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Heritage Systems Engineering Lessons Learned from NASA Deep Space Missions

In the design and development of complex spacecraft missions, project teams frequently assume the use of advanced technology systems or heritage systems to enable a mission or reduce the overall mission risk and cost. As projects proceed through the development life cycle, increasingly detailed knowledge of the advanced and heritage systems within the spacecraft and mission environment identifies unanticipated technical issues. Resolving these issues often results in cost overruns and schedule impacts. The National Aeronautics and Space Administration (NASA) Discovery & New Frontiers (D&NF) Program Office at Marshall Space Flight Center (MSFC) recently studied cost overruns and schedule delays for 5 missions. The goal was to identify the underlying causes for the overruns and delays, and to develop practical mitigations to assist the D&NF projects in identifying potential risks and controlling the associated impacts to proposed mission costs and schedules. The study found that optimistic hardware/software inheritance and technology readiness assumptions caused cost and schedule growth for all five missions studied. The cost and schedule growth was not found to be the result of technical hurdles requiring significant technology development. The projects' institutional inheritance and technology readiness processes appear to adequately assess technology viability and prevent technical issues from impacting the final mission success. However, the processes do not appear to identify critical issues early enough in the design cycle to ensure project schedules and estimated costs address the inherent risks. In general, the overruns were traceable to: an inadequate understanding of the heritage system's behavior within the proposed spacecraft design and mission environment; an insufficient level of development experience with the heritage system; or an inadequate scoping of the system-wide impacts necessary to implement an advanced technology for space flight applications. The paper summarizes the study's lessons learned in more detail and offers suggestions for improving the project's ability to identify and manage the technology and heritage risks inherent in the design solution.