# Methodology for evaluating Simulation Software for Engineering Management Courses

**Erick C. Jones and Jayakumar Narasimhan**
**Department of Industrial and Management Systems Engineering**
**University of Nebraska-Lincoln**
**Lincoln, Nebraska, U.S.A.**

Simulation has proven to be an efficient tool to reproduce industrial environments without the actual cost of construction. Simulation is a process of enacting the actual or conceptual situation in a computer based environment and enables assessment, understanding and decision making of the situation under study. Simulation software uses previously collected data and mathematical approximations as inputs which allow the creation of real-world models that generates results which engineering managers can use to make decisions.

In engineering management curriculum operational processes and systems are evaluated using mathematical derivations and then compared against operational simulations. Several simulation software packages are commonly used in engineering management classes. Each has a unique way of representing the system and calculating the outputs of interest. This paper provides a methodology that uses specific criterion for selecting appropriate software for a given system of interest and includes a case study using two simulation software packages that are commonly used in academia (ARENA and SIMUL8), to demonstrate the methodologies. This study provides a methodology that can assist instructors, students, and practitioners in selecting appropriate software for their operation.

**Keywords:** Simulation, Software selection, Arena, Simul8

## 1. Introduction

Simulation is a process of enacting the actual or conceptual situation in a computer based environment. Simulation enables the assessment, understanding and decision making in the situation under study. Simulation process is widely used in shop floor environment to verify the efficiency of the layout or to identify solution for improvements, in service industry it is used to manage the customers by assessing the time spent on the phone or waiting time in the queue.

Computer simulation eliminates the cost of building the actual system to study its feasibility. It enables the user to play with scenarios and identify the best possible ones. As the computer technology grows faster, variety of simulation tools are available to suit the requirement of the situations under study. Simulation software are available commercially from under $500 to over $50,000 and each tool has various strengths and weakness[1]. Few softwares are custom built for particular situation with lots of inner details and others are developed for common scenarios with limitations and reduced flexibility.

Most software allow users to draw inferences about the new systems, without building or changing the existing system, to verify the feasibility of new system. They also prepare reports to present to the management, to identify and eliminate the bottlenecks and improve the system. However, a simulation tool cannot optimize a system, provide correct results for inaccurate model, rectify the problems by itself and provide simple answers for complex situations[1].

The objective of this paper is to provide a methodology that assists the users to select appropriate software for educational purpose. A case study is also been provided where softwares from two vendors are compared for appropriate selection.

## 2. Literature on software selection

The simulation models currently developed can be classified into three categories: (1) the general purpose language (FORTRAN, C++), (2) simulation programming (SIMAN, GPSS/H) both needs powerful programming knowledge and skill, and (3) simulation environment (Simul8, AutoMod) that uses graphical user interface[2]. According to 2002 IIE Solutions Simulation Buyer's Guide, 25 of them claim to work well for process control, 32 for scheduling and 38 poses best animation[3]. The simulation tool developed by different vendor provides variety of applications. But, not all of them emerge as the best tool for any given situation. One dominates the other given the real situation and the results desired. Therefore, an appropriate software evaluation technique is required to distinguish one tool from another. Given the quantity of software this task becomes difficult and more complex. This section highlights few of the evaluation criterion provided by some of the researchers.

Banks et al. states that critical areas that need to be considered in selection of simulation software include: input, processing, output, environment, vendor, and cost[4]. He also warned the users to know their appropriate required feature, not to select based on Yes / No answers and not to pay more for unwanted features. Table 1. summarizes the criterion formulated.

Reducing the time spent to evaluate software packages save money and speed up the process of learning and testing. Nikoukaran et al. proposes a Hierarchical Framework strategy to evaluate the software packages[5]. Figure 1. shows the main criteria groups for the hierarchy. The difference between this criteria and the one given by Banks is that testing and users have been added.

**Table 1.** Selection consideration[4]

| Category | Sub features |
|---|---|
| Input | Point and click, CAD translation, Import file, Export file, Syntax, Interface, Data analysis |
| Processing | Powerful constructs, Speed, |

| | |
|---|---|
| | Runtime Flexibility, Portability Attributes & Variables, Number generator, Independent replicates |
| Outputs | Standardized report, Customized report, Business graph, Database maintenance, Performance measures |
| Environment | Ease to use, Ease to learning Animation, Run only version |
| Vendor | Stability, History, Track record Support |
| Cost | - |

Hlupic et al. formed 13 groups with 250 evaluation criteria categories to evaluate simulation software packages. The categories were general features, visual aspects, coding aspects, efficiency, modeling assistance, testability, software compatibility, input/output, experimentation facilities, statistical facilities, user support, financial and technical features and pedigree[6]. Rauniar et al. summarized all the work done on simulation software evaluation till the year 2002 [7].

