

National Aeronautics and Space Administration



# HEO Status Report

William H. Gerstenmaier

Associate Administrator

Human Exploration & Operations Mission Directorate

Nov. 29, 2017

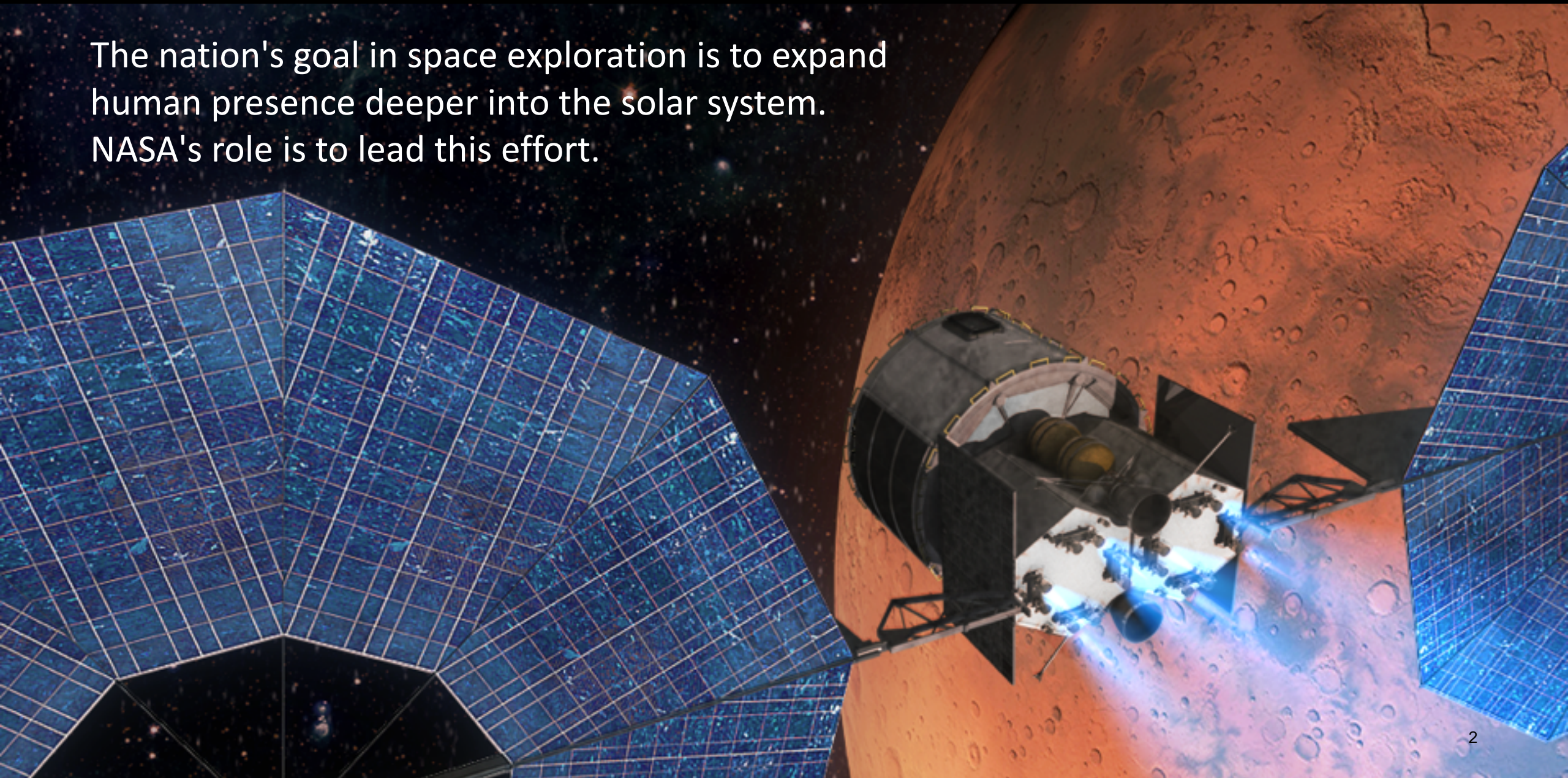




## HUMAN SPACEFLIGHT GOAL



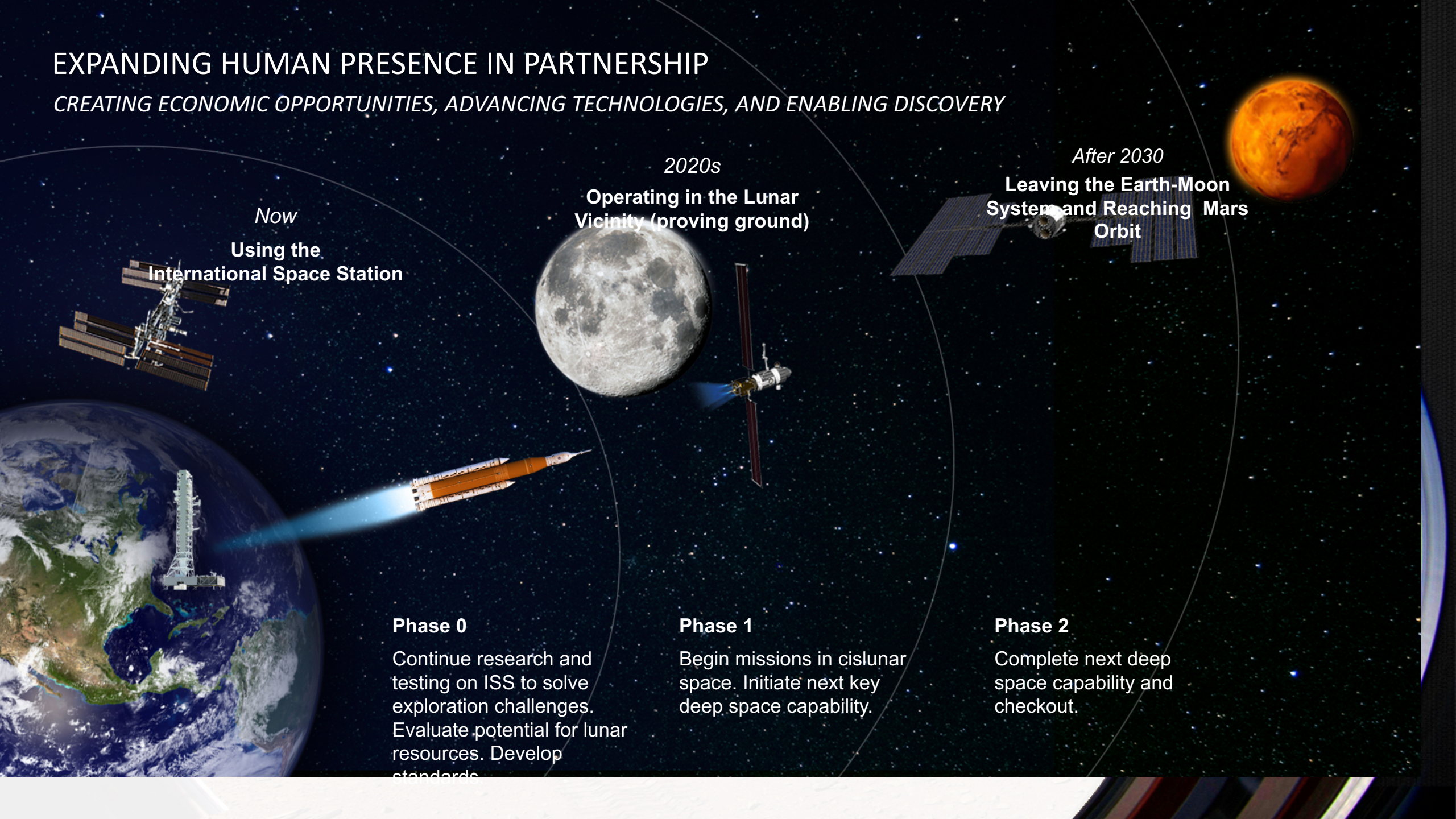
The nation's goal in space exploration is to expand human presence deeper into the solar system. NASA's role is to lead this effort.





