manufacturing (ISAM)
- ISAM benefits to SNP
- Challenges to incorporating ISAM into SNP
- In-Space Assembled Telescope (iSAT): An analogous story
- Current efforts
- Concluding remarks

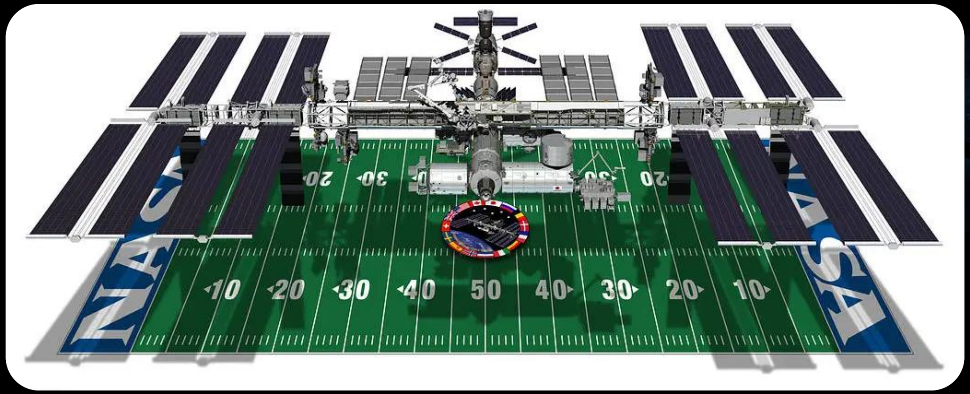




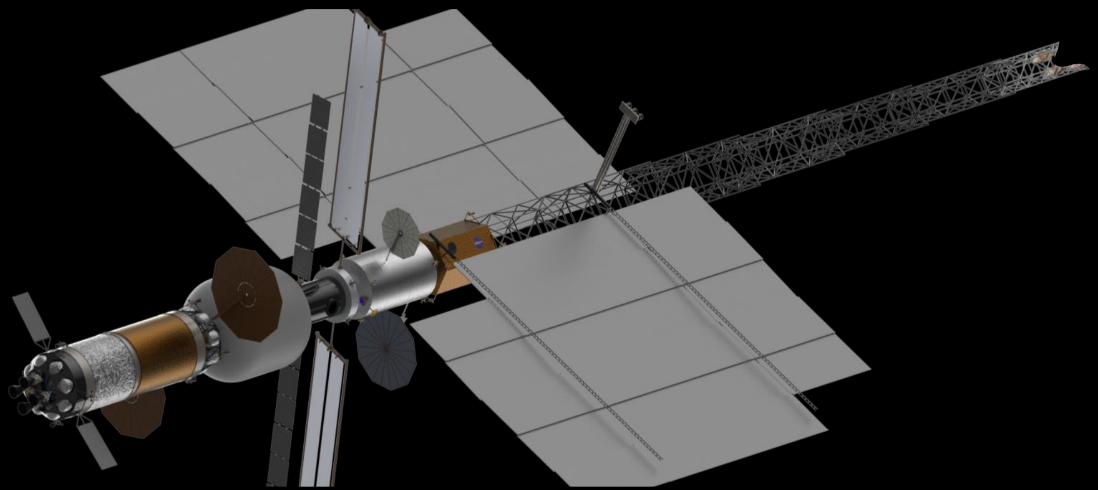
Space Nuclear Propulsion Enhances Mission Efficiency for:

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

SNP vehicles are estimated on the size order of the International Space Station



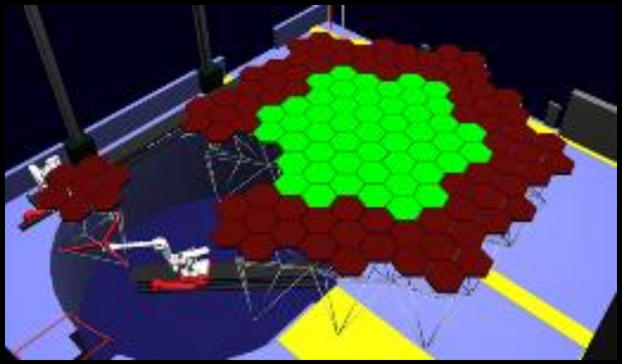
ISS is 109-m end-to-end – almost equivalent to the length of a football field (including end zones)



