

STEM Journey Presentation

ISS to Gateway

Forging the Path to Space Exploration

Dr. Luke Roberson / NASA, Kennedy Space Center, FL
Anne Marie Campbell / Aerodyne, Kennedy Space Center, FL

March 2, 2019

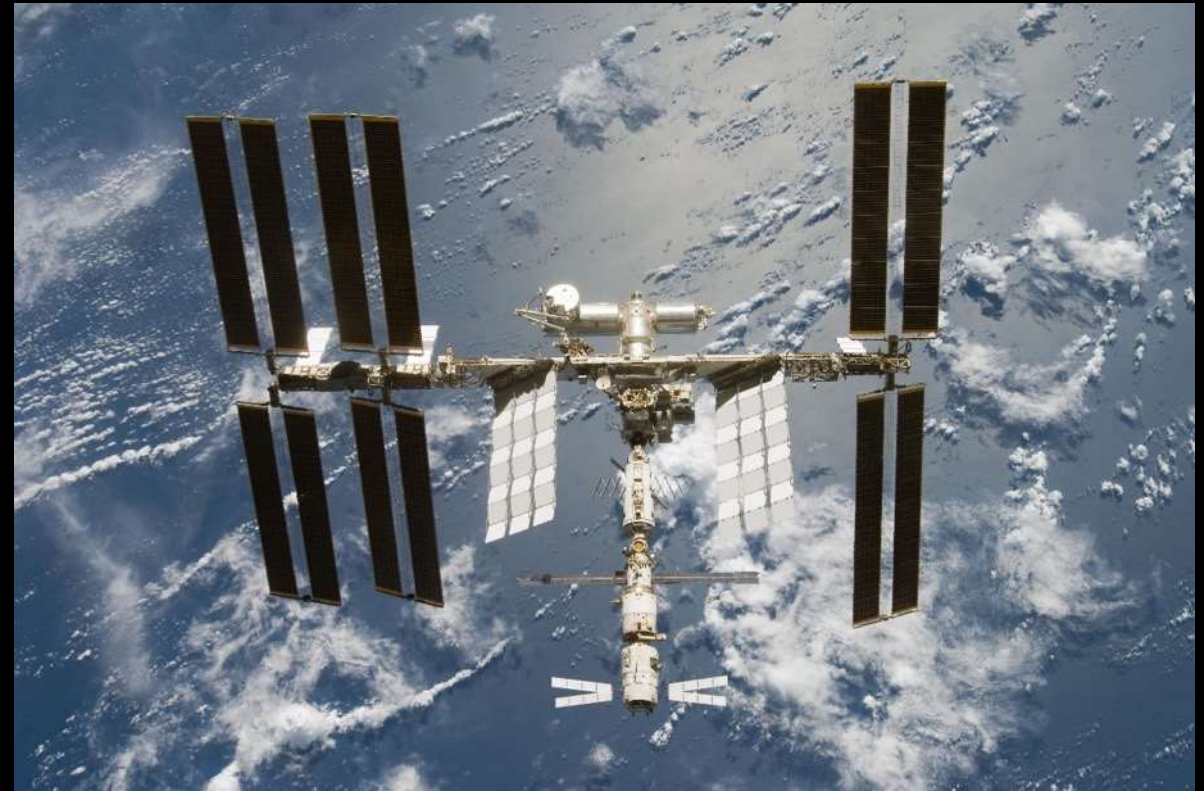
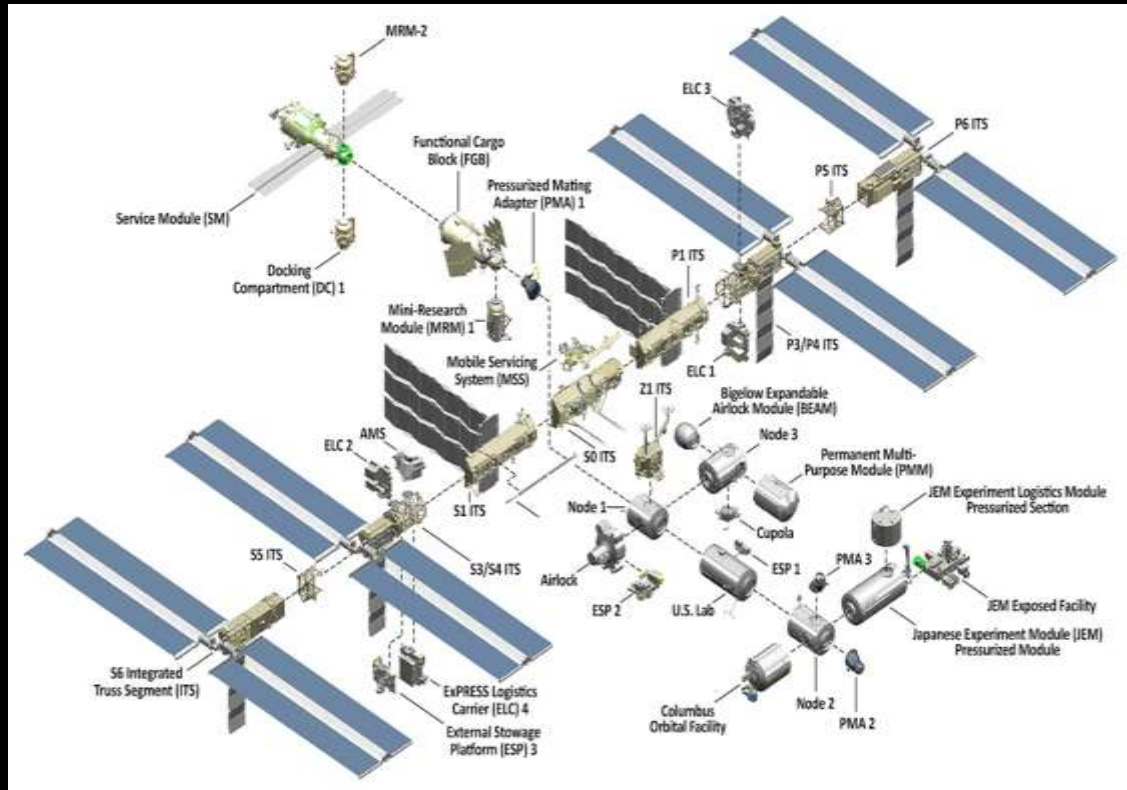
Space Policy Directive-1



“Lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities.

Beginning with missions beyond low-Earth orbit, the United States will lead the return of humans to the Moon for long-term exploration and utilization, followed by human missions to Mars and other destinations.”

The International Space Station



Animation of ISS Assembly

ISS Fun Facts

Continuously Occupied Since	November 2000
Travel Speed	5 miles per second
Orbits Earth	Every 90 minutes
One Earth Day	16 ISS Sunrises/Sunsets
Length	357' (American football field)
Travel Time to ISS	6 hours
Solar Panels Size	1 acre
Size	Larger than a 6 bedroom house
Space Walks	More than 200
Assembly	42 assembly flights: 37 NASA shuttle, 5 Russian Proton/Soyuz
Research	>2,500 research investigations

Views from ISS



Posted to Twitter by @Astro_Alex, European Space Agency astronaut Alexander Gerst, this image shows our planet's Moon as seen from the International Space Station.



The Aurora Borealis seen from the ISS

ISS Research

What Happens in Microgravity, doesn't stay in Microgravity

ISS as a US National Lab

“In 2005, Congress designated the U.S. portion of the ISS as the nation’s newest national laboratory to maximize its use for improving quality of life on Earth, promoting collaboration among diverse users, and **advancing science, technology, engineering, and mathematics (STEM) education**. This unique laboratory environment is now available for use by non-NASA U.S. government agencies, academic institutions, and the private sector, providing these customers access to a permanent microgravity setting, a powerful vantage point in low Earth orbit, and the extreme and varied environments of space.”



ISS Research for you!

https://www.nasa.gov/mission_pages/station/research/nlab/research_opportunities

<https://www.issnationallab.org/>

<https://nspires.nasaprs.com/>

National Lab Research Opportunities

The ISS National Laboratory welcomes proposals for research and product development that might be suitable for the space station.

For more information, please see:

[ISS National Lab Solicitations](#)

[ISS National Lab Research Proposal Submission and Evaluation Processes](#)

NASA is seeking innovative partnerships for new capabilities. For more information, please see:

[NASA Research Announcement: Research Opportunities for International Space Station Utilization, Solicitation: NNJ13ZBG001N \(UPDATED: November 14, 2014\)](#)

ISS Research Client Service and IT Customer Service Helplines

ISS Research (Client Service) Helpline

The ISS Research Integration Office has both a phone and an email client service helpline that Payload Developers and others interested in doing research on ISS can contact to get assistance. The phone is staffed during regular business hours. After hours, please leave a message and a representative will return the call on the next business day. Or send us an email with your contact info, affiliation, detailed question(s), and how you are planning to use the info.

Phone: 281-244-6187

Email: jsc-iss-research-helpline@mail.nasa.gov

ISS IT PD Liaison/Customer Service

If you have questions regarding NASA/JSC badging, security or remote computer access (e.g., to NASA internal websites, ISS Payload documentation, etc.), please email the ISS IT PD Liaison or call Customer Service. The phone is staffed live during regular business hours. After hours, please leave a message and a representative will return the call on the next business day.

Phone: 281-244-8999

Email: jsc-iss-it-pd-liaison@mail.nasa.gov

ISS Ongoing Operations

CREW OPERATIONS



Health monitoring aboard the ISS

STATION OPERATIONS



NASA astronaut Serena Auñón-Chancellor performs plumbing duties inside the ISS toilet, also known as the Waste and Hygiene Compartment, located in the U.S. Tranquility module.

