HUMAN MISSIONS TO NEAR-EARTH ASTEROIDS: AN UPDATE ON NASA'S CURRENT STATUS AND PROPOSED ACTIVITIES FOR SMALL BODY EXPLORATION.

P. A. Abell[1], D. D. Mazanek[2], B. W. Barbee[3], R. G. Mink[3], R. R. Landis[4], D. R. Adamo[5], L. N. Johnson[6], D. K. Yeomans[7], D. M. Reeves[2], K. T. Larman[8], B. G. Drake[9], and V. P. Friedensen[10], [1]Astromaterials Research and Exploration Science Directorate, NASA Johnson Space Center, Houston, TX 77058, paul.a.abell@nasa.gov. [2]Space Mission Analysis Branch, NASA Langley Research Center, Hampton, VA 23681. [3]Navigation and Mission Design Branch, NASA Goddard Space Flight Center, Greenbelt, MD 20771. [4]NASA Wallops Flight Facility, Wallops Island, VA 23337. [5]Aerospace Consultant, Houston, TX 77059. [6]Planetary Science Division, NASA Headquarters, Washington, DC 20546. [7]Solar System Dynamics Group, Jet Propulsion Laboratory, Pasadena, CA 91109. [8]Analytical Mechanics Associates, Inc. Hampton, VA 23666. [9]NASA Johnson Space Center, Houston, TX 77058. [10]Human Exploration and Operations Mission Directorate, NASA Headquarters, Washington, DC 20546.

Introduction: Over the past several years, much attention has been focused on the human exploration of near-Earth asteroids (NEAs). Two independent NASA studies examined the feasibility of sending piloted missions to NEAs, and in 2009, the Augustine Commission identified NEAs as high profile destinations for human exploration missions beyond the Earth-Moon system as part of the Flexible Path. More recently the current 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.

Dynamical Assessment: The current near-term NASA human spaceflight capability is in the process of being defined while the Multi-Purpose Crew Vehicle (MPCV) and Space Launch System (SLS) are still in development. Hence, those NEAs in more accessible heliocentric orbits relative to a minimal interplanetary exploration capability will be considered for the first missions beyond the Earth-Moon system.

Given that velocity change and mission duration are the most critical factors in any human spaceflight venture, the most accessible NEAs are those that have orbits similar to Earth's (i.e., semi-major axis near ~1 AU, low eccentricity, and low ecliptic inclination). If total mission durations for the first voyages to NEAs are to be kept to less than one year, with minimal velocity changes, then NEA rendezvous missions ideally will take place within 0.1 AU of Earth (~15 million km or 37 lunar distances).

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 via ground-based telescopes 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 NEA survey telescope could more efficiently find these targets in a timely, affordable manner. Such a system could be ready to launch within a few years of project commitment and find most NEA targets within two years of launch if optimized for human mission NEA target selection. A space-based NEA survey telescope is not only able to discover new objects, but also track and characterize objects of interest for human space flight consideration.

Once suitable candidates have been identified, precursor spacecraft will be sent to perform basic reconnaissance of a few NEAs under consideration to inform the subsequent human-led mission. Robotic spacecraft will assess targets for any potential hazards that may pose a risk to the deep space transportation vehicle, its deployable assets (e.g., surface science packages, rover system, etc.), and the crew. Additionally, the information obtained about the NEA's basic physical characteristics during the reconnaissance 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. Missions to NEAs would undoubtedly provide a great deal of technical and engineering data on spacecraft operations for future human space exploration while conducting detailed scientific investigations of these primitive objects. Current analyses of operational concepts suggest that stay times of 15 to 30 days may be possible at these destinations. In addition, the resulting scientific investigations would refine designs for future extraterrestrial *In Situ* Resource Utilization (ISRU), and assist in the development of hazard mitigation techniques for planetary defense.

Conclusions: The scientific 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.