Simulating in the Real World

IIE Solutions April 2001
by Jerry Banks and Randall R. Gibson
View the PDF.

The process of conducting real simulation studies differs from the idealized process often presented in marketing literature, textbooks, and many published articles. Simulation practitioners soon discover that reality differs from theory, and in the process of learning this hard truth, they are faced with a number of myths. In fact, for every step in the simulation process, there seems to be a corresponding myth..

Step 1: Problem formulation Clearly state the problem and define the study goals

Myth: The client understands the goals of the project. The client will usually not have a clear understanding of, or internal agreement on, the project goals. But all of the members of the client's staff will have questions they want answered by the model. These questions often are at odds with the initial project scope or assumptions. It is up to the simulation analyst to help synthesize these into clear project goals and priorities, reconcile them with project assumptions, and obtain agreement among the client's project staff before proceeding further with the study. Neglecting to do so means risking failure of the project if the model does not address a key issue of concern to management.

The project objectives need to be stated clearly in writing. Without a written record of the goals of the project, the simulation analyst will be at the whim of the client's recollection, which may not be accurate.

Step 2: Setting objectives and overall project plan Plan the

schedule and resources for the project, including staffing needs and review meeting dates.

Myth: After the kickoff meeting, the client need not be involved until the presentation of results. Simulation analysts who follow this procedure are in for a rude surprise. The client should be involved during the entire simulation process. When the problem is formulated, the client's input should be sought. The client should verify the list of assumptions. Data collection needs should also be discussed with the client. After the initial model is developed and there is some output, the client should provide input on the interpretations and findings. When the final version of the simulation model is developed, the client should again review the output that is being generated. The client should help in the preparation of the final report to help determine whether the output is realistic. Often, the client is involved in the presentation of the final report to managers. Without client involvement throughout the simulation process, there is a great risk that the client will not accept the results and the implementation stage will be ignored. If this happens, the project will be regarded as a waste of time and money, an the simulation team will likely be blamed.

Step 3: Model conceptualization Extract the essential features of the problem, select proper assumptions, and complete the model design.

Myth: Assumptions relating to the system are accurate. Early in the simulation process, the simulation analyst develops a list of assumptions to limit or control the scope of the project and the level of model detail. This is analogous to the meeting between the umpires and managers before a baseball game, at which time the rules of the park are discussed. The umpire might say, "If the ball hits that yellow advertising sign on top of the wall in in left field, it's a home run. But if the ball rolls in that drain over there in right field, it's a double." In simulation, it might be said this way: "We won't include the shipment of subassemblies from Johnson Manufacturing in our model. We will simply assume that they are at the right place at the right time when needed." The assumption list is critical, but it can be inaccurate. It is important to continue to review it as the simulation analyst becomes more familiar with the system.

Step 4: Data collection Identify and collect input data for the model.

Myth: The client has the data we need. Actually, there are several parts to this myth. First, the client often doesn't even know what data they have. The client might say that the data exists, but it doesn't. The client might say that the data doesn't exist, but it does. Second, the data is usually in the wrong format. We want orders from a distribution center by shift, and the client has it by the month, for example. Third, the data can be stale. The client has the data for a time period that ended 12 months ago and we want the data for the past 12 months. Fourth, the client will probably not know how to collect data correctly. Be explicit and complete in creating and reviewing a written plan for how the processes are to be observed and how data samples will be collected and verified. Plan on spending two or three times as long to complete this step as you initially think is necessary.

Step 5: Model translation Constructing or programming the model.

Myth: Model construction will follow the "40-20-40" rule. This rule of thumb is that only a minor part – 20 percent – of the project effort should be involved with model construction. The bulk of the time should be spend on project planning and design (40 percent), as well as testing, analysis, and obtaining useful results (40 percent). Although this general rule is a valid guideline, the actual split is more like 40–40–40, meaning that the model construction usually takes longer (twice as long or even more) as planned. Developing and debugging valid models — even with the powerful software available today — is still time-consuming.

Step 6: Verification Test the model to see if it is correct and complete.

Myth: Animation is everything. This is a very dangerous myth. Animation is important for visualizing and demonstrating how the system will work and for spotting obvious problems (during preliminary model verification). But interpreting the numerical output of the model is much more important. Relying on observation of the animation for verification is not only tedious, it can be misleading and almost certainly inconclusive. Animation may be worth a thousand words for a presentation, but it is not worth a thousand statistical results. Use is for its intended purpose: to visualize system interactions and augment understanding the results of the statistical output analysis.

Step 7: Validation Determine if the model is an accurate representation of the real system.

