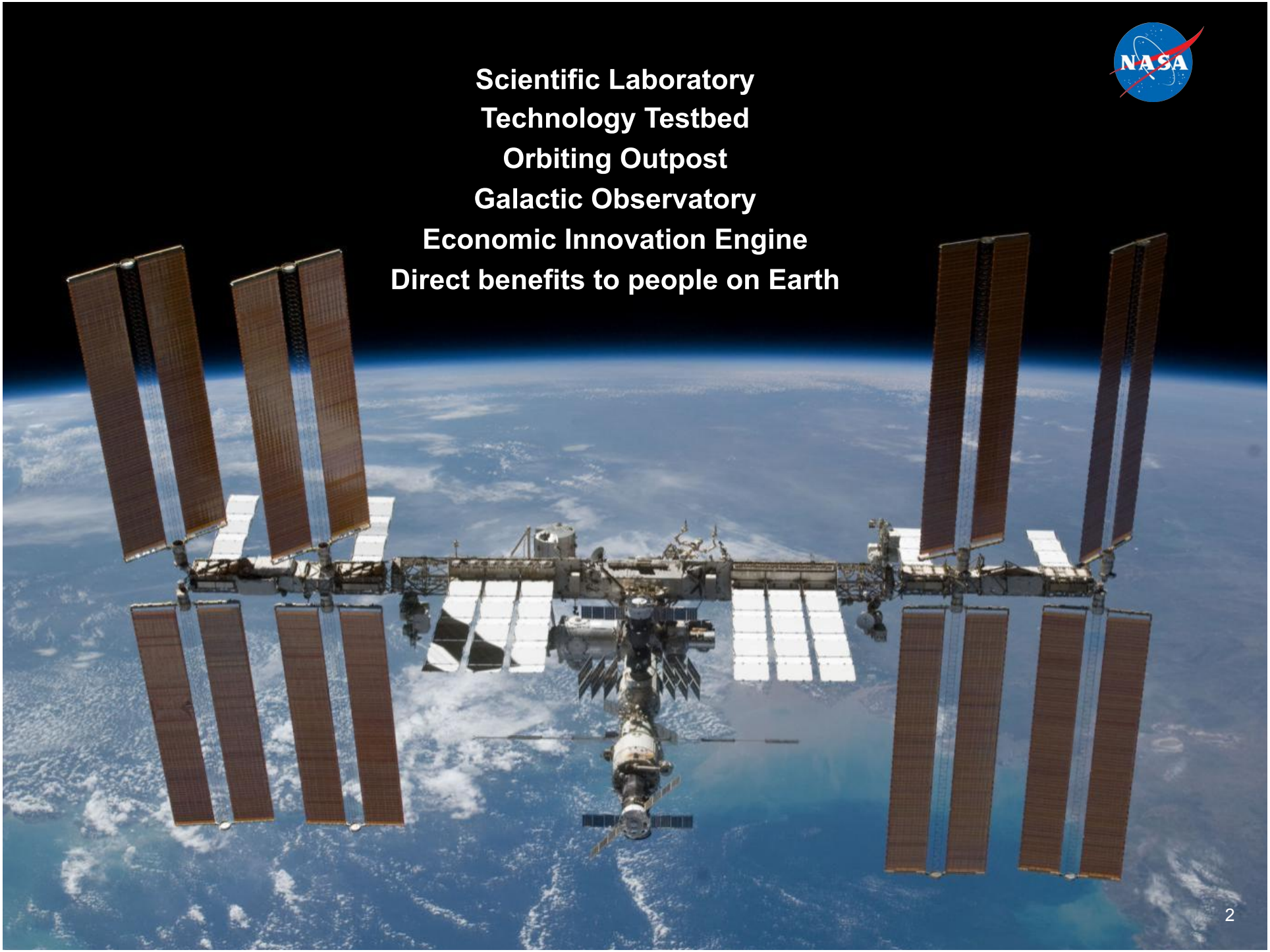
# NASA Advisory Council Meeting: Full Session

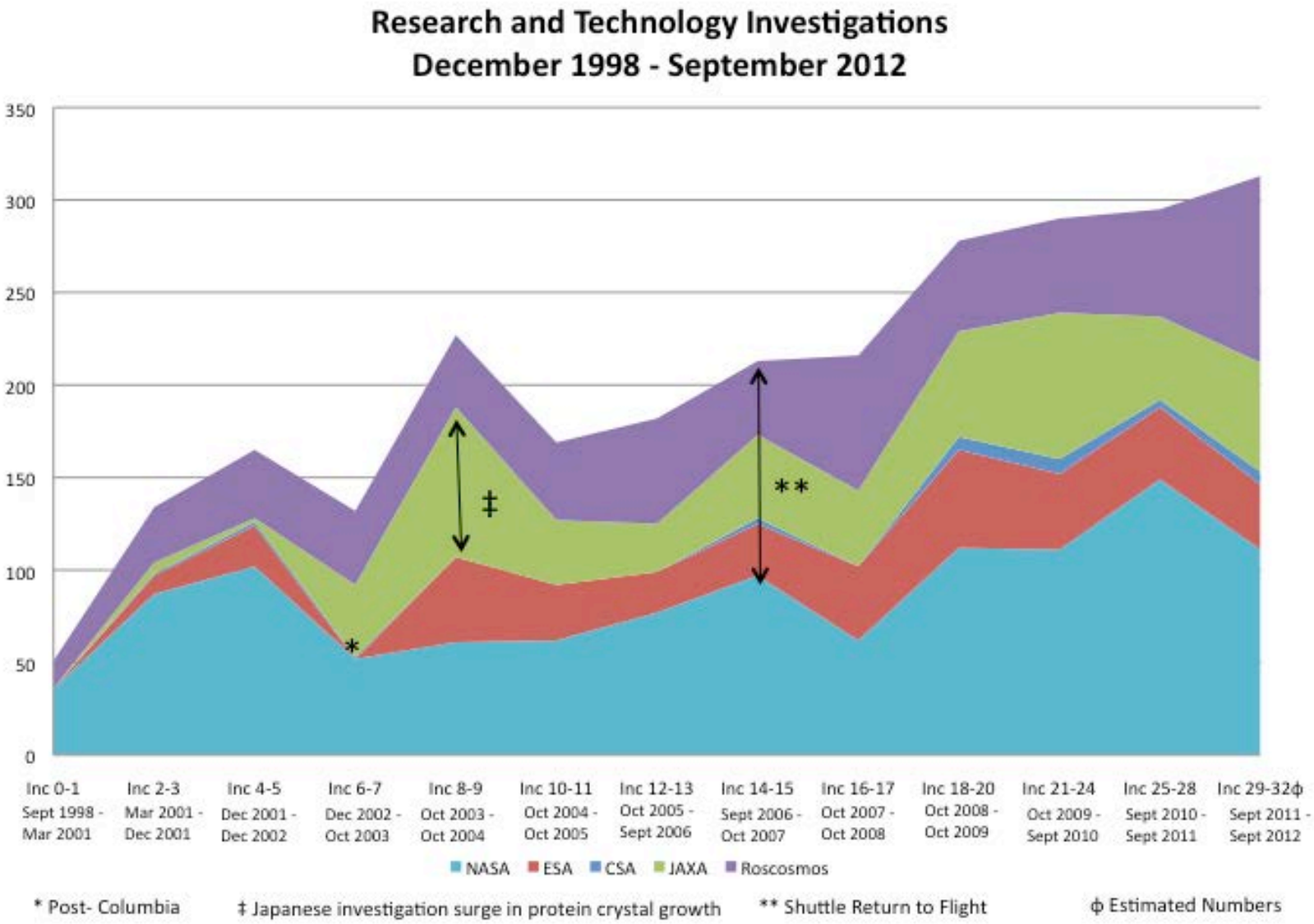
William Gerstenmaier | November 28, 2012


