Proper Management Techniques Are Keys to A Successful Simulation Project

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Simulation modeling is a sophisticated systems analysis and management activity where the success of a project depends as much on the proper management of the project as on the systems analysis techniques used in the study. Assuming that all the required system analysis tools are available for a project, how can one manage a simulation project for success?

Production Modeling Corporation (PMC) has developed some simulation project management planning, scheduling, reporting, and control techniques that a simulation project manager may employ in conducting a simulation project. These techniques have been developed to standardize the simulation project management activities throughout the company and to insure a high customer satisfaction for simulation projects.

At PMC, these techniques have been applied to medium and large-size projects; where a medium-size project is a project that takes one to three man-months to complete and a large project takes four man-months or more. These techniques have been applied successfully to projects that use a general-purpose simulation language (e.g., SIMAN/Cinema, SLAMSYSTEM, GPSS/H) and to those that use a simulator (e.g., WITNESS, ProModelPC, SIMFACTORY).

The simulation project management techniques to be discussed revolve around a document called the simulation project book. Table 1 gives the table of contents of the simulation project book, which may be a one to four-inch binder depending on the type and size of simulation study.

- **Project Record**
- **Proposal**
- **Purchase Notification and Payment Record**
- **Project Estimate**
- **Project Specification**
- **System Data**
- **HourLog**
- **Meeting Minutes**
- **Change Log**
- **Run Logs**
  - ✓**Base Model Verification**
  - ✓**Base Model Validation**
  - ✓**Base Model Analytical Runs**
  - ✓**Alternate Model Verification**
  - ✓**Alternate Model Validation**
  - ✓**Alternate Model Analytical Runs**
- **Code for Base Model**
- **Code for Alternate Model**
- **Final Report**
- **Users Manual**
- **Maintenance Manual**

Table 1. Contents of the simulation project book

In some cases, the final report, users manual, and maintenance manual may each be a separate binder, depending on the size of the project and client requirements. On the other hand, the project record is a one-page document that gives the client company name, client company contact person, project name, brief project description (one-paragraph), consultant company project manager, consultant and engineer(s), job number, start date, and estimated total hours of the project.

The simulation project book will assist the successful execution and management of the simulation project. The following criteria will define the successful management of a simulation project:

a) Simulation contract is awarded to the consulting company.
b) Simulation project is completed on time.
c) Simulation project is completed within budget.
d) Client uses the results of the simulation project in the decision-making process.
e) Client saves money in using the results of the simulation project.
f) Client accepts simulation as a design and analysis tool within the company.
g) Client company representative earns visibility and recognition due to his/her involvement with the simulation project.
h) New and better solutions are generated as a result of using simulation.
i) Client company becomes interested in using other industrial engineering productivity tools (e.g., computerized scheduling, statistical analysis, time and methods analysis, financial models).

Based on a client's simulation background and project requirements, one can identify three major types of simulation projects:

1. Client is from a corporate (or divisional) simulation group and employs the consulting firm because he/she does not have the time to develop the simulation model. The

consulting company supplies the model and performs base model analysis. Generally, alternate models are developed and analyzed by the client. Users and maintenance manuals are submitted with the project final report and final model at the conclusion of the project. (Simulation projects done for the U.S. government and its agencies fall within this category, too.)

2. Client is the end-user of the simulation model and typically is a plant, industrial, or manufacturing engineer or manager. The consulting company may be asked to supply user-friendly input and output user-interfaces (which may be based on spreadsheet programs such as Lotus 1-2-3 and EXCEL or based on programming languages such as FORTRAN and C) with the simulation model. The client performs the alternate scenario analysis using the input and output user interfaces but the alternate model development is completely done by the consulting company. The client generally requires a users manual with the project final report and final model.

