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USING PROJECT OBJECTIVES TO DRIVE SIMULATION QUALITY CONTROL

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ABSTRACT

How do we know if the results of a simulation analysis are useful, accurate, reliable and credible? This is an important and fundamental question. If a simulation produces invalid results, yet the client accepts and acts upon them, then they're heading into a world of pain. Just as bad is the situation in which the results are valid but are distrusted by the client and so are disregarded. In both cases, the outcomes can be catastrophic for the client. If the model is invalid, and the client rightly rejects it, then we've wasted our time and dented our credibility. The usefulness, accuracy and reliability of a simulation model—and the client's trust in its results—are key factors for a successful outcome; this presentation will demonstrate how project objectives should drive the model's content, its verification & validation, and experimentation.

1 INTRODUCTION

Many simulation software vendors promote the idea that their software is easy to use, and that, with a little training, anyone can build and use simulation models. That's largely true. But are the resulting models useful, accurate, reliable, and credible, and do they address the problems the client is facing?

The statistician Dr. George E. P. Box once famously observed "essentially, all models are wrong, but some are useful", referencing the fact that models are simplified versions of the systems they purport to represent. But there are varying degrees of *wrongness*, and the *usefulness* of the model will depend upon how well it addresses specific requirements; usefulness depends upon both your objectives and the nature of the model.

2 CLARIFY AND STATE OBJECTIVES

Let's start by assuming that we have a client whose issues can be resolved through a simulation study.

Firstly, define the *objectives* of the simulation study. This is the most critical step in the project. The behavior of the model we end up with will be dictated by these objectives; given different objectives, we'll create a very different model.

Ruthlessly prune the project's objectives to only those that really matter, simplifying the resulting model, speeding up the project in the process, and quickly providing value to your client.

Objectives must be specific, measurable goals that the simulation study must achieve.

3 SPECIFY, REVIEW & APPROVE THE CONCEPTUAL MODEL

Next, we must consider the model that will fulfill these documented objectives.

Some objectives will require the simulation model to process one or more *inputs*, also termed *factors*, *model parameters*, etc.; they provide instructions for how each simulation run can be configured.

Inputs that do not address any of the objectives are superfluous and can be eliminated. Each input should be precisely defined and documented in the conceptual model specification.

As the objectives are measurable, they must dictate the *outputs*, also termed *responses*, *statistics*, *key performance indicators*, etc., that report required aspects of the model's performance, subject to its inputs.

Outputs that do not address any of the objectives are superfluous and can be eliminated. Each output should be precisely defined and documented in the conceptual model specification.

We can define *initial experiments* to address our objectives. (Additional, *further* experiments, may arise during initial experimentation). These experiments identify how we must configure simulation runs, collate and analyze the results, and satisfy our objectives, and should be documented in the specification.

What model will accept these inputs, perform the necessary actions, then generate and report the outputs? Interview the client's *subject matter experts* (*SME*s) to comprehend the system and its behavior.

There are two controls on model complexity. The first is its *scope*, determining the processes that will be included. Criteria: If omitting a process compromises the required accuracy of the outputs, then it must be included and documented; if not, then document the rationale for excluding it as a *modeling assumption*.

The second control is to define the model's *level of detail*, the modeled behavior of the included processes. As Albert Einstein said: "Everything should be made as simple as possible, *but not simpler*." Allow all simplifications that do not compromise output accuracy and document as modeling assumptions; document required behavior in detail, as this will form the basis of later *model verification*.

The client and their SMEs can and should assist determining the impact of these modeling decisions, which are necessarily subjective. Err on the side of widening scope or including additional detail if in doubt.

Review the specified model with the capabilities of the chosen simulation software. It should be possible to implement the conceptual model in just about any simulation product, but it's also possible to mow a football field with a pair of nail scissors. If implementing the model is going to prove challenging, consider using a different simulation tool, simplifying your objectives to eliminate the difficulty, or accepting that constructing the model will take more time or resources than you anticipated. Never make modeling assumptions only due to limitations in your software!

Finally, review the specification with the client and their SMEs, and have them sign their approval.

4 DEVELOP, VERIFY, VALIDATE & APPROVE THE COMPUTER MODEL

Only now is it time to translate the conceptual model into a computer model. This should be done iteratively using *defensive programming* techniques, such as using *assertions*. Make use of *encapsulation* to simplify interactions between model components. Verify behavior against the specification continually. Automated testing is highly recommended to save time and ensure testing thoroughness. Assume the model is buggy and verify it performs correctly, fixing issues in the process.

Review the modeling assumptions and validate the completed model with the client and their SMEs. To this point, it will not have been possible to execute the conceptual model, so errors in the conceptual model are possible. Assume the model is invalid, validate its behavior in detail, correct errors as necessary.

By engaging the client and their SMEs throughout the project, there should be no problem with their credibility of the model once it has been validated. Ensure they formally sign their approval of the model.

5 EXPERIMENTATION

Never conduct experiments on, or report results to the client from, an unapproved model; if model results change due to fixing bugs or correcting invalid behavior, it will destroy the client's credibility in the model.

Once the model is approved, undertake the initial experimentation and satisfy the project's objectives.

Often, you'll identify problems with the system being modeled, requiring changes be made to it. It's essential that these changes be represented by the model to demonstrate that they resolve the problems identified. This is termed further experimentation, and may require changes to the objectives, specification, and model; ensure that the changed are reviewed and approved as appropriate.

6 SUMMARY

The project's objectives dictate the inputs, outputs & experiments. These dictate the content and behavior of the model. The content dictates the verification & validation. Craft the objectives carefully and stay focused on them through the project. Keep the client engaged throughout the project, ensuring credibility.