

# Human Exploration & Operations Briefing to NRC/SSB & ASEB



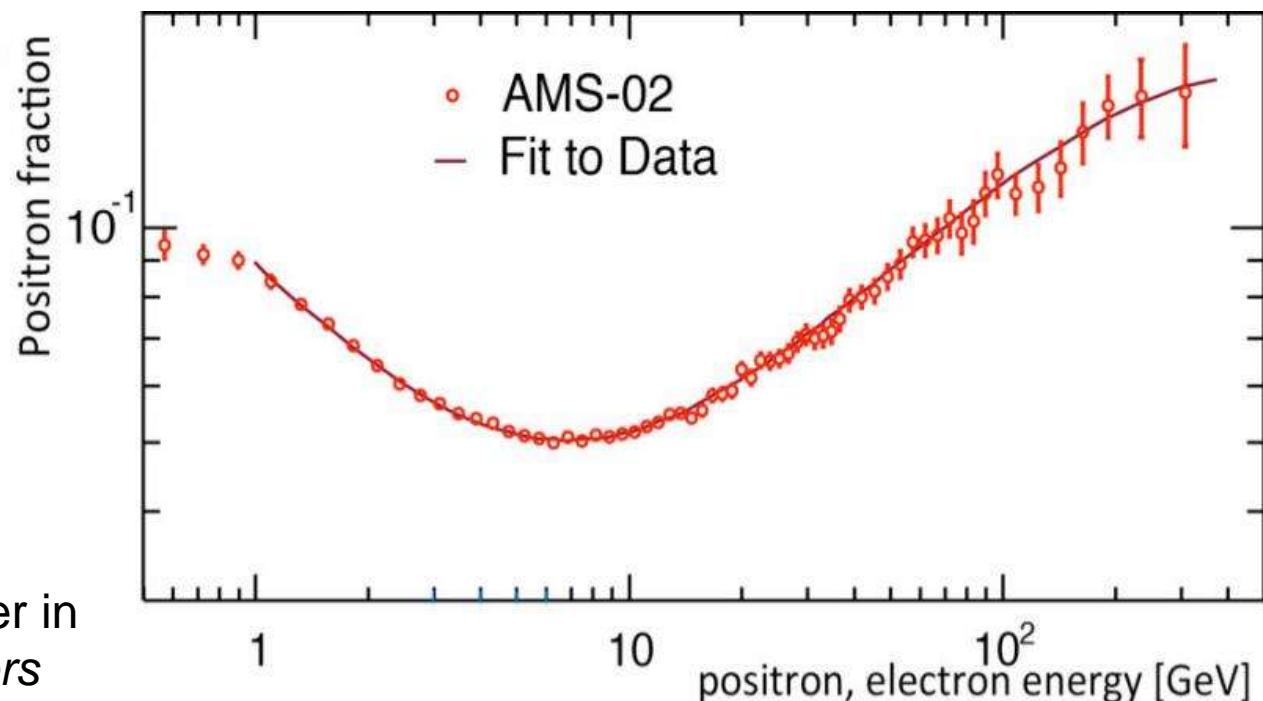
Bill Gerstenmaier | April 4, 2013



# First Results from AMS



“The exact shape of the spectrum...extended to higher energies, will ultimately determine whether this spectrum originates from the collision of dark matter particles or from pulsars in the galaxy. The high level of accuracy of this data shows that AMS will soon resolve this issue.”



Credit: CERN Press  
Office release on paper in  
*Physical Review Letters*

# Topics



- **Budget Status**
- **Exploration Systems Development Progress & Industrial Base Considerations**
- **Future Exploration Planning**

