

Introduction to VVUQ | Part 3

Validation

Task Group on VVUQ Concepts in Engineering Education

ASME Codes & Standards | Committee on Verification, Validation, and Uncertainty Quantification

Contacts: Lydia Stanford (stanfordl@asme.org) | Daniel Papert (papertd@asme.org)

V. 3, Draft, 2026

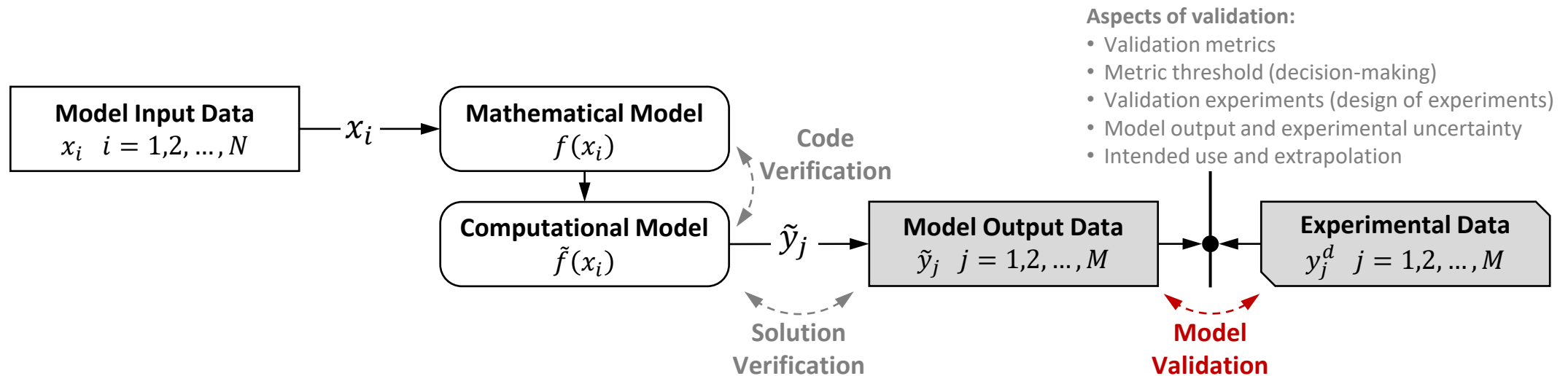
© 2026 by ASME Task Group on VVUQ in Engineering Education is licensed under CC BY 4.0. To view a copy of this license, visit <https://creativecommons.org/licenses/by/4.0/>

Outline

- What is validation and why do we care?
- How is validation performed?
- What is prediction?
- How does validation inform the model's *predictive capability*?

What is model validation and why do we care?

- Computational modeling and simulation are used to aid the decision-making process
 - e.g., Predicting deformation of a structure: an inaccurate model could lead to poor decisions, potentially resulting in excessive deformation or even failure of a bridge or building.
- **Validation** compares the simulation model results to real-world observations (data) to ensure it captures essential features (physical phenomena) of the real system.
- Validation data should reflect the conditions of the intended use of the model.
 - e.g., Assessing the predicted deformation of a structure against measured deformation under realistic or maximum loading conditions.



How is validation performed?



- **Create model:** build a computational model for a specific context of use
- **Verification:** assess numerical errors (see previous module)
- **Collect measurements:** conduct validation experiments (preferred) or collect historical data
- **Quantify uncertainty:** estimate for both model outputs and measurements
- **Validation assessment/model error estimation:** compare model outputs to measurements via
 - qualitative assessment by expert judgment
 - quantitative assessment using mathematical validation metrics
- **Note:** There is often a hierarchy of validation in real-world complex systems
 - validation of individual components or subsystems
 - validation of the entire system

How are validation experiments different from other experiments?

- Traditional experiments/tests are conducted to:
 - Improve physical understanding of the physical processes occurring
 - Calibrate/update model input parameters
 - Assess or certify system/subsystem performance or safety
- **Model validation experiments** are conducted for the primary purpose of assessing the ability of the simulation model to predict the system responses for the experiment that is conducted.
- Validation experiments can be conducted on the actual system of interest, but more commonly it is:
 - A subsystem, assembly, or component of the actual system of interest
 - The experimental conditions are not fully representative of the actual operating conditions of the system
- Other important features of validation experiments:
 - Experimental measurement uncertainty should be estimated in both the system response quantities of interest and the input quantities that are used the simulation model
 - Quantitative methods should be used to assess the agreement between simulation and experimental results
 - *Blind model predictions* of the validation experiment are the most informative of predictive capability

What is model prediction?

