Asteroid Redirect Mission and Human Exploration

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Asteroid Redirect Segment
Reference 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
Reference Interplanetary Trajectory

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

Asteroid Redirect
DV = 152 m/s  TOF = 1092 days (2.99 yr)
Possible Alternatives

- Requesting ideas through RFI

- One additional concept study underway to demonstrate altering the trajectory of a large NEA and return part of it to trans-lunar space
  - 100 meter diameter or larger NEA (potentially hazardous size)
  - Measurably alter the trajectory of the NEA
  - Capture a 1 to 10 meter diameter boulder (coherent rock) and return it to trans-lunar space in the 2020-2025 timeframe
  - Assess options for deflection demonstrations and delivery of other payloads
    - Take advantage of spacecraft power available and/or captured mass
    - Payload(s) emplaced prior to capture operations and/or left before spacecraft departure
  - Identify required NEA stay time to perform proximity and surface operations
Asteroid Redirect
Crewed Mission Overview

Return crew safely to Earth with asteroid samples in the Orion

Attach Orion to Robotic Spacecraft

Deliver Crew in Orion

Perform Extra-Vehicular Activity (EVA) to retrieve asteroid samples
Nominal Orion Mission Summary

### Outbound
- Flight Day 1 – Launch/Trans Lunar Injection
- FD2-FD5 – Outbound Trans-Lunar Cruise
- Flight Day 6 – Lunar Gravity Assist (LGA)
- FD7-FD9 – Post LGA to DRO Cruise

### Joint Operations with Robotic Spacecraft
- Flight Day 10 – Rendezvous/Grapple
- Flight Day 11 – EVA #1
- Flight Day 12 – Suit Refurbishment, EVA #2 Prep
- Flight Day 13 – EVA #2
- Flight Day 14 – Contingency Day/Departure Prep
- Flight Day 15 – Departure from DRO

### Inbound
- Flight Day 16 – DRO to Lunar Cruise
- Flight Day 17 – Lunar Gravity Assist
- FD18-FD21 – Inbound Trans-Lunar Cruise
- Flight Day 22 – Earth Entry and Recovery

Note: Mission Duration Varies From 22-25 Days
Notional EVA Operations for Orion

- Two EVAs executed from Orion
- Crew translates from Orion to Robotic Spacecraft
- EVA Tool box prepositioned on Robotic Spacecraft
- Telescoping booms pre-stowed on Robotic Spacecraft
- Crewmember stabilized on Portable Foot Restraint for Worksite
- Loops available on Capture Mechanism Bag for additional stabilization
Capability Driven Framework

Incremental steps to steadily build, test, refine, and qualify capabilities that lead to affordable flight elements and a deep space capability.
Asteroid Mission Supports
Long-Term Human Mars Exploration Strategy

• Demonstration of core capabilities for deep space missions:
  – Block 1 SLS, Orion, and Asteroid Redirect Mission robotic spacecraft
  – 30-50 kW Solar Electric Propulsion System
  – EVA, rendezvous, proximity operations, docking or grapple, deep space navigation and communications
  – Human operations and risk management beyond low earth orbit
  – Sample acquisition, caching, storage operations, and crew transfer operations for future sample return missions

• Demonstrates ability to work and interact with a small planetary body:
  – Systems for instrument placement, sample acquisition, material handling, and testing
  – Understanding of mechanical properties, environment, and mitigation of hazards
The Future of Human Space Exploration

*Exploration Destinations and One-Way Transit Times*

- **International Space Station**: 2 Days
- **Moon**: 3-7 Days
- **Lagrange Points and other stable lunar orbits**: 8-10 Days
- **Distant Retrograde Orbit (DRO)**: 6-10 Days
- **Near-Earth Asteroid**: 3-12 Months
- **Mars**: 6-9 Months

Asteroid Redirect Mission benefits near term exploration objectives for carrying humans further into space than ever before while providing the building blocks for even more ambitious future missions to Mars.
Request for Information
System Concepts and Innovative Approaches

• Asteroid Observation
• Asteroid Redirection Systems
• Asteroid Deflection Demonstration
• Asteroid Capture Systems
• Crew Systems for Asteroid Exploration
• Partnerships and Participatory Engagement

• This RFI is open to all types of organizations, including U. S. industry, universities, non-profit organizations, NASA Centers, Federally Funded Research and Development Centers, other U. S. government agencies, and international organizations.