HUMAN EXPLORATION OF PHOBOS & DEIMOS: ENGINEERING CHALLENGES & UNIQUE OPPORTUNITIES. Michael D. West[1,2] and Pascal Lee[2], [1]Research School of Physical Sciences & Engineering, The Australian National University, Mills Rd, Canberra, ACT, 0200, Australia, michael.west@anu.edu.au [2]Mars Institute, Unit 97, 35287 Old Yale Rd, Abbortsford, BC, V3G 8H5, Canada.

Introduction: Since their discovery Phobos and Deimos have been a source of puzzlement. Spectra acquired from the Earth and spacecraft have yielded ambiguous and conflicting links with different types of asteroids; while imaging data from past missions have revealed these moons as irregular shaped, heavily cratered, regolith-covered bodies. Despite the repeated flybys and the global imaging coverage now available, several fundamental questions remain unanswered – principally their origin, evolution and current state.

The low ΔV's required to reach the surface of these moons, and particularly Phobos, makes these objects one of the most economical targets for human exploration in the Solar System. Several different approaches and scenarios have been proposed [1-3] but significant support or in-depth investigations of such ventures have yet to materialize.

Traditional Rationales: These rationales have included the use of Mars' inner moon as a platform for observing the surface of Mars and the teleoperation of rovers on the martian surface [3]. Speculation about the presence of H_2O [4] and other in-situ resources have led to proposals for mining operations and the use of the moons as 'interplanetary gas stations' [5-6] that could aid the exploration of Mars and other parts of the Solar System. Sadly, advances in robotic technologies have made the former rationale obselete and the later is based on very speculative observations of Phobos' regolith which await future confirmation.

Engineering Challenges: Human exploration of Phobos and Deimos is not without some interesting engineering challenges that will require innovative and robust solutions. Mobility on or above the surface is a concern given the low escape velocities and variable gravity fields of the moons [1,7]. The nature of the regolith and the stability of dust clouds may also pose a hazard to EVAs, equipment and crew health [7].

Unique Opportunities: The engineering challenges aside, the human exploration of Phobos and Deimos remains attractive for various reasons in addition to the compelling scientific questions. Many have only matured in recent years and include:

EVA Experience. Further expertise will be gained in operations both near and on small, essentially gravity free planetary bodies which is of value to the exploration of near Earth asteroids and comets in the future. This experience is also a natural progression from the EVA experience obtained during the Shuttle, Mir & ISS programs before progressing to more challenging Mars surface EVAs.

Planetary Protection. A crewed outpost on Mars' moons could support preliminary analysis, screening and quarantining of martian surface material prior to forwarding the samples to Earth for detailed examination [8]. This would mitigate the risk of human-induced forward contamination of the martian environment and the risk of any martian biology to the crew and Earth.

Mission Support Infrastructure. The deployment of strategic infrastructure on the martian moons would greatly enhance future robotic and human missions to the Mars system. High-precision navigational beacons [9], environmental monitoring equipment and communications relays will provide high-precision position and gravitional field determination, greater knowledge of the martian surface and orbital environments and enhanced data relay capability between Earth and Mars' surface, respectively.

Radiation Shielding. By executing a retrograde synchronous orbit around Phobos or Deimos at a low altitude or landing at the right location it is possible to always stay on the down sun side of the moons. Such a maneuver would allow the mass of the moon to be used for shield the crew from radiation, particularly during solar flares.

Catalyst for Human Mars Exploration. Phobos and Deimos are technically feasible targets in the immediate wake of humans returning to the Moon and reduce the risks of progressing directly to a full-scale manned Mars mission [7]. The martian moons will also provide a steady cadence of exciting, meaningful and tangible near-term missions at Mars, thus ensuring programmatic focus and continued public support.

References: [1] NASA Office of Exploration. (1988) NASA TM 4075. [2] Ladwig, A. & T. Ramlose. (1989) *Space Policy*, **5**, pp. 138-146. [3] Singer, S. F. (1981) The Case for Mars, P. Boston, ed., AAS 81-231, pp. 39-65. [4] Fanale, F. P. & J. R. Salvail (1990) *Icarus*, **88**, pp. 380-395. [5] O'Leary, B. (1992) *Acta Astronautica*, **26**, 1, pp. 37-54. [6] PHOBIA Corp. (1989) NASA CASI, NASA-CR-186234. [7] Neal, V., et al. (1989) NAS9-17779 – Phase III, pp.181-191. [8] Lee. P., et al. (2005) *Space Resources Roundtable VII*, Abstract #2049. [9] Chadwick, W. J. III., et al. (2004) *Advances in Astronautical Sciences*, **119**, 1, pp. 509-528.