How to Validate Your Models and Simulations

Overview

This 1.5-day onsite or live online course discusses 12 techniques for building new simulation models that are valid, credible, and at an appropriate level of model detail as well as the 7 general-purpose methods for validating existing models. The material for the course came from three major sources: (1) reading hundreds of technical papers and books on simulation modeling, (2) performing 50 real-world simulation studies, and (3) the positive and negative experiences of the 8000 simulation practitioners who have attended my simulation short courses. All techniques will be illustrated by one or more examples based on actual simulation projects.

A highlight of this seminar is the discussion and illustration of an **assumptions document**, which is a detailed report delineating all model assumptions, algorithms, input parameters, output performance measures, and data summaries. It serves as the main vehicle for communications among the project team, and it is a "blueprint" for creating the simulation computer program. It should not be confused with a conceptual model, which can be thought of as *initial ideas* on what a model will look like. Most models and simulations are simply not well documented, resulting in communication errors and costly, incorrect decisions.

The development of the course greatly benefited from a two-year contract from the Defense Modeling and Simulation Office to write the paper "A Practitioner's Perspective on Simulation Validation."

Dr. Averill M. Law, the course instructor, has been intimately involved in the problem formulation, validation, and analysis of approximately 50 models and simulations. He has been a validation consultant to organizations such as Booz Allen and Hamilton, Ford, ITT, Stanley Black & Decker, U.S. Air Force, U.S. Army, U.S. Marine Corps, and U.S. Navy.

Live versions of this seminar have been presented to Australian Department of Defence (2 times), Boeing, Engineering Industries eXcellence, Georgia Tech Research Institute, Lockheed Martin, National Security Agency, Raytheon, Sasol Technology (South Africa), U.S. Army (2 times), U.S. Navy (2 times), International Council on Systems Engineering (INCOSE), International Society for Optical Engineering (SPIE) (3

times), International Test and Evaluation Association (ITEA) (5 times), and Military Operations Research Society (4 times).

Outline

1. **Seven Important Steps in a Sound Simulation Study**
2. **The Importance of Formulating the Problem Precisely**
   - All stakeholders should be present at the initial kick-off meeting
   - Required to determine an appropriate level of model detail and the relevant performance measures
3. **Talking to Appropriate Subject-Matter Experts (SMEs)**
4. **Interacting with the Decision-Maker on a Regular Basis**
   - Helps ensure that the correct problem is being addressed
   - Maintains decision-maker's interest throughout the study
   - Enhances the credibility of the simulation model because key model assumptions are understood and, hopefully, agreed with
5. **Using Quantitative Techniques to Validate Components of the Model**
   - Graphical plots and goodness-of-fit tests to determine the appropriateness of the selected input probability distributions
6. **Developing a Written Assumptions Document**
   - Documents all model assumptions, algorithms, input parameters, performance measures, and data summaries
   - Should be written in bullet format for easy review at the structured walk-through (see below)
   - Blueprint for creating the simulation computer program
   - More detailed than a requirements document or a conceptual model
7. **Performing a Structured Walk-Through of the Assumptions Document**
   - All stakeholders should be present
   - Assumptions document should be reviewed bullet by bullet to make sure that the proposed model is correct and at an appropriate level of detail
   - The interactions that take place are invaluable

- It is *extremely likely* that errors and omissions will be found that should be corrected before programming begins

8. **Using Sensitivity Analysis to Determine Important Model Factors**
    - The critical danger of varying one factor at a time
    - Introduction to the proper design of experiments
9. **Results Validation**
    - Comparison of model output data with the comparable output data from a similar *existing system* using numerical statistics and graphical plots
    - Use of a Turing test
    - Evaluation of model output data by SMEs (i.e., does the model have *face validity*)
    - Comparison of model output data with the comparable output data from *another model* that is thought to be "valid"
    - Use of confidence intervals and hypothesis tests to make comparisons
10. **Using Animation to Show that a Model is not Valid and to Enhance Credibility**
11. **Guidelines for Obtaining Good Model Data**
    - Two fundamental principles
    - Five potential problems with data
    - Statistical tests for determining whether "similar" data sets can be merged and used for a particular purpose
12. **Additional Topics**
    - Model calibration and how it differs from validation
    - Model validation by an independent organization
    - Validation of machine-learning models