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REVISITING THE FOUR C'S OF MANAGING A SUCCESSFUL SIMULATION PROJECT

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ABSTRACT

This paper aims to discuss four key elements imperative to conducting an effective simulation study and how they impact the progress of the study.

- The Clue: determining when and why to use simulation and what issues will be addressed
- The Cash: understanding the financial costs and the impact of the project
- The Commitment and the Courage: the importance of having a team committed to the endeavor and having the courage to make hard decisions so that the project will be successful

Each of these key factors are critical to starting a successful project and keeping it on track towards proposing effective solutions for the problems the model was designed to address.

1 INTRODUCTION

Today there are many simulation tools and they may be easy to use, but simulation project management is another animal altogether. Ease of use has made creating the simulation model easier, but it can result in the end user selecting a tool before having a clue as to why they really want or need simulation. There are many papers and there have been countless lectures on how to conduct a proper simulation study; while we will cover the basics in this paper, there are far more important things to understand.

Computer simulation modeling has been around for over 35 years and is a very powerful tool for making critical decisions about various scenarios. Simulation is applied in making decisions about capital expenditures, disaster preparedness, staffing, and healthcare, and is used operationally in making decisions on a weekly or daily basis. For its great value, one would ask why discrete event simulation isn't widespread across all industries. One possible answer is that as easy as today's modern tools are to use, they are just tools. The work behind creating simulations requires that the humans using those tools be able and willing to commit to the building of a valid simulation model.

In the ideal world, project steps would proceed in the order shown in Figure 1. We would define our project, create the model without any errors, validate it, and then analyze and present our results.

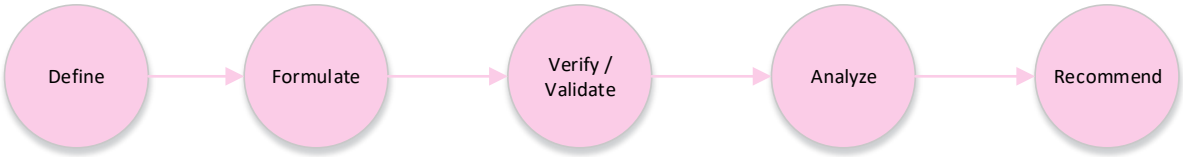

Figure 1: Project management cycle.

However, the real-world project cycle often ends up looking more like the one in Figure 2. Projects still move from one phase to the next, but often require revisiting previously completed steps before moving on to the next phase. Sometimes this occurs because project requirements have changed during development, but this cycle can also be greatly affected by making crucial mistakes at or during the project.

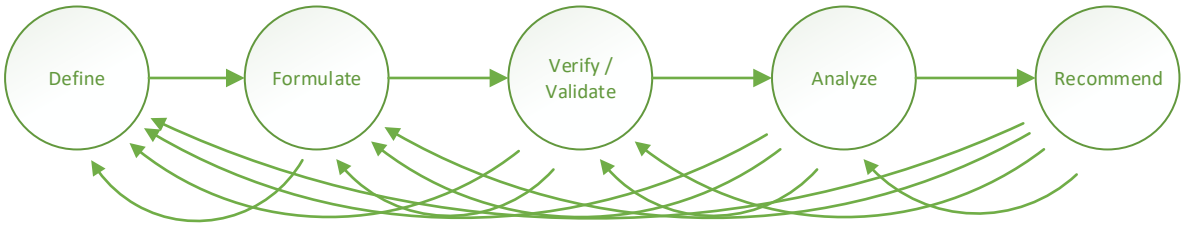

Figure 2: Project management cycle in the real world.

In the CIO article, *12 Common Project Management Mistakes – How to Avoid Them*, Jennifer Lonoff Schiff explains how to avoid project management problems in IT projects; these same points are valid for simulation projects. Many of her points pertain directly to the four Cs of this article. While they can fit under multiple categories, we are choosing to focus on one or two for each area and how that mistake is affected by that particular "C" category.

