**M&S STUDIES IN THE CONTEXT OF
T&E AND ACQUISITION**

Diagnosis of the Problem:
What Prior Studies Have to Say

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Presentation Outline

- **M&S and T&E Background**

- **Overview of Prior Acquisition M&S Studies**

- **Selected Study Recommendations for M&S Related to T&E**

- **Some Common Themes in Acquisition M&S Study Recommendations**

- **Some Personal Observations on the Way Ahead**

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T&E and M&S: Definition Linkages

Test and Evaluation (T&E)

Process by which a system or components are exercised and results analyzed to provide performance-related information. The information has many uses including risk identification and risk mitigation and empirical data to **validate models and simulations**. T&E enables an assessment of the attainment of technical performance, specifications, and system maturity to determine whether systems are operationally effective, suitable and survivable for intended use, and/or lethal. …
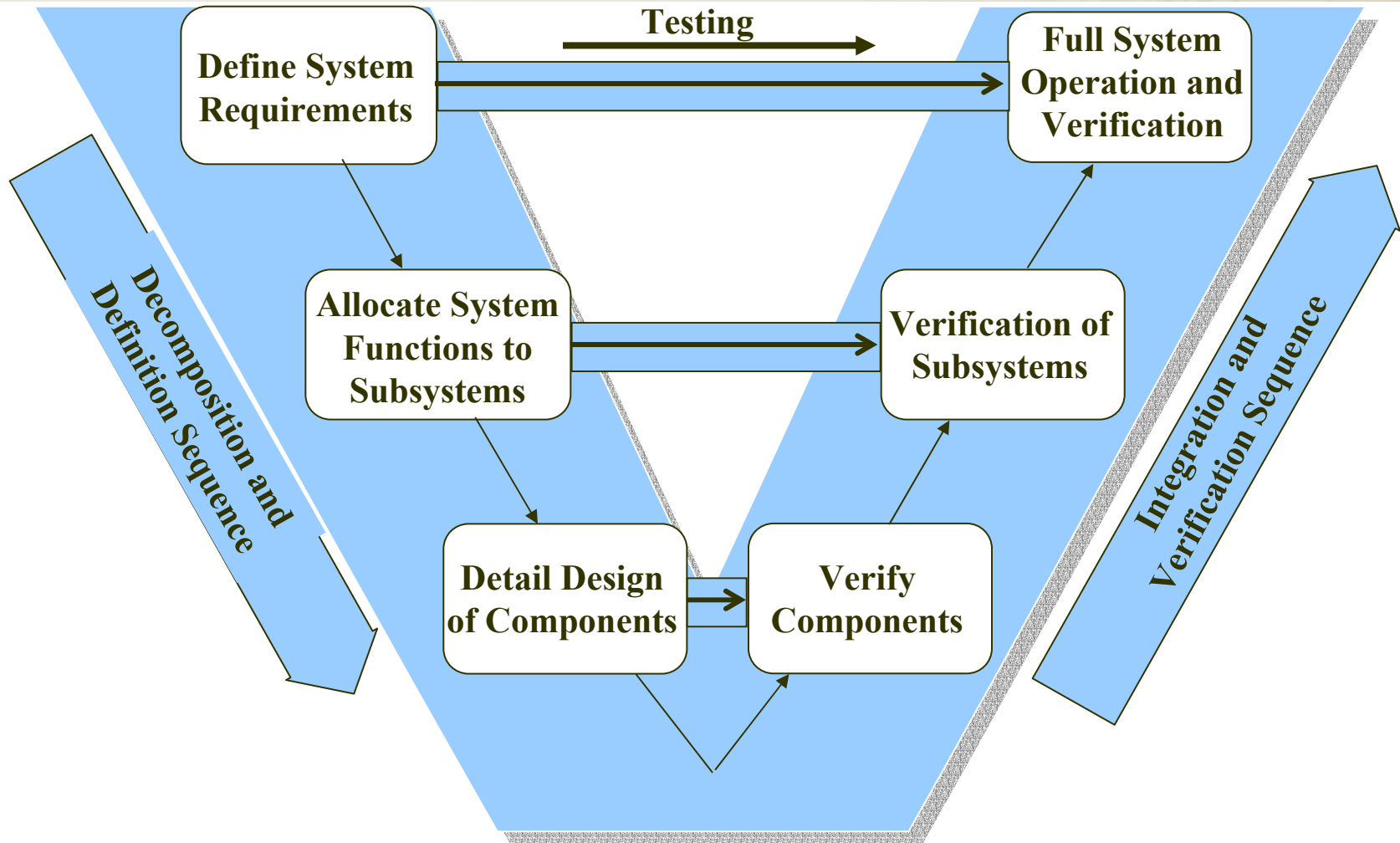
Model

