Thoughts on “Protocols” for Model Assisted POD

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MAPOD

- Primary issue - Model Validation
- Extensive background
  - Verification and Validation (V & V)
  - Modeling and Simulation (M & S)
- ***V&V State of the Art:*** *Proceedings of Foundations '02 a Workshop on Model and Simulation Verification and Validation for the 21st Century,* October 22-24, 2002
  - Recent '04 follow-on in Arizona

Sessions in ’02 Workshop

A1: Verification Technologies
A2: Validation Methods and Technologies
A4: SME Use in M&S V&V
A5-T5 combined session: Formal Methods in V&V
A6: M&S Foundations
B1: Computational Science/Engineering V&V
B2: V&V for HWIL/System in Loop M&S
B3: V&V of M&S with People or HBR (Human Behavior Representation)
B4: Estimating V&V Resource Requirements
B5: V&V of M&S with Adaptive Processing
B6: V&V of Multi-Resolution M&S
T1: V&V Education in Academia
T2: Managing V&V
T3: V&V Research
T4: V&V Issues re M&S Reuse
T6: V&V Tools, Templates, and Resources
T7: V&V Policies, Guides, Standards
T8: V&V Education in the Workplace

Foundations ‘02 V&V Bibliography

- 649 Entries
  - Books
  - Journal Articles
    - IEEE, AIAA, OR, Simulation, Statistics ….
  - Conferences

Sample V&V Standards List

AFSC/AFLCP 800-5 - *Software Independent Verification and Validation.*

Air Force Instruction 16-1001, *Verification, Validation And Accreditation (VV&A)*, 1 June 1996.

ANS 10.4 - *Guidelines for the Verification and Validation of Scientific and Engineering Computer Programs for the Nuclear Industry*, 1987.

DI-M-2051A *Technical Manual Quality Assurance Data*, Navy, 8 Sept. 1976.

DI-MCCR-80770, *Software Independent Verification and Validation Plan*, 21 Feb. 1989.

FHWA Handbook, Wentworth, James A., Knaus, Rodger, and Aougab, Hamid, *Verification, Validation, and Evaluation of Expert Systems: An FHWA Handbook,* Version 1.2 - 1st Edition (McLean: Federal Highway Administration, Jan. 1997).

FIPSPUB 101 - *Guideline for Life cycle Validation, Verification, and Testing of Computer Software.*

FIPSPUB 132 - *Guideline for Software Verification and Validation Plans*, 19 Nov. 1987.

IEEE 1012 *Standard for Software Verification and Validation Plans*, 1988.

IEEE Standard 1074, *Software Quality Management Process and Verification and Validation Process*, 30 Oct. 1992.

IEEE/EIA 12207.0-1996 - *Software Life Cycle Processes*, March 1998.

IEEE/EIA P12207.1 (Draft) *Guide for information technology: - Software life cycle processes, - Life cycle data*, 11 February 1997.

IEEE/EIA 12207.2-1997 *Software life cycle processes - Implementation considerations*, April 1998.

Sample V&V Standards List (continued)

ISO 9001, *Quality Systems - Model for Quality Assurance in Design, Development, Production, Installation, and Servicing*, (Geneva, International Organization for Standardization, 1994).

ISO 9000-3, *Quality management and quality assurance standards - Part 3: Guidelines for the application of ISO 9001 to the development, supply and maintenance of software*, (Geneva, International Organization for Standardization, 1991).

JPL D 576 - *Independent Verification and Validation of Computer Software Methodology*, 1983.

MIL-M-81203, *Validation / Verification Plan.*

MIL-STD-499B, *Systems Engineering Management Plan* (SEMP).