Scientific Laboratory
Technology Testbed
Orbiting Outpost
Galactic Observatory
Economic Innovation Engine
Direct benefits to people on Earth

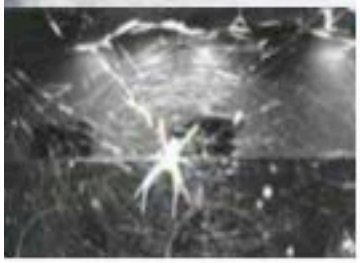
# Examples of Major ISS Benefits from the Decade of Assembly

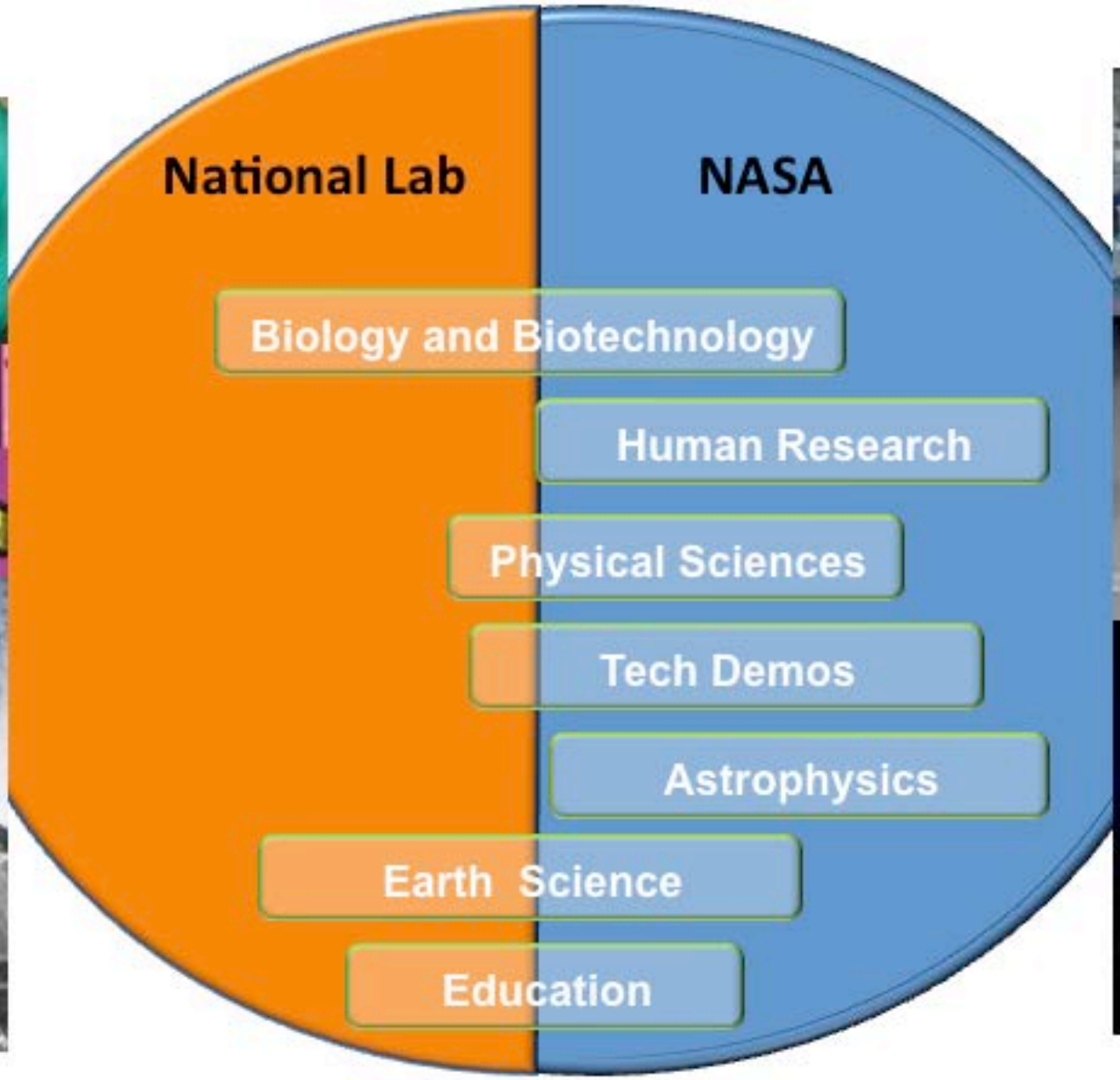
- Discoveries
  - MAXI black hole swallowing star (*Nature*)
  - Vision impacts and intracranial pressure (*Opthalmology*)
  - Microbial virulence (*Proc. Nat. Acad. Sci.)*
- NASA Exploration Mission
  - Life support sustaining and reliability
  - Success in bone health maintenance resistive exercise (*J. Bone Mineral Res.*)
  - Models for Atomic Oxygen erosion in orbit
- Results with potential Earth benefit
  - Candidate vaccines for Salmonella and MRSA
  - Candidate treatment for prostate cancer
  - Candidate treatment for Duschenne's muscular dystrophy
- Technology Spinoffs
  - Robotic assist for brain surgery
  - TiO2 for filtering bacteria from the air in daycares
  - Remotely-guided ultrasound for maternal care in remote areas

# Record Throughout



# What Are We Doing On ISS Today?






# Space Life and Physical Sciences 2012 Highlights

- Completed research demonstrating that exercise prescriptions using the ISS Advanced Resistive Exercise Device, together with appropriate nutrition, is an effective countermeasure against bone and muscle loss in space.

- Delivered an updated radiation risk assessment tool to manage the risk to crew members for future space missions. The tool supports mission planning and spacecraft shielding design.

- Implemented high fidelity biomedical imaging using the recently delivered Ultrasound 2 device. This will support research and monitor crewmembers to understand the connection between decrements in visual acuity and increased intracranial pressure in long duration space flight.

