National Aeronautics and Space Administration

The International Space Station, Exploration and the Commercial Development of LEO

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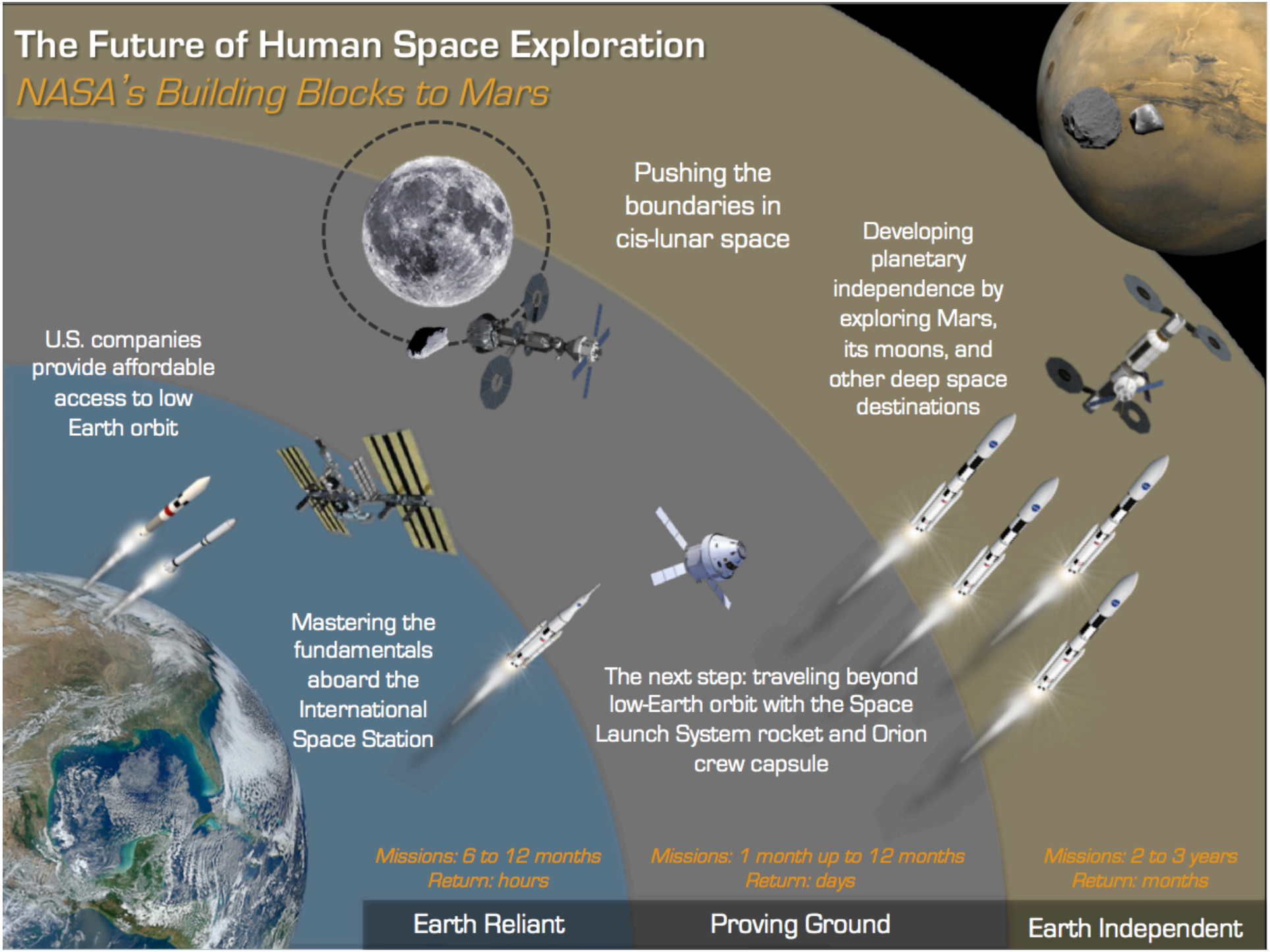
The Space Station will be around
for at least another 10 years…
The use and evolution of the ISS is directly
linked to deep space human spaceflight
and the commercial development of LEO


