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VERIFICATION AND VALIDATION IN THE REAL WORLD

Renee Thiesing[1]

[1]Promita Consulting LLC, Louisville, KY, USA

ABSTRACT

Verification and Validation (V&V) are foundational to building trust in simulation models, yet their application in practice frequently involves ambiguity and difficulty. This case study explores how simulation practitioners navigate the complexities of V&V across different industries. Drawing on academic frameworks, practitioner interviews and industry case studies, we examine the disconnect between textbook theory and real-world implementation.

1 INTRODUCTION

Simulation modeling serves as a critical decision support tool, enabling the analysis of complex processes and systems. However, the usefulness of any simulation model is contingent upon its credibility, which is assessed through the process of verification and validation. Verification refers to the mechanism of ensuring that the simulation model has been implemented correctly in accordance with its conceptual design. Validation is determining whether the model sufficiently represents the real-world system to support the intended modeling objectives. While the methodologies of verification and validation are well established in academia, industry professionals frequently encounter challenges when applying them in practice.

2 RESEARCH AND METHODOLOGIES

The field of simulation has benefited from decades of scholarly attention to verification and validation, resulting in a well-developed body of knowledge that defines both the importance of V&V and the methods by which it should be conducted. Kleijnen (1995) highlights statistical techniques for model validation, such as the use of *t* tests, testing for correlation and using sensitivity analysis for insight into inputs. However, he also points out that in some applications, certain techniques do not apply at all. Kleijnen asserts that V&V techniques are applied in a haphazard way in practice and he urges practitioners to pay for attention to the aspects of verification and validation. Sargent (2010) shares various techniques to achieving model validity along with recommended procedures depending on the size of the model, but shares that there is no algorithm to determine what techniques or procedures to use. Methodologies for effective V&V can be found in research papers dating back to the 1970s, so there is extensive guidance on approaches. Yet despite the extensive research and education around the importance of following certain frameworks and statistical analysis, industry practitioners tend to follow more informal and opportunistic approaches to verification and validation.

3 INDUSTRY APPLICATION

While academic frameworks emphasize the importance of statistical testing, formal procedures and full traceability, industry practitioners tend to focus on practicality, such as sanity-check simulations, expert-driven validation, and approval from stakeholders. They rely heavily on continuous communication and context-specific judgment. Realistic constraints, such as time, lack of data and evolving requirements, shape industry V&V more than what is recommended by research as best practice approaches. Practitioners

balance rigor with feasibility by including expert input, leveraging visualization and engaging stakeholders to build confidence in the model's insights.

To verify a model, practitioners often begin by testing components or sections of the model in isolation before growing the model or integrating pieces together. They might conduct code reviews and have peer feedback sessions to review the model logic with subject matter experts. As the model is being developed, verification that the model outputs respond appropriately to defined inputs provides visibility into the accuracy of the intended behavior. Utilizing the trace or logging features of the simulation model allows intricate testing at an individual entity or resource level. And in many instances, if animation is available, it is often a powerful tool used to confirm intended behavior.

For model validation, practitioners often use a combination of historical data comparison and stakeholder confidence to assess how well the model replicates how the system behaved. One of the most important elements of model validation is whether or not the stakeholder trusts the model. This should not be the sole indicator of a valid model, but it is an important aspect of the process. In order to achieve the desired level of trust, continuous stakeholder engagement is critical. Practitioners will iterate and review model assumptions, the logic of the business rules and the validity of the input data. A review of the intermediate results with the stakeholders will provide timely feedback on accuracy and areas where model rework or more detailed validation might need to occur.

4 CHALLENGES IN PRACTICE

Despite the wealth of academic guidance on verification and validation, practitioners struggle to implement these methodologies in practice due to a range of actual constraints. One of the most pervasive challenges is the availability and quality of data. Models are frequently built using incomplete datasets that undermine efforts to conduct rigorous validation against historical performance. In other cases, the systems being modeled do not yet exist, such as proposed facilities, new policies, or future operating conditions. Traditional validation in this case is impossible and forces reliance on expert judgment or hypothetical scenarios. Time and resource constraints further complicate matters, as many simulation projects operate under tight deadlines and limited budgets that impede extensive statistical testing or iterative model refinement. Finally, practitioners present their models to stakeholders who are usually unfamiliar with simulation, and who may be skeptical of its outputs. Convincing these stakeholders that a model is sufficiently valid requires not just quantitative analysis, but also effective communication, trust-building, and alignment with decision-making needs.

REFERENCES

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