- **Prediction** involves producing model outputs for which corresponding measured data is *not available*.
- **Validation domain:** A model is validated against experimental results at a specific set of input conditions ('validation points') that form the *validation domain*.
- **Intended use domain:** Predictions in the *intended use domain* of the model input space may be **interpolative** or **extrapolative** with respect to the *validation domain*.

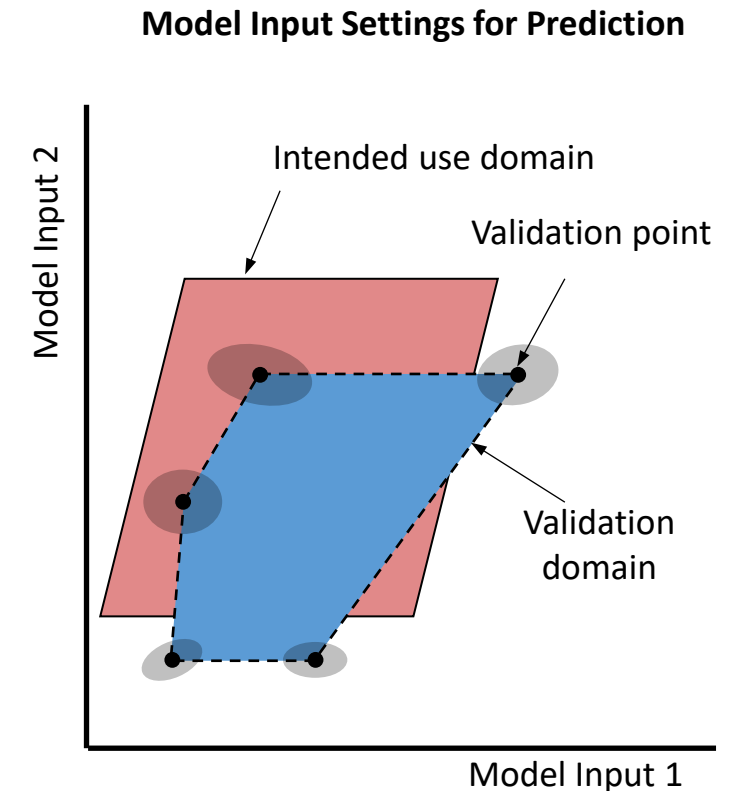


Image credit: adapted from V&V 10

What is predictive capability of a model?

- **Predictive capability** is producing a simulation result, including all sources of uncertainty, at conditions where *no experimental measurements* are available.
- Predictive capability is informed by:
 - Quantitative validation assessment at conditions relevant to the prediction conditions of interest
 - The similarity of the conditions at the prediction conditions to the model validation conditions
 - The estimated magnitude of all the numerical solution uncertainties at the prediction conditions of interest
 - The effect of the model input uncertainties at the prediction conditions of interest
 - The uncertainty due to the model formulation itself, i.e., model form uncertainty
- A simulation model's **adequacy** for intended use involves diverse requirements such as:
 - Requirements for model accuracy plus uncertainty at the prediction conditions of interest
 - Economic, safety, and liability risks if the simulation model is potentially *inaccurate*
 - Personnel, computer, and software costs to produce the simulation results
 - Experience level required of the personnel to produce credible simulation results

References

- ASME (2022), "Verification, Validation, and Uncertainty Quantification Terminology in Computational Modeling and Simulation," American Society of Mechanical Engineers, [ASME VVUQ 1-2022](#), New York, NY.
- ASME (2019), "Standard for Verification and Validation in Computational Solid Mechanics." American Society of Mechanical Engineers, [ASME Standard V&V 10-2019](#), New York, NY.
- ASME (2009), "Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer." American Society of Mechanical Engineers, [ASME Standard V&V 20-2009\(R2021\)](#), New York, NY.
- Oberkampf, W. L. and C. J. Roy (2010), Verification and Validation in Scientific Computing, Cambridge University Press, UK.
- NaRC (2012), "Assessing the Reliability of Complex Models: Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification." National Research Council of the National Academies, ISBN-13: 978-0-309-25634-6, Washington, DC.