A Case for Generic, Custom-Designed Simulation Applications for Material Handling and Manufacturing Industries

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ABSTRACT

This paper will explore the concept of using discrete event simulation software engines on which to build application-specific models for use by non-simulation personnel. The purpose of application-specific models is to provide a means to speed decisions from simulation modeling efforts, to reduce the over-all cost of simulation analysis, and to provide a management tool for continuous improvement. Examples of application-specific simulation tools that will be explored in this paper include KanbanSIM, PDSIM, PowertrainSIM, and ToolSIM.

INTRODUCTION

Company decision makers are forced to get more done and make more accurate decisions in less time; they must do it with significantly fewer resources than in the past. Doing more with less is critical in today's competitive environment. For a company to remain healthy, competitive, and, in some cases, in business, decisions must be made quickly and accurately. The mandate to reduce costs and increase productivity is under constant, heavy pressure. For example, offshore competition is at an all-time high and growing. Time, speed, and effective decisions are at a premium. Managers simply cannot afford to make the wrong decision.

"Improvement of manufacturing systems was one of the earliest significant applications of discrete event process simulation analysis." (Ülgen, Williams, DeWitt 2002). Simulation software can be used to analyze process improvement ideas, evaluate lean manufacturing proposals, provide detailed material handling analysis, optimize resource utilization, conduct theory of constraints analysis, and much more. With a well-crafted model, an analyst can determine the financial and operational performance impact of hundreds, if not thousands, of interacting, variable production events in a relatively short period of time. It provides a means to analyze and review highly complex situations with equally high levels of variability in a detailed manner. Simulation modeling provides the manager with insurance that his/her decision will be a highly effective and accurate one. Making a decision without consideration of these interacting events can be costly and disastrous.

In a general sense, discrete event simulation is often perceived as being time-consuming and expensive. The use of discrete event simulation does require a technical specialization and building an accurate model does take time. In many cases, this is time many managers are simply not willing to invest, for whatever reasons. In many cases, company managers find it difficult to justify the financial investment in simulation expertise, tools, and support because the return on investment of insurance at the beginning portion of a project seems so intangible. While other managers may recognize the value of simulation, there is a genuine fear of actually taking the plunge because they don't really believe simulation will be worth the effort and they're not willing to gamble their job on it. They would rather take their chances on conventional and historic wisdom. They get caught in the "this is the way we've always done it" syndrome. Consequently, this does not fit a competitive mandate to do more with less and continuous improvement projects are not as productive as they could be.

SIMULATION MODELING SCENARIOS

There are basically two types of simulation modeling scenarios. The first scenario is when a simulation model is constructed, verified and validated, and then applied to collect answers to a particular problem.

"After system testing and implementation, many models are 'shelved', having served their purpose" (Heilman 2001). The model gets reduced to SPOTS – Simulation Placed On Top Shelf – never to see the light of day again. This type of modeling scenario has only one chance to provide a return on investment. The dollars invested can be high for both the cost of developing and experimenting with a simulation model and also the financial impact of the final plant implementation decision.

The second scenario is when a simulation model is built in such a way that non-simulation users can use the model on a frequent, recurring basis to make day-to-day decisions and conduct continuous improvement projects. The simulation model becomes a decision support tool that is included as part of the business processes of the organization. To become a management decision support tool, simulation models must be developed beyond becoming additions to the corporate SPOTS library and be employed into an organization's business decision-making processes.

The balance of this paper will focus on the second of these scenarios as one means to increase the return on investment from a simulation model. We will do this by defining what a reusable simulation application is, and how it works, by reviewing several examples and illustrating the potential ROI for these examples.

DATA-DRIVEN, TEMPLATE MODELS

What are data-driven, template models? Let's take a look at the first half of this description – data-driven. A data-driven model is a model where a user can input data used to "drive" the model. Generally, this is done through the use of data files or user interfaces that are external to the model. This is a convenient way for the model designer to allow a non-simulation user to experiment with different scenarios of the same model.

Now let's consider the second part of this description –template model. A template model is a simulation model built in such a way that allows one to create other similar models very quickly (Johnson 1999) without having to recreate the model in its entirety. A template model increases the speed at which new models of similar applications can be constructed. This requires building a model in the first place, that is general enough to cover most situations possible under the definition of the application. If all of the variables and parameters are hard-coded into a model, excessive time, manpower, and overhead will be spent to make the required changes (Celik and Shore 1999).

Two of the most significant reasons for building data-driven, template models are:

1) Eliminate the need to completely recreate a model when changes or new, similar situations occur.

2) Allow non-simulation users to make decisions using pre-built template models by "driving" the model with their own day-to-day data.

Both of these reasons significantly contribute a positive impact on a company's return on investment when deciding to use simulation as part of their business decision processes.

EXAMPLES OF TEMPLATE MODEL APPLICATIONS

Following are summary descriptions of several simulation template model applications:

KanbanSIM

Kanban: A Japanese term meaning "signal". Kanban is one of the primary tools of a just-in-time (JIT) system. It signals a cycle of replenishment for production and materials. Its function is to maintain an orderly and efficient flow of materials throughout an entire manufacturing process. It is usually a printed card (and can be electronic as well) that contains specific information such as part name, description, quantity, etc.

KanbanSIM is dynamic simulation tool used to measure material flow system performance across time as well as optimize Kanban-based inventory levels in an assembly line application. KanbanSIM is a generic simulation template model with a reconfigurable Excel™ user interface.

