Proceedings of the 2003 Winter Simulation Conference
S. Chick, P. J. Sánchez, D. Ferrin, and D. J. Morrice, eds.

REDUCING HUMAN ERROR IN SIMULATION IN GENERAL MOTORS

Demet Wood

General Motors
30007 Van Dyke
Warren, MI 48090, U.S.A.

Echo A. Harger

Production Modeling Corporation
Three Parklane Blvd.
Suite 1006 West
Dearborn, MI 48126, U.S.A.

ABSTRACT

This paper focuses on the steps taken to minimize human error in simulation modeling in General Motors. While errors are costly and undesirable in any field, they are especially harmful in simulation which has been struggling to gain acceptance in the business world for a long time. The solution discussed in this paper can be summarized as "enter the data once and use the best tool for the job."

1 INTRODUCTION

In General Motors simulation is used to validate the production capacity of every new manufacturing system. Most of the workload lies in supporting New Vehicle Programs, which takes anywhere from 18 to 24 months from concept to start of production. In last the 10 years simulation has been gaining a more important role in this process and is now consistently used. In addition to the changes in the time span of use, the purpose of simulation's use has changed as well. In the last year the use of simulation went from answering the "does this design make rate" question to answering the "what is the best design for this process" question. This progress in the use of simulation is a product of many initiatives including training, strong leadership and establishing consistent business process. In spite of all the progress we have made in recent years, as in many other companies, the benefits and accuracy of simulation is always under question and there is still a multitude of people in various parts of the corporation that are not familiar with it. Under this situation, the simulation organization cannot afford to have timing or accuracy problems or request more resources. In order to sustain our latest gains and continually improve the progress of simulation in General Motors, we had to develop tools and methods that improved our efficiency and accuracy. This paper focuses on the improvements we made on minimizing human error in the area of simulation.

In the next section we will talk about the challenges we face at our business environment.

In Section 3 we talk about our solution. In sections 4, 5 and 6 we talk about specific types of human errors in detail. In Section 7 we discuss our conclusions and recommendations.

2 CHALLENGES

In General Motors there is a group of 15 to 20 simulation engineers supporting 20 to 25 New Vehicle Development Process at any time.

We are in a business environment where it is our job to point out the flaws in a manufacturing design. Fixing these flaws usually requires additional investment, time, and floor space. Our function is directly associated with the famous quote "Garbage in Garbage Out". We need to gain and maintain the confidence of the organization before more time and money is spent based on simulation results. We cannot afford to have any errors in model logic, data or in the reports.

On the other hand we are under pressure to produce these models, results and reports quickly before the window of opportunity for the design change closes. Unfortunately human error is inevitable and it is more likely when under pressure.

In addition to the basic challenge explained above other conditions add complexity to the business. The New Vehicle Programs last for 18 to 24 months during which the group of customers as well as the simulation engineers involved are very likely to change several times. Every simulation engineer has his/her own style for modeling and reporting the results. Every customer has a different background and a different understanding of simulation. The level of model detail increases as the program progresses through time. All these conditions create an environment where communication and training become a major challenge.

In the next section we will talk about the latest methods and tools we developed to alleviate some of these problems and survive in this challenging business environment.

3 OUR SOLUTION

The solution we have today can be summarized as using the best tools for different purposes and eliminating replication in data entry. Microsoft Visio, Simul8, and a spreadsheet-like interface are our choice of tools. We use Microsoft Visio for graphical representation of the model and its results. A spreadsheet-like interface for data entry and Simul8 is used as our primary discrete event simulation tool. We developed applications to transfer data between these tools to eliminate the need for entering data several times.

We use xml data format to store all data at a central location and communicate only the relevant part of this data to relevant tools. Figure 1 shows the overall architectural structure of how these tools are integrated.

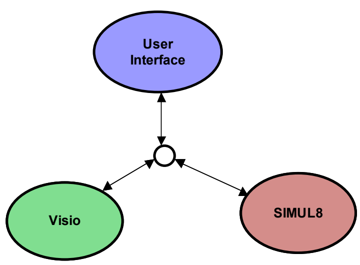

Figure 1: Architectural Structure of the Solution

In the next three sections we will talk about specific human errors and how this solution helps minimize them.

4 REPORTING ERRORS

Reporting errors include erroneous documentation of input data or results. These errors can be as simple as typographical errors in reports or as widespread as changing large amounts of data in the model and neglecting to update documentation.

Microsoft Visio is our standard documentation package. With this package, simulation engineers document the model layout, part flow, and input data including such details as machine cycle times and down times. Visio reports may also include statistical results and analysis details.

A review of reports versus simulation models in our department revealed that all Visio documentation contained a discrepancy between what was modeled and what was reported. The matter was further complicated because the Visio reports were our ISO records of the simulation. What was documented was considered “real”, not what was modeled.

