System of Systems Engineering Collaborators Information Exchange (SoSECIE)

Tuesday, October 21, 2014
11:00 a.m. to Noon Eastern Time

Results from Applying a Modeling and Analysis Framework to an FAA NextGen System of Systems Program

Dr. Mark Blackburn, Stevens Institute of Technology

Abstract
The Next Generation Air Transportation System (NextGen) is the Federal Aviation Administration (FAA)'s vision of the National Airspace System (NAS) for the next 15 years. NextGen is a complex system of systems (SoS) with a significant amount of asynchronous integration and deployment. The 2012 NDIA presentation "Modeling an Acquisition Decision-Making Process for the FAA NextGen Systems of Systems" discussed the challenges of the FAA to plan, develop, and deploy NextGen capabilities. The research team formulated a conceptual model and the success criteria for an analysis and modeling framework that can assist the FAA with the challenging decision-making process.

This presentation discusses the results from applying the model and analysis framework to FAA NextGen programs in order to support risk-informed decision-making. The diverse set of stakeholders make the NextGen planning process challenging as there are a large number of very different stakeholder groups, often with competing interests. Ongoing discussions have been held with more than 70 stakeholders from the senior levels of the FAA, NASA, Industry, and the Joint Planning and Development Office. There are many challenges, such as all component dependencies are not systematically being identified, all interface dependencies are not being formally tracked, and tradeoff impacts are difficult to assess, especially in the face of changes. This is not simply an interface management problem. What people know matters significantly, because their internal knowledge is much greater than what is captured externally or formally. However, this knowledge and the causal relationships to the various program factors are not formalized in a way to support this complex decision-making process.

The current process relies on significant human judgment, with tools such as spreadsheets that are ill defined to factor complex SoS interactions into the estimates of cost, schedule, benefit and the associated risks, especially in the face of continuous change. While these approaches may have worked on a single or small system, the asynchronous nature of the NextGen SoS integration and deployment requires new approaches to deal with situations such as complex SoS interdependencies and coordinated collaboration between stakeholders of aircraft, airport infrastructures, air navigation service providers, and NextGen development contractors.

The team has built four different models that apply to the Mission Analysis, Investment Analysis, and Solution Implementation phases of the FAA Acquisition Management System (AMS). The models combine quantitative historical data with qualitative subjective judgment about SoS program factors to improve the predictability of the cost, schedule and expected benefit and associated risk. The approach is based on a set of Bayesian network models. Bayesian Networks (Pearl 1985) also referred to as Bayesian Belief Networks, describe relationships between causes and effects. Bayesian networks are represented as a directed graph modeling conditional dependencies using probabilities. The model captures the causal relationship of the program factors to calculate risk-based probabilities that can be shared with stakeholders to support a collaborative decision-making process.

The presentation focuses on the results achieved by applying the modeling and analysis framework to a NextGen program. The presentation discusses:

- Interactions the research team had with the project team
- High-level description of the Bayesian Network model
- Factors used to create the model
- Results of the model prediction

The results support the hypothesis that models that include the subjective factors related to program knowledge can improve the prediction of the schedule. This same method can be used to predict cost too. The presentation closes by summarizing how risk-based visualizations of cost, schedule, and benefits help stakeholders understand complex causal relationships, where an informed decision can minimize the impacts of cost overruns and schedule slips.

FAA Acquisition Management System [http://fast.faa.gov/].
Pearl, J. "Bayesian Networks: A Model of Self-Activated Memory for Evidential Reasoning" (UCLA Technical Report CSD-850017). Proceedings of the 7th Conference of the Cognitive Science Society, 1985.

Biography

Dr. Mark R. Blackburn is an Associate Professor with Stevens Institute of Technology and primarily responsible for research focused on methods, modeling, simulation, visualization, and automated tools for reasoning about computer-based systems. He is the Principal Investigator (PI) on a Systems Engineering Research Center research task sponsored by NAVAIR investigating the most advanced and holistic approaches to model-centric engineering, and co-PI on a related task for Quantitative Risk. He has also been the PI on research tasks for the National Science Foundation, Federal Aviation Administration, and National Institute of Standards and Technology. He holds a Ph.D. from George Mason University, M.S. in Mathematics (emphasis in C.S.) from Florida Atlantic University, and a B.S. in Mathematics (C.S. option) from Arizona State University.