3. Client is interested only in the results of the simulation project and is typically a plant, industrial, or manufacturing engineer or manager. The consulting company supplies the project final report that recommends the "best" solution for the problem. About 50 percent of the time, the client is uninterested in receiving a copy of the simulation model(s). The consulting company must maintain all the documentation on the model and may be asked to make further runs of the model at a later date.

It should be noted that for classifications 2 and 3, the consulting company may be the corporate (or divisional) simulation group of the client company.

The successful management of a simulation project requires that all the simulation systems analysis tools required for the success of the project are available to the project team and the project team is fully aware of the systems analysis pitfalls to avoid in the simulation process (e.g., objectives well-defined, level

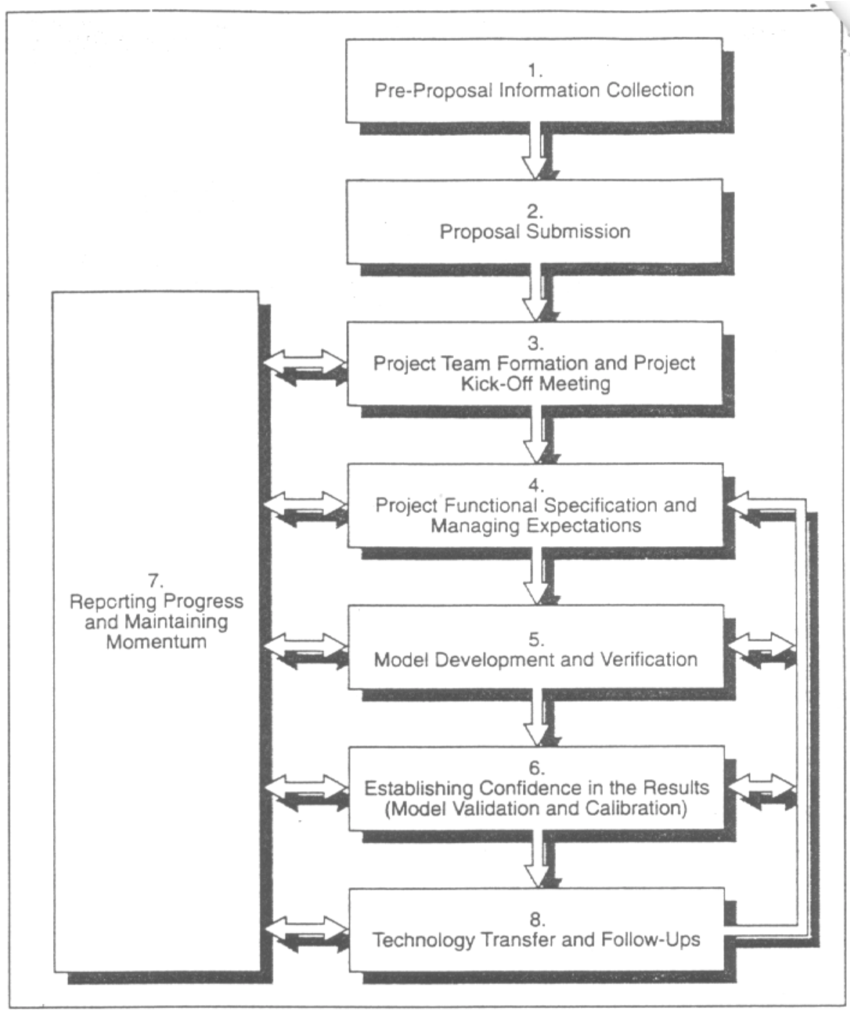

Figure 1. Major steps for the successful management of a simulation project

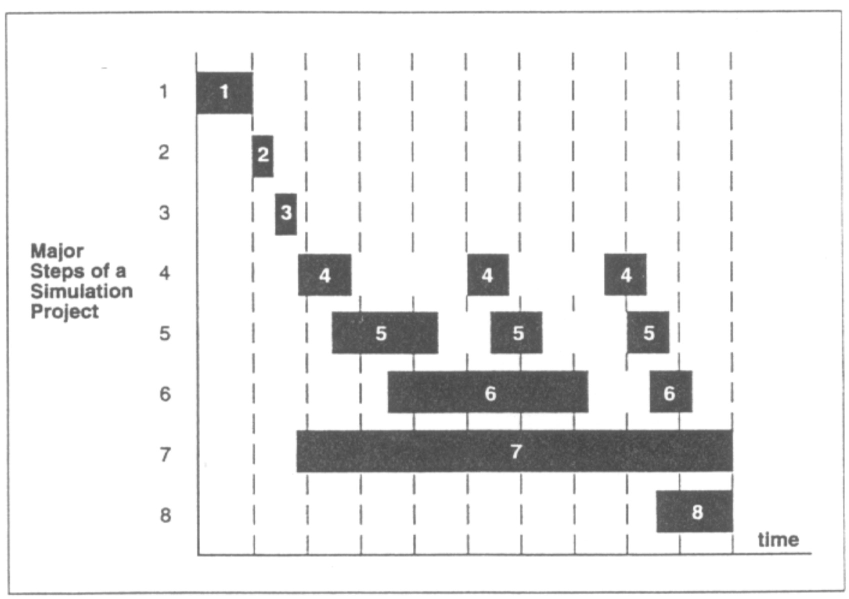

Figure 2. Gantt Chart of the major steps of a simulation project

of detail is appropriate, sufficient simulation and statistics training, simulation software selected is appropriate, model is verified and validated for the purpose). Balci, Law and McComas, and Sadowski (see *For further reading)* give an excellent treatment of these topics. The following eight steps for the successful management of a simulation project are:

1) Pre-proposal information collection.
2) Proposal writing and submission.
3) Project team formation and project kick-off meeting.
4) Project functional specification and managing expectations.
5) Model development and verifica tion.
6) Model validation and establishing confidence in the results.
7) Reporting progress and maintaining momentum.
8) Transferring the technology and follow-ups.

