National Aeronautics and Space Administration

NASA's Moon to Mars Architecture Workshop

White Paper:
Gateway: The Cislunar Springboard for International and Sustainable Human Deep Space Exploration

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Architecture Workshop Participants

Brazilian Space Agency

Canadian Space Agency

CDTI-EPE

CNES

DLR, German Space Agency at the German Aerospace Center

ESA

ISAS, JAXA

Israel Space Agency

Italian Space Agency

JAXA Space Exploration Center

Kenya Space Agency

Korea Aerospace Research Institute (KARI)

Korea Astronomy and Space Science Institute (KASI)

Luxembourg Space Agency

Mohammed Bin Rashid Space Centre

NASA

Polish Space Agency

Saudi Space Commission

UKSA

WHEN WILL WE ACHIEVE LUNAR OBJECTIVES?

Multi-decadal campaign

Support annual cadence of crewed missions

Development of permanent infrastructure

Expansion of economic sphere to the Moon

WHO DOES THIS APPROACH INCLUDE?

NASA

U.S Government

Industry

International Partners

Academia

Public

WHAT FOUNDATIONAL CAPABILITIES ARE NEEDED

Long-duration microgravity systems

Partial gravity destination platforms

Low Earth Orbit assets and infrastructure

WHERE SHOULD SYSTEMS BE?

Ensure access to the Lunar South Pole

Capability for non-polar expeditions

HOW WILL WE GET THERE AND RETURN?

Lunar Microgravity staging in NRHO

Earth ⟷ NRHO ⟷ Lunar surface

Surface Mobility

WHY EXPLORE?

- SCIENCE -

Understand the universe
Direct observations

- INSPIRATION -

“Artemis Generation”
Overcome challenges
Succeed with hard work

- NATIONAL POSTURE -

Enrich lives on Earth
Technology development
International partnerships

The Gateway to Exploration

- Gateway is a multi-purpose, long-duration cislunar platform.
- With our international and commercial partners, Gateway is expanding the frontier of human exploration from LEO to cislunar while simultaneously preparing to springboard humans deeper into the solar system.
- Just like we learned with the International Space Station (ISS), Gateway's foundation of interoperability and flexibility enable future growth, expansion, and adaptability
- The ACR22 White Paper and this presentation outline how Gateway supports multiple Moon to Mars Recurring Tenets, Goals, and Objectives.

Gateway Integrated Spacecraft + Partner Programs

Co-manifested (PPE/HALO)
Launch Vehicle

SPACEX

Gateway External
Robotic System (GERS)
Canadarm3

CANADIAN SPACE AGENCY
AGENCE SPATIALE CANADIENNE

Logistics Module
Dragon-XL

SPACEX

Co-manifested
Artemis IV, V and VI
Launch Vehicle

BOEING

NORTHROP GRUMMAN

AEROJET ROCKETDYNE

Power and Propulsion
Element (PPE)

MAXAR

ESPRIT-Refueler

esa

Airlock
Provider TBD

Human Landing
System (HLS)
(government reference
concept shown)

Habitation and Logistics
Outpost (HALO)

NORTHROP GRUMMAN

JAXA

esa

International Habitat
(I-HAB)

