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Strategies & Architectures as the Framework for Future Building Blocks in Space Exploration and Development (1)

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TOWARDS A COMPREHENSIVE REUSE STRATEGY FOR SPACE CAMPAIGNS

Abstract

The history of architectures for space exploration endeavors can largely be characterized as mostly technically dissimilar systems designed in somewhat "stovepipe" fashion to accomplish the goals of a particular mission or campaign. Now that we are in the midst of a greater push for exploration to the Moon, Mars, and beyond, (both human and robotic) a more concerted and intentional effort may be required for exploiting technologies and capabilities common across destinations and objectives. This suggests that a strategy similar to the one taken in product platforming might be appropriate. Platforming, which defines a baseline set (or "platform") of elements onto which product (or mission) specific elements can be added may allow for decreased costs due to design reusability, more responsive and upgradeable fleets, and prudent technology prioritization decisions. This paper investigates this claim in three related analyses: 1) investigation on the reasons for and ramifications of one-off designs in space exploration endeavors; 2) survey of existing literature on platform-based approaches for space mission and campaign design; 3) initial development of a framework for platform-based space exploration campaigns.

The first section looks at several examples of past flagship exploration missions. Missions with similar destinations and objectives are compared in terms of similar vs. dissimilar technologies and capabilities employed. This analysis finds that key reasons for one-off approaches include large time gaps between related missions, evolution of technology over those times, and a lack of long-term vision in campaign development.

The survey in the second section finds growing interest in lifecycle properties related to platform-based approaches, like modularity and commonality. We also find that platform-based approaches have been developed for particular spacecraft subsystems; however, no unified platforming strategy exists for campaign-level architecting.

The third section of this paper sets the groundwork for a platform-based campaign architecting framework. Namely, we develop and demonstrate a classification scheme for space exploration missions that considers destination, agent (i.e. human vs. robotic), and campaign objectives. We explore subsequent steps in the framework by application to a simple example: Jupiter/Saturn probes. The framework is built on the methodologies of Model-Based Systems Engineering which helps to develop and inspect standardized, consistent and reusable mission models.

This work finds that while one-off designs are suitable for particularly unique mission objectives, a platform-based campaign may yield significant benefits in system development while also fostering a sustainable, building-block strategy to exploration campaign.