

**Approved – 12 Nov 01**

**Minutes of the  
USACM Committee on Verification and Validation in  
Computational Solid Mechanics**

Hyatt Hotel, Dearborn MI  
1 August 2001

The third meeting of the USACM V&V Committee was held Wednesday 1 August 2001 at the Hyatt in Dearborn, MI. The meeting was called to order by Len Schwer at 8:30 AM. In attendance were committee members Len Schwer, Don Simons, Ben Thacker, Bill Oberkampf, Tim Hasselman, Michael Ortiz, Jim Gran, John Cafeo, Tom Paez, Allan Pifko, Paul Senseny, Mike Giltrud, Hans Mair, Dale Pace, Tinsley Oden, Ren-Jye Yang, and Mark Shephard; and guests Petr Krysl, Bob Lust, Howard Levine, Roger Logan, and Tom Pucik.

Minutes of the second meeting were approved as posted on the Committee web site.

Schwer reported that:

1. The Committee's proposal to ASME had received one negative vote from the BPTC; The Committee responded to the issues raised and requested that the negative vote be removed; and that we have not yet received a report back from ASME. Pifko thought we should send a representative to the BPTC meetings, even if we had no official slot.
2. Dan Chwirut would serve on both the V&V committee and the one on biomedical devices, and act as liaison between the two.
3. The Committee web page would probably be moving to USACM
4. Our agreed-upon election cycle (half the slots every two years) may be in conflict with the BPTC's 3-year cycle. BPTC will be asked to accept the 2-year cycle. If they agree, there will be a lottery to decide which slots will expire first.
5. The next meeting will be 11/11 or 11/12 in NY at the IMECE. Dale Pace noted that the Foundation '02 meeting in Baltimore during October 02 would be another meeting opportunity.

There followed some general discussion on the Guidelines. Oberkampf said committee members could help the writers by suggesting what to leave out. Senseny pleaded for a clearer vision of what the document will contain and what actions it would generate. Oberkampf wanted to emphasize usefulness, building on the AIAA document, e.g., promoting good benchmarks and including references to web sites. Gran asked for definition of the audience for the document: code developers, code users, or managers. Pace thought more than one document might be an appropriate goal, e.g., the main Guide, several technical white papers, a management perspective, a catalog of examples, and a specific end-to-end application of the V&V process. Oberkampf took exception, asking for one document with some slant toward management. Cafeo thought a discussion of resource requirements would be useful to management. Hasselman emphasized the usefulness of a specific V&V example.

## Presentations

Next, there was a series of presentations of summaries of various white papers, most of which had been posted on the Committee web site.

Mair discussed *Calibration*, noting that we seem to agree that it should be approached with reservation. He noted that what we need is a way to quantify its effects. Senseny re-emphasized that one must calibrate first, then validate. Hasselman took a different view, that sometimes validation is impossible and calibration is the only option.

Oberkampf presented Trucano's comments on *Verification* and *PIRT*. He emphasized the distinction between Code Verification (which deals with software quality standards, configuration management, and documentation) and Calculation Verification (which deals with algorithm testing, convergence studies, and benchmarking). The group appeared to favor emphasis on the latter. Oberkampf presented PIRT as a way of prioritizing what calculations and experiments you conduct during the V&V process. Mair asked that an example be shown at the next meeting.

Oden briefly described *A Posteriori Error Estimation*. It is based on a single mesh, although it provides a basis for systematic mesh adaptivity to reduce error. It uses residuals in the PDE's to provide either global or local bounds on the error between the exact and numerical solutions and other features of the exact solution of interest. Oberkampf prefers such methods be called "solution accuracy assessment," to suggest that they do not provide comparisons to the exact solution of the underlying continuum problem. Shepard thought for some classes of problems the two were equivalent.

Senseny presented his, and Gran's, comments about *Experimental Data Requirements*.

During lunch, Roger Logan (LLNL) discussed the need to provide consumers of numerical simulations with an indication of the extent to which the code/calculation had been verified and validated.

Thacker presented general guidelines for treatment of *Non-Determinism in V&V*. In a related presentation, Hasselman presented an example of his method of parameter estimation and model updating.

Schwer discussed *V&V of Constitutive Models*. He noted that even when a code includes a material model driver, it is usually limited to completely strain-controlled paths. To check or calibrate against lab data along mixed paths, many people run a single-element model, but this brings in code machinery and effects external to the material model, for example inertia.

Simons discussed the particular problems of *Softening Material Models*. He noted that introducing such behavior into a rate-independent model causes a change in the type of PDE, rendering inapplicable numerical solution methods restricted to a single type of PDE. He listed the various types of localization limiters seen in practice.

Oden discussed *Benchmarking*. He believes there is only limited value in code-to-code comparisons, except when one of the codes is an established and well verified and validated code. He discounted the notion of any benchmark experiments, since there would always be questions about measurements in the experiment.

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Ahmed Noor's slides on *Risk Management* were shown by Mair. Since Noor could not be present, it was difficult to appreciate the content.

