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**BINARY ASTEROIDS AND HUMAN EXPLORATION CONSIDERATIONS.** P. A. Abell<sup>1</sup>, <sup>1</sup>Astromaterials Research and Exploration Science, NASA Johnson Space Center, Mail Code KR, Houston, TX 77058, [paul.a.abell@nasa.gov](mailto:paul.a.abell@nasa.gov).

**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. Subsequently, the U.S. presidential administration directed NASA on April 15, 2010 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.

**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 5 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.

**Human Spaceflight Issues:** The main concerns for sending astronauts to encounter any asteroid in deep space are related to the maneuvers they must make and the near-surface particulate environment of the asteroid. It is generally accepted that most binary NEAs are probably rubble-pile asteroids with relatively high porosities. There is a considerable lack of knowledge concerning the nature of NEA geotechnical properties, and even less is known about binary NEAs. Ultimately the crew will have to perform close proximity operations via an excursion spacecraft and/or during extra-vehicular activities (EVAs), and then interact with the asteroid's surface to conduct scientific investigations and engineering experiments. It is not clear how the

particles at the surface of the primary and secondary will react to forces brought about by the crew's activities. The particles levitated could represent a simple nuisance or a more serious hazard. In addition, the presence of a secondary in a microgravity regime may present an operational challenge for spacecraft maneuvers. However, the secondary could also provide a benefit if it is gravitationally bound to the primary. Such a configuration could provide a slowly rotating surface from which to interact with, and to conduct investigations of the binary system.

**Binary NEA targets:** The current NASA strategy is to select a single asteroid without any companions. This is true for both the robotic capture/redirect concept and sending humans to a NEA scenario. The NASA approach is to limit the complexity of the mission during close proximity operations near and/or at the surface of the NEA. A binary (or ternary) system could provide operational challenges that may present a hazard to the spacecraft and crew. These systems could also provide some advantages as discussed above. Until NASA has more experience with these types of NEAs *in situ* (e.g., via robotic investigations), it is unlikely that binary NEAs will be considered as viable targets for future human expeditions.

However, it should be noted that the current estimate of binary asteroids among the NEA population is roughly 16%. Hence this represents a significantly large fraction of the potentially accessible NEA target population both for robotic missions and human exploration. Given subsequent experience with future robotic missions to these objects, NASA may decide to relax their risk posture for eventual human exploration. Also, once NASA performs a human-led NEA rendezvous to a single NEA it is also quite possible that the scientific and operational knowledge gained from this mission will give confidence to NASA and government stakeholders that such missions to binary NEAs are also viable and should therefore be considered as potential human exploration targets.

**Conclusions:** Current NASA plans to explore NEAs do not include binary systems. However, with a few *in situ* robotic precursor missions to binary NEAs, and increased confidence in human mission capabilities, the scientific and hazard mitigation benefits, along with the programmatic and operational benefits of a human venture beyond the Earth-Moon system, make a mission to a binary NEA using NASA's proposed exploration systems a compelling endeavor.