A representation of an actual or conceptual system that involves mathematics, logical expressions, or computer simulations that can be used to predict how the system might perform or survive under various conditions or in a range of hostile environments.
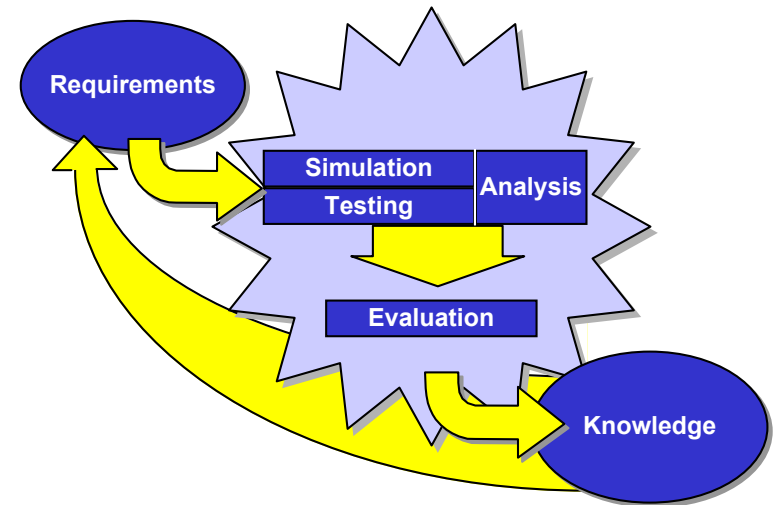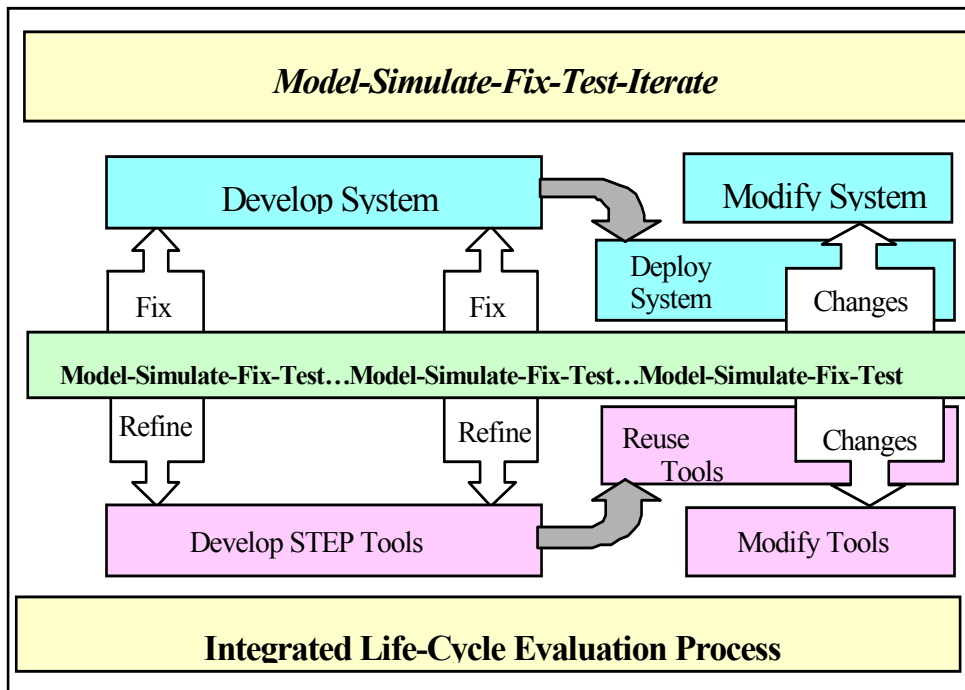
Simulation