Figure 1 shows the highly interactive nature of these steps. Also note that even though a large portion of Step 7 is done after Step 6, Step 7 actually starts once the proposal is accepted and continues through the life of the project. The relationships among the major steps with respect to time is delineated in Figure 2. Note that Steps 4 through 6 are revisited a number of times throughout the project life depending on the number of alternative scenarios to be examined by the project team.

The first major step of a successful Proposal information collection step. The consultant has to identify the key client representative and collect information on preliminary objectives of the study, the problem areas, client resource and budget constraints, and desired timing.

The agenda of the first meeting should be set together with the key client representative. If practical, a brief site visit should be planned as part of the first meeting. One objective of the first meeting is to inform the client about the consultant and his/her organization. The consultant must demonstrate that the consulting firm has the skills to do the job, the project personnel to be assigned to the project have the proper skills and experience, and the consultant understands the basic problem and the client's constraints.

The second major step is to write the proposal and present it to the client. Table 2 gives the contents of a proposal for a simulation project. The consultant should set up a meeting with the key client to present the proposal and explain it in detail. The consultant should tell the client that the proposal at that point is only a draft proposal and the client is welcome to suggest changes to it.

Shortly after the meeting, the final version of the proposal should be submitted to the client. One of the key issues in a proposal is estimating how long the project will take. Table 3 gives a form that may be used in estimating the total time a project will take. Note that three rows in Table 3 need to be estimated at a minimum (i.e., base model development and verification (A), user-friendly I/O development (B), and alternative scenario analysis (C).