The next five sections of this paper will focus on these potential errors and how they can be avoided, specifically using simulation project examples.

2 THE CLUE

Often we ask people why they are using simulation and in many cases they list reasons such as optimizing an operation, increasing throughput, or understanding the system better. While these are valid reasons, they are amorphous. The problem is that without a clearly defined project, you aren't going to be able to gain the traction necessary to pursue a project. So this brings about the first "C" and that is the Clue.

Technically it's not just a single clue, it is the project objective, and it has to have bounds and a purpose. Without those, it becomes much harder to sell the project to your boss and the executives who may have to fund the cost of a simulation tool as well as the time you will need to spend on the project. There may be glaring issues, or possibly a future capital improvement project, and you know that a simulation would help to determine the best path to take.

Why is the project necessary and what will you need to know about the system in order to begin analysis? Seems pretty simple, but often defining the purpose and objective isn't easily done. Questions that should be asked as you look to use simulation are:

- What do we want to improve?
- Does the process being analyzed have variability?
- Is the system working as expected?

- Are we expecting to stress the system by taking on more work?
- Are we expecting a downturn? Should we look at making this process work with less and how will it impact our deadlines?

Another factor to consider is the cost of the simulation versus the value you are likely to get from the simulation. These are two factors that people don't often think about and the better you are able to define this, the more likely you are to gain buy in for the project or stop yourself before proposing something that may not be worth doing. For example, determining whether a new office printer is necessary may not be a good candidate for a simulation project if the cost of the printer and installation will be far less than one day of your time. Simple analyses usually call for simple methods. In industry, there are some simulation departments that have set specific costing criteria for when they will consider simulation. Even if a decision may be very complex, a rudimentary solution may be the right answer if the effort needed to determine the perfect answer is not justified.

There are many analysis techniques available today to help make decisions. Some decisions can be made quickly from a spreadsheet, but these techniques usually make many assumptions that may or may not be valid. Once the decision has been made that simulation is the right approach, the key is to focus on the most important aspects that the simulation will address and the system that will be modeled by asking questions such as: What are the starting and stopping points of the simulation? What kind of data would be necessary to conduct analysis?

Identifying the main objectives of the proposed simulation will provide the purpose for the project. If one of the objectives is to improve throughput time, then list some specifics that will be considered in the project that you or others suspect are having an impact on efficient processing. It is also important to share your thoughts with others at this early stage, as you are likely to find others who have similar concerns and perhaps have additional feedback that can enhance the value of the project. This is also a good point in the process to formulate an initial draft of the functional specification that will be used as the road map for the simulation project. The functional specification, along with a clear outline of your project objectives, will create the basis for your project proposal.

The functional specification contents typically include the following:

- Objective of the simulation study and questions that it is intended to answer
- Explanations of the processes to be modeled, at the appropriate level of granularity
- Assumptions about the system, as well as which conditions will and will not be modeled
- Descriptions of the input data needed to run the simulation
- Method for deciding if the model is accurately representing the system
- Key metrics that will be generated by the simulation to enable the modeler to evaluate the system performance

Appendix A of the *Simulation with Arena* has an example of a functional specification. By requiring you to describe the process in detail, creating the functional specification can help you uncover areas where you need to learn more about the process or the data that you will need to drive your model. It's better to realize that you need more information before you start modeling instead of in the middle of your project. Clues can be costly when they are needed at that stage.

Schiff mentions several potential pitfalls that could apply to this section.

- Expecting software to solve the problems
    - The software is a tool. The software doesn't write the functional specification, and it can't know whether your definition of the system is correct or if your logic is adequately matching the system that has been defined. The tools report data; they can't tell you how to interpret it or what you might need to do next. The most important tool is your brain and using it is essential.