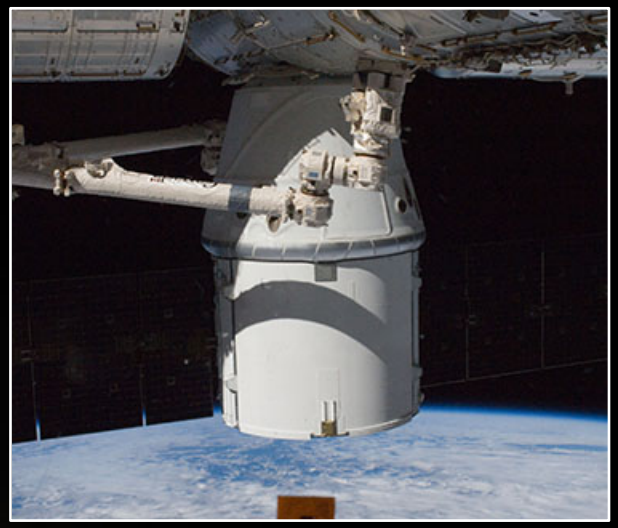
- Combustion research on ISS advanced the understanding of “cool flames,” a combustion process that occurs at temperatures below normal combustion. This phenomenon is a key to homogeneous charge compression ignition, an advanced clean-burning diesel technology.

# Space Life and Physical Sciences 2012 Highlights
*- continued*

- Results from ISS experiments on magnetorheological fluids, published with authors including Barratt, De Winne, Finke, Magnus, Wakata, and Whitson, demonstrated how pulsating magnetic fields can be harnessed in the creation of unique materials and electromechanical devices.

- Work has begun to reestablish an animal research capability on the ISS. Validation experiment design is underway and concept of operations is being refined for a first launch planned for SpaceX-4.

- CASIS announced selections from its initial research solicitation in protein crystal growth, an area identified by a team of science advisors as having strong economic potential. Projects are being evaluated for flight in FY 2013 and 2014.



The SpaceX Falcon 9 rocket and Dragon capsule lifting off from Cape Canaveral. SpaceX CRS-1 is the first of twelve contracted commercial resupply missions to the International Space Station.