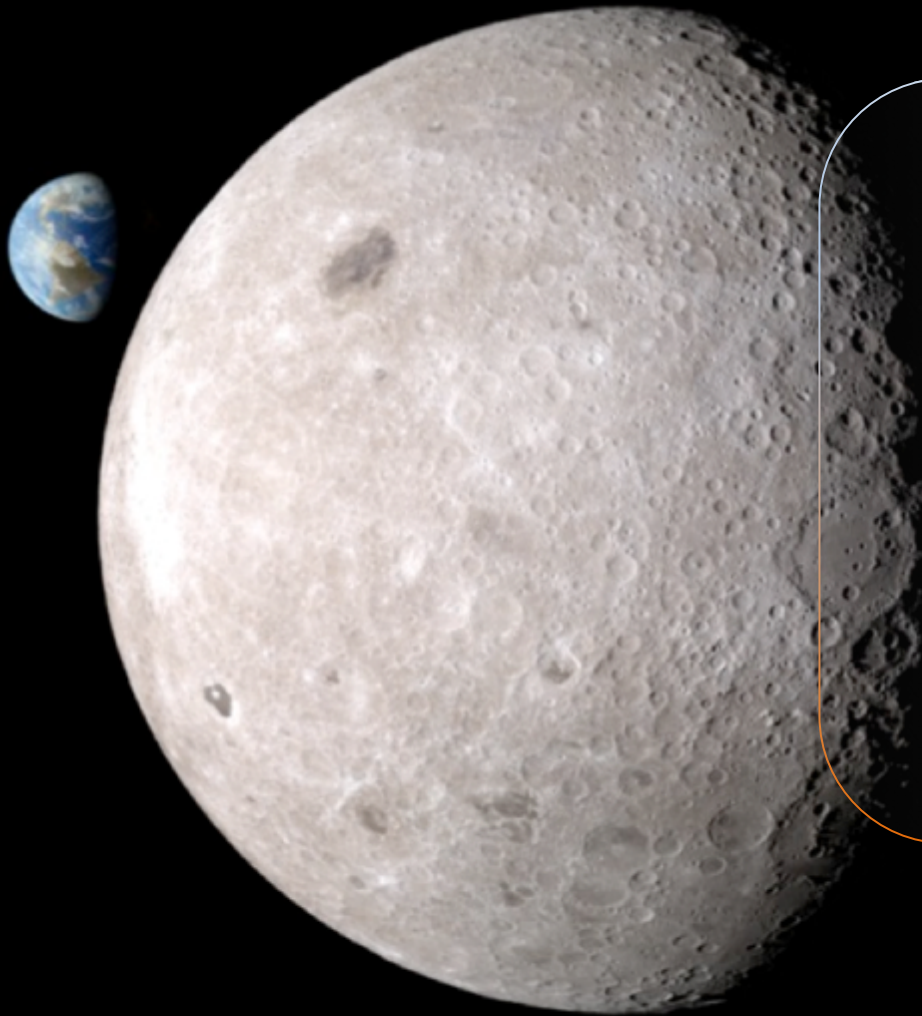
# EXPANDING HUMAN PRESENCE IN PARTNERSHIP

*CREATING ECONOMIC OPPORTUNITIES, ADVANCING TECHNOLOGIES, AND ENABLING DISCOVERY*





# HOW ARE WE LEADING FUTURE EXPLORATION



- **Maximizing utilization of the International Space Station**
- **Actively promoting LEO commercialization**
- **Resolving the human health and performance challenges**
- **Expanding partnerships with commercial industry**
- **Growing international partnerships**
- **Building the critical *Deep Space Infrastructure***
- **Enabling the capabilities to explore multiple destinations**





# STRATEGIC PRINCIPLES FOR SUSTAINABLE EXPLORATION

- **FISCAL REALISM**

Implementable in the near-term with the buying power of current budgets and in the longer term with budgets commensurate with economic growth;

- **SCIENTIFIC EXPLORATION**

Exploration enables science and science enables exploration; leveraging scientific expertise for human exploration of the solar system.

- **TECHNOLOGY PULL AND PUSH**

Application of high Technology Readiness Level (TRL) technologies for near term missions, while focusing sustained investments on technologies and capabilities to address the challenges of future missions;

- **GRADUAL BUILD UP OF CAPABILITY**

Near-term mission opportunities with a defined cadence of compelling and integrated human and robotic missions, providing for an incremental buildup of capabilities for more complex missions over time;

- **ECONOMIC OPPORTUNITY**

Opportunities for U.S. commercial business to further enhance their experience and business base;

- **ARCHITECTURE OPENNESS AND RESILIENCE**

Resilient architecture featuring multi-use, evolvable space infrastructure, minimizing unique developments, with each mission leaving something behind to support subsequent missions;

- **GLOBAL COLLABORATION AND LEADERSHIP**

Substantial new international and commercial partnerships, leveraging current International Space Station partnerships and building new cooperative ventures for exploration; and

- **CONTINUITY OF HUMAN SPACEFLIGHT**

Uninterrupted expansion of human presence into the solar system by establishing a regular cadence of crewed missions to cis-lunar space during ISS lifetime.



