Human Exploration and Operations
FY 2014 Budget Overview

• FY 2014 Budget Submit provides $7.798 billion for HEO to lead and manage human spaceflight in and beyond low Earth orbit

• Guiding principle: focus on the mission
  – Utilize the International Space Station (ISS) to the fullest extent possible

• Develop human exploration capabilities required to explore beyond Earth orbit

• Partner with US industry to develop an American commercial crew capability to enable crew and cargo transportation to ISS

• Provide safe, reliable, access to space for NASA and NASA-sponsored payloads

• Deliver space communications and navigation services to customer missions

• Provide advanced research and technology for beyond low Earth orbit mission capabilities including an asteroid retrieval mission
## Human Exploration and Operations

### Program Financial Plan - FY 2014 President’s Budget Request

<table>
<thead>
<tr>
<th>Budget Authority ($ in Millions)</th>
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Orion Accomplishments

- Completed heat shield ready for transport to Textron in Boston, MA for Avcoat application
- Inert Abort motor delivered to Operations and Checkout Building at KSC
- Launch Abort System Ogive panel work at the Michoud Assembly Facility
- Backshell panel drilling at the Operations and Checkout Building at KSC
- Service module assembly at the Operations and Checkout Building at KSC
- Super Guppy carrying the Orion Heat Shield arriving at Hanscom Air Force Base in Boston, MA
SLS Accomplishments

Systems Engineering & Integration
SLS model wind tunnel testing at Langley Research Center
Nov 2012

J-2X upper stage engine hot-fire test at Stennis Space Center
Feb 2013

Multi-Purpose Crew Vehicle Stage Adapter (MSA) Flight Hardware at Marshall Space Flight Center
March 2013

Kennedy Space Center Pad 39B (artist’s concept) with new crawler transporter and control room
Jan 2013

RS-25 Engines at Stennis Space Center Oct 2012, shown with future RS-25 Test Stand A1

F-1 engine gas generator - technology demonstration for an optional Advanced Booster concept - hot-fire test at Marshall Space Flight Center, Jan 2013

Qualification Motor 1 casting at ATK
Oct 2012

System Requirements Review/System Definition Review Completed
Stages Manufacturing, Assembly, & Production/Operations Snapshot at MAF

Next Big Step

<table>
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<tr>
<th>Tooling Availability</th>
<th>May- Enhanced Robotic Weld Tool (ERWT)</th>
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<td>June- Vertical Weld Center (VWC)</td>
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CDWT

SRT

VAC

ERWT

VWC
### Stages “Green Run” Test Buildup at SSC B-2

**Stage is 211” Tall**

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<th>Upper Superstructure</th>
<th>Next Big Step</th>
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<td><strong>Stage Testing</strong></td>
<td>April 30% Design on Structural Build- Out &amp; Electrical Restoration</td>
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<td>June Work Package 3 of 5 Awarded</td>
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**Level 18**

**Level 16**

**Level 11**

**Level 8**

**Level 7**

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**NASA Stennis Space Center, MS**

**Test Stand B-2 Stages Green Run**

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**Level 7 Side after Demo & LOX Transfer Line**

**Above: Aspirator and Level 7 Demolition**

**Left: B-2 Flame Deflector Flow Testing**
GSDO Accomplishments

Crawler-transporter Modifications

Crawlerway Modifications

VAB Modifications

Pad 39B Modifications including new hydraulic elevators

Testing of Crawler-Transporter 2

Pad 39B new interface connections
Antares A-ONE Launch
Commercial Crew Transportation System Development (Public Purpose)

Certification for ISS Crew Transportation (NASA Purpose)

ISS Crew Transportation Services
ISS - Orbiting Microgravity Laboratory with Continued Human Presence in Low Earth Orbit
Ongoing Research:
- Biology and Biotechnology
- Earth and Space Science
- Human Research
- Physical Research
- Technology

Expeditions 35/36 Investigations - 140 Total
- 82 NASA/U.S.-led
- 58 International led
- More than 400 investigators represented
“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
Asteroid Strategy

- NASA’s asteroid strategy aligns relevant portions of NASA’s science, space technology, and human exploration capabilities for a human mission, advanced technology development, efforts to protect the planet, and engages new industrial capability and partnerships