- Objectives of the Study
- Scope of the Study
- Detail Level to be Used in the Model
- Questions to be Answered by the Study
- The Description of the Base Model
- The Description of the Alternate Model(s)
- Verification and Validation Procedures to be Used
- Model Input and Output
- User-Friendly Features of the Model
- Client's Role and Duties
- Background of the Consulting
- Company and Project Personnel
- Project Deliverables and Delivery Time
- Project Options
- Simulation Software and Hardware
- Contract Payment Terms
- Project Exclusions
- Warranty
- Case Studies on Similar Projects Done by the Consulting Company

Table 2: Contents of a proposal for a simulation project

Based On	Category	Rounded Days	Actual Hours	Calc. %	Rounded by Day	Increased by 20%	Model Only
(A)	System Definition and Problem Formulation	1	8.0	1 0.00%	8	10	10
(A)	Data and Information Gathering	2	16.0	20.00%	16	19	19
(A)	Data Analysis	1	8.0	1 0.00%	8	10	10
(A)	Specification Writing	5	40.0	50.00%	40	48	48
(A)	Specification Review	1	8.0	1 0.00%	8	10	10
A	Base Model Development and Verification	10	80.0		80	96	96
(A)	Base Model Validation and Calibration	3	24.0	30.00%	24	29	29
(A)	Base Model Animated Graphics Design	3	24.0	30.00%	24	29	29
b	User Friendly I/O Development	0	0.0		0	0	
(A)	Simulation Runs and Systems Analysis	3	24.0	30.00%	24	29	29
C	Alternative Scenario Analysis	5	40.0		40	48	
(A+C)	Statistical Analysis of Output	3	24.0	20.00%	24	29	
(A)	Project Management	1	8.0	1 0.00%	8	10	10
(A)	Project Reviews and Meetings	2	16.0	20.00%	16	19	19
(A+C)	Final Report Writing	3	18.0	1 5.00%	24	22	
(A)	Users Manual Writing	1	8.0	1 0.00%	8	10	
(A)	Maintenance Manual Writing	2	12.0	1 5.00%	16	14	
(A)	Technology Transfer and Training	1	8.0	1 0.0O%	8	10	
	Total Time Estimate	47	366		376	442	309
	Total Cost Estimate						

Table 3. Simulation Project Estimate Worksheet

All the other steps of the simulation process may be based on steps A and/or C. The percentages in column 5 are just average percentages and may change from one simulation project to another based on client and project requirements. In fact, PMC uses two different tables, one for projects using simulators and the other for projects using general purpose simulation languages. It is a good management technique to have at least two consultants estimate a project independently and that one of the consultants be a pessimistic estimator while the other an optimist. A final estimate should be given only after the two estimators discuss their estimates and agree on a final figure for each step of the simulation process.

Project Name: ______

Change Requested by: ______

Change Submitted by: ______

Date Requested: ______

Description of Change: ______

______

______

______

Modification(s) Required: ______

______

______

______

Impact of Change: ______

______

______

______

Additional Hours: ______ Additional Costs: ______

Change Approval:

Client Signature ______ Date ______

PMC Project Manager ______ Date ______

Table 4. Project change log

Forming a team

Once the proposal is accepted by the client, the third major step of the project is to form the project team. The project team should have a combination of skills including modeling, programming, project leadership, knowledge of the real system and its interactions, statistics, technical writing, and presentation. The team should involve a senior person from both the consultant's and client's organization.

If no team member from the client's organization has overall system familiarity, the client's representative(s) should have access to people with such generic knowledge. The team members should understand their roles and their availability for project-related activities and the limits of their authority and responsibility. All team members should be involved actively throughout the project and feel ownership of the project. Informal team interaction should be encouraged and the team should be rewarded as each project milestone is reached. There should be at least two consultants/engineers from the consulting company in the team to guarantee continuity in support of the client's project even though one of the consultants/engineers may be just observing the progress of the project and not involved in model development.

The fourth major step of a successful simulation project is to write a detailed project functional specification and set up realistic expectations for the project. The project specification is the detailed version of the project proposal and is written by the project team. It details the project goals, project deliverables, project scope, model assumptions, model input and output, description of logic used in building the base and alternate models, modeling approach to be used, and detailed description of the analysis to be carried for the project.

