

Mars Indirect: Phobos as a Critical Step in Human Mars Exploration

Pascal Lee¹, Stephen Braham², Brett Gladman³, Greg Mungas⁴, Matt Silver⁵, Peter Thomas⁶, and Michael West¹.

¹ Mars Institute, SETI Institute, & NASA Ames Research Center
MS 245-3, Moffett Field, CA 94035-1000, USA

² Simon Fraser University, Vancouver, B.C. Canada

³ University of British Columbia, Vancouver, B.C., Canada

⁴ Firestar Engineering, LLC & Mars Institute, Denver, CO, USA.

⁵ Massachusetts Institute of Technology, Cambridge, MA, USA

⁶ Cornell University, Ithaca, NY, USA

Phobos, the inner satellite of Mars, has long been considered a possible stepping stone in the human exploration of Mars (Singer 1974, O'Leary 1980, NASA 1990). However, classical arguments in favor of a human mission to Phobos, which include:

- Minimal delta-v's needed to reach Phobos's surface
- ability to monitor Mars from a stable platform in low Mars orbit (LMO)
- ability to teleoperate robots on Mars without significant time delay
- opportunity to advance the scientific investigation of small bodies
- potential of finding H₂O on Phobos which might be used as a resource

have generally not been compelling enough to create a broad consensus placing Phobos on the critical path of human Mars exploration. We suggest here that at least three additional considerations which have matured only in recent years should prompt a review of Phobos's role in human Mars exploration and may well position the satellite as a critical next step immediately following the human return to the Moon:

1) *Phobos as a "Library of Alexandria" of Mars.* As the Earth receives a flux of martian meteorites, the following question is asked: might Phobos's regolith hold a well-preserved record of martian crustal material of meteoritic origin, accumulated throughout Phobos's circum-martian history, having sampled Mars on a global scale, and offering possibly unique insights into Mars's geology and potential biology? Preliminary estimates suggest that impact velocities of martian ejecta onto Phobos are high, making survival unsystematic. But if a meteoritic record were confirmed (through more detailed modeling and possibly robotic scouting), humans on Phobos could do much to advance the scientific exploration of Mars itself. (Deimos does not present a similar potential).

2) *Phobos as a glove box for Mars.* In the context of current and anticipated planetary protection requirements regarding Mars exploration over the next decades, humans on Phobos would be ideally positioned to teleoperate robotic scouts on aseptic, in-depth reconnaissance missions on Mars prior to their physical arrival (Landis 2005). The infrastructure established on Phobos to teleoperate robots could be used to process/quarantine/screen returned martian samples before Earthbound forwarding.

3) *Phobos as a catalyst for human Mars exploration.* The bulk of the challenge, specific hardware development, and cost of a human mission to Mars lies in that part of the mission that brings astronauts all the way down to the martian surface, enables their surface ops, and returns them to LMO. If no human journey to Mars were undertaken before humans are ready for an actual landing, decades could elapse after the return to the

Moon before humans venture to Mars. Phobos presents the key *programmatic* advantage of a) being a martian target that is technically achievable in the *immediate* wake of humans returning to the Moon, requiring only a low-cost near-term spiral development (lunar systems readily qualifiable for Phobos); b) reducing risk through a stepwise build up to full-up Mars landed missions, c) enabling a steady cadence of exciting, meaningful and tangible near-term missions at Mars, thus ensuring programmatic focus and continued public support.