Stevens Institute of Technology
&
Systems Engineering Research Center (SERC)

Model Centric Engineering Enabling a New Operational Paradigm for Acquisition
Presented by:
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With Contributing Sponsors (NAVAIR, ARDEC, DASD(SE))
With Contributing Researchers (RT-48, 118, 141, 157, 168, 170, 176)

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Outline

• Historical perspective and resources

• Systems Engineering Transformation (SET) Framework for a new operational paradigm between government and industry

• Surrogate pilot experiment(s) for Executing the SET Framework
  — Research emphasis
  — Methodology for modularizing models
  — Integrated Modeling Environment and approach to demonstrate Authoritative Source of Truth
  — “Specification generation” from models

NAVAIR is Interested in Sharing Concept and Getting Feedback
Historical Perspectives and Resources

- **Resources**

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**NAVAIR: RT-141**  
Phase I Summary

**NAVAIR: RT-157**  
Phase II – SET Initiated

**ARDEC: RT-168**  
Synergistic
# Research Tasks and Collaborator Network

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<td>Robin Dillon-Merrill – Georgetown Univ.</td>
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Mark Austin – Univ. of Maryland
Leonard Petnga – Univ. of Maryland
Maria Coelho (Grad) – Univ. of Maryland
Russell Peak – Georgia Tech.
Stephen Edwards – Georgia Tech.
Adam Baker (Grad) – Georgia Tech.
Marlin Ballard (Grad) – Georgia Tech.

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Research Phase I: Model Based System Engineering (MBSE) versus Model-Centric Engineering (MCE)

• Over 30 organizational discussions “**tell us about most advanced and holistic approach...**”:
  — Model-Based Engineering (MBE), Integrated Model-Centric Engineering, Interactive Model-Centric Systems Engineering (IMCSE), Model-Driven Development, Model-Driven Engineering (MDE), and even Model-Based Enterprise, which brings in more focus on manufacturability

• **MCE** characterizes the goal of integrating different model types with simulations, surrogates, systems and components at different levels of abstraction and fidelity across discipline throughout the lifecycle with manufacturability constraints

• SERC Research Supports **Digital Engineering** (DE) Thrust by DoD:
  — *An integrated digital approach that uses authoritative sources of systems' data and models as a continuum across disciplines to support lifecycle activities from concept through disposal*
Phase II: Systems Engineering Transformation Initiated at NAVAIR

- Organizations (with a few exceptions) were unwilling to share quantitative data, however

- Qualitative data in the aggregate suggests that **MCE technologies and methods are advancing and adoption is accelerating**

NAVAIR Executive Leadership Response:

- NAVAIR must move quickly to keep pace with other organizations that have adopted MCE

- NAVAIR must transform in order to perform effective oversight of primes that are using modern modeling methods for system development

March 2016: Change of Command has Accelerated the Systems Engineering Transformation and Broadened the Scope
Current Research Trusts Investigated in Evolving Pilots

Semantic Web Technologies

- Enforces **Modeling Methods**
- Underlying technologies for reasoning about completeness and consistency **Across Domains** in modeling tool agnostic way

Modeling Methodologies

- Guides proper usage to ensure **Model Integrity** (trust in model results) for decision making

Multidisciplinary Design, Analysis and Optimization MDAO

- Provides optimization analysis **Across Domains** to support KPP and alternatives trades at mission, system, & subsystem levels

MDAO Workflow

Digital System Model: Single Source of Truth *(authoritative source of truth)*

Integrated Modeling Environment

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Surrogate Pilot focus is on **Execution** of SET Framework

- Elimination of paper CDRL artifacts and large-scale design reviews
- Continuous insight/oversight via digital collaborative environment and interaction with the Single Source of Truth

**Single Source of Truth**

- Instantiate System Spec in a model
- Right-size CDD – very few KPPs, all tied to mission effectives
- Re-balance as required

**INSIGHT/OVERSIGHT**

- Instantiate and validate design in models

**MDAO*/SET-BASED DESIGN**

- Mechanical Design Models
- Electrical Design Models
- Software Design Models
- Testing Methods & Models

**Analysis Tools**

**Element 1**

- Element 1
- Element 2
- Element 3
- Element 4

**Spec Generation of RFP**

- V5.0

**Mission Area Modeling & Effectiveness Analysis**

- Conceptual Design RO
- Conceptual Design R0
- Conceptual Design R3

**Integration Events**

- Design & Manufacture Release
- Integrated Test Vehicle #1

Move rapidly to mfg. Substantiation and insight via modeling environment

**NAVAIR Public Release 2017-370. Distribution Statement A – “Approved for public release; distribution is unlimited”**
Surrogate Pilot Overview

