Category: **Technologies Required to Meet Space Exploration**

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Abstract: ***A Sustainable, Reliable Mission-Systems Architecture that Supports a System of Systems Approach to Space Exploration***

A mission-systems architecture based on a highly modular "systems of systems" infrastructure utilizing open-standards hardware and software interfaces as the enabling technology is absolutely essential for an affordable and sustainable space exploration program. This architecture requires (a) robust communication between heterogeneous systems, (b) high reliability, (c) minimal mission-to-mission reconfiguration, (d) affordable development, system integration, and verification of systems, and (e) minimum sustaining engineering. This paper proposes such an architecture. Lessons learned from the space shuttle program are applied to help define and refine the model.

This mission-systems architecture consists of three major components:

- A hardware layer based on a node-based network with tunable redundancy, automated fail-over based on intelligent agents, and plug and play interaction that includes automatic reconfiguration
- A software architecture applicable from the lowest level subsystem to the integrated mission system based on open-standards middleware
- A transparent switching framework of flight hardware, flight equivalent hardware, emulation of flight hardware, and network-connected computers containing high-fidelity software models

"A central concept of the new U.S. National Vision for Space Exploration is that space exploration activities must be 'Sustainable'" (NASA's 2004 H&RT Formulation Plan). Sustainability encompasses four key areas. The mission-systems architecture clearly supports all areas.

Affordability

- Transparent switching significantly reduces costs by supporting new systems concept validations earlier without real hardware, by reducing hardware requirements for training scenarios, and by reducing systems integration efforts.
- Reliable automatic reconfiguration virtually eliminates expensive ground-based reconfiguration applications and reduces human-in-the-loop interaction requirements.
- Incremental building block approach simplifies integration of new systems into existing flight systems.

Reliability/Safety

- Redundancy tuned to the level required, whether N+1, N+M or full duplication where necessary, to give quantifiable probability of mission success.

Effectiveness

- Building upon recognized industry/space standards significantly reduces costs and the risk of development while offering a highly effective combination of real-time performance, scalability, and fault-tolerance.