LEADING THE MOVEMENT OF HUMANS INTO DEEP SPACE REQUIRES:  
DOING, INFLUENCING, CONNECTING AND ORCHESTRATING



- ① **AGENCY**
- ② **GOVERNMENT / PEOPLE**
- ③ **INDUSTRY**
- ④ **INTERNATIONAL  
PARTNERSHIP**







Agency

**NASA Centers**

**Building Blocks to Deep Space**

**Mission Directorate Collaborations**







# BUILDING BLOCKS TO DEEP SPACE

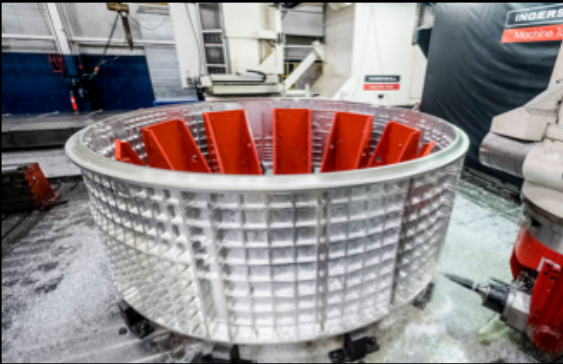
*ORION – SPACE LAUNCH SYSTEM – EXPLORATION GROUND SYSTEMS*

Launching from a modernized Kennedy spaceport, Exploration Mission-1 is the first integrated flight of the SLS rocket and Orion spacecraft demonstrating our commitment and capability to push farther into deep space – to the Moon, Mars, and beyond.