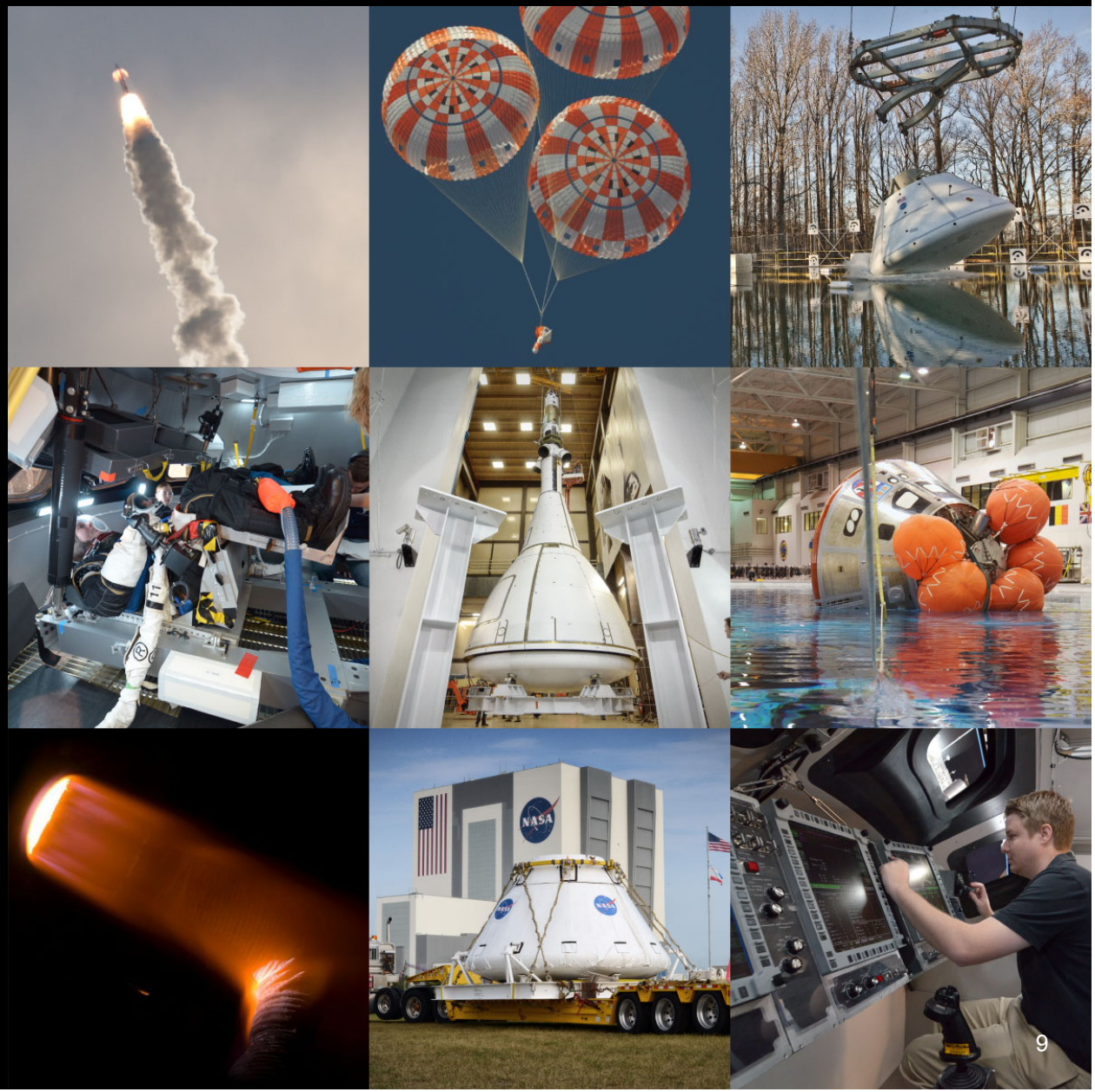
# MPCV - Orion

Initial test flight (no crew) on Delta IV in 2014 – vehicle assembly underway

First MPCV/SLS (no crew) flight in 2017

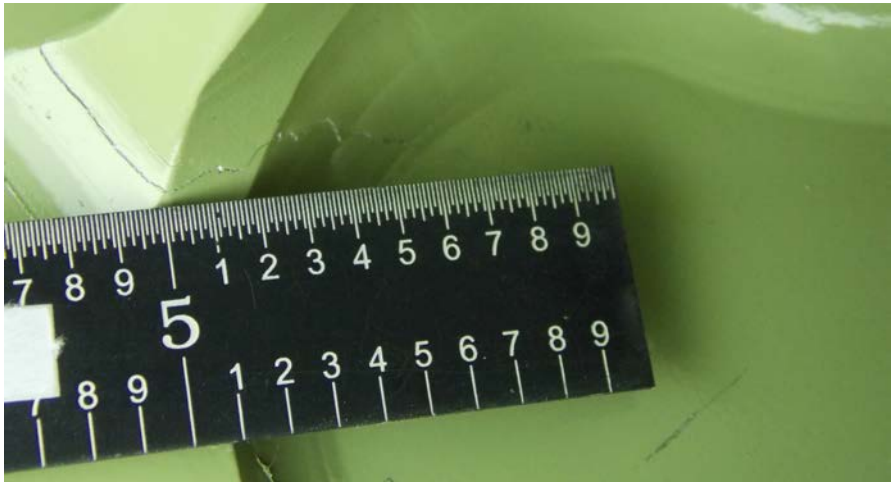
<u>Demonstration Tests completed:</u>

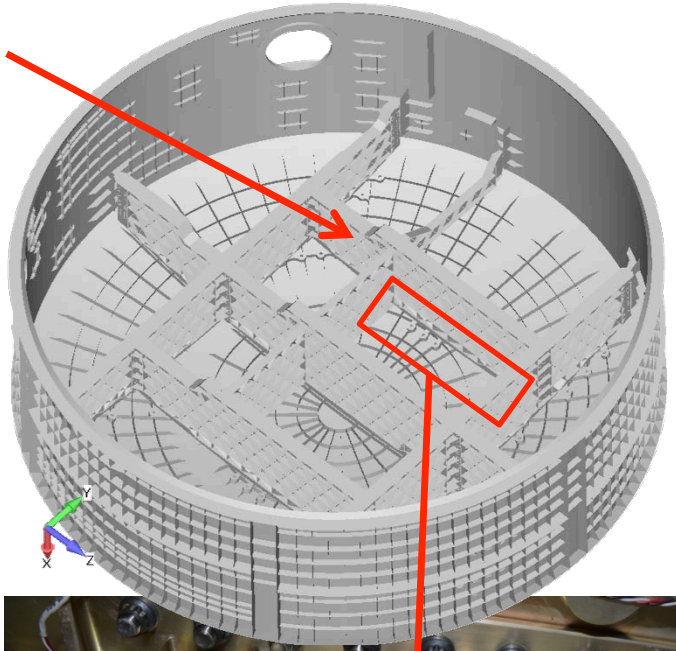
- Launch Abort System
- Parachute Drop Testing
- Water Drop Testing
- Human Factors Testing
- Vibration Testing
- Landing & Recovery Testing
- Thermal Protection System Testing



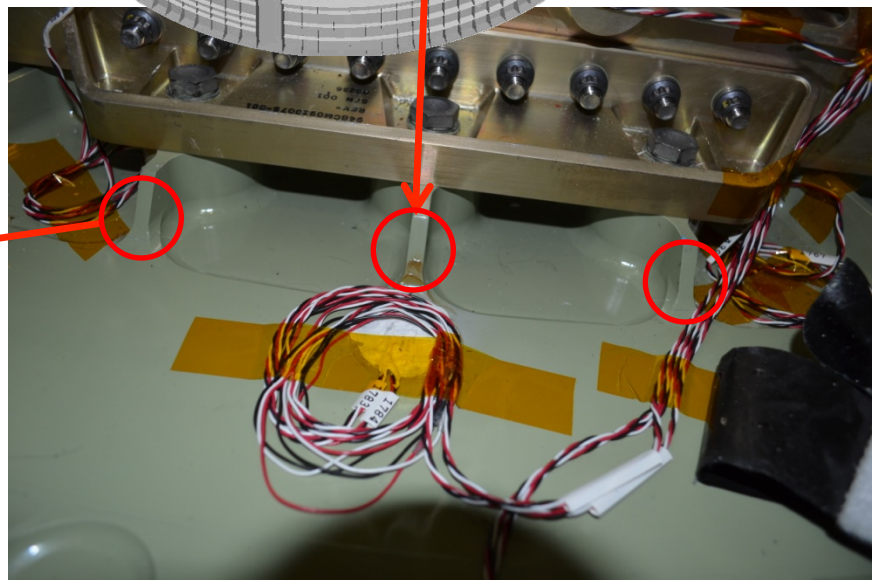
# Orion Capsule Cracks During Pressure Test

Backbone panel 4





3 cracks at radius of rib run-out on far side of backbone panel 4



SLS

Ground Systems Development

Orion

Orion will serve as the exploration vehicle that will carry the crew to space, provide emergency abort capability, sustain the crew during the space travel, and provide safe re-entry from deep space return velocities.

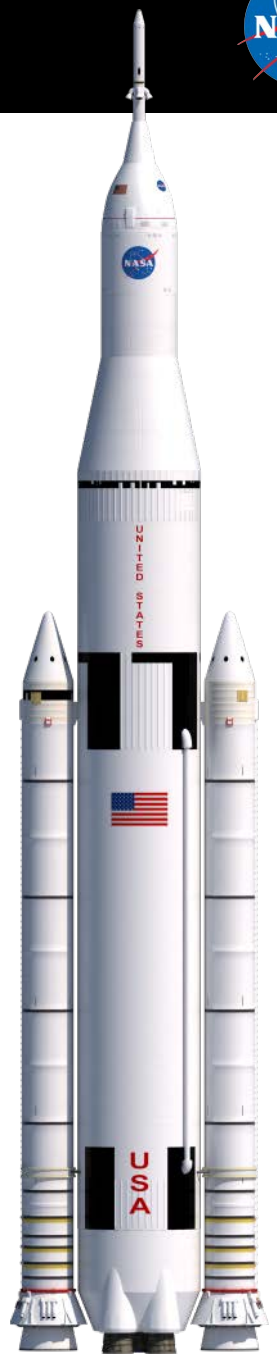
# Exploration Flight Tests: Entering a New Era of Human Spaceflight

- The SLS and MPCV programs are actively working toward the goal of sending humans to explore deep space, with flight tests starting in 2014.

- The Un-crewed Exploration Flight Test-1 (EFT-1) in 2014 and Exploration Mission 1 (EM-1) in 2017 will validate innovative approaches to space systems development to ensure the systems are safe for human travel, reduce cost, and demonstrate spacecraft post-landing recovery procedures.

- The crewed Exploration Mission 2 (EM-2) will validate human risk mitigation techniques developed for the integrated SLS-MPCV system.

