ASME VVUQ 50.1-2025

Guide to a Model Life Cycle Approach That Incorporates Verification, Validation, and Uncertainty Quantification

AN AMERICAN NATIONAL STANDARD

The American Society of Mechanical Engineers

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FOREWORD

This Guide, authored by the ASME VV50 Subcommittee on Verification and Validation of Computational Modeling in Advanced Manufacturing, provides guidance on how the processes associated with model verification and model validation may be incorporated into the engineered life cycle of a computational model.

Such a life cycle includes establishing requirements, model development, and model deployment and use in specific applications. Accordingly, this Guide provides an integrated view that includes both the perspective of ASME VVUQ 1–based standards, which are concerned with characterizing the computational model quantitative accuracy but not requirements for model accuracy in the context of use, and the perspective of ISO/IEC 15288 and related standards, which are concerned with engineering in the context of requirements for end applications. This Guide includes both computational models that become embedded engineered components that are built into products (such as manufacturing shop floor equipment) and computational models used during the product engineering and life cycle management processes to gain confidence in product designs or products' longer-term behaviors. The concerns of these two different standards' frameworks are related, but in some cases they use the same terms (e.g., "verification" and "validation") with significantly different meanings. This Guide differentiates and explains these terms in their related but different contexts.

The target audience of this Guide includes all stakeholders with a vested interest in the model life cycle, including individuals seeking guidance on implementing a model life cycle strategy. The following two scenarios are typical:

(a) A model life cycle view will be strategically integrated into advanced manufacturing production systems (AMPS) throughout the enterprise.

(1) Those responsible for strategic decision making may want to read sections 1 through 3.

(2) Individuals responsible for developing policies, processes, and other relevant activities for a model life cycle in an AMPS should read the complete Guide.

(b) A computational model will be incorporated into a specific system of interest.

(1) Project managers responsible for a specific computational model project should be familiar with the entire life cycle to best tailor and adapt it as needed.

(2) The following individuals, who are tasked with participating in the model life cycle project, should read material relevant to their role and responsibilities:

(-a) model developers and modelers

(-b) model implementers and programmers

(-c) model users, operators, mechanics, installers, and quality inspectors

(-d) model maintainers, system maintainers, and developers

This first edition of ASME VVUQ 50.1 was approved by the American National Standards Institute on October 27, 2025.

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In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive email notifications of posted errata.

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Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Guide

(4) to permit the use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Guide.

(c) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Guide and the paragraph, figure, or table number

(4) the editions of the Guide to which the proposed case applies

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ORGANIZATION OF ASME VVUQ 50.1

Sections 1 through 3 constitute the Guide; the nonmandatory appendices are considered supplementary. Section 3 is a condensed guideline (what to do) and is introduced, contextualized, and motivated by sections 1 and 2. Section 3 also condenses the content of the five nonmandatory appendices. Nonmandatory Appendix A addresses details of establishing computational model requirements; Nonmandatory Appendix B addresses the process of developing computational models, including an assessment of computational model credibility; Nonmandatory Appendix C addresses the process of deploying computational models; Nonmandatory Appendix D addresses the process of using and maintaining computational models; and Nonmandatory Appendix E describes the process of retiring computational models.

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GUIDE TO A MODEL LIFE CYCLE APPROACH THAT INCORPORATES VERIFICATION, VALIDATION, AND UNCERTAINTY QUANTIFICATION

1 GENERAL

1.1 Scope

This Guide provides a guide to the life cycle of a computational model from an engineering perspective, with particular reference to the associated verification and validation processes. The material is presented in the application context of advanced manufacturing and demonstrates how verification and validation processes incorporate into the following iterative stages: establish model requirements, develop the model, deploy the model, use and maintain the model, and retire the model. The emphasis of this Guide is on how the verification and validation processes bear on the life cycle stages; how they are performed is outlined, but further details (including their theoretical basis) are the proper scope of other references, standards, and guidelines.

As explained in the Foreword, the life cycle scope of this Guide necessitates the use of the perspectives of both ASME VVUQ 1–based standards, which are concerned with model quantitative accuracy but not end application requirements, and ISO/IEC 15288–based standards, whose scope includes engineering products in the context of end application requirements. These two types of frameworks should work together across a computational model's life cycle. One of the challenges faced when integrating the two frameworks arises from the differences in meaning associated with the terms "verification" and "validation" in the frameworks. This Guide explains these differences and illustrates how the terms may be integrated in practical engineering contexts.

While the examples provided in this Guide focus on computational models for advanced manufacturing production systems (AMPS), the overall principles and approach described can be applied equally well to models of any system, process, or other subject described by computational models; can be used for diverse but identifiable purposes; and can be used by diverse but identifiable model users. Nevertheless, this Guide primarily addresses computational models of advanced manufacturing and not models of the design of manufactured products or other special cases.

This Guide may be used as

(a) a general end-to-end narrative providing guidance across the computational model life cycle, including informal story narratives and examples

(b) a reference on specific stages of the computational model life cycle

(c) an importable object-based data model, speeding the implementation of this Guide by importing and directly applying the related guidance in the form of a model-based, reusable, configurable system pattern of the higher-level situation and specific enterprise

(d) an instantiation of a model for a specific project, for direct use in projects

1.2 References

The following is a list of publications referenced in this Guide.

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