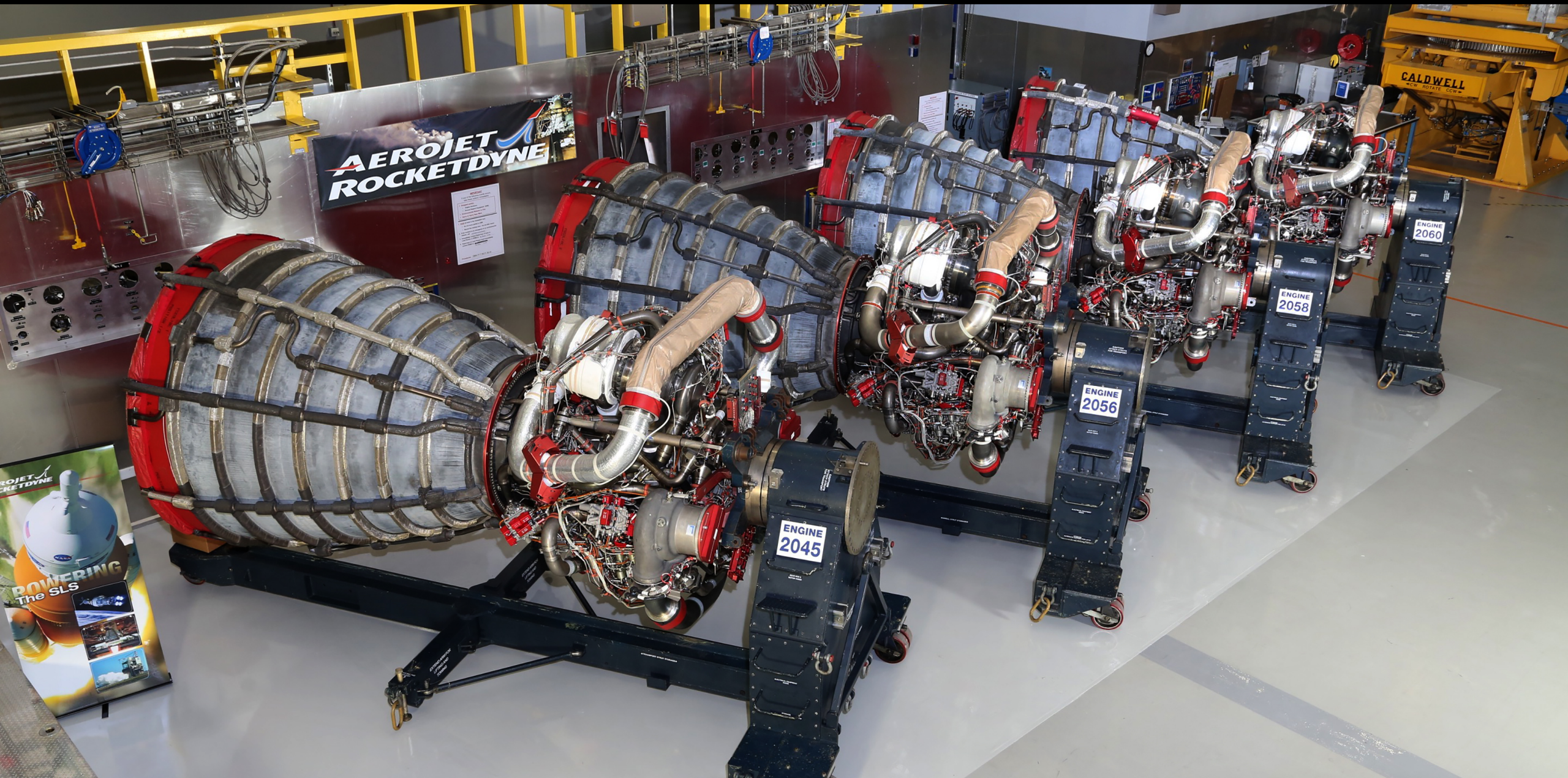
# EXPLORATION SYSTEMS DEVELOPMENT



ORION    SPACE LAUNCH SYSTEM    GROUND SYSTEMS

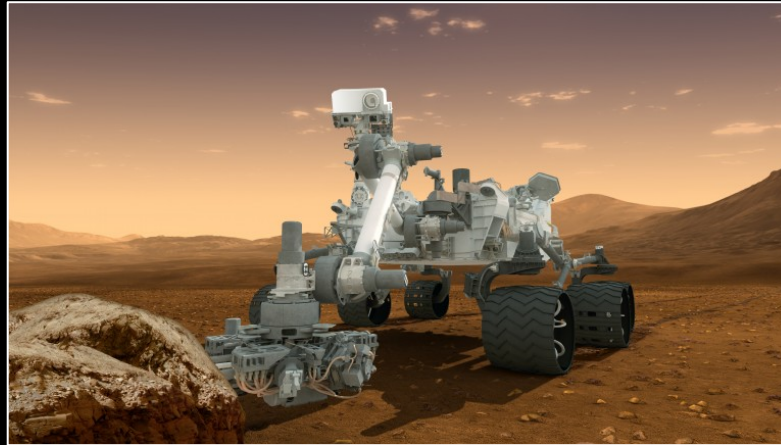


# RS-25: ENGINES FOR SLS'S FIRST FLIGHT





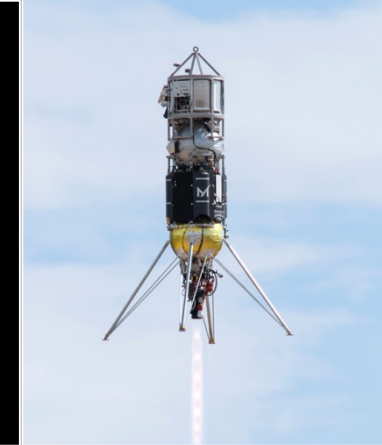
# HEOMD-STMD COLLABORATION



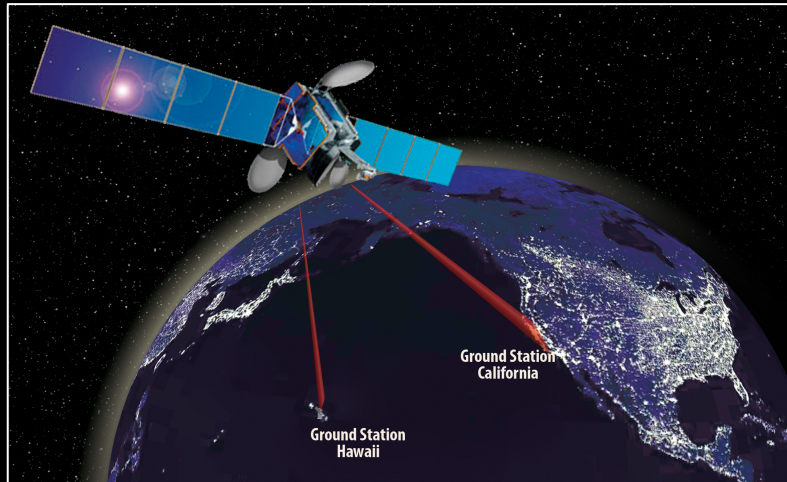
HEOMD & STMD are co-funding three payloads on Mars 2020: MOXIE, MEDA, MEDLI-2



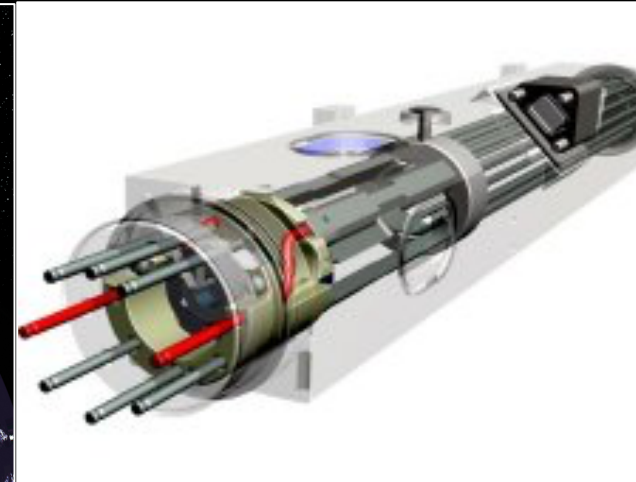
STMD is developing the solar electric propulsion system for the Deep Space Gateway Power & Propulsion Element



HEOMD is flight testing a Navigation Doppler Lidar and lander vision system on a STMD Flight Opportunities Program lander

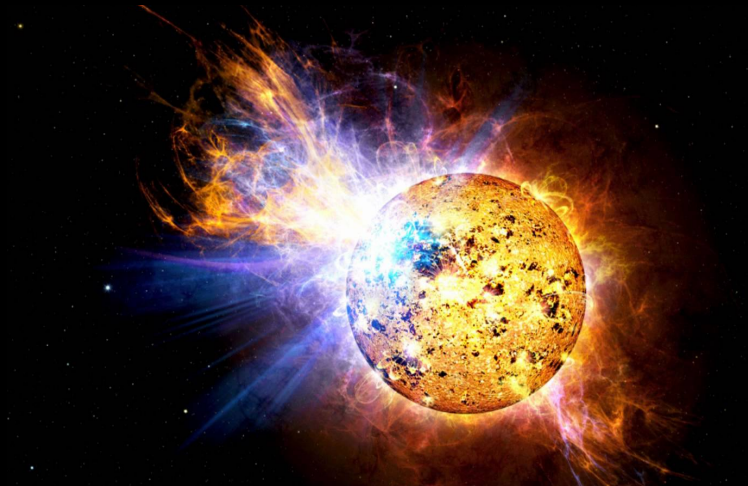
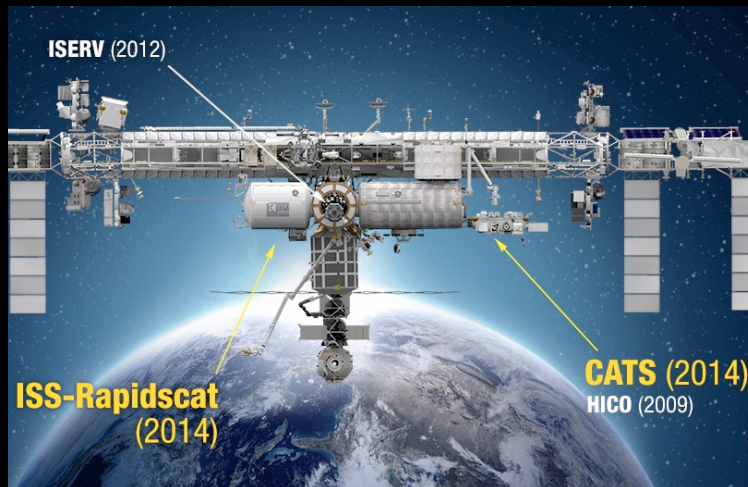
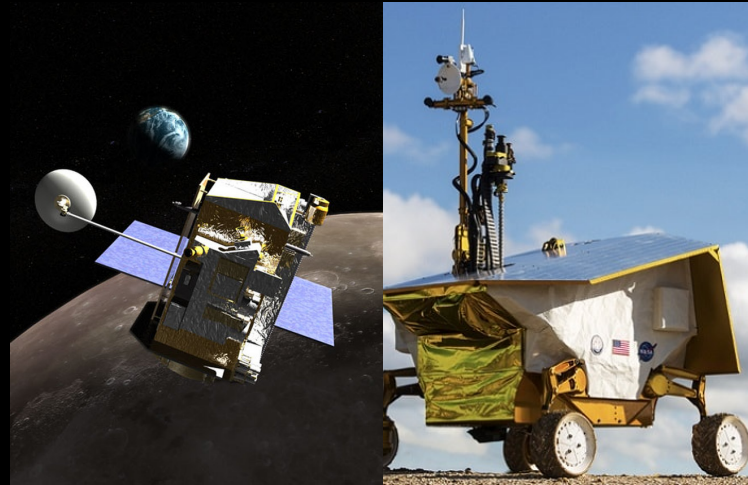


STMD is developing Laser Communications Relay Demonstration and HEO/SCaN is providing the ground terminals



Joint development of Deep Space Atomic Clock for precision navigation

# HEOMD-SMD COLLABORATION



And many others...

- Deep Space Optical Communications (DSOC)
- Launch Services
- Space Communications and Navigation (SCaN)
- Planetary Protection
- Science in Cislunar Space
- Korea Pathfinder Lunar Orbiter
- Etc.





