



# M&S Engineering Complex Systems; Research Challenges

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September 2017

## Events/History

- Tech/R&D Mission Statement Approved by Policy Board (Sep 2014)
- Committee Meetings (2015) Expand M&S Coalition and Promote National Agenda
- National Science Foundation (NSF) Workshop (21-22 Jan 2016 - Washington, DC)
- NM&SC Leadership Conference (8-9 Feb 2016 Chesapeake, VA)
- I/ITSEC 2016 – Orlando FLA
- *New NM&SC Technology/R&D Director (2017) Bob Armstrong, Director, Sentara Center for Simulation and Immersive Learning, Eastern Virginia Medical School*



## Technical/R&D Agenda

*Mission Statement:* Expand the coalition of experts within the field of Modeling and Simulation, leverage this expertise to promote a national research agenda supporting national challenges.

*Goal:* Establish a National M&S Research Agenda

# NSF Research Agenda Workshop (January 13-14, 2016)

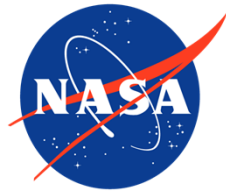
## Addressed research challenges in M&S for Engineering Complex Systems

- Initiative launched by NM&SC R&D Committee.  
(Supported by several conference panel sessions leading up to workshop)
- Workshop held at the National Science Foundation
- Attended by 65 M&S Scientists/Researchers selected through an open nomination process
- Workshop report available via NM&SC web site

<http://trainingsystems.org/publications/Research-Challenges-in-Modeling-and-Simulation-for-Engineering-Complex-Systems.pdf>

# Workshop Sponsors

- National Science Foundation
- National Aeronautics and Space Administration
- Air Force Office of Scientific Research
- National Modeling & Simulation Coalition
- National Training & Simulation Association



## Some General Findings

- Advances in *conceptual modeling* are required to enable effective integration across multiple engineering disciplines.
- New *computing platforms* (mobile to supercomputer architectures) require new M&S research to exploit capabilities.
- Models and simulations *embedded in real world systems* to monitor and steer activities toward more desirable end states.
- Advancements in theory and methods needed to *better estimate and manage uncertainty* in M&S AI applications.
- While there has been progress on *understanding humans as decision makers*, utilization of this knowledge in M&S activities has been limited. Research on how to model how decisions are made is needed.
- Advancements in the theory of *reuse* are needed to provide concerted robust and reliable reuse practices.



# I/ITSEC Panel (November 2016)

## *Complex Systems/Challenges*

Addressed Academic/Industry/DoD Applications of NSF Workshop Findings

*Conceptual Models:* System Model, Analysis and Selection, Model Decision, Domain and Stakeholders

*Computation:* Emerging Computation Platforms for M&S

*Pervasive Simulation:* The Internet of Sims™, Plethora models™

*Fidelity and Uncertainty:* Role of Uncertainty Quantification (UQ), Predictions and Comparing Alternatives. Processes for Improving Model Fidelity

*Reuse:* M&S Reuse, Data Reuse, Knowledge Management and Discovery (Reuse and Conceptual Models interdependencies)

## Where do we go from here?

### *Leverage Input from Supporting Meetings/Events:*

- Conceptual Models
- Computation
- Fidelity and Uncertainty
- Reuse

### *National Applications:*

- First Responders and Emergency Management
- Advanced Manufacturing and Engineering
- Cyber
- Unmanned Platforms and Vehicles
- Smart Cities
- Data Analysis, Gaps and Complex Problem Sets



# Back up Slides

National Research Agenda - Where does the  
Tech/R&D Subcommittee go from here?

# Agenda

## **Concerted effort to develop a common research agenda**

- Application challenges due to increasing size and complexity
- Recent technological advances offer new capabilities and areas for M&S to expand

## **Fundamental Issues to address:**

- conceptual modeling
- how to address/handle uncertainty
- new computational approaches
- reuse: of models ; of simulations

## **How to get as Funded Requirements**

## **How best leverage M&S Congressional Caucus**

## **Recommendations to Policy Board**

# General “National” Applications

## **Model Based Systems Engineering**

Models Should Reflect the Actual Design

Requirements Need to be Communicated Effectively

## **Big Data**

Predictive Analytics Simulations Need Improvement

Machine Learning Techniques Need to Evolve

## **Cybersecurity**

Conceptual Modeling Needs Standardization

Interoperability of Models Needs Definition

## **Cloud Computing, Advanced Analytics & Open Architectures**

## **Modeling Socio-Technical Systems**

## **Impact of M&S on Healthcare – Digital Patient**

## **Unmanned Systems**

## **M&S Engineering/Science Fundamentals**

# Leveraging Model Reuse

Three distinct areas recommended for further study

## **Advancements in the theory of M&S reuse**

Without a firm theoretical foundation, we cannot fully know the fundamental limits of what we can hope to accomplish with reuse. Properly formulated, good theory may also be exploited to produce robust and reliable reuse practices.

