Modeling and Simulation in the T&E Process

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Introduction

Agenda

- Motivations and roles for M&S in T&E
- Problems
- Recommendations

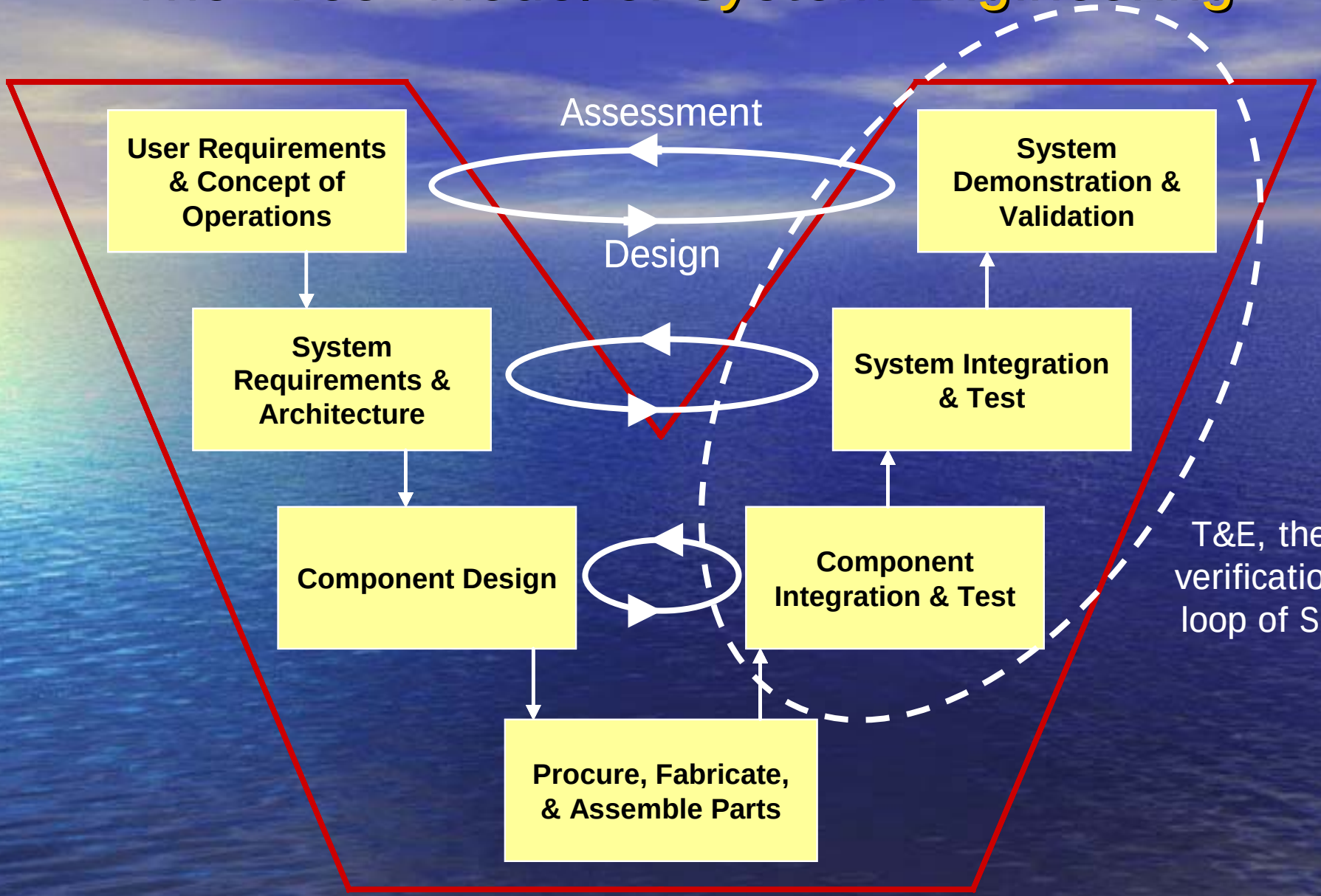
Perspective

- The views are mine, as informed by
  - Experience as an aerospace engineer, Naval Aviator, project manager, DMSO Director, M&S/SE consultant
  - Public law and DoD policy
  - Expertise and insights of others

