Proceedings of the 1995 Winter Simulation Conference
ed. C. Alexopoulos, K. Kang, W. R. Lilegdon, and D. Goldsman

STEPS FOR PROPER SIMULATION PROJECT MANAGEMENT

William B. Nordgren

F&H Simulations, Inc.
PO Box 658
Orem, Utah 84059-0658, U.S.A.

ABSTRACT

This paper summarizes the steps and procedures of performing a simulation study. Simulation studies are complicated by nature and without any formal procedure can present a large challenge for engineers. This paper develops a step-by-step approach to aid in the management of real life simulation projects. A list of tasks needed to complete each step is presented to help the engineer document and validate the project. This approach has been used for the successful development and conclusion of several real-life simulation projects.

1 INTRODUCTION

When a engineer undertakes a simulation project, a majority of time and effort are spent selecting, learning, and modeling with the software product. Little time is spent on planning for the success of the project. As a result, simulation has received a reputation of being difficult and complicated. Selecting a simulation software is important, but it has been proven time and time again that regardless of the software used, successful projects have been completed. This book of proceedings is full of examples to support this point. Success of a simulation project is not based on the simulation software, rather it is based on the successful management of the project.

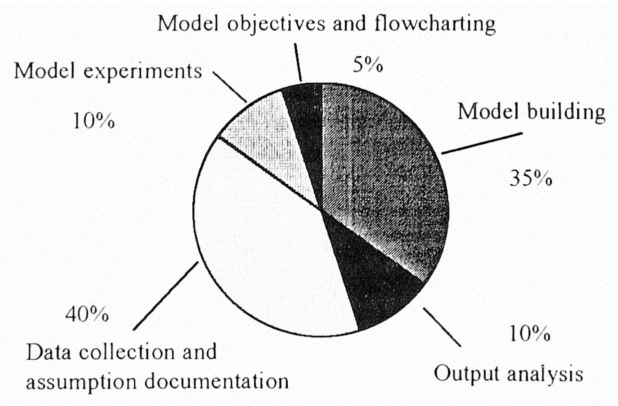

Figure 1

When a simulation project is viewed as a whole, the simulation software is used about 30 to 40 percent of the time (see Figure 1).

The purpose of this paper is to help the engineer plan for successful simulation projects. After all, simulation is only a worthwhile exercise if the project is a success. Success is based on getting some kind of meaningful information that will help you make correct decisions, and make your enterprise more profitable.

The body of this paper is solely devoted to the steps and tasks required to help all simulation projects be more successful. Some of the tasks may seem unnecessary, but if followed, the modeler will gain a greater understanding of the process that is being modeled, and the model will be easier to complete and the analysis will have purpose and direction.

2 STEPS IN A SIMULATION PROJECT

Simulation studies are divided into nine steps which are essential if the study is to be performed correctly.

1. Review of facilities and processes
2. Establishment of goals and objectives
3. Design of experiments
4. Flow charting of system elements
5. Data collection and system assumptions
6. Phased model development
7. Model validation and verification
8. Run experiments
9. Simulation output analysis

An in-depth look at each of the following steps will now follow. At the end of each step you will be given a list of tasks that will help document the project. Take the time to do every task listed. By completing all the tasks you will have completed your simulation study. Just remember that nothing is real until it is written down.

2.1 Review of Facilities and Processes

A complete review of the facilities and the processes for the proposed simulation model is the starting point for any study. This review can be an actual tour of an existing facility, or it may be a detailed review of the design documentation for a proposed system if it does not exist. In either case, the engineer must have a complete understanding of the operational characteristics of the system. Several things need to be accomplished in this review:

2.1.1 Tour Existing Facility

A complete tour of the facility is the starting point for any simulation model. Even if the engineer works in this facility, a complete review will be helpful.

2.1.2 List System Components

During the tour, list all the system components. Machines, storage locations for work in process, work tables, tool locations, or anything that is used to produce the product. Product components, parts, and assemblies should also be listed.