# Human Exploration and Operations

## FY 2013 Post Sequestration Controls



(Dollars Millions)	FY 2012 Appropriation (P.L. 112-55, Div. B, Title III)	FY 2013 Appropriation (P.L. 113-6, Div. B, Title III)	Recissions (-2%)	Sequestration Reduction (~5%)	FY 2013 Final Appropriation	FY 2013 President's Budget Request	Delta
<b>HEO</b>	<b>8,004.4</b>	<b>7,840.0</b>	<b>(162.5)</b>	<b>(401.8)</b>	<b>7,275.6</b>	<b>7,946.0</b>	<b>(670.4)</b>
<b>Exploration</b>	<b>3,770.8</b>	<b>3,887.0</b>	<b>(80.6)</b>	<b>(189.5)</b>	<b>3,616.9</b>	<b>3,932.8</b>	<b>(315.9)</b>
<b>Exploration Systems Development</b>	<b>3,060.0</b>	<b>3,054.0</b>	<b>(63.3)</b>	<b>(148.9)</b>	<b>2,841.8</b>	<b>2,769.4</b>	<b>72.4</b>
Multi-Purpose Crew Vehicle	1,200.0	1,197.0	(24.8)	(58.4)	1,113.8	1,024.9	89.0
Space Launch System	1,860.0	1,454.2	(30.1)	(70.9)	1,353.2	1,340.0	13.1
Exploration Ground Systems	316.5	402.8	(8.4)	(19.6)	374.8	404.5	(29.7)
<b>Exploration Research and Development</b>	<b>304.8</b>	<b>308.0</b>	<b>(6.4)</b>	<b>(15.0)</b>	<b>286.6</b>	<b>333.7</b>	<b>(47.1)</b>
AES	147.1	150.3	(3.1)	(7.3)	139.9	169.0	(29.1)
HRP	157.7	157.7	(3.3)	(7.7)	146.7	164.7	(18.0)
<b>Commercial Spaceflight</b>	<b>406.0</b>	<b>525.0</b>	<b>(10.9)</b>	<b>(25.6)</b>	<b>488.5</b>	<b>829.7</b>	<b>(341.2)</b>
<b>Space Operations</b>	<b>4,233.6</b>	<b>3,953.0</b>	<b>(82.0)</b>	<b>(212.3)</b>	<b>3,658.7</b>	<b>4,013.2</b>	<b>(354.5)</b>
<b>Space Shuttle</b>	<b>573.0</b>	<b>70.0</b>	<b>(1.5)</b>	<b>(3.8)</b>	<b>64.8</b>	<b>70.6</b>	<b>(5.8)</b>
<b>International Space Station</b>	<b>2,830.0</b>	<b>2,958.0</b>	<b>(61.3)</b>	<b>(158.9)</b>	<b>2,737.8</b>	<b>3,007.6</b>	<b>(269.8)</b>
Satellite Servicing	50.0	50.0	(1.0)	(2.7)	46.3	10.0	36.3
<b>Space and Flight Support (SFS)</b>	<b>830.6</b>	<b>925.0</b>	<b>(19.2)</b>	<b>(49.7)</b>	<b>856.1</b>	<b>935.0</b>	<b>(78.9)</b>
21st Century Space Launch Complex	168.0	41.1	(0.9)	(2.2)	38.0	41.1	(3.1)
SCaN	426.0	645.6	(13.4)	(34.7)	597.6	655.6	(58.1)
HSFO	111.4	111.1	(2.3)	(6.0)	102.8	111.1	(8.3)
LSP	81.3	81.2	(1.7)	(4.4)	75.2	81.2	(6.0)
RPT	43.9	45.9	(1.0)	(2.5)	42.5	45.9	(3.4)
<b>Exploration CECR (CoF Funds)</b>	<b>-</b>	<b>265.7</b>	<b>(5.5)</b>	<b>(7.5)</b>	<b>252.7</b>	<b>143.7</b>	<b>109.0</b>
SLS	-	211.3	(4.4)	(6.0)	200.9	89.3	111.6
EGS	-	51.1	(1.1)	(1.5)	48.6	51.1	(2.5)
MPCV		3.3	(0.1)	(0.1)	3.1	3.3	(0.2)
<b>Space Ops CECR (CoF Funds)</b>	<b>28.9</b>	<b>21.9</b>	<b>(0.5)</b>	<b>(0.6)</b>	<b>20.8</b>	<b>21.9</b>	<b>(1.1)</b>
21CLSC		5.9	(0.1)	(0.2)	5.6	5.9	(0.3)
SCaN	17.3	14.4	(0.3)	(0.4)	13.7	14.4	(0.7)
LSP	1.6	1.6	(0.0)	(0.0)	1.5	1.6	(0.1)

Note: Amounts not in italics were stipulated in Legislation

Amounts in CECR are in a separate account and are not included in the HEO total

# The Future of Exploration

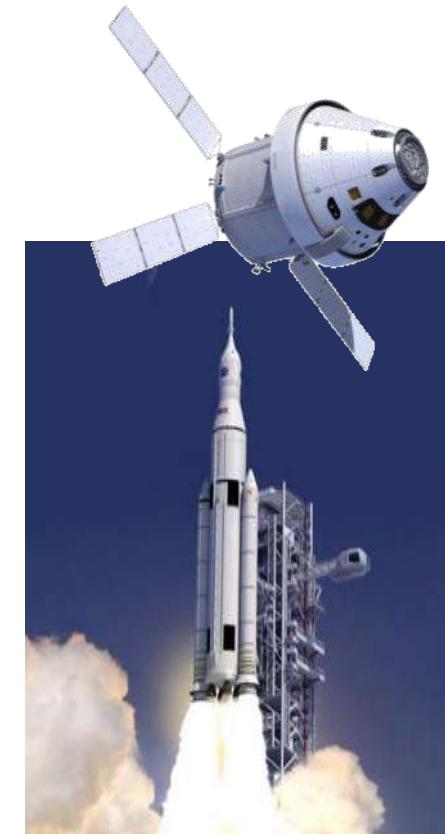


*The Space Launch System [will] be the **backbone** of its **manned spaceflight program** for decades. It [will] be the **most powerful** rocket in NASA's **history**...and puts NASA on a more **sustainable** path to continue our tradition of **innovative space exploration**.*

# Exploration Systems Development (ESD)



- **Space Launch System (SLS) Program:**
  - Initial capability: 70 tonnes (t), 2017–2021
  - Evolved capability: 105 t and 130 t, post-2021
  - Evolution strategy dictated by Mission Capture
- **Orion Program:**
  - Initial test flight (no crew) on Delta IV in 2014
    - Vehicle assembly underway
  - First Orion/SLS (no crew) flight in 2017
  - First crewed Orion/SLS flight in 2021
- **Ground Systems Development and Operations (GSDO) Program:**
  - Developing launch site infrastructure to prepare, assemble, test, launch and recover the SLS and Orion flight systems



