

VERIFICATION AND VALIDATION IN COMPUTATIONAL SOLID MECHANICS

**AN OVERVIEW OF THE
ASME PTC #60 STANDARDS COMMITTEE**

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PRESENTATION OUTLINE

- I. *Overview of Verification & Validation*
- II. Professional Society Standards
- III. ASME V&V Standards Committee

MODELING & SIMULATION WHERE WE ARE HEADED

Trends in *Computational Solid Mechanics*

Bigger, Better, & Faster → Higher performance

Negative (or at least worrisome) Trends:

Less Physical Testing

Increased Product Liability

Increased Self-Certification

From Developer/Analyst to Black-Box/User

Positive Trends:

Less Physical Testing

Increasing Awareness of Need for Verification & Validation

V&V (Modeling) to aid Decision Makers, i.e. cost, risk, schedule

SYSTEMS WITHOUT VALIDATION

- Nuclear Weapons Effects
- Terrorists Threats
- Mars Landers & Probes
- Earthquake Response
- Biomedical Devices/Applications
- Accident Reconstruction
- Weather Forecasting

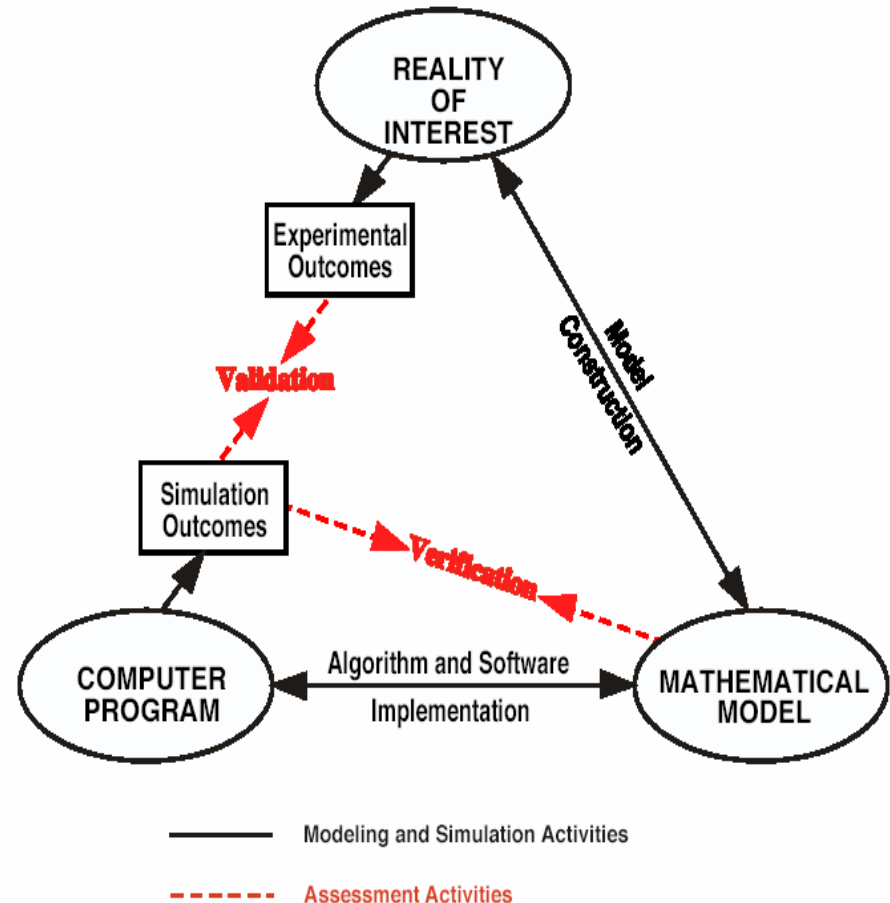
CRITICAL QUESTION

How should confidence in modeling and simulation be critically assessed?

- **Verification** is the assessment of the accuracy of the **solution** to a computational model by comparison with **known solutions**.
- **Validation** is the assessment of the accuracy of a computational **simulation** by comparison with **experimental data**.

WHAT IS VERIFICATION AND VALIDATION?

- **Verification** ~ solving the equations right.
- **Validation** ~ solving the right equations.



