A Methodology for Designing M&S
That Integrates VV&A Processes and Documentation

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Introduction

• In the past few models developed with VV&A as part of design process
• Declining resources have resulted in a growing reliance on M&S to support major decisions
• DoD policies have been written requiring VV&A to be integrated into M&S design / development process
  – Instruction 5000.61 requires that M&S used to support major DoD decisions shall undergo V&V throughout their lifecycle and be accredited for a specific purpose
Risk of Not Using VV&A

• Model may fail to support intended use
• Model may fail to meet requirements
• Model may be difficult, if not impossible, to use
• Risks can be quantified in a way that allows optimal decisions to be made
• M&S must be credible in order to be used as a tool for decision-making

Incorporating VV&A into the design process early, reduces the risk of developing an M&S that does not meet requirements or of using an inappropriate simulation to support a decision.
Capability and Risks

• Credibility is a function of three components
  – Capability
  – Accuracy
  – Usability

• Failure to meet any of these components results in its own particular risks

• Capability
  – Answers question: “Does the M&S do what I need it to do?”
  – M&S requirements flow from Intended Use Statement
  – VV&A reduces risk that M&S does not meet requirements
Capability and Risks

• Accuracy
  – Answers question: “How well does the M&S do what I need it to do?”
  – Three types of Accuracy
    • Software Accuracy - reduces risk that M&S doesn’t performed as designed
    • Data Accuracy – reduces risks that data used are inappropriate for application, of poor quality, or improperly transformed
    • Output Accuracy – reduces risk that outputs from M&S do not match the “real world”

• Usability
  – Answers question: “How easy is it to use M&S correctly?”
  – Reduces risk that M&S will be misused
V&V Process: Verification

- DoD Instruction 5000.61 defines verification as "the process of determining that a model or simulation implementation and its associated data accurately represent the developer’s conceptual description and specifications."
- Verification answers the question: “Did I build the model right?”
- Used to demonstrate software accuracy
Verification Process

Begin Verification Process

- Intended Use Statement (IUS) User defined based on need
  - Acceptability Criteria
  - M&S Requirements

- Develop & Validate Conceptual Model
  - Conduct and Document Preliminary Risk Assessment (Tailor V&V Activities Based on Results)

- Conceptual Model Documentation
  - Verify Model Design
  - Verify & Validate Data & Data Transforms (Accuracy)

- Document Model Design (Capability)
  - Verify Model Design

Assess Quality of Computer Programs / Code Tests (Accuracy)
- Document Data Verification / Validation, Code / Code Test Results & Software Quality Metrics
  - Document Model Design (Capability)

- Verify & Document Model Calibration Results (Accuracy)
  - Verify & Document Model Calibration (Collect Data on Simulation Trials & Sensitivity Analysis)

Verification Phase Ends / Begin Validation Process

All model/design and code must be documented and placed under Configuration Management.
Verification Process (cont.)

Begin Verification Process

- Intended Use Statement (IUS) User defined based on need
- Acceptability Criteria

M&S Requirements

- Conceptual Model Documentation
- Conduct and Document Preliminary Risk Assessment (Tailor V&V Activities Based on Results)
- Develop & Validate Conceptual Model

Document Model Design

- Assess Quality of Computer Programs / Code Tests (Accuracy)
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Verification Process (cont.)

- Verify Model Design
- Document Model Design (Capability)
- Verification Phase Ends / Begin Validation Process

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- Intended Use Statement (IUS) User defined based on need
- M&S Requirements
  - Acceptability Criteria
  - Conceptual Model Documentation

Develop & Validate Conceptual Model

- Conceptual Model Documentation

Verify Model Design

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Begin Verification Process → Intended Use Statement (IUS) User defined based on need → M&S Requirements → Acceptability Criteria → Conceptual Model Documentation → Conduct and Document Preliminary Risk Assessment (Tailor V&V Activities Based on Results) → Verify Model Design → Document Model Design (Capability)

- Verify & Document Model Calibration (Collect Data on Simulation Trials & Sensitivity Analysis)
- Assess Quality of Computer Programs / Code Tests (Accuracy)
- Verify & Validate Data & Data Transforms (Accuracy)
- Begin Verification Process

- Document Model Calibration Results (Accuracy)
- All model/design and code must be documented and placed under Configuration Management.

- Develop & Validate Conceptual Model
- Document Model Design (Capability)
- Verification Phase Ends / Begin Validation Process
- Document Data Verification / Validation, Code / Code Test Results & Software Quality Metrics
V&V Process: Validation

- DoD Instruction 5000.61 defines validation as “the process of determining the degree to which a model or simulation and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model.”
- Verification answers the question: “Did I build the right model?”
- Used to demonstrate output accuracy
Validation Process

Validation Process

Begin Validation Process

Compare simulation results to “real” system outputs
- Compare to test measurement data
- Benchmark to another validated M&S
- Conduct SME Review

Validation Phase Ends

Document Validation results

Review & Improve Conceptual Model
Update Model / Simulation Design

Do simulation outputs match “real” system results?

Yes

Conduct and Document Final Risk Assessment

Repeat Calibration

No

Are Verification results and process satisfactory? (But outputs not matching real system)

Yes

Review Verification Processes and Results

No

Improve Verification Processes & Repeat Verification as necessary

All model/design and code must be documented and placed under Configuration Management.
Validation Process (cont.)

Begin Validation Process

Begin Validation Process

Document Validation results

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Validation Phase Ends

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- Yes
- No

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    - No
      - Repeat Calibration

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Conclusion / Take Away

• Many things can go wrong when an M&S is not properly accredited:
  – M&S may not be capable of meeting its requirements
  – M&S may not be right model for answering questions of interest
  – Data used may be inappropriate and inaccurate
  – Software could have bugs
  – Outputs may not match “real world”
  – Model may be difficult to use
• More reliance is being placed on M&S for decision-making as a result of declining resources
• Potential consequences of poor M&S design include schedule slips, cost overruns, and even death
• Only way to significantly reduce risk is to integrate VV&A processes into model design process from the very beginning