SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS (D2)
Upper Stages, Space Transfer, Entry and Landing Systems (3)

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HUMAN PLANETARY SPACECRAFT DESIGN LESSONS

Abstract

NASA's Constellation Program has successfully advanced the design of multiple human spacecraft, and each spacecraft project within Constellation has contributed both technical and programmatic lessons that can be applied to any future human planetary spacecraft. Each spacecraft design specifically addresses both the physics of spaceflight as well as the dynamics of human-vehicle interactions – the combination of the two have a significant influence on the scale and configuration of the vehicle. Further, the technology that is assumed to be available for the development timeframe completes the definition of the total "design space" that is available to the spacecraft engineering design team. Human spacecraft development also creates management and administrative issues which are unique to human spacecraft and human spaceflight programs. Acquiring the skilled expertise to design, develop, test and operate a human spacecraft has become a challenge as the time interval between new human spaceflight projects grows larger. This is why it has become imperative to clearly articulate mission needs and commensurate vehicle requirements and capture them in a traceable manner to prevent turnbacks later in the cycle after considerable effort has been expended. Furthermore, driving the vehicle design concept only to these needs, and nothing more, is a must for constructing a viable architecture. To staff the human spacecraft design teams, NASA has reached into its robotic lander experience, space shuttle and ISS development expertise, and its Apollo Program heritage to bring the correct experience base to the current design challenge. Additionally, large-scale human space programs involve multiple projects that may simultaneously be within drastically different phases of their lifecycles maturity. As a new project is beginning development, an associated project may at the same time be peaking in its development and resource needs. Aligning project milestones, defining requirements and interfaces among these elements, and not having the more mature projects dominate the later starting projects presents management challenges. Designing a new human planetary spacecraft is a multi-layer systems challenge. Future human spaceflight projects must reflect the physics of spaceflight and limitations of human performance while balancing performance, cost, schedule and risk; working within an integrated program architecture (with its own performance, cost profile, schedule, and integrated risk and reliability targets); and fulfilling the policy directives of the partner agencies. Success requires a diverse team with a true systems perspective—an understanding of how a change made to one spacecraft parameter affects other factors, both technical and programmatic.