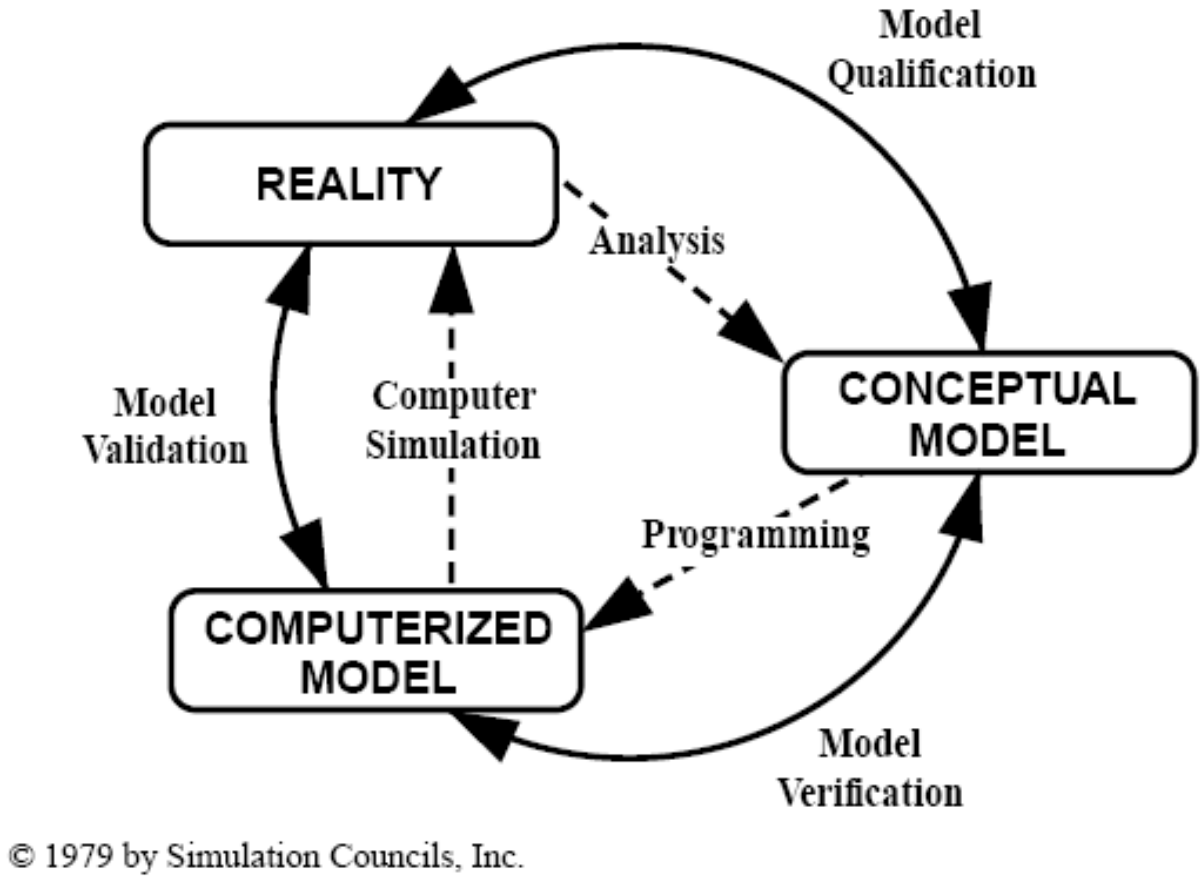
NASA-GB-002-95, *Formal Methods Specification and Verification Guidebook for Software and Computer Systems*, Volume I: Planning and Technology Insertion, Release 1.0, kemp@ivv.nasa.gov.NBS.

NBS Special Publication 500-93, *Software Validation, Verification, and Testing Technique and Tool Reference Guide*,
National Bureau of Standards, Computer Science and Technology, Washington, DC, Sept., 1982.

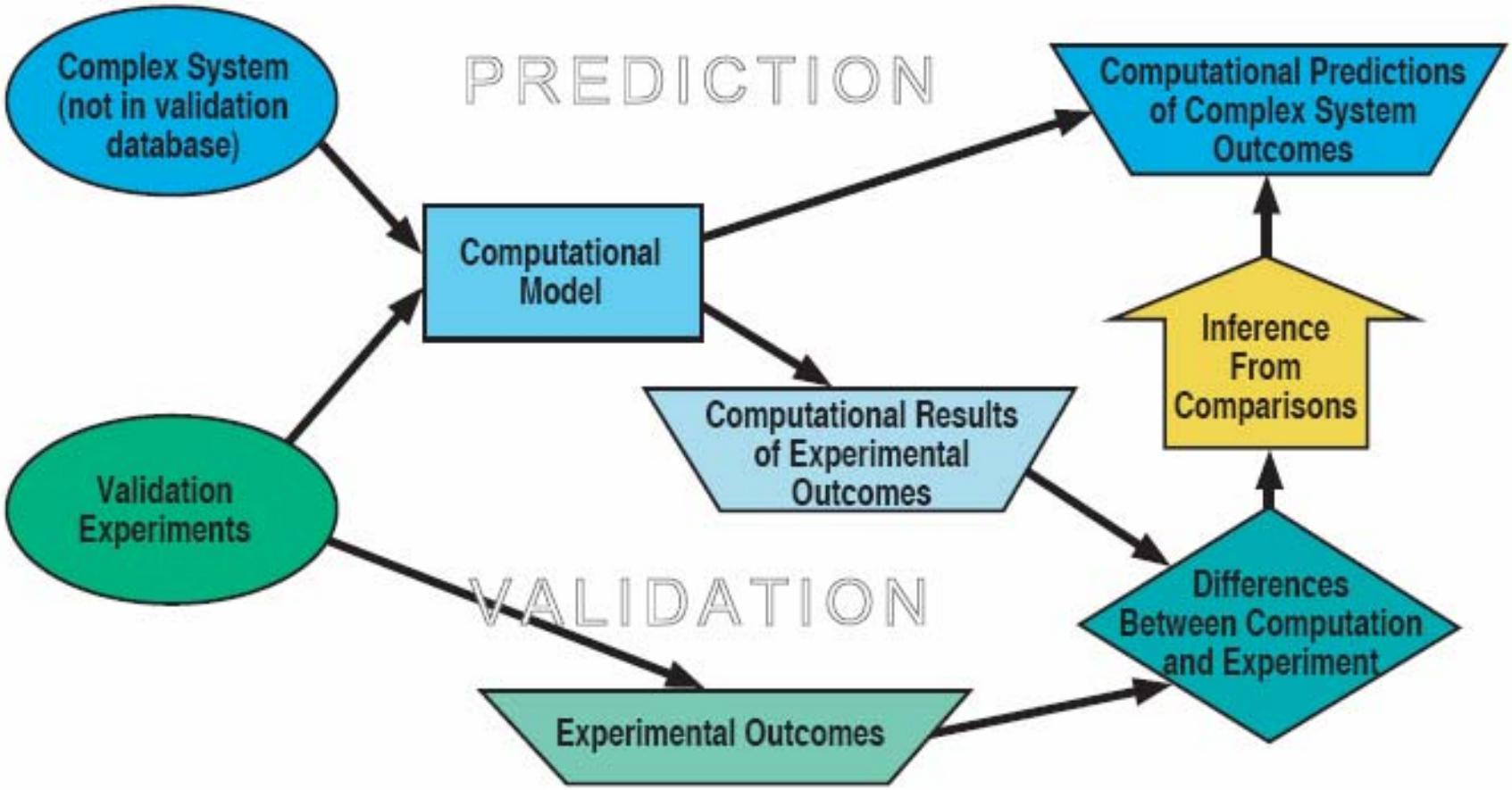
NIST Special Publication 500-234, Wallace, Dolores R., Ippolito, Laura M. and Cuthill, Barbara, *Reference Information for the Software Verification and Validation Process*, National Institute of Standards and Technology, Computer Systems Laboratory, Gaithersburg, MD 20899, 29 March 1996.

