To the Moon by way of Mars: A unique, robust and holistic architecture for long duration exploration initiatives

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Abstract:

A conceptual mission and vehicle architecture for initiating near term permanent Mars exploration, development and habitation is presented based on an integrated mission, environment and systems design approach. Five key drivers of this human behavior and operations centric architecture are planetary dust mitigation, radiation protection, redundancy, standardization and in-situ water reclamation and processing. The architecture directly supports human Mars exploration initiatives and was inspired in part by several previous designs, which inferred the direct surface-to-surface operations methodology. Yet, this architecture quickly departs from all previous piloted space exploration missions and designs in several ways; most notably being that an original crew of six is divided into two crews of three during the return portion of the mission. Design redundancy and safety is thus heightened by flying pairs of vehicles during each transfer conjunction. Increased vehicle production rates afford assembly standardization, rapid design upgrade and safety enhancement opportunities; and should ultimately reduce long term costs.

This design is comprised of two vehicles. The first is the Surface-to-Surface Return Vehicle (SSRV), and it is nominally designed to return three people from the surface of Mars to the surface to the Earth. The second vehicle, called the Planetary Habitat Vehicle (PHV) is a three deck, six-person habitat designed to support long duration Mars surface operations. The PHV is designed to support a piloted, two segment mission of interplanetary and permanent surface operations; whereas the SSRV will support one unpiloted and one piloted interplanetary flight, along with a lengthy, 560-day interval of planetary surface hibernation. Each module is uniquely designed to adapt, function and survive the various environments in which they operate. Combining this mission concept with the given a priori requirements of heavy-lift, In-situ Resource Utilization (ISRU) and nuclear electric power production, directly engenders a robust, adaptable, cost effective and long-lived Mars exploration and colonization venture. A design as much about philosophy as it is about vision.

A simple radiation analysis of model structures was performed using the HZETRN 2005 transport code to assess the conceptualized protection characteristics. The results demonstrated the design intent to reduce expected radiation dose rates by nearly one third while including a creative ordering of vehicle mass impacts on specific phases of flight such as entry and landing.

Ultimately, in detailing the vehicle’s systems and mission architectures it is shown that such an initial judicious design enables parallel long duration exploration initiatives by supporting a return to the moon; and thus was adopted the edict of 'Build for Mars, fly at the Moon'.