esa

JAXA

Orion

NASA

esa

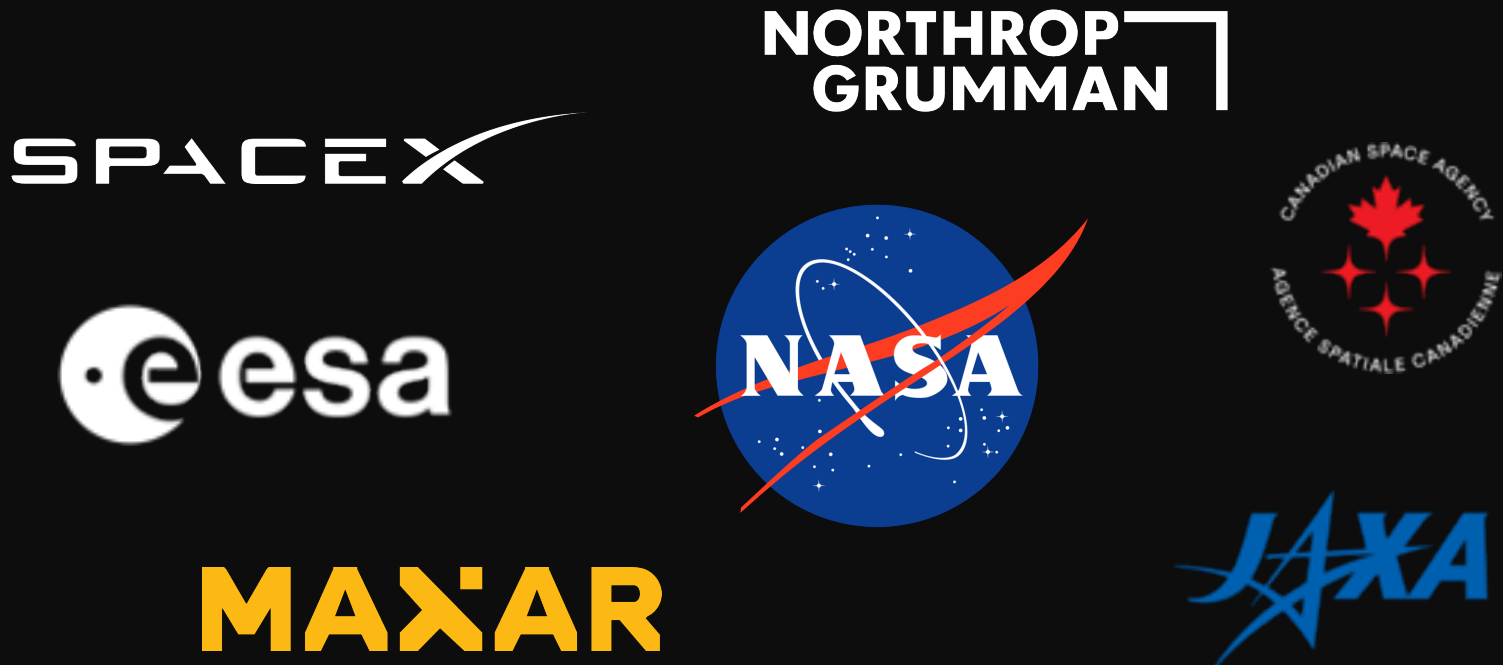
LOCKHEED MARTIN

Logistics Module
HTV-XG

JAXA

Recurring Tenet – International and Industry Collaboration

- Gateway advances International Partnerships founded in ISS with future opportunities for additional international collaborations
- Industry Partners building off LEO experience and expertise expanding the frontier of sustained human exploration

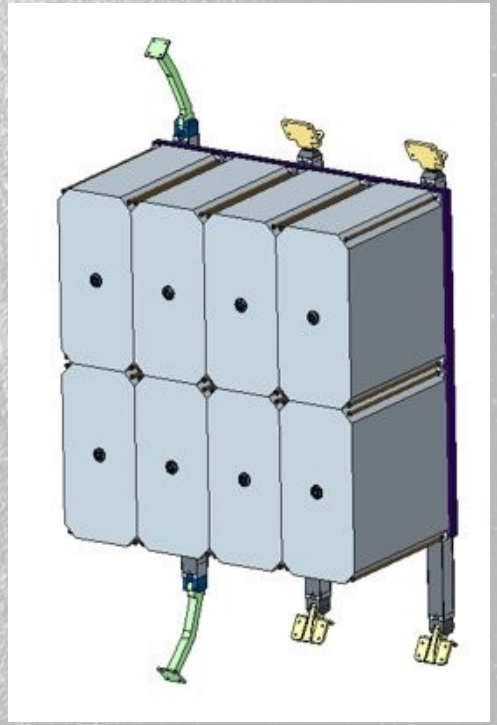


Gateway Supports M2M Science Objectives

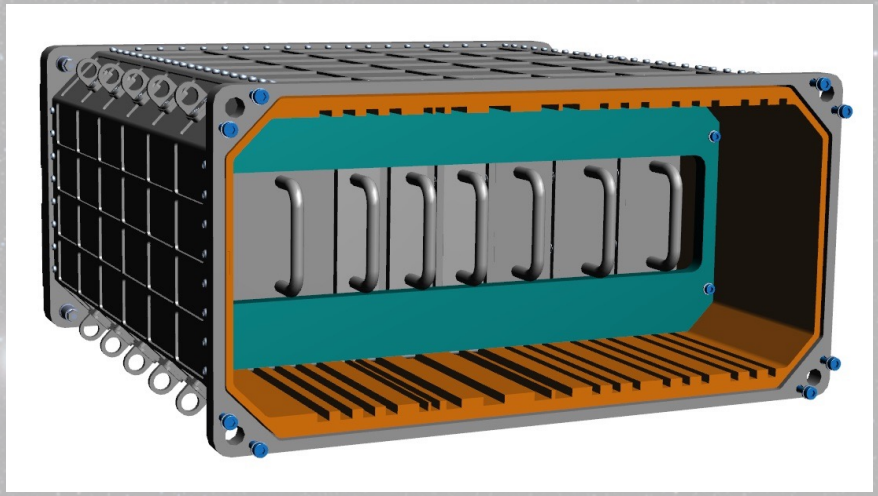
- **Laboratory operating in cislunar space year round**
  - **Moon to Mars Objectives: heliophysics, human and biological science, physics and physical science, science-enabling and applied science**
  - **Gateway was designed with capabilities for science, technology, and research in mind with accommodations and standard interfaces for internal and external utilization**
  - **Potential for additional research platform via logistics vehicles**

