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Architecture for humans in space: design, engineering, concepts and mission planning (1)

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SYSTEMS ENGINEERING FOR MARS POLAR RESEARCH BASE

Abstract

Mars Polar Ice caps have been known ever since Cassini first saw them with his telescope. Robotic exploration missions, starting with Mariner 9 have confirmed that they are composed of water ice. Later missions (MOLA instrument onboard of Mars Global Surveyor) have established their proper topography (about 3km in their thickest part) and detailed internal structure has been investigated by MARSIS (Mars Express) and SHARAD (Mars Reconnaissance Orbiter) orbital radars. We propose to establish a base near North Polar Layered Deposits to provide easy access to water ice.

In this work we describe a high level design for a Mars Research base using systems engineering approach. The main goal of the work is to establish total mass, power and data budget needed for expedition to explore internal properties of the North Polar layered Deposits (NPLD) in-situ. We identified the following driving requirements for the base:

- The expedition shall consist of crew of 6 people to allow for doubling of the roles.
- The crew has to travel safely to Mars, land in a designated area, perform their mission and return safely to Earth
- The manned part of the expedition shall last for at least 8 Earth months on the surface.
- The project shall ensure life support, environmental, hygiene, dietary, logistical, professional, and psychological needs for crew comfort.

We have specifically left out of scope of this paper all aspects related to the details of Mars-Earth and Earth-Mars transfers (including launch capabilities), however we have given some thought to radiation protection of the crew during cruise and possible mission scenarios.

We derived necessary requirements related to crew composition, human requirements, science requirements, communication and habitat structure and usability requirements. Given these requirements we identified possible technological solutions for life support systems, radiation protection, in situ propellant production, thermal control, air pressure difference compensation and availability of power. At the end of this step, we compiled mass, volume, data and energy consumption.

We have found, that approximately 115 metric tons are required to enable a manned Mars Polar mission. We will present a mission scenario with four SLS LUS-modified rockets to stage deliveries of modules and crew to Mars. We identified key technologies and challenges in the areas of propulsion, access to space, life support systems, inflatable structures and automation. These developments may serve as priorities for current Mars settlement programs.