# ESD Mission Overview



## Exploration Mission One (EM-1)

First Uncrewed BEO Flight

2017

- **Mission objectives**

- Demonstrate integrated spacecraft systems performance prior to crewed flight
- Demonstrate high speed entry (~11 km/s) and TPS prior to crewed flight

- **Mission description**

- Un-crewed circumlunar flight – free return trajectory
- Mission duration ~7 days

- **Spacecraft configuration**

- Orion Uncrewed

- **Launch vehicle configuration**

- SLS Block 1, 5-segment RSRMV, 4 RS-25, 70mt
- Interim CPS

- **Launch site**

- KSC LC-39B

## Exploration Mission Two (EM-2)

First Crewed BEO Flight

2021

- **Mission objectives**

- Demonstrate crewed flight beyond LEO

- **Mission description**

- Crewed lunar orbit-capable, or other destinations
- Mission duration 10-14 days

- **Spacecraft configuration**

- Orion Crewed

- **Launch vehicle configuration**

- SLS Block, 5-segment RSRMV, 4 RS-25, 70mt
- Interim CPS

- **Launch site**

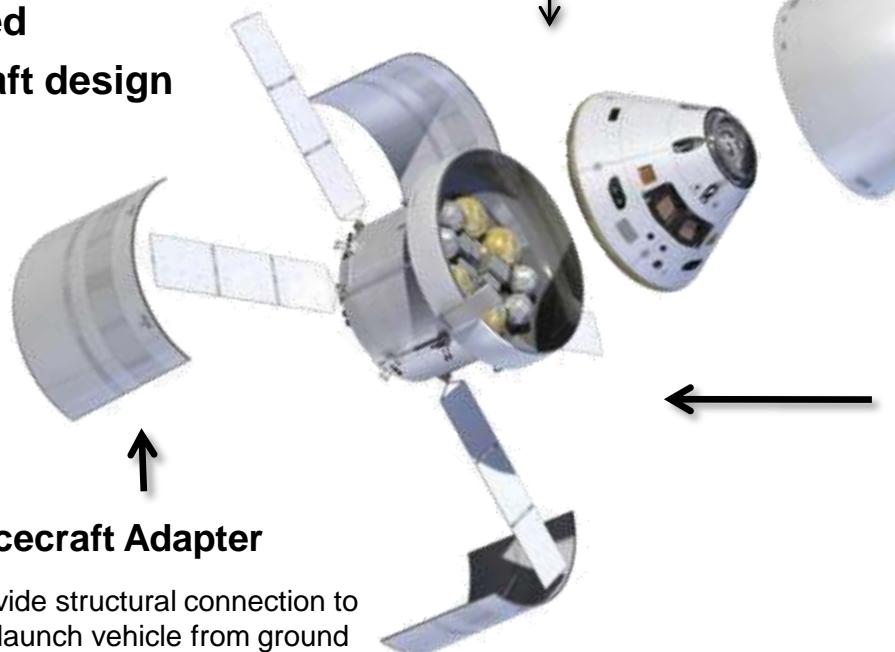
- KSC LC-39B



# Orion MPCV Spacecraft Overview



**Orion MPCV design divides critical functions among multiple modules to maximize the performance of the integrated spacecraft design**

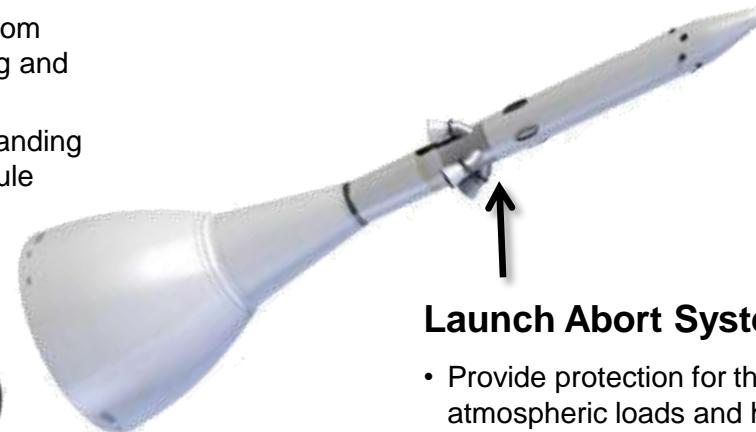


## Spacecraft Adapter

- Provide structural connection to the launch vehicle from ground operations through CM Separation
- Provide protection for SM components from atmospheric loads and heating during first stage flight

## Crew Module (CM)

- Provide safe habitat from launch through landing and recovery
- Conduct reentry and landing as a stand alone module



## Launch Abort System

- Provide protection for the CM from atmospheric loads and heating during first stage flight
- Safely jettison after successful pad operations and first stage flight

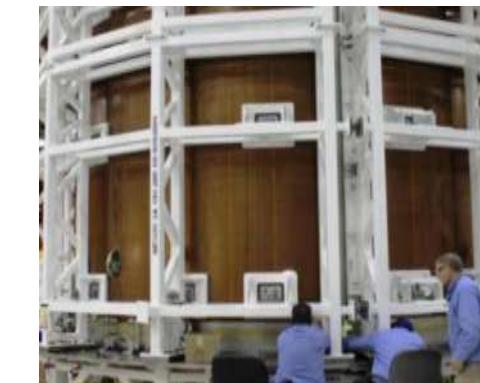
## Service Module (SM)