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	Involves the alteration of space systems after initial launch
Assembly	Involves aggregation and connection of components to create space systems that cannot be achieved with traditional deployment methods and available launch vehicles
Manufacturing	Involves in situ transformation of raw or recycled materials into useable components, products, or infrastructure

Servicing

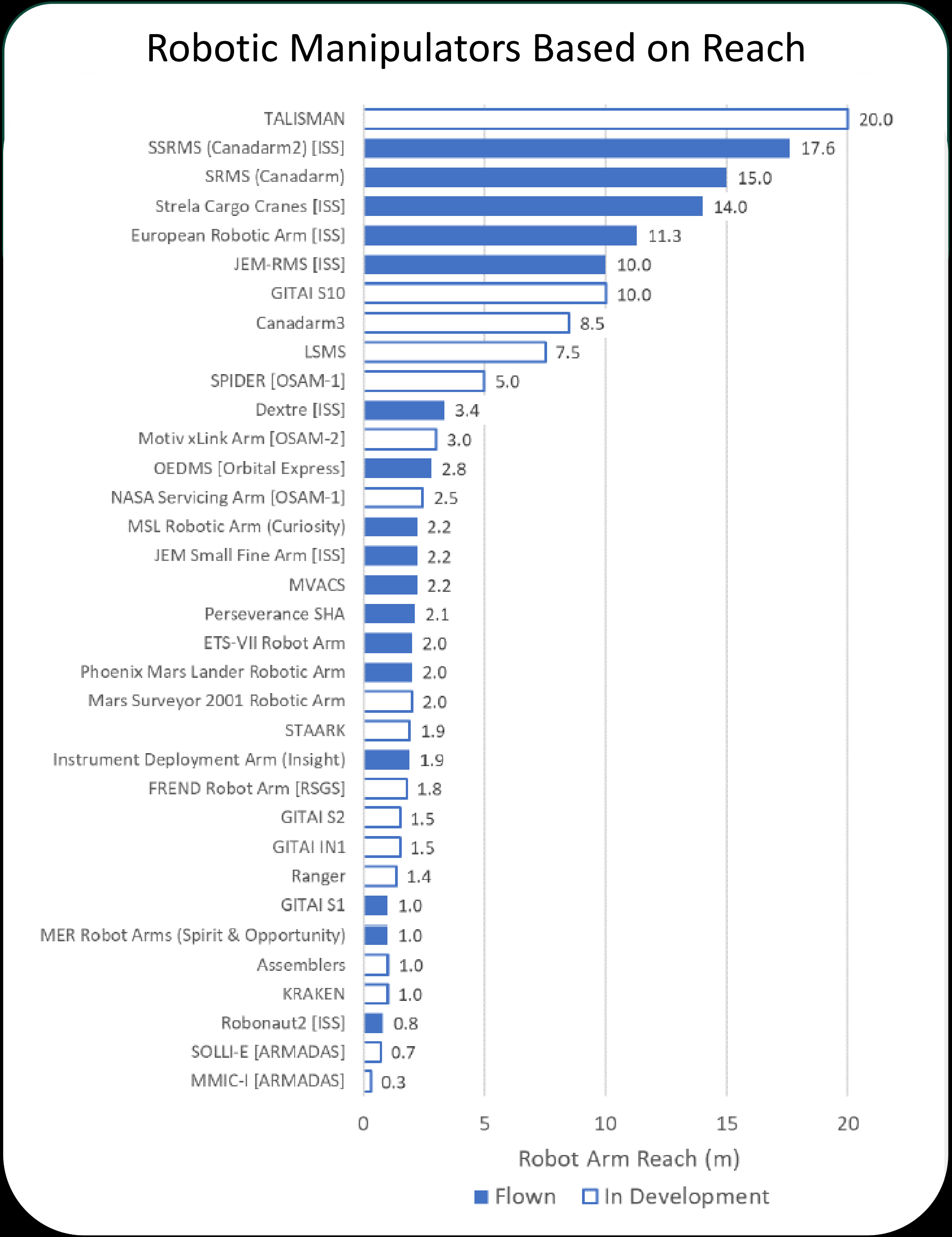


Assembly

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

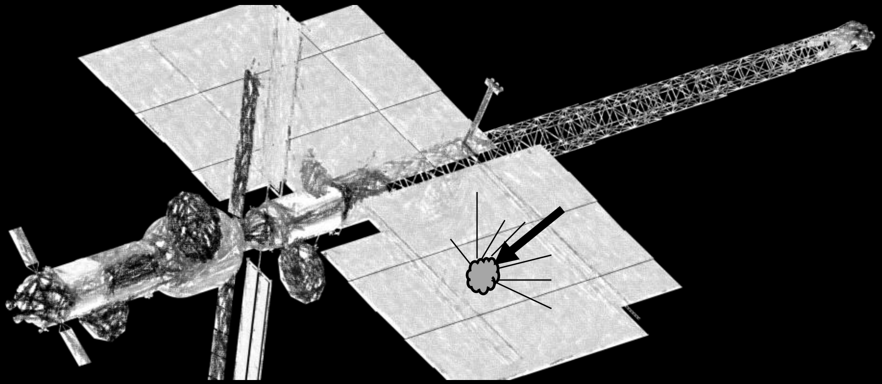


2024 ISAM State of Play: https://ntrs.nasa.gov/citations/20240012414