ISS Research This Week – Astrobee

Terry Fong, Ph.D. NASA Ames Research Center, Moffett Field, CA



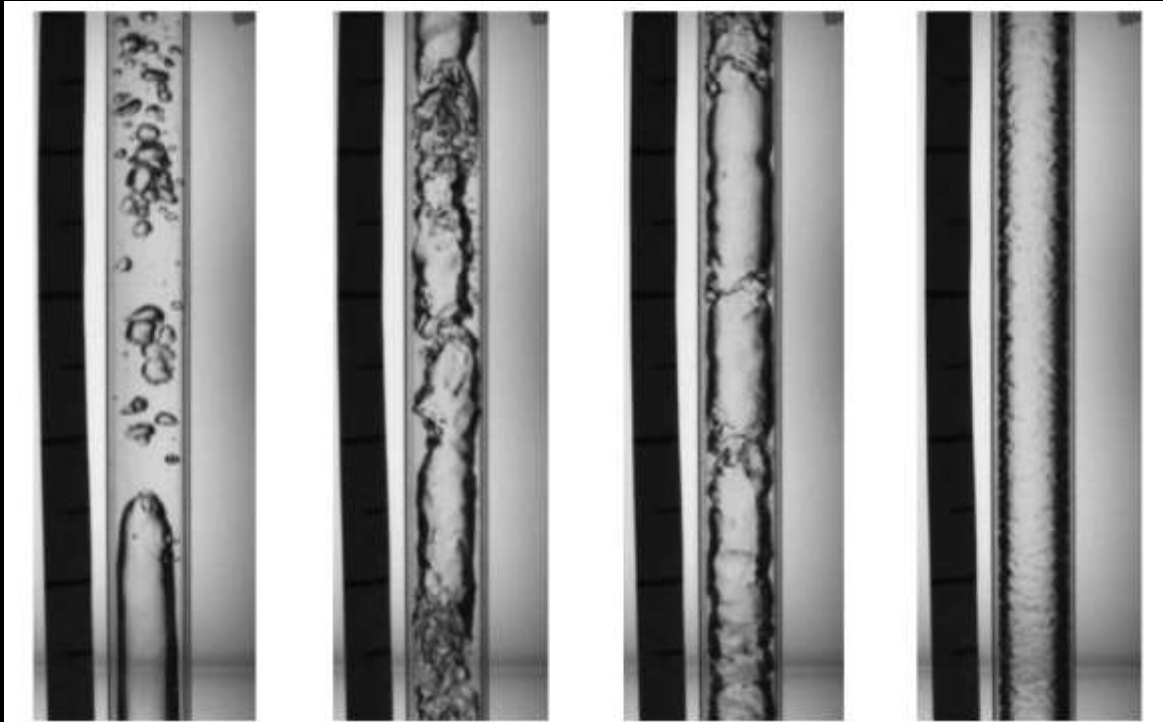
<https://youtu.be/XqyA0trJUqI?t=10s>

https://www.nasa.gov/mission_pages/station/research/experiments/explorer/Facility.html?#id=1891

ISS Research This Week – Flow Dynamics



Japan Aerospace Exploration Agency (JAXA)