- Provide support to the CM from launch through CM separation to missions with minimal impact to the CM

# Orion Progress and Accomplishments



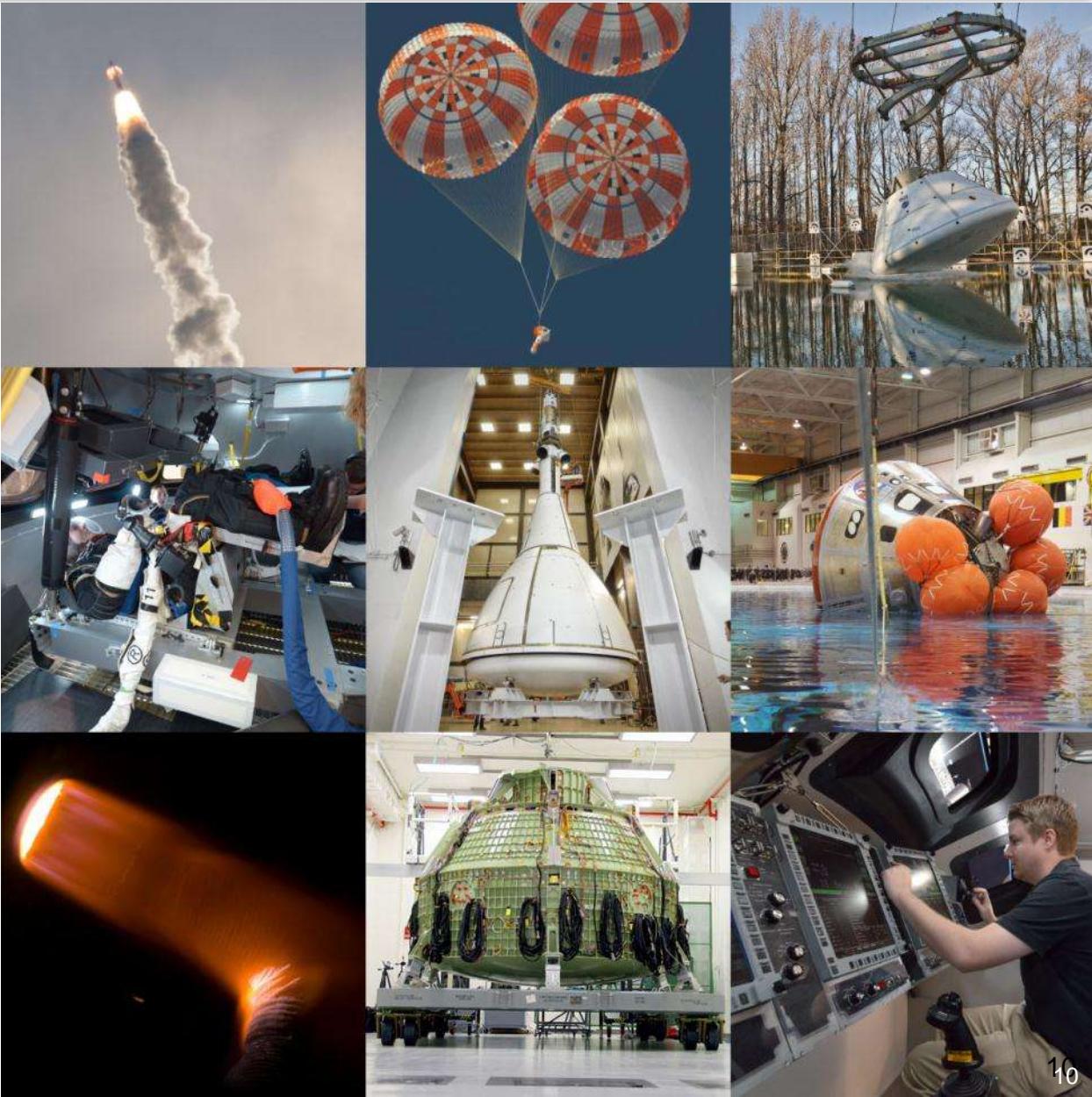
- EFT-1 is scheduled for September 2014 and the flight test articles for the crew module (shown) and service module are being assembled at KSC.
  - EFT-1 Inert Abort Test Motor arrived at KSC
- Heat shield assembly was shipped to Textron in Wilmington, Mass., in March for installation of ablative protective coating.
- Orion EM-1: Partnership with ESA to deliver elements of Orion Service Module was signed 12/2012.
- Orion EFT 1 hardware continues to stress the capability of industry to supply large scale hardware
  - Eg. Quality findings, supply chain lessons, EEE piece part suitability
- Orion continues to share development test result data with CCDev2 and its partners, leveraging investment in common suppliers base.



