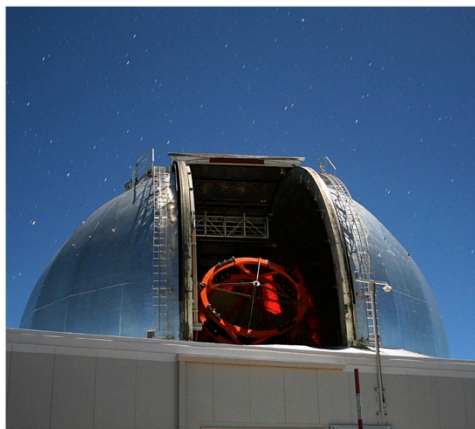
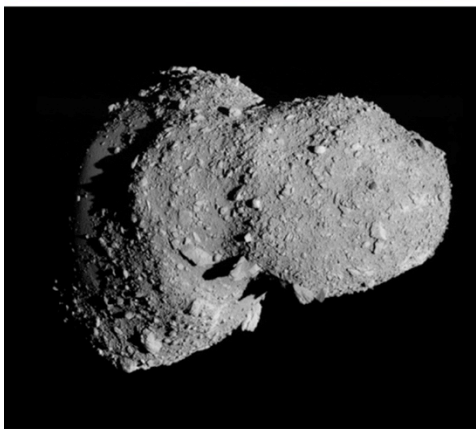


National Aeronautics and Space Administration



Asteroid Redirect Mission Mission Formulation Review Results and Status

R. Lightfoot, NASA Associate Administrator



September 14, 2013

Leveraging Capabilities for an Asteroid Mission



- **NASA is aligning key ongoing activities in Science, Space Technology, and Human Exploration and Operations Mission Directorates**
 - Asteroid identification and characterization efforts for target selection
 - Solar electric propulsion for transport to and return of the target asteroid
 - Autonomous guidance and control for proximity operations and capture
 - Orion and Space Launch System (SLS) vehicles for asteroid rendezvous
 - Technologies for astronaut extra-vehicular activities
- **Each individual activity provides an important capability in its own right for human and robotic exploration**
- **We are working to utilize all of these activities to**
 - Identify and redirect a small asteroid to a stable orbit in the lunar vicinity;
 - Test human spaceflight systems and operations beyond LEO; and
 - Investigate and return samples with our astronauts using the Orion and SLS assets.
- **The FY14 budget supports continued advancement of the important individual elements and furthers the definition of the overall potential mission.**

Overall Mission Consists of Three Main Segments



Identify



Asteroid Identification

Ground and space based NEA target detection, characterization and selection

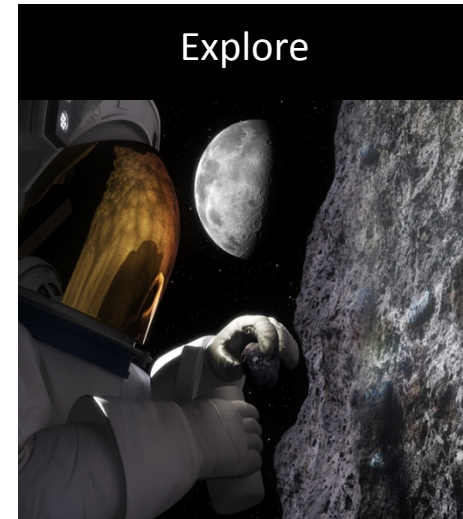
Redirect



Asteroid Robotic Redirection Mission

Solar electric propulsion (SEP) based robotic asteroid redirect to trans-lunar space

Explore



Asteroid Redirect Crewed Mission

Orion and SLS based crewed rendezvous and sampling mission to the relocated asteroid

The Vision (1)



The Vision (2)