4.1 Source of Error

A review of our business process showed that documentation of models was largely manual, requiring conveyance of data from the simulation model to the documentation. Not only was this data re-entry error prone, but it required considerable time investment. It was not uncommon for the documentation of a model to require more time, checking, and rework than the time required to build the simulation model.

At the completion of a project, even after spending 50% of the project time generating the documentation, any effort to reproduce the model from the documentation would end in different simulation results.

4.2 Solution

The solution to documentation errors was to use automation to generate simulation documentation from the simulation model. A standard for all body shop and general assembly models was agreed upon between the simulation engineers, clients, and management. This report, which would be generated in Microsoft Visio, not only reported the results of the simulation study, including bottleneck analysis and statistical analyses of the throughput results, but also included all simulation inputs.

The link between the documentation and the simulation was bi-directional. Therefore, any change in the simulation could be exported to report. Any change in the report could be imported to the simulation for analysis.

4.3 Results

The benefits of this solution were far-reaching. Since simulation engineers are not responsible for re-entering data in the report, the input data and results reported are always indicative of the actual simulation, provided the engineer remembers to export the data.

Because of the bi-directional link, and as an ISO record of the simulation, many Visio reports can be imported into the simulation tools to re-create simulations and results. Not all aspects of the simulation can be captured in the Visio report; however, many models can be reproduced from the documentation.

In addition to quality gains, engineers save hours generating reports and correcting errors, increasing the amount of time they could spend on analysis and model validation.

As a drawback, we also found that it was not always ideal to document exactly what was in the simulation. When systems are modeled to behave like the system of study, and the model looks significantly different from the system of study, our techniques become apparent to our customer base. We see an increase in the number of customers challenging our modeling techniques. This requires more time investment from the simulation engineer to educate the customer on the specific models of interest and simulation in general. Eventually, our customers became more interactive in reviewing and critiquing documentation, and thus simulation, which also greatly increases quality.

5 MODELING ERRORS

Errors in modeling include any aspect of a model where the behavior of the simulation is not what the engineer intends. The most common errors in modeling encountered include the following:

- Errors in Defining Part Routing,
- Using Wrong Distributions on Input Data,
- Overlooking User Code When Maintaining Models.

5.1 Source of Error

Since simulation has been a part of the vehicle development process at General Motors for 10 years, the GM simulation community has been able to develop standardized methods for many aspects of modeling. These standards encompass techniques for building base models, using standard forms of data, and analyzing results.

Although these methods are standardized, a review of errors in simulations showed that these methods were often where errors occurred. Because this work was the boilerplate of the simulation, it was often completed quickly under the pressure of a demanded project schedule. Because this work was done early in the lifecycle of a model, before the model was validated, errors often were not recognized early. Only when the complex work was complete, and the model was being validated, did such errors in the base code become apparent. By this time, it required much more work to fix these errors.

5.2 Solution

The solution to the problem of errors in modeling includes two aspects: automate the creation of the standard elements of a simulation and implement automated model verification.

When automatically generating a model, the simulation engineer provides the data in a central file or application that is designed specifically for entering large amounts of data quickly and accurately. After the data is entered, the base simulation model is created by the application. All department standards are automatically followed, because the application, instead of the engineer, builds the model. The goal is to generate the 80% of the model that is standardized: how data is entered, common distributions, how data is collected from the model, the logic behind most part routings. The engineer then completes the remaining 20% of the simulation including special logic cases and additional data collection for special studies.

The simulation engine of choice in our simulation community is Simul8. This tool is the standard tool for all throughput simulation of GM's body and general assembly applications. When the engineers complete the final 20% of the simulation, this is typically done in Simul8. While the automatic generation of base code allows for standardized work, the engineers use Simul8 to provide the flexibility they need to attack less standard issues.

When verifying the simulation model, the application analyzes the final simulation model for discrepancies between the settings and pre-defined standards. Discrepancies such as deviations from standard distributions on input data and conflicting settings on part routings are flagged as potential errors and reported.

In addition to flagging potential errors, areas in the model where important information may not be visible upon a cursory scan, often where user code is written, are flagged. The flag alerts simulation engineers that are picking up a model after some dormant time or picking up a model from another engineer, that there is important information in the simulation element.

5.3 Results

Automatic generation of the base model significantly reduces errors and rework. In addition to reducing initial errors, since the application generating the models never deviates from the standards, the long term quality of the simulation is protected.

Any simulation engineer looking at a model that was built a year ago is assured that the base model is consistent with department standards.

The built-in checkers and flags alert the simulation engineer to areas of the model that require special care or attention.

One unanticipated effect we saw after implementation was an increased anxiety level in simulation engineers. At first, it was thought this was due to learning a new tool, which was a taxing event in their already full schedules. Then, it became apparent that many engineers used their time working on model boilerplate to let more complex matters "percolate" in their minds. In one sense, by removing the "easy" work, we removed a much needed period of meditation from the simulation engineers' day.

