National Modeling & Simulation Coalition

M&S Engineering Complex Systems; Research Challenges

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National Modeling & Simulation Coalition

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

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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

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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.

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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)

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Looking Forward

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

M&S CM-level Reusability

Network-Centric M&S Application-level Reusability
(HLA, SOA)

M&S Application-level Reusability
(MSRR)

M&S COTS and GOTS Products-level Reusability

M&S Component-level Reusability

M&S Design-level Reusability
(Design Patterns, OOD, UML)

M&S Programming Frameworks-level Reusability
(OOP, ES, AS, TPA, PI)

M&S Programming-level Reusability
(IDEs, Class Libraries, C, C++, C#, Java)

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