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MONEYBALL - FINDING LOW COST MISSION ARCHITECTURES BY DESIGN SPACE EXPLORATION USING PATTERN LANGUAGES AND HOUBOLT QUESTIONS

Abstract

With the advent of the Commercial Lunar Payload Services Program and the envisaged increase in human activity in cis-lunar space and on the lunar surface, space mission designers will need to create economically feasible and environmentally sustainable mission architectures for complex-mode missions.

The current standard for space mission design involves experts creating alternative mission architectures from their knowledge base and performing trade-studies to select the most promising candidates. This process searches only a limited part of the design space as it relies on human imagination to generate the concepts and thus it risks missing the most cost effective mission architectures.

This paper demonstrates a model-based method to exhaustively chart the design space for space missions using pattern languages and Houbolt questions. Pattern languages are a way of expressing ConOps as a series of characters arranged together according to a set of simple grammatical rules. Houbolt questions are key choices which are made when designing a space mission such as the propulsion choice, technological development strategy, spacecraft production method and reusability considerations. Pattern languages and Houbolt questions are used for combinatorial exploration of the design space.

Cost estimations and assessments of risk, uncertainty are performed on each mission architecture in the design space using a modified version of TruePlanning cost estimation software. The method returns a set of promising mission architectures which is more likely to contain the solution which is the optimum of the optimum than the existing method of ideation of concepts of operations based on expertise, and can create new unimagined low cost mission architectures.

The method is to be tested on a case study of the European Rosetta mission: A comet orbiter/lander mission which visited asteroid 67p in 2016. The results show that exhaustive design space exploration can find the pareto-optimal set of mission architectures for this case study, and can produce some interesting alternative solutions for space missions.