Proceedings of the 1996 Winter Simulation Conference
ed. J. M. Charnes, D. J. Morrice, D. T. Brunner, and J. J. Swain

SO YOU WANT TO BE A SIMULATION CONSULTANT

John S. Carson II

AutoSimulations
1827 Powers Ferry Road
Bldg 17, Suite 100
Atlanta, Georgia 30339, U.S.A.

ABSTRACT

This presentation is for those who want to be a simulation consultant, whether in an independent consulting company or within a consulting group in a larger company. Both practical project management and good technical fundamentals are critical for success. Does a simulation consultant need to be an expert in all disciplines? Does he or she need to be an engineer, a modeler, a statistician, and a computer scientist? The ideas presented in this tutorial are based on many years of practical simulation experience. Examples from real-world projects will be used to illustrate various points. The author's woeful experience will be used to illustrate pitfalls to avoid.

1 INTRODUCTION

Practical project management and sound technical fundamentals both play key roles in being a successful simulation consultant. Section 2 provides a brief overview of the key management issues; section 3 covers some of the technical issues that have arisen in the author's experience over 20 years in consulting, model development, and management of simulation analysts. During the first part of the presentation, the author will reveal his biases and discuss his past and present employment and simulation experience.

2 MANAGEMENT ISSUES

A well managed simulation project proceeds by a set of steps that provide general guidelines for success (Banks, Carson and Nelson 1996, Law and Kelton 1991). Some steps involve mostly the simulation analyst, but all involve the customer or model user to a more or lesser extent. These steps include:

- Problem formulation:
    - Statement of objectives
    - Specification document
- Model design
- Data collection
- Model development
- Verification and validation
- Experimentation and analysis
- Documentation

Although called "steps", in reality they are activities that the consultant will do repeatedly and iteratively, often not exactly in the order outlined here. An excellent set of guidelines for implementing these steps in a project are presented in Musselman (1994) in an entertaining and instructive fashion. In the following subsections, we discuss some of the key ideas.

2.1 Problem Formulation

Good communication with the customer is the single most important key to success. Communication includes determining the customer's true problem, setting objectives, setting project scope, coming to agreement on model assumptions, and developing understanding of model input requirements and model outputs. These items should be formalized in a Specification Document and a Project Plan.

2.2 Model Design

Model design involves abstracting the system and determining its elements and their interactions. The objectives and questions being asked determine the level of detail of each of the model's components.

2.3 Data Collection

To assist the customer in collecting the necessary data, the consultant must identify and clearly define the data needed to drive the model. While the model itself determines what data is needed, practical considerations and data availability may affect a model's structure and level of detail. The consultant should question the data:

How was it collected? How was it measured? Are their outliers that do not make sense? Has the process fundamentally changed since the data was collected?

2.4 Model Development

Keep the model as simple as possible. Any complexity introduced should be related to project objectives; without it, it would be impossible to address one of the questions being asked. Always keep in mind that the project goal is not to get the model running, but to provide possible solutions and insights into the customer's problem.

2.5 Verification and Validation

To verify the model, the analyst attempts to confirm that it works as intended. A good test for model robustness is to make as many runs as computer time allows, as soon as the model is running, over different random number streams and scenarios; a quick check for reasonableness of key outputs and re-running the scenarios with errors to make fixes is a powerful way to move in the direction of model accuracy. If the model runs perfectly, you haven't tested it enough.

To validate the model, the analyst involves the customer to assure, within reasonable accuracy, that the model corresponds to the real world system, or for new systems, meets customer expectations. Before validation, the model must be updated with the customer's most recent and accurate data.

Keys to success include regular model reviews with all members of the customer's team, controlling (and minimizing) changes in scope and assumptions, and most importantly, quick fixes for any perceived problems. If the customer thinks it's a mistake, it is.

2.6 Experimentation and Analysis

Conduct experimentation with the Base Model as early as possible, even before the model is complete. Early feedback keeps the customer's attention. Capture numerous outputs beyond the primary outputs that address customer's questions; model verification continues throughout model experimentaiton. Question and thoroughly examine all outputs.

Keep in mind that the purpose of modeling is to provide insight and offer possible solutions. It does not replace careful analysis and human thought. It can help in avoiding costly errors and can suggest solutions, but it does not provide *the answer*.

2.7 Documentation

With updating, the Functional Specification Document provides the basis for documentation of model assumptions, model inputs and outputs. Monthly progress reports for longer projects, and written confirmation of assumptions discussed over the telephone, are also important. Internal documentation of model components (resources, variables, etc) is invaluable when a model is modified at a later date.

3 TECHNICAL ISSUES

Simulation modeling and analysis requires a range of skills and fundamental technical competencies.