The complete functional specification becomes the contractual agreement between the client and the customer for the model to be delivered at the conclusion of the project. Once the project specification is formally accepted by the client (a signature of acceptance is recommended), work can begin.

The project team should revisit the project goals and expectations frequently and discuss major deviations from the initial project specifications, if any. Changes to specifications during the life of the project may require higher-level management interaction. It is important that a written project scope change document be approved and signed by project leaders from both the consultant's and the client's sides (See Table 4 for a typical project change log form). As the project progresses, the team should report on the objectives reached at each stage.

The fifth major step is model development and verification. Success here depends on how much the team gets involved in model development. Input data analysis is a subprocess of model development where for each random variable in the model, a distribution with its parameters is identified.

The model should be developed in an evolutionary manner rather than in a revolutionary fashion. It should start simple at a macro level and detail should be added later whenever necessary. It should utilize available software engineering techniques such as block diagrams and structured walkthroughs.

Documentation should go hand-in-hand with model development. A run log form should be kept for the runs made for model verification. Deterministic verification runs should be made to check extreme conditions and complex logic in the model (e.g., end of shifts, multiple failures occurring at the same time, model entities from separate model segments talking to each other), and the stochastic variables should be added to the model only towards the end of the verification step.

The modeler should use previous code whenever possible but shouldn't let the old code redefine the model. He or she should review the developed code often with the project team and get users involved in debugging. The team should deliver results as early as possible and deliver often, making sure that the project progress is known and reporting successes early and often.

The sixth major step is to make sure that the model is validated for the purposes of the study and the project team has confidence in the results. It is important that the users are confident the model accurately represents the real system. This can be accomplished by running alternate scenarios of the system under conditions known to the user so that the user can compare model output with real data or his/her expectations of the system under similar conditions.

A run log similar to verification run log should be kept for the validation runs, too. Animation also helps at this step of project development to increase the credibility of the model. At this point, the project team may involve client personnel outside the team with the project to ensure the validity and increase the confidence in the results of the study. It is important that the client's project team members directly get involved in selling the computerized model to the people outside the project team ("Ownership").

Making progress known

The seventh major step is to make sure project progress is known to everybody interested in its results. The project team, through its meeting minutes, short articles, and presentations, should report on the project status through the life of the project. This is especially true in studying alternate solutions to the problem. All interested parties should know why some solutions work and some don't and why the solution picked is the "best" solution for the problem.

The team should also give equal recognition to all its members throughout the project life cycle. In order to maintain momentum, project team members can identify the short-term goals and deliverables of the project and deliver them on time. Steps four through seven should be repeated for each alternate scenario to be investigated in the project. Statistical design of experiments can be used to minimize the number of runs to be made in the study.

The eighth and last major step of a successful simulation project is to transfer the technology successfully to the client and periodically follow up on the client's proper use of the model. It is important that, at the completion of the project, the client should be able to use the model to continue analysis and support of the system without requiring any aid from the consultant (for client types 1 and 2). In all cases, the consultant should help the client end-user in presenting the results of the study to his/her management.

It is important that the model be used for its original intent by the end-user. A final report should be submitted at the project conclusion which should summarize the objectives, assumptions, results, and conclusions of the study. A users and maintenance manual may also be submitted at this phase if the end-user will reuse the model. The end user has to be supported after project delivery to make sure that the model is also used appropriately for future applications.

The forms that have been covered bring discipline to the simulation project management process, accountability to the project, and improve on the planning, scheduling, and control of simulation projects.

The simulation project team should be able to generate new engineering solutions to the problem.

The consulting company will increase the success of a simulation project if it can also provide front end project support such as developing forecasting models, time and methods studies, data analysis, engineering design and layout, and back-end support such as development of a dynamic scheduler, project management support, and financial analysis.

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For further reading:

Balm, O., "Guidelines for Successful Simulation Studies," *Proceedings of the 1990 Winter Simulation Conference,* New Orleans, 1990.

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