Modeling and Simulation

Is VV&A the real stumbling block?

Are we using M&S correctly?

What is V&V if we use models correctly?

Ernest.Seglie@osd.mil

Modeling has not worked as often as we would like

- the **context** in which the modeling work is to be done,
- the **best uses** of modeling,
- the **environment needed** for successful modeling and a
- discussion of **reasons for the lack of success** in use of models.

Context for modeling

- Models should *help* critical thinking; then go test.
- Modeling is the hypothesis step of a scientific method. It generates the "I'll bet 'ya'" type statements that then should be tested.
- Models provide insight, they do not make decisions. They are not an answer-machine. "Good judgment comes from experience and experience comes from bad judgment." Allow decision-makers to get experience with the models – where the losses are only 'virtual.'
- Models provide a framework around which quantitative questions can be asked.

Best uses of models

- Hypothesis generation
- Sensitivity Analysis – models provide the logical consequences of explicit assumptions.
- Generation of imaginable situations. The "outlier" results are important and the reasons should be clearly understood. The range of situations and the range of responses are important to know. Policy makers need to appreciate the outliers as well as the most probable outcomes.

Best uses of models

- Scenario generation. "Unpack" the distribution to look at the 3-sigma case. The danger is that the assumptions become hidden.
- To facilitate a "rolling reassessment". This is as part of a feedback loop of Operations -> Field Data -> Data Analysis -> Quality Controlled Database -> What-if analysis with models -> Operations. Hard to start but becomes self-re-enforcing.
- Explicitly model the uncertainties in a problem.
- When there is nothing else to do. (e.g., nuclear case)

Best uses of models

- In some cases, nothing else will do better. Mostly to crystallize thinking on some point.
- To accelerate knowledge. To help in the visualization of results or technology transfer. The workers in the program must internalize the results.
- Sharpen critical thinking.
- To suggest experiments that are difficult, and would not get done if the importance of them were not demonstrated by modeling.

Environment needed for successful modeling

- Multidisciplinary team including operational expertise, engineering, physical understanding, mathematical, statistical, etc.
- Understanding the fundamental processes modeled.
- Mathematical understanding. Models must be analyzed and understood well enough to reformulate them when required.
- Computational power

Environment needed for successful modeling

- The use must be timely and meet resource constraints
- Ease of use determines use. From the industry perspective, spread sheet models were the ones used most, because people understood them.
- Models must account for people and this is difficult.
- To make the modeling work requires the right data at the right time and at the right place.
- Integration of diverse models is difficult and requires a special environment.
- Simulation has to have feedback from field data.

Lack of success in use of models

- Inadequate physical modeling.
- Inappropriate formulation or representation of the problem.
- Inefficient computational procedures or the use of (COTS) software environment.
- Ill-conceived multi-disciplinary integration.
- Lack of procedures to assess magnitude, propagation and impact of uncertainty.
  The explicit identification of uncertainty needs to be clear to the audience.

Why a modeling effort can fail, other items

- The divisive effect of jargon to the communication between multidisciplinary team members.
- Few existing value/reward systems actually reward collaboration.
- Funding sources deal awkwardly with multidisciplinary work
- Isolation of modeling community.
- Difficulty in integrating models of different resolution.
- The practical sociology between modelers and decision-makers

How uncertainty could arise?

- Missing components or potential errors in inputs
- Known processes but unknown functional relationships
- Known structures but unknown or erroneous values in some important parameter
- Unknown appropriateness of underlying assumptions
- Noise in data, bias or incomplete observation
- Historical data not accounting for changes over time
- Stochastic nature of process
- Uncertainty due to projections
- Human behavior
- Numerical processes

Conclusion, and implications for testing

- Policy makers at high levels are just interested in an answer such as: what will happen. Instead they should be interested in what can happen, what are the odds and how do we know.

  In short, modeling should be an aid to clear thinking not a substitute for it.

How could DoD incorporate these insights?

- Integrate modeling into development and decision process.
- The proposal to use modeling should wait until:
  - A multi-disciplinary team is functioning.
  - The feedback loop has worked through the cycle, and the model has been used in some early operational assessment;
  - The model sufficient resolution so that the testing planning parameters can be, and are, calculated using the model.
- At that point the model should be able to provide on-going evidence that it is a useful tool to aid clear thinking, is integrated into the program processes, and is contributing to the program.

How could DoD incorporate these insights?

- In TEMP: the modeling should provide estimates of the resources, and scenarios needed in the IOT&E (for example, number of test items, number and type of scenarios, other resources such as threat type and size.)
- As part of the test concept brief to OSD, the model, using the current values of system parameters from testing to date should predict the OT&E results and provide sensitivity analysis around those points.
- The above suggestions amount to a shift in emphasis.