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Transforming Systems Engineering through a Holistic Approach to Model-Centric Systems Engineering

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Abstract
In 2013, the Naval Air Systems Command (NAVAIR) at the Naval Air Station, Patuxent River, Maryland initiated a Systems Engineering Research Center research task. The objective was to assess the technical feasibility of creating and leveraging a more holistic Model-Based Systems Engineering approach, which we are now referring to as model-centric engineering (MCE). The expected capability of such an approach would enable mission-based analysis and engineering that reduces the typical time by at least 25 percent from what is achieved today for large-scale 5th generation air vehicle systems.

The larger context of the NAVAIR mission seeks a Transformation of Systems Engineering through MCE. The research need includes the evaluation of emerging system design through computer (i.e., digital) models.

In 2014, we presented to NDIA our research strategy and findings from face-to-face discussions with over 20 Industry, Government and Academia organizations. Our research suggests that MCE is in use and adoption seems to be accelerating. MCE can be characterized as an overarching digital approach for integrating different model types with simulations, surrogates, systems and components at different levels of abstraction and fidelity across disciplines throughout the lifecycle. We seem to be getting closer to a tipping point and progressing beyond model-based to model-centric where integration of computational capabilities, models, software, hardware, platforms, and humans-in-the-loop allows us to assess system designs using dynamic models and surrogates to support continuous and often virtual verification and validation in the face of changing mission needs.

Enabling digital technologies are changing how organizations are conceptualizing, architecting, designing, developing, producing, and sustaining systems and systems of systems (SoS). Some use model-centric environments for customer engagements, as well as design engineering analyses and review sessions. While they do use commercial technologies, most have been innovating and have developed a significant amount of enabling technology – some call it their "secret sauce." We have seen demonstrations of mission-level simulations that are being integrated with system simulation, digital assets and aircraft products providing cloud-like services enabled by the industrial Internet. We have seen demonstrations of 1D, 2D, and 3D

modeling and simulations with a wide array of solvers and visualization capabilities. We have been in an immersive Cave Automated Virtual Environment. We have seen the results of platform-based approaches directly focused on speed-to-market.

MCE technologies enable more automation and efficiencies; however, while research findings suggest that it is technically feasible to create a holistic approach for conceiving innovative concepts and solutions enabled through model-centricity, NAVAIR seeks a radical transformation to change how we operate to coordinate the efforts across multiple disciplines with all relevant stakeholders at the right time and virtually. While there are many opportunities, there are still challenges, such as:

1. The discussions with organizations often stated known facts such as 90 percent of the functionality in a 5th generation air vehicle system is in software noting that the growth and complexity of software requires a significant amount of software verification, which is essential to airworthiness and safety, but often resulting in longer than expected durations and schedule slips.

2. It was stated in meetings that there is an “explosion of models”; however, there is a lack of cross-domain model interoperability, consistency, and limitations transforming models with the required semantic precision to provide accurate information for decision making.

3. It was stated that unvalidated models are used leading to incorrect or invalid results leading to organizations not identifying design or integration problems until late in the lifecycle.
Item number 3 relates to a question posed by our sponsor after hearing the result presented at NDIA in 2014, paraphrased:

If we are going to rely more heavily on model-centric engineering, with an increasing use of modeling and simulations, how do we know that models/simulations used to assess “performance” have the needed “integrity” to ensure that the performance predictions are accurate (i.e., can we trust the models)?

This presentation provides additional information from another year of research, and additional targeted organizational discussions with more details on the evidence to address the research question, the concept of a “future” state and new operational model, and a risk framework to address the model integrity concerns.

Author 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 for NAVAIR, co-PI on a related task for Quantitative Risk, and has been the PI on research tasks for National Science Foundation, Federal Aviation Administration, and National Institute of Standards and Technology.