

## **System of Systems Engineering Collaborators Information Exchange (SoSECIE)**

**July 30th, 2019  
11:00 a.m. to Noon Eastern Time**

### ***Graph Theoretic Architectural Analysis: Analysis of Complex Systems and Systems of Systems***

***Presenter: Ms. Laura Antul, The MITRE Corporation***

#### **Abstract**

In a SoS, constituent systems are often at different stages of development. This increases the difficulty in continuously guaranteeing the delivery of a capability, as well as non-functional requirements such as interoperability and resilience. Currently, the DoD has access to extensive M&S capabilities that are based on analysis methods such as physics-based analysis and operational analysis. However, these methods often require detailed information about the constituent systems and environmental variables for the given SoS architecture and scenario which is then analyzed by complex mathematical models, making this kind of analysis computationally expensive and time consuming to set up. We've identified an opportunity to leverage computationally inexpensive methods for analyzing SoS alternative architectures and prioritizing them for detailed M&S evaluation.

The DoD expects their SoS architectures to be resilient to a wide variety of threats, yet there is a lack of quantitative methods capable of providing valuable insight at the SoS level. A common definition for resilience is captured by the initial performance loss of an entity's capability and its subsequent recovery over time. However, there are proxies for resilience that are not as heavily tied to performance, and one example would be robustness. Robustness in this case is defined as the magnitude of initial drop in performance after an adverse event. Based on the connectivity of a SoS architecture it is possible to apply graph theory to objectively quantify indicators of the drop in performance for a given SoS architecture [1] [2]. Combining the graph theoretic measures and Model-Based Engineering Software tools that support SysML and UML enables a user to rapidly determine and compare the robustness of SoS alternative architectures.

#### **Biography**

Ms. Laura Antul is a multi-discipline systems engineer at the MITRE Corporation. In her three years working at the MITRE Corporation she has assisted in teaching training events using IBM's Rational Rhapsody, researched methods for quantitatively analyzing Model Based Systems Engineering (MBSE) models, developed custom plug-ins for MBSE tools, and created a SoS primer. Laura's background is in Mathematics and she has lead the research and development of the Graph Theoretic Architecture Analysis plug-in since its inception.

[1] E.-P. Han and D. Delaurentis, "A Network Theory-based Approach for Modeling a System-of-Systems," in 11th AIAA/ISSMO Multidisciplinary Analysis and Optimization Conference, 2006, pp. 1–16.

[2] W. K. Harrison, "The Role of Graph Theory in System of Systems Engineering," IEEE Access, vol. 4, 2016.

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