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TECHNOLOGY PRIORITIZATION AND ARCHITECTURE FLEXIBILITY FOR SPACE SYSTEM-OF-SYSTEMS

Abstract

Decision makers face a difficult task when planning large-scale space missions or long-term development of technologies for space systems architectures. The difficulties arise from multiple factors. First, the size of the problem, the diversity of the involved systems and technologies, and the variety of stakeholders and their needs result in a large a complex trade space. Second, technologies are continuously evolving, and it can be hard to find data and model for new technologies, which increases the uncertainty about availability and performance. Third, in these complex problems decision makers need to account not only for traditional engineering trade-off (including cost, time, performance, and risk) but also for policies, stakeholder preferences, and flexibility of space architectures. Building on our previous research in System-of-Systems methodologies, we propose a combination of tools to support decision-making for technology prioritization and analysis of development time, risk, and flexibility of space architectures. Based on developmental dependencies between technologies, Technology Readiness Level (TRL), mission requirements, uncertainty, cost, and budget limitations the tools produce the optimal expected schedule. Further results include the outcome of delays in the development of one or more technologies on the overall schedule. These results allow the user to identify potential bottlenecks and risks, and the probability of meeting deadlines. Different strategies for prioritization of technologies can also be compared. The tools can also handle constraints such as policies or stakeholder preferences, which impose prioritization of certain technologies or space missions. Finally, since long-term space mission planning is very dynamic and specific objectives change often, we implemented a tool to add analysis of flexibility on top of the technology prioritization tools. This analysis is performed from two different perspectives. First, from a mission viewpoint, given a selected mission category (and its associated technologies), we assess how many different mission variants are achievable under a limited budget and estimate the increase in cost and development time should stakeholders change their preferences. This analysis identifies the most flexible mission architectures. Second, from a technology viewpoint, given a selected set of initial technologies, we evaluate the potential change in cost and development time required to complete the development of various alternative missions. This analysis identifies the most flexible technologies. We use case studies of Moon and Mars exploration architectures to demonstrate the application of the methodology.