Government

**National Space Council**

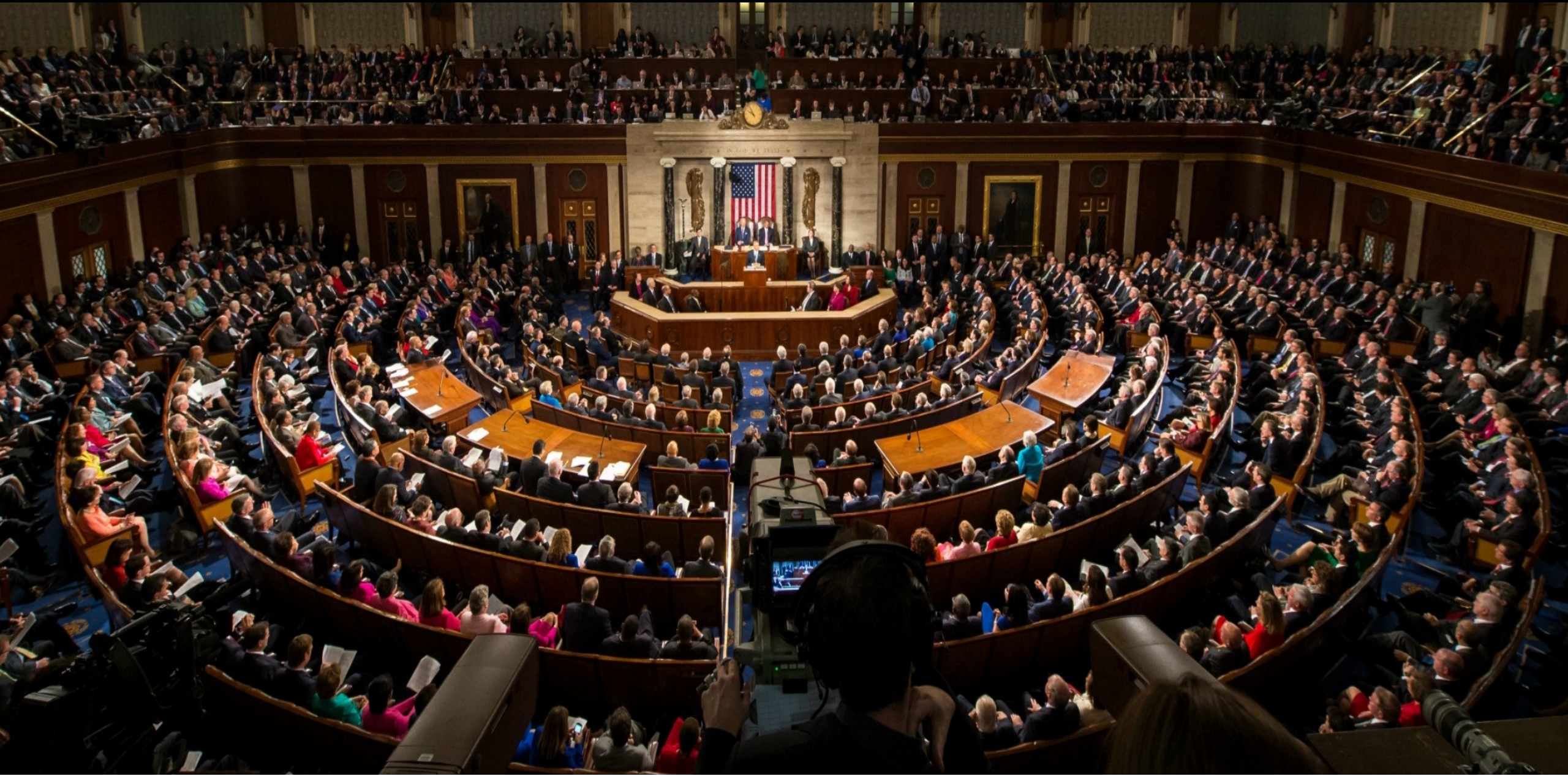
**Congress**

**Government-wide Utilization**











GOVERNMENT-WIDE UTILIZATION



U.S. DEPARTMENT OF  
**ENERGY**





OF THE PEOPLE, BY THE PEOPLE, FOR THE PEOPLE







Industry

**Commercial Partnerships**

**Suppliers**

**Organizations**





## BENEFITS OF PUBLIC-PRIVATE PARTNERSHIP

In addition to financial investments NASA helps its commercial partners:

- By sharing the knowledge NASA has matured through over 50 years of space flight allowing them to access unique expertise, goods, and services
- By making available valuable infrastructure and assets; thus providing emerging space companies with capabilities they could otherwise not afford
- By providing substantial early demand as an anchor customer

In return, an emerging space industry sparked by the initiative of private entrepreneurs:

- Are dedicated to creating new markets for goods and services that will be integral to helping NASA and the nation continue expand the space economy and sustain deep space exploration.
- Are lowering the cost of launching cargo into space and transforming economic decision-making, therefore markets for services that once were cost-prohibitive are becoming increasingly realistic.
- Are regularly developing, testing, and implementing cutting-edge research, which yields potentially transformative solutions that can accelerate timelines, slash costs, or multiply science return.



# LAUNCH SERVICES PROGRAM: CURRENT FLEET



## Vehicles On NLS II Contract

Certified\*



Pegasus XL



Minotaur- C  
Formerly Taurus XL



Atlas V



Delta II\*\*



Delta IV  
Heavy

## Launch Sites



Falcon 9 FT ♦



Antares



Delta IV



Falcon  
Heavy

## Venture Class Launch Services



Rocket Lab  
USA  
Electron



Virgin Orbit  
(Formerly Virgin  
Galactic)  
Launcher One

## Emerging Vehicles

OATK Next Generation Launcher  
Blue Origin New Glenn  
ULA Vulcan

Vulcan Aerospace Stratolauncher  
Boeing Phantom Express (XS-1)  
Generation Orbit Launcher2  
Super Strypi  
Vector Space Vector-R & H  
Whittinghill Aerospace Aurora

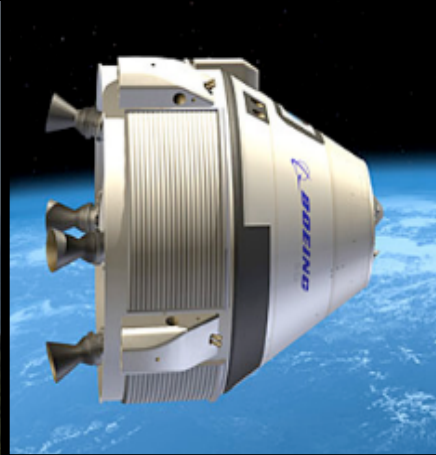
\*Launch certification is meant to understand and possibly mitigate risks; not to ensure every last item and process is reviewed on every launch vehicle. Governed by NASA Policy Directive (NPD) 8610.7, Launch Services Risk Mitigation Policy for NASA-Owned or NASA-Sponsored Payloads.

