DESTINATION DEIMOS: A DESIGN REFERENCE ARCHITECTURE FOR INITIAL HUMAN EXPLORATION OF THE MARS SYSTEM. J. S. Logan[1] and D. R. Adamo[2], [1]NASA Johnson Space Center, james.s.logan@nasa.gov, [2]Independant Astrodynamics Consultant, adamod@earthlink.net.

Introduction: The two biggest challenges to successful human operations in interplanetary space are flight dynamics, constrained by the cold hard physics of the rocket equation, and bioastronautics, the psychophysiological realities of human adaptation, or lack thereof, to the deep space environment. Without substantial innovation in project/mission architecture and vehicle design, human exploration of the Mars system could be problematic for decades.

Approach: Although a human landing on Mars is inevitable, humans-in-the-loop telerobotic exploration from the outer Martian moon Deimos is the best way to begin. Precursor robotic missions for reconnaissance and local site preparation will be required.

Virtues of Deimos: Deimos, 12 km across and located just above Mars Synchronous Orbit, is not as deep in the Martian gravity well as Phobos. From Deimos, Mars slowly rotates eastward at 2.7 degrees per hour. Mars surface features undergo two sunrises and two sunsets, remaining continuously visible from Deimos' Mars facing side. With several Mars surface assets positioned at regularly spaced longitudes, teleoperator astronauts could circulate westward from one to the next and explore 24/7. Over a period of 5 days 11.2 hours, nearly the entire planet is visible. Only 20,000 km from Mars itself, the round trip light time, very important for line-of-sight telerobotics, is only 156 milliseconds, almost seventeen times less than the Earth-Moon round trip light time.

Architecture Hallmarks: Our design reference human mission assumes *existing* technologies with one exception: heavy lift. Other key hallmarks include chemical propulsion (no cryogenic propulsion after Earth departure), open-loop consumables for a crew of three, and standard exercise and deconditioning countermeasures. Initial analysis revealed the need to minimize weight/volume of the crewed Mars Transfer Vehicle (MTV) by preemplacement of stay-time resources and return consumables at Deimos (necessitating "Abort to Destination" capabilities after Earth departure). Radiation exposure constraints and stay time durations mandate the requirement for a fully radiation protected subsurface habitat (100% radiation protection equivalent of Earth's atmosphere or RP100) upon reaching Deimos and MTV radiation protection equivalent to 5% Earth protection (RP5) for outbound and Earth return legs. This will entail a combination of innovative vehicle design and mass shielding.

Duration and Mass: The 2011-2012 launch season was chosen because it is a worst case scenario. Mars is near aphelion, its farthest point from the Sun, so a round trip is of nearly maximum duration and propulsive expense. The outbound leg would take 240 days and Earth return another 249 days. The Deimos stay time would be 469 days for a total mission duration of 949 days. A 5.1% pad for consumables is added, bringing the total number of days to 1000. Consumables mass estimate calculations are based on slightly modified NASA Open Loop Life Support [1] numbers for 1000 days for a crew of three: Water (18,000 kg), Oxygen (2170 kg) Food (5700 kg), Crew Supplies (2071 kg), Gasses lost to space (2071 kg), and Systems maintenance (2071 kg); a total of 32,084 kg. The outbound and 5% pad consumables are transported on the MTV, leaving 22,747 kg to be preemplaced on Deimos prior to Earth crew departure.

MTV Configuration: Assuming propulsive "stages" are 15.7% structure, launch packages limited to 187.7 mT initial mass in LEO (think Ares V) and preemplacement of all return consumables at Deimos, including a crew Earth-return vehicle required for direct atmospheric entry, an MTV could be configured in four heavy-lift launch packages: Cargo Element #1 (CE1), first half of hypergolic propulsion stage for Mars orbit insertion and Deimos rendezvous; CE2 identical to CE1; CE3, an inflatable "TransHab" module (28.1 mT), open-loop crew consumables for 8 months plus 5.1% margin (9.4 mT) plus additional 23 mT of radiation shielding; and a Human Element (HE) consisting of a Trans Mars Insertion stage (46.9 mT) plus crew exploration vehicle (18.6 mT). Since an Earth-return vehicle has been preemplaced on Deimos, the CEV is deorbited following a successful TMI burn.

Earth Departure Orbit: To leverage the cryogenic upper stage of each launch package, elements are placed into a highly elliptical two-day parking orbit (120,000 by 500 km) that is almost out of the Earth-Moon gravity well. After the first three elements are configured (robotically), the Human Element performs a rendezvous with the package and uses its cryogenic TMI stage to provide the 2.959 km/s boost for Earth departure.

Exploration Objectives: This telerobotic exploration concept satisfies every objective in NASA's Mars Design Reference Architecture, Version 5 [2].

References:

[1] Ewart M. (2007) *Life Support system Technologies for NASA Exploration Missions*, 7-8.

[2] Drake B. G. et al. (2009) *Human Exploration of Mars Design Reference Architecture 5.0, 10-19.*