ISAM benefits SNP architectures through reusability, repair, refueling, and design

Reusability for multiple missions

Design for the mission, not to package “origami” style to a launch fairing



Repair/replacement of components during mission

Refueling of consumables (like propellant)

There is a perception that ISAM adds cost, schedule, and risk concerns to an already risky mission

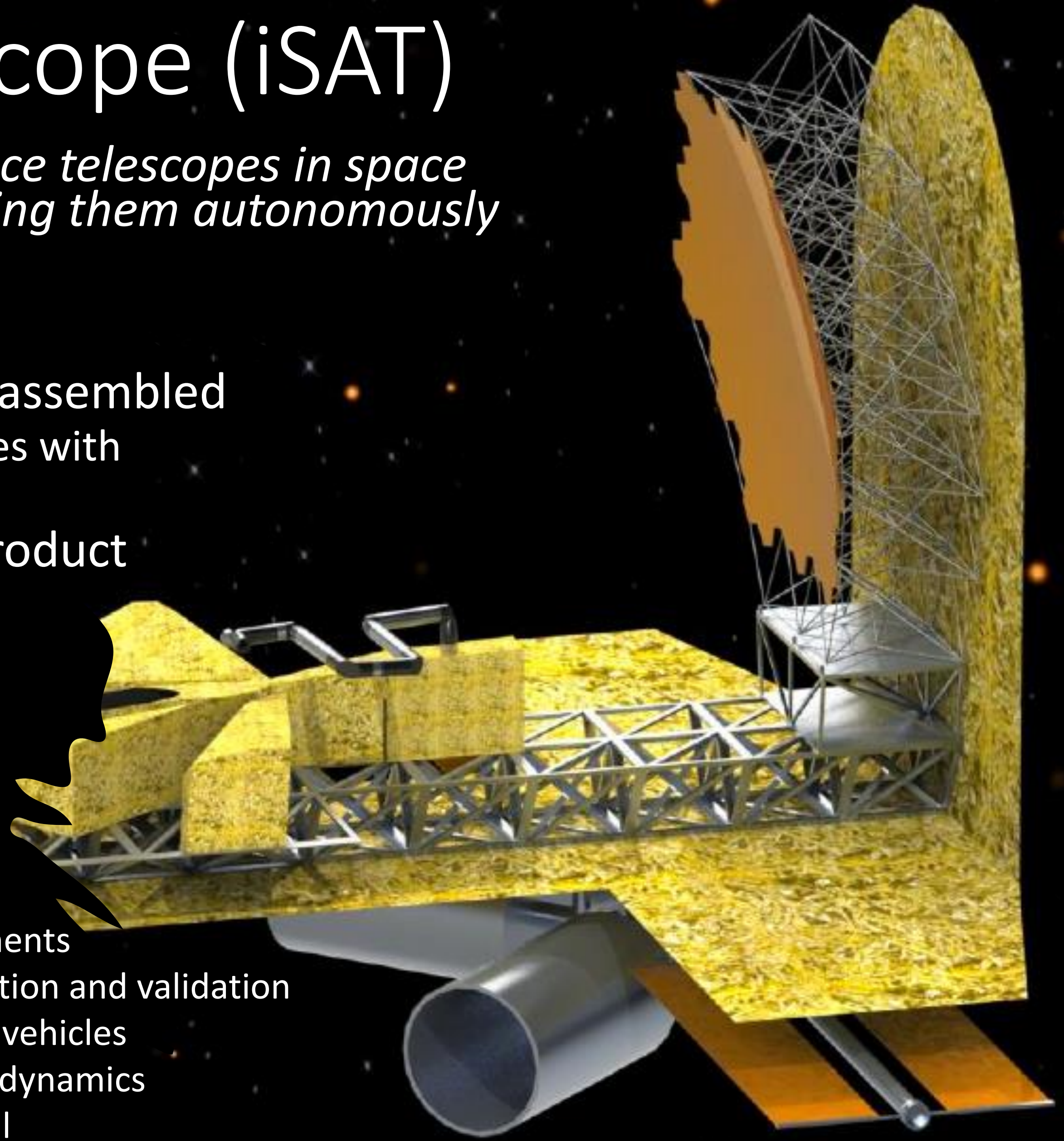
- ISAM should be considered from the onset of mission/vehicle architecture design
- Canceled On-orbit Servicing Assembly and Manufacturing 1 (OSAM-1) mission targeted refueling of a satellite that was not designed to be serviced
- How do we overcome the perceived cost, schedule, programmatic risk?