A Decade of Studies on M&S Support to Acquisition

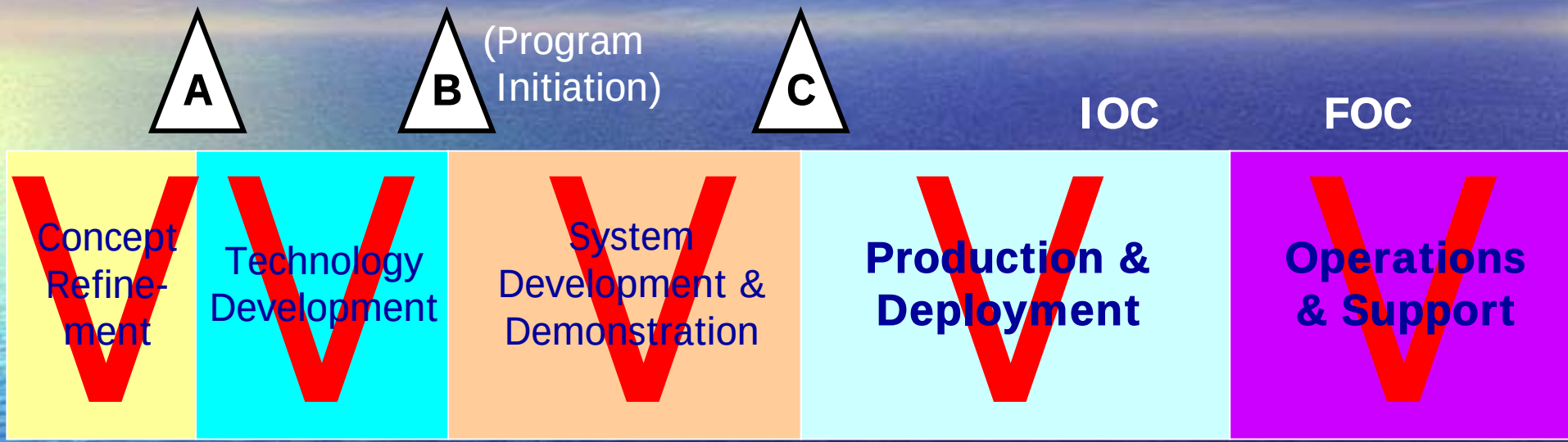
- Report of the DDR&E Acquisition Task Force on M&S, 1994
- Naval Research Advisory Committee Report on M&S, 1994
- Naval Air Systems Command Collaborative Virtual Prototyping Study, 1995
- NATIBO Study: Collaborative Virtual Prototyping, 1996
- ADPA Study: Application of M&S to Weapon System Acquisition, 1996
- DTSE&E Study: Effectiveness of M&S in Weapon System Acquisition, 1996
- NRC Study: Technology for USN and USMC, Vol. 9: M&S, 1997
- Simulation Based Acquisition Task Force Study (A Road Map for SBA), 1998
- Defense Science Board on M&S for Analyzing Advanced Combat Concepts, 1999
- NRC Study: Advanced Engineering Environments, 1999
- DOT&E Studies on M&S in Acquisition, 1999 and 2002
- Defense Science Board Study on Test and Evaluation, 1999
- MORS “SIMTECH 2007” Workshop Report, 2000
- NRC Study: M&S in Manufacturing and Defense Systems Acquisition, 2002
- NDIA M&S Committee Report: M&S Support to New DoD Acquisition Process, 2004
- Defense Science Board Study on Missile Defense Phase III M&S, 2004

The "Vee" Model of System Engineering



Source: International Council on Systems Engineering,1999

The "V" Process is Iterative Across a System Lifecycle; Likewise M&S in Assessment/Testing



Motivations for Increased Use of M&S in T&E:
Decreasing Viability of Traditional Approach

- Assessing/testing IT-intensive, complex multi-mission systems is increasingly difficult
  - Comprehensiveness, realism, time, cost
- Live testing is increasingly impractical
  - Limited availability of other systems/forces in an SoS
  - Limited set of adversary forces/systems, other players
  - Range limitations (volume, security, safety, environmental)
  - Cost
- Can't afford to wait for prototypes to assess designs
  - Delays in choosing among alternative designs/correcting mistakes costs time/$
  - Must get smarter faster, reduce program-threatening risks

Motivations for Increased Use of M&S in T&E:
New Challenges of Functional Capabilities/Systems of Systems

- Desire to acquire functional capabilities, reliant on a system of systems (SoS), explodes T&E complexity
  - Many more interactions/impacts must be considered
  - More risks of error, more test events, more time, more cost
- Non-synchronous development/evolution of SoS component systems will require frequent testing of the FC/SoS
  - Reliance on live testing is impractical and unaffordable

M&S Roles

- Improving the systems engineering process
- Enabling better planning of live test events
- Representing system attributes that cannot be examined realistically in live testing
- Acting as surrogates for other systems/effects to cost-effectively flesh-out the battlespace in live tests
- Providing a practical means for FC/SoS testing

