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Author: Mr. Chel Stromgren
Binera, Inc., United States, c.stromgren@binera.com

Mr. Steven Rivadeneira
Binera, Inc., United States, s.rivadeneira@binera.com
Ms. Michelle Rucker
NASA, United States, michelle.a.rucker@nasa.gov

DEFINING THE REQUIRED NET HABITABLE VOLUME FOR LONG-DURATION EXPLORATION MISSIONS

Abstract

As the National Aeronautics of Space Administration continues planning for long-duration space missions, specifically to Mars, it will be necessary to understand the requirements for a "transit habitat"; the element that the crew will live in as they travel to and from Mars. In particular, understanding of volume requirements for the transit habitat is of significant importance because the volume is a first order driver of the habitat size and mass, and therefore the propulsion requirements for future Mars missions. Despite this importance, there is significant uncertainty regarding how much habitable volume is required to support the crew on these missions. Prior studies provide valuable background, but their focus has largely been on investigating historical analogs in order to develop parametric sizing formulas. While this type of data is valuable, there is large variability in the results and there have been limited efforts to establish a comprehensive minimum required habitable volume based on crew activity needs and health requirements. This paper will describe a detailed effort to establish the minimum required net habitable volume for the Mars Transit Habitat employing a "bottom-up" methodology. The process used to establish volumetric requirements involves the definition of a set of specific "crew activities" and the assignment of required volumes to each activity. This type of approach is the most accurate method to establish required habitat volume and is specifically recommended by the NASA Chief Medical Officer for future space missions. The authors established a taxonomy of crew activities that could be required during a Mars transit. These activities include direct operational activities, such as command and control and system repair, habitation activities, such as eating and sleeping, and health maintenance activities, such as exercise and leisure. Health maintenance also includes "pseudo-activities", such as psychological well being, that are directly related to habitat volume. The authors defined required volumes for each defined activity, based on habitat analogs, prior research, and SME input. The potential for various activities to share volumetric space was evaluated, based on temporal usage and compatibility of tasks. Finally, the required minimum net habitable volume for a 4-crew Mars Transit Habitat was assessed, including consideration of specific geometrical constraints. Results of this study will be used to evaluate deep space habitat options, and also help formulate future Mars mission requirements. Ultimately, results of this study will support the refinement of NASA's Mars DRAs, and help realize future long duration exploration missions.