

# Asteroid Redirect Mission (ARM) Overview

Space Mission Planning Advisory Group (SMPAG) 7<sup>th</sup> Meeting – October 14, 2016

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## **Asteroid Redirect Mission Objectives**



- 1. Conduct a human exploration mission involving in-space interaction with an asteroid boulder in the mid-2020's, providing systems and operational experience required for human exploration of Mars.
- 2. Demonstrate an advanced solar electric propulsion (SEP) system, enabling future deep-space human and robotic exploration with applicability to the nation's public and private sector space needs.
- 3. Enhance detection, tracking and characterization of Near Earth Asteroids, enabling an overall strategy to defend our home planet.
- 4. Demonstrate basic planetary defense techniques that will inform impact threat mitigation strategies to defend our home planet.
- 5. Pursue a target of opportunity that benefits scientific and partnership interests, expanding our knowledge of small celestial bodies and enabling the mining of asteroid resources for commercial and exploration needs.

# **Asteroid Redirect Mission Alignment Strategy**





#### **ARM** Demonstrates Key Technologies for the Journey to Mars





#### **IN-SPACE POWER &** PROPULSION:

- High efficiency 40kW SEP extensible to Mars cargo missions
- Power enhancements feed forward to deep-space habitats and transit vehicles

#### **EXTRAVEHICULAR** ACTIVITIES:

- Two in-space EVAs of four hours each
- Primary Life Support System design accommodates Mars
- Sample selection, collection, containment, and return

#### **TRANSPORTATION & OPERATIONS:**

- Capture and control of noncooperative objects
- Common rendezvous sensors and docking systems for deep space
- Cislunar operations are proving ground for deep space operations, trajectory, and navigation



Electric Propulsion Technology Development Unit Wear Testing at NASA's Glenn Research Center



Robotic Operations Center at NASA's Goddard Space Flight Center

## **Asteroid Redirect Mission Highlights**





### **Current Candidate Target Asteroids**





Asteroids not to scale

#### Comparison of current candidate target asteroids

	Itokawa	Bennu	2008 EV <sub>5</sub>	1999 JU <sub>3</sub>
Size	535 x 294 x 209 m	492 x 508 x 546 m	420 x 410 x 390 m	870 m diameter
V <sub>∞</sub>	5.68 km/s	6.36 km/s	4.41 km/s	5.08 km/s
Aphelion	1.70 AU	1.36 AU	1.04 AU	1.42 AU
Spin Period	12.13 hr	4.297 hr	3.725 hr	7.627 hr
Туре	S	B (C-grp volatile rich)	C (volatile rich)	C (volatile rich)
Precursor	Hayabusa (2005)	OSIRIS-REx (launched 9/8/2016, 8/2018 arrival)	None currently planned (boulders implied from 2008 radar imaging)	Hayabusa 2 (launched 12/4/2014, 7/2018 arrival)

NASA continues to look for additional targets in accessible orbits.

**Reference ARRM Target** 

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## **ARM** Animation



https://www.youtube.com/watch?v=qoqfSYZufGY#action=share

### **ARM Recent Progress and Upcoming Milestones**



✓ SRB Face-to-Face at JPL	May 3-5			
✓ Asteroid Redirect Robotic Mission (ARRM) Project Implementation Plan Vol 1 ready for signature	May 6			
✓ ARRM requirements freeze for Key Decision Point (KDP) -B	May 13			
External event: Humans to Mars Summit: ARM update	May 17-19			
✓ ARRM MDR-Lite	May 18-19			
✓ ARM HQ: Periodic update to House Science Committee staff	May 23			
✓ ARM HQ: cleared messages for external pre-announcement	mid-June			
✓ Asteroid Redirect Crewed Mission (ARCM)/ARRM interface kickoff safety review	Jun 22-23			
✓ External event: New Space Conference Panel – NASA as an Accelerator	Jun 21-23			
✓ Kick-off ARCM safety review	Jun 22-23			
✓ ARRM spacecraft contractor study final presentations	Jun 24			
✓ ARRM KDP-B	Jul 15			
✓ ARRM strategic partner intent closure	Aug 5			
✓ ARM-Umbrella for Partnerships (ARM-UP) Broad Agency Announcement synopses release Aug 15				
✓ ARM-UP BAA including ARRM hosted payload and ARM Investigation Team releases	Sep 6			
✓ ARM HQ event: ARM Community Update and Virtual Industry Day	Sep 14			
✓ External event: IAC	Sep 26-30			
External event: SMPAG	Oct 14			
External event: DPS	Oct 16-21			
<ul> <li>ARRM capture module architecture study complete</li> </ul>	Dec 2016			
<ul> <li>STMD/SEP electric propulsion string Preliminary Design Review</li> </ul>	Mar 2017			
<ul> <li>HQ checkpoint prior to ARM IT, ARRM hosted p/I, and ARRM spacecraft bus awards</li> </ul>	Mar 2017			
<ul> <li>ARM IT, ARRM hosted p/I, and ARRM spacecraft bus aware selections announcement</li> </ul>	Apr 2017			

### **ARRM Key Decision Point-B Outcomes**



- NASA determined the readiness of ARRM to proceed to Phase B and established the content, cost, and schedule commitments for the Phase B activity.
  - Launch date: December 2021
  - Availability for crewed mission: By the end of 2026
  - Estimated ARRM cost cap: \$1.4B (Phases A-D except launch vehicle)
- Received authority to proceed with release of solicitations for:
  - Partner-provided hosted payloads on ARRM
  - Investigation Team members
  - JPL release of solicitation for Phase 2 spacecraft design, with option for development



- Phase 1:
- Conceptual Studies (Jan Jun 2016)
  - Scope:
    - Develop conceptual designs
    - Understand trades, risks, limitations, heritage and future applications
    - Help refine Phase II requirements.



#### **Two-Step Spacecraft Procurement Process**



#### • Phase 2:

- Down-select to a single provider to build and deliver the robotic spacecraft
  - Request For Proposal (RFP)
  - Proposals due:
  - Expect to award:

released: September 8, 2016 October 24, 2016 March 2017

### **ARM Umbrella for Partnerships (ARM-UP)**



- ARM-UP is an umbrella solicitation covering all aspects of applied research and technology for collaboration research and partnerships on the ARM.
- Although ARM is primarily a capability demonstration mission, there exist significant opportunities to advance our knowledge of small bodies in the synergistic areas of science, planetary defense, asteroidal resource utilization, and other capability and technology demonstrations.
- Awards resulting from this Broad Agency Announcement (BAA) will enable partnerships within the U.S. and internationally for enabling broader benefits from ARM, e.g.
  - Commercial, scientific, exploration technology/capability, and/or planetary defense applications
- Initial Appendices currently open are:
  - Partner-provided investigations through systems/payloads to be hosted on the Asteroid Redirect Robotic Mission (ARRM)
  - Collaboration through the ARM Investigation Team to support definition of mission investigations

Notices of Intent (NSPIRES) – Strongly encouraged, but not required	Oct. 6, 2016
Last day for inquiries	Oct. 24, 2016
Proposals due (NSPIRES) – No extensions will be granted	Nov. 3, 2016
Planned date for awards	March 31, 2017