2.1.3 List System Resources

System resources include conveyors, fork trucks, AGVs, maintenance personnel, machine operators, overhead cranes, robots, or any other resource that is used for production.

2.1.4 Make Note of Operational Characteristics

As each system element is reviewed, make notes of the operational characteristics. Are there any special processing logic, how does the machine interact with other elements of the system.

2.1.5 Make a List of System Terminology and Acronyms

Most facilities have names or acronyms that are used to describe equipment or parts. Make a note of these names and use them in the simulation, this will make the model familiar to all who know the process.

2.1.6 Draw or Obtain a Drawing of the System Layout

Before the tour, obtain a drawing of the facility, or while on the tour draw the facility and make notes on the drawing for each element in the system. After the tour is complete, this drawing will serve as a "trip to the floor" whenever you need to review the facility.

2.1.7 Get to Know the System in Detail

The more you know about the processes and capabilities of the system, the more capable you will be in modeling it correctly. If the system is not modeled correctly, no amount of good data is going to produce results that will be worth anything.

2.1.8 List of Tasks for Step 1

List system components: Make a list of all the elements in the system. This list should be complete. Make sure to note any special operating characteristics.

List system resources: At this point make a list of all the system resources. Make sure to note any special operating characteristics.

List system terminology and acronyms: Be complete on this step. You may know exactly what they mean but others may not.

Draw and label system layout: A CAD drawing or a hand drawing will work. Include this in your final documentation so make it look nice.

2.2 Establishment of Goals and Objectives

Once the engineer knows in detail how the system operates and the interactions of all system elements, he needs to establish goals and objectives. The goals and objectives will determine the focus of the model. Important questions are asked at this point:

- What is the primary reason for the simulation model? Why are you simulating in the first place? What are you trying to find out?
- What is the scope of the model? How much detail the model will have will be defined by the scope of the project. What part of the process are you modeling, and what will be modeled is the scope.
- What questions will the simulation answer? What do you want to find out, or what do you want the simulation to tell you.
- What kind of changes need to be made for the study?
- What is the impact of changes?

- What issues need to be investigated?
- What are the measures of performance?
  What specific performance measures are you looking for? Throughput, overall production time, demand and resources, and system delays are some valid measures of performance.

The goals and objectives will determine how the model will be defined and what aspects of the system will be modeled.

2.2.1 List of Tasks for Step 2

Define the purpose of the simulation: Write a short paragraph that defines the purpose of the simulation.

Define the scope of the project: Define what will be in the simulation and what the delimitation's will be. What does not need to be included is just as important as what is included.

Define the questions that the simulation will answer: Write the questions that they want to have answered by the simulation. Make sure that these are realistic, and are ones that can be answered through simulation. Questions such as "how many times does the machine operator stop to talk with friends?" are not valid.

Define the addition or changes to the system: Define what options or changes, if any, that might be added to the current system.

Define the issues to be investigated: List the issues that have need of close study. Utilization percentages, effects of downtimes, and bottlenecks are some examples.

What are the performance measures (PFMs): List the performance measures (PFMs). Remember, this is what you will be looking at to determine the outcome of the simulation. A simulation model will give you all kinds of output data, your PFMs will help you cut to the quick when looking at output results.

2.3 Design of Experiments

The design of experiments is where the tests are established and designed that will provide the information that is desired from the goals and objectives. This step is where the different simulation scenarios will be defined that experiment with the system configuration. It is also important to determine how system parameters can be compared in order to analyze the system.

2.3.1 Define the Base Scenario

The base scenario is the basic system configuration. This should be the current system, and is the scenario that is used to validate the model. All other scenarios will be compared to the base.

Define the changes that need to be investigated: The changes that need to be made will correspond directly to the changes defined in the goals and objectives. New machines may be added, operation times changes, or different methods of material handling may be used.

Establish the number of scenarios: There needs to be a limit on what is changed for each scenario. If to many things are changed it will make it impossible to determine what change caused what effect. It is advised that each change will result in an additional scenario.