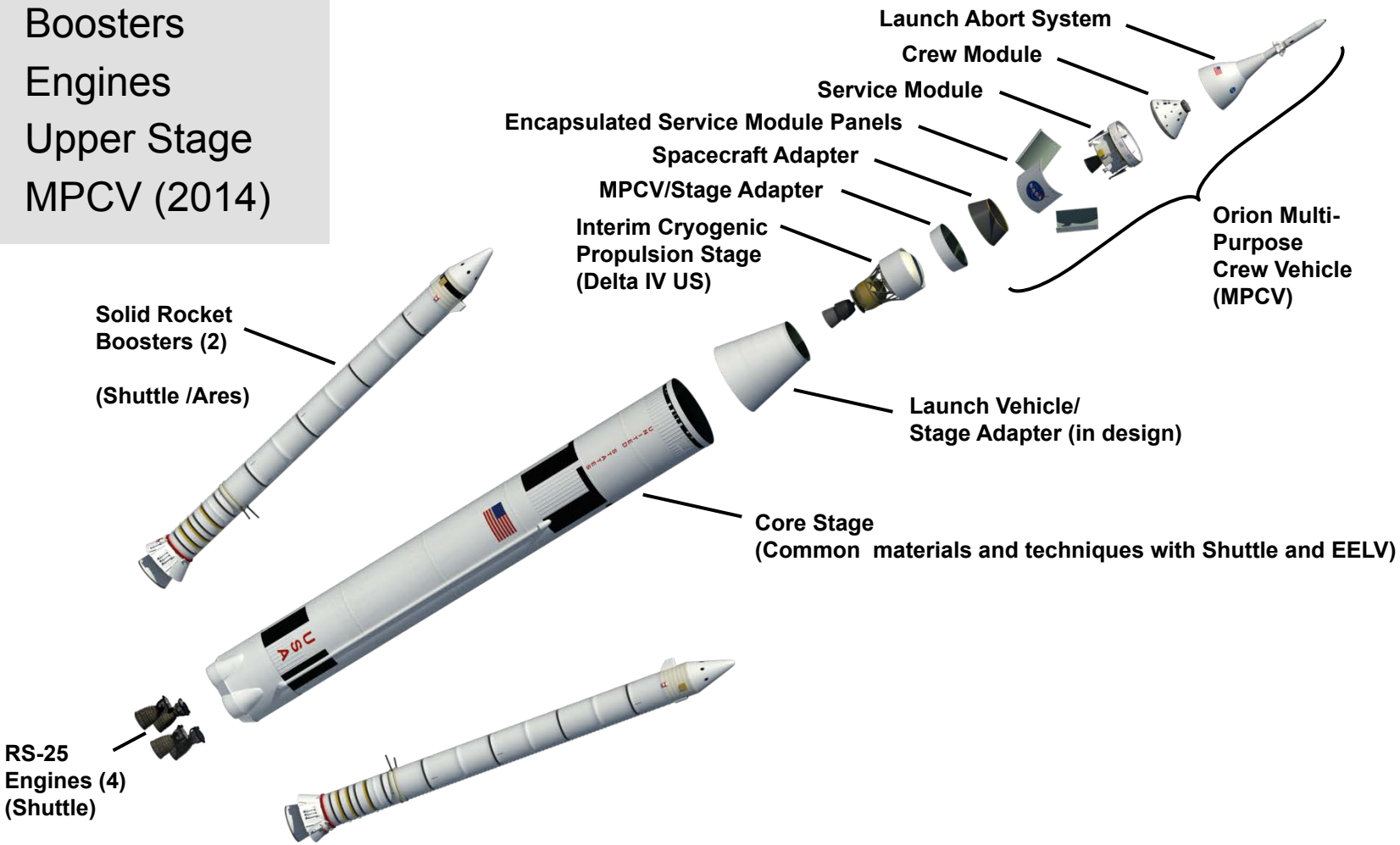
- Current flight test plans take the integrated SLS-MPCV system to lunar fly-by and high lunar orbit. Current assessments are evaluating alternate destinations to address long-term exploration and science-based objectives.



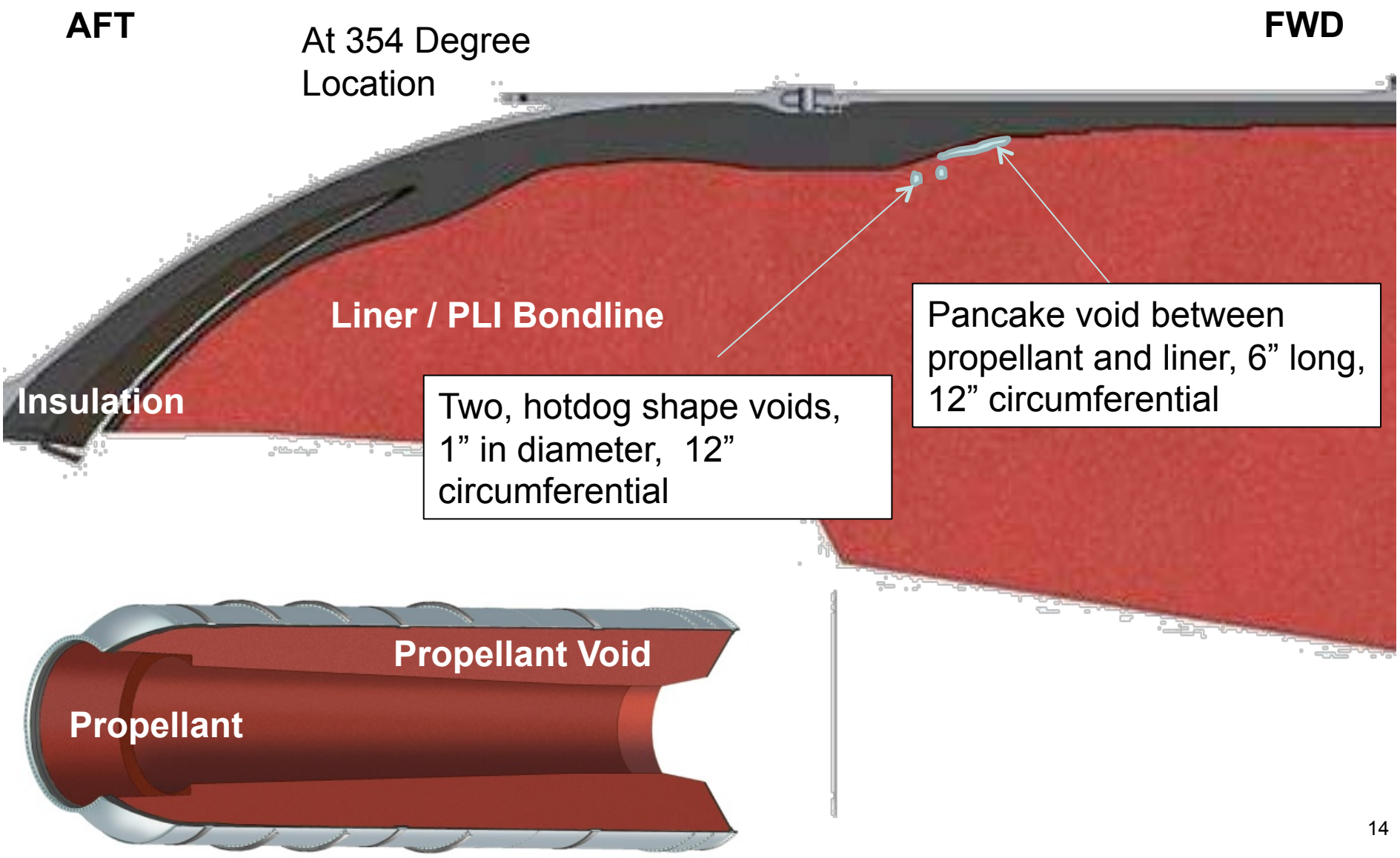
# Space Launch System

Hardware Tested:

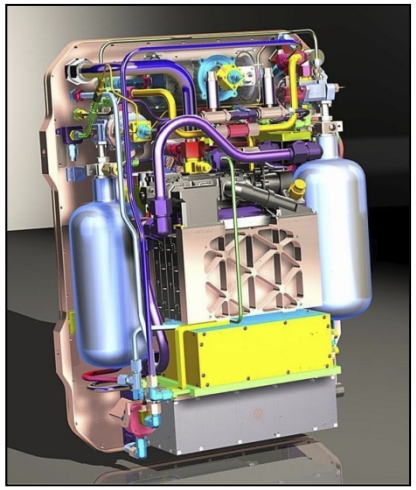
- Boosters
- Engines
- Upper Stage
- MPCV (2014)



