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SELECTING SIMULATION SOFTWARE FOR MANUFACTURING APPLICATIONS

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ABSTRACT

The number of simulation packages available for performing manufacturing analyses has grown tremendously during the past five years, making it increasingly more difficult for an analyst to choose simulation software for a particular application. In this paper, we present a set of features which should be considered when evaluating simulation software, and also a four-step selection strategy.

1. INTRODUCTION

There has been a dramatic increase in the use of simulation for manufacturing analyses during the past few years. This has been caused by the greater complexity of automated systems, reduced computer costs brought about by microcomputers and engineering workstations, improvements in simulation software which have reduced model development time, and the availability of graphical animation which has resulted in greater understanding and use of simulation by engineering managers. This increased interest in simulation has in turn led to an explosion in the number of simulation packages with a strong orientation toward manufacturing problems, with more than 25 such products now being available (see Law and Haider [1989]). As a result, a person trying to select simulation software for his/her organization or for a particular application is now faced with a bewildering variety of choices in terms of technical capabilities, ease of use, and cost. The situation is exacerbated by frequent changes or additions to existing software and by the regular introduction of entirely new simulation products. A person new to the field of simulation modeling could literally spend three or more months carefully evaluating software for a particular simulation project.

The goal of this paper is to provide the simulation analyst/engineer with a set of features and a strategy which should be considered when selecting simulation software.

There is an unfortunate impression that simulation is largely a complicated exercise in computer programming. Thus, in many simulation "studies" a significant amount of the effort is spent on "coding" the simulation model in a simulation package and, also, possibly in selecting the software in the first place. In fact, we believe that <u>model coding will represent only thirty to forty percent of the total required work</u> in a typisound simulation study. Other important activities include project formulation, data and information collection (e.g., control logic for a conveyor system), statistical modeling of system randomness such as machine breakdowns, validation of the model, and the statistical design and analysis of the simulattion runs (see Law [1986], Law and Kelton [1982], and Law and McComas [1989]). Furthermore, these tasks are, for the most part, not performed by existing simulation software, regardless of how easy these products are to use. Thus, it is incumbent on the simulation developer or user to have a fair amount of expertise in <u>simulation methodology</u> per se, in addition to the use of one or more simulation products. Many universities offer courses which cover the above important simulation project activities. There are also public seminars which cover the same topics.

The remainder of this paper is organized as follows. Section 2 discusses the major classes of simulation software and also the principal types of manufacturing analyses performed by simulation. Desirable features for simulation software are given in Section 3.

2. TYPES OF SIMULATION SOFTWARE AND MANUFACTURING ANALYSES

There are two major categories of software for simulating manufacturing or warehousing systems. A <u>general-purpose simulation language</u> is a simulation package which is general in nature (e.g., it could also be used for modeling computer or communication systems), but may have special features for manufacturing such as workstations or material handling modules. Examples of simulation languages are AutoMod II, GPSS/H, GPSS/PC, SIMAN, SIMSCRIPT II.5, and SLAM II. A model is developed in a simulation language by writing a program using the language's modeling constructs. The major strength of simulation languages is the ability of most of them to model almost any kind of manufacturing system, regardless of the complexity of the system's material handling equipment or control logic. Possible drawbacks of simulation languages are the need for programming expertise and the possibly long coding and debugging time associated with modeling complex manufacturing systems.

A manufacturing simulator is a computer package that allows one to simulate a system contained in a specific class of manufacturing systems with little or no programming. Examples of simulators are PROMOD, SIMFACTORY, WITNESS, and XCELL+. The particular system of interest (in the domain of the package) is typically selected for simulation by the use of menus or graphics, without the need for programming. The major advantage of a simulator is that "program" development time may be considerably less than that for a simulation language. This may be very important, due to the tight time constraints in many manufacturing environments. Another advantage is that most simulators have modeling constructs specifically related to the components of a manufacturing system, which is particularly desirable for production personnel. Also, people without programming experience or who use simulation only occasionally (e.g., a manufacturing engineer) often prefer simulators because of their ease of use. The major drawback of many simulators is that they are limited to modeling only those manufacturing configurations allowed by their standard features. This difficulty can be largely overcome if the simulator has "programming-like" commands to model complex decision logic; most of the model would still be developed using menus and graphics. (This capability might be available in the simulator itself or in external routines called by the simulator.)

Note that a complex model developed in a simulation language by an analyst can be made more accessible to manufacturing personnel by adding a flexible, menu-driven "front end" and also tailored output reports. The front end allows one to make a certain set of modifications to the model without programming.

There are two major types of manufacturing analyses for which simulation is used. In a high-level analysis, the system is modeled at an aggregate level and details of the operating or control logic are not included. (A high-level analysis is often performed in the initial phases of manufacturing system design, since detailed system information is not then available.) Typical objectives are determining the required numbers of machines and material handling equipment, evaluating the effect of a change in product volume or mix, and determining storage requirements for work-in-process. Manufacturing simulators are often used for high-level analyses, but a language could be used as well.

A detailed analysis is performed to fine-tune or "optimize" the performance of a system, and the corresponding simulation models typically represent operating or control logic in considerable detail. Most analyses of this type are done for existing systems, because of the need for a precise system description. An example of a detailed analysis would be determining the best operating strategy for a complicated conveyor system. Many detailed analyses are done using a simulation language because of the need to model complex decision logic, which may be unique to the system being studied. In some cases, simulators can also be used, particularly if they have programming-like commands.

