Less is More:

Successful simulations using Six Sigma Methodologies

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Today, manufacturing engineers and managers are faced with large scale changes and ever shortening development cycle plans. They may have to deal with a significant change to the volume of product, or even a completely new facility. The managers will be faced with representatives from different areas in the plant, each with their own set of objectives, turning the decision making process into a cacophony of viewpoints with an abundance of unanalyzed data.

Ultimately the goal is the same, launch the new schedule or facility, meeting its objectives, within the requirements of an Affordable Business Structure. How can today's manufacturing managers keep the team focused on a shared goal, and stay on track to deliver such large-scale changes?

In this short paper I will explore the success of having managers and key simulation engineers trained with Six Sigma Methodologies to lead the team, keep them focused on the key input factors and reduce the time to reaching answers through a 'Less is More' approach.

Six Sigma and Simulation

Six Sigma is a methodology which focuses on the key input factors and your dependent outputs. These are commonly referred to as your x's (inputs) and Y's (outputs). This basically creates a function of your key input variables such as Y=f(x). For a much more powerful study than afforded by static analysis or a mathematical equation, you can build a discrete event simulation (DES) model.

The dynamic analysis capability of a DES tool, like SIMUL8, can capture the stochastic behavior of any system. SIMUL8 provides the basic entities and logic to create realistic simulations of any process or manufacturing facility. These core building blocks within SIMUL8 are known as: Start Point, Queue, Activity, Conveyor, Resource, and End Point. See Figure 1.

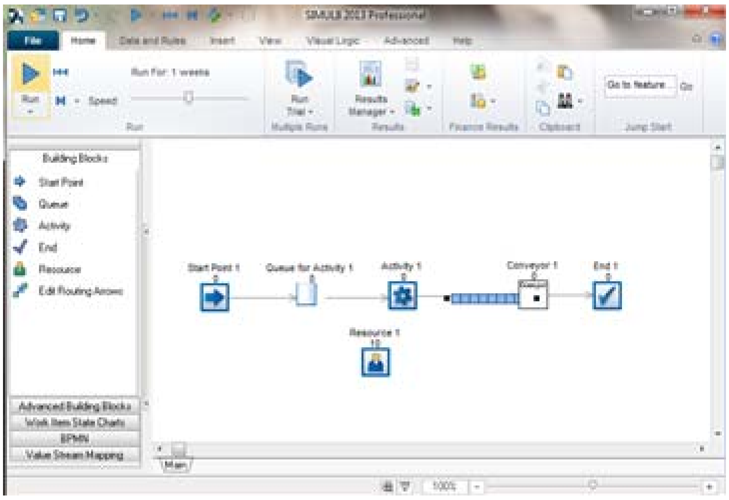

Figure 1: SIMUL8 Core Objects

These 6 core building blocks when coupled with attributes (Labels) and Logic (Visual Logic) become all that is required for modeling even the most complex of systems. The significant aspects of parts traversing through a facility utilizing: machines, resources, material handling systems can all be captured using SIMUL8's diverse results functionality.

Turning static data into a dynamic simulation model can help you find the answers to your 'what if' scenarios in the planning stage. However, a common modeling error is to add too much detail to the model at this early stage; attempting to simulate every move or event within the system.

Experienced modelers tend to create a model with the least amount of objects to meet the objective, just as experienced analysts use only the relevant data in their analyses. They find that 'Less is More'.

How to choose a simulation’s scope

Simulations don’t need to mimic your system exactly - it is very rarely necessary to have a one-to-one correspondence between every event in the system and every event in the simulation, but you need to get the balance right. Determining the right level of data to put into your simulation is more of an art than a science. So how do you choose the right level of detail?

To select the relevant data, two key questions must be asked: “What are the Key Input Factors?” and “How do we control it?” This is where the Six Sigma knowledge becomes valuable.