Pace presented the recently revised *Sargent's Circle*. He emphasized that whatever form of the diagram is adopted for use in the Guidelines, it should be simple, include the key elements of V&V, tie computations to experiments and the real world, and clarify relevant terminology.

Schwer presented observations about material emerging from ERCOFTAC, a well-funded European effort aimed at constructing a database of V&V case studies or examples.

## Discussion

Mair led a general wrap-up discussion. The following are key comments.

Schwer: We're too close to the trees. Concepts are what we need to get across, without too many details.

Mair (not sure if this is in the correct location): Said that we don't want to include anything in the V&V Guide that is not well-known, accepted, and generally available.

Senseny: We need an action guide. A checklist would be useful. Should include recommended simple problems and an estimate of the number of problems to be included in a V&V study. Should discuss consequences of non-validation. Should limit the scope of the document. Should set a goal for the Committee by more clearly defining what goes into the document.

Mair: Detailed guidance cannot be given since we don't have documentation to back it up.

Thacker: An action guide is difficult to write right now. Agreed that it was the most useful, but that the committee should write a philosophical guide to keep from getting bogged down in details.

Oberkampf: Must keep in mind that many people are not familiar with even the basic concepts of V&V.

Pace: Should use modern software development practice and documentation. In answer to a comment from Simons that these practices did not seem applicable to pre-existing codes, Pace said that some were in fact applicable.

Senseny: Suggested separating (Software Quality Engineering) SQE from Verification.

Oberkampf: Wanted to recognize SQE as a component of verification, e.g., regression testing, and let other components address algorithm testing.

Logan: Software vendors are the ones who should be performing SQE; users will then do their own algorithm-based verification of models and specific calculations.

Mair will recommend that Trucano outline the Verification section generally following the AIAA guide, with an emphasis on calculation verification and less on code verification (SQE). Focus on prediction for a particular application.

Oden: We really want to verify a model, not a code. Must choose the right equations, then solve them correctly.

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Logan: Mentioned “Quality Function Deployment (QFD).” Was advised to discuss with Trucano whether this is similar to PIRT.

Mair & Oberkampff: When doing hierarchical validation tests, need guidance on how far to go. PIRT provides this.

Mair: Approach to V&V is inherently hierarchical. In CSM, most important sub-models are constitutive models.

Hasselmann: Should recognize options of top-down vs. bottom-up V&V.

Pace: Most top-down reviews ask for lower level documentation.

Mair: PIRT deals with this directly.

Lust: The type of use of a model will determine how it is validated. For GM production uses, any V&V will be offline, by a specially constituted group. Its goal is to produce uncertainty bars on predictions. In answer to a question, he said no such group currently exists.

Paez: (Addressing experimental requirements) Be sure to assess measurement error.

Thacker: Experimental data requirements section (Senseny and Gran) will require coordination with the Non-determinism section, i.e., the Guide must recognize and recommend ways for uncertainty and error to be assessed for both predictions and measurements.

Hasselmann: Model validation experiments should be driven by model requirements.

Mair: Perhaps we should wait until V&V procedures are better defined before getting specific on measurement guidelines.

Lust: Advocate replicate tests (as a means of defining random error).

Hasselmann: Replicate tests are the only way to quantify experimental uncertainty. This means truly replicate tests where the entire test is rerun, including disassembly and reassembly of the test installation if the same test article is retested, or a retest of an “identical” test article if the test article is destroyed by the test. It goes beyond redundant measurements, which can only be used to quantify measurement uncertainty.

Oden (on error estimation) grid convergence testing is just another method for *a posteriori* error estimation.

Thacker: Constitutive model softening should not be singled out for special discussion under material model V&V.

Simons: Softening is distinct from other model features, e.g. rate-dependence, in that its introduction can render an acceptable numerical method unacceptable.

Logan: Guide should recognize that people solve unstable problems because they have to, but they should document how they went about it.

Shepard: Mesh-dependent solutions of softening problems should not be recommended.

Simons: There are ways of adjusting material models with mesh size to give proper fracture energies, thereby counteracting the effects of mesh-dependence.

Mair: Recommends as a goal for the next meeting a revamped outline. Will propose an agenda.

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Thacker: Recommends that the committee focus on developing and accepting an enhanced Sargent diagram as a way for the committee to reach a consensus on what the activities of V&V are and what the relationship between activities are. Once this is done, it will be a lot easier for people to write their respective sections.

Oberkampf will work on a strawman Sargent diagram for discussion on the mailing list prior to the next meeting.

Thacker will think about how to fold non-determinism into the diagram.

For the next meeting, all were urged to think about who is the Guidelines customer.

The meeting was adjourned at approximately 6:00 PM.

### **Action Items:**

Mair – Revise Draft Outline of Guidelines.

Oberkampf – Revised Sargent's Circle.

Thacker – Work with Oberkampf to propose how to include non-determinism in Sargent's Circle.

Schwer – Agenda and schedule for next meeting week of 11 Nov in New York.