# Orion Demonstration Tests Completed



- Launch Abort System
- Parachute Drop
- Water Drop
- Human Factors - Suit
- Acoustic Vibration
- Up-righting System
- Thermal Protection System
- Landing & Recovery
- Controls Evaluation



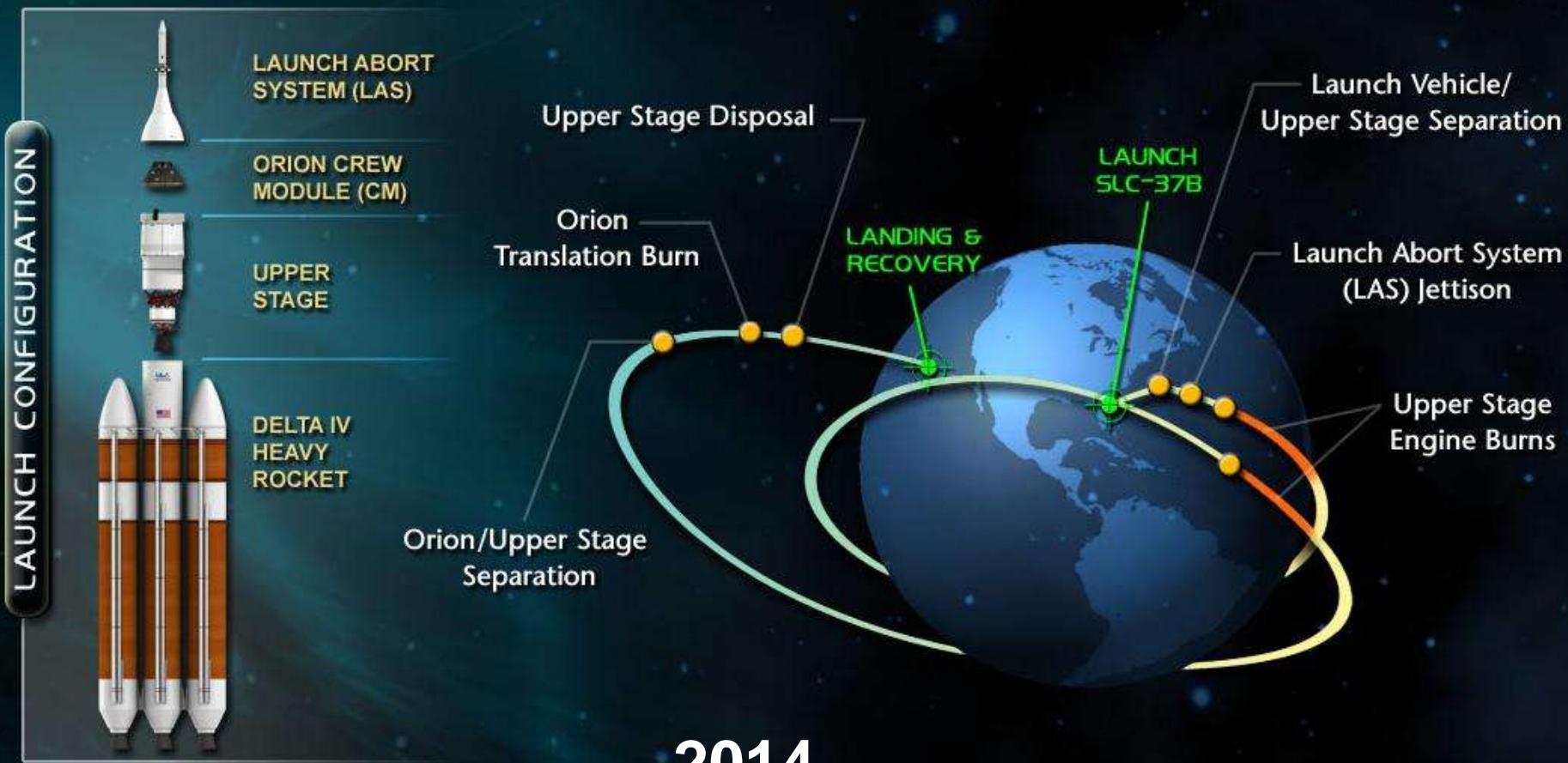
# Exploration Flight Test – 1



## EXPLORATION FLIGHT TEST ONE

### OVERVIEW

TWO ORBITS • 20,000 MPH ENTRY • 3,671 MILE APOGEE • 28.6 DEGREE INCLINATION



# SLS Evolution



- **SLS Initial capability: 70 tonnes (t), 2017–2021**
  - Closes EM1, EM2, and cis-lunar
  - Can enable scientific and DoD payloads with requirements beyond commercial lift capabilities
- **SLS Evolved capability: 105 t, post-2021**
  - Enhances Exploration architecture capability, sustainability, and affordability by closing virtually all DRMs except Mars
  - Advanced Booster as current plan, while assessing Dual Use Upper stage as an alternate next evolution step for affordable mission capture.
  - Assessing potential partnerships (commercial & international) reducing technical and programmatic risk
- **SLS Final capability: 130 t, post-2021**
  - Needed to close Mars and challenging NEAs
  - Requires both an Upper stage and Advanced Booster
  - Exploration will require in-space long-term cryo-propulsion element, for full mission capture