# QM-1 AFT Segment X-ray Tangent Image



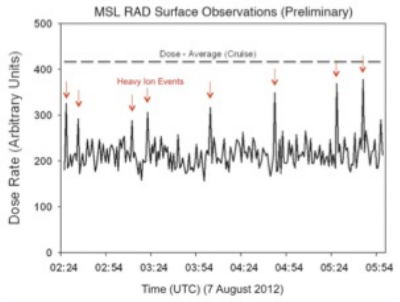
# Advanced Exploration Systems FY12 Accomplishments



**EVA:** Assembled prototype Portable Life Support System for advanced space suit.

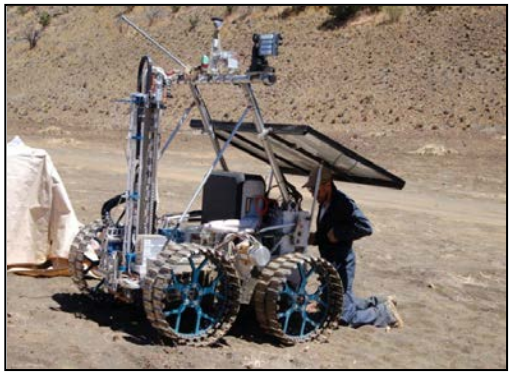
**Life Support:** Tested ISS-based air revitalization systems to improve reliability.

**Morpheus Vertical Test Bed:** Completed 20 tethered flight tests of Morpheus lander.



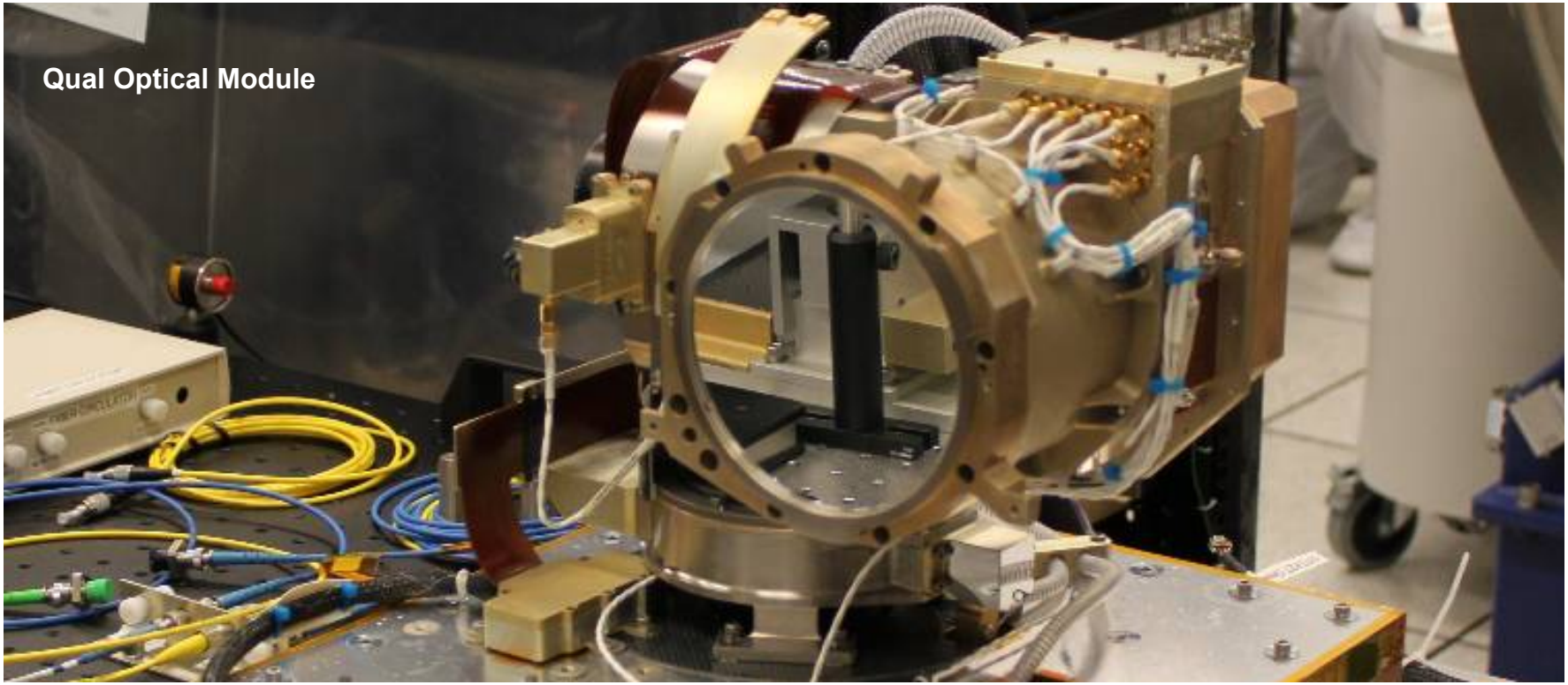

**Radiation Assessment Detector:** Acquired radiation data during MSL's interplanetary cruise and on surface of Mars

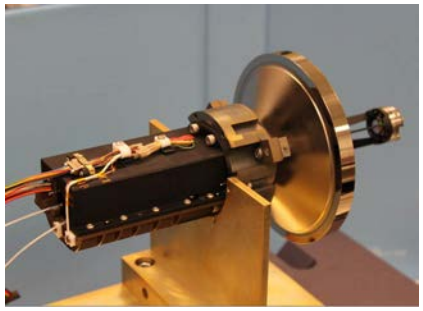
**Goldstone Radar**: Imaged 12 near-Earth asteroids to determine their orbits, size, shape, and spin rate.



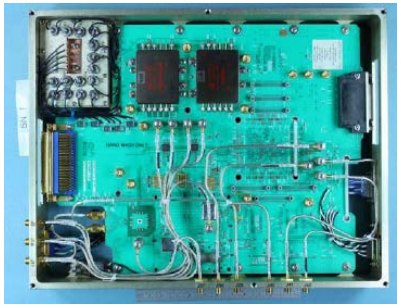
**RESOLVE**: Conducted field test in Hawaii of lunar ice prospecting experiment in partnership with Canadian Space Agency.

# Lunar Laser Space Terminal



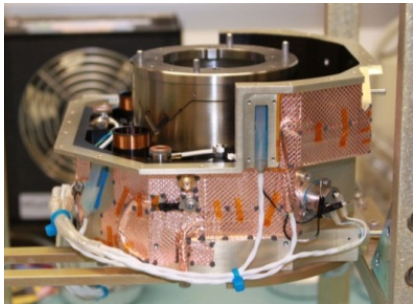



**Flight Optical Subassembly**



**Flight Modem Module Digital Board**

**Flight Controller Electronics**



**Flight MIRU**
(Magneto-hydrodynamic reference stabilized Inertial Reference Unit)

# Launch Services Program – FY13 Plan

- **Successfully launch the following missions this fiscal year (i.e., FY2013):**