Because the KanbanSIM simulation model is designed as a template, it can be reconfigured very quickly and for a fraction of the cost of a model started from scratch. It can, therefore, accommodate almost any company's specific Kanban applications. The Excel user interface provides the ability for non-simulation users to "drive" the model for day-to-day decision-making and experimentation.

With KanbanSIM, a user can experiment with model parameters via:

1) Changing material usage points and rates of consumption.

2) Manipulating delivery routes.

3) Changing train schedules.

4) Seeing the impact of loading and unloading delays.

5) Seeing what replenishment method is best for each material.

Non-simulation users, through the Excel interface, can do all this without anyone ever entering the actual model.

PDSIM

PDSIM stands for Program Development SIMulator. PDSIM is an application that is, perhaps, a departure from what we would normally think of using discrete event simulation for. PDSIM is focused specifically on solving the problem of managing vast Engineering and Program Management resources for large companies with a multitude of long-term projects.

In the automotive industry for example, automotive OEM's have quite a number of new products in the design "pipeline" in various stages of development at any given time. There are numerous manpower resources, numbering into the thousands, which must be coordinated over the life of each and every project. The issues involved in managing this manpower allocation are mind-boggling.

Some of the issues that must be dealt with include:

1) The number of resources available, while can be quite high in comparative terms, is limited.

2) There are numerous sets of products or programs that must be completed in any given time period.

3) New programs are added to and taken away from the portfolio in a random dynamic fashion throughout the year.

4) Products and programs differ in complexity and timing.

5) Each program can have different cost objectives, due dates, returns on sales, etc.

6) Programs may be delayed or expedited at any time for any reason.

7) Programs may be deleted irrespective of where they are in the development cycle.

8) Politics between business units and departments can determine availability of resources.

9) Governmental regulations can change and new laws can enter the picture at any time

So, how does one manage all the variables and multiple program resources in a large design environment in the most efficient and cost effective way? While somewhat unconventional, the application of discrete event simulation to the management of project design processes is a quite reasonable application. Discrete event simulation is a tool best applied in situations where there is great complexity and variability and this certainly applies to any large Engineering and Program Management situation.

PDSIM is a data-driven, template-based simulation application, just like KanbanSIM. The template can be readily configured for any customer with a minimum of effort and cost compared with starting from scratch. The custom user interface provides a vehicle for data-driven experiments and daily decisions by non-simulation-savvy personnel.

PowerTrainSIM

PowerTrainSIM is a simulation application that applies to the specifics of the manufacture and test of automotive power train components. Powertrain components are typically thought of as engines and transmissions. While one automotive plant's physical layout will be different from another plant's layout, the processes that go into the manufacture and assembly of powertrain components are similar. These processes are so similar from one plant to another that they lend themselves nicely to a template simulation model, thus, PowerTrainSIM.

A few of the issues that must be decided in a power train assembly operation include (Jayaraman):

1) System throughput determination.

2) Bottleneck detection.

3) Manpower allocation.

4) Evaluating different operational scenarios.

5) Evaluating various production shift patterns.

6) Efficiency of rework loops.

PowerTrainSIM is another example of a data-driven, template-based simulation model. The power of the template concept allows the model developer to build a custom application for a specific situation quickly, easily, and at less cost than a cold start. The data-driven element allows a non-simulation user to evaluate production scenarios and efficiencies daily if they so desire.

ToolSIM

ToolSIM is a highly developed example of the data-driven template model concept. ToolSIM is expressly specific to the simulation needs of the semiconductor wafer handling robot tool industry. The robot hardware configurations are quite stable and consistent from one application to the next and this allows the development of templates that don't require any changes at all. ToolSIM templates are highly developed and specific to certain types of semiconductor wafer processing machines. Thus, all that is required to use ToolSIM is data. A non-simulation person can input the operational parameters for the wafer-handling robot and perform the simulation.

WHAT DO THESE EXAMPLES HAVE IN COMMON?

We have examined four examples of data-driven, template-based simulation applications. Each example is unique to a specific industry or application. Data-driven, template-based; so what?

Each of these examples possess the following common characteristics:

1) Each application has a foundation model already constructed, which can readily and easily be reconfigured. This saves considerable time and money in the development of the simulation for a specific situation.

2) Each application is data-driven. This feature allows high levels of flexibility in experimentation and daily decision-making by non-simulation-savvy personnel.

The point of all this is that data-driven, template-based simulation applications have the ability to present significantly higher returns on your simulation investment dollar. Data-driven, template-based models can be implemented much faster, thereby getting the user to a higher value decision much sooner. These applications add additional return to your investment by virtue of their being a tool that can be reused every time as necessary by personnel not experienced in simulation model development.

SUMMARY

AutoMod is an ideal platform on which to build data-driven, template-based applications. AutoMod's flexibility, one-to-one constructs, true-scale environment, ability to connect to outside data sources and programs, and powerful programming language allows one to build reusable template models that save significant time and money.

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BIOGRAPHIES

Onur M. Ülgen is the President and founder of Production Modeling Corporation (PMC), a Dearborn, Michigan-based productivity improvement services company. He is also Professor of Industrial and Manufacturing Systems Engineering at the University of Michigan-Dearborn. He received his Ph.D. degree in Industrial Engineering from Texas Tech University in 1979. His present consulting and research interests include simulation and scheduling applications, lean manufacturing, and ERP systems.

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