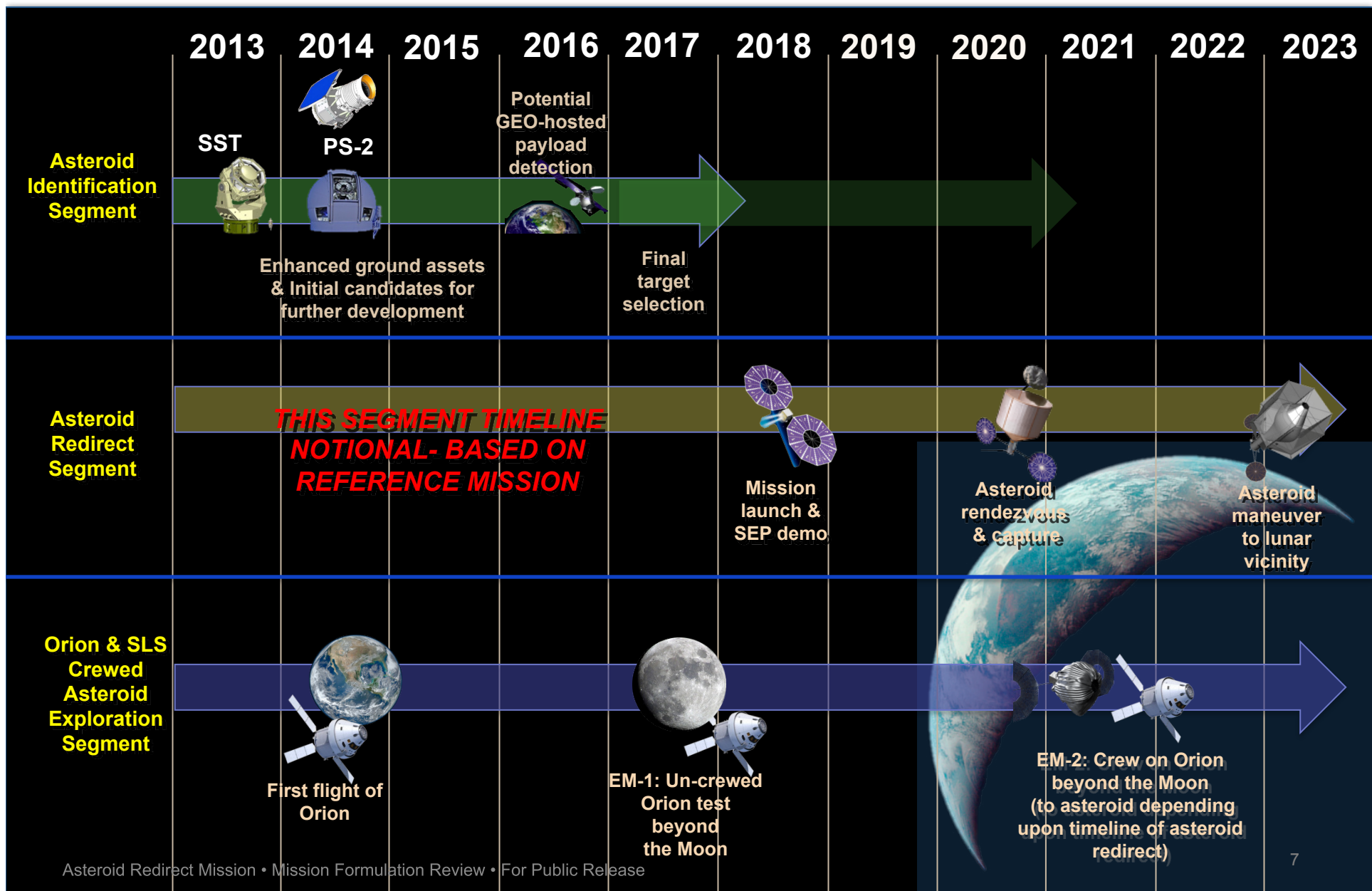


First Steps to Mars and Other Destinations

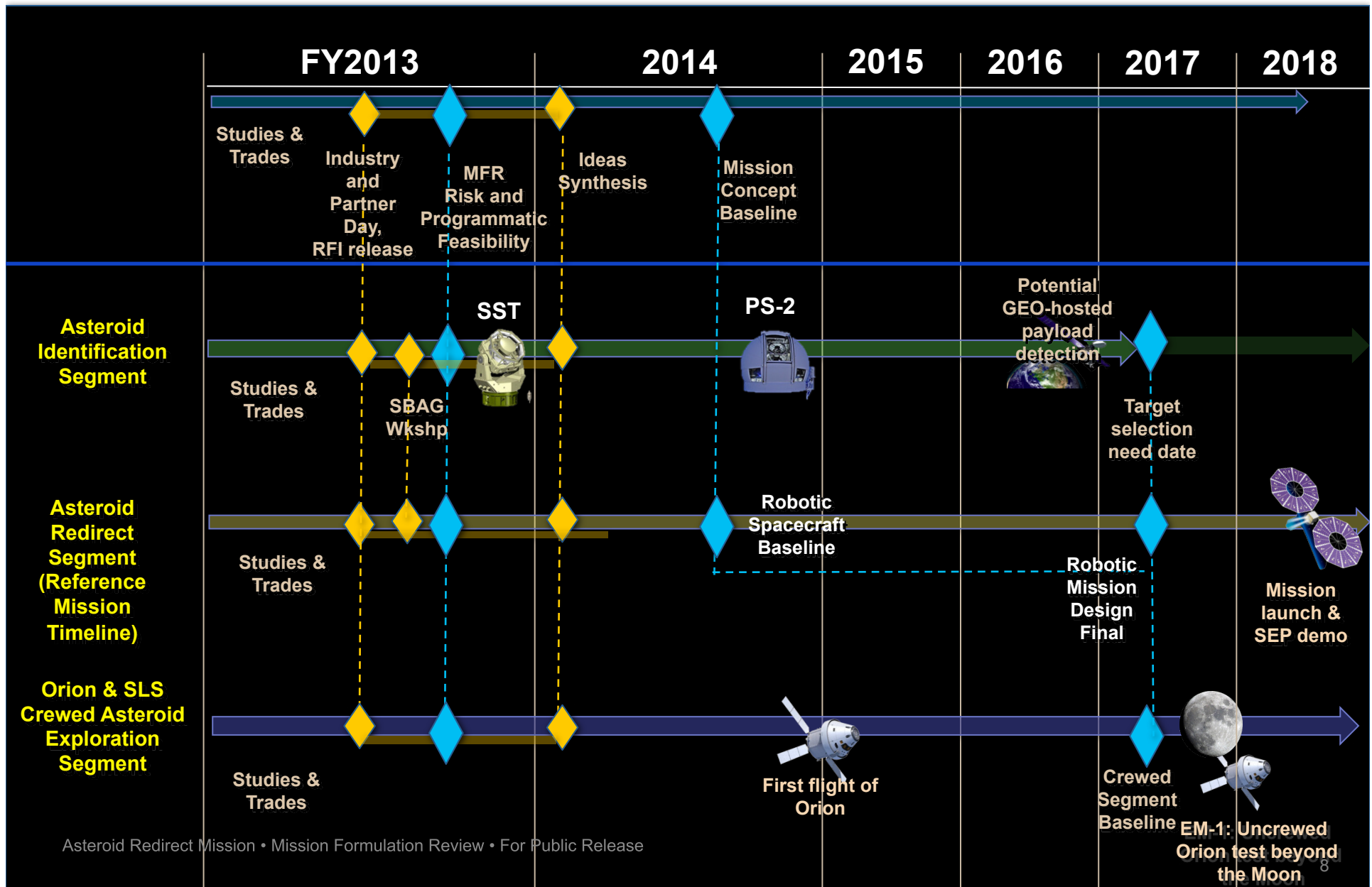


Sequence \ Mission	Current ISS Mission	Asteroid Redirect Mission	Long Stay In Deep Space	Humans to Mars Orbit	Humans to Surface, Short Stay	Humans to Surface, Long Stay
In Situ Resource Utilization & Surface Power						X
Surface Habitat						X
Entry Descent Landing, Human Lander					X	X
Aero-capture				X	X	X
Advanced Cryogenic Upper Stage				X	X	X
Solar Electric Propulsion for Cargo		X	X	X	X	X
Deep Space Guidance Navigation and Control		X	X	X	X	X
Crew Operations beyond LEO (Orion)		X	X	X	X	X
Crew Return from Beyond LEO - High Speed Entry (Orion)		X	X	X	X	X
Heavy Lift Beyond LEO (SLS)		X	X	X	X	X
Deep Space Habitat	X		X	X	X	X
High Reliability Life Support	X		X	X	X	X
Autonomous Assembly	X		X	X	X	X