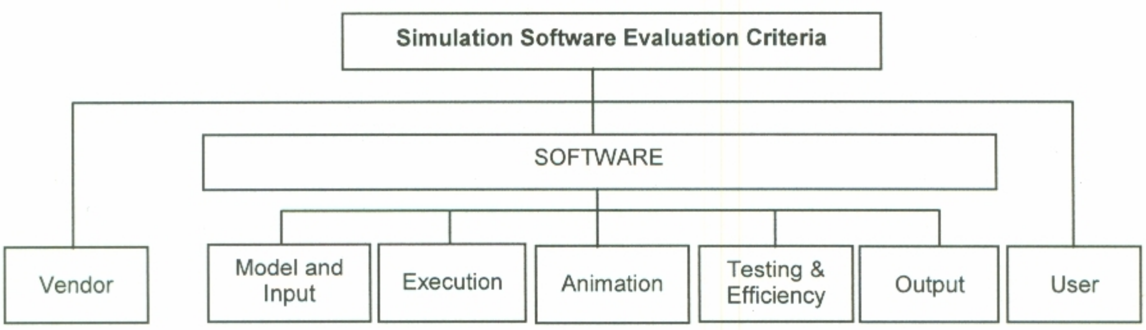


**Figure 1.** Main Criteria Groups of the Hierarchy

In spite of all these evaluation criteria, users with specific requirements find it very difficult to use them because of their generality and failure to include criteria like sensitivity and accuracy. Therefore, new methodology for software selection was developed and is being discussed in following section.

## 3. Methodology for software selection

The manufacturing industries are currently making themselves more flexible to provide their customers with custom made products. They all believe that satisfied customers increase their product sales and revenue. In order to make their customer delighted they have to match their product feature list with customer wish list. Simulation software are product too, where industries and educational institutions are customers. Therefore, the customer should make sure that the available software tool is comparable to their wish list to consider for purchase.

The evaluation criterion for the software selection needs to have same categories that will have place in most of the wish lists. So, the first step in the methodology is to list are the categories of interest. These categories need to be broad enough to take many sub categories.

**Categories and sub categories**. There are seven major categories identified Accuracy, Sensitivity, Presentation, Logic Ease build & debug, Features and Price. Each category is broad to take many sub items.

***Accuracy*** – The model should accurately represent the system that is simulated. Therefore, it needs to eliminate the assumptions and give the user the flexibility to mold the model as they like.
***Sensitivity*** – The change in the output of the model to react to a small change in input is called sensitivity. High sensitive simulation software may not provide accurate results with data that was not collect in a controlled environment.
***Presentation*** – The output of the model needs to be easily understood. A good animation with matching image will be helpful for consultants who are trying to sell their ideas.
***Logic*** – Most of the engineers work forward from the input to the output in a system. Sometimes system can be modeled best when started in between or from the end. Therefore, the software needs to have different directions of simulation flow.
***Ease to build & debug*** – It should be easier to create small segments and connect them together to form a huge system. It also enables the user to test each segment for its accuracy.
***Features*** – Additional features like import file and run subroutines using other programming language will increase the flexibility of the tool.
***Price*** – Purchasing a simulation tool is an investment. Therefore, the price paid should be recovered as early as possible. Huge difference in price has significant influence on the software selection process.

**Ranking.** After listing the categories and subcategories, rank them in the order of importance. In most of the cases accuracy precedes the price.

**Compare.** Make the list of categories the software under consideration. This information can be obtained from the vendors. The two list needs to be compared for the match.

**Select.** The software that matches the wish list and the software provided list is the best candidate. Prior knowledge and software training will speed up the evaluation process and guarantee a best selection. This procedure is graphically represented in the figure 2.

