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**Session Proposal: The Multiple Dimensions of System of Systems Engineering – "Easy To Do" Is Easy To Say**

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**Statement of Purpose:** Lessons learned from the front lines of the aerospace industry.

The aerospace industry has long recognized the necessity to combine the disciplines of Systems Engineering and Systems Architecture to facilitate System of Systems Engineering. Although our vision of their integration is well represented in the industry's objectives, implementation plans, and jargon, we consistently experience obstacles in successfully implementing the many dimensions of System of Systems Engineering. This panel takes a pragmatic perspective on the topic to share lessons learned in developing and implementing System of Systems architectures for large space and airborne programs, applying operations and engineering expertise in the system development process, implementing new technologies in a relatively mature environment, and integrating existing limited-purpose systems into more complex System of System applications.

**Proposed Papers:**

(a) *The Changing Role of Requirements and Architecture in Systems Engineering* – Reggie Cole

In the past, requirements were the principal tool for defining the problem, with architecture being the domain of the designer. This makes sense under a static model in which user requirements are well understood, technology is evolving slowly, organizational dynamics can be mapped out in advance and external interfaces are stable. The world of system-of-systems engineering is anything but static.

The term "System Architecture" has traditionally meant the technical architecture of the system – the design of the technical portion of the system. But that definition is changing. The term "System Architecture" is being used increasingly to refer to the overall form of the system, the arrangement of people, processes and technologies necessary to meet the systems intended purpose within its operating environment.

This paper examines two key architecture/requirements challenges in a dynamic system-of-systems context: (1) the use of architecture in defining the problem; (2) parallel development/management of architecture and requirements.

(b) *Walking the Tightrope – Balancing Abstraction and Implementation Constraints When Specifying Problems* – Glenn Char

The globalization of enterprise systems is challenging traditional approaches to problem definition. Increasingly, customers are defining their needs with capabilities descriptions and effects based concepts. Their operational systems-of-systems perspective often simply aggregates desired information and functionality. This is advantageous, as it does not constrain designers to a pre-conceived solution. However, their conceptual descriptions fail to account for the complexity of combining normally independent systems to achieve the desired emergent behavior. Their capability statements abstractly describe concepts which are interactively complex and often difficult to support. High system interdependencies demands system support structures be properly integrated, often nationally or globally. This situation creates a discontinuity between specifying desired outcomes and functionality with few operational boundaries, but which still have formal organization, ownership and contractual boundaries. Without balancing the two opposing perspectives, abstracted needs are indirectly specifying systems changes that are unrealistic for actual implementation.

(c) *System of Systems (SoS) Engineering and Architecture Challenges in a Net-Centric Environment* - Abe Meilich, Ph.D., C.C.P.

This paper will discuss the following topics:

- Some Observations on Architecting and Engineering of Systems of Systems: Based on industry thinking, challenges of looking at emergent behavior, and thinking beyond the "M" in DOTMPLF (Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities)
- Systems of Systems vs. Families of Systems: implications for implementation
- Net-Centric Operations and Net-Centric Warfare – Implications for SoS Implementation
- The future warfighting environment complexity: Implications for the practice of SoS engineering.

(d) *Balancing complexity, risk, and opportunity* – David Lopez

The demand for C4I services to support interagency coordination and cooperation is growing at all levels of government. In meeting this growing need, we face challenges in interoperability, complexity, unity of effort, and affordability. To compound the effort, our operating environment is characterized by significant annual growth in information, communications, and computing capabilities.

The challenge of providing the right balance of C4I services to a complex set of customers is immense and potentially very costly. System engineers and system architects must play a fundamental role in:

1. Understanding and reducing the complexity of systems operation with the end user in mind
2. Enabling the integration of multiple, complex systems to maximize interoperability
3. Identifying risks and developing sound mitigation plans for systems integration
4. Identifying risks and developing sound mitigation plans for new systems development
5. Conducting analysis for service solutions that may not involve system development.

(e) *Breaking Down the Artificial Barriers* – Jim Bowlin

As we approach the 40th anniversary of spaceflight, we are finding that many of the systems engineering principles and business practices that our industry has purposely honed no longer function effectively in a System of Systems environment. This paper will address some of the barriers to SoS implementation that are built upon the artifacts of our individual disciplines, focused career paths, organizational roles and responsibilities, and common business practices. The SoS Renaissance dictates that we break down these barriers through education, training, organizational restructuring, and the implementation of transformational business practices to better meld the "art and science" of systems engineering.