In addition to the two types of manufacturing analyses discussed above, simulation is increasingly being used to support daily scheduling decisions on the shop floor. FACTOR and InterFaSE are scheduling-oriented manufacturing simulators with utilities for accessing the necessary manufacturing databases.

3. DESIRABLE FEATURES FOR SIMULATION SOFTWARE

We now discuss six groups of specific features that, in the opinion of the authors, are important for simulation software to be used in the analysis of manufacturing systems.

General Features. One of the most important features is modeling flexibility, because no two manufacturing systems are exactly the same. If the simulation package doesn't have the necessary capabilities for a particular application, then the system must be approximated resulting in a model with unknown accuracy. For a simulator, it is desirable for parts (or entities) to have general attributes (e.g., part number, due date, etc.), which can be appropriately changed.

Ease of model development is another very important feature, due to the short time frame for many manufacturing analyses. The accuracy and speed of the modeling process will be increased if the package has good debugging aids, such as an interactive debugger, on-line input error checking, and on-line help.

Fast model execution speed is particularly important when the simulation model is to be run on a microcomputer (PC). For a simulation model of a food manufacturing plant, it took seven hours to simulate two weeks of production on a (fast) 16 megahertz PC.

The maximum model size allowed by the simulation package may be an important factor when the model is to be executed on a PC. For some packages, the maximum model size is currently less than 100K bytes. This potential difficulty will become less important since some vendors are beginning to offer extended model sizes based on the OS/2 operating system.

It is also desirable for software to be compatible across computer classes. Thus, for example, a model could be developed on a PC and executed on a minicomputer or mainframe.

Animation. Animation has become a widely accepted part of the simulation of manufacturing systems. It is particularly useful for communicating the essence of a simulation model (or of simulation itself) to managers or other manufacturing personnel, which greatly increases the model's credibility. For systems with complex logic, animation may also be useful for "program" debugging, for model validation, and for suggesting new control strategies. Desirable animation features include ease of development, user creation of high-resolution icons (using bit-mapped graphics), and smooth movement of icons across the computer screen.

A useful graphical companion to animation is dynamic presentation-quality graphics, where histograms, level meters, dials, etc. are updated as the simulation progresses through time.

Statistical Capabilities. Since almost all manufacturing systems exhibit random behavior, it is imperative for a simulation package to contain good statistical capabilities and for them to be actually used. In general, each source of randomness (e.g., processing times, machine operating times, machine repair times, etc.) needs to be modeled by a probability distribution not just its mean (see Law and McComas [1989]). A simulation package should contain a wide variety of standard distributions (e.g., exponential, gamma, and triangular), should be able to use distributions based on observed shop-floor data (see Law and Kelton [1982, Chapter 5]), and should contain a multiple stream random-number generator to facilitate the comparison of alternative system designs (see Law and Kelton [1982, Chapter 11]).

Since random samples from the input probability distributions "drive" a simulation model through time, simulation output data (e.g., daily throughputs) are also random and appropriate statistical techniques must be used to design and interpret the simulation runs. A simulation package should contain a command to make independent replications of the model automatically, with each replication using different random numbers, starting in the same initial state, and resetting the statistics to "zero." It is also desirable to have the ability to specify a warm-up period (at the end of which output statistics are reset to zero) and to construct a confidence interval for a desired measure of performance (e.g., mean daily throughput) in order to determine the statistical accuracy of the simulation results.

Material Handling Modules. Material handling systems are an important part of most modern manufacturing systems and, furthermore, are often difficult to model. Therefore, the availability of flexible, easy-to-use modules for modeling transporters (e.g., forklift trucks), AGVS (including contention for guide paths), conveyors (both transport and accumulating), AS/RS, cranes, and robots can significantly reduce model development time. It should be noted, however, that the existing material handling modules in some simulation packages may not always be sufficient due to the great diversity of available material handling systems.

Customer Support. Most users of simulation software require some level of on-going support from the vendor. This can be in the form of general software training or may be in providing technical support for specific modeling problems encountered by the user. Good documentation, including numerous detailed examples, is important for software use as well as initial installation.

Output Reports. It is desirable for a simulation package to provide time-saving standard reports for commonly occurring performance statistics (e.g., utilizations, queue sizes, and throughput), but also to allow tailored reports to be developed easily. (For example, standard reports are often not suitable for management presentations.) Furthermore, it is often of interest to obtain (static) presentation-quality graphical displays (e.g., histograms, bar charts, or time plots of important variables) and to have access to the individual model output observations (rather than just the summary statistics) so that additional analyses can be performed. For example, one might want to export the output observations (e.g., daily throughputs) to a graphics package, a spreadsheet, or a statistics package.

We have discussed types of simulation software and have given a detailed list of features to consider when choosing software for a particular application. However, the choice of a simulation package may still be a difficult decision due to the proliferation of simulation products and their widely varying capabilities and prices. We recommend that the potential modeler consider the following activities when making their decision:

(1) Carefully determine the types of manufacturing issues that you want to address by simulation, paying particular attention to the required level of model detail.
(2) Develop a short list of candidate simulation packages based on your requirements in item (1) above, on features of the available software, and on cost considerations.
(3) Talk to several users of each product on your list to get independent assessments of software strengths and weaknesses.
(4) If possible, get a 30-day free trial of each product to see how they perform on applications of particular interest to you.

The reader should be aware that there is no simulation package which is completely convenient and appropriate for all manufacturing applications. Thus, organizations that do a large amount of simulation may want to consider having several simulation packages, which are used for different types of analyses and by people with different backgrounds.

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