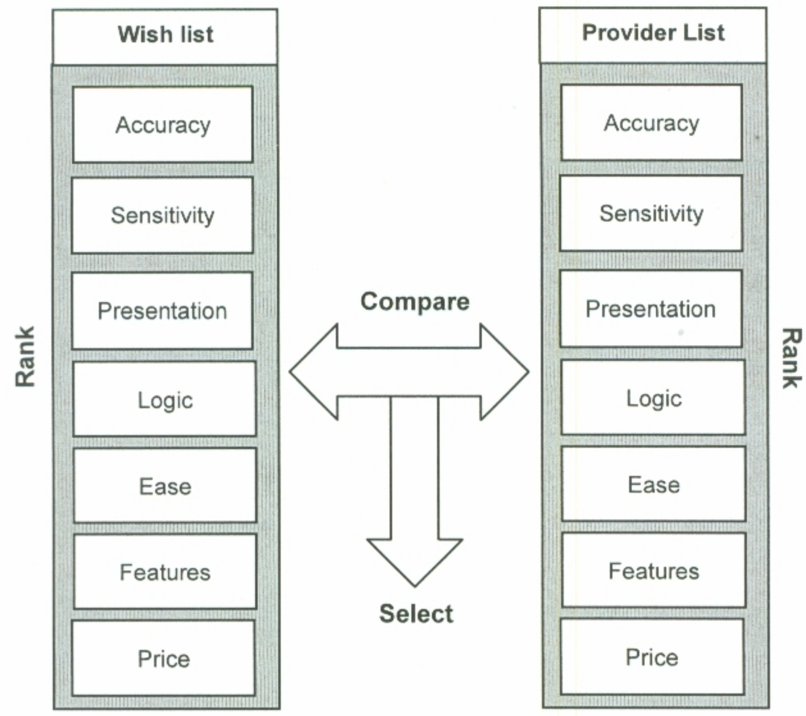


**Figure 2.** Methodology for software selection

## 4. Case Study

Two software tools: Arena and Simul8 are compared using various scenarios to find which software works better. Arena enables user to evaluate complex systems, operations, and processes. Users can measure and predict performance, animate systems, and explore alternative designs without disrupting business operations. Arena offers a flexible flowchart modeling environment. Simul8 is developed by Simul8 Corporation which provides resources and templates for fast solutions. Users can quickly create simulation models with client and save parts of models for reuse.

Three scenarios were selected for the analysis. First, illustrates a bank with two tellers. Customers arrive in predetermined distributions to do money transactions like deposits, withdrawal and checking balances. It is assumed that all this processes requires service time which is normally distributed. Figure 3 describes the activities of a customer in this scenario and Table 2 list the data required to setup the process.

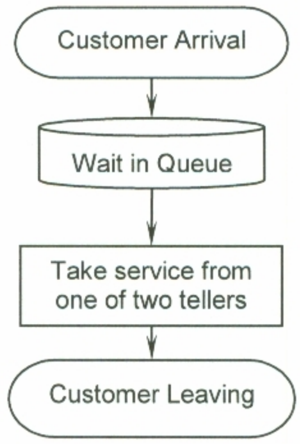


**Figure 3.** Model 1 (Bank scenario)

**Table 2.** Data for Model 1

| | |
|---|---|
| Customer Interarrival rate | EXPO(*) |
| No. of teller | 2 |
| Teller service time | NORM(3,1) |

Second scenario is a laundry facility. The clothes given by the customers are separated as suits and pants. The suits and pants are cleaned using different equipment and they are delivered to the customers together. Figure 4 illustrates the flow of activities involved in the laundry facility. The data for the system is given in the Table 3.

The third process scenario illustrates a motor manufacturing environment. Two types of orders arrive to the facility, Washing machine motors and Air conditioning motors. Figure 5 illustrates the process involved in the motor manufacturing and Table 3 list the data involved.

**Results:** The inputs for the simulation are changed for each model and the outputs are plotted. The simulation for model 1 and 2 are run for eight hours. The results from the model 1 shows that the Simul8 exhibit higher time spent in the bank compare to Arena (Figure 6). This may be critical for software selection. The ANOVA (Table 5) validates that both the software give different results for the same input conditions. When the figure 7 is projected for 100% utilization of the teller, Simul8 suggests that third teller is needed at EXPO(0.5), but Arena suggests that two tellers are enough. Therefore, the decisions made are differ with the software.