2.3.2 List of Tasks for Step 3

Define the base scenario: Define the parameters of the base scenario.

Define the changes that will be investigated: Review the goals and objectives that have been defined. From the goals and objectives, list the changes or experiments that need to be conducted to answer the questions defined.

2.4 Flow Charting of System Elements

A flow chart of the system is now developed of the proposed model as defined by the goals and objectives, and will include any features that will facilitate the design of experiments. The flow chart should be constructed so that any data that is associated with any of the system elements can be added during the data collection step. This is an important procedure to help facilitate the organization of the data and system assumptions.

List all parts or entities: Make a list of all the parts that will be processed through the system.

Define the flow of the model: Define the flow for each part through the system.

Make note of any special operational logic: For each part at each location, make note of any special operational logic as required.

Construct the flow chart: Using flow charting methods, flow chart the system.

2.4.1 List of Tasks for Step 4

Construct system flow chart: Draw the flow chart for the entire system. Include as much data as possible.

2.5 Data Collection and System Assumptions

After the system has been flow charted and organized, pertinent information about the system is collected. Operation characteristics, such as operation time, move time, setup time, and downtime, are collected for each element in the system. Operational assumptions are also established for system elements when actual data is in short supply, or non-existent. System elements are assumed to operate in a certain manner for the purposes of the simulation model. These assumptions need to be documented and modeled correctly.

2.5.1 Define the Scope of the Data Needed for Each System Element

Certain information about each location is vital for the modeling of the system. Unless specifically noted in the objectives, highly detailed data is discouraged. For example, if there is a small setup time for each part at a location, this time can be added to the overall operation time, thus eliminating the need for a setup time to be input for each part at each location. Using the proper distribution, combining process information, will speed model runtime, and will shorten the time to build the model.

2.5.2 Develop the Assumptions Document Data

The assumptions document is where all the information that will be used to build the model is combined. This document is the most important item of the project. It is the blueprint by which the model is built. It is also the document that is used to validate the model after it is built. The following list are items that usually require data collection for each element of the system.

Operation rates: Operation times for each part and process.

Scheduling: How and when parts arrive at each location.

Downtimes: Scheduled and unscheduled, as well as mean time to repair(MTTR) and mean time between failures (MTBF).

Change over and setup times: Change over time for different products or part types.

Material handling interfaces: Material handling interfaces as well as detailed information on the material handling device itself.

Operational constraints due to other system elements: What constraints if any are placed as a result of the interaction with other system elements.

Other important factors: Any other information or data that is required for the system to operate correctly.

2.5.3 List of Tasks For Step 5

Collect your data for each element of the system: This will be an ongoing effort during the simulation process, but try to get as much as you can before you start modeling.

Creating the assumptions document: An assumptions document contains all the information about the system, by defining the purpose of the simulation, and defining each element in the system. This document becomes the specification for your simulation model. Your model is validated by what is written so don't leave anything out.

2.5.4 Sections of the Assumptions Document

The following should be included in the assumptions document. Note that previous exercises have been designed to complete several sections of this document.

Introduction: The introduction should be a brief summary of what is to be accomplished in the study, the scope and important points to be made.

System layout: This should be your CAD, or hand drawing of your system to be simulated. You should identify elements and resources on the layout.

Overall objectives: This is where you state the goals and objectives of your simulation.

Issues to be investigated: This is the issues that will be looked at in the simulation.

Measures of performance: These are your PFMs.

System description and assumptions for each element and resource: Here is where you list each element and resource of your system that you want to simulate along with all the data that has been collected. All the assumptions that will be made about every part of your model will be documented as well. Take your time and make sure this part is correct. No matter how good your model is, if the data that you input is wrong the model is no good.

Definition of each experiment to be conducted: Here you will list all the experiments that you will perform with your model once it has been completed. By knowing exactly what you want to do with your model before you build it, your model will contain everything you need for your experiments.
Start writing the assumption document. This exercise may take several days depending on the availability of the data. This document should be completed before modeling is started.