Gateway Science – Internal Payloads

- **ESA's Internal Dosimeter Array (IDA) includes instruments provided by JAXA; will be integrated and launched in HALO**
- **Accommodations for a total of 16 locker-based and mounted payloads**
- **Capabilities for cabin deployed payloads**
- **Gateway's payloads are being designed for autonomy**



Gateway Payload Bank Concept

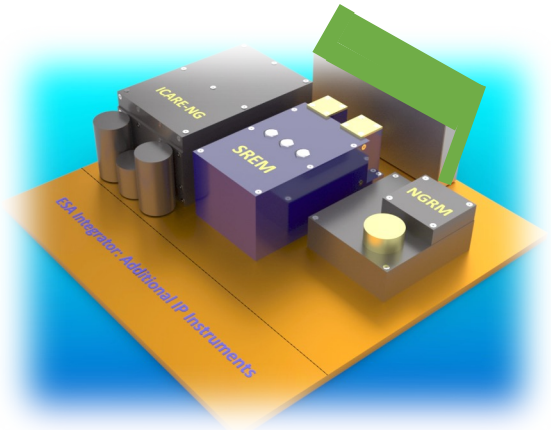


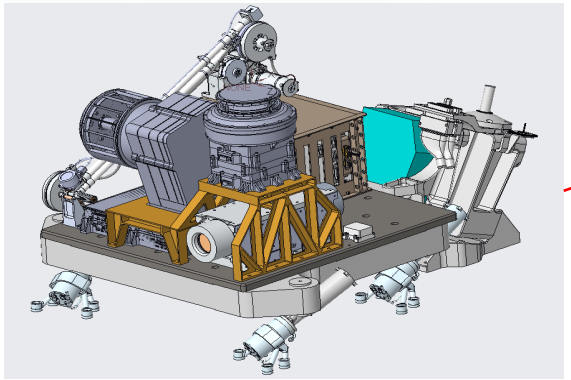
Internal Dosimeter Array

Gateway Portable Equipment Panel Concept

Gateway Science – External Payload Accommodations

ESA/ESTEC
Space Weather
(Includes JAXA Low-Velocity Dust Monitor)





Heliophysics Environmental & Radiation Measurement Experiment Suite (HERMES)
NASA/GSFC
Heliophysics

PPE SORI Payload
(not visible, empty at launch)

Airlock Module Payload Support TBD

I-Hab SORI Payloads
(I-Hab PDR assumption: one at launch)

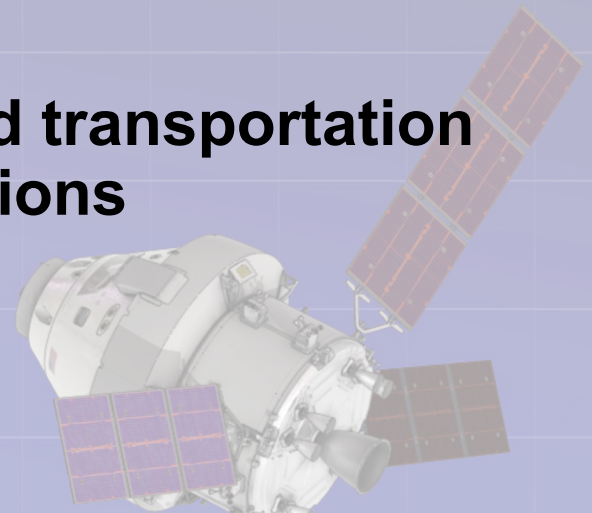
+Y +X +Z

Gateway Supports Infrastructure, Transportation & Habitation Objectives

- **Habitation supporting 4 crew**
  - Accommodations, life support systems, medical and crew support for 30+ days stays at Gateway with consumables resupply via logistics
  - Reliability and maintenance enhancements focused on future exploration needs
- **Gateway infrastructure enabling missions**
  - Communications to Earth as well as relay between Earth and lunar surface
  - High powered solar electric propulsion coupled with refueling
- **Future additions increase capability**
  - Mars class transit habitat