Myth: Someone in the facility can tell you how the place operates. Don't bet on it. There is rarely one person that knows everything about a facility, and the necessary information is never found in written form. The simulation analyst needs to talk to lots of people to understand how the system operates. He or she needs to verify the information by observing the real system: what the client thinks is true may not be. At this point, the simulation analyst might know more about the facility than any one person who works there. Summarizing this in written form and obtaining agreement and approval from the client during the conceptualization step is crucial and will be required again during validation to compare the model output to the real system. This quest for knowledge often results in solutions to problems even before the model is built.

Step 8: Experimental design Determine which and how many model experiments (or runs) are needed.

Myth: A few model runs are all that are needed. Don't shortchange the project. Design of experiments, determining how many model replications will be needed for each experiment, and generating the necessary model run outputs is a significant part of the project. A common mistake is not taking the time to make additional runs that may be suggested by the initial results. Following the sequence of hypothesize–simulate–analyze–interpret will require time but can produce additional insight into the system and value from the project. An inexperienced simulation analyst may plan only a single series of runs and not allow the time necessary to look deeper into the (simulated) system by pursuing these additional analysis trails.

Time budgeting in the model–building phase is key here. There needs to be a definite freeze point on model building, verification, and validation. When the model is modified or additions are made, the whole V&V process needs to be started again. This cycle of build – verify– validate has been the downfall of many an analyst. When the time comes to do experimentation and give real value, there is no time left.

Step 9: Production runs and analysis Run the model to generate

results for defined scenarios.

Myth: All you need is one long model run to develop sufficient results. Output analysis is too often limited or inappropriate. There are lots of excuses given for this. For example, some simulation analysts studied engineering statistics a long time in the past and have forgotten most everything they knew about the topic. Relearning this material might be a pain they don't want to endure. They rationalize their unwillingness to learn by making a long run of the simulation and using the output measure from that run. But the variance from one observation is nonexistent, so no confidence interval determination is possible. In addition, a single model run may highlight unusual process interactions or correlations that occur infrequently (it just happened to occur on this run), leading the analyst to incorrectly conclude that these events and the resulting system behavior are normal.

Step 10: More runs? Determine if more runs are needed and which ones.

Myth: The numbers tell the story. We are not after numbers. We seek understanding. How do you determine if you have generated the necessary results from the first runs? A cursory review of output data from a few model runs is usually not sufficient and can even be misleading, showing any snapshots of the true system behavior. Building an understanding of the simulated system and its behavior requires investigating and correlating a variety of output performance measures across multiple analysis scenarios, as well as many model runs. Often, these will need to be displayed in graphical form to see trends or important relationships between variables. The simulation analyst may need to design specific measures of performance that get to the heart of the analysis issues. These will usually need to be formatted before presentation to a client to avoid confusion. Questioning the results is often necessary, and confirming them through further experiments may be required. This level of understanding takes time, experience, and a knowledge of the underlying processes in the simulated system. You can't analyze (output data form) a system that you don't understand.

Step 11: Documentation and reporting. Document the project, model, and results.

Myth: Documentation and reporting are only important if the client requests them. This is absolutely not true. You never know who will question — or challenge — the model assumptions, procedure, scope, or results later. Documenting what was done and agreed upon (and by whom) is critical since the analyst may not remember or may not be available for consultation. Or the client may disagree with the analyst's recollection. Documentation and reporting are often needed later, when the client asks for additional explanation of the results, for more analysis, or for more development of the same model. This can happen months or even years later. It can be difficult for the same simulation analyst to pick up a model one year later, and much more difficult for someone different to pick up the model. But with proper documentation and reporting, it is quite possible to return some time later and pick up the trail.

Step 12: Implementation. Put the results to use.

Myth: There will be time for the model results to influence decisions. If only this were true. All to often, a simulation study is commissioned only as a last resort when the client realizes that they may be in trouble. Usually, this is late in a project schedule — just prior to committing to a design or ordering equipment. There wasn't time planned for this step. The simulation model is suddenly urgent. If the simulation analyst or team takes too long to complete the model and results, the client may make the decisions and proceed anyway to stick to the original schedule — even if the model shows problems with the design.

As Shakespeare said, "All that glitters is not gold." And so it is with simulation. Don't believe everything that you have heard or read.

JERRY BANKS retired from the School of Industrial and Systems Engineering at Georgia Tech in 1999.   and joined Brooks Automation, AutoSimulations Division as Senior Simulation Technology Advisor. He is the recipient of the 1999 Distinguished Service Award from INFORMS-CS.

Randall Gibson is president of Diamond Head Associates, Inc., a consulting firm based in San Diego, California, that specializes in supply chain strategy, analysis, and performance improvement. He is a senior member of IIE.