- Not having a metric to define success
    - Generally the final report on the findings of a simulation study constitute success. However we would argue that as important as that can be, you should be sure to advertise the savings the project and how this was accomplished via simulation. Squeaky wheels get the grease and if you expect to continue to use simulation, you need to make sure that you quantify in dollars just how valuable simulation has been to your organization.
- Putting too many projects into production at once.
    - Trying to tackle a simulation project and get your "regular" job done can be a problem. Many folks realize the value of simulation and invest in tools; the problem is that while they may have many potential simulation projects that can be undertaken, they may not have the time to do it. In this case, the simulation tool turns into shelf ware. What if your company doesn't have a simulation department and you don't have the time for the project or the expertise to complete it. One approach is to pick a project, invest the time in building a functional specification and a business plan, and have an outside consultant come in and complete the simulation model.

From our personal experience the lack of a functional specification is usually a death sentence for a serious simulation project and yet it happens more frequently than people would believe. Why? There are a lot of reasons, the design and creation of the specification is the ground work that isn't glamorous or fun. It requires time to interview experts in order to research and understand the system and its rules, constraints, and variability. Documenting the process and the expected objectives takes time, and to managers expecting results this time can appear to be a waste since there is no model building occurring. There are many people who skip this step and open up a software application and begin building a model of a system; with no roadmap, the project can easily go off track and lead to inaccurate results.

3 THE CASH

The next hurdle for any project is getting the go ahead to proceed, and that typically boils down to The Cash needed to obtain the resources responsible for accomplishing the project. Will the project be saving money and will the amount saved or realized more than make up for the time and effort necessary to conduct a simulation project?

The presentation of the proposed project needs to outline:

- Objective: how and why it makes sense economically – what are the potential cost savings or productivity gains that the simulation might provide?
- Schedule for the project: when will results and analysis be expected? If there is more than one person working on this project or if there are additional groups responsible for providing data, you need to define realistic time frames and deadlines for the work to be completed. There are many projects that are placed on hold because the data to drive the project is delayed or the individuals needed to work on the project are already committed to other projects.
- Resources necessary, including the tools, people, and any outside sources of data or assistance, plus a summary of estimated costs for each component.

Many companies have requirements for the minimum expected return on investments. Once you know these requirements and you have your estimated project costs, you can determine the necessary savings or gains that the project will need to generate. Is the project likely to meet these requirements? Are you comfortable committing to those estimates? Just like with understanding the variability in your system, it's good to have both an optimistic and pessimistic estimate for the ROI of your simulation project. Remember: the better organized the approach and preparation work is for the project, the more likely you are to gain buy in.

Cash can make many problems go away, and the lack of it is definitely symptomatic of issues with the Commitment as well. Schiff's list of mistakes include several that can be affected by The Cash, but there are two most directly impacted by not assigning the right resources needed to the project.

- Not assigning the right person to manage the project
    - Depending on the size of the project, this may or may not be the person leading the modeling effort. If the project leader is not doing the modeling, then it will be their job to make sure that the modeler understands the project requirements, assist the modeler with getting data or further system information when needed, and keep the modeler on schedule. The project manager acts as a gatekeeper for the modeler in order to keep them focused on the modeling effort instead of the project management. Most small projects do not have the luxury of employing a project manager in addition to the person creating the model, so the modeler will have to double as the project manager. Even in these cases, it can greatly improve the success of the project when there is an additional resource to assist with the project, even if just part time as a sounding board for solving project or modeling issues.
- Lack of regular communication.
    - This is just common sense, but so many times people get busy and the project gets pushed aside. Scheduling meetings and sticking to them will make a big difference and make sure to give all players a voice. When the original resources are estimated for the project, this ongoing time needs to be included in the costs.

Be persistent. If you are working on a project, be conscious of the deadlines because time is money and you don't want to waste your time and have the project be delayed because you are waiting to hear back from someone. A lot of projects die on the vine because no one put the energy into regular communication and consistent follow-up.

4 THE COMMITMENT

Your presentation goes well, everything looks great and next thing you know, you are now going to work on the project. This is where your commitment to the project becomes paramount. Good project management is essential to the success of a project. Commitment isn't just about completing the project; it's about completing it the right way.