A simulation is a method for implementing a model. It is the process of conducting experiments with a model for the purpose of understanding the behavior of the system modeled under selected conditions or of **evaluating** various strategies for the operation of the system within the limits imposed by developmental or operational criteria. Simulation may include the use of analog or digital devices, laboratory models, or **"testbed" sites**. …

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The "V" Process Model for Systems Engineering

The "V" Process Model diagram showing:

- **Define System Requirements** → **Full System Operation and Verification** (Testing)
- **Allocate System Functions to Subsystems** → **Verification of Subsystems**
- **Detail Design of Components** → **Verify Components**

Left side: Decomposition and Definition Sequence

Right side: Integration and Verification Sequence

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One View of the Relationships among Modeling, Simulation, Test, and Evaluation

Source: *Simulation, Test, and Evaluation Process (STEP) Guidelines*, Director, Operational Test and Evaluation, and Director, Test, Systems Engineering and Evaluation, 4 Dec 1997.

A Decade of Acquisition M&S Studies (1 of 2)

1994 **J** Final Report of the Acquisition Task Force on Modeling and Simulation (DDR&E)

     N Naval Research Advisory Committee Report on Modeling and Simulation (NRAC/ASN(RDA))

1995 **N** Collaborative Virtual Prototyping: An Assessment for the Common Support Aircraft Initiative (NAVAIR)

1996 **I** Collaborative Virtual Prototyping Sector Study (North American Technology and Industrial Base Organization)

     I Study on the Application of Modeling and Simulation to the Acquisition of Major Weapon Systems (American Defense Preparedness Association (ADPA))

     J Study on the Effectiveness of Modeling and Simulation in the Weapon System Acquisition Process (DoD Director, Test, Systems Engineering and Evaluation)

1997 **P** Technology for the United States Navy and Marine Corps, 2000-2035, Becoming a 21st Century Force, Volume 9: Modeling and Simulation (Naval Studies Board, National Research Council (NRC))