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



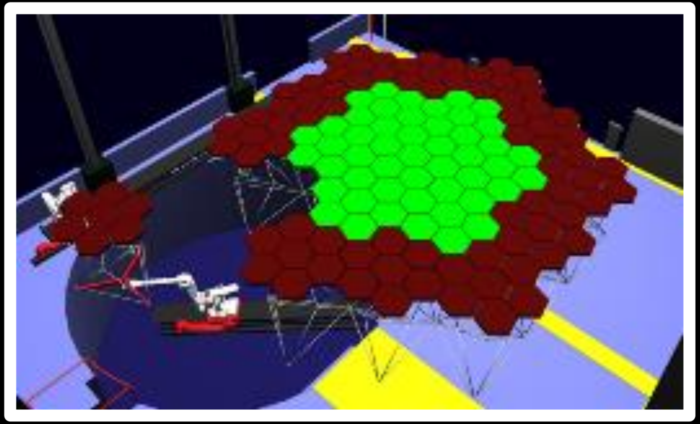
Study involvement:

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

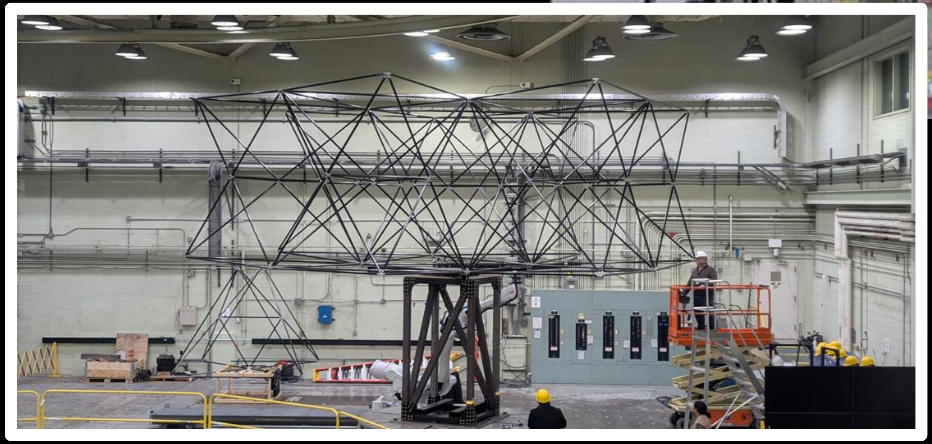
Disciplines:

