System of Systems Engineering Collaborators Information Exchange (SoSECIE)

October 10, 2013
11:00 a.m. to Noon Eastern Time

A Portfolio Approach to System-of-Systems Acquisition and Architecture

Dr. Navindran Davendralingam and Dr. Daniel DeLaurentis, Purdue University

Abstract
The complexity of modern military entities has seen the emergence of large scale, heterogeneous and independently operating systems that work cooperatively to achieve a desired set of overarching military capabilities. These conglomerations of systems or 'System-of-Systems (SoS)' often exhibit managerial and operational independence; however their hierarchical structure works collaboratively in achieving a common goal. The Department of Defense (DoD) management of technical and acquisition aspects of SoS have been greatly guided by policies and guidance set forth in the DoD 5000 series acquisition policy, the Defense Acquisition Guidebook, and the System Engineering Guide for System of Systems (SoS-SE). However, the inherent difficulties in architecting these highly complex and interconnected collection of systems presents the need for more effective tools in mitigating risks, minimizing unnecessary costs and maximizing warfighter capabilities.

The introduction of cost and performance control measures such as the Weapon Systems Acquisition Reform Act of 2009 (WSARA) and Better Buying Power initiatives have helped improve defense acquisition by incorporating stronger elements of technical accountability and competitive contracting within the acquisition process. Even so, acquisition management, in general, still lacks sufficient tools to adequately navigate the acquisition trade space that transcends both the programmatic and technical dimensions of SoS development. The need to balance decisions in acquiring new systems, extricating redundant (or obsolete) legacy frameworks, mitigation of risks (schedule, technical readiness) and reduction of costs in the midst of evolving requirements is truly a formidable task for acquisition practitioners and systems engineers alike. The interdependencies between systems present an added dimension of risk where disruptions in individual systems can have cascading repercussions throughout the network, thus compromising overall capability and greatly increasing developmental costs.

Our ongoing research work seeks to advance current knowledge in the area of system architecture and acquisitions by introducing an investment portfolio approach to decision making and SoS trade space exploration. The framework leverages tools from financial engineering and operations research circles to construct optimal 'portfolios' of interconnected systems that work cohesively in fulfilling an overarching capability. Each system is modeled as a generic node that can be assembled to form a hierarchical SoS network construct. Each node possesses a set of requirements and capabilities that are subject to rules of connections such as compatibility, bandwidth, ability to relay and number of allowed links.

By modeling systems with these generic behaviors, the identification of optimal constructs of interlinked systems, under conditions of uncertainty, can be found using an array of robust optimization techniques. While the research employs academic rigor in developing a portfolio-based approach, the end objective is the establishment of a decision support framework where acquisition practitioners can identify optimal collections of systems from large pools of candidate systems that follow specific interconnectivity rules. This includes consideration for transitions from existing platforms of 'portfolios' of systems. The

presented methodology considers the effects of uncertainty and formulates the framework as a robust optimization problem. This work is funded by the Naval Postgraduate School (NPS) Acquisition Research Program and the Systems Engineering Research Center (SERC) and extends current knowledge in the area of program management. The presentation will illustrate the proposed portfolio optimization framework and demonstrate it for a sample case based on the Littoral Combat Ship (LCS) program.

Biographies

Navindran Davendralingam is a Senior Research Associate at Purdue's School of Aeronautics & Astronautics. He works as part of the Center for Integrated Systems in Aerospace (CISA) led by Dr. Daniel DeLaurentis and received his Ph.D. in Aerospace Engineering from the Purdue University in 2011. He currently works on projects that are funded by the DoD Systems Engineering Research Center UARC and the Naval Postgraduate School. His main research includes using robust financial engineering methods in dealing with uncertainties in systems and system of systems engineering problems. He is a member of the American Institute of Aeronautics and Astronautics (AIAA) and the Institute for Operations Research and Management Sciences (INFORMS).

Daniel DeLaurentis is an Associate Professor in Purdue's School of Aeronautics & Astronautics. He leads Purdue's Center for Integrated Systems in Aerospace (CISA), which is home to 20 faculty affiliates, three research staff, and numerous dedicated graduate students. He also leads the ISA Center's largest recent project with the Missile Defense Agency's Enhanced C2BMC program developing agent-based modeling and simulation for development of advanced battle management architectures. His research is conducted under grants from NASA, FAA, Navy, the DoD Systems Engineering Research Center UARC, and the Missile Defense Agency. Dr. DeLaurentis is an Associate Fellow of the American Institute of Aeronautics and Astronautics and served as Chairman of the AIAA's Air Transportation Systems Technical Committee from 2008-2010. He is also AIAA Deputy Strategic Technologies Coordinator since 2011. He is also Co-Chair of the System of Systems Technical Committee in the IEEE System, Man, and Cybernetics Community and is Associate Editor for the IEEE Systems Journal. Dr. DeLaurentis is Fellow of Purdue's Center for Education and Research in Information Assurance and Security, 2012. He received his Ph.D. in Aerospace Engineering from the Georgia Institute of Technology in 1998.