

Introduction to VVUQ | Part 1

Simulation Credibility Assessment

Task Group on VVUQ Concepts in Engineering Education

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

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Outline

- Why do we care?
- Structure of a simulation model
- How is a simulation model assessed?
- How is simulation credibility assessed?
- Context of use of the simulation

Why do we care?

- “All models are wrong – some are useful.” – Prof. George E. P. Box
- Why is this true?
 - All models rely on assumptions and approximations in the formulation of the model
 - All models require input data to describe the system of interest and its surroundings, which are approximate or possibly not measurable
 - All models require numerical solution, which results in numerical errors
- Infamous system failures due to erroneous modeling:

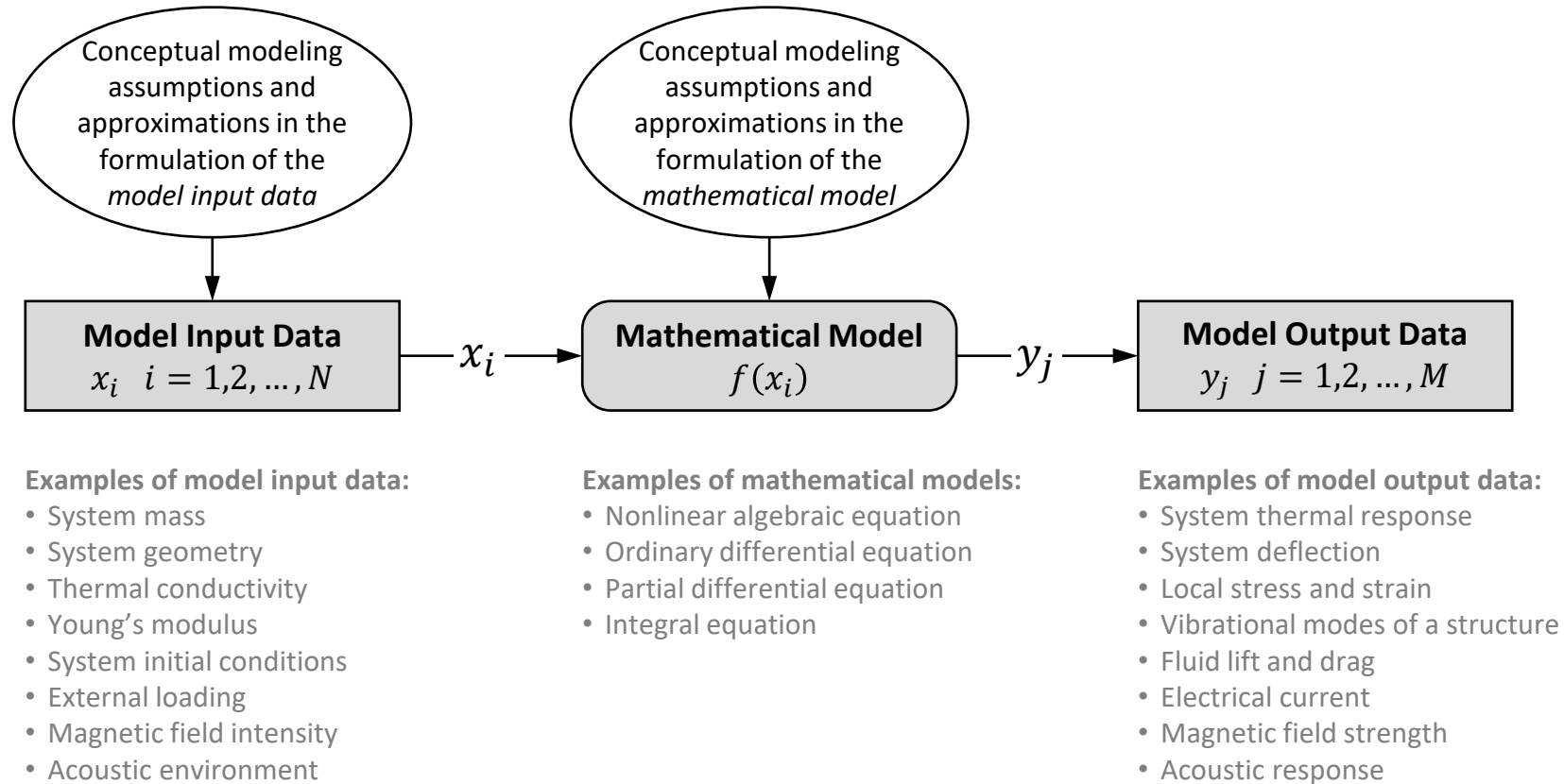


Space Shuttle Columbia Disaster



Fukushima Nuclear Disaster

Structure of a simulation model



What do simulation models produce and how is it used?

- Simulation models are used to produce **information** about the system of interest and its responses.
- When simulation results are used in business and government:
 - Simulation is referred to as a **decision support tool**
 - The process is also referred to as **simulation-informed decision making**
- Examples how this information can be used:
 - Design of new systems or modification of existing systems
 - Optimization of system design to increase performance, reliability, and safety
 - Reduce development time and physical testing of the final system
 - Optimize manufacturing processes
 - Assess system safety in untestable environments such as accident scenarios or those that produce unacceptable risks to humans and the environment

How is simulation credibility assessed?

- Numerical accuracy is assessed by simulation verification:
 - **Simulation verification:** assessment of the accuracy of the numerical solution relative to the exact solution to the mathematical model
- Physics-based accuracy is assessed by model validation:
 - **Model validation:** assessment of the accuracy of the simulation results relative to experimental measurements of system responses
- Uncertainty in the simulation results is assessed by uncertainty quantification:
 - **Uncertainty quantification:** estimation of the total uncertainty in the simulation result due to all sources of error and uncertainty in the modeling and simulation process
- These assessments are collectively referred to as **VVUQ**.
- Note: These concepts of verification and validation are *distinctly different* from the systems engineering concepts of V&V.

Context of use of the simulation

- **Context of use:** the relationship between the applicability and accuracy of the simulation model relative to the requirements for the intended use of the model.
- Examples of issues related to the context of use:
 - Are the assumptions and approximations of the formulation of the model consistent with the intended use of the model?
 - Is the accuracy and uncertainty of the simulation results sufficient for the needs of the intended use of the model?
 - Are the VVUQ assessment activities sufficient to insure credibility for the intended use of the model?
 - Are the conditions of model validation sufficiently relevant to the actual conditions of interest for the system/subsystem under considerations?
 - What are the consequences and risks involved if the simulation results are inaccurate?

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