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DECISION-BASED SYSTEM ARCHITECTING FOR LUNAR SURFACE SYSTEMS

Abstract

This paper details the process of using decision-based system architecting to model the Lunar Surface System (LSS). A decision-based architecture model represents the problem as a four interconnected sets: decisions represent the parameters of the system that can be traded by the design team, constraints represent the propositional statements that limit the alternatives of a decisions based on other decisions, metrics represent the system properties that are used to evaluate the feasible architectures, and metrics functions represent the calculations that use the decisions as inputs to determine the metrics.

The modeling of the LSS began with the choice of the 17 metrics based on stakeholder analysis and the decomposition of NASA's six exploration themes, which outline why we should explore the Moon. The metrics are connected to 11 system-level decisions, which are divided into two major classifications: operational strategy decisions and functional allocation decisions. Each decision was populated with alternatives taken from currently or previously proposed elements and options. The final step included limiting the set of architectures to only include feasible architectures by adding constraints based on physical limitations, architectural assumptions, and system requirements.

Once the model of the LSS was developed, it was used to enumerate the set of feasible architectures based on the principles of solving a Constraint Satisfaction Problem. This simulation enumerated 12,636 feasible architectures that could be evaluated based on the set of metrics.

Based on the concept of non-dominance, 1,402 preferred architectures were determined. In order to rank these preferred architectures, a piecewise linear utility function was developed for each of the metrics and an aggregate benefit utility score was determined for each architecture. Several of the highest rank system designs did correspond to those being investigated by current NASA studies. While providing significantly less utility, Apollo-like architectures appeared as the most efficient designs in terms of utility per dollar.

The other information that can be taken from an model is how important each decision is to the overall value of the architecture. This information can be displayed using a Decision Space View, which plots each decision as a point on a graph of how many constraints each decision is connected to versus how sensitive a given metric is to changes in the decision. Using this information, it is shown that two of the most influential decisions include the choice of duration for crewed missions and the choice of habitation type.