An excellent tool is a **P-Diagram** (Parameter Diagram). Similar to a “Cause & Effect”, or Fishbone diagram; this tool assists in organizing and determining what the Key Input factors will be and which factors are outside of the scope of the analysis.

The P-Diagram is a descriptive schematic of entire system that includes the following: Signal Factor, Control Factor, Noise Factor, Error States, and the Response Variable. See the example in Fig 2.

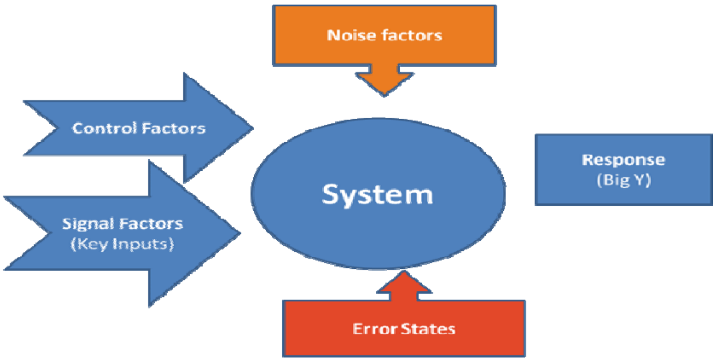

Fig 2: P-diagram

- The **Signal Factors** (the key input variables) enter the system and are transformed via the Control Factors to hopefully produce the desired **Response** (Output).
- The **Control Factors** are usually the aspects of the system that engineers and managers have ‘control’ over such as: process steps, design, shifts, resources, material handling systems, robots, etc.
- The **Noise Factors** are usually the items that the engineer doesn’t necessarily have direct control over such as: environmental influences, customer expectations, interaction with other systems, etc. Noise factors can have undesired impacts on the inputs; causing them to fail to meet the desired output.
- Finally, the **Error States** are deemed as the possible failure modes of the system.

The P-Diagram also acts as an excellent communication tool for review points, acting as a framework for the project.

It is important to note that the system usually contains several other subsystems; so signal factors should be aligned to what is relevant to delivering the response. For example, we might not include the diameter of a hole drilling operation within the overall assembly of a particular product. The significant piece of data just might be the overall cycle time of the station. Therefore, these finer level details would be considered out of the scope of the model.

Define the problem and solve it quickly

Following the DMAIC Process (Define, Measure, Analyze, Improve, and Control) can also help the simulation team to find the key input variables, and determine the Performance Measurable. The Performance Measurable might be “Jobs per Hour” or “Work in Progress” size; these are the Key Outputs which will be used to compare simulation results against each other to see which solution is optimum.

Once the team has a sound definition of the problem statement, the objectives should be prioritized. The goal of a successful simulation project should be to answer the “Big Y” objective as soon as possible. For example, if the team is faced with a 30% proposed increase in throughput of an overhead sequencing bank of finite capacity, the main objective (Big Y) might be to find out: “Do we need to add capacity (an additional lane), or can we maintain the current size and improve our sequencing routing logic?” See Fig 3.

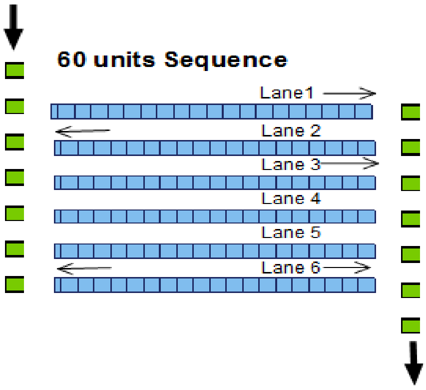

Figure 3: Sequencing Bank

If they are sticking to the Six Sigma ‘Less is More’ methodology, the team should firstly assume that all internal moves are ideal, and see if the existing capacity is capable of the proposed increase in volume. By making assumptions that all actions and cycle times are perfect, the team can find out if the bank could handle the proposed increase if it performed flawlessly.