The first mistake from Schiff's list is basic.

- Failing to get everyone on the team behind the project.
    - If you can't sell the idea to the rest of your team and get the support of your superiors, then you may find that it is hard to get the information you need to continue the project. Without the commitment of the entire team to project success, it will be difficult to do so.

Next, we group three mistakes from Schiff's list together, because they all describe reactions to one problem: change. During a project, especially a lengthy one, it is likely that needs and priorities will change and scope may start to grow. A system that is in development may be further defined, and not in the way initially expected. It is important to strike a balance between being flexible as changes occur and adhering to the original project plan. If the potential areas for change are known ahead of time, this can help the modeler choose ways of modeling that can more easily accommodate updates. It is important to know and clearly communicate what kind of changes can be handled and what will derail or require the project to start over.

Project success to a great degree hinges on the functional specification as stated previously. Having a functional specification is fundamental to a successful project because it not only defines why, how, and what you are modeling but it also allows you to keep a record of changes and why they were made and any assumptions that are being made about a system. Later, the document becomes valuable as a basis for project documentation.

Below are key factors in the use of the functional specification and its role in your project.

- Not being specific enough with the scope
    - This can be especially critical to outside consulting companies. Not having been specific enough with the scope can leave too much open to opinion as to what a complete project entails. Documenting the processes with sufficient detail, listing your assumptions and defining the project properly can avoid unnecessary cost overruns because too much was left open and not decided.
- Allowing the scope to frequently change
    - Changing the purpose of the project or the scope of the work too frequently indicates that perhaps the project is not yet ready to take place because key decision makers are not on the same page.
- Not being flexible
    - There are a few areas where this can apply in simulation, and while you should be open to changing some aspects of the project, be careful not to change it so much that the project changes entirely. If it is absolutely necessary to make major changes, you must make sure all team members and executives are aware of this and the impact on the schedule.
- Not having a system in place for approving and tracking changes
    - The functional specification is developed to act as the roadmap for projects, but it has a dual role in that it can be used to track changes and explain why they were made.
    - Additionally, many organizations have systems in place to help with tracking projects. Using mail calendars to set up your regular meetings and keeping necessary data on a shared drive is a good way to give project members visibility into the process.

One of the things we have discovered is that commitment may be there but people must have the time for the project. Generally small, bite-size projects are a good start when groups are adopting simulation. Those small successes will help to build more internal interest and the leadership will then budget for the time necessary to commit to larger projects.

5 THE COURAGE

From the beginning to the end of a simulation project, courage is needed to make decisions. Sometimes you have to pull the plug on a project because the data is not there or the project team doesn't have the time or in some cases the project is trying to model a chaotic situation that you cannot actually define. It takes courage to walk away, but remember that it is better than wasting more time and effort.

Courage is also needed when we are not sure of our results. In this situation, we are less likely to have the courage to report on them and more likely to bury the work or avoid it. If you are not able to get the information needed to build the simulation you must make a decision on whether to proceed with the project. In some cases it may be acceptable to create a high level model based on minimal information if the alternative is to make a decision without any quantitative data. For this reason, the validation and verification of the model is critical to having enough confidence in your model to use it for analysis. We are not always afforded the luxury of having historical data, and in the case of new or proposed systems this makes the validation process more challenging. For existing systems, running the model with historical data and referencing the results against what did happen is one method of validation. Subject

matter experts and data from similar systems or processes will help to validate those systems that are being designed and perfected via simulation models.

As a rule of thumb, it is better to do smaller modular verifications of logic as you build the model. As you add logic, testing it at certain intervals will help you to avoid having to do a much more intensive debugging of logic at the end when you were expecting to be focused on analysis.

In the cases where the model is not valid, the questions to be answered are why and then how to go about fixing the model? This is where having a functional specification to reference against the logic is going to make a difference. The specification should include all aspects of the system that were included in the model, as well as the business rules and assumptions that were made. Review the model logic as well as the data. Sometimes it isn't the logic, but the data that is the issue. For example, process times read in from a data source that you expected to be the time for processing, may be in fact include queue, changeover and processing times.