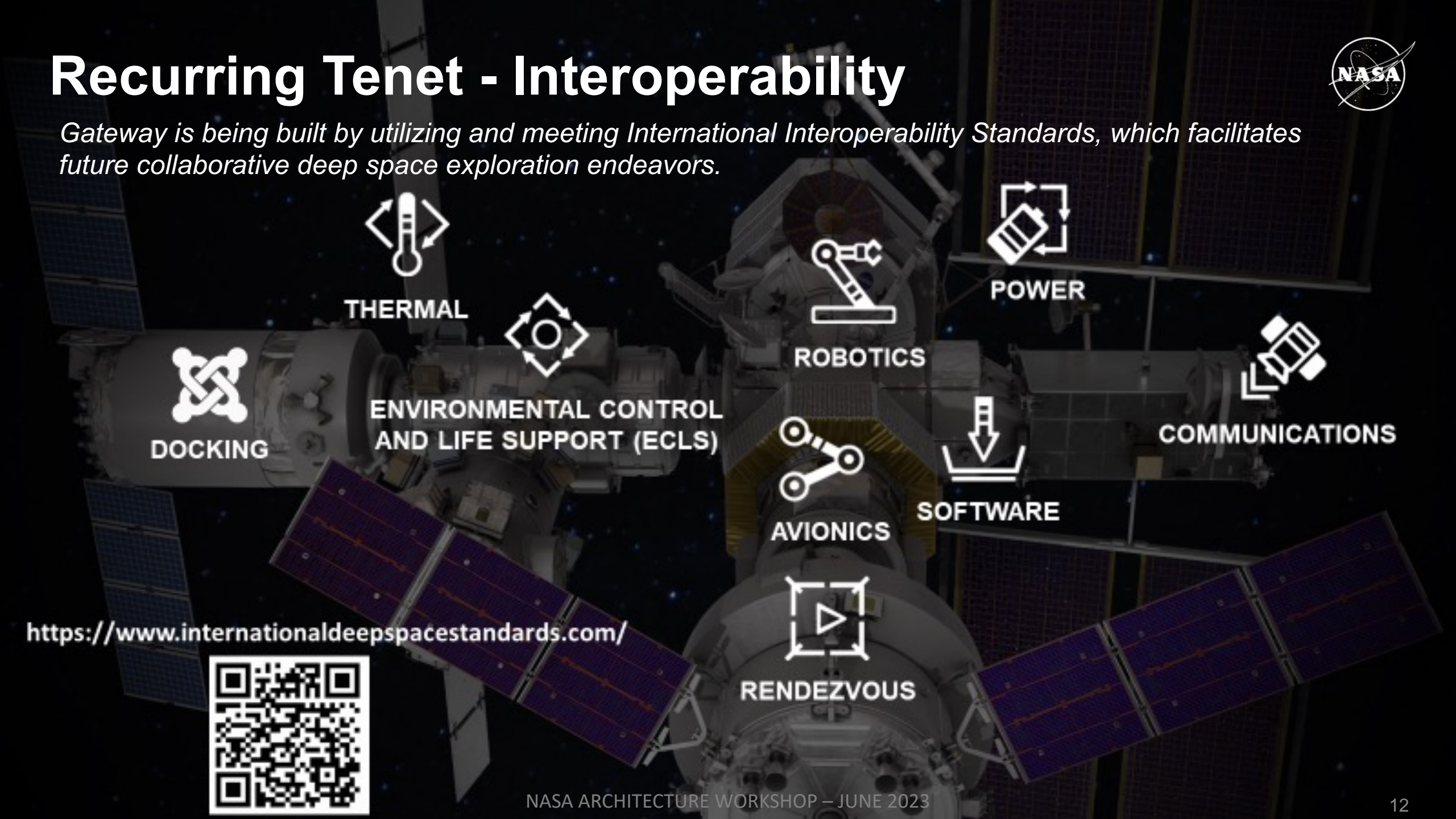
Gateway Supports Operations Objectives

- Continuous operations in a relevant deep-space environment
- Crewed and uncrewed operations farther from Earth
- Crew tended vehicle vice permanently crewed vehicle
- Advancements in maintainability, reusability, quiescence, and autonomy
- Robotics
- NRHO location opens up ability for multiple launch and transportation vehicles to access Gateway and support Artemis missions