By doing this, the team is using the least amount of data to answer one of the objectives; they can shelve the complex detailed sequencing rules for now. The team will have a critical answer sooner; and managers have more time to budget funding for the proposed add if necessary. A ‘quick answer’ is also an excellent technique to establish credibility with the team as the model progresses.

By establishing these initial answers, the team can then focus their efforts by reducing the overall scope of scenarios within the analysis. Moreover, by bringing additional detail in as necessary as the model progresses keeps the simulation team from getting overloaded in data and detail.

Gathering and choosing the right data

Another common simulation error is to create the model to meet all of the objectives at once. Usually the inexperienced modeler is looking for a home run, chasing down all possible aspects of the model. This usually ends with the simulation team becoming engulfed within an absorbent amount of unfeasible scenarios, missed milestones, and the management team losing faith in the analysis. The important lesson is to **start simple and add detail as the model progresses**.

By prioritizing the core objective the simulation team can dive deeper into the next level of details. The initial answers provided and backed by data will keep the stakeholders in the process engaged, and eager to provide further details.

Another important area to consider is to consolidate data and fully leverage the power of statistical distributions. The data collection phase of modeling can be the lengthiest and most time consuming. Manufacturing engineers can spend weeks collecting data, such as: cycle times, downtime data, change over times, etc. Some facilities might have real-time data collection systems in place; but they often require data filtering to acquire accurate values.

The simulation team can keep the analysis moving on pace by using known statistical distributions. For instance in manufacturing they can use known downtime distributions like Exponential for Mean Time Between Failures (MTBF) and Erlang for Mean Time to Repair (MTTR). Similarly, cycle times often use a fixed distribution; that is the “Design Cycle Time”. By using these standard inputs, the simulation team can keep the project moving along as additional data comes in.

When the data does arrive, it is critical that the team stays focused on the “Steady State” values of the system; by ignoring outliers. A common data collection error is to capture all of the data points and attempt to force them into a distribution. The distorted distribution might become a bi-modal or even tri-modal curve. By using ‘Less’ of the data points and categorizing them as Steady State values and catastrophic values is far superior for the simulation analysis. The team needs to know the answers of how the system is going to work as planned; they can use the outliers to look at how to react to a catastrophic breakdown or a different special scenario.

Keep it simple

The ‘Less is More’ approach basically states: “**Keep it simple and add detail as necessary”** This also aligns well with the “Divide & Conquer” strategy. These two proven techniques have historically worked well for computer programmers. The credibility and buy-in from management comes in when you can demonstrate why the simulation is focusing on these “few key inputs” and achieving answers quickly.

Utilizing Six-Sigma tools in conjunction with model building keeps the team informed on what is of most importance to get the program launched. Therefore, when organizations are trained within Six-Sigma methodologies the overall simulation analysis can become much more effective and efficient. This is how several large manufacturing companies are able to shorten the overall launch time, and bring their new product to the market before the competition. So, if you find yourself caught up in a tornado of change; just remember ‘Less is More’!

About the Author

Brian Harrington is a Six Sigma Black Belt with 20 years operations research and simulation experience at Ford Motor Company. He designs and implements manufacturing process improvements which incorporate many conflicting objectives such as robust, flexible, and Lean systems.

His experience has included Process Driven Product Design (Design in a Manufacturing Context) utilizing a 3-D CAD environment. He has successfully completed hundreds of large scale discrete event simulation studies and is responsible for all FMC internal Theory of Constraints training.

For the past 3 years Brian is also acting as a Professor at Wayne State University teaching a graduate level Stochastic Systems Class. As a certified Black Belt he has led offer 50 major six-sigma projects. He is also a certified MODAPS practitioner.

Now running his own discrete event simulation specialists firm, he continues to deliver high quality complex models for a wide range of manufacturing, healthcare, and business process improvements. He also acts as a technical ambassador for SIMUL8 Corporation assisting in teaching, mentoring, marketing, and consulting projects.