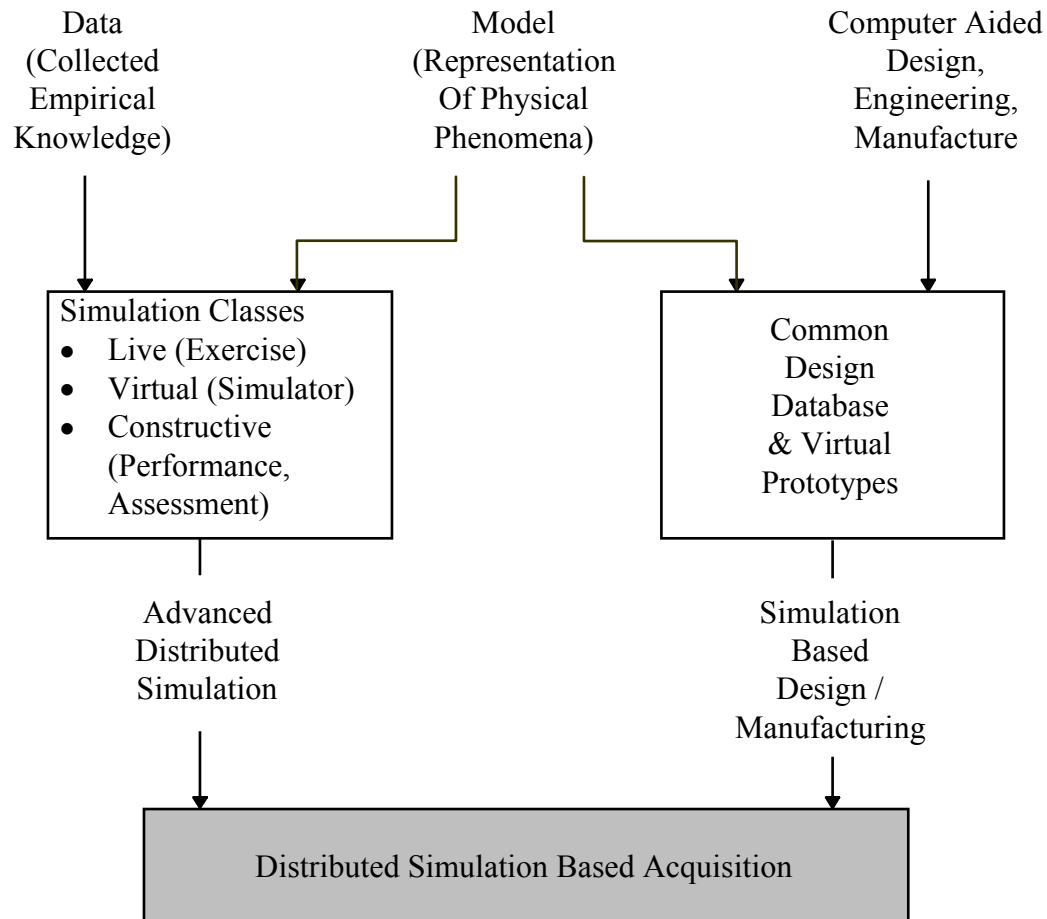   **J** Simulation, Test, and Evaluation Process (STEP) Guidelines (DOT&E and DTSE&E), December 4, 1997

■ Joint DoD (J)   ■ Navy-oriented (N)   ■ Industry-driven (I)   ■ Private organization (P)

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A Decade of Acquisition M&S Studies (2 of 2)

1998   **J**   A Roadmap for Simulation Based Acquisition – Report of the Joint Simulation Based Acquisition Task Force, December 4, 1998

       J   Simulation Based Acquisition: A New Approach – Report of the Military Research Fellows, Defense Systems Management College, 1997-1998

1999   **P**   Advanced Engineering Environments: Achieving the Vision, Phase 1 (NRC – prepared for NASA)

2000   **P**   SIMTECH 2007 Mini-Symposium and Workshop Proceedings: Session 1, December 1997, and Session 2, August 1998 (Military Operations Research Society (MORS))

2001   **J**   Results of the DOT&E/LFT&E Survey of Modeling & Simulation

2002   **P**   Modeling and Simulation in Manufacturing and Defense Systems Acquisition: Pathways to Success, June 2002 (NRC – prepared for Defense Modeling and Simulation Office (DMSO))

2004   **I**   M&S Support to the New DoD Acquisition Process, February 2004 (National Defense Industrial Association (NDIA) Systems Engineering Division, Modeling & Simulation Committee)

2005   **J**   Acquisition Modeling and Simulation Master Plan (Preliminary Draft), Acquisition M&S Working Group

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Naval Research Advisory Committee: Distributed Simulation Based Acquisition

Data
(Collected
Empirical
Knowledge)

Model
(Representation
Of Physical
Phenomena)

Computer Aided
Design,
Engineering,
Manufacture

Simulation Classes
- Live (Exercise)
- Virtual (Simulator)
- Constructive (Performance, Assessment)

Common
Design
Database
& Virtual
Prototypes

Advanced
Distributed
Simulation

Simulation
Based
Design /
Manufacturing

Distributed Simulation Based Acquisition

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Selected Finding / Recommendation from Study on Effectiveness of M&S in Acquisition (1996)

- The issue is, to what degree can M&S replace or augment field tests?

  □ There is no universal answer, but the message received in part by the community is that the thought and guidance are there, but the implementation and acceptance are not.

- To meet the challenge of institutionalizing the use of available technology, the Services must be committed to **providing funds for modeling and simulation at the inception of the program**.