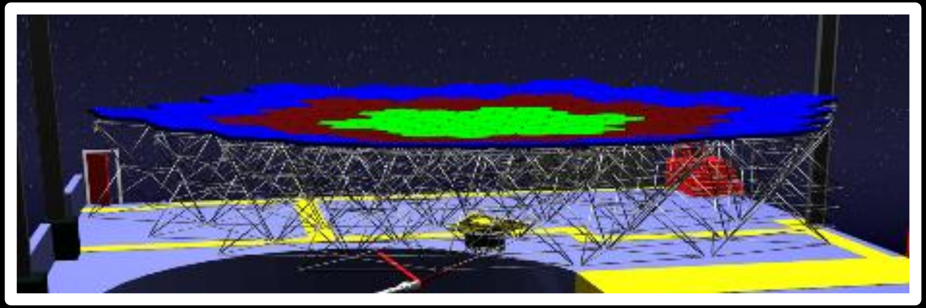
- Rendezvous and proximity operations
- Telescope optics
- Robotics
- Structures
- Sunshade
- Instruments
- Verification and validation
- Launch vehicles
- Orbital dynamics
- Thermal
- Astrophysics

Identifying technology gaps allows research to focus on closing those gaps

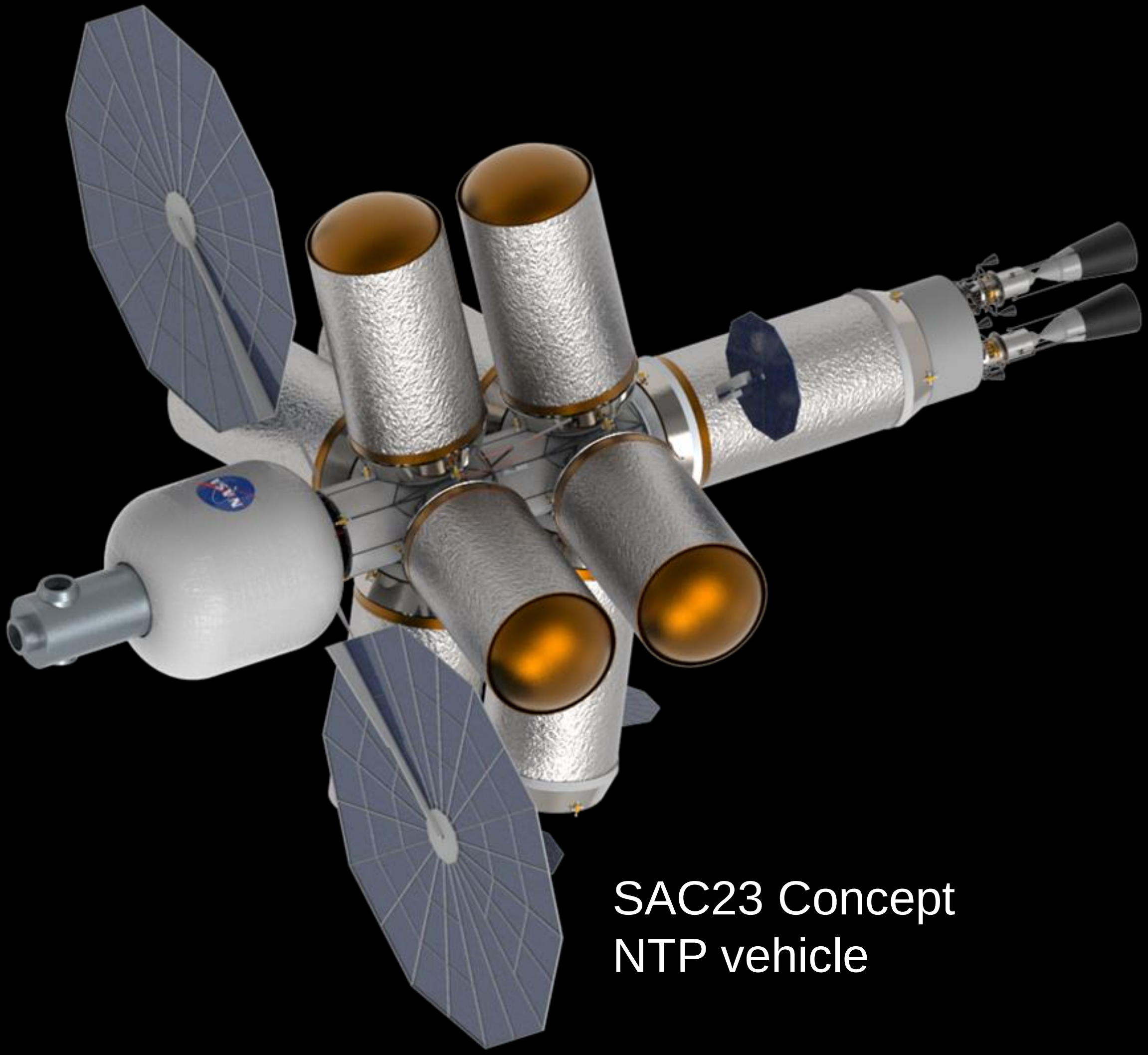


Precision Assembled Space Structures (PASS) Project





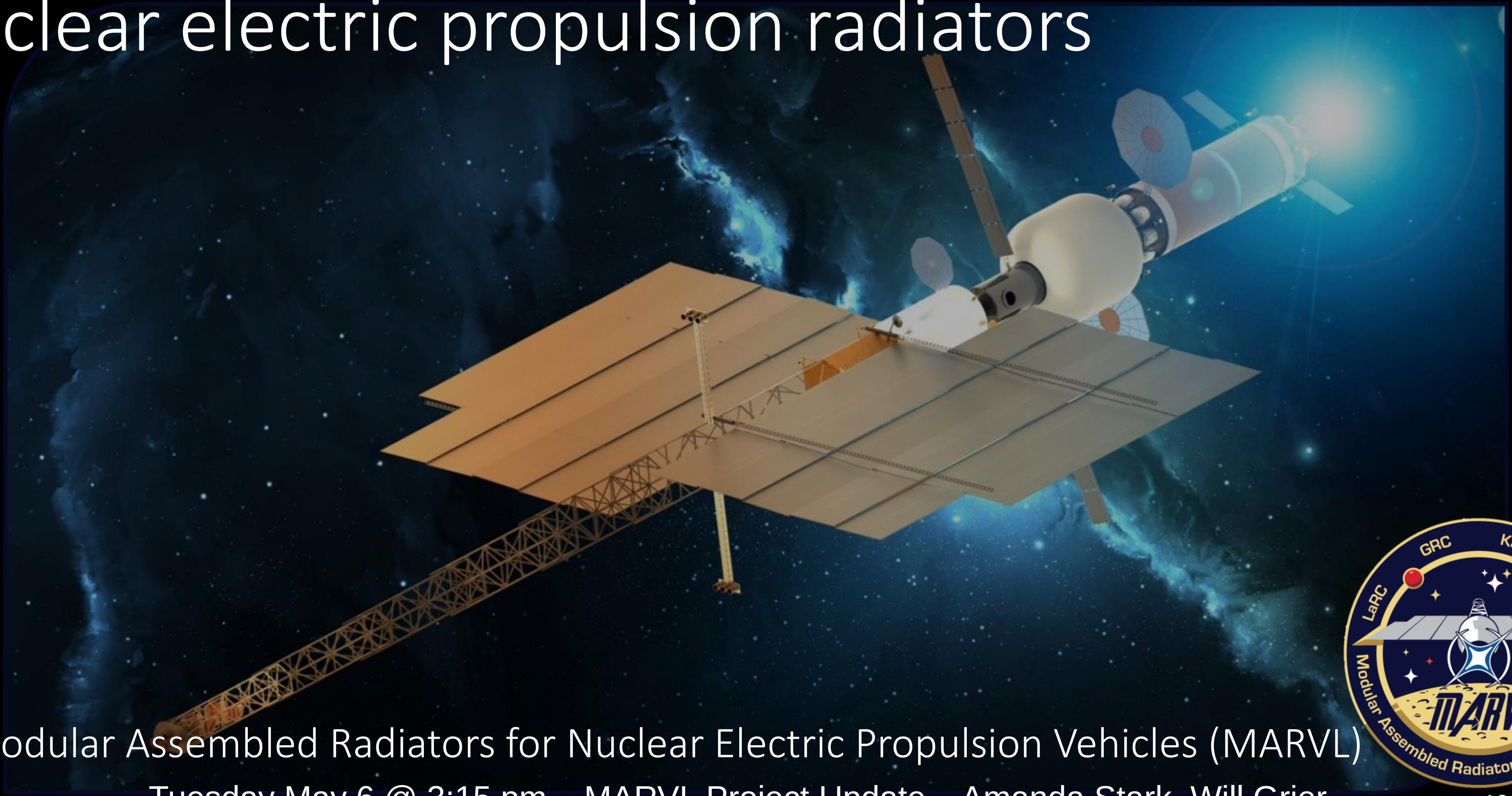
More recent SNP vehicles are starting to consider ISAM for on-orbit aggregation