\*\* Launch Vehicle configuration not available to order

♦ Certification on going



# COMMERCIAL CREW: AIMING TO LAUNCH ASTRONAUTS FROM THE U.S. BY THE END OF 2018





# COMMERCIAL CARGO



SPACEX

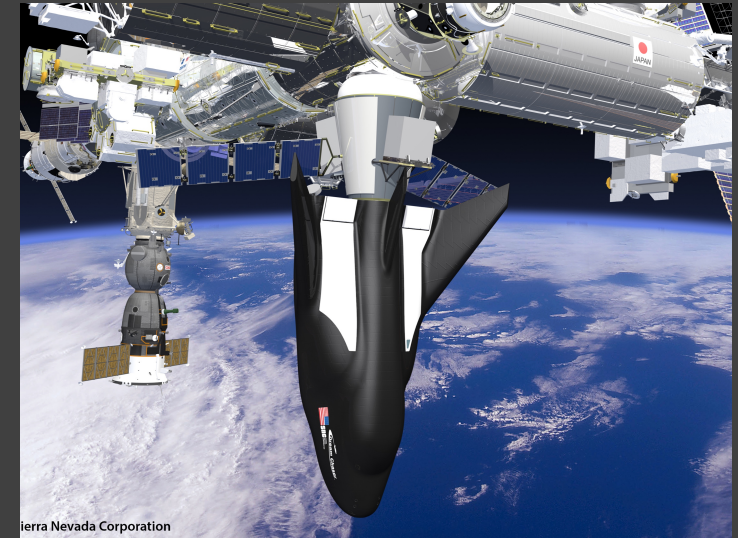


Orbital ATK



*\* Currently conducting resupply missions to ISS*

SNC SIERRA  
NEVADA  
CORPORATION



*Missions flying to ISS in 2019*



# NEXTSTEP HABITATION OVERVIEW



## NextSTEP Phase 1: 2015-2016

Cislunar habitation concepts that leverage commercialization plans for LEO



LOCKHEED MARTIN



BIGELOW AEROSPACE



ORBITAL ATK



BOEING

### FOUR SIGNIFICANTLY DIFFERENT CONCEPTS RECEIVED

Partners develop required deliverables, including concept descriptions with concept of operations, NextSTEP Phase 2 proposals, and statements of work.

## NextSTEP Phase 2: 2016-2018

- Partners refine concepts and develop ground prototypes.
- NASA leads standards and common interfaces development.

### FIVE GROUND PROTOTYPES BY 2018



BIGELOW AEROSPACE



BOEING



LOCKHEED MARTIN

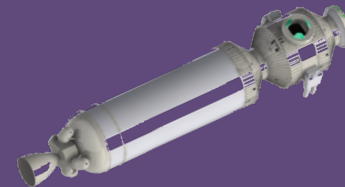


SIERRA NEVADA CORPORATION



ORBITAL ATK

### ONE CONCEPT STUDY



NANORACKS

Define reference habitat architecture in preparation for Phase 3.



Initial discussions with international partners



## Phase 3: 2018+

- Partnership and Acquisition approach, leveraging domestic and international capabilities
- Development of deep space habitation capabilities
- Deliverables: flight unit(s)





# Lunar **CATALYST**

Lunar CArGo Transportation And Landing bY Soft Touchdown

**In 2014, NASA competitively selected U.S. private-sector partners, based on likelihood of successfully fielding a commercially-viable lunar surface cargo transportation capability. Agreements renewed in 2017 for two more years.**



