**PRELUDE TO HUMAN EXPLORATION OF PHOBOS AND DEIMOS: THE NEO FACTOR.** R.R. Landis[1], D.J. Korsmeyer[2], P.A. Abell[3,*], D.R. Adamo[4], T.D. Jones[5], E.T. Lu[6], L. Lemke[7], A. Gonzales[7], R. Gershman[8], D. Morrison[7], T. Sweetser[8] and L. Johnson[9], [1]Mission Operations Directorate, NASA Johnson Space Center, Houston, TX 77058, rob.r.landis@nasa.gov. [2]Intelligent Systems Division, NASA Ames Research Center, M/S 269-1, Moffett Field, CA 94035. [3]Planetary Astronomy Group, Astromaterials Research and Exploration Science, NASA Johnson Space Center, Mail Code KR, Houston, TX 77058, [4]Trajectory Consultant, 4203 Moonlight Shadow Court, Houston, TX 77059. [5]Association of Space Explorers, Chantilly, VA 20153. [6]Google, 1600 Amphitheater Parkway, Mountain View, CA 94043 [7]NASA Ames Research Center, Moffett Field, CA 94035. [8]Jet Propulsion Laboratory, Pasadena, CA 91109. [9]NASA Headquarters, Washington, DC 20546. [*]Research Scientist, Planetary Science Institute, 1700 East Fort Lowell, Suite 106, Tucson, AZ 85719.

**Introduction:** In terms of Δv and mission length, piloted human missions to near-Earth objects (NEOs) prior to human exploration of Phobos and Deimos can provide unique opportunities to acquire deep space operational experience (i.e., the manned CEV Orion spacecraft will be several light-seconds from the Earth but, not light-minutes); risk reduction for space hardware; confidence building for future mission scenarios (e.g., lunar poles and farside, other NEOs, and eventually, Phobos, Deimos and Mars); early *in situ* resource utilization (ISRU) evaluation; as well as a rich scientific return. Sending a human expedition to a NEO will help NASA regain crucial operational experience conducting human exploration missions – which has not been attempted since *Apollo 17*.

**History:** The notion of a piloted mission to a NEO was first discussed in 1966 as an alternate follow-on utilization of the Apollo spacecraft and Saturn 5 hardware. The mission would have been a flyby for the 1975 opposition of 433 Eros [1]. During the 1975 opposition, Eros came within 0.15 AU of the Earth and Smith (1966) examined the necessary capabilities to upgrade the Apollo/Saturn 5 hardware for a 500+ day round trip mission [1]. More than 20 years later, NASA re-examined the ideas of visiting NEOs in greater depth as part of the Space Exploration Initiative in 1989 [2]. Since then, four other studies have examined the details of sending humans to NEOs [3,4,5,6]. The most recent assessment has been undertaken by the Advanced Programs Office (APO) within NASA's Constellation Program. This particular study team includes representatives across NASA and is examining the feasibility of sending a Crew Exploration Vehicle (CEV), the Orion spacecraft, to a NEO. Depending on the suite of spacecraft and integrated components, a mission profile would include two or three astronauts on a 90 to 120 day spaceflight; including a 7 to 14-day stay at the NEO itself, which would be an ideal *Apollo 8*-style of mission prior to visiting Phobos and Deimos.

**Comparative Δv's:** The orbits of NEOs are often quite similar to the Earth's orbit, and therefore require a fairly small Δv for rendezvous provided launch occurs near a close approach. In addition, due to their small size and consequent shallow gravity wells, only a very small Δv is required to brake into the vicinity of, and to depart from, a typical NEO. For comparison, the Δv required to brake into or depart from lunar orbit is of order 0.8 km/s, which when combined with the 3.2 km/s lunar transfer Δv means that a lunar orbital mission requires a total Δv ~4.8 km/s. To visit a NEO in an Earth-like orbit, such as 2000 SG344, depending on the mission scenario, the total Δv is between 5 – 6.5 km/s; for Phobos ~7.9 km/s; Deimos ~ 7.5 km/s (depending on the method of capture into Mars orbit); for a lunar surface mission ~9.1 km/s; and, for a Mars surface mission the total Δv tally tops out at ~15.6 km/s [7].

**CEV (Orion) Science Capabilities:** A CEV-type mission will have a much greater capability for science and exploration of NEOs, as well as Phobos and Deimos, than robotic spacecraft. The primary advantage of piloted missions to NEOs is the flexibility of the crew to perform tasks and to adapt to situations in real time. Factoring NEOs (as well as the flight and exploration techniques of these small bodies) into the Mars-forward fabric has obvious implications for human exploration of Phobos and Deimos.

**References:** [1] Smith, E. (1966), "A Manned Flyby Mission to [433] Eros," World Space Congress. [2] Davis, D. R. *et al.* (1990), The Role of Near-Earth Asteroids in the Space Exploration Initiative. SAIC-90/1464, Study No. 1-120-232-S28. [3] Nash, D. B. *et al.* (1989), "Science Exploration Opportunities for Manned Missions to the Moon, Mars, Phobos, and an Asteroid," NASA Document No. Z-1,3-001 (JPL Publication No. 89-29). [4] Jones, T. D. *et al.* (1994) Human Exploration of Near-Earth Asteroids. In *Hazards Due to Comets and Asteroids*, 683-708, Univ. of Arizona Press, Tucson, AZ. [5] Jones, T. D. *et al.* (2002) The Next Giant Leap: Human Exploration and Utilization of Near-Earth Objects. In *The Future of Solar System Exploration*, 2003-2013 ASP Conference Series, 272,141-154. [6] Mazanak, Daniel, *et al.*(2005), "The Near-Earth Object Crewed Mission Concept Status," NASA Langley Research Center [internal Constellation/ESMD study]. [7] Adamo, D. R. (2007), 'Round-Trip ΔV', personal communication.