Asteroid Redirect Mission and The Future of Human Spaceflight

Asteroid Initiative Idea Synthesis Workshop

November 20-22, 2013

Join the discussion and send questions to: #NASAasteroid
Principles for Incrementally Building 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 and commercial participation, leveraging current International Space Station partnerships and commercial companies

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ISS Enables Long Duration Exploration

- Health and Human Performance
- Crew Habitability and Logistics
- System and Technology Testbed
  - Docking
  - High Reliability Closed Loop Life Support
  - Long Term System Performance
  - Logistics and Maintenance Reduction
- Commercial Cargo and Crew Transportation Services to LEO
- Commercial Application of Microgravity and Space Research for Terrestrial Application

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Space Launch System is a versatile rocket capable of transporting humans, habitats, and support systems directly to deep space.

Three Successful Ground Tests of Booster Developmental Motors

Core Stage Flight Computers Installed

Barrel Section Complete at MAF

RS-25 Test Firing

Barrel Weld Center
Orion is the first spacecraft in history capable of taking humans to multiple destinations in deep space.
2014 Exploration Flight Test One (EFT-1)
Exploration Mission One (EM–1)

Distant Retrograde Orbit

SIMULATED LAUNCH ABORT SYSTEM (LAS)
ORION CREW MODULE (CM)
LAUNCH VEHICLE/STAGE ADAPTER
CORE STAGE
SOLID ROCKET BOOSTERS (2)
RS-25 ENGINES (4)

DRO Arrival
MOON
Stay in DRO
DRO Departure

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Asteroid Redirect Crewed Mission Overview

Deliver crew on SLS/Orion

Perform extra-vehicular activity (EVA) to retrieve asteroid samples

Return crew safely to Earth with asteroid samples in Orion

Attached Orion to robotic spacecraft
ARM Trajectory and Rendezvous

- Common sensors derived from knowledge gained from Space Shuttle Detailed Tests
- Synergy between crewed and robotic mission sensors
- Trajectory launch constraints, rendezvous techniques, navigation enable deep space

Outbound Flight Time: 8 days, 9 hrs
Return Flight Time: 11 days, 6 hrs
Rendezvous Time: 1 day
DRO Stay Time: 5 days

Notional Relative Navigation Sensor Kit

STORRM Camera Image
STORRM LiDAR Images

Lunar Gravity Assists

Outbound Flight Time
9 days

Outbound/Return

Moon

EARTH

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Docking System

- Docking System for Orion and Robotic Spacecraft leverages development of International Docking System Standard
- Orion Active Docking Mechanism (extended)
- Robotic Spacecraft Passive Docking Mechanism
- International Docking Adapter will create a docking port on ISS
- Compatible with new International Standard
- Provides Power and data utility connections to visiting vehicles
- Delivered to ISS in trunk of SpaceX Dragon Cargo Vehicle

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Watch the video at:

http://youtu.be/1OwmZYrTsGY
EVA Suit and Primary Life Support System (PLSS)

- Exploration PLSS technology being developed as multi-suit compatible life support system
  - Initial prototype completed in FY13
  - Integrated metabolic and functional testing to be completed this fiscal year
- Analyzing interface design for Asteroid Redirect Mission
- Additions to Modified Advanced Crew Escape Suit (MACES) that allow for extended EVA

**MACES with PLSS and EVA Suit Kit**
- Helmet Cameras & Lights
- PLSS Backpack & Suit Adaptors
- Display & Control Module
- EMU Heated Gloves
- Tether & Tool Harness
- Thermal Micro-meteoroid Garment

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High Powered Solar Electric Propulsion Enables Exploration

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<th>Power</th>
<th>40-50 kW</th>
<th>90-100 kW</th>
<th>250+ kW</th>
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<tr>
<td>Thrusters</td>
<td>3 @ 13.3kW ea</td>
<td>7 @ 13.3kW ea</td>
<td>7 @ 35kW ea</td>
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Solar Arrays

Thruster and Power Processing Unit

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## ARM Provides First Steps to Mars/Other Destinations

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<td>Mars Destination Capabilities</td>
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The Asteroid Redirect Mission is a critical first step to reducing risk and advancing core capabilities and mission operations required for human exploration of Mars.

- **System Capabilities**
  - Orion crew vehicle and SLS launch vehicle performance
  - Solar electric propulsion for pre-deployment of logistics
  - Potential addition of Exploration Augmentation Module
    - Provide long duration system testing
    - Deep space environmental testing
    - Integration of vehicle systems
  - Rendezvous and Docking

- **Deep Space Operational Capabilities**
  - Autonomous operations to mitigate moderate communication time delays
  - Deep space navigation
  - Potential high band-width deep space communications (follow on to lunar communication)
  - Surface system interactions and mobility with near zero-g solar system objects (EVA suit and tools, surface ops)
  - Sample collection and curation (science, analog to Mars planetary protection operations)