44th COSPAR Scientific Assembly - COSPAR 2022
Athens, Greece, 16 - 24 July 2022

Reference Surface Activities for Crewed Mars Mission Systems and Utilization

Stephen J. Hoffman
The Aerospace Corporation, Houston, Texas
stephen.j.hoffman@nasa.gov

Michelle A. Rucker
NASA Johnson Space Center, Houston, Texas
michelle.a.rucker@nasa.gov

Alida D. Andrews
The Aerospace Corporation, Houston, Texas
alida.andrews-1@nasa.gov

Kevin D. Watts
NASA Johnson Space Center, Houston, Texas
kevin.d.watts@nasa.gov

Abstract

For many years NASA has investigated alternative human Mars missions, examining different mission objectives, trajectories, vehicles, and technologies, the combinations of which have often been referred to as reference missions or architectures. This paper describes the current reference being used by NASA for the surface exploration portion of a human Mars mission architecture. The last Mars reference architecture, published in 2009 [1], outlined a 4- to 6-person crew, long stay on Mars (~500 sols), maximizing use of infrastructure such as in situ resource utilization (ISRU) to manufacture propellant for a crew ascent vehicle. In 2019, mission planners and analysts were challenged by senior NASA leadership to develop a much different architecture and mission profile: one designed for a very short round-trip duration, with only a 30-sol surface stay for two crew and utilizing minimal surface infrastructure, for the first human mission. There were several motivations for this shorter duration mission, including emerging nuclear-enabled space transportation technologies that could make a short round-trip mission possible, as well as a risk assessment that indicated shorter missions could reduce crew health risk. Efforts by mission planners focused on the 30-sol surface mission, anchoring the shorter end of possible surface stay durations. The results of these efforts have been documented in a NASA report, HEOMD-415, that is now available for public use [2]. It is important to note that no decisions have been made by NASA regarding human Mars mission objectives, durations, or architectures, and this document is intended to aid in analysis of options.

HEOMD-415 details the surface exploration phase constraints and considerations in planning daily activity timelines for crewed exploration on Mars. This work was done for the purpose of estimating how much time during each martian sol might be available for exploration activities, (also referred to as utilization activities in this document), after accounting for time needed for crew and equipment care.

The document begins with a description of the overall mission architecture, including such items as flight times between Earth and Mars, predeployment of certain hardware elements on the surface and in orbit, parking orbit characteristics, etc. that provide context and set certain constraints for the surface mission. This is followed by a description of key assumptions, from currently available sources, that were used to develop the timelines. To build a realistic timeline, all tasks the crew will perform – of which utilization-driven tasks (e.g., planetary science, human performance research, technology demonstrations, etc.) are only one part – need to be properly accounted for and the capabilities and limitations of a human crew need to be reflected in the assigned duration for these tasks. Lessons learned from decades of International Space Station (ISS) operations as well as surface mission analogs provided guidance for the type and duration of non-utilization activities that are likely independent of utilization activities. In addition to accounting for crew non-utilization tasks (and the time needed to accomplish them), the assumed time needed for non-utilization tasks associated with operating hardware used on the surface (e.g., recharging stored power systems, restocking logistics, periodic maintenance, etc.) was described.

With this foundation, HEOMD-415 described a sol-by-sol surface exploration mission timeline. At the conclusion of this description, the total amount of time used in the activities was presented, summarized into relevant mission planning categories. In addition, the amount of time used specifically for extravehicular activities (EVAs) was gathered in a tabular form, showing the amount of time by sol and by crewmember that resulted from this analysis. As future analyses related to this surface mission are conducted, these summary results will be updated and revisions of the document will be released.

References

[1] Mars Architecture Steering Group. Human Exploration of Mars Design Reference Architecture 5.0 Addendum. Houston, TX: NASA; 2009 Jul. Report No.: NASA/SP-2009-566-ADD.

[2] Mars Architecture Team. Reference Surface Activities for Crewed Mars Mission Systems and Utilization, Houston, TX, 2022 Jan. Report No.: NASA/HEOMD-415.