SAC23 Concept
NTP vehicle

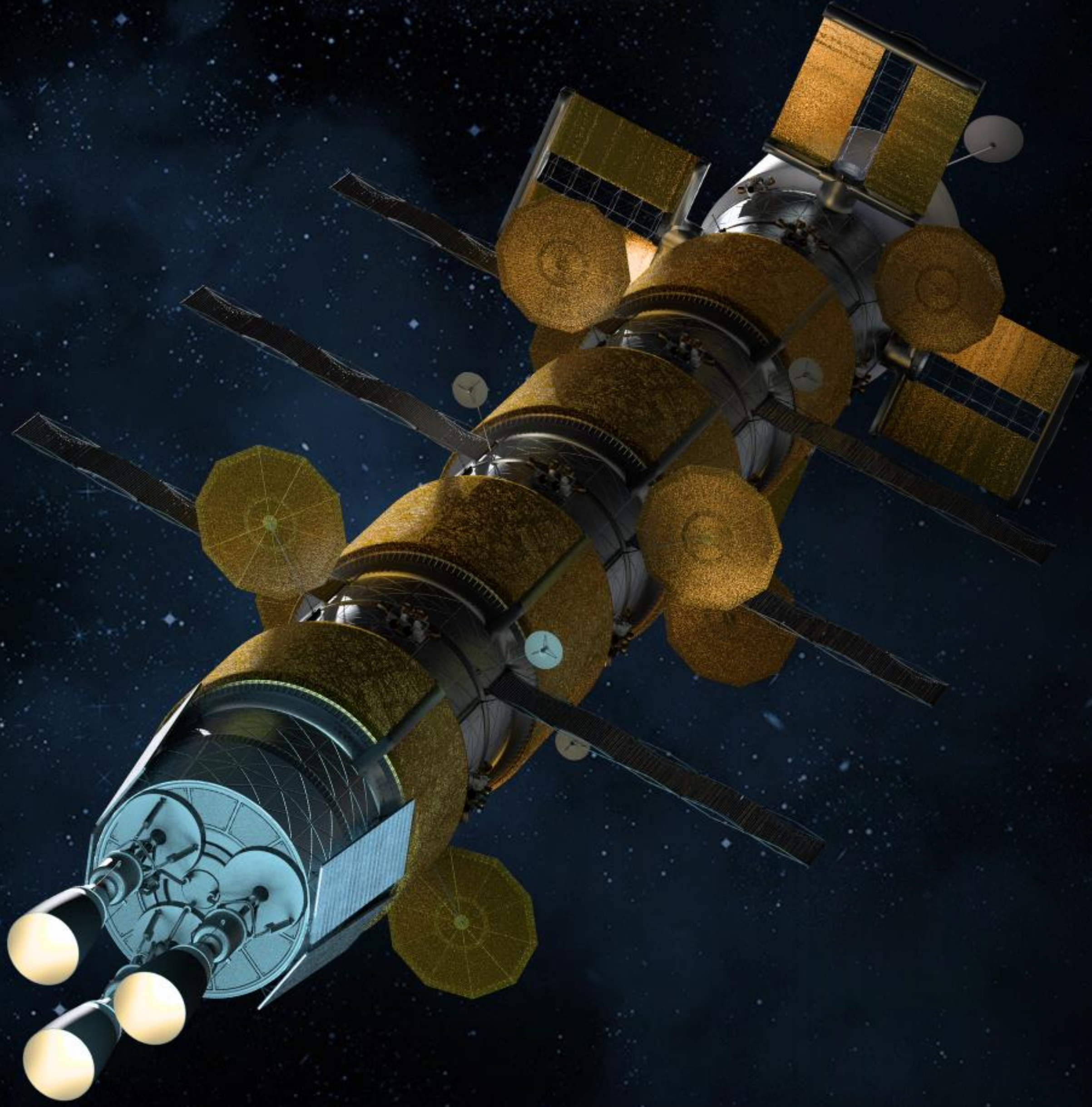
Tendon-Actuated Lightweight In-Space MANipulator (TALISMAN)