3.1 Simulation Software: Power versus Ease of Use

Many articles have been written on simulation software, including the overview by Banks (1995) and articles written by vendors in each year's Proceedings of the Winter Simulation Conference. One point to consider for the budding simulation consultant: The package that is easy for an end user who develops the occasional simulation model, may or may not be the right tool for the consultant who does models of larger and more complex systems, especially data-driven generic or template models that allow a user to select from a wide range of scenarios.

If a package requires no programming, then somebody somewhere who never saw your customer's system wrote the model for it. Are you buying a house, or the hammer and the saw? It may be easy to use off-the-shelf for direct models, but will it help you build a more generic model that will cover all desired scenarios and be easy to use by your customer? Do you like pulling teeth (your own)?

Talk to a number of independent simulation consultants who use a range of products and find the one (or ones) most suitable for the types of systems you simulate. (Forget not the author's biases.)

3.2 Knowing the Insides

A detailed knowledge of the simulation package's internals is essential for knowing exactly what your model is doing, and for debugging those complex situations that often arise in a consultant's life between midnight and 3 am. For details and examples of how seemingly similar models can do quite different things, see Schriber and Brunner (1995).

3.3 Statistical Issues

Papers on statistical guidelines and pitfalls in input modeling include Vincent and Law (1995); background material is provided by Leemis (1995). Kelton (1995) provides an overview of experimental design and output analysis.

3.3.1 Do Downtimes Matter?

Low frequency, high impact downtimes make huge differences in throughput; for example, for one downtime per day of duration 6 hours on average, the statistical distribution assumed makes a large difference in many model outputs. High frequency, short downtimes (many downtimes per production cycle, each of short duration) can often be accounted for with a deterministic adjustment to production rates, without causing undue changes to model output.

3.3.2 Animation

Statistical analysis is no substitute for a good animation. The most technically competent statistical analysis will do no good without model credibility. The single tool that has increased modeling credibility the most in recent years is animation.

A good animation requires a good story line and immediate recognition by the customer. A good animation provides insight into poor system performance and directs attention toward problem areas. However, without a good explanation of why something is happening, its value decreases and credibility suffers. A poor animation is like a cartoon with the sound turned off.

3.4 Other Topics

When do statistical replications matter? What can you compute ahead of time to verify models? What types of systems are prone to model lock-up and can have too simple a model? What type of data do customers most often provide incorrectly? It's difficult to tell when steady state is reached, but how do you tell if it's ever reached? How do you model rush hour or seasonal arrivals?

4 SUMMARY

Both practical project management and technical competency play key roles in successful simulation consulting.

REFERENCES

Banks, J. 1995. Software for Simulation. In *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W.R. Lilegdon, and D. Goldsman, 32-38. Arlington, VA.

Banks, J., J.S. Carson, and B.L. Nelson. 1996. *Discrete-Event System Simulation*. Second Edition. Upper Saddle River, NJ: Prentice-Hall.

Kelton, W.D. 1995. A Tutorial on Design and Analysis of Simulation Experiments. In *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W.R. Lilegdon, and D. Goldsman, 24-31. Arlington, VA.

Law, A.M. and W.D. Kelton. 1991. *Simulation Modeling and Analysis*. Second Edition. New York: McGraw-Hill.

Leemis, L.M. 1995. Input Modeling for Discrete-Event Simulation. In *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W.R. Lilegdon, and D. Goldsman, 16-23. Arlington, VA.

Musselman, Kenneth J. 1994. Guidelines for Simulation Project Success. In *Proceedings of the 1994 Winter Simulation Conference*, ed. J.D. Tew, S. Manivannan, D.A. Sadowski, and A.F. Seila, 88-95. Lake Buena Vista, Florida.

Schriber, T.J. and D.T. Brunner. 1995. Inside Simulation Software: How It Works and Why It Matters. In *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W.R. Lilegdon, and D. Goldsman, 110-117. Arlington, VA.

Vincent, S. and Law, A.M. 1995. ExpertFit: Total Support for Simulation Input Modeling. In *Proceedings of the 1995 Winter Simulation Conference*, ed. C. Alexopoulos, K. Kang, W.R. Lilegdon, and D. Goldsman, 395-400. Arlington, VA.

AUTHOR BIOGRAPHY

JOHN S. CARSON, Senior Simulation Analyst, has been with AutoSimulations since 1994. He has over 20 years experience in simulation modeling for manufacturing, distribution, warehousing and material handling, transportation, port operations, and medical/health care systems. He has been a simulation consultant, and has taught at Georgia Tech, the University of Florida, and the University of Wisconsin-Madison. He is the co-author of two textbooks, including Discrete-Event System Simulation, Second Edition (1996). He holds a Ph.D. in Industrial Engineering and Operations Research from the University of Wisconsin-Madison, and is a member of IIE and INFORMS.