1. Improving Systems Engineering

- Disciplined, trustworthy M&S (a big “if”) can speed development, reduce mistakes
  - Design using modeling environments (e.g., CAD, CORE)
  - Assess designs in models & simulations (at all levels)
- M&S tracks relationships and interaction details at the micro-level, presents macro-level impacts/measures of merit to decision makers
- Tightens the design-assessment cycle, saving time/$
- A repeatable, defendable analytical underpinning for system development decisions

2. Enabling Better Planning of Live Tests

- Simulate full range of possible scenarios, actions and responses
- Identify most important circumstances, capabilities and interactions upon which to focus live tests
- Focus live testing on critical issues/high risk areas

3. Representing System Attributes That Cannot Be Examined in Live Testing

- Live testing some system attributes is impractical
  - Limited number of systems/expense
  - Security
  - Environmental impact
- Examples may include hazardous effects on humans, EMP, information warfare, civil infrastructure effects
- Models and simulations, if properly validated, can credibly represent such factors
  - Public Law (10 USC 2399) only prohibits IOT&E based exclusively on M&S

4. Fleshing Out the Live Testing Battlespace

- Concept:
  Federating real systems (on ranges or elsewhere), lab hardware/software, simulations and utilities (e.g., data collectors) to provide a testing environment
- Simulate:
  - Threats, other systems and humans present in the battlespace
  - Environmental effects, external event stimuli, etc.
- Composable as appropriate to the task at hand
- Concept validated by JADS, JDEP, etc.

5. Providing a Practical Means for FC/SoS Testing

- Sets of models and simulations can provide increasingly accurate and unambiguous understandings of a system
  - M&S of the system begin early in its development and iteratively becomes more granular, comprehensive and accurate
  - Under a model-test-model approach, live testing further refines these system models
- Models are becoming normative artifacts of the development process
  - Already authoritative master for machining, software, etc.
  - A particular system is an instantiation of such models and is evaluated against a model (e.g., RCS)
  - Models are jumping-off point for upgrades, mishap investigations, etc.
- Such models can credibly represent the system for T&E of other components of the SoS or the entire SoS
  - Augmented by live testing only as required (zero-based)

Current Policy

DoDI 5000.2 Extracts

- Development and demonstration are aided by the use of simulation-based acquisition and test and evaluation integrated into an efficient continuum (Para 3.7.1.1, SDD Purpose)
- Successful development test and evaluation to assess technical progress against critical technical parameters, early operational assessments, and, where proven capabilities exist, the use of modeling and simulation to demonstrate system integration are critical during this effort. (Para 3.7.5, System Demonstration)
- The PM, in concert with the user and test and evaluation communities, shall coordinate DT&E, OT&E, LFT&E, family-of-systems interoperability testing, information assurance testing, and modeling and simulation (M&S) activities, into an efficient continuum, closely integrated with requirements definition and systems design and development. ... The T&E strategy shall provide empirical data to validate models and simulations... Adequate time and resources shall be planned to support pre-test predictions and post-test reconciliation of models and test results, for all major test events. (Para E5.1, Integrated T&E)

More DoDI 5000.2 Extracts

- OT&E shall require more than an OA based exclusively on computer modeling, simulation, or an analysis of system requirements, engineering proposals, design specifications, or any other information contained in program documents (10 U.S.C. 2399 and 10 U.S.C. 2366)
  (Para E5.2, Integrated T&E)
- Appropriate use of accredited models and simulation shall support DT&E, IOT&E, and LFT&E.
  (Para E5.4.7)
- The PM shall plan for M&S throughout the acquisition life cycle. The PM shall identify and fund required M&S resources early in the life cycle.
  (Para E5.10, M&S)

So Why Aren't We Better at M&S in T&E?