2.6 Phased Model Development

The simulation model is the most visible part of the simulation study. The model development will adhere to the goals and objectives and will be completed in phases of increasing complexity. The model will first capture the basic flow and logic of the system. Part movement and elements will be added and verified as the model develops. As soon as basic model function has been encoded, more detail can be added for each location until the desired function is achieved. It is important to keep in mind that a simulation model is a representation of the system, and should be constructed to model the effect of the system.

Since this paper does not cover the modeling techniques you may use with your particular simulation software, it will be assumed that you have the skills necessary to build a correct model with your software.

2.6.1 Model Documentation

Variables, part attributes, and functions: One of the most important parts of building the simulation model is to fully define and document the use of variables, part attributes, and functions. If possible, this definition should be done within the simulation software. The more complex the logic within a model, the more information about variables and attributes, their use and function needs to be documented. Most simulation models are self documenting as a result of entering the data required to build the model. There are several small things that you can do to make it easier for the engineer in the future, or others to understand the logic when the model is looked at. Use comment lines to explain logic wherever possible. Things that may seem unimportant at the time may mean a great deal in the future when you have forgotten why the model was developed the way it was.

Code documentation: Any use of subroutines or program files should always be included in the model documentation. It is important that everything used to make the model run is included. Spreadsheet files and any data that has been imported into the model should also be documented. If you have done anything for the model, document it and include it. Everything is important.

2.7 Model Verification and Validation

Model verification ensures that you have input data correctly, and model validation ensures that the model has successfully captured the operational characteristics of the system.

To verify your model you should check all the data entered into the model and make sure that it is correct as specified in the assumptions document.

All elements of the system need to be validated to ensure that the proper effect and representation is correct. If there is an actual system that is being modeled, the computer model can be validated against the actual system and the assumptions document. When the model is of a system that does not currently exist, the model will be validated according to the system assumptions document.

The basic rule of thumb for model validation is that the model behaves as expected. If it doesn't, check your logic and make sure it is working correctly.

2.8 Run Experiments

Once the model has been verified and validated, the design of experiments can now be conducted. The scenarios and scenario replications can now be run, and the output results compared.

Hopefully, the software has the capability to run your experiments for you automatically. If not, you will have to make the necessary changes in your model for each experiment and run it separately for a sufficient number of replications.

As you run all your experiments, make sure you save all the separate output data files so you can compare the results and calculate confidence intervals for your performance measures (PFMs).

2.9 Simulation Output Analysis

The simulation output is the final step of the process, and it needs to be understood that if any of the previous steps have been neglected or performed incorrectly, the results may be invalid. Good output analysis involves correct application of statistical analysis.

Your focus on the output analysis should be on your PFMs. Simulation software can inundate you with output data, so you will need to be able to cut through the smoke to find the important results. Your PFMs will help you identify what is important and what is not.

Once you have identified the important data, you should make charts and graphs that will visually convey this information to management. The way you present the data is sometimes more important than the model itself. Take your time and do a good job in presenting your data.

AUTHOR BIOGRAPHY

WILLIAM B. NORDGREN is President of F&H Simulations, Inc. U.S.A. He received his Master's of Science degree in Computer Integrated Manufacturing (CIM), and Bachelor's of Science degree in Manufacturing Engineering form Brigham Young University. Bill was a co-founder of ProModel Corporation and served as Vice President of Customer Services and Training from 1988 until 1992. In 1993, Bill joined F&H Simulations B.V. and founded F&H Simulations, Inc. U.S.A. Through this union, Taylor II Simulation Software was introduced into the United States, Canada, Mexico, and South America. He is listed in 22nd, 23rd, 24th, and 25th editions of Who's Who in the West. He has done simulation projects for several large corporations including: Andersen Consulting, Black & Decker, Boeing, Eastman Kodak, IBM, Pillsbury, Thiokol, TRW, and Whirlpool.