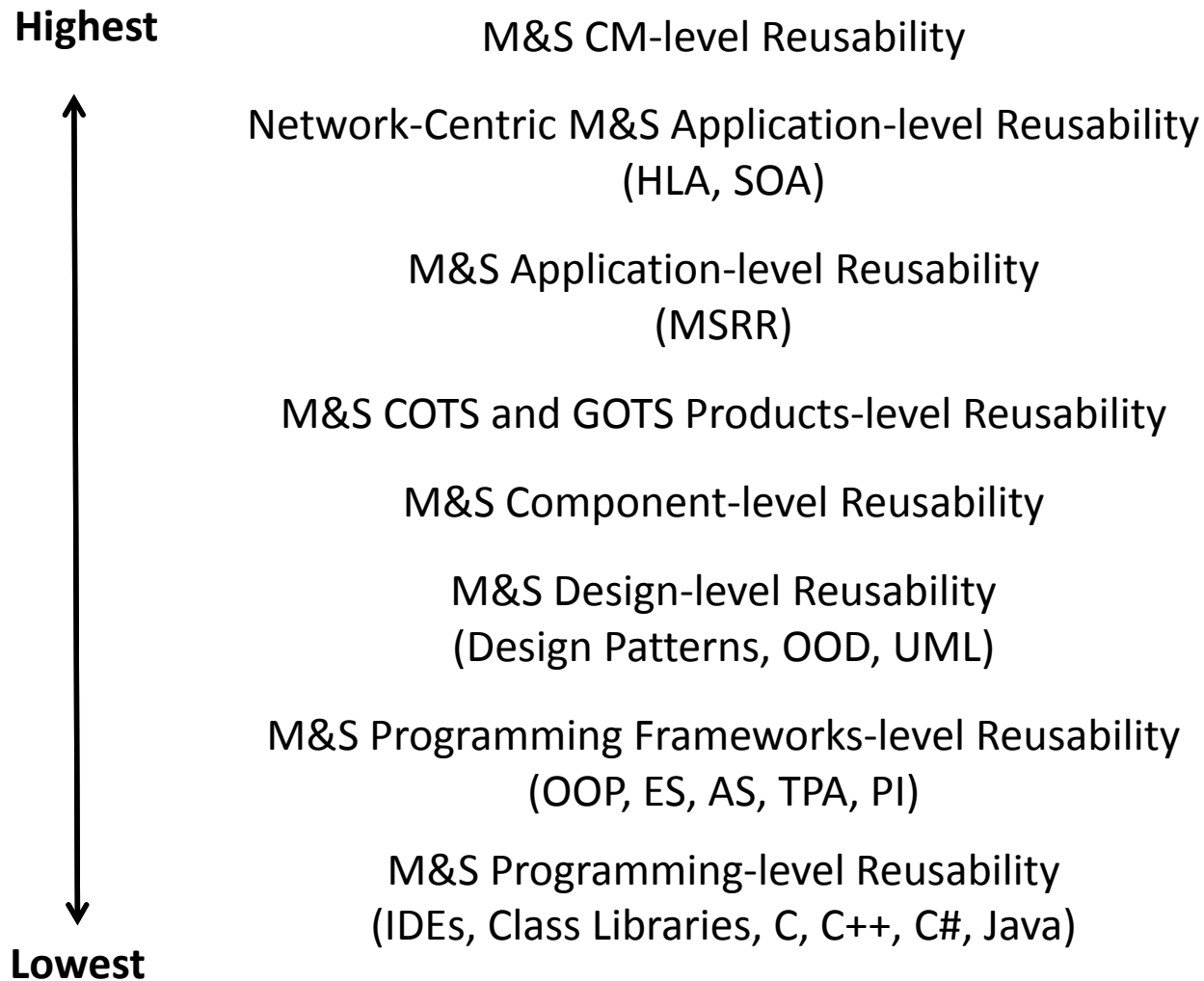
## **Advancement in the practice of M&S reuse**

(1) M&S broadly, (2) data, &(3) discovery and knowledge management.

## **Advancements in the social, behavioral, and cultural aspects of M&S reuse**

How incentives may stimulate or impede reuse.

# Levels of Reusability versus Achievability



In Research Report, Figure 6.1, p. 79. Ref: Balci, Arthur, & Ormsby, *Achieving Reusability and Composability with a Simulation Conceptual Model*