SUCCESSFUL SIMULATION PROJECTS - A GUIDE FOR CLIENTS

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Abstract

The title of this paper indicates that it is addressed to clients who have simulation models built for them. However, it is really equally addressed to those who build the models for the clients! The major message is that working with the client throughout the project is essential to a successful project. The specific roles the client and simulation consultant will play in the various phases of a project are discussed. In particular, the client is a key figure in conceptualizing the model, validating it, and using it. This does not reduce the simulation consultant to a mere programmer. On the contrary, it means that doing simulation is as much or more a process of working with people to achieve certain goals, as it is a process of working with the computer.

INTRODUCTION

We are a group of internal consultants in Du Pont, specializing in operations research and simulation models. By "internal consultants", I mean that we serve clients within the Company who "hire" us for specific projects. There is a written contract describing the work and cost, and a payback system whereby the client's budget is debited for the time and computer cost of our work. Clients in Du Pont don't have to use our services; they are free to use external consultants, or none.

This keeps us honest. While not every simulation consultant is in such an entrepreneurial consulting relationship with the client, I believe that the approach to simulation projects which we have found to be successful applies to any simulation project.

I want to describe how a typical large simulation project develops in our group. What I want to stress above all is this:

> The client is deeply involved in all stages of the project, and must make a commitment of time and attention. In very large part, the success of the simulation project depends on client involvement.

To give an idea of the level of effort required, the client effort on a recent project was estimated at about 6 client-months. This client effort included running all the case studies, as well as the time put into the model development phase. Note that this is quite a large model. At the other extreme, one small model required about 3 client-weeks of effort from development to end of study.

There are several identifiable phases in a typical simulation project:

1. INITIATION
2. SYSTEM ANALYSIS
3. MODEL CONSTRUCTION
4. CASE STUDIES
5. MODEL MODIFICATION

INITIATION

The client decides that there is a problem on which our group may be able to help. Someone in the group will explore the problem with the client in general terms to determine if the problem really falls under our expertise. Then, usually, an initial meeting with the client and relevant personnel is set up.

At this meeting, the main goals are to agree on the study objectives, discuss the general background of the problem, set the boundaries of the system to be studied, and agree on the assumptions and general level of detail. In addition, the next step must be decided on. For example, it may be possible at this first meeting to decide that simulation is an appropriate tool,

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and that the client wishes to go on to the next phase of the project. Or it may require further exploration to decide how and whether to attack the problem.

Suppose that the client has decided that simulation promises to provide the information needed. At this point, if the project is fairly large, the consultant cannot give a very firm estimate of what a complete simulation project will cost. A very rough estimate for the complete project can be given to help the client look ahead, but this estimate might be off by 100%. However, a much firmer estimate of time and cost (say, within 10%) can be made for the next phase of work: System Analysis. At this point, the client makes a decision whether to go on to the next phase. The decision to go on to System Analysis commits the client to a substantial expenditure of time.

We can summarize the Initiation phase as follows:

- Goals

  Client and Consultant:

  - Define in general terms the system to be studied.
  - Define the broad objectives of the project.
  - Define, in very general terms, assumptions and level of detail to be used.
  - Define in general terms the results to be provided.

  Consultant:

  - Give a firm estimate of time and cost for the next phase.

  Client:

  - Decide whether to proceed to next phase.

- Method

  - One or more meetings of consultant, client, and relevant personnel.
  - Phone interviews.
  - Examination of client-supplied data, drawings, charts, etc.

- Results

  If client decides to go to next phase, consultant prepares:

  - Report of work and results to date, including description of all items under "Goals".
  - A request for funds for the next phase.

SYSTEM ANALYSIS

In this phase of the project, the general conclusions of the Initiation phase are made concrete, specific, and detailed. To a large extent, the model is built conceptually in this phase. But no computer programming is done yet. At the end of this phase, a reasonably firm estimate can be given of the time and cost for completion of the rest of the project.

It should be understood that the separation of System Analysis from the subsequent phases of project development only occurs for large simulation project. In small ones, things proceed so rapidly that in essence there are only two phases to development - Initiation and Construction/Use. Even in a large project, System Analysis and Model Construction may merge somewhat.

