# STEPPING STONES TO MARS: RECONSIDERING HUMAN EXPLORATION OF PHOBOS

**Michael D. West**
Board of Advisors & Undergraduate Student Intern, Mars Institute, NASA Research Park, P.O. Box 6, Moffett Field, CA 94035-0006, USA. Current address Research Student School of Aerospace, Mechanical & Mechatronic Engineering, University of Sydney Building J07, University of Sydney, NSW, 2006, AUSTRALIA

Phobos is one of the most attractive candidates for human exploration in the Solar System, particularly given the low $\Delta V$ required to reach its surface. Various rationales for Phobos' exploration by humans have been presented over the past three decades (see Adelman et al, 1985 for a good review). These include the use of Mars' inner moon as a platform for observing the surface of Mars and for tele-operating rovers on Mars. Other motivators have invoked the potential scientific insights into small bodies and the dynamics of the Mars-Phobos-Deimos system that such an exploration may yield. Some have speculated that the presence of $H_2O$ (Fanale et al, 1990) and other in-situ resources would make Phobos a viable 'interplanetary gas station' and mining outpost that could aid exploration of Mars and other planetary bodies (O'Leary, 1985, PHOBIA Corp, 1989 & O'Leary, 1992). Several different approaches and mission scenarios have been proposed (NASA, 1988, Ladwig et al, 1989 & Singer, 1981) but significant support or in-depth investigation of such ventures has yet to materialize.

Recent studies and results from robotic spacecraft approaching Phobos have given new insights into the nature and origin of this martian moon, rekindling some old debates and raising new questions (Murchie, 1996 & Veselovsky, 2004). The fact that meteorites of martian origin have reached the surface of the Earth suggests that an object closer to Mars would have likely received a significant *flux* of martian material as well, raising the question of whether Phobos's regolith might hold a record of martian crustal material of meteoritic origin. Preliminary estimates suggest that the impact velocities of martian ejecta material upon the surface of Phobos would be high, making survival problematic, but uncertainties concerning the physical properties of Phobos's regolith leave the possibility open (Gladman & Lee, in preparation). If a martian meteoritic record could be confirmed, Phobos could provide access to a global sampling of martian geologic materials without the challenge of actually landing humans on Mars. Such a discovery would make Phobos a 'Library of Alexandria' of Mars, likely increasing our understanding of Mars and of the early Solar System in profound ways (Lee et al, 2005).

Planetary protection concerns are likely to place strict requirements on a human mission to the martian surface. A crewed outpost on the surface of Phobos could support preliminary analysis, screening and quarantining of martian surface material collected by tele-operated rover and sample return missions prior to forwarding the samples to Earth for detailed examination (Landis, 2005). That is, Phobos could act as a 'glove box' for Mars, mitigating both the risk of human-induced forward contamination of the martian environment and the risk of any martian biology to the crew (Lee et al, 2005).

The Vision for Space Exploration, as well as activities in Russia, Europe and China, have set the Moon and Mars as the next targets for human exploration in space. As far as human Mars exploration is concerned, it is well known that the bulk of the complexity, specific hardware developments and costs lie in landing a spacecraft on the surface of Mars once it has reached

martian orbit, executing surface activities safely and productively, and returning the crew to martian orbit for the trip home. Given these factors, it is possible that following the successful return of humans to the Moon, human Mars exploration might be stalled for decades while the challenges of landed Mars missions are met. Phobos presents the key programmatic advantage of offering a martian exploration target that is technically achievable in the immediate aftermath of successful lunar activities, as only a low-cost, short term spiral development of already qualified lunar systems would be needed for a crewed Phobos mission. Such a crewed Phobos mission would also reduce the risk of and increase the knowledge of the challenges associated with landing a crewed mission on the surface of Mars. Finally, human exploration of Phobos would enable a steady cadence of exciting, meaningful and tangible missions in the Mars system, thus ensuring programmatic focus and continued public support (Lee et al, 2005).

These new considerations have only matured in the past few years and indicate that Phobos should be revisited as a high-priority target for short-term robotic reconnaissance missions and human exploration, particularly as a strategic intermediate step between humans returning to the Moon and the more difficult and therefore distant goal of landing humans on Mars. Far from being a distraction from the goal of human Mars exploration, Phobos should be viewed as a stepping stone that will make human missions to Mars happen earlier, more safely, and more productively. This presentation will provide a review of past Phobos exploration proposals and motivations as well as highlight some of the specific challenges associated with the human exploration of Phobos. The new rationale for the robotic and human exploration of Phobos proposed by Lee et al (2005) will be detailed.

**References**

S. J. Adelman & B. Adelman, *The Case for Phobos* , The Case for Mars II, Christopher McKay, editor, 1985, pp. 245-252; presented at the 2nd Case For Mars conference, Boulder, CO, July 10-14, 1984, AAS 84-165.

F.P. Fanale & J.R. Salvail, *Evolution of the Water Regime of Phobos*, Icarus, Vol. 88, 1990, pp. 380-395.

A. Ladwig & T. Ramlose, *Beyond Earth's Boundaries: Human Exploration of the Solar System,* Space Policy, Vol. 5, No. 2, pp. 138-146, May 1989.

G. Landis, Lunar & Planetary Science Conference, League City, TX, March, 2005.

P. Lee, S. Braham, B. Gladman, G. Mungas, M. Silver, and M. West, *Mars Indirect: Phobos as a Critical Step in Human Mars Exploration.* International Space Development Conference, Washington D.C., May, 2005.

S. Murchie, *Spectral Properties and Heterogeneity of Phobos From Measurements from Phobos 2,* Icarus, Vol. 12, 1996, pp. 63-86.

Office of Exploration, *Exploration Studies Technical Report: FY 1988 STATUS - Volume I: Technical Summary,* NASA, December, 1988, NASA TM 4075.

B. O'Leary, *Phobos & Deimos as Resource & Exploration Centers*, The Case for Mars II, Christopher McKay, editor, 1985, pp. 225-245; presented at the 2nd Case For Mars conference, Boulder, CO, July 10-14, 1984, AAS 84-164

B. O'Leary, *International Manned Missions to Mars and the Resources of Phobos and Deimos,* Acta Astronautica, Vol. 26, No. 1, pp. 37-54, 1992, 0094-5765/92.

PHOBIA Corp, *A Robotically Constructed Production and Supply Base on Phobos,* NASA Center for AeroSpace Information (CASI), May 4, 1989, NASA-CR-186234 & NAS 1.26:186234.

S. F. Singer, *The Ph-D Proposal: A Manned Mission to Phobos and Deimos,* The Case for Mars, Penelope Boston, editor, 1984, pp. 39-65; presented at the Case For Mars conference, Boulder, CO, April 29-May 2, 1981, AAS 81-231.

I.S. Veselovsky, *Is Phobos Magnetized,* Solar System Research, Vol. 38, No. 3, 2004, pp. 188-193.

**NOTES**