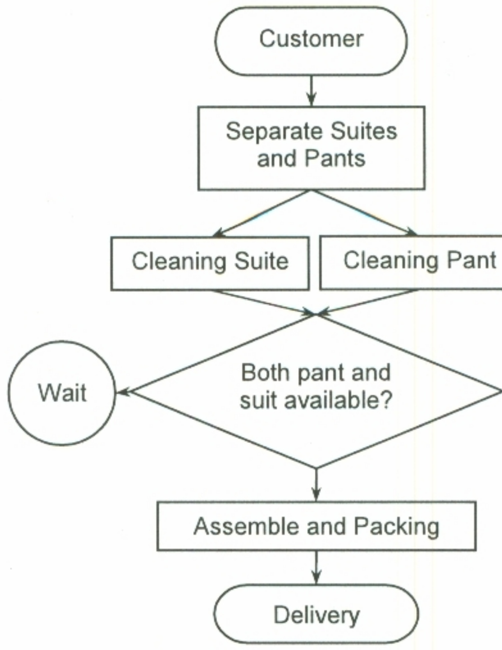


**Figure 4.** Model 2 (Cleaners scenario)

**Table 3.** Data for Model 2

| | |
|---|---|
| Customer Interarrival rate | NORM(*, 0.25) |
| Billing and separation | EXPO(2) |
| Suit cleaning time | NORM(25,5) |
| Pant cleaning time | NORM(30,4) |
| Assembly and delivery | EXPO(2) |

**Table 4.** Data for Model 3

| | |
|---|---|
| Order batch size | * |
| Order processing time | NORM(2,0.25) |
| Stator manufacturing time | EXPO(20) |
| Rotor Manufacturing time | EXPO(15) |
| Assembly | NORM(3,0.25) |
| Testing | EXPO(2) |
| Testing Good | 95% |
| Reworking time | EXPO(4) |
| Painting | NORM(5,0.25) |
| Conveyor length | 10 ft |
| Conveyor Speed | 1 ft/minute |
| Packing time | EXPO(2) |

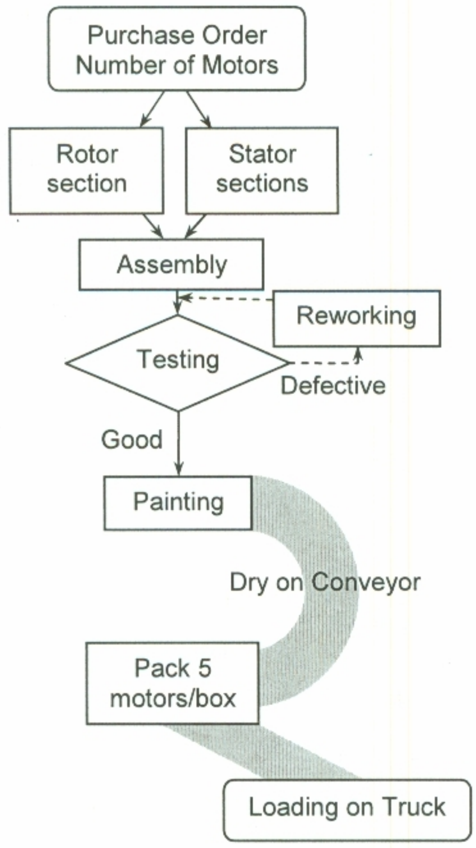


**Figure 5.** Model 3 (Motor Manufacturing)

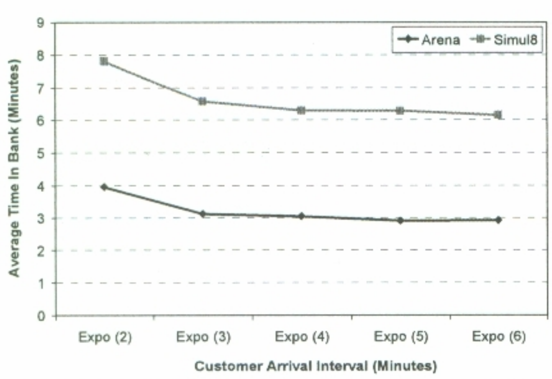


**Figure 6.** Model 1: Arrival interval vs. Time in bank

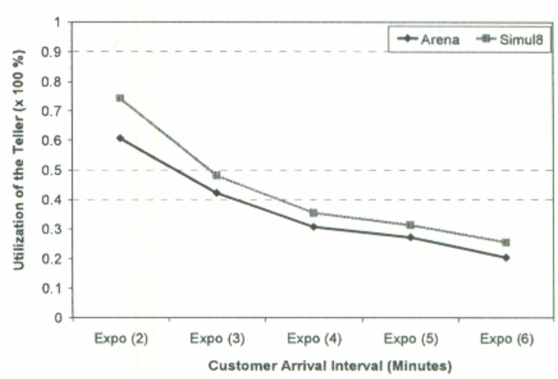


**Figure 7.** Model 1: Arrival interval vs. Resource utilization

**Table 5.** Model 1 ANOVA

| Model 1: Source | Sum of squares | Df | Mean Square | F-Ratio | P-value |
|---|---|---|---|---|---|
| Between Software | 29.463 | 1 | 29.463 | 88.440 | 0.000 |
| Within Software | 2.665 | 8 | 00.333 | | |
| Total | 32.128 | 9 | | | |