Masten Space Systems



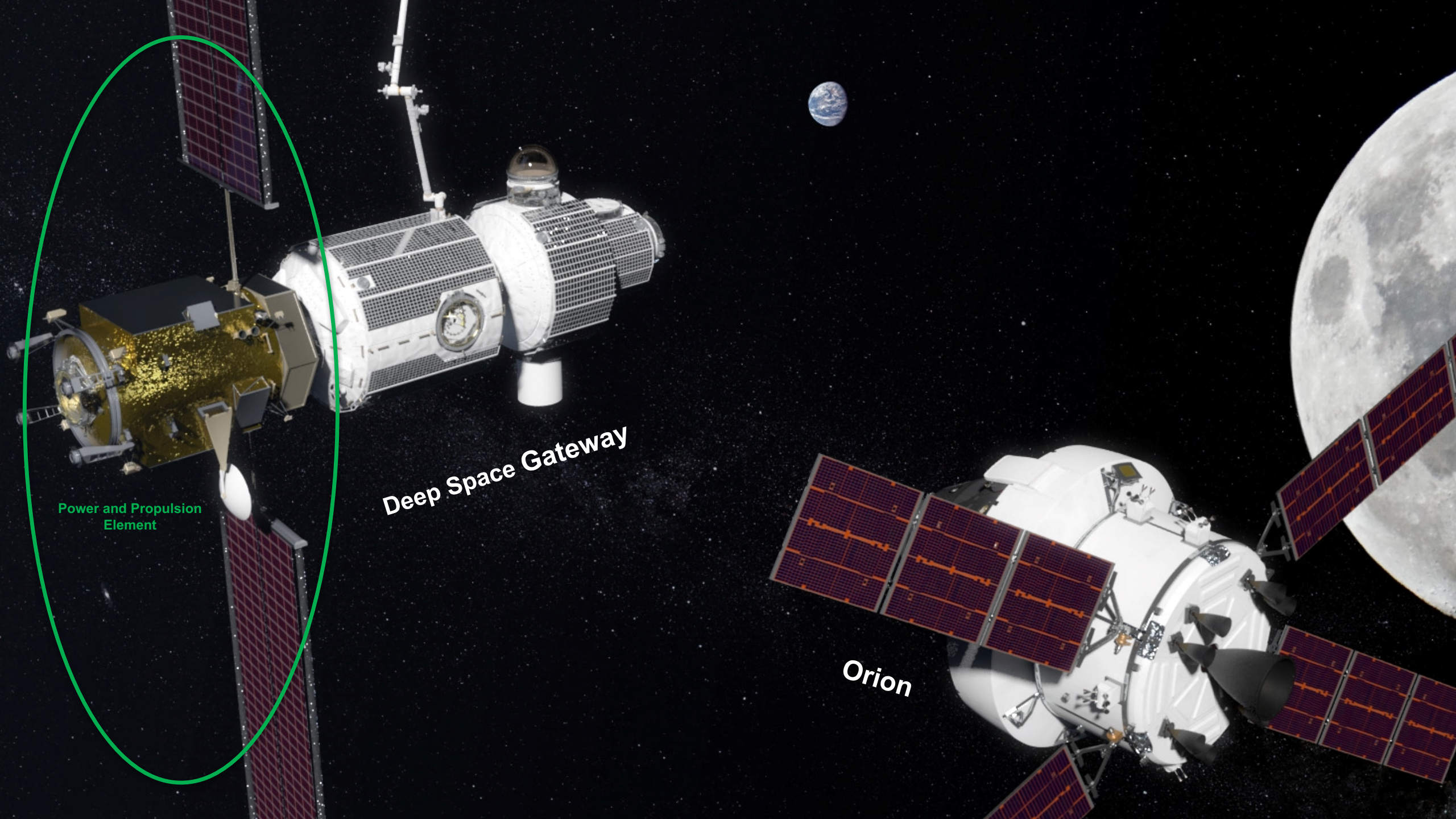
Moon Express



Astrobotic Technologies

**HELPING U.S. INDUSTRY PARTNERS TO**  
**LOWER RISKS | CONDUCT TEST | ACCELERATE VEHICLE DEVELOPMENT TO LAUNCH**





Power and Propulsion  
Element

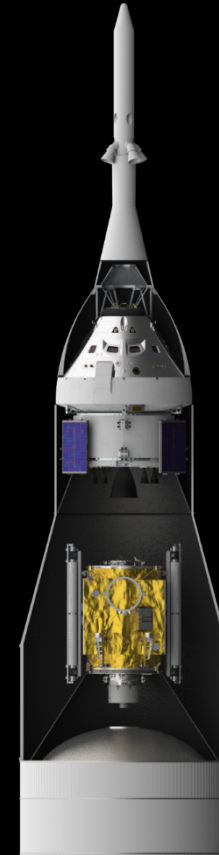
Deep Space Gateway

Orion



## POWER AND PROPULSION ELEMENT FOR CISELUNAR GATEWAY PLAN

- **A power and propulsion element (PPE) would be the first element in a cislunar gateway**
  - Uses highly mass efficient advanced solar electric propulsion (SEP) technologies
- **The PPE would provide key functionality for the gateway including**
  - Transportation & controls for lunar orbital operations
  - Power to gateway elements
  - Communications
- **PPE will launch co-manifested with Orion crew vehicle on the Space Launch System for the EM-2 flight**





# DEEP SPACE EXPLORATION SYSTEMS

## *PARTNERS & SUPPLIERS IN AMERICA*



NASA's Deep Space Systems for human exploration are being built in all 50 states.





International

**Space Communications and Navigation**  
**International Space Station**  
**Orion**




# NASA'S NETWORKS SPAN THE GLOBE



- **HEO/SCaN represents NASA's interests at all national and international organizations related to space communications and navigation.**
  - Interoperability Plenary (IOP)
  - Interagency Operations Advisory Group (IOAG)
  - Consultative Committee for Space Data Systems (CCSDS)
  - Spectrum Frequency Coordination Group (SFCG)
  - International Telecommunications Union/World Radiocommunications Conference (ITU/WRC) - Dept. of State
  - International Committee on Global Navigation Satellite Systems (ICG) and Providers Forum (PF)
  - Space Mission Operations and Ground Data Systems (SpaceOps)
  - Space Generation Advisory Council (SGAC)
- **Global Participation**
  - ITU - 193 nations
  - CCSDS - 26 nations and 150 commercial entities





A photograph of the International Space Station (ISS) in orbit above Earth at night. The station's complex structure, including multiple modules and solar panel arrays, is illuminated by a bright light source, likely the Sun, which is not visible in the frame. The Earth's surface below is dark, with numerous city lights glowing in clusters. A thin, bright blue and white atmospheric layer is visible along the horizon of the planet. The background is a deep black space filled with many small, distant stars.

The International Space Station (ISS) is a platform for deep space exploration, scientific research, economic growth and global diplomacy. ISS brings the world together to discover, develop and advance solutions for a better life both here on Earth and in space.



# INTERNATIONAL SPACE STATION PARTNERSHIPS



**Created by a partnership of 5 space agencies representing 15 nations**



**esa**



**The largest peace time effort amongst the most countries in recorded human history.**

**Creating knowledge that improves life here on earth and provides a stepping stone for humanity's destiny . . . to live among the stars**

**Today, some 90 nations are involved in research on ISS**

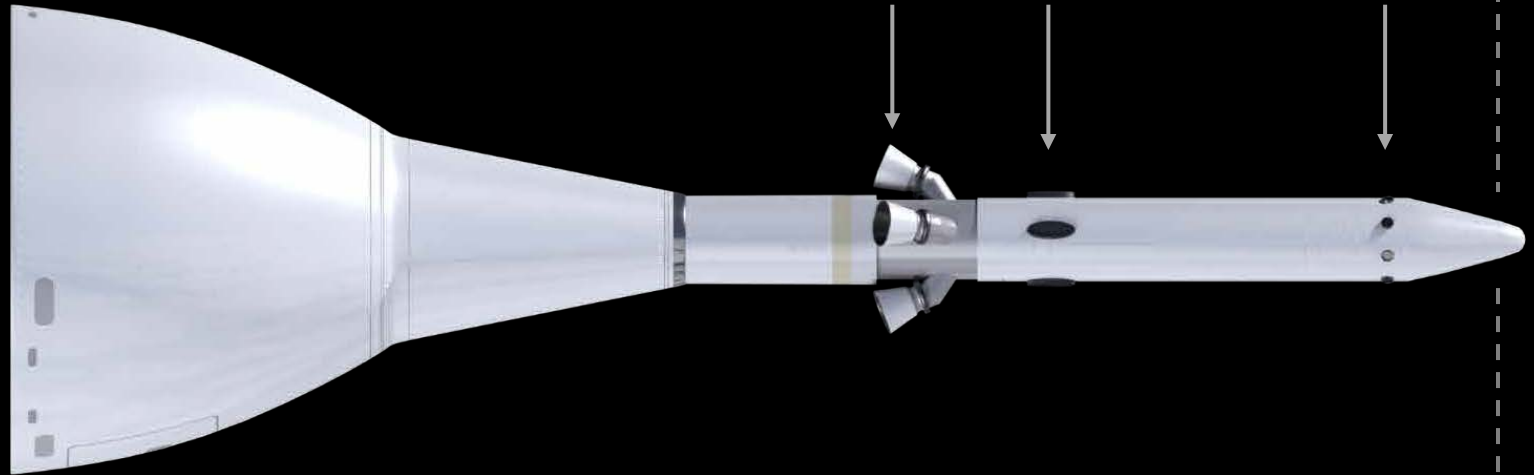
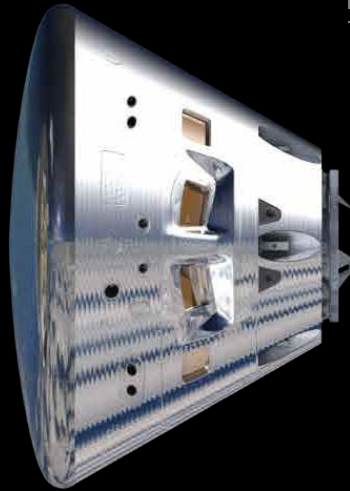
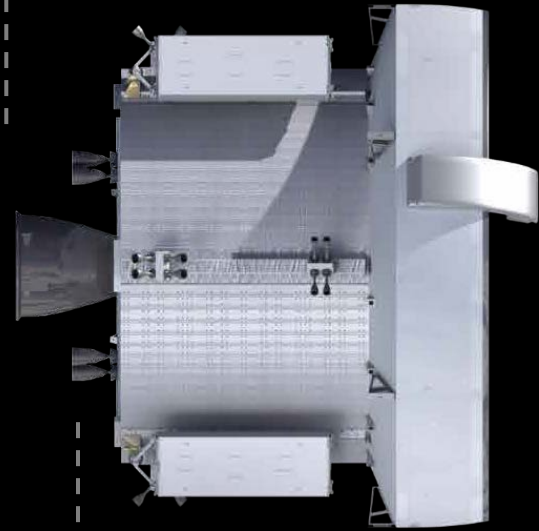


