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ASSESSMENT OF LUNAR LANDER ARCHITECTURES IN TERMS OF PROGRAMMATIC STAKEHOLDER OBJECTIVES

Abstract

A lunar lander architecture is complicated by the vast number of design decisions, competing metrics and complex interdependencies. The resulting combination space of potentially feasible architectures is massive and often difficult to evaluate and compare. This paper demonstrates a number of methods used in the evaluation of the lunar lander architecture trade space. The study is split into three phases: an initial scoping of the problem, including trajectory analysis, staging points and potential transfer trajectories, a characterization of potential systems that define the trade space, and a portfolio optimization method that accounts for interdependencies, schedule dependencies and stakeholder metrics. Copernicus, a NASA in-house trajectory design and optimization software, is used to evaluate several different orbital staging locations and trajectories between these points and potential landing sites. Given the trajectory analysis, a library of potential systems is utilized to compare potentially viable mission scenarios. This library includes US government, commercial, and international heritage hardware, as well as proposed future systems that span all types of potential systems in a lunar architecture. The Beyond LEO Architecture Sizing Tool (BLAST) is a parametric design tool used to evaluate and characterize several of these potential systems based on mission criteria, system performance, and orbital dynamics. BLAST provides the ability to examine system mass sensitivities based on various inputs such as ΔV, crew size, engine performance, or mission duration. Several potential elements are sized for each of the major design decisions to fully encompass the design space. These elements are further evaluated in terms of their cost and schedule, represented by individual lifecycle phases, based on the Technology Readiness Level, system sizing and concept of operations. A portfolio optimization method is used to evaluate the combinations of potential elements in terms of their interdependent operational relations, scheduling dependencies, and stakeholder objectives. Several programmatic metrics are assessed including stakeholder value of exploration, total architecture cost, annual budget, schedule metrics, and methods of estimating architecture robustness. The result of this study is the comparison of several promising architectures in terms of their performance in key metrics. The approach illustrates the complexity associated with this architecture synthesis problem and features several potential solutions. In particular, the Stakeholder goals and objectives (e.g. time of return to lunar surface or annual cost/budget) significantly impact the decision variables (e.g. staging location, duration of surface operations, crew size, etc.) as seen via the overall portfolio optimization.