Recurring Tenet - Interoperability

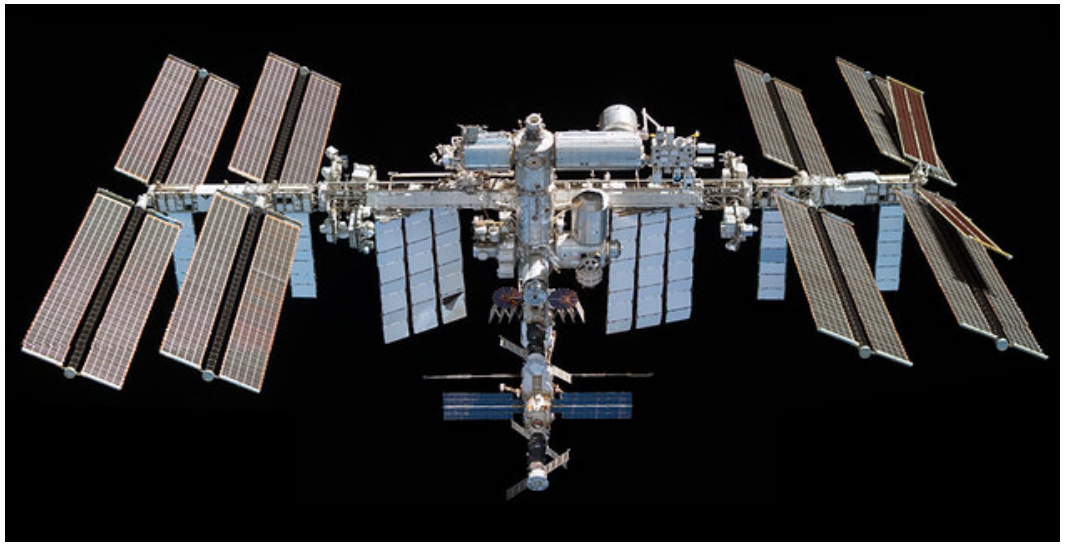
Gateway is being built by utilizing and meeting International Interoperability Standards, which facilitates future collaborative deep space exploration endeavors.



https://www.internationaldeepspacestandards.com/

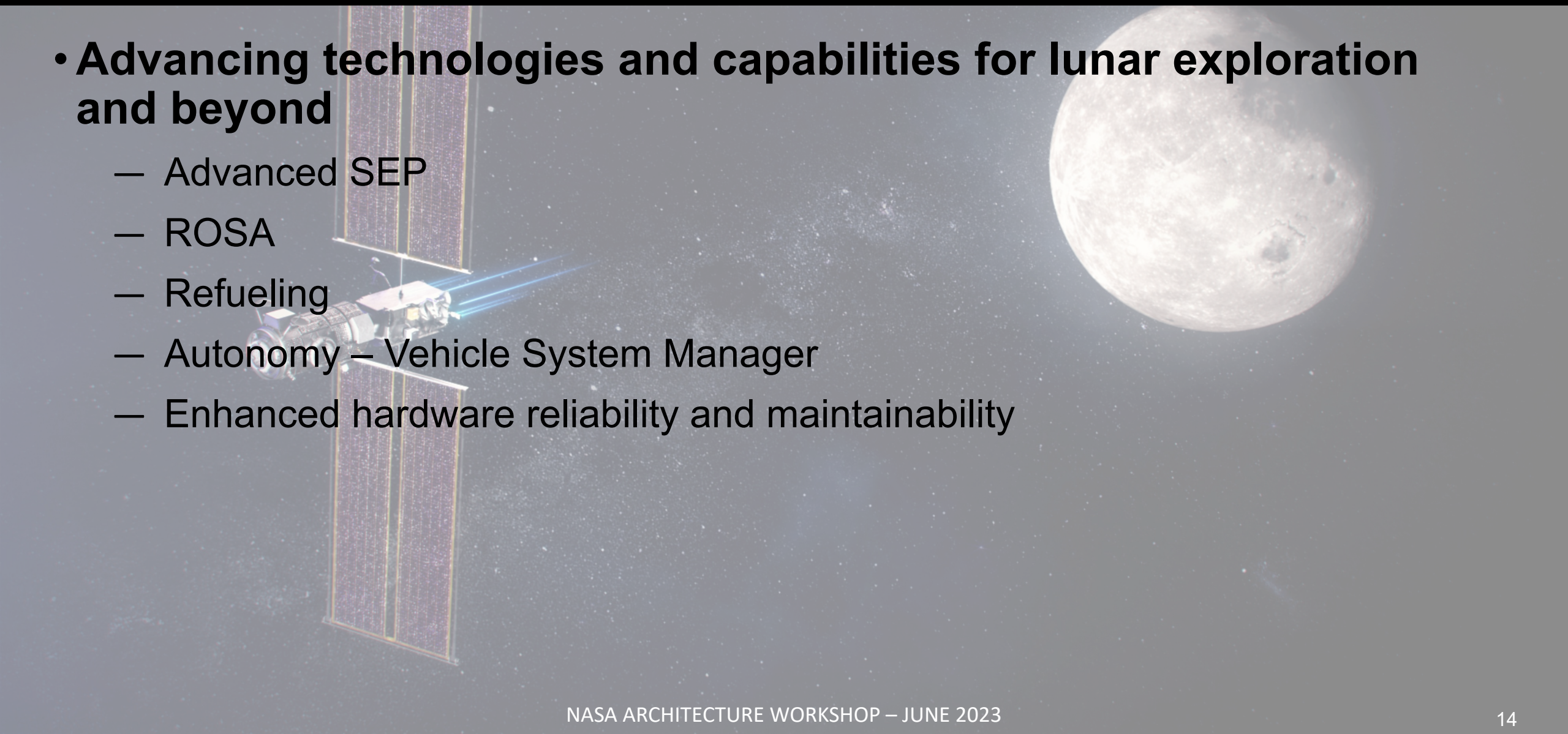
Recurring Tenet – Leveraging Low-Earth Orbit