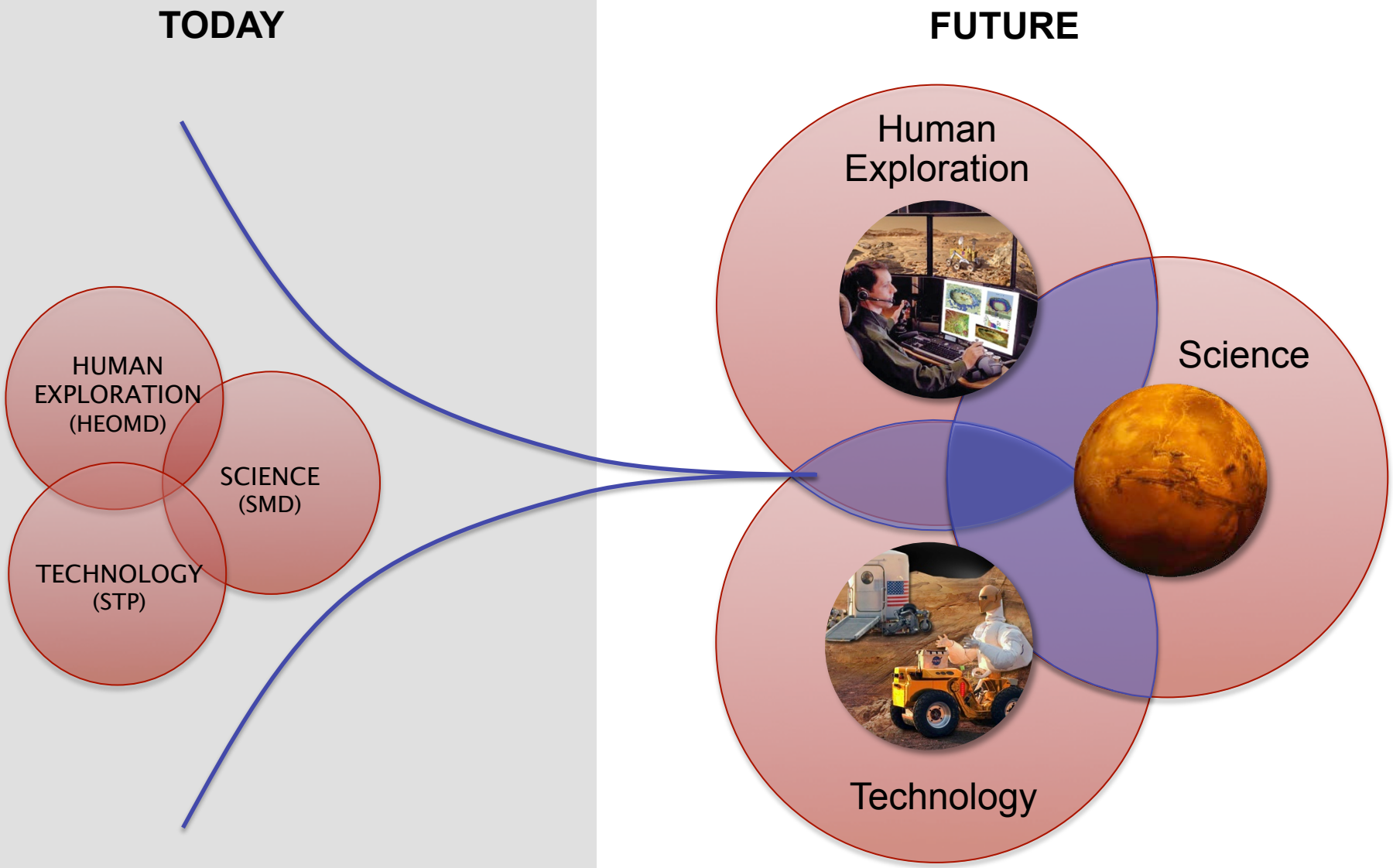

NET January 25, 2013
Atlas V 401 CCAFS, FL


NET February 11, 2013
Atlas V 401, VAFB, CA


NET February 27, 2013
Pegasus XL, VAFB, CA

- **Conduct the LSTO selection process for the following missions:**
  - Medium-class launch service for the SMD/Earth Science Division *Ice, Cloud, and land Elevation Satellite-2* (ICESat-2) mission
  - Intermediate-class launch service for the SMD/Planetary Science Division *Origins Spectral Interpretation Resource Identification Security-Regolith Explorer* (OSIRIS-REx) mission

# Human Mars Exploration Focuses Agency Technology and Capability Development



# Identifying Future Exploration Mission Needs

## Capability Driven Human Space Exploration


**Human Exploration of Mars**
**The "Horizon Destination"**

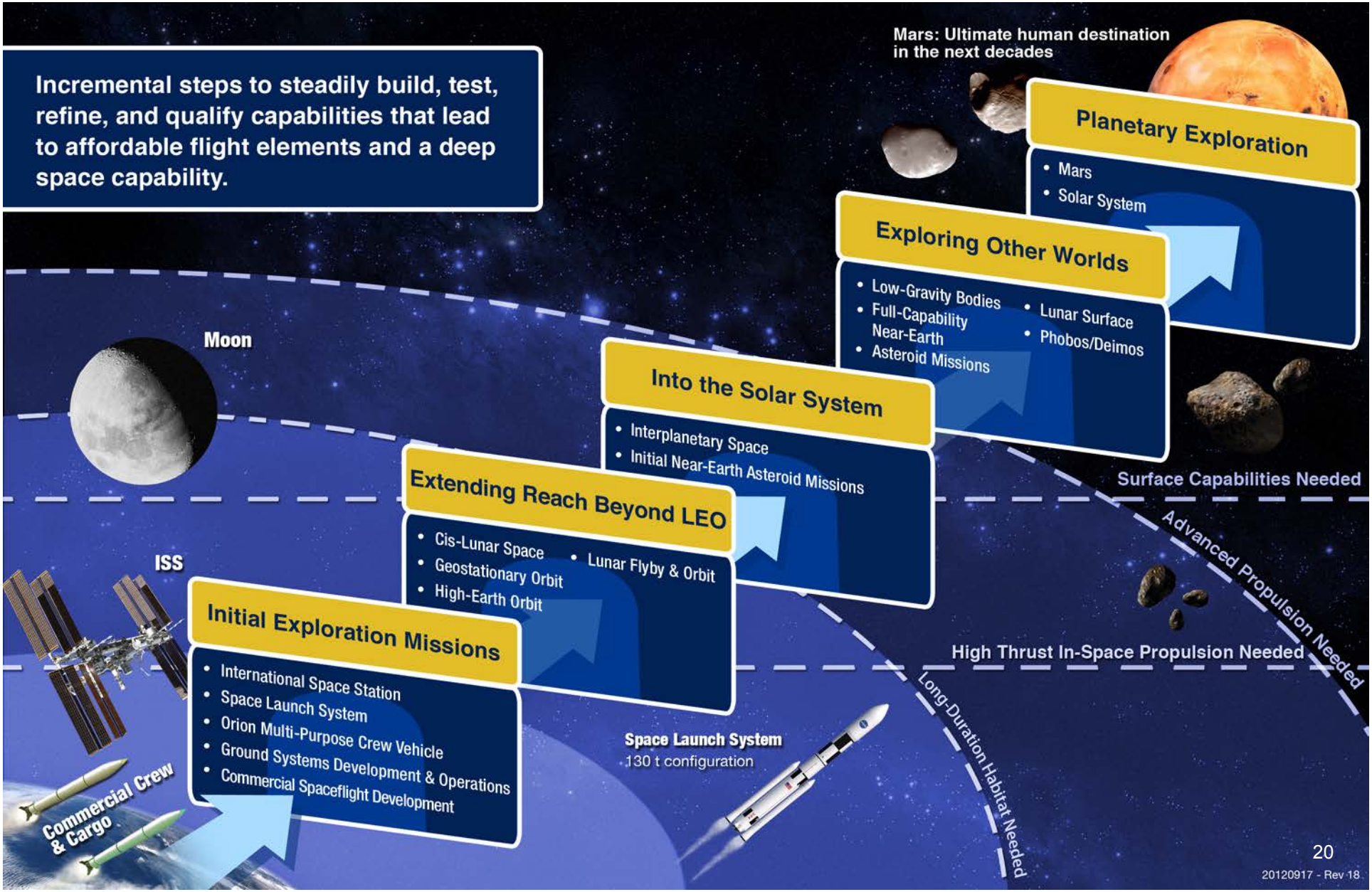
## Common Mission Needs Seeking Solutions