70 t Class  
EM1 in 2017



130 t Class  
Needed to Close Mars  
and challenging NEAs

# SLS Hardware in Production and Testing

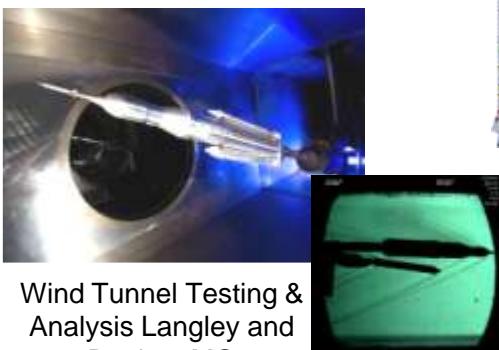
## First Flight 2017



MPCV Stage Adapter Production  
Marshall Space Flight Center, AL



Booster Motor  
production & Firing  
at Promontory, UT



Wind Tunnel Testing &  
Analysis Langley and  
Boeing, MO



Avionics Testbed  
Marshall Space Flight Center, AL



Stages manufacturing  
and tooling preparation  
Michoud Assembly Facility, LA



RS-25 Consolidation  
Stennis Space Center, MS



J-2X Engine Testing  
Stennis Space Center, MS



Advanced Development F-1 Gas  
Generator (GG) testing  
Marshall Space Flight Center

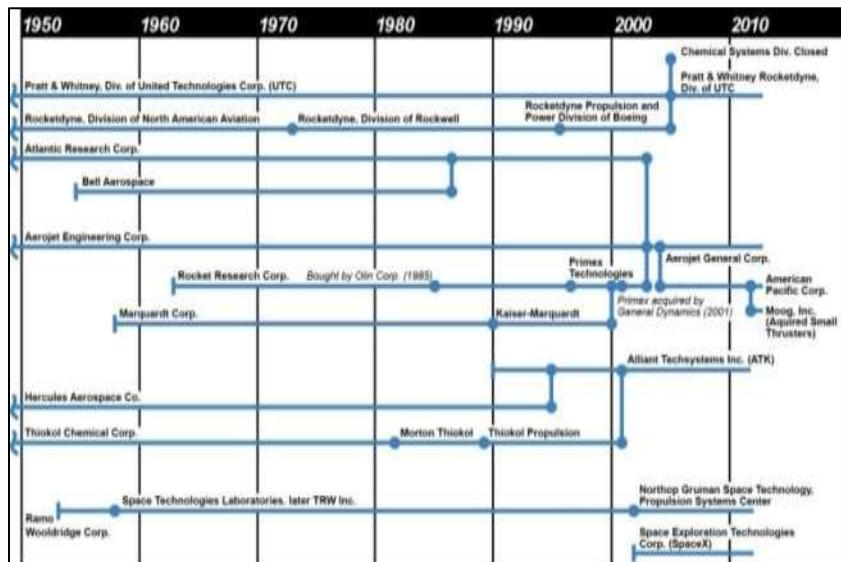
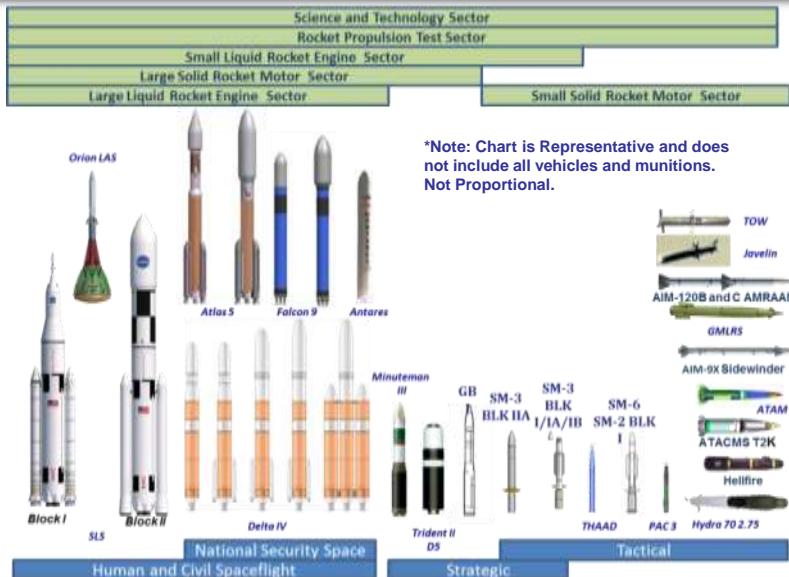


Launch Complex 39B Preparation  
Kennedy Space Center, FL

# Rocket Propulsion Industry



- Rocket propulsion is a key subsystem in all phases of the lifecycle that provides a needed capability for launch, munitions, & in-space
- Findings from prior reports are still valid
  - Propulsion remains a highly specialized field
  - Competitiveness & resilience of the propulsion industrial base has led to consolidation
  - O&S continues to streamline to reduce capacity and costs
  - R&D and DDT&E is critical aspect
    - Retention & advancement of critical skills
    - Mitigates risk of obsolescence
    - Revitalizes Science, Technology, Engineering and Mathematics (STEM)
    - Cost reduction in development & sustainment of components & systems
      - Re-certification cost is a barrier to innovation
- Key future decision point that impacts industry involves SLS's evolution
- NASA & DoD are collaborating to address Rocket Propulsion Industry Base



