EPSC Abstracts
Vol. 10, EPSC2015-232, 2015
European Planetary Science Congress 2015


# Technologies for the Asteroid Redirect Robotic Mission

B. Cichy (1,3), B. Naasz (1), D. Mazanek (2), and the ARM team. (1) NASA Goddard Spaceflight Center (2) NASA Langley Research Center (3) Arctic Slope Regional Corporation (Benjamin.D.Cichy@nasa.gov)

## Abstract

The Robotic segment of NASA's Asteroid Redirect Mission (ARM) will demonstrate key capabilities that will enable new frontiers of future human and robotic spaceflight. We introduce the current robotic mission concept, and detail the technologies and capabilities that will be demonstrated by the mission.

## 1. Introduction

The Asteroid Redirect Mission (ARM) consists of three major segments – a target identification campaign to characterize and select a target for the robotic mission, a robotic mission to capture and redirect asteroidal mass into a stable orbit around the moon, and a crewed mission in the mid-2020s to rendezvous with the returned vehicle, collect samples, and return them to earth.

ARM has five mission objectives:

1. Conduct a human exploration mission to an asteroid in the mid-2020s, providing systems and operational experience required for human exploration of Mars.
2. Demonstrate an advanced solar electric propulsion 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.

## 2. Robotic Mission

The ARM robotic segment will launch in the early 2020s, collect a boulder from the surface of a near earth asteroid, and return it to a stable, crew-accessible, lunar distant retrograde orbit (DRO) [1].

The robotic mission will use a high-power advanced Solar Electric Propulsion system to transit to the asteroid and to return home with a multi-ton boulder.

After arriving at the asteroid, the team will spend approximately four months characterizing the surface, selecting the candidate boulders, and checking out the key spacecraft systems.

Once a prime boulder has been selected, and all systems have been confirmed to be functioning properly, the operations team will command the vehicle to autonomously land, capture the boulder, and ascend to a safe distance.

Figure 1. Boulder Capture Illustration

The mission operations timeline includes up to five attempts at collecting a boulder at three different landing sites.

To accomplish this mission, the team designed the Asteroid Redirect Vehicle (ARV) consisting of a 5.5 meter SEP/Mission module and a 6 meter Capture module.

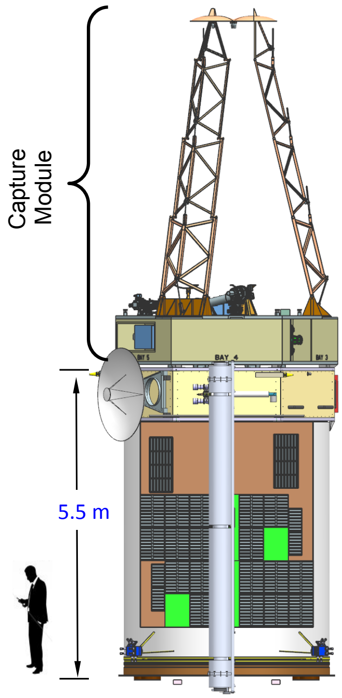


Figure 2: Notional Asteroid Redirect Vehicle

This vehicle can return boulders of up to 4 meter mean diameter.

## 3. Enabling Technologies

The ARM robotic segment will demonstrate key technologies and capabilities for NASA's future human missions to Mars and robotic missions throughout the solar system. These include:

Advanced Solar Electric Propulsion

The ARV includes a new 50 kW class Solar Electric Propulsion (SEP) system with up to 10 tons of Xenon propellant. This system will be capable of moving massive payloads throughout the solar system, ultimately including the systems required for a human expedition to Mars [2].

Autonomous Rendezvous and Docking

The ARV lands on the asteroid within 0.5 meters of the selected boulder using a precision Autonomous Rendezvous and Docking (AR&D) system. This system includes:

- A gimbaled camera platform that hosts narrow and medium field of view optical cameras for characterizing the landing site
- A deck mounted relative navigation sensor suite including redundant wide (60 degree) field of view optical cameras and redundant FLASH LIDARs
- Advanced Terrain Relative Navigation algorithms that autonomously process the optical and FLASH LIDAR data to determine relative position and attitude.

Micro Gravity Landing Systems

Three Contact and Restraint Subsystem (CRS) landing "legs" actively absorb the impact of landing on the asteroid, and perform the departure maneuver by pushing-off the asteroid surface after boulder collection. These same landing systems can be directly extended to enable missions to a wide range of airless bodies.

Multi-Mission Robotics

After landing on the surface of the asteroid, two seven degree-of-freedom robot arms reach out and "grab" the boulder using an innovative Microspine gripper.

These robotic elements will demonstrate key capabilities that can be used on future missions. For example the robot arms include a tool change out mechanism that allows for both mission specific tools to be mated to the multi-mission arms, and for tools to be changed during the mission. The Microspine gripper will demonstrate a novel approach to collecting natural rock samples that can be directly utilized on a range of future human and robotic missions.

## References

[1] Mazanek, D., Merrill, R., Belbin, S., Reeves, D., Earle, K., Naasz, B., and Abell, P., "Asteroid Redirect Robotic Mission: Robotic Boulder Capture Option Overview," AIAA SPACE 2014 Conference and Exposition, San Diego, CA, August 2014.

[2] Brophy, J., "Technology for a Robotic Asteroid Redirect Mission," IEEE Aerospace 2014, Big Sky MT, March 2014