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Request for an

ASME Standard
on
Verification and Validation in Computational Solid Mechanics

Submitted on behalf of the
United States Association for Computational Mechanics
ad hoc Committee on Verification and Validation in Solid Mechanics

July 2000

Identification of the Need

Modeling and simulation are valuable tools in assessing the safety, performance, and reliability of many simple and complex systems. In many cases the results of these analyses are supported, or supplemented, by physical tests. A growing number of such analyses are performed without the benefit of testing, due to increasing testing costs, but also because no tests are possible, e.g. space probe entry to other planets, earthquake response of civil structures, nuclear power plant containment postulated accidents, and exposure of nuclear weapons to postulated accidents.

There is a need to assess the accuracy of computational results, both when physical tests exist and without tests. However, there are no recognized guidelines in computational solid mechanics that analysts, code developers, and decision makers can follow to make an appropriate assessment of accuracy.

It is therefore proposed that ASME establish a standards committee with the following charter:

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

The lack of guidelines, for computational fluid dynamics, changed recently when the American Institute of Aeronautics and Astronautics (AIAA) published its:

> "Guide for the Verification and Validation of Computational Fluid Dynamics Simulations," (AIAA G-077-1998)

This document presents guidelines for assessing the credibility of modeling and simulation in computational fluid dynamics. It represents the first, and very significant, step in the AIAA ANSI approved process of developing a standard that progresses from guidelines, to recommended practices, and then a standard.

Perhaps the most demonstrable need for guidelines in verification and validation for computational mechanics is the extensive effort currently underway by the US Department of Energy:

> "The Department of Energy's (DOE's) Accelerated Strategic Computing Initiative (ASCI) is designed to develop high performance computational tools and models to help manage the safety and reliability of the enduring nuclear stockpile. An important element of the high consequence modeling and simulation (M&S) is a sound and viable verification and validation (V&V) program – one that will substantively increase the credible predictive content of M&S for Science Based Stockpile Stewardship while remaining within the constraints of available funding.[1]"

Why is a Standard the Proper Solution

ASME Codes and Standards literature provides this answer to 'What is a Standard?' A standard can be defined as a set of technical definitions and guidelines -- 'how to' instructions for designers and manufactures.

All over the world, every day, decision makers are asking analysts the essential question: "How good are those results?" Obviously the answer to this question varies widely, but unfortunately, for both the analyst and decision maker, so does the rationale for arriving at the answer. A voluntary set of verification and validation guidelines, a standard, would give both the analyst and decision maker a widely accepted process which would not answer their question of accuracy of results, but provide a common rationale for making that assessment.

In the process of developing the verification and validation guidelines, the first step will be to define the terminology and language to be used in the guidelines. An ASME standard that achieved this first step would be most useful in helping members of the computational solid mechanics community communicate with a common language. Today, even the fundamental words "verification" and "validation" are used, not only incorrectly, but interchangeably, leading to unnecessary confusion, and in some cases unnecessary costs.

Who is the Identified User

The prospective users of the proposed standard can be grouped into three broad categories:

1. Code developers who need to verify the numerical algorithms comprising their software,

[1] Trucano, T.G. and J.L Moya, "Guidelines for Sandia ASCI Verification and Validation Plans – Content and Format: Version 1.0," Sandia Report SAND99-3038, December 1999.

2. Code users who need to validate the results generated, with the models they develop, and using codes provided by the code developers,
3. Decision makers who need to accept or reject the results, provided by the code users, based upon the validated accuracy of the results, and their intended use.

All three of these categories of standard users would benefit from the ability to refer to and follow an accepted standard for the verification and validation in computational solid mechanics. The most important user category is that of the decision makers; the efforts of the other two categories support the decision makers. Of the three categories, decision makers have the most responsibility for the ultimate outcome of the computational results, but are frequently the furthest removed from any direct assessment of the accuracy of the results. The choice of how to allocate resources and proceed with a complex project, that includes computational results as part of the decision process, is where the most benefit can be achieved by assessing the computational results with the aid of the processes described in a standard.

Does a Technical Base Exist for Standard Development

A considerable amount of effort has already been directed at establishing a formalism for verification and validation in computational mechanics.

In addition to the above mentioned efforts by the AIAA Computational Fluid Dynamics Committee and that of the Department of Energy ASCI, there are other US Government organization participating in this activity, on a much broader scope, such as the Joint Accreditation Support Activity (JASA):

> "JASA is a DoD resource provided under the auspices of the Joint Technical Coordinating Group on Aircraft Survivability. JASA specializes in modeling and simulation support services and VV&A (verification, validation, & accreditation)."
>
> www.nawcwpns.navy.mil/~jasa/

Perhaps the best illustration of the existing technical basis for developing a verification and validation standard is the recent book by Patrick J. Roache:

"*Verification and Validation in Computational Science and Engineering*"
Hermosa Publishers, Albuquerque, NM, 1998 [ISBN 0-913478-08-3]

This 446 page volume organizes, references, and demonstrates all of the critical issues that comprise computational verification and validation and is recognized as the definitive source by experts and practitioners.

All of the known activities associated with verification and validation in computational solid mechanics lack the wide acceptance that would result from following an ASME ANSI-approved procedure.

Is there a Broad Constituency for Use of the Standard

There is both a growing need for a standard on verification and validation in computational solid mechanics, and more importantly right now, a growing recognition that such a standard is needed. As computational mechanics simulations replace more, and perhaps most, physical testing, more organizations will realize the need to assess the accuracy of these simulations, and lacking any standard, spend resources devising their own means of assessing accuracy. Not only could these resources be saved by referring to an existing standard, but the standard would,

"… serve as a common language for defining quality and establishing safety criteria."

American Society of Testing Materials, 1991 Annual Report

Efforts of the USACM ad hoc Committee on V&V in Computational Solid Mechanics

The motivation for forming a committee on verification and validation in computational solid mechanics arose from the successful efforts of the AIAA Computational Fluid Dynamics Committee. In their wisdom, they realized their efforts in fluid dynamics were only addressing half of the computational mechanics community, and that a similar effort was needed in solid mechanics.

The United States Association for Computational Mechanics (USACM) offered to host an ad hoc committee on verification and validation in solid mechanics, so that an organized, and recognized, effort could be started with the goal of establishing guidelines. The first meeting of this ad hoc committee was held in November 1999 during the ASME IMECE in Nashville, with one of the main agenda items focused on how this ad hoc committee could become an ASME standards committee.

Towards the goal of becoming an ASME standards committee the current committee membership reflects a broad base from the computational community and includes members from industry, Government, and academia. A list of the current membership and their affiliations is attached. The ad hoc committee has voted to accept an Organization and Membership Policy (22 Mar 00), a copy of which ***WILL BE*** attached.

The ad hoc committee communicates through an email distribution list `vnv@usacm.org` and archives important information on its web site `www.schwer.net/VnV`.

The ad hoc committee is currently completing the draft outline of its proposed guidelines for verification and validation in computational solid mechanics. This document will parallel that already published by the AIAA CFD Committee, and will bring the whole of the computational mechanics community closer to having standards in both computational fluid and solid mechanics.

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USACM ad hoc Committee on Verification and Validation in Computational Solid Mechanics

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June 2000

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