The Future of Human Space Exploration
NASA's Building Blocks to Mars
U.S. companies provide affordable access to low Earth orbit
Mastering the fundamentals aboard the International Space Station
Pushing the boundaries in cis-lunar space
The next step: traveling beyond low-Earth orbit with the Space Launch System rocket and Orion crew capsule
Developing planetary independence by exploring Mars, its moons, and other deep space destinations
Missions: 6 to 12 months
Return: hours
Earth Reliant
Missions: 1 month up to 12 months
Return: days
Proving Ground
Missions: 2 to 3 years
Return: months
Earth Independent

From Earth Reliant

~ 2 days transit time

Communications (near real-time)

Crew exchanges

Crew supplies and logistics

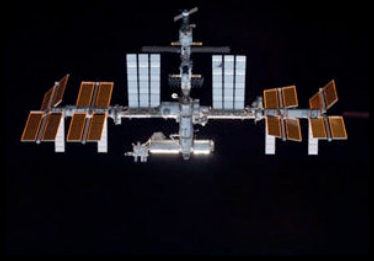
Crew and atmosphere samples

Modified hardware

Emergency Crew Return

Trash

~400 kilometers



“car camping in space”

To Earth Independent

~228,000,000 kilometers

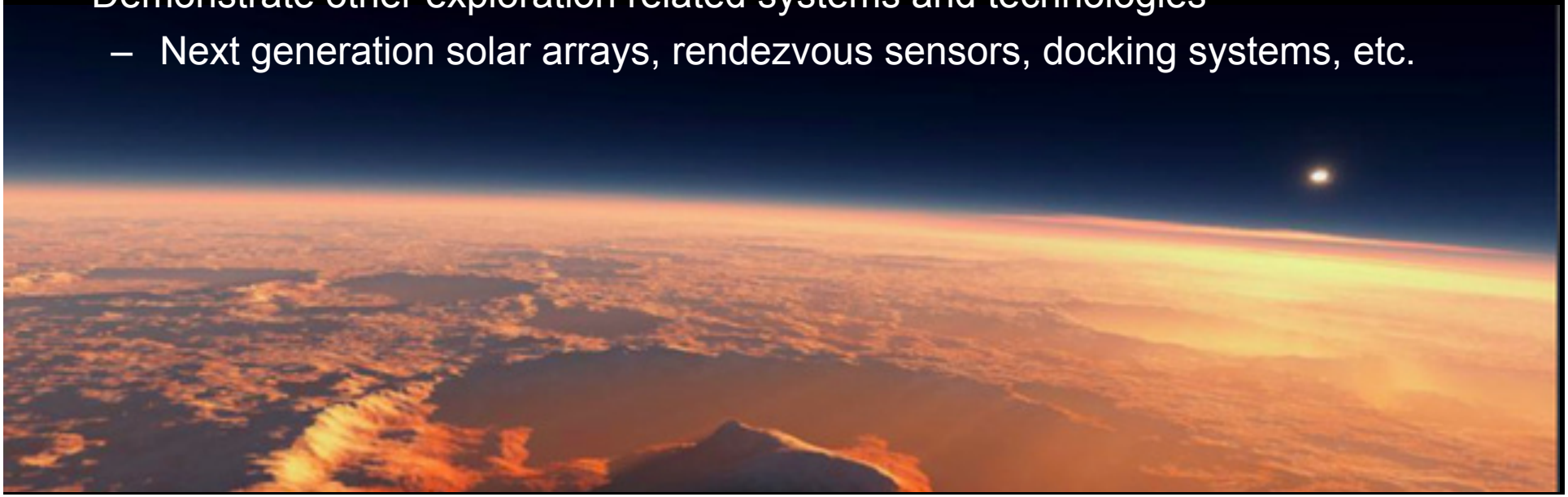
~2 - 3 years transit time

Communications (up to 42 minutes)

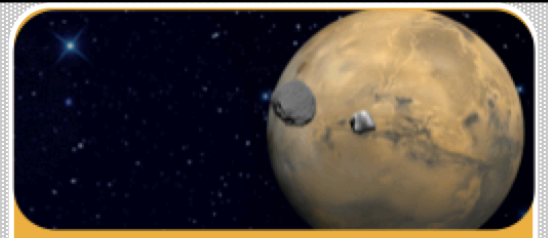
“recreate living on Earth”

What is ISS doing to fill in the gap between Earth Reliant to Earth Independent

- Demonstrate the life support system that will take us to Mars
- Validate micro-gravity human health, performance and countermeasures
- Learn how to break the bonds to the earth
  - Logistics, crew health monitoring, ground-to-crew communications, etc.
- Demonstrate other exploration related systems and technologies
  - Next generation solar arrays, rendezvous sensors, docking systems, etc.



