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HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5)
Human Exploration of Mars (2)

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A METHOD TO EVALUATE ARCHITECTURAL COMPARISONS FOR A CAMPAIGN TO EXPLORE THE SURFACE OF MARS

Abstract

There is a general consensus that Mars is the next high priority destination for human space exploration. However, the specific techniques for evaluating these missions are unclear. There has been no lack of analysis and recommendations for human missions to Mars, including, for example, the NASA Design Reference Architectures and the Mars Direct proposal. Most of these recommendations either (a) focus on the analysis of a pre-selected architecture or (b) select a baseline architecture for the entire system, then trade off individual architectural decisions in that context.

The approach of selecting a baseline mission architecture and running individual trade studies for single systems has some benefits, however, this approach misses system interactions across non-baseline architectures that could positively or negatively affect the output of each individual trade. An alternative approach is to holistically analyze the entire architectural trade-space such that all of the possible system interactions are identified and measured. Without this holistic approach, there could well be blind spots where the cost of an architectural decision outweighs its value in the overall mission.

An important aspect of the holistic approach is to measure the impact of architectural decisions and interactions with regard to both mission cost and delivered value. The cost measurement of human spaceflight missions is relatively well-defined, however, there are no agreed upon quantitative methods for estimation and measurement of mission value.

When comparing mission plans and architectures in the context of a Mars exploration, the scientific findings (while difficult to forecast) are of great relevance. There is a plethora of literature that compares the favorability of specific scientific metrics. These metrics often pertain to a single discipline, such as weighing the probability for present or extinct life on the planet. However, these metrics fail to factor in all of the mission elements that are necessary to complete that research.

In order to explore and compare mission architectures, we propose a metric for the estimation and measurement of the scientific value of a human exploration mission to Mars. In this metric, we consider the impacts of the mission system constraints, the limitations imposed by the viability of the overall architecture, and an aggregate of the scientific value. Since the proposed metric enables comparison across scientific domains and across multiple architectures, it provides a framework for decision makers and scientists to reanalyze the delivered value in the face of new data, changing inputs, or changing scientific priorities.