VERIFICATION AND VALIDATION ARE *PROCESSES*

An appropriate analogy is the demonstration of **evidence** in a legal proceedings, where sufficient **evidence** must be presented to allow a decision to be made.

STATE-OF-THE ART V&V REVIEW

“Verification, Validation, and Predictive Capability in Computational Engineering and Physics”

William Oberkampf, Timothy Trucano, and
Charles Hirsch

www.usacm.org/vnvcsm/PDF_Documents/Oberkampf-Trucano-Hirsch.pdf

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WHY STANDARDS?

- Standards are a vehicle of *communication* for producers and users. They serve as a common language, defining quality and establishing safety criteria.
- *Costs are lower* if products are standardized; training is also simplified.
- And consumers *accept* products more readily when they can be judged on intrinsic merit.

PRACTICAL IMPLICATIONS OF STANDARDS

A standard can translate into an economic force that sets **minimum** requirements.

Example: Would you consider the implantation of a *non-compliant* life saving medical device, over a *complaint* device, even if it was *free*?

PROFESSIONAL SOCIETIES V&V STANDARDS

- American Institute of Aeronautics and Astronautics (AIAA) Computational Fluids Dynamics Committee on Standards (*AIAA CFD V&V Committee*)
- American Society of Mechanical Engineers (ASME), Board on Performance Test Codes, Committee on Verification and Validation in Computational Solid Mechanics (*ASME V&V Committee*).

COMMITTEE DOCUMENTS

- **Code** – an enforceable standard.
- **Standard** - a set of technical definitions and guidelines – ‘how to’ instructions for designers and manufacturers; verify compliance.
- **Recommended Practices** – evolve into standards.
- **Guides** - evolve into recommended practices.
- **Special Project Reports** – supporting documents.

COMMITTEE PROCEDURE

- **Consensus** – substantial agreement.
- **Due Process** – hearing and appeals board.
- **Openness** – public committee meetings and comments on committee documents.

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V&V IN CSM

STANDARDS PETITION - JULY 00

Charter

*To develop standards for assessing the **correctness** and **credibility** of modeling and simulation in computational solid mechanics.*

V&V COMMITTEE HISTORY

- **AIAA V&V Guidelines for CFD** (Started 1992, Published 1998)
- **USACM ad hoc V&V Committee on CSM** (Aug 1999)
- **1st Committee Meeting** (ASME IMECE Nov 99 Nashville)
- **Organization & Membership Policy** (Mar 00)
- **Request to Form an ASME Standards Committee** (Jun 00)
- **Presentation to Board on Performance Test Codes** (Nov 00)
- **2nd Committee Meeting** (ASME IMECE Orlando FL Nov 00)
- **Board Performance Test Codes Ballot #01-17** (Jul 01)
- **3rd Committee Meeting** (USACM Congress Dearborn MI Aug 01)
- **Board Performance Test Codes Ballot #01-17 Approved** (Aug 01)
- **ASME Council on Codes and Standards - Approval** (Sep 01)

COMMITTEE MEMBERSHIP

Industry (14)		Government (10)	Academia (4)
ANSYS	Boeing	NASA	
MSC SOFTWARE	Northrop Grumman	DTRA/DoD	Johns Hopkins
SRI	Medtronic	IDA/DoD	Rensselaer Polytechnic
SwRI	FM Global	LANL/DoE (3)	Texas A&M
Ford Motor	ACTA	LLNL/DoE	University of Texas
General Motors	Consulting (3)	SNL/DoE (3)	

Bill Oberkampf co-author of AIAA CFD Guidelines

Patrick Roache author "V&V in Computational Science & Engineering"