| | | | | | | |
|---|---|---|---|---|---|---|
| Low Earth Orbit Crew and Cargo Access | Human - Robotic Mission Ops | In-Space Propulsion | Adv. In-Space Propulsion | Deep Space Habitation | Ground Operations | High Reliability, Low Maintenance Systems |
| Beyond Earth Orbit Crew and Cargo Access | Robotic Precursor | EVA | Mobile EVA and Robotic Platform | Destination Systems | Autonomous Mission Operations | Crew Health & Protection |

## Technologies, Research, and Science

- OCT Technology Development Efforts
- HEO and SMD Cross Cutting Research & Science
- Advanced Exploration Systems Projects
- Human Exploration Specific Technologies

# Capability Driven Exploration



# Mission Needs for Humans at Mars

**Epoch of first use:**

| 2012-2024 | 2024-2033 | 2033+ |
|---|---|---|
| Mars Orbit | | |
| - Orion MPCV<br>- SLS Initial Capabilities: 70-105t<br>- Interim Cryogenic Stage<br>- 21st Century Ground Ops<br>- Optical Communication | - Large Propulsive Stage<br>- Deep Space Habitat (365 days)<br>- 300kW+ SEP Stage<br>- Orion+ Upgrades | - SLS Upgrade (130t)<br>- Deep Space Habitat (900 days)<br>- Advanced Propulsion (e.g., NEP,<br>Capability architecture to Mars System under study |
| | | Mars Surface |
| Robotic demonstration of human mission relevant sub-scale surface access technologies can support EDL, ascent and ISRU | | - Lander<br>- Ascent Vehicle<br>- ISRU<br>- Surface Habitat<br>- Surface Suit<br>- Rover |

Building up system capabilities, gaining deep space operational experience and reducing risk as we move further out into the solar system.

# Human Exploration System Development and Risk Reduction

- HEOMD is demonstrating capabilities and reducing risk toward eventual human Mars exploration
  - Near Term (2012-2022): Core Capability Development, Mid-Phase Risk Reduction
  - Mid-Term (2022-2033): Core Capability Operations and Upgrade and Late Phase Risk Reduction
  - Long Term (2033+): Humans at Mars

- Primary risks to mitigate, including on ISS, for deep space travel
  - Life support
  - Spacecraft reliability, supportability and maintainability
  - Human performance for long durations in deep space
    - » Radiation protection
    - » Physiological degradation prevention
  - Transportation system performance

# ISS: A Complement and an Enabler to Deep Space (1)

- Long duration missions
  - Crew health, human support
    - Life support
    - Microgravity:  bone density loss, intracranial pressure, and exercise regimes
  - Planning one year mission for 2015
- Reliability, supportability, maintainability
  - Spacecraft and systems operations, maintenance and logistics
- Mars mission operations simulations
  - Crew autonomy, time delayed communications, mission planning

# ISS: A Complement and an Enabler to Deep Space (2)

- Technology Testbed
  - New systems/ technologies critical for long duration deep space missions
- International Partnership
  - Strong partnership, led by the United States
  - Proven barter system in place
  - Maximizes resources by avoiding duplication
  - Partners want to explore with us and they have useful hardware
  - NASA is exploring leveraging partnership to go beyond LEO
- Proving Ground for Commercial Cargo and eventually Commercial Crew and other commercial activities

# ISS Technology Demonstrations & Critical Exploration System Development

## Technology Demonstrations

- Technology demonstrations are on-board or manifested on ISS, with plans in place to prepare additional technology demonstrations for future flights.
  - ISS partners are discussing ways to ensure that priority technology demonstrations are able to be flown to ISS.
  - Examples of technology demonstration activities onboard or planned for launch include demonstrating:
  - Use of RFID tags, smart enclosures, and portal readers for improved inventory management;
  - Autonomous vehicle fault management, power automation, disruption tolerant network (DTN) communications, and use of software controlled radios;
  - Demonstrating use of on-board and surface robots/assets for mission-enhancing IVA, EVA, and surface routine, emergency, ISRU, and scientific operations.

## Systems Development

- To meet beyond LEO exploration requirements, the state of the art of critical systems sustaining the ISS crew must be advanced. Examples include:
  - ISS environmental control and life support system (ECLSS); initial focus for this effort
    - Advanced carbon dioxide removal systems, Advanced oxygen generation systems, Advanced atmospheric monitoring systems, New trace contaminant control systems
  - Robotics, Comm and Nav, Power Generation, Thermal Control

# ISS Activities to Support Human Health Management for Long-Duration Space Travel & Operations Techniques and Simulations

## Human Health Management for Long-Duration Space Travel

- NASA and its international partners are conducting over 160 studies and activities onboard the ISS to address Top human health and performance risk:
  - Immune system studies
  - Nutrition studies
  - Integrated cardiovascular system studies
  - Functional task studies
  - Vitamin studies
  - Exercise effectiveness studies
  - Crew performance studies
  - Ocular health studies
  - Medical operations and health management studies

## Operational Techniques and Simulations

- ISSP plans to conduct a one year increment on-board ISS
  - This is to validate our current state of physical performance countermeasures; those which address:
- Bone density and strength
- Muscle mass and strength
- Aerobic capacity and overall fitness.

- Other planned activities to demonstrate exploration operations concepts and techniques include:
  - Demonstrating just-in-time medical and other training
  - Evaluating a crew's ability to schedule their own activities
  - Increased crew autonomous procedure execution

# Beyond LEO Demonstration Capability is Needed

- Operational experience is needed for deep space rendezvous and navigation
- Need to learn to mitigate or better understand deep space radiation
- Need experience in risk mitigation for activities beyond LEO

# Summary Remarks

- Directorate is making tremendous progress in a very constrained environment
- Budget is a primary concern
- Capability driven context offers significant benefits in this environment
- Science, technology and human systems all need to be a part of exploration for NASA
- All new systems development need to be designed for use in future systems

**For more information about the HEO directorate visit:**

www.nasa.gov/directorates/heo

**For the latest news about human exploration visit:**

www.nasa.gov/exploration