  □ OSD and the Services should commit Science and Technology dollars to upgrade capabilities and facilities **that could serve many weapon system acquisitions**.

  □ **Program managers should be encouraged to use these facilities** and capabilities instead of contracting to have their own system specific facilities and tools built.

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Background / Motivation for Several DoD Acquisition M&S Studies in the late 1990s

DoD Simulation Based Acquisition
Vision Statement and Goals

Vision: An Acquisition Process in Which DoD and Industry Are Enabled by Robust, Collaborative Use of Simulation Technology That Is Integrated Across Acquisition Phases and Programs.

Goals: The Goals of Simulation Based Acquisition (SBA) Are to:

- Substantially Reduce the Time, Resources, and Risk Associated With the Entire Acquisition Process;

- Increase the Quality, Military Worth and Supportability of Fielded Systems, While Reducing Total Ownership Costs Throughout the Total Life Cycle;

- Enable Integrated Product and Process Development (IPPD) Across the Entire Acquisition Life Cycle.

Source: Acquisition Council of the DoD Executive Council for Modeling and Simulation (approved 5 Dec 1997).

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Some Sound Bites from the STEP Guidelines: M&S and the TEMP

The TEMP should

- document how the early use of M&S will aid in assessing vulnerability and lethality
- address STEP resources that will help identify areas where data is needed and where M&S development is needed
- identify areas where actual testing either can be augmented by M&S or used to validate the models and simulations
- summarize the M&S VV&A and the data certification to be conducted
- reflect the integration of models, simulations, and test events to obtain the most credible data with which to conduct a comprehensive evaluation of performance
- include a discussion of the mission-level and engagement-level models and simulations, that will be used to identify COIs and the operationally significant MOEs and MOPs, so CTPs can be derived
- document how the early use of M&S will aid in assessing the operational impact of suitability issues (the "ilities") and logistics, and in determining initial tactics, training, and procedures
- document the integrated use of accredited models and simulations with OT to increase the knowledge and understanding of the capabilities and the limitations of the system as it will be employed
- include the resources required to VV&A the models and simulations; the resources required to obtain, maintain, and M&S; and the resources required to archive data for the M&S

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Some Recommendations from the SBA Roadmap (1998)

- Short Term:
  - The T&E community should **develop additional Deskbook practices** addressing the specifics and actual examples of M&S integrated with T&E in the evaluation strategy (layer of detail more specific than **Simulation, Test, and Evaluation Process (STEP) Guidelines**).
    - Criteria for accepting verification and validation (V&V) for models to be accredited by the T&E community should be addressed
    - Practices and procedures should also include techniques regarding the pooling of test data with simulation data, and associated limitations.
  - Continue to fund and support **development of virtual T&E infrastructure** to include synthetic test environments, virtual firing ranges and proving grounds, etc.

- Long Term:
  - Review OT and Live Fire Testing policies with respect to M&S as technological advancements occur (and M&S capabilities improve) to determine if **changes to legislation** should be proposed.
  - Continue efforts to evolve and advance **virtual T&E infrastructure**.

A Road Map for Simulation Based Acquisition

Report of The Joint Simulation Based Acquisition Task Force

Selected Recommendations from DOT&E / LFT&E Survey of Modeling & Simulation (2001)

- Emphasize the important role that acquisition programs must play in the development of M&S

  □ address M&S in the 5000 series

  □ **incentivize Program Office investment** in M&S

- Foster an improved understanding of the interrelationship of T&E and M&S

  □ **Endorse pilot programs** with the SAEs that examine and demonstrate the utility of M&S for T&E

Some Sound Bites from the NRC M&S in Manufacturing and Acquisition Study (2002)

- "It will therefore be necessary to create and sustain an acquisition infrastructure, including an M&S infrastructure. DOD acquisition personnel could use M&S to predict the cost-effectiveness of potential solutions, thereby **reducing the need to produce and test expensive hardware prototypes**."