Alignment Strategy



Decision and Engagement Strategy



Planning Status



- **NASA internal study activities led by two teams for ~ 7 months**
 - Concept definition study, led by JPL, examining both the asteroid target identification as well as the asteroid redirect mission segment
 - Concept definition study, led by JSC, examining the asteroid crew rendezvous and sampling mission segment
- **Target identification plan – Science Mission Directorate**
- **Independent analysis of alternatives/trades**
 - Electric propulsion: VASIMIR/Hall thruster/Russian EP (Space Technology Mission Directorate)
 - Capture mechanism (Human Exploration and Operations Mission Directorate/Advanced Exploration Systems)
 - Alternative mission concepts (Science Mission Directorate)
- **Review was conducted July 30**

Asteroid Initiative Request for Information



- **RFI released June 18; responses due July 18**
- **Areas of request:**
 - Asteroid Observation
 - Asteroid Redirection Systems
 - Asteroid Deflection Demonstrations
 - Asteroid Capture Systems
 - Crew Systems for Asteroid Exploration
 - Partnerships & Participatory Engagement
- **402 responses received**
- **Ideas Synthesis Meeting Sept 30 - Oct 2**
 - Transparently explore the 96 highest rated responses
 - International, industry, science will be specifically invited
 - Meeting structured to provide input to planning

Mission Formulation Review (MFR) purpose



- **Reviewed the results of three component studies of the reference mission concept**
 - Identification of candidate targets for the reference mission
 - Feasibility assessment of robotic redirection of a small near Earth asteroid (NEA)
 - Feasibility assessment of astronaut exploration and sampling of the asteroid using the Orion
- **Also reviewed three high-level trades to examine alternatives (shorter studies than the reference)**
 - Alternate approach to robotic mission – demonstrate planetary defense and retrieve boulder(s) from a large NEA (potentially hazardous size)
 - Alternative Robotic Mission System trades
 - Capture System
 - Solar Electric Propulsion (SEP)

MFR Agenda



Time (EDT)	Topic	Speaker
8:00	Introduction, including review objectives	Robert Lightfoot, NASA HQ
8:15	Observation Campaign	Paul Chodas, NASA JPL
8:45	Asteroid Redirect Robotic Mission	Brian Muirhead, NASA JPL
11:45	Break	
12:30	Asteroid Redirect Crewed Mission	Steve Stich, NASA JSC
2:30	Alternate Approach to Robotic Mission Study	Dan Mazanek, NASA LaRC
3:30	Alternate Capture System Trade	Jasen Raboin, NASA JSC
4:00	Alternate SEP Trade	Roberto Garcia, NASA MSFC
4:30	RFI Response Summary	Chris Moore, NASA HQ
4:45	Board discussions	



- **Assessment against MFR criteria**

- The objectives for the reference mission concept were sound. Preliminary cost and schedule estimates provided for the robotic concept were reasonable given the minimum success criteria, launch date, and reference asteroid target assumptions.
- The options provided through the trade study on solar electric propulsion confirmed the use of advanced high power solar arrays and magnetically shielded Hall thrusters.
- The capture mechanism and process for both the reference and alternate concept represent the greatest area of risk and require further study.
- The study on the alternate approach to the robotic segment provided a promising mission option which responds to a broader set of mission objectives. This concept should also continue to mature.

- **MFR Outcomes**

- The concept of an asteroid redirect mission can be both technically and programmatically feasible within the constrained budget environment likely to persist into the out years when this mission would be conducted.

All MFR objectives were met

Path Forward – Near Term Specifics



- **Concept teams will fold in RFI synthesis.**
- **Follow on tasking to better understand technical and programmatic aspects.**
 - Provide an option for reference robotic segment launch on a heavy lift launch vehicle (Falcon 9H or SLS) to avoid the spiral out.
 - Mature alternate robotic approach
 - Mature crewed mission segment risk assessment and feed forward to Mars
 - Potential tasks on RFI ideas
- **Charter a robotic concept integration team**
 - Assess the internal concepts and RFI synthesis recommendations against a set of mission objectives and figures of merit
 - Manage the technical assumptions and study interfaces
 - Results inform FY14 activities and mission planning
- **Consistent with strategic guidance, acquisition strategy foundation is to leverage on-going work**
- **Pursue industry partnerships and participatory engagement**