



Systems of Systems

A 3-Day Course

Use Sound Collaborative Systems Engineering Processes to Ensure Architectural Integrity and Interoperability for Systems of Systems

Today's operational environments are dominated by complex Systems of Systems. As a result, systems engineers now have the responsibility to create systems of unprecedented scope and complexity. Such development objectives are not the only challenges. The development environment for a system of systems is typically characterized by its own unique challenges, such as an extended life cycle, requirements to use legacy systems as components, and ongoing re-architecting throughout the lifecycle of the system and its component systems. Success under these conditions requires developing a sound design, managing complexity, maintaining the integrity of that design, and supporting shifting operational priorities over significant time spans while avoiding the lurking potential of chaotic conditions.



To meet these challenges, the course presents detailed, useful techniques to develop effective systems of systems and to manage the engineering activities associated with them.

You should attend this course if you are:

- A leader or a key member of a system of systems project team
- A leader or a key member of a project team for a system that will be used as a component in a System of Systems
- Looking for practical methods to use today

The course is aimed at

- Program managers,
- Project managers,
- Systems engineers,
- Technical team leaders,
- Logistic support leaders, and
- Others who participate in defining and developing complex systems.

Practice the skills on a realistic exercise. Create an SoS Architecture. Plan and implement integration. Use collaborative Systems Engineering Processes.

The *System of Systems Robotics Exercise* gives students the opportunity to practice the skills taught in the course while collaboratively developing an evolving system of systems consisting of interoperating robots.

Topics Covered in the Course

Introduction – Systems of Systems Concepts. Project integration and scope management. Expectations for what an SoS can achieve. Terms and definitions.

- What is a system of systems?
 - Capabilities engineering vs. requirements engineering.
-

- Operational environment: geographic distribution, concurrent operations
- Development issues: evolutionary, large scale, distributed
- Interoperability and synergy in C4ISR
- Roles of project leaders in SoS development

Systems of Systems Challenges – Complexity issues versus traditional systems engineering. Systems engineering in transition. Paradigm shifts. Framework for working with systems of systems

- Complexity and chaos as an underlying principle
- Issues in complex adaptive systems: scale free nets, adaptation, autocatalysis, nonlinear dynamics
- Emergent behavior and the use of patterns
- Model / view / process as a way to observe and change
- Problems with traditional systems engineering in relation to SoS.
- New paradigms for engineering complex systems



Architecture – Design strategies for SoS reflect the independent origin of the included systems, greater scale and complexity of the SoS environment, and the distinct lifecycle of the SoS.

- Large scale architectures
- Architectural Frameworks – DODAF, TOGAF, Zachman, FEA
- Using the DOD Architectural Framework (DODAF)
- Design Patterns
- Constitutions
- Re-Architecting in an evolutionary environment

- Working with legacy systems
- Robustness and graceful degradation at the design limits
- Designing synergies and interoperability
- Optimization and measurement of quality

Integration – Integration strategies for SoS cope with the dynamic character of the SoS environment, the presence of systems that originated outside the immediate control of the project staff, and the difficulty of anticipating shifting SoS priorities over the operating life of the systems.

- Loose coupling integration strategies
- The design of open systems
- Open systems technologies
- Integration planning and implementation
- Interface design
- Legacy Systems
- COTS

Collaboration – The SoS environment puts special demands on the systems engineering processes. Collaborative efforts often extend over long periods of time and can require effort across organizational contexts. SoS often have many systems engineers collaborating explicitly or implicitly, at the same time (concurrently) or at disjoint times. Collaboration may occur over decades.

- Responsibilities from the SoS side
- Responsibilities from the component systems side

-
- Strategies for managing collaboration
 - Concurrent systems engineering
 - Disjoint systems engineering; building on the past to meet the future
 - Strategies for maintaining integrity of systems engineering efforts over long periods of time when working in independent organizations.

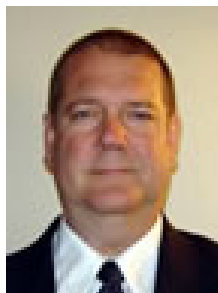
Testing and Evaluation – Testing and evaluation in the SoS environment present unique challenges due to the evolutionary nature of development. Multiple levels of T&E are necessary, and the usual success criteria no longer suffice.

- Why interface testing is necessary but isn't enough
- Operational definitions for evaluation
- Multiple levels of T&E
- Testing for chaotic behavior and emergent behavior
- Testing responsibilities in the SoS environment

Summary - Review of the important points of the workshop. Interactive discussion of participant experiences that add to the material.

The Presenters:

Mr. Eric Honour has been in international leadership of the engineering of systems for over a decade, part of a 36-year career of complex systems development and operation. His energetic and informative presentation style actively involves class participants. He was the founding Chair of the INCOSE (International Council on Systems Engineering) Technical Board in 1994, was elected to INCOSE President for 1997, and continued as Director of the Systems Engineering Center of Excellence (SECOE). He was selected in 2000 for Who's Who in Science and Technology and in 2004 as an INCOSE Founder. He is on the editorial board for *Systems Engineering*. He has been a systems engineer, engineering manager, and program manager at Harris Information Systems, E-Systems Melpar, and Singer Link, preceded by nine years as a US Naval Officer flying P-3 aircraft. He has led or contributed to the development of 17 major systems, including the Air Combat Maneuvering Instrumentation systems, the Battle Group Passive Horizon Extension System, the National Crime Information Center 2000, and the DDC1200 Digital Zone Control system for heating and air conditioning. Mr. Honour now heads Honourcode, Inc., a consulting firm offering effective methods in the development of system products. Mr. Honour has a BSSE (Systems Engineering) from the US Naval Academy and MSEE from the Naval Postgraduate School.



Dr. Scott Workinger has led innovative technology development efforts in complex, risk-laden environments for 30 years in the fields of manufacturing (automotive, glass, optical fiber), engineering and construction (nuclear, pulp & paper), and information technology (expert systems, operations analysis, CAD, collaboration technology). He currently teaches courses on program management and engineering and consults on strategic management and technology issues. Scott has a B.S in Engineering Physics from Lehigh University, an M.S. in Systems Engineering from the University of Arizona, and a Ph.D. in Civil and Environment Engineering from Stanford University.