- "The **desire to achieve and maintain interoperability requires** early and continuing commitment to several orchestrated activities. These include development of **common standards, protocols, and data definitions**; agreed-upon concepts of operation; testing and evaluation to ensure that agreed-upon actions have been implemented properly; and configuration management of systems to assure proper management of evolutionary changes."

- "Task Force XXI demonstrated two important acquisition needs: first, the significance of coevolving the system-of-systems with continual dialogue among all major stakeholders; and second, the **need for a virtual M&S testbed** to enable this dialogue."

- "As M&S is used more in operational testing, the **demands on the validation of the simulation will increase**. … Validation methods that quantify the bounds of validity and risk of error in a model can help to establish the limits of M&S applicability in operational test and evaluation."

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Selected Findings from the NDIA Systems Engineering M&S Committee Report (2004)

- Distributed simulation offers a practical, cost-effective way to integrate and test systems of systems.

  □ **Rounding up all the actual hardware** to compose an entire system of systems for integration and/or test **becomes increasingly impractical** as the number of systems in an SoS grows.

- Substituting *credible* simulations for the real weapon systems not under test offers an optimal way to integrate individual systems

  □ It is flexible, scalable, and **protects proprietary/intellectual property**.

  □ The capability to intermix simulations, real systems, and lab assets ("hardware in the loop") in a distributed simulation federation has been repeatedly shown to be both feasible and helpful

- A promising example of the above approach is the Joint Distributed Engineering Plant (JDEP), but it is currently **under-resourced**.

  □ A non-proprietary, tailorable, reasonably-available family of such federations would go a long way toward providing the **'standard' environments** needed to explore the time-coordinated, dynamic interactions of an SoS.

- The existence and **adoption of open standards** can allow M&S tools to be flexibly used together to address the challenges of the new acquisition process.

Some Recommended Actions from the Acquisition M&S Master Plan (Preliminary Draft, 2005)

- Establish policy to **require documented M&S planning** at the joint capability & program levels as part of the Systems Engineering Plan, **T&E Strategy and T&E Master Plan**

- Establish **policy on appropriate use of M&S to plan tests, to complement system live tests**, and to evaluate joint capabilities

- Establish a forum to clarify the characteristics and application of various **distributed simulation standards** (HLA, TENA, DIS, SI3, etc.); examine opportunities for convergence

- Enable readily-available distributed **live-virtual-constructive environments**, leveraging related initiatives
  - Establish DoD-wide **standards** for distributed environments
  - Make candidate simulations, labs and ranges compliant with these standards

- **Centrally develop and maintain** high-priority, broadly-needed M&S tools

Source: "Report of the Acquisition M&S Working Group regarding an Acquisition M&S Master Plan," J. W. Hollenbach, 2005 Fall Simulation Interoperability Workshop, Orlando, FL, Sep 2005.

Some Common Themes in Acquisition M&S Study Recommendations

- That M&S can reduce T&E costs seems intuitive and is accepted
- Need for cross-program M&S capabilities (but how to fund them?)
- Need for "virtual" testbeds (again, how to fund them?)
- Need for open M&S standards (applications, data, …)
- Concern for proprietary data / intellectual property
- Need for education of acquisition community in M&S
- Recommendations for pilot programs (but few ever funded)
- Need for incentives to use M&S (but few, if any, actionable ideas)

A combination of technical, process, and culture issues remain

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Some Personal Observations on the Way Ahead

- As cross-cutting enterprise-level functional disciplines in the acquisition process, M&S and T&E have to work together
  - □ *"If we don't hang together, we will surely … "*
- M&S standards supporting T&E need to be "harmonized" to better support multi-Service, Joint and coalition T&E
  - □ *HLA … TENA … DIS …*
- A way must be found to fund "common good" M&S-in-T&E activities that support multiple programs across Services
- A consensus-based process should be initiated to develop an M&S-in-T&E Recommended Practices Guide (RPG)
  - □ *Use DMSO's DoD M&S VV&A RPG development process as an exemplar*
- Be cognizant of the recommendations of prior studies, how they were received, and what results they achieved
  - □ *"Those who ignore history are condemned to repeat it."*