- **Leverages existing NASA efforts**
  - Asteroid Identification and Characterization efforts for target selection
  - Solar Electric Propulsion for transport to and return of the target asteroid
  - Robotic servicing techniques for capture
  - SLS and MPCV missions for asteroid rendezvous

- **Benefits future exploration objectives for carrying humans further into space than ever before**
  - Deep space navigation and rendezvous to enable crewed operations in deep space
  - High power solar electric propulsion to enable efficient transportation to deep space destinations
  - In space robotics for capture/control of uncooperative objects
Asteroid Mission Would Consist of Three Main Segments

**Identify**

**Asteroid Identification Segment:**
Ground and space based NEA target detection, characterization and selection

**Redirect**

**Asteroid Redirection Segment:**
Solar electric propulsion (SEP) based asteroid capture and maneuver to trans-lunar space

**Explore**

**Asteroid Crewed Exploration Segment:**
Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid
Near-Earth Asteroids (NEAs) at a Glance

Approximately 300 10-m-class asteroids have been found, about 13 of which meet orbital criteria.
Asteroid Capture & Retrieval Mission Concept

- Capture and redirect a 7-10 meter diameter, ~500 ton near-Earth asteroid (NEA) to a stable orbit in trans-lunar space
- Enable astronaut missions to the asteroid as early as 2021
- Parallel and forward-leaning development approach
**Interplanetary Trajectory**

**Trajectory to Asteroid**
- DV = 3868 m/s
- TOF = 671 days (1.84 yr)

**Asteroid Retrieval**
- DV = 152 m/s
- TOF = 1092 days (2.99 yr)
Inertial view

9.9 s

Spacecraft view

[0.0000 0.2000]

0.0461 g
Solar Panel 1 Acceleration
Earth-Moon System Trajectory

Trajectory to Storage Orbit

- **DV** = 35 m/s
- **TOF** = 251 days (0.7 yr)

Orbit Trim Maneuvers
(for long term stability)

- **DV** = 25 m/s
- **TOF** = 257 days (0.7 yr)
22 Day Nominal Asteroid Retrieval & Utilization
Mission Overview

Outbound
- FD01 - Launch/TLI
- FD02-FD05 - Outbound Trans-Lunar Cruise
- FD06 - Lunar Gravity Assist
- FD07 - FD09 - Lunar to DRO Cruise

Joint Operations
- FD10 - Rendezvous
- FD11 - EVA #1
- FD12 - Suit Refurbishment, EVA #2 Prep
- FD13 - EVA #2
- FD14 - Contingency/Departure Prep
- FD15 - Departure

Inbound
- FD16 - DRO to Lunar Cruise
- FD17 - Lunar Gravity Assist
- FD18-FD21 - Inbound Trans-Lunar Cruise
- FD22 - Earth Entry and Recovery

Outbound Flight Time 9.8 days
Return Flight Time 6 days
Rendezvous time: 1 day
DRO Stay time: 5 days
• **Demonstration of Core Capabilities for deep space missions:**
  - Block 1 SLS, MPCV, and ARV with 40kW Solar Electric Propulsion (SEP) system
  - EVA, proximity operations, AR&D, deep space navigation and communications
  - Human operations in beyond low earth orbit
  - Robotic sample acquisition, caching, storage operations, and crew transfer operations for future sample return missions (potential Lunar/Mars Sample Return options)

• **Demonstrates ability to work and interact with a small planetary body:**
  - Systems for instrument placement, sample acquisition, material handing, and testing
  - Understanding of mechanical properties, environment, and mitigation of hazards
Capability Driven Framework

Incremental steps to steadily build, test, refine, and qualify capabilities that lead to affordable flight elements and a deep space capability.
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
## Elements Required By Potential Destination

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<th>Capability</th>
<th>Potential Required Element</th>
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**Note:**

X - Required Elements/Capabilities for these potential destinations

Option - Element/Capability may be needed or multiple options could exist to enable missions for that specific potential destination or could be for verification for future needs.
• **Budget allows HEOMD to continue solid progress on existing activities**
  - SLS/Orion/Ground operations
  - ISS research, operations, and transportation
    - ISS proving value to research folks
  - Space Communications
  - Launch services
  - Commercial crew for low earth orbit
  - ISS research
  - Rocket propulsion and test

• **Budget is tight but workable**

• **Offers a strategy to link several planned activities into asteroid redirection**

• **Points the way an integrated approach to long term goal of Mars exploration**