Missions to Near-Earth Asteroids: Implications for Exploration, Science, Resource Utilization, and Planetary Defense

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Introduction: In 2009 the Augustine Commission identified near-Earth asteroids (NEAs) as high profile destinations for human exploration missions beyond the Earth-Moon system as part of the Flexible Path. More recently the U.S. presidential administration directed NASA to include NEAs as destinations for future human exploration with the goal of sending astronauts to a NEA in the mid to late 2020s. This directive became part of the official *National Space Policy of the United States of America* as of June 28, 2010.

NEA Space-Based Survey and Robotic Precursor Missions: The most suitable targets for human missions are NEAs in Earth-like orbits with long synodic periods. However, these mission candidates are often not observable from Earth until the timeframe of their most favorable human mission opportunities, which does not provide an appropriate amount of time for mission development.

A space-based survey telescope could more efficiently find these targets in a timely, affordable manner. Such a system is not only able to discover new objects, but also track and characterize objects of interest for human space flight consideration. Those objects with characteristic signatures representative of volatile-rich or metallic materials will be considered as top candidates for further investigation due to their potential for resource utilization and scientific discovery.

Once suitable candidates have been identified, precursor spacecraft are required to perform basic reconnaissance of a few NEAs under consideration for the human-led mission. Robotic spacecraft will assess targets for potential hazards that may pose a risk to the deep space transportation vehicle, its deployable assets, and the crew. Additionally, the information obtained about the NEA's basic physical characteristics will be crucial for planning operational activities, designing in-depth scientific/engineering investigations, and identifying sites on the NEA for sample collection.

Human Exploration Considerations: These missions would be the first human expeditions to interplanetary bodies beyond the Earth-Moon system and would prove useful for testing technologies required for human missions to Mars, Phobos and Deimos, and other Solar System destinations.

Current analyses of operational concepts suggest that stay times of 15 to 30 days may be possible at a NEA with total mission duration limits of 180 days or less. Hence, these missions would undoubtedly provide a great deal of technical and engineering data on spacecraft operations for future human space exploration while simultaneously conducting detailed investigations of these primitive objects with instruments and equipment that exceed the mass and power capabilities delivered by robotic spacecraft.

All of these activities will be vital for refinement of resource characterization/identification and development of extraction/utilization technologies to be used on airless bodies under low- or micro-gravity conditions. In addition, gaining enhanced understanding of a NEA's geotechnical properties and its gross internal structure will assist the development of hazard mitigation techniques for planetary defense.

Conclusions: The scientific, resource utilization, and hazard mitigation benefits, along with the programmatic and operational benefits of a human venture beyond the Earth-Moon system, make a piloted sample return mission to a NEA using NASA's proposed human exploration systems a compelling endeavor.