MARVL is investigating use of ISAM for the nuclear electric propulsion radiators



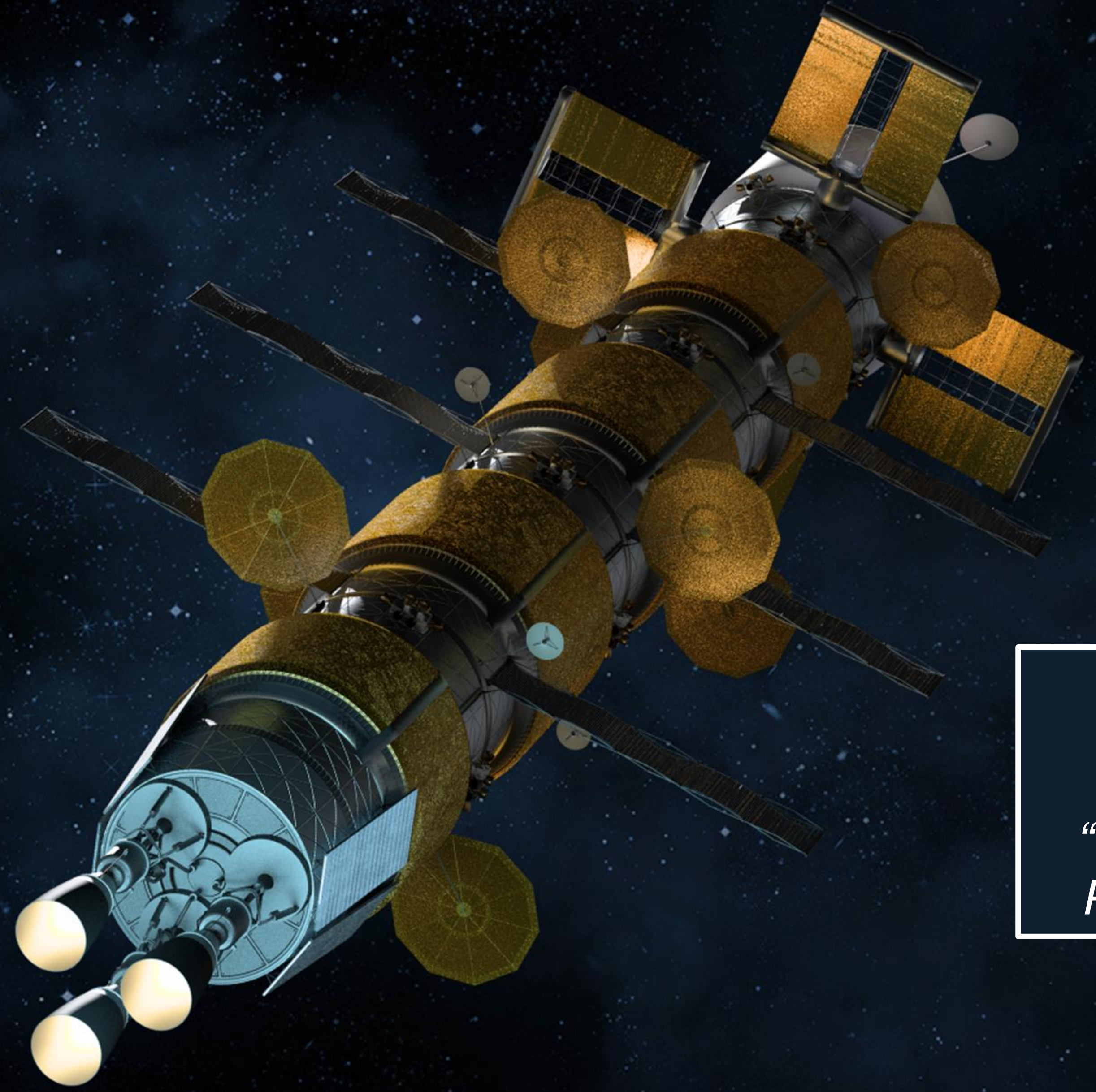
Modular Assembled Radiators for Nuclear Electric Propulsion Vehicles (MARVL)

Tuesday May 6 @ 3:15 pm – MARVL Project Update – Amanda Stark, Will Grier



Concluding Remarks

- The role of ISAM for SNP is currently undefined in mission/vehicle architectures
- 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.

The conversation continues
Tuesday May 6 @ 1:00 pm CDT
SPOC A (Space & Rocket Center)
“Tangential Technologies for Space Nuclear Propulsion Architectures” Panel Discussion

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