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Prospects for Future Human Space Flight Missions to Near-Earth Asteroids

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ABSTRACT

The forthcoming Near-Earth Object (NEO) Surveyor space telescope is a foundational asset designed to complete NASA's congressionally-mandated goal[1] of cataloging ≥90% of NEOs ≥140 meters in size as soon as practical, and discover Earth impactors far in advance. NEO Surveyor is also critical to near-Earth asteroid (NEA) exploration because it will find suitable low-Δv NEAs for robotic and human missions, often on Earth-like orbits with long synodic periods. Such NEAs have usually not been detected until imminent Earth launch opportunities because they were not observable until close to Earth. Discovering them far enough in advance to deploy missions requires a deep-space infrared survey telescope such as NEO Surveyor [1,2].

In addition to posing hazards and being scientifically important, NEAs contain resources, such as water (OH), that could be utilized off-Earth. They also offer unique opportunities for the most ambitious human voyages ever undertaken. The Apollo program forever changed humanity's perspective by showing us Earthrise from our Moon through human eyes. Crewed missions to NEAs will forever change

[1] "National Aeronautics and Space Administration Authorization Act of 2005," Public Law 109-155–Dec. 30, 2005, https://www.congress.gov/109/plaws/publ155/PLAW-109publ155.pdf

our perspective again by showing us Earth as a distant point of light in the heavens as seen from an asteroid by astronauts.

Planetary defense endeavors to understand asteroid and comet impact risks and develop mitigation capabilities [2]. NEA exploration is synergistic in multiple ways. NEO Surveyor will discover and help characterize Earth impactors and accessible NEAs. Heavy-lift launch is highly enabling for both human NEA missions and planetary defense. Reconnaissance missions for planetary defense can also characterize NEAs prior to crewed missions. In situ resource utilization (ISRU) systems may be applicable to deflecting or destroying hazardous NEAs. NEA characterization data critically inform planetary defense efforts and indicate NEA types suitable for human exploration or ISRU.

In 2010, NASA performed the Near-Earth Object (NEO) Human Space Flight (HSF) Accessible Targets Study (NHATS), creating an automated online system monitoring mission accessibility of NEAs[2] [3,4]. NHATS database NEAs meet criteria that require less total mission Δv and/or round-trip mission duration than the Martian surface or even Mars orbit. There are currently 4,658 NHATS NEAs, and many rival or exceed lunar orbit/surface accessibility. Thus, NHATS NEAs could be explored by humans prior to attempting a Mars mission.

Human missions to NEAs would test human-rated spacecraft systems with less cost and risk than Mars missions. Thus, human missions to NEAs are compelling in their own right while also providing prudent preparation for more demanding Mars missions. Lunar missions can offer similar opportunities, but they differ from NEA missions in important ways. Lunar missions pose less demanding psychological challenges to crew and ground staff. Earth light-time delay for communications is significantly longer during NEA missions. NEA missions are available that require more propulsion system consumables than lunar missions but less than Mars missions.

In this paper, we summarize NEA accessibility for human missions, discuss motivations for such missions, survey knowledge about NEAs that informs future human missions, present exemplar mission opportunities to the currently known NHATS NEAs, and describe future work towards enabling human NEA missions.

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