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INTEGRATING THREE DISCIPLINARY PERSPECTIVES IN AN ITERATIVE DESIGN PROCESS FOR THE SURFACE HABITAT OF THE FIRST HUMAN MISSION TO MARS

Abstract

Human factors engineering has only recently gained attention in research on feasibility of human Mars mission architectures. (Häuplik-Meusburger et al., 2017) However, the risks concerning Behavioural Health and Performance are still too high for a human exploration mission to the surface of Mars. (ISECG, 2013) Research in space psychology supports designing for habitability in space architecture. Habitability is thought to decrease stresses on the crew and therefore improve the crew's performance in ICE environments. (Kanas, 2009; Bassingthwaighte, 2017)

This research proposes a methodology for integration of three disciplinary perspectives in an iterative design process for martian surface habitat development, namely mission engineering, space psychology and architecture. The architect has to synthesise quantitative constraints, concerning the constructibility of the habitat as a mission sub-system, and qualitative requirements, related to the habitability of the architectural program organization, into one integrated design. During habitat design and development, a continuous design iteration will be necessary between the architect and mission engineers as well as space psychology experts. The architect will develop the habitat's configuration of system elements and organization of functional activities. In turn, the other experts will evaluate the proposal based on the constructibility and habitability of the habitat system, therefore qualifying the design in terms of its feasibility.

To test the proposed methodology, a design exercise was conducted for the habitat of the first human settlement on Mars. The mission architecture, or concept of operations, resulted in several baseline assumptions. Based on these assumptions the criteria for constructibility of the surface habitat were quantified. In addition, the characteristics of the crew and their psychological and physical needs were defined. These requirements formed the driving parameters for the space architect's design of the surface habitat. Through an iterative process this design concept was then verified again in light of the original requirements, and optimizations were drawn up where needed.

The results of the preliminary iterative design exercise revealed the impact of the chosen mission parameters, such as the EDL-strategy on the volumetric constraints, on the design of the habitat. Volumetric constraints were stressed by the crew's spatial needs concerning habitability. It was concluded that for a 1000-day mission to Mars with a crew of seven and a HIAD EDL, two deployable habitat modules would have to be landed in order to answer habitability needs.