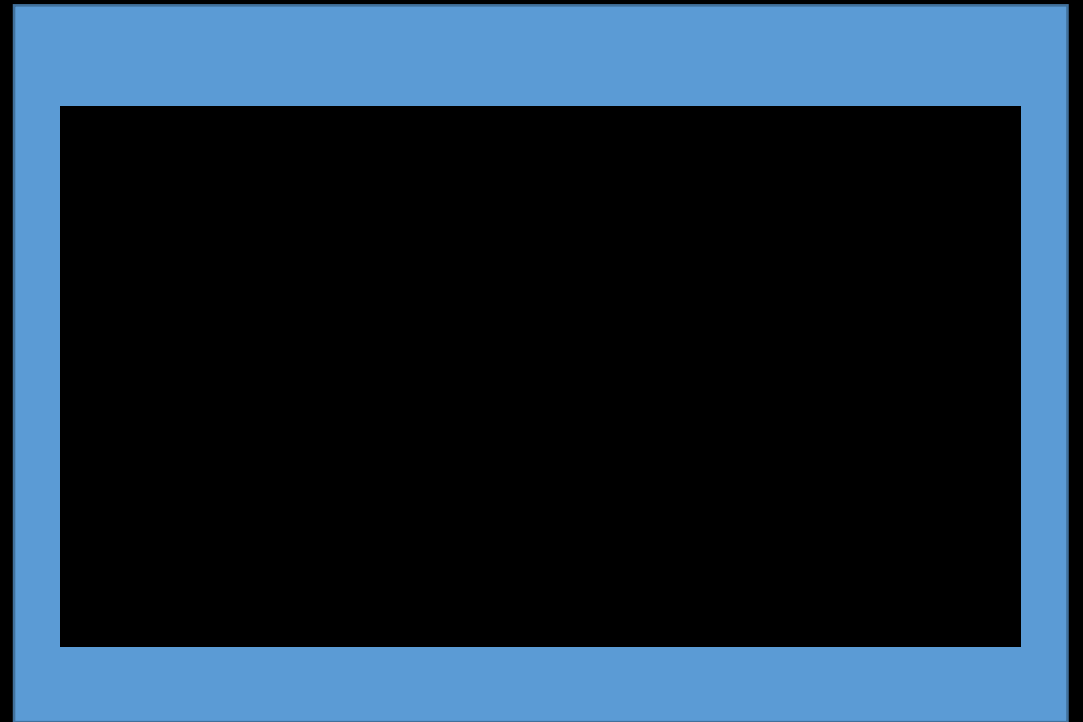


SLUG FLOW

CHURN FLOW

SEMI-ANNULAR

ANULAR



S Baba, et. Al. 2011. J.Phys: Conf. Ser. **327** 012055

<https://iopscience.iop.org/article/10.1088/1742-6596/327/1/012055/pdf>

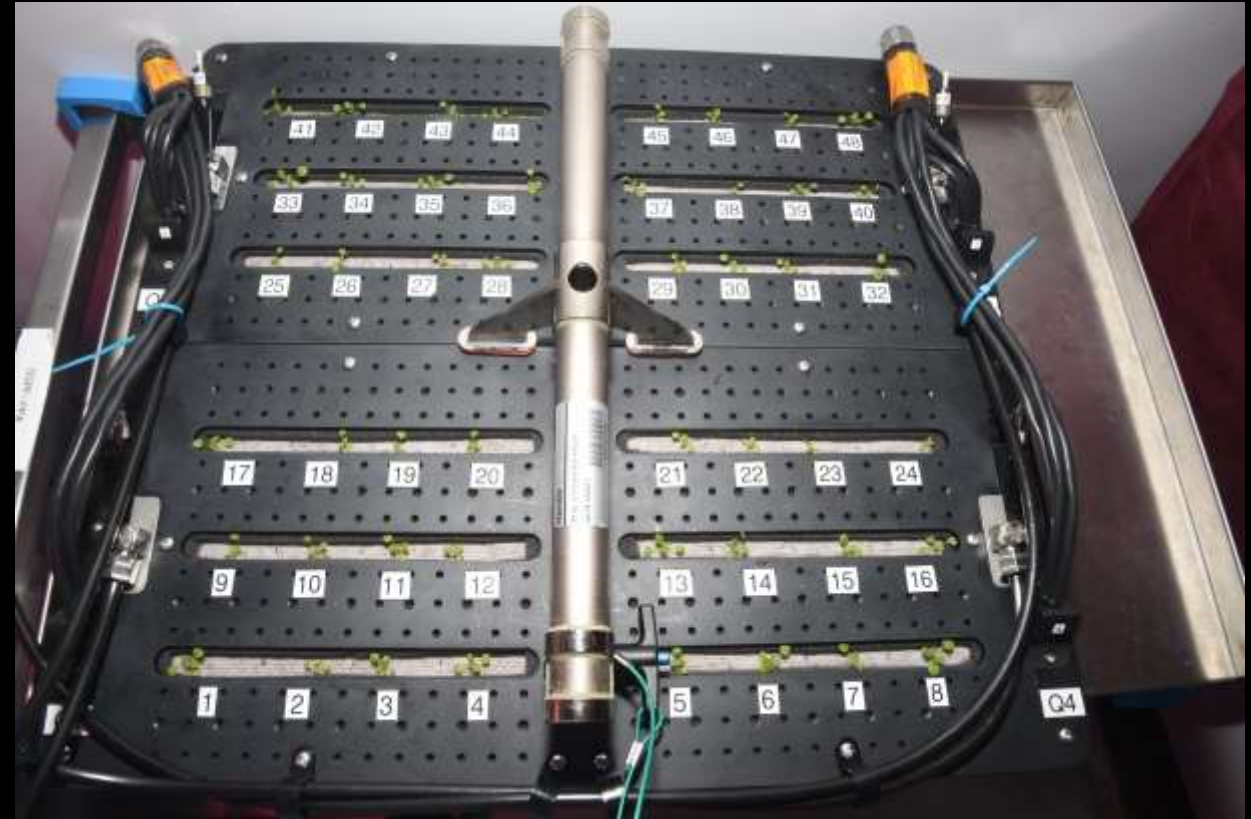
ISS Research This May – VEG04A



https://www.youtube.com/watch?v=c1Gxn_nfgWA