Greenfield projects are scenarios where validation of the system is going to be more of a challenge. In cases where you are building a "to be" system, the functional specification will be the main document that holds the key points about the system and the individuals involved in its development will have to provide their insight during the validation of the model. Subject matter experts as well as data from systems similar to the one being planned are useful in this type of validation scenario.

So, the model has been validated. The analysis is next, and this is where the courage to make decisions becomes crucial. Analysis of the various scenarios being tested may lead to a conclusion that everyone expected and wanted, which makes reporting the results a piece of cake.

However, there are cases where unexpected results may be found and this is where it takes courage to report back that there may be some problems. What if the new process everyone is counting on to boost production is actually not going to improve it by very much? What about the new facility that is being planned and it is discovered that it might not be sized appropriately based on sales and marketing needs? Then the team or the modeler must have the courage to trust their model and their experience to continue to advocate for their results. Hard as it is to share unexpected or unwanted results, it is better to learn about them from the simulation rather than from the actual system after implementation.

Be honest and forthright. Frequently in consulting arrangements we find that people are concerned about questioning the client because "the customer is always right". The problem is that making assumptions can create more problems. We conducted a project with company that is renowned for being at the top of their industry and great innovators, we were a bit star struck, because of this company's reputation many other members of the team were assuming that a comprehensive approach had been used for the initial sizing of the system. Our initial job was to just create a simulation model of the system and turn it over to them for analysis. Soon after we scoped and started the project we discovered that their new system would not deliver anywhere near the throughput they expected and that their design would lead to gridlock. Our team created a small model that highlighted our concerns. Having a quantitative model that illustrated the potential issues helped refocus the team on an area that had been previously overlooked.

And the last example from Schiff's list follows:

- Providing aggressive and overly optimistic timelines
    - There may be pressure to deliver a solution faster than is reasonable. It's important to allocate enough time for specification development and model validation, usually with other team members involved, as well as model creation. Make sure that people can hold to dates and build in some buffer if you suspect that there may be delays. Better to set up a realistic schedule with some buffer time and be ahead of schedule on delivery than to explain why you are late.

6 THE CLOSING

Closing the deal and selling your analysis is the last step in the simulation project and could be considered an extra 'C'. The executive team will want to know what you have learned from the study and they want you to provide them with answers.

A more formal report should be prepared ahead of a meeting with the executive board that includes all the necessary data to support your statements. Simulation studies don't typically just report back a specific answer like "42". Hopefully through your analysis, you have found a few alternative methods of addressing the objective of the study and you will need to outline the pros and the cons of each method and pick the one that you feel is the most sensible. From Nick Morgan's article on Forbes.com, *5 Quick Ways to Organize a Presentation*, there are two styles for both strategic as well as alternative approach presentations. Be prepared because you will be expected to provide either additional data or the specifics of your analysis to back up your statements during the presentation. The executive board wants to hear hard facts and the costs of implementation as well as the expected ROI on the implementation of a proposal. If your audience includes other engineers, you may also be asked to explain how you conducted the analysis.

Keep in mind that sometimes what you have proposed may or may not be implemented. There can be many reasons for this and they may include loss of funding for the project that the simulation was built to study or unanticipated changes in market that make one of your least favored alternatives more attractive. You may be asked to go back and amend the simulation and rework your analysis for a change in plans that was not expected.

The value of capital project simulations may not be realized for weeks, months, or years and as more time passes it is likely that people may not remember that it was the simulation study that was a determining force in the decision and planning process for a system. It is important for industrial and systems engineers to track the progress of these projects, because tracking the value of the simulation in these instances will be a positive reference for future projects. From our experience, operational simulations, which are those used on a consistent basis to make system decisions, are the best way to show the value of simulation and are easier to track.

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