Over time, this phenomena subsided as engineers found ways to fill the "extra" time in their days. Most simulation engineers added extra analysis time to their projects. They set-up more experiments and automated runs. This provided a more thorough analysis which was much appreciated by customers. This also provided more time to think about more complex modeling issues which was much appreciated by our simulation engineers.

6 DATA ERRORS

Data errors include using wrong data, using old data, or entering data incorrectly. In General Motors, we have the benefit of working closely with a department that continually collects, analyzes, and reports operating data from our manufacturing facilities. This data is refreshed and revised often and is published as a standard data set for use by simulation engineers.

A review of models showed that the most common data errors were either typographical errors while entering data or using an out-of-date data set.

6.1 Source of Error

As in the problems associated with documentation, most data errors were caused by manually conveying data from published reports of the data set or from customers. Often, data is read off a local intranet website where the latest information is posted, manually entered into Microsoft Excel reports by clients, and then manually entered into simulations by engineers. Any step in this process is a prime opportunity for typographical errors. Since most simulation packages hold the data "inside" the simulation object, errors in data entry were often not discovered until late in a project, if at all.

In addition to typographical errors, the web site showing the latest data may be updated between the time the client pulls data down and the time the simulation engineer begins building the model. At this point, the simulation engineer is using out-of-date data.

6.2 Solution

The solution to correct data errors is two-fold. First, a user interface was developed that had features that help reduce errors when entering data:

- Microsoft Excel-like interface where pertinent data is at one level, not hidden, allowing error to be seen early in a project,
- Interface that allows copy and paste activity between raw data from clients such as Microsoft Excel files or other tab-delimited files,
- Data entry rules that apply to our business, not the entire client base of the simulation software vendor.

In addition to an easy interface for data entry, the tools were linked to the data sets available on the intranet. Any time the data collection department refreshes data, the system notifies the simulation engineer and updates the data.

6.3 Results

The ease of data entry, and ease of data transfer from other files and the intranet, reduced errors by simulation engineers. Engineers find the Microsoft Excel-like grids faster for data entry than most commercially available simulation software. Customers also like the ease at which information can be viewed. If errors occur, which are now rare because data is imported from the intranet or client files, the errors are quickly identified and corrected.

7 CONCLUSIONS AND RECOMMENDATIONS

The approach discussed in this paper was designed to answer the major problems we were facing in our business environment. Although most of these problems may be common to other businesses the same solution may or may not apply to them. Before any company decides to develop a new process or tool set for simulation they need to consider the size of the group, turn-around rate, general experience level of the work force, repetitiveness of the simulation models, their customers' needs and backgrounds.

Standardizing model structures makes a lot of sense when the models are similar in nature. However for a consulting company building models for a variety of industries, with a variety of tools it probably will not work.

Eliminating the need for entering the same data several times is a big enabler in minimizing human error, saving time and gaining customers' confidence.

Using the right tools for the right purpose is a solution we arrived at after long trials of using a single tool for the sake of standardization. The balance between the two measures needs to be carefully evaluated for each business.

None of the steps we took were free of cost or easy to implement. The development of the architecture and the application required additional resources with strong development skills and a working knowledge of simulation. To have successful implementation of the new tools and the process the user community has been involved in developing requirements and testing frequently.

Our recommendation to anybody considering a similar approach is to do a thorough analysis of the current problems and business case for the possible solutions. Developing a solution to a problem you think that exists and then expecting the users to happily accept your solution will not be successful.

ACKNOWLEDGMENTS

This document was prepared based on the ongoing support of Kevin A. Kohls, director of General Motors' Throughput Analysis and Simulation Group. Without Kevin's support of business-case based development of simulation tools, the solutions herein would not have been possible.

REFERENCES

Eaton, Nannet ed., and Resources Online. 2001. *Microsoft Visio Version 2002 Inside Out*. Seattle, WA: Microsoft Press.

Hauge, Jaret W., and Kerrie N. Paige. 2001. *Learning Simul8 The Complete Guide*. Bellingham, WA: PlainVu Publishers.

AUTHOR BIOGRAPHIES

DEMET WOOD, Ph.D. is Engineering Group Manager, Central Simulation Support at General Motors in Warren, MI, U.S.A. She received her Ph.D in 1995 from Purdue University, School of Industrial Engineering. Her interests include developing methodologies and business processes that enable the use of simulation for increasing the profitability of General Motors. You can reach her by e-mail at <demet.wood@gm.com>.

ECHO A. HARGER is an Applications Engineer for Production Modeling Corporation in Dearborn, MI, U.S.A. She is an on-site consultant to General Motors' Central Simulation Support group. Her work includes developing tools and processes to increase speed, accuracy, and profitability of simulation. She has a degree in Chemical Engineering from Florida Institute of Technology. You can reach her by e-mail at <echo.harger@gm.com>.