- **Gateway is an evolution of ISS, building off 24+ years of operations, technology development and maturation as well as lessons learned**



- **Leveraging ISS capabilities for Artemis**
  - HTV-X -> HTV-XG
  - iROSA -> ROSA
- **Utilizing ISS as a LEO test bed for Gateway**
- **Gateway and ISS are complementary, research and utilization that can be done in LEO will be done there, opening new potentials for commercial LEO**

Key Driver – Technology Development & Readiness

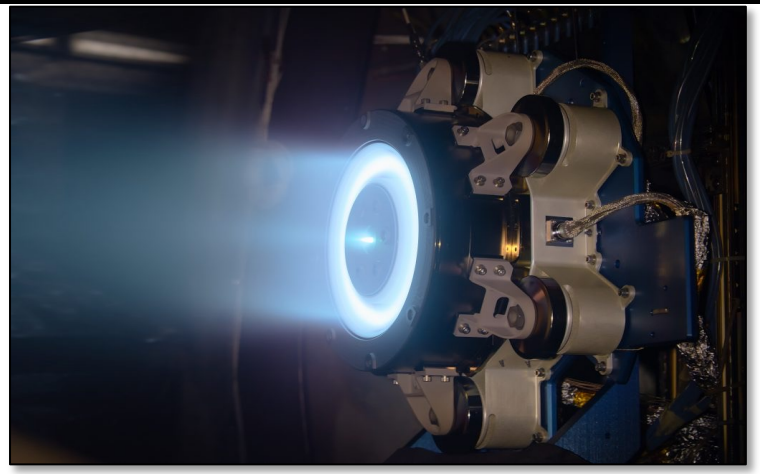


- **Advancing technologies and capabilities for lunar exploration and beyond**
  - Advanced SEP
  - ROSA
  - Refueling
  - Autonomy – Vehicle System Manager
  - Enhanced hardware reliability and maintainability

Gateway is taking shape

HALO structure in the friction stir weld machine (TASI, Italy)

PPE flight batteries have all been delivered.



Testing of the integration of Aerojet Rocketdyne's thruster with Maxar's power procession unit and Xenon Flow Controller

NASA Docking System Block 2 Passive Unit – flight unit for HALO

PPE Central Cylinder. At Maxar's facilities in Palo Alto, California

12-kilowatt Advanced Electric Propulsion System (AEPS) qualification thruster

Summary

- **Gateway is a multi-purpose, long-duration cislunar platform**
  - Supports multiple Moon to Mars goals and objectives
- **Critical element of sustained deep space infrastructure**
  - Serves as a stepping-stone beyond the Earth-Moon system to Mars

Access the white paper with this QR code or at www.nasa.gov/MoonToMarsArchitecture