The consultant and the client each have important goals in the System Analysis phase. They also have joint goals.

The consultant has the primary goals of working with the client and relevant personnel to do the following:

- Gain a detailed, accurate, quantitative understanding of the system to be modeled;
- Describe the system in detailed documentation;
- Establish a firm estimate of time and cost for the rest of the project.

The joint goals which the client and consultant have are these:

- Decide together on the specific assumptions and level of detail;
- Decide together what the data input will be;
- Decide together what the specific quantitative output will be.

The client is crucially involved in deciding on the assumptions and level of detail because of the following fundamental points:

No real system can be modeled with total accuracy.

No real system needs to be modeled with total accuracy.

The reasons why a system cannot be modeled with total accuracy are these:

- Parts of the real system are too complex. It is impractical to model these in complete detail.
- Input data describing the system are subject to uncertainties in measurement.

- It is not known with precision exactly how parts of the system operate.

Fortunately, there are reasons why a system need not be modeled with complete accuracy. They are these:

- The model is built to provide information to answer certain specified questions. Detailed modeling of certain aspects of the system may have no significant effect on this information. These aspects can be modeled in a less detailed way.

- Much of the information needed by the user is statistical, in terms of probabilities, averages, maximums, minimums, histograms. Statistical modeling of parts of the system in terms of averages and probabilities can be adequate to provide this information.

- Simplifications in the model consistent with the uncertainties in the input data do not affect the real quality of the information coming out of the model.

- The user needs answers to questions only with a certain degree of accuracy. Simplifications of the model consistent with such accuracy cause no decrease in usefulness.

When the opportunities for simplification correspond to the problems of modeling with complete accuracy and detail, a successful model is possible. Simplification also means decreased time and cost to build the model.

It should now be apparent why the client is deeply involved in deciding how the system will be modeled, and in deciding what the input and output information will be. The consultant must make the technical decisions required by computer and simulation technology about how to model, but the decisions about how to conceptualize the system with simplifications which do not sacrifice the model's purpose can only be made by the client and the consultant jointly. The consultant can suggest simplifications and discuss their implications; the client must judge their acceptability. Furthermore, the client must judge the practicality of providing the required input data, and the usability of the output information.

The consultant has some further objectives growing out of the joint goals. Earlier we said that the consultant must describe the system in detailed documentation. But with respect to the model, the consultant must also:

- Describe how the system will be modeled, making explicit all agreed on simplifications and assumptions.

- Describe in detail the input data required.

- Describe in detail the output information to be generated (the exact format need not be decided yet, but the content is to be specified).

Usually the description of the system and the description of how it will be modeled are combined into one document.

The goals of the System Analysis phase which are specific to the client all grow out of the joint goals discussed above. The client must:

- Decide whether the simulation model will represent the real system adequately for the client's purposes;

- Decide whether the required input data can be obtained with reasonable effort and accuracy;

- Decide whether the output information will answer the client's questions;

- Decide whether to continue with the project when the estimates of time and cost to complete the conceptualized model are made.

It is clear from the discussion above that the client must make a large commitment of time and effort to the System Analysis phase. The commitment continues - to a somewhat lesser extent - in Model Construction.

MODEL CONSTRUCTION AND REPORT DESIGN

The format of reports can make the reports convenient and useful for the client. In some cases, successful use of the model at the client's site depends on the reports being in a suitable format; if they are not, the model will be neglected.

Obviously, the client is strongly involved in suggesting and approving the design of reports. But the client will be involved also in the model construction itself, as explained below.

Model construction, which is the actual programming of the model for the computer, is the responsibility of the consultant. But as programming goes on, questions will inevitably arise that were not answered previously, and the consultant will turn to the client for additional discussion. Also, further simplifications may suggest themselves, or unforeseen problems may require consultation with the client to find a resolution. The client may initiate some changes in the previously established decisions on how to model the system, either because new information about the system becomes available, or because the client's needs change. Decisions about how to model the system are not fixed for all time at the end of the System Analysis phase. However, changes introduced later may affect time and cost to complete the project. For all these reasons, the consultant and the client have an on-going interaction as the model is programmed.

