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COMPUTER SIMULATION: A MODERN DAY CRYSTAL BALL?

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ABSTRACT

It has long been the desire of managers to be able to look into the future and predict the outcome of decisions. With the advent of computer simulation and the tremendous capability provided by personal computers, that desire can now be realized. This paper presents an overview of computer simulation and modeling, and discusses the capabilities of *Extend*. *Extend* is an iconic-driven Macintosh-based software tool that brings the power of simulation to the average computer user.

An example of an *Extend* based model is presented in the form of the Space Transportation System (STS) Processing Model. The STS Processing Model produces eight shuttle launches per year, yet it takes only about ten minutes to run. In addition, statistical data such as facility utilization, wait times, and processing bottlenecks are produced. The addition or deletion of resources, such as orbiters or facilities, can be easily modeled and their impact analyzed. Through the use of computer simulation, it is possible to look into the future to see the impact of today's decisions.

OVERVIEW OF COMPUTER SIMULATION AND MODELING

Computer simulation and modeling is one of many types of decision support tools. A decision support tool, defined as something that aids in making a decision, can take on many different forms. The simplest of the tools is a coin toss, hopefully employed when the stakes are low, and they increase in sophistication from experience/intuition, spread sheets, math models, and computer simulation. Each decision support tool has its strengths and weaknesses, and therefore must be applied to the situation for which it is best suited. The advantage of computer simulation is that it provides the ability to model processes to predict outcomes in an interactive fashion. Although computer simulation and modeling has been used for many years, it has traditionally been used solely by large companies, universities, and government agencies due to the large investment in hardware, software, and specialized personnel required. Recent changes in the availability of software and hardware have brought the power of computer simulation and modeling to everyone. Figure 1 provides an overview of the three

Format	Strength	Weakness
Language Based	Can be Tailored Across a Range of Applications	Specialized Software Language General Simulations Requires Experts in Coding and Simulation to Operate
Data Driven	Uses Pre-Built Graphical Blocks	Limited to the domain (i.e., manufacturing) for which the blocks were built
Hybrid	Easy to use Customizable Blocks	

Figure 1. Simulation Software Formats and Their Characteristics

types of simulation formats that are currently available.

STS PROCESSING MODEL

An example of the use of simulation is provided by the STS Processing Model. The purpose of developing the Model was to determine the impact of changes such as the number of orbiters required to be processed, facility shutdown for modifications (to either the facility or to an orbiter inside the facility), major flight part unavailability, or GSE disruptions. Other changes, such as the processing impact of a new launch vehicle upon the facilities and the ability of the launch site to effectively process both vehicles can also be modeled. These changes can seriously impact facility utilization and annual launch rate. The facilities at Kennedy Space Center, as in all types of manufacturing or processing operation, are limited. The processing of the space shuttle is performed mainly in three types of facilities. The three Orbiter Processing Facility (OPF) bays are used to de-service and remove payload unique equipment from the orbiter after a mission, perform repairs and modifications, and install equipment and supplies in preparation for the next mission. The two Vehicle Assembly Building (VAB) bays are where the external tank (ET) is attached to the solid rocket boosters after they are stacked, and is also where the orbiter is attached to the ET. The two launch pads are used to prepare the vehicle for launch, including payload installation, fueling, and final checkout. Figure 2 presents an overview of the current STS processing flow.