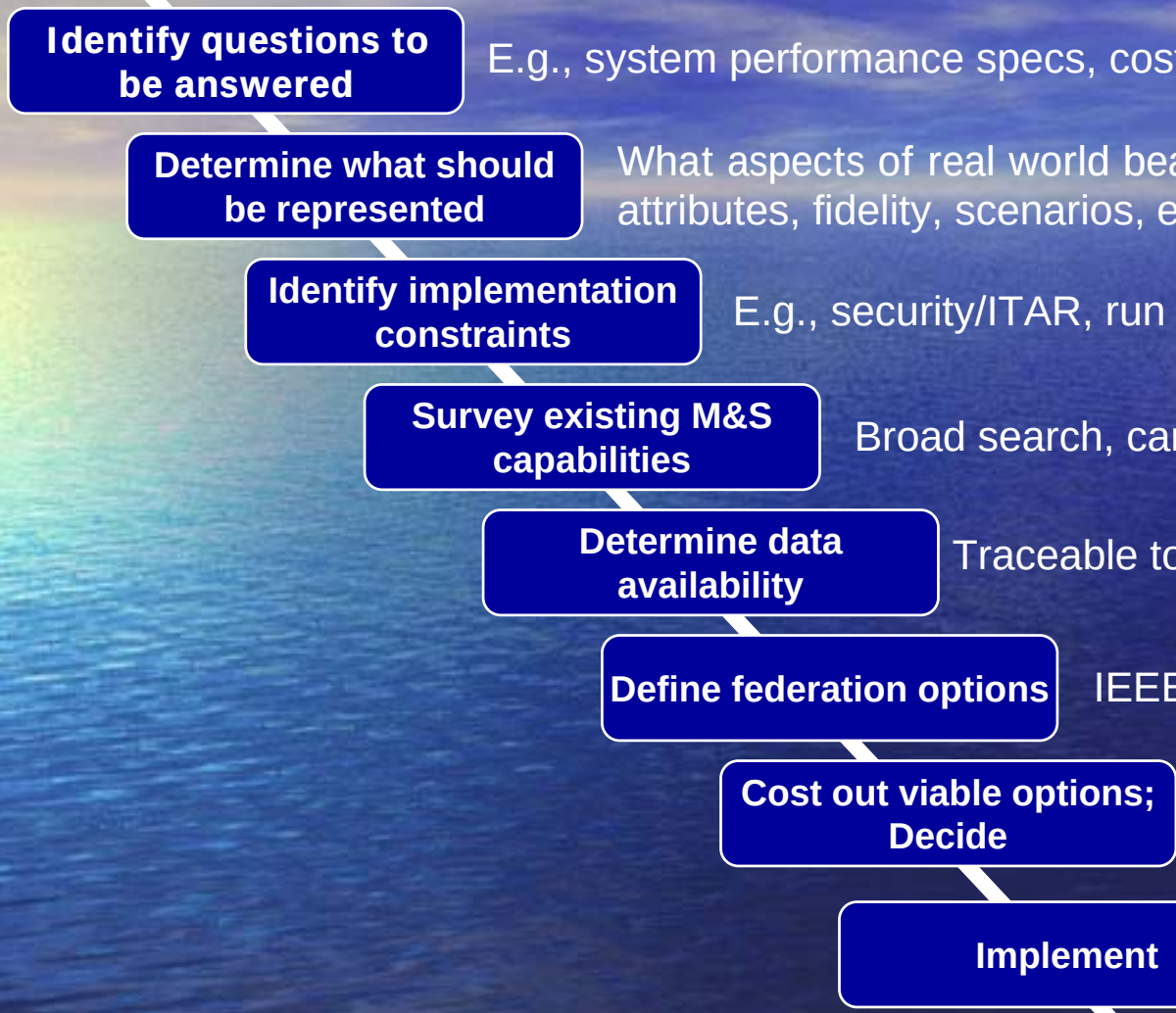
- It still "takes too long and costs too much"
  - Many impediments to efficient M&S
- Inadequate discipline in planning/applying M&S
- VV&A often neglected, poorly documented, rarely examined/enforced
- PMs start thinking about M&S for DT/OT&E too late
- Zealots oversell M&S, don't state model assumptions, limitations & uncertainties
- Defense community not functioning as a team
  - Better ideas (tomorrow) trump adequate approaches today
  - No coherent plan & little info sharing = misaligned vectors
  - No one wants to pay for the infrastructure

Three Recommendations

A. Remove the Impediments

- No easy way to discover, get and understand data
- No easy way to find and rent/share M&S tools
- Model & simulation maintenance is largely inadequate
- Standards missing; no incentives for stds. compliance
  - E.g., Data exchange, VV&A documentation; distributed simulation architecture
- Inadequate M&S expertise/perspective in many program offices and defense companies

B. Adopt Disciplined M&S Planning
(Left Side of Systems Engineering "V" for M&S)



Effective M&S Support to T&E

• Fill the Policy Holes

- Assign responsibility for broadly-needed M&S capabilities
- Define a viable business model for reuse of M&S tools and data
- Establish contract guidelines for data rights and sharing of M&S tools, including M&S-related GFE/GFI
- Define and enforce VV&A requirements. including independent reviews and explicit disclosure of model assumptions, limitations, uncertainties

• Fill the Policy Holes (cont.)

- Assign responsibility for SoS engineering, incl. test
  - Model the FC (i.e., produce an integrated architecture) to define the SoS and serve as the "contract" for system developments and benchmark for system/SoS tests
  - Drive requirements for the distributed testing infrastructure
- Revise the test paradigm
  - Early, iterative operational assessments of entire FC/SoS
    - Integrated SE, DT&E and OT&E strategy
    - Evaluations on demand to support fielding decisions
  - System T&E to use real systems, lab HW/SW and M&S mix
  - SoS T&E to use M&S, augmented by zero-based live testing
- Unambiguously mandate the information, models, and simulations each program must provide