$F_{critical}(\alpha=0.05,1,8) = 5.32$

The figure 8 and 9 suggests that the simulation software provide same results for model 2 and 3 with both Arena and Simul8. Therefore, after listing the categories and ranking the Simul8 and Arena are proven to be good for the given scenarios. But Simul8 is very ease to model because of its easy graphical interface. But, Arena is more robust can take more details.

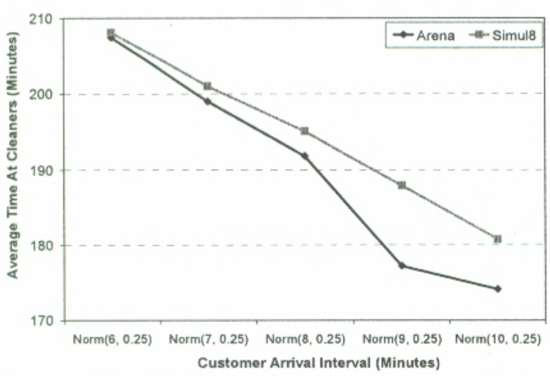


**Figure 8.** Model 2: Arrival interval vs. Time at cleaners

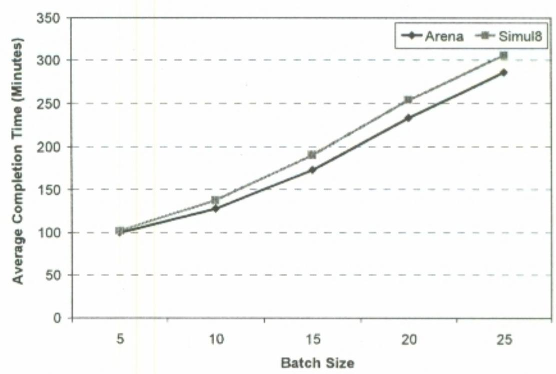


**Figure 9.** Model 3: Batch size vs. Processing time

## 5. Conclusion

After ensuring the vendor is viable, the software is reliable, the cost is acceptable, your environment will support the available output options, the most critical factor is selecting a software application that will mimic all the functions you wish to have. The proposed methodology will assist in appropriate software selection.

The case study proved that both Arena and Simul8 work similar for the sample scenarios. Therefore, for educational purposes appropriate software selection can be selected according to the course needs and budget restrictions.

## Bibliography

[1] McIntosh, S.L., (1999) How computer simulation reduces costs in the underground mining industry," Technical paper presented to McIntosh Engineering. Retrieved April 1, 2004,from http://www.mcintoshengineering.com/Services/newservices/simulationpaper.htm
[2] Simulation Software. Retrieved April 1, 2004, from http://njcmr.njit.edu/mpids/deep-eng/IE/Simulation/Chapter4-%20Final.htm
[3] Simulation software Buyers Guide (2002), IIE Solutions, May.
[4] Banks, J., "Selecting Simulation Software," AUTOFACT '95 Conference Proceedings, Vol. 1, Chicago, Illinois, November 13-16, 1995.
[5] Nikoukaran, J., Hlupic, V., and Paul, R.J., "Criteria for Simulation Software Evaluation," Procedding of the 1998 Winter Simulation Conference, 399-406, 1998.
[6] Hlupic, V., "Simulation software selection using SimSelect", Simulation 69 (4), 1999, 231-239.
[7] Rauniar, R., Rawski, G., and Shah, S., "Simulation Software Selection for Manufacturing: A Review," Proceeding of Decision Sciences Institute, 2002, 2013-2016.

**ERICK C. JONES** is an Assistant Professor at the University of Nebraska-Lincoln in the Department of Industrial and Management Systems Engineering Department.

**JAYAKUMAR NARASIMHAN** is a graduate student at the University of Nebraska-Lincoln in the Department of Industrial and Management Systems Engineering.