Golden Rules of Verification & Validation

Federal Aviation Administration

Presented to:

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Background

- **“Golden Rules of Verification, Validation, Testing, and Certification of Modeling and Simulation Applications” by Osman Balci**
  - Department of Computer Science, Virginia Tech
  - SCS M&S Magazine – 2010 / n4 (Oct)
  - “This paper presents 20 golden rules to guide an M&S practitioner in conducting verification, validation, testing, and certification. Proper application of these golden rules *increases the probability of success in establishing the sufficient credibility* of an M&S application.”
  - In this context, testing denotes testing the software, not physical tests/experiments.

Rule 1

- **“Model and/or Simulation (M/S) VV&T should be conducted hand in hand as integrated within the entire M&S application development life cycle.”**
  - V&V is not a single step in the M&S process, it is a continuous activity that needs to be integrated into the entire M&S program.
  - You need to evaluate your models and document the V&V activities as you build them.

Rule 2

- **"M/S VV&T outcome should not be considered as a binary variable where M/S accuracy is either perfect or totally imperfect."**
  - V&V is about quantifying the accuracy of the model.
  - "Accuracy assessment is made for each component, subassembly, and assembly in every level of the validation hierarchy for which validation data are produced."[1]
  - "Partial validation is not uncommon."[1]

[1] ASME V&V 10-2006

Rule 3

- **“An M/S is built for a prescribed set of intended uses and its accuracy is judged with respect to those intended uses.”**
  - The intended use of a model impacts the level of accuracy necessary to meet project goals.
  - “The adjective “sufficient” should be used in front of terms such as accuracy, verity, validity, quality, and credibility, to indicate that the judgment is made with respect to the prescribed set of intended uses. It is more appropriate to say “the model is sufficiently valid” than saying “the model is valid.””

Rule 7

- **“M/S accuracy can be claimed only for the intended uses for which the M/S is tested.”**
  - As we move away from the initial/boundary conditions that were evaluated during the validation process, the accuracy of the model is unknown (extrapolation).
  - This can also apply to interpolation.

Rule 8

- **“Complete testing is not possible for large and complex models and/or simulations.”**
  - “The question is not how much test data are used, but what percentage of the potential model input domain is covered by the test data. The higher the percentage of coverage the higher the confidence we can gain in model accuracy.”
  - This focuses on code verification, but can also be applied to validation of a complex system.

Rule 9

- **“M/S VV&T activities should be considered as confidence building activities.”**
  - V&V activities allow us to demonstrate the accuracy of our model and therefore build confidence that we are getting the right answer for the right reason.
  - “Credibility is related to the rigor of the verification and validation activities and the subjective relationship between the validation domain and the context of use.”[2]
  - Confidence combines accuracy and rigor.
    - How many features of my model did I test and how accurate are those features?

[2] Draft ASME V&V 40-201X

Rule 10

- **“M/S VV&T activities should be planned and documented throughout the entire M&S development life cycle.”**
  - Need to allocate resources to V&V.
  - Need communication between the analysts and the experimentalists.
  - For certification, need communication with the regulatory authority.

Rule 11

- **“Errors should be detected as early as possible in the M&S application development life cycle.”**
  - Do verification before validation, eliminate ‘math’ errors.
  - Find issues on component level models.
    - The errors can become masked in more complex models.

Rule 13

- **“Successfully testing each submodel (module) does not imply overall model validity.”**
  - “It is reasonable to expect that the accuracy requirement for component behavior will be more stringent than the accuracy requirements for the complete system due to the simpler nature of problems at the component level.”[1]
  - “Interaction effects that are not exhibited by the individual components are likely, such as effects of frictional interfaces and joints.”[1]

[1] ASME V&V 10-2006

Rule 14

- **“Formulated problem accuracy greatly affects the acceptability and credibility of M&S results.”**
  - A comprehensive definition of the project, documented in the V&V Plan, will assist in the allocation of resources and the understanding of roles and responsibilities.

Rule 15

- **“Type I, II and III errors should be recognized and prevented.”**
  - Type I Error: results rejected when they are sufficiently credible.
  - Type II Error: results accepted when they are insufficiently credible.
  - Type III Error: wrong problem solved.
- **Risks**
  - Model Builder’s Risk: probability of committing Type I Error.
  - Model User’s Risk: probability of committing Type II Error.

Rule 20

- **“Certification outcome should be presented with a level of confidence.”**
  - “The combination of CM&S influence and decision consequence drives the selection of the V&V activities and credibility goals needed to support CM&S.”[2]
  - The level of confidence we have in the results should impact how much we trust the decisions based on those M&S results.
  - If we have low confidence in the results, we need more supporting data.

[2] Draft ASME V&V 40-201X

Omitted

- **Rule 4: M/S VV&T requires independence to prevent developer's bias.**
- **Rule 5: M/S VV&T is difficult and requires creativity and insight.**
- **Rule 6: M/S VV&T is situation dependent.**
- **Rule 12: Double validation problem should be recognized and resolved properly.**
- **Rule 16: Certification should be conducted by an independent third party.**
- **Rule 17: Certification should be conducted concurrently throughout the entire development life cycle of a new M&S application.**
- **Rule 18: A certification agent should be accredited.**
- **Rule 19: M&S application sponsor should clearly dictate the rules of conduct between the M&S application developer and M&S application certification agent.**