UDI-M-23928 *Validation and Verification Plan, Navy*-SH, 2 Jan. 1973.

View of Modeling and Simulation by the Society for Computer Simulation



Schlesinger, S., "Terminology for Model Credibility," *Simulation*, Vol. 32, No. 3, 1979, pp. 103-104



Oberkampf, W. L., and Trucano, T. G. Verification and Validation in Computational Fluid Dynamics, *Progress in Aerospace Sciences*, Vol. 38, No. 3,

Definitions

Model. - A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

Modeling. - Application of a standard, rigorous, structured methodology to create and validate a physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process.

Modeling and Simulation (M&S). - The use of models, including emulators, prototypes, simulators, and stimulators, either statically or over time, to develop data as a basis for making managerial or technical decisions. The terms "modeling" and "simulation" are often used interchangeably.

Validation. - The process of determining the degree to which a model or simulation is an accurate representation of the real-world from the perspective of the intended uses of the model or simulation.

DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994

Frequently used techniques for model validation

Face validation:	Gathering of opinions about the reasonableness and accuracy of the model from people knowledgeable of the system.
Tracing	Following the behavior of specific entities through the model calculations
Internal validation	Stochastic analysis to determine the variability of the model.
Sensitivity analysis	Effects of changing input parameters on the model behavior and its output. Comparison to other models in terms of structure and output.
Historical validation	Using part of historical data to determine if the model behaves as the system did.
Predictive validation	Determining if the system's behavior and the model predictions are the same.
Events validation	Comparing the events occurrences in the model with the distribution of these in the system.
Turing tests	To verify if knowledgeable people can distinguish between the real system and model outputs.
Spectral analysis	To evaluate if, in the frequency domain, the dynamic behavior of the model differs from the behavior of the system.
Experimentation	Manipulating variables in both the real-world and the model and then comparing the outputs.
Convergent validation	Comparing the model's predictions with those of experts

Landry, M., Malouin, J.L., and Oral, M., (1983) "Model Validation in Operations Research," European Journal of Operational Research 14 p207-220

Categorization of nondeterministic features

Type	Aliases	Mathematical representation	Comment
Variability	Stochastic uncertainty aleatory uncertainty inherent uncertainty irreducible uncertainty	Probability or frequency distributions	Substantial literature concerning propagation through models and simulations
Uncertainties (lack of knowledge)	epistemic uncertainty reducible uncertainty.	Probability or frequency distributions (Bayesian) Intervals	Proper representation has been a debated issue for some time - especially in the risk community
Modeling Error (including numerical error)	Examples Incomplete model Spatial discretization Temporal discretization	Intervals (relative errors)	Numerical errors usually addressed in “verification” phase

Features Needed in Validation Study

- A list of model features or inputs (parameters) of potential importance
- A list of potentially important factors not included in model
- Uncertainties for each input of the model
  - Identification of type of uncertainty and range or distribution and how the input is treated in the model
- List of known modeling errors (mesh size)

Features (continued)

- Specification of evaluation criterion for model output
- Specify domain of input for which evaluation will be done
- Specify the necessary “field data” to be used to match criteria to reality