https://www.nasa.gov/mission_pages/station/images/index.html

ISS Research October – PH02



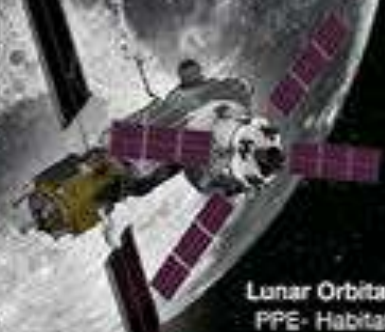
Radish

Earth



Commercial Launch Vehicles

Moon



Mars



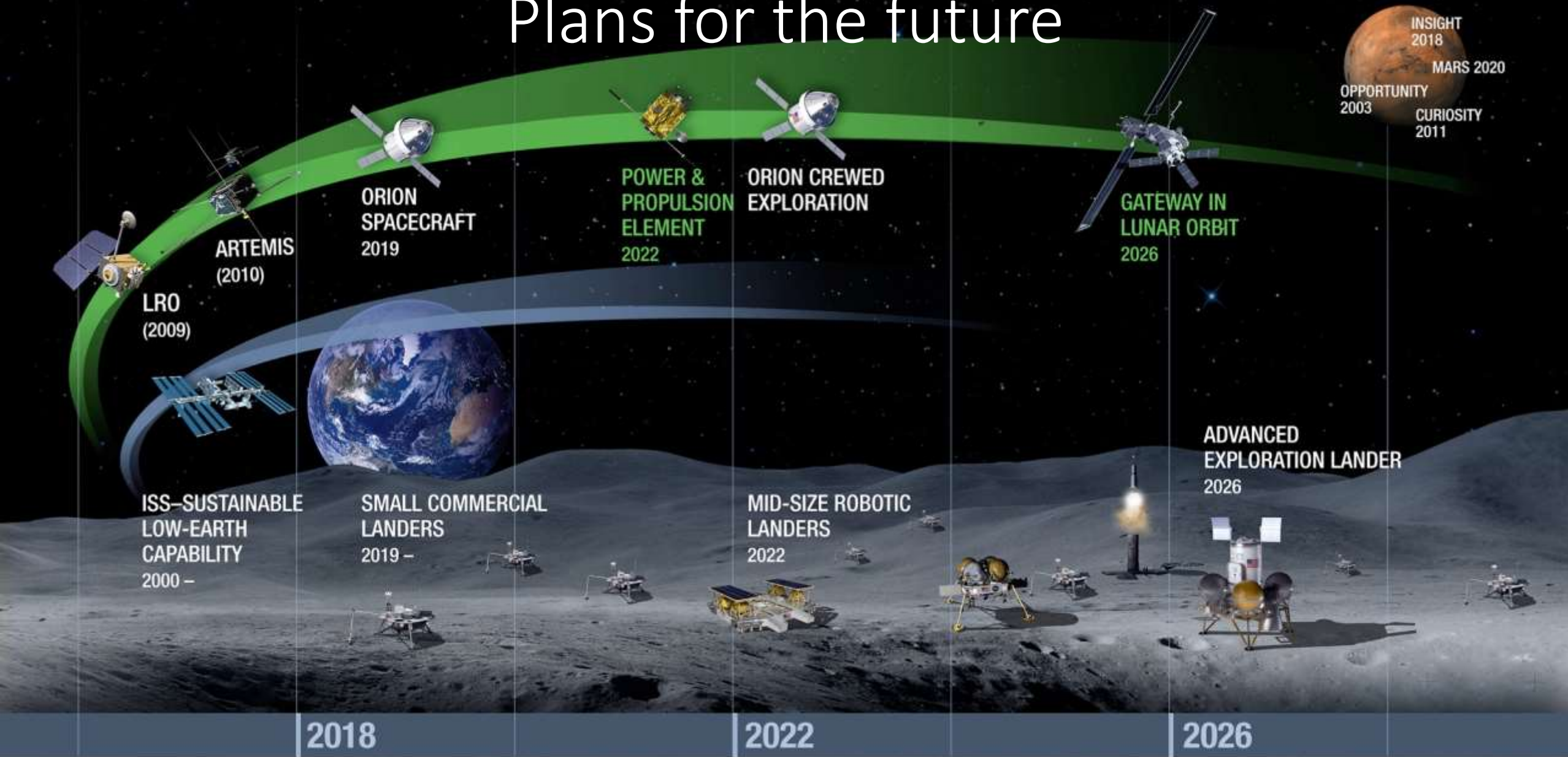
In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions

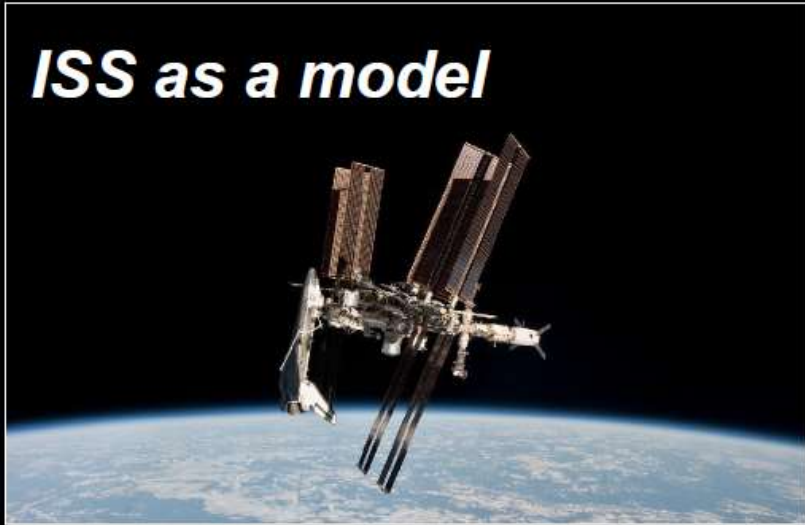
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Plans for the future



NASA'S Open Architecture Develops Space

ISS as a model



Cygnus (Orbital ATK)



Dragon (SpaceX)



Dream Chaser (SNC)



Dragon Crew (SpaceX)



Starliner (Boeing)

INTERNATIONAL



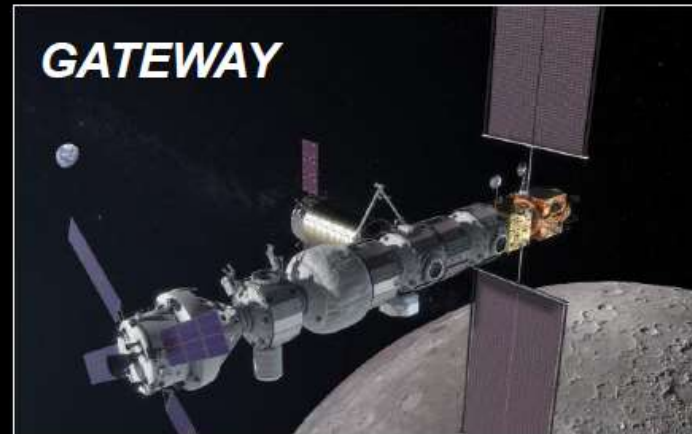
Soyuz & Progress
(Roscosmos)



H-II Transfer
Vehicle (JAXA)



Orion/European
Service Module (ESA)



Multiple providers expected in lunar orbit and on the surface



Lunar Surface

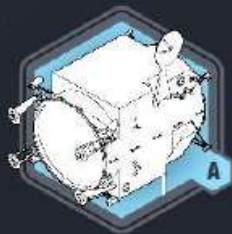
GATEWAY

An exploration and science outpost in orbit around the Moon

<https://www.nasa.gov/topics/moon-to-mars/lunar-outpost>

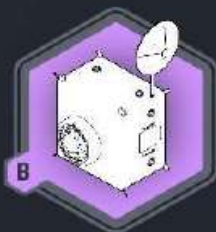
Power and Propulsion Element:

Power, communications, attitude control, and orbit control and transfer capabilities for the Gateway.



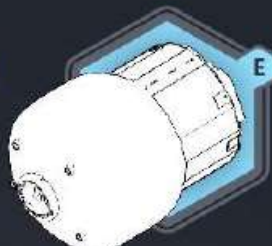
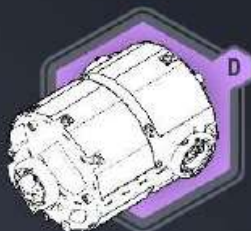
ESPRIT:

Science airlock, additional propellant storage with refueling, and advanced lunar telecommunications capabilities.



Utilization Element:

Small pressurized volume for additional habitation capability.



Habitation Modules:

Pressurized volumes with environmental control and life support, fire detection and suppression, water storage and distribution.

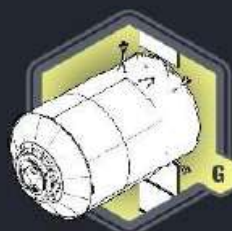
Robotic Arm:

Mechanical arm to berth and inspect vehicles, install science payloads.



Logistics and Utilization:

Cargo deliveries of consumables and equipment. Modules may double as additional utilization volume.



Airlock:

Enables spacewalks, potential to accommodate docking elements.



Sample Return Vehicle:

A robotic vehicle capable of delivering small samples or payloads from the lunar surface to the Gateway.