CURRENT COMMITTEE FOCUS

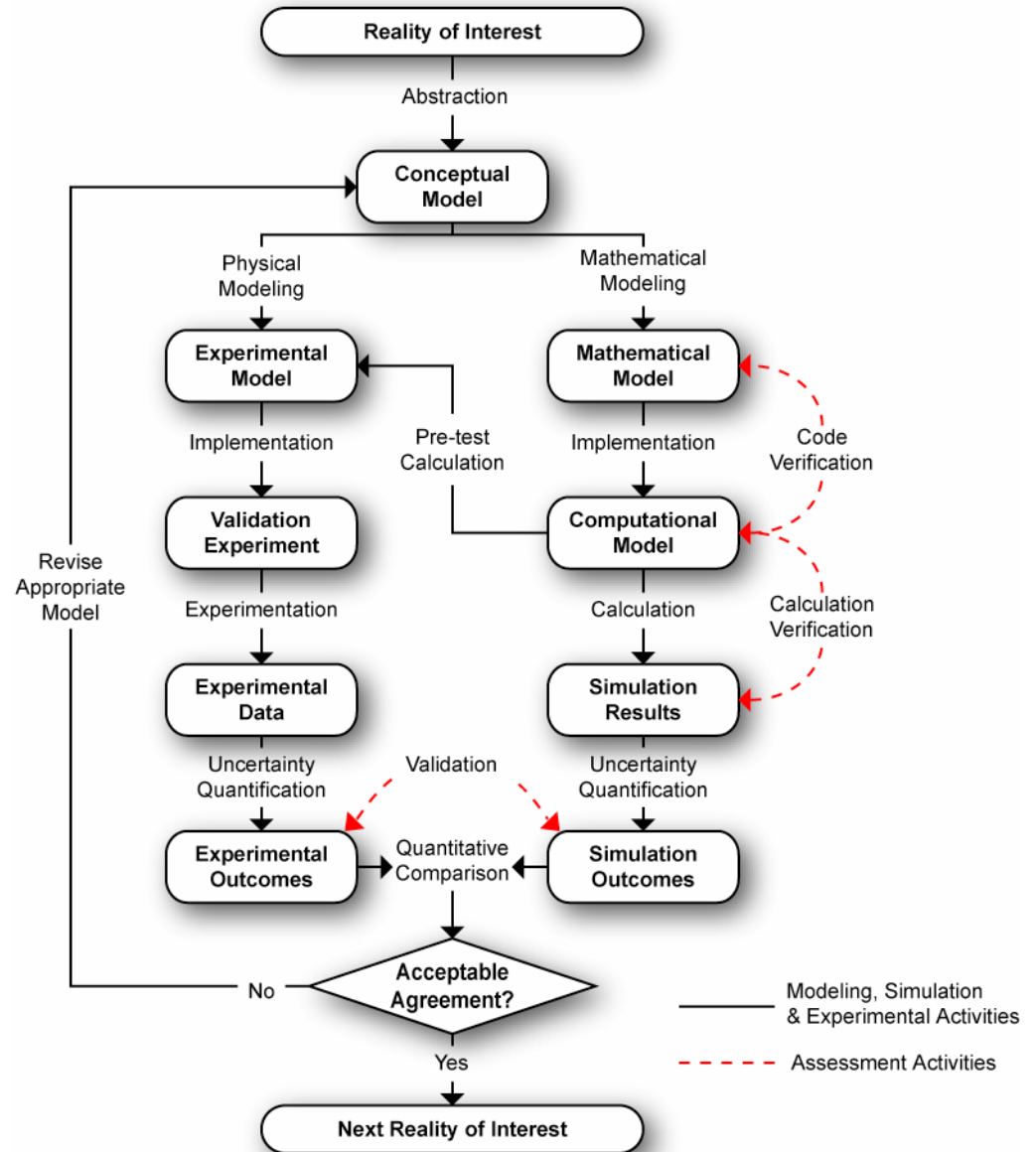
“Elements of V&V Guideline” (~30 pages)

Intended to establish philosophy and basic principles.

Users: Analysts, managers, and software developers

- Introduction (Cafeo & Anderson; Thacker)
- Definitions (Cafeo & Roache)
- Verification (Trucano & Hemez; Anderson)
- Validation (Senseny & Thacker; Gran)
- Modeling (Doebling; Logan)

VERIFICATION & VALIDATION PROCESS



KEY AREAS IN MODEL VALIDATION

1. **Validation Testing** – What is required to specify and perform experiments that will be useful for model validation?
2. **Validation Metrics** – How do we quantify the comparisons between measurement and simulation results?
3. **Uncertainty Quantification** – How do we quantify the degree of agreement between test and simulation when both are subject to errors and uncertainties?

CONTACT INFORMATION

- Committee web site:
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- Open email list:
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