# ORION SPACECRAFT

SERVICE MODULE

CREW MODULE

LAUNCH ABORT SYSTEM



ABORT  
MOTOR

JETTISON  
MOTOR

ATTITUDE CONTROL  
MOTOR

ESA

NASA

## Germany

- Prime Contractor
- European Service Module Assembly Integration & Verification
- Propulsion and Propulsion Drive Electronics
- Centralised Parts Procurement Agent
- On Board Data Network Harness for Qualification Module

## Italy

- Structure
- Thermal Control System
- Consumable Storage System
- Power Control and Distribution Unit
- Photovoltaic Assembly
- Meteoroid and Debris Protection System

## Switzerland

- Secondary Structure
- Solar Array Drive Assembly
- Solar Array Simulator
- Mechanical Ground Support Equipment

## USA

- Gas Tank
- Valves
- On Board Data Network Harness for Flight Module

## France

- System Tasks
- Avionics qualification
- Direct Current Harness
- Front End Electronics
- Helium Filters

## Belgium

- Tank Bulkhead
- Electrical Ground Support Equipment
- Pressure Regulation Units

## Sweden

- Propulsion Qualification Module Integration

## Denmark

- Front End Electronics
- Electrical Ground Support Equipment

## Norway

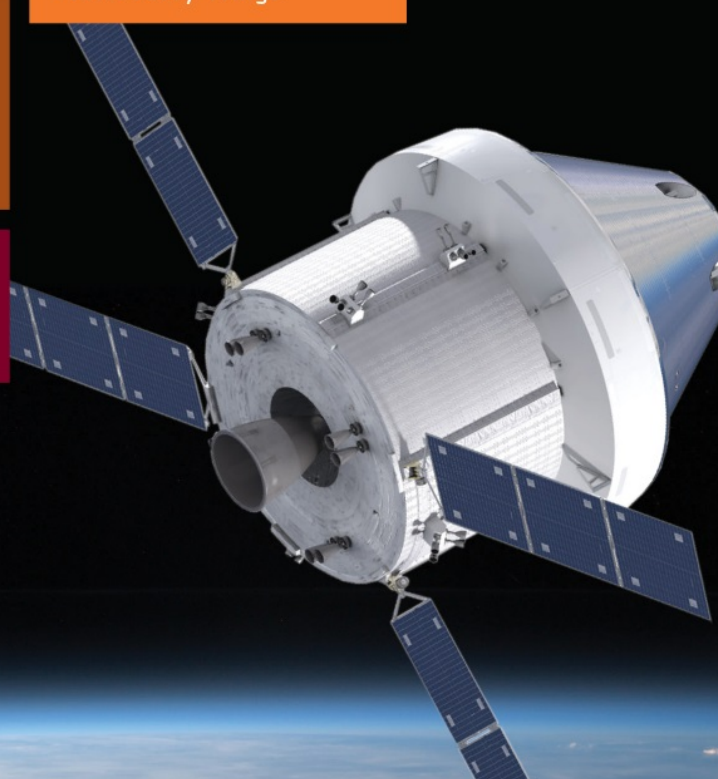
- Hydrophobic Filter

## Spain

- Thermal Control Unit

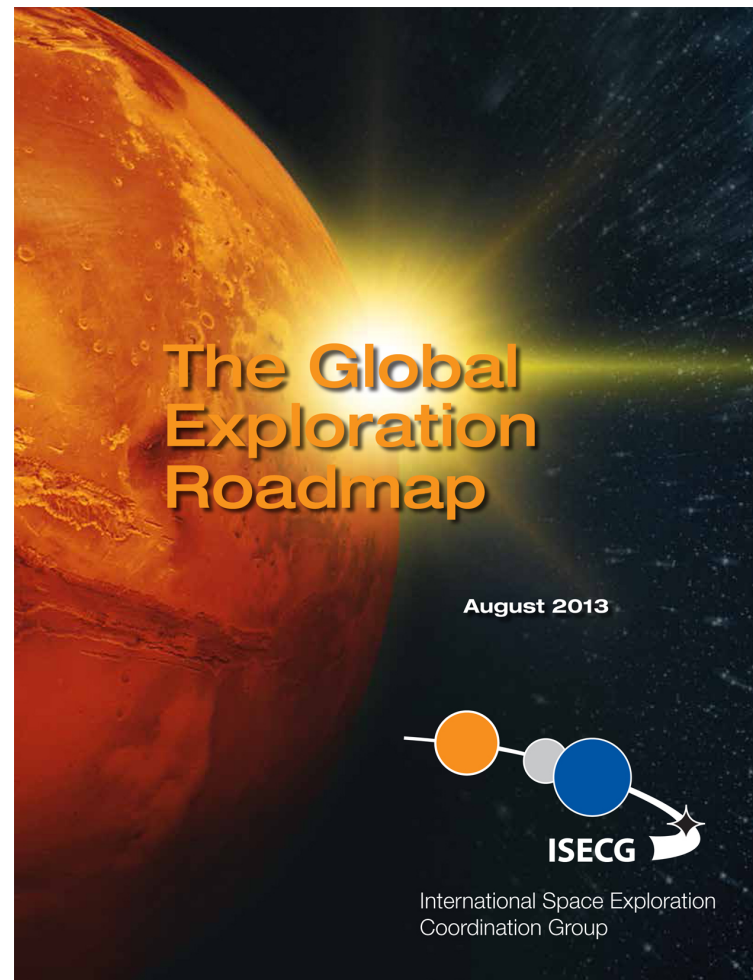
## The Netherlands

- Solar Array Wings





# INTERNATIONAL SPACE EXPLORATION COORDINATION GROUP GLOBAL EXPLORATION ROADMAP



**Global Exploration Roadmap –  
Version Three scheduled for  
release January 2018**



With creative leadership we can have a sustained human presence in low Earth orbit supported primarily by the private sector, and used by broad sectors of the economy while we advance human presence into the solar system.