# Examples of Sub-Tier Commonalities in Rocket Propulsion Industrial Base



- SLS Booster Element Office is phasing its ammonium perchlorate buy. Plan to buy 1M lbs of AP a year through FY16
  - Results in predictable AP demand curves & prices
  - Benefits EELV Strap-on and Army Guided Multiple Launch Rocket System, continues synergy with Navy Trident D5
- SLS Liquid Engine Office continues to enable O&S streamlining to reduce costs and improve commonality for RS-68, RS-25, & J-2X
  - J-2X development continuation
  - RS-25 restart and vendor selection is not finalized opening door for additional commonality
  - RL-10 has limited supplier commonality. Future synergy needs to be investigated for affordability and sustainment



Critical Supplier	RS-25	RS-68	J-2X
Aerospace Tech.	X		X
Alcoa		X (RL10)	
ATK Launch Sys.		X	
Beranek		X	X
Boeing		X	
Carlton Forge	X		X
Eaton	X	X (RL10)	
FAG	X	X	X
FMH	X	X	X
FPI		X	
GKN Chemtronics	X		
Hi Temp Insulation	X		X
Honeywell	X		X
Howmet Hampton	X	X	X
Lefiell Mft	X	X (RL10)	X
Major Tool		X	X
z	X	X (RL10)	X
MHI		X	X
Pacific Scientific		X	X
PCC Large Structures	X		X
Remmele Eng.		X	
Special Metals	X	X	X
Spincraft	X	X	X
Turbocam		X	
Weldmac		X	X
Woodward, Textron	X		

Green Common NASA/DoD, Blue Common to NASA Systems, Orange Not Common, Yellow Potential Change for Commonality & Efficiency