- **Mission:** Collaboration between Government and Industry in Model-based Acquisition under SET Framework
- **Goal:** Execute SET Framework to Assess, Refine, and Understand a New Paradigm for Collaboration in Authoritative Source of Truth (AST)
- **Objectives** (non exhaustive):
  - Formalize experiment to answer questions about executing SET framework using Surrogate Contractor (SC)
  - “Government team” creates mission, system (& other) models, “generates specification/RFP,” & provides acquisition models to SC as Government Furnished Information (GFI)
  - SC refines GFI reflects corrections/innovations with physical allocation views with multi-physics-based Initial Balanced Design
  - Simulate continuous virtual reviews and derive new objective measures for assessing maturing design in AST
  - Demonstrate visualizations for real-time collaboration in AST
  - Demonstrate and document methods applied
  - Investigate challenging areas and research topics in series of pilots
Formalizing the Use of Models... 
Creating a Digital Thread...

Operational Models

Other Business Models
Personnel, support, training, etc.

User Capability Model

System Model
- Initial System Model
- Final System Model

Sub-System 1 Model
Sub-System 2 Model
Sub-System n Model

Component 1 Model
Component 2 Model
Component n Model

SoS Level

System Level
Functional Baseline

Sub-System Level
Allocated Baseline

Acquisition Agreement
Main Contract
Sub Contracts

Acquirer
Prime Contractor
Sub Contractors

Warfighter
Example of Surrogate Questions
(not exhaustive)

- Learning about new operational paradigm between government and industry in the **Execution** the SET Framework (NOT an air vehicle design)
- We are concerned with interactions (non-exhaustive):
  - Simulating prior to contract award (now)
  - Formalization of a “specification” for “Request for Proposal (RFP)” and methods for providing models to contractor
  - Simulating “Execution” of Oversight / Insight in AST per SET Framework for real-time collaboration in heterogeneous environments
  - **Simulating feedback back to mission engineering caused by specified objectives for unachievable Key Performance Parameters (KPP)**
  - Objective measures for evaluating evolving design maturity, with the reduction of risk
  - Simulating approach for “faults in specification/model” detected after contract award
  - Simulating source selection – desirably as a dynamic simulations and V&V
  - Working with contracts/legal to get agreement on what a “specification” would be
  - Methods for modularizing model used to “generate specification”
  - How will we use the Systems Engineering Technical Review (SETR) guide and checklist that NAVAIR uses? And, how will we make recommendations for its evolution
  - Use of Multidisciplinary Design, Analysis and Optimization (MDAO) at mission, systems, and subsystems (by surrogate contractor)
Formalize and Refine SET Framework

SysML Activity Diagram is draft Process Model for SET Framework

Need to Simulate Acquisition-related feedback paths (not exhaustive)
Methods for Partitioning of Work and Modularization of Models
Using OpenMBEE Model Development Kit/DocGen for Generating Specification from Modularized Model
Open Model Based Engineering Environment (OpenMBEE)

Model Development Kit/DocGen
View and Viewpoint Hierarchy

Model Management System

Visualization in View Editor

http://www.openmbee.org
Surrogate Pilot Using OpenMBEE as Basis for Demonstrating Authoritative Source of Truth

Where Are We:
Increment 1 and Elements 1 & 2

We are here
Our Research Efforts are Synergistic With Our ARDEC Sponsor and Other Collaborators
Collaborations

- SERC Collaborator: Georgia Tech, Georgetown, Naval Postgraduate School, Univ. of Maryland, Univ. of Massachusetts, Univ. of Southern Cal., Wayne State

- Digital Engineering Working Group

- Airspace Industry Association: CONOPS for Industry/Government Collaborative Framework

- Semantic Technologies for Systems Engineering Foundation

- NDIA Working Group – Using Digital Engineering for Competitive Down Select

- NASA/JPL

- OpenMBEE Collaborator Group
  — https://groups.google.com/d/forum/openmbee/
• For more information contact:
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  — Stevens Institute of Technology
  — Links to technical reports: http://www.sercuar.org/researcher-profile/mark-blackburn/
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<td>CDD</td>
<td>Capability Description Document</td>
<td>MCSE</td>
<td>Model-Centric System Engineering</td>
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<td>CONOPS</td>
<td>Concept of Operations</td>
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<td>Contract Data Requirements List</td>
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