Evolutionary Capabilities

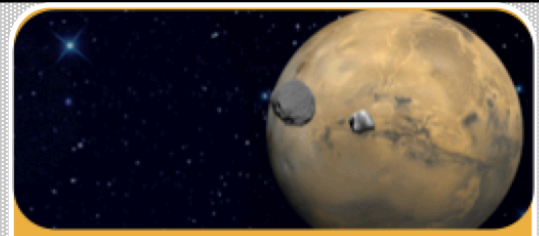


	EARTH RELIANT Return to Earth: hours	PROVING GROUND Return to Earth: days	EARTH INDEPENDENT Return to Earth: many months
Working In Space	EARTH-BASED SUPPORT: HIGH *Mastering the Fundamentals*	EARTH-BASED SUPPORT: LIMITED *Pushing the Boundaries*	EARTH-BASED SUPPORT: NEGLIGIBLE *Exploring Independently*
Exploration and Science	• Microgravity science and human physiology research	• Sampling asteroid for return to Earth for analysis	• Mars moons and surface exploration and search for life with in-situ analysis
Communicating with Earth	• Immediate and continuous support from mission control	• Limited delay with minimal crew impact	• Independent and self-reliant crew operates with up to 40 min. delay
Spacewalk and Mobility	• Zero-g outside spacecraft for short distances	• Zero-g systems for short-distance, exploration	• Surface exploration in partial gravity with longer distance and duration
Spacecraft Assembly & Maintenance	• Crew-assisted ISS Assembly • Frequent deliveries & servicing	• Limited deliveries requires more efficient systems with common, interchangeable parts	• Maintenance with only the parts and tools they carry or produce in-situ
Human-Robotic Interactions	• Testing safety and control methods for efficient human-robotic teams	• Human- robot teams, with periods where robots are left alone	• Pre-deployed equipment depends on robots until humans arrive, then human-robot teams share critical tasks
In-situ Resource Utilization	• Recycle and reuse water and trash	• Learning to recycle destination resources for fuel, water, oxygen, and building materials	• Crew harvests destination resources to create fuel, water, oxygen, and building materials

Evolutionary Capabilities

EARTH RELIANT
Return to Earth: hours

PROVING GROUND
Return to Earth: days



EARTH INDEPENDENT
Return to Earth: many months

Staying Healthy	EARTH-BASED SUPPORT: HIGH *Mission Duration: 6-12 months*	EARTH-BASED SUPPORT: LIMITED *Mission Duration: 1-12 months*	EARTH-BASED SUPPORT: NEGLIGIBLE *Mission Duration: 2-3 years*
Spacecraft Life Support Systems	• Developing onboard life support systems for long-duration missions	• Validating onboard recycling and regenerating life support systems without resupply	• Living and working in spacecraft that must fully support crew for years
Human Health and Performance	• Studying space environment health risks and testing solutions	• Applying health and performance risk mitigation techniques	• Living in space for years while maintaining crew health and performance
Autonomous Medicine	• Developing integrated medical capability and crew-reliant medical care	• Testing semi-autonomous integrated medical capability and crew-reliant medical treatment	• Autonomous medical capability and medical crewmember for diagnosis and treatment
Environmental Monitoring	• Testing on-board environmental monitors with ground validation	• Demonstrating onboard environmental monitoring systems (no sample return)	• Monitoring crew environment for hazards, eliminating environmental emergencies
Advanced Space Suits	• Testing next-generation space suits	• Demonstrating advanced space suits in deep space	• Conducting EVAs in unprecedented planetary environments

Deep space human spaceflight and the commercial market in LEO

Many of the systems and capabilities needed for the LEO commercial market
- evolved from ISS - can be utilized for deep space missions

Habitat Structures

Environmental support and monitoring systems
- Regenerative ECLSS
- Waste systems
- Sabatier
- Atmosphere monitoring

Crew Health and Performance Equipment
- Medical equipment
- Exercise equipment

EVA Support Systems

Spacecraft Systems

Cargo Resupply