# ESD Hardware / Test / Mission Milestones



2008



2009

Ares 1-X  
Launch

Water  
Recovery  
Training



2010

Attitude Control  
Motor Test

Pad abort 1  
stacking

Pad abort 1 test



2011

First Orion  
Environmental  
Testing

Parachute  
Tests

Solid Rocket  
Booster  
development  
motor test



2012

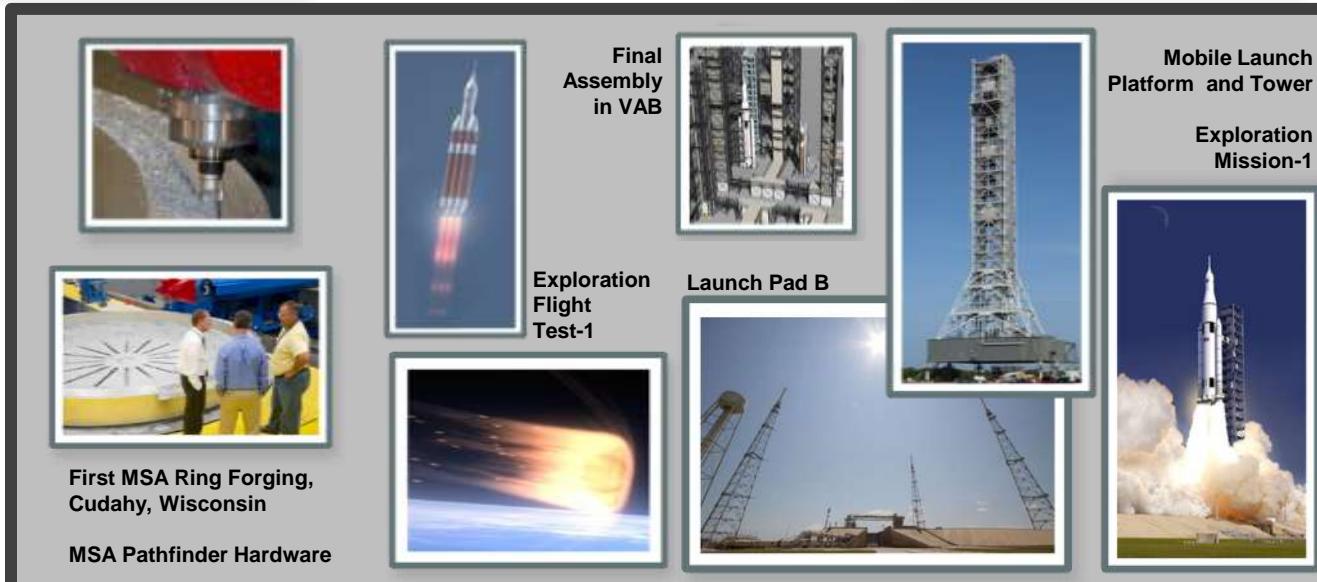


EFT-1 Crew Module

Solid Rocket Booster  
development motor  
test

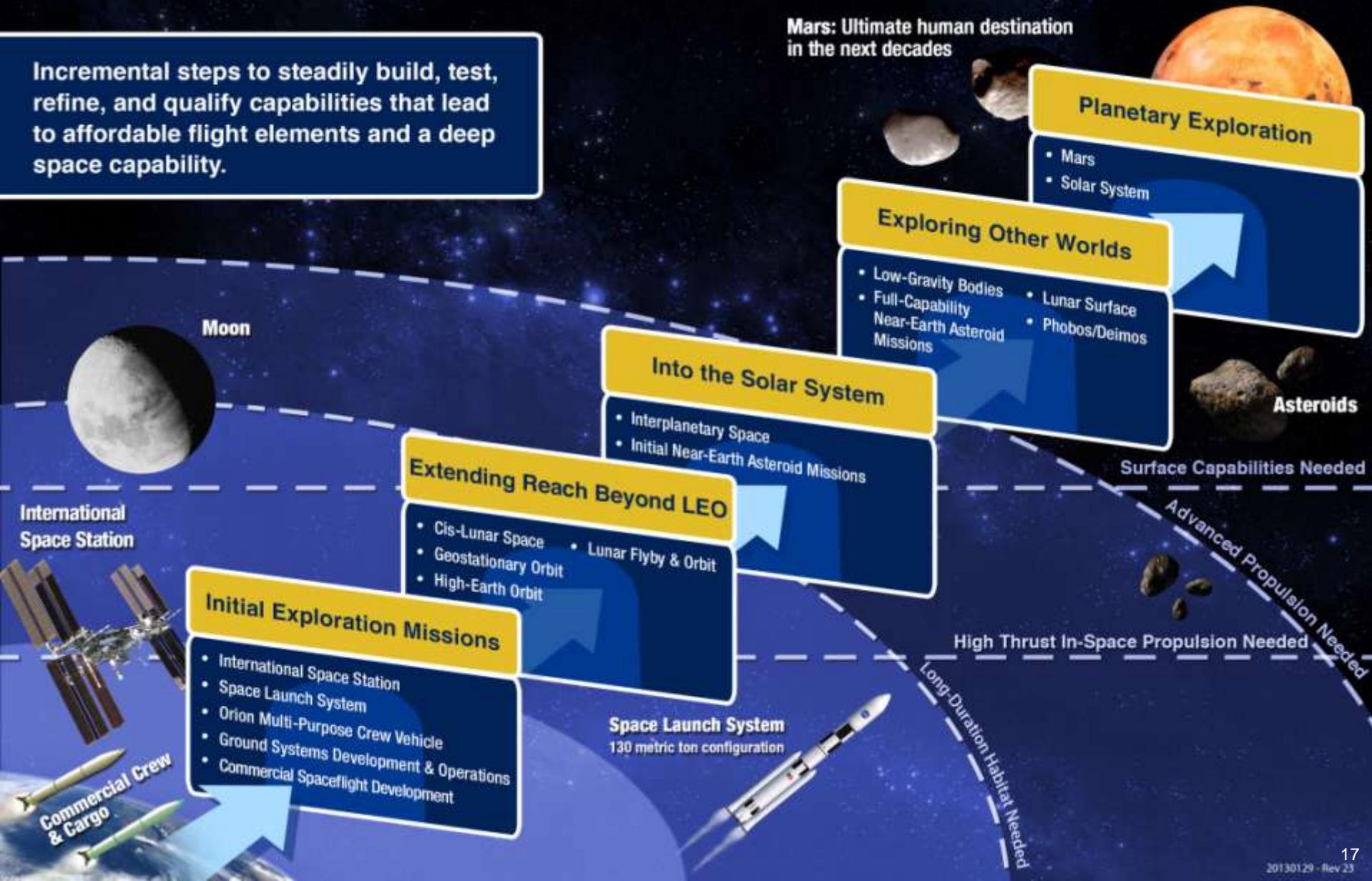


RS 25 Processing  
KSC Facility  
delivered to KSC



LOOKING AHEAD 2013 - 2017

# Capability Driven Framework



# Strategic Principles for Incremental Building of Capabilities



## Six key strategic principles to provide a sustainable program:

1. Executable with current *budget with modest increases*.
2. Application of *high Technology Readiness Level* (TRL) technologies for near term, while focusing research on technologies to address challenges of future missions
3. *Near-term mission* opportunities with a defined cadence of compelling missions providing for an incremental buildup of capabilities for more complex missions over time
4. Opportunities for *US Commercial Business* to further enhance the experience and business base learned from the ISS logistics and crew market
5. *Multi-use* Space Infrastructure
6. Significant *International participation*, leveraging current International Space Station partnerships

# Common Capabilities Identified for Exploration



Human Exploration of Mars  
The “Horizon Destination”

Low Earth Orbit  
Crew and Cargo  
Access

Human -  
Robotic  
Mission Ops

Adv. In-Space  
Propulsion

Habitation

Ground  
Operations

Beyond Earth  
Orbit Crew and  
Cargo Access

EVA

Robotics &  
Mobility

Crew Health &  
Protection

Autonomous  
Mission  
Operations

Avionics

Communication /  
Navigation

ECLSS

Entry, Descent  
and Landing

In-Situ  
Resource  
Utilization

Power and Energy  
Storage

Thermal

Radiation  
Protection

SKGs Measurements /  
Instruments and  
Sensors

# NRC Committee on Human Spaceflight



- HEO briefed the full Committee on our capability-driven framework and their Technical Panel on progress on SLS/Orion
- HEO briefed their Technical Panel on March 27 on technologies needed for future exploration beyond LEO
- HEO will brief the full Committee on April 22<sup>nd</sup>, which will include the FY14 budget request



For the latest news about  
human exploration visit:

[www.nasa.gov/exploration](http://www.nasa.gov/exploration)