Two other important activities occur in this phase: debugging the model, and validating it. To some extent, particularly with debugging, these activities will not necessarily follow sequentially after the programming of the model, but will be mingled with it. The bulk of validation may occur after programming, however.

Debugging covers essentially two activities. First, as surprises no one, programs when first written usually contain mistakes which makes it impossible for them to run on the computer. These mistakes must be identified and removed.

Second, once the program will run, the question arises, does the program operate exactly as the consultant and client have conceptualized it? There can be many subtle interactions, especially in large programs. The consultant must extensively test the program with specially prepared data, and analyze the output, to be as sure as possible that it is operating as intended.

Debugging is the responsibility of the consultant. Validation is the joint responsibility of consultant and client. Validation means this: the model has been programmed and debugged - it is running as intended, which means according to the detailed description of the model jointly established by the consultant and client; but does the behavior of the model adequately represent the behavior of the system? Does the model behave realistically enough so that the information it generates can genuinely help answer the client's questions?

There are many steps which can be taken to validate the model, depending on the particular application. If the model represents an expansion of an existing system, for example, it can be run with input data which matches historical conditions, and the results checked against the actual system experience. On the other hand, if the system does not yet exist in any form, the judgment of the client must be mobilized to examine the reasonableness of model results in test cases, along with the consultant's knowledge of the inner workings of the model to explain why it behaves as it does.

In any case, the client is the key in validation. The model must be demonstrated to be valid to the client. Generally, this requires a cyclic process of test case, client judgment of results, consultant analysis of model behavior, model modifications or satisfactory explanation to the client of the results, and around again, until the client is satisfied.

It should be noted that debugging and validation are not as separate as I have painted them. The client's skeptical response to test case results often reveals a bug still hidden in the model!

We can summarize the Model Construction phase as follows:

- Goals

  Consultant:

  - Design reports to suit client's operations.
  - Program model.
  - Debug model.
  - Demonstrate validity of model to client.
  - Prepare instructions for client to use model, and instruct client in its use and interpretation.

  Client:

  - Become convinced of validity of model.
  - Learn how to run cases using the model.

- Method

  - Consultant: computer programming, queries to client, computer runs with test data.
  - Client: response to specialist's queries, examination of model results, comparison with client data and experience.

- Results

  - Completely programmed model, debugged, validated, ready to run case studies.

CASE STUDIES BY CLIENT

We believe it is important and useful to let the client access the model and run cases with it. Our computer systems and the simulation language we use make it easy to set the model up to do this. Our models are also written to be as data-driven as possible, so that the client has great control over the model structure simply by changing input numbers.

Some will argue that the client shouldn't be allowed to touch the model for fear of misuse or misinterpretation. However, after the intimate collaboration of client and consultant that has already been described, there should be no serious problems. Part of the consultant's task in the System Analysis phase is to make very clear the limitations of the model and the correct interpretation of results. The consultant is also available for advice and troubleshooting.

Moreover, we believe there are significant advantages to putting the model in the hands of the client. The client is in a far better position than the consultant to decide what case studies to run. The client has the best knowledge of

- the real system and its environment
- the array of questions to be addressed
- the priorities on those questions

especially since the system, the questions, and the priorities are always in flux. Since our models are basically data-driven, the client can keep them up to date and continue to use them through a long useful life.

Another advantage accrues from the client's experience with the model, leading to the next phase of the project.

MODEL MODIFICATION AND EXPANSION

The client's experience with the case studies, combined with the client's evolving needs, often suggests ways the model might be modified or enhanced to provide further information. This is not only very common; we would call it normal experience, and a sign of a good model. It shows that the client has expanded insight into the system through use of the model. The consultant is called in to modify and enhance the model as the client's needs change. In many cases, there may be several go-rounds from case studies to model modification, as the client finds new potential in the changing model.

SUMMARY

In this picture of a simulation project, I have tried to stress the fact that client and the consultant form a team. They have different roles to play, but both are vital to the project's success, and each should understand the other's role.