NASA-led architecture and integration

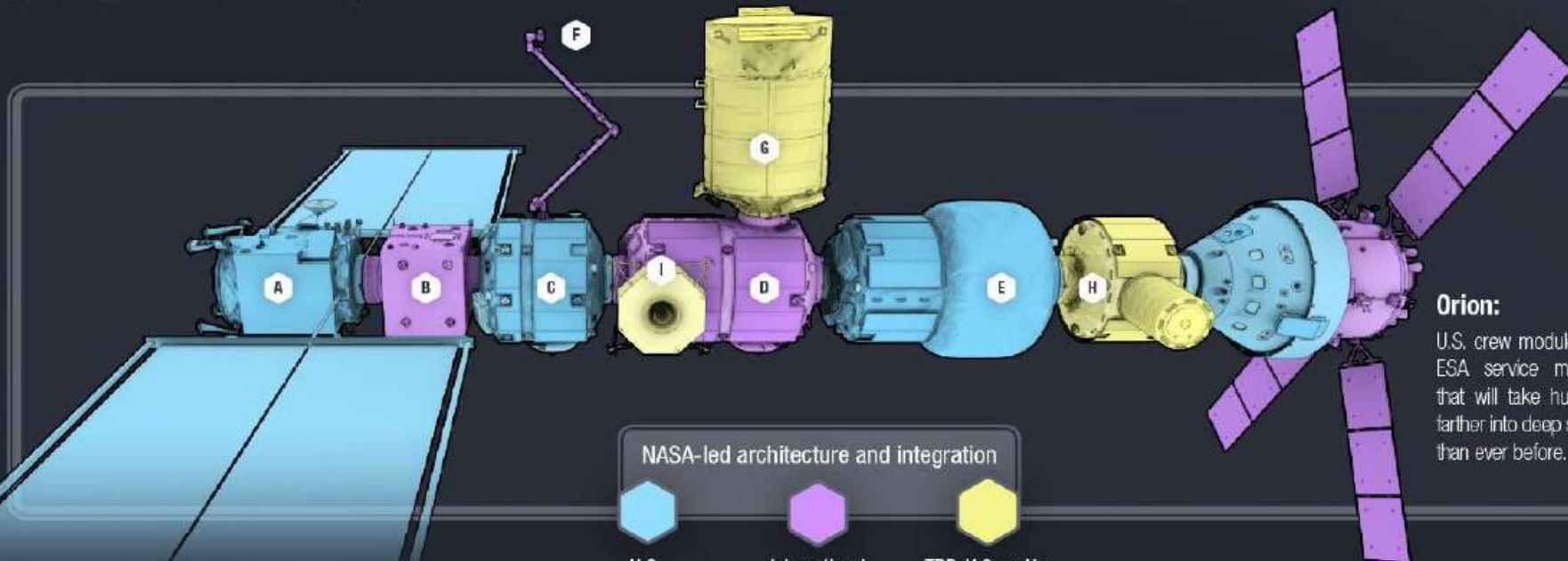
U.S.

International

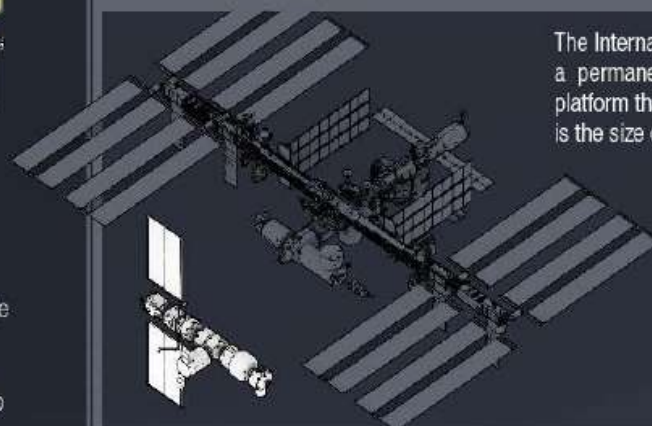
TBD: U.S. and/or International

Orion:

U.S. crew module with ESA service module that will take humans farther into deep space than ever before.



Gateway Compared to the International Space Station



The International Space Station is a permanently crewed research platform that has 11 modules and is the size of a football field.

The Gateway is a much smaller, more focused platform for extending initial human activities into the area around the Moon.

INTERNATIONAL INTEROPERABILITY STANDARDS



**Draft Deep Space Interoperability System Standards
Posted for feedback on March 1, 2018**

- Avionics
- Communications
- Environmental Control and Life Support Systems
- Power
- Rendezvous
- Robotics
- Thermal

NextSTEP Habitation



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: 2016-2019

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



BIGELOW
AEROSPACE



BOEING



LOCKHEED MARTIN



SIERRA NEVADA
CORPORATION



NORTHROP GRUMMAN



NANORACKS



NASA defines reference habitat architecture in preparation for Phase 3.

Phase 3: 2019+



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

<https://www.nasa.gov/nextstep/habitation>

Habitation Development Partnerships

Five full-sized ground prototypes will be delivered for testing in 2019. In final negotiations with NanoRacks for sixth habitat prototype demonstrator.

Lockheed Martin
Denver, CO



Refurbishes
heritage hardware

Government Evaluation Location:
KSC

Northrop Grumman
Dulles, VA



Builds on proven
cargo spacecraft
development

JSC

**Bigelow
Aerospace**
Las Vegas, NV



Expandable

Las Vegas

Boeing
Pasadena, TX



Leverages existing
technologies

MSFC

Sierra Nevada
Louisville, CO



Modular buildup

JSC

NanoRacks
Louisville, CO

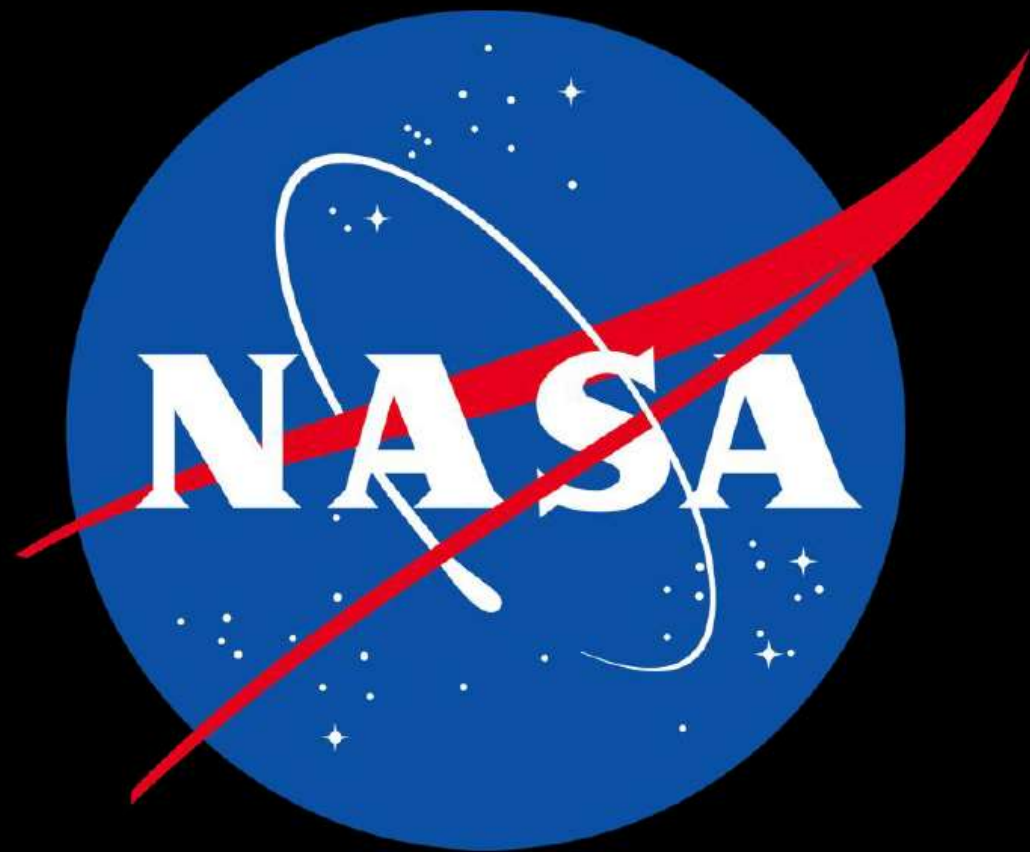


Converted Centaur
upper stages

MSFC

What's Next? And What Can You Do?

- ISS National Lab Research is ramping up.
 - Check NSPIRES for Proposal Opportunities! (www.nspires.nasa.gov)
- Gateway is real. Congress approved FY19 NASA Appropriations.
- NextSTEP Phase 2 testing and closeout in 2019; Phase 3 build.
- Stay tuned for updates on your favorite NASA channel.



2020

2030

2040

ON TO MARS

MARS SURFACE

MARS ORBIT

Robotic Mars Sample Return



Goal of
Humans on the
Martian Surface

Mars
Orbital Mission

Mars
Transportation
Capabilities

TO THE MOON

LUNAR SURFACE

LUNAR ORBIT

Robotic Resource Prospecting Missions



Human Lunar Surface Exploration

Gateway Moon and Mars Mission Support Operations

Deep Space Gateway

IN LEO

EARTH ORBIT



*Orion
and SLS*



*Commercial
Transportation
Systems*



*Russian Crew
Transportation System*

International Space Station

China Space Station

Future Platforms

Plans for the future

HUMAN EXPLORATION

NASA's Path to Mars



EARTH RELIANT

MISSION: 6 TO 12 MONTHS
RETURN TO EARTH: HOURS



Learning fundamentals
aboard the
International Space Station

U.S. companies
provide access to
low-Earth orbit

PROVING GROUND

MISSION: 1 TO 12 MONTHS
RETURN TO EARTH: DAYS



Expanding capabilities
by visiting an asteroid in a lunar
distant retrograde orbit

Traveling beyond low-Earth orbit
with the Space Launch System
rocket and Orion spacecraft



MARS READY

MISSION: 2 TO 3 YEARS
RETURN TO EARTH: MONTHS



Exploring Mars, its moons
and other deep space
destinations