V&V and QA throughout the M&S Life Cycle

OSMAN BALCI
Professor

Department of Computer Science
Virginia Polytechnic Institute and State University (Virginia Tech)
Blacksburg, VA 24061, USA

https://manta.cs.vt.edu/balci
M&S Life Cycle

Legend:
- Document
- Executable Model
- Results
- Quality Assurance (QA)
- Process
- Iteration
- Maintenance
- COI’s Responsibility
- Organization’s Responsibility

Problem Domain

Formulated Problem

Requirements Engineering

Requirements Specification

Conceptual Modeling

Architecting

Design

Architecture Specification

Design Specification

Simulation Model

Simulation Results

Presentation

Certification

Simulation & Certification Phase

Design & Programming Phase

Maintenance

Storage & Reuse Phase

Reuse

Repository of Certified Simulation Models

Certified Simulation Model

Presented Results

M&S Life Cycle
Definitions of Terms

- **Model and/or Simulation** = M/S
- **Models and/or Simulations** = Ms/Ss
- **Modeling and Simulation** = M&S
- **M/S Quality Assurance (QA)** refers to the planned and systematic activities that are established throughout the M&S life cycle to substantiate adequate confidence that a M/S possesses a set of characteristics needed and expected by the user for a set of intended uses.
- **Testing** is the process of designing a test, specifying test conditions and data, and determining a procedure to follow for the purpose of judging transformational accuracy (verity) and/or representational/behavioral accuracy (validity).

Testing is conducted to perform verification and/or validation.
The terms Verification and Validation (V&V) are consistently defined for whatever entity they are applied to. Let X be that entity such as model, simulation, software, data, or a life cycle artifact (work product) such as requirements specification, conceptual model, design specification, or executable submodel. Then, V&V can be defined generically as follows:

- **X Verification** deals with the assessment of transformational accuracy of the X and addresses the question of “Are we creating the X right?”

- **X Validation** deals with the assessment of behavioral or representational accuracy of the X and addresses the question of “Are we creating the right X?”

For whatever entity to be subjected to V&V, substitute the entity name in place of X above, the definitions will hold.
Importance of Quality

- Quality is a critically important issue in almost every discipline.
- Many associations have been established worldwide for quality. Examples:
  - American Society for Quality [http://www.asq.org](http://www.asq.org)
  - European Organization for Quality [http://www.eoq.org](http://www.eoq.org)
  - Society for Software Quality [http://www.ssq.org](http://www.ssq.org)
- Manufacturing companies have **Quality Control** departments, business and government organizations have **Total Quality Management** programs, and software development companies have **Software Quality Assurance** departments.
If our objective is to assess the accuracy of an M&S application by conducting V&V, why should we be concerned with M&S quality assessment?
The Four Ps Influencing M/S Quality

- The M/S Quality Assurance (QA) strategy should involve the measurement and assessment of a particular life cycle stage’s
  1. output work product (or artifact),
  2. process used in creating the output work product,
  3. quality of the people employed, and
  4. project characteristics (e.g., configuration management, risk management, planning, documentation).

Quality is Job 1!
A Quality Model for M&S Applications

**M&S Application Quality**

- **Dependability**
  - Availability
  - Reliability
  - Safety
  - Security

- **Functionality**
  - Capabilities
  - Detailedness
  - Feature Set
  - Generality
  - Accuracy

- **Performance**
  - Algorithmic Efficiency
  - Architectural Efficiency
  - Communication Efficiency
  - Resource Use Efficiency

- **Supportability**
  - Compatibility
  - Configurability
  - Conformity
  - Installability
  - Interoperability
  - Localizability
  - Maintainability
  - Portability
  - Testability

- **Usability**
  - Documentation Quality
  - Ease of Experimentation or Exercise Specification
  - Ease of Input Specification
  - Ease of Learning
  - Output Understandability

**Levels**

- **Level 1**
  - Dependability
  - Functionality
  - Performance
  - Supportability
  - Usability

- **Level 2**
  - Availability
  - Reliability
  - Safety
  - Security
  - Capabilities
  - Detailedness
  - Feature Set
  - Generality
  - Algorithmic Efficiency
  - Architectural Efficiency
  - Communication Efficiency
  - Resource Use Efficiency
  - Compatibility
  - Configurability
  - Conformity
  - Installability
  - Interoperability
  - Localizability
  - Maintainability
  - Portability
  - Testability
  - Documentation Quality
  - Ease of Experimentation or Exercise Specification
  - Ease of Input Specification
  - Ease of Learning
  - Output Understandability

- **Level 3**
  - Accuracy
  - Mean Time to Failure
  - Mean Time to Restore
  - Recoverability
  - Verity
  - Validity

- **Level 4**
  - Accuracy
  - Mean Time to Failure
  - Mean Time to Restore
  - Recoverability
  - Verity
  - Validity
  - Adaptability
  - Correctability
  - Extensibility
  - Preventability

**M&S Application Quality Level 1 Indicators**

- **Dependability**
  - Dependability is the degree to which the M&S application (a) delivers services when requested, (b) delivers services as specified, (c) operates without catastrophic failure, and (d) protects itself against accidental or deliberate intrusion.

- **Functionality**
  - Functionality is the degree to which the M&S application completely captures all of the desired functional modules that need to be present.

- **Performance**
  - Performance is the degree to which the M&S application executes its work in a speedy, efficient, and productive manner.

- **Supportability**
  - Supportability is the degree to which the M&S application can be supported.

- **Usability**
  - Usability is the degree to which the M&S application can easily be employed for its intended use.
Undoubtedly, **accuracy is the most important quality characteristic** of an M&S application, and is assessed by conducting **V&V**.

However, under the current state of the art, **we are unable to claim a level of accuracy of a reasonably large and complex M&S application with 100% confidence** due to many reasons including M&S complexity, reliance on human judgment, qualitative measurements, lack of data, and lack of exhaustive testing. Hence, **M&S V&V is viewed as a “confidence building” activity**.

For a reasonably large and complex M&S application, **the “confidence building” activity must be performed by assessing not only the M&S accuracy, but also the other M&S quality characteristics** such as the ones given in the quality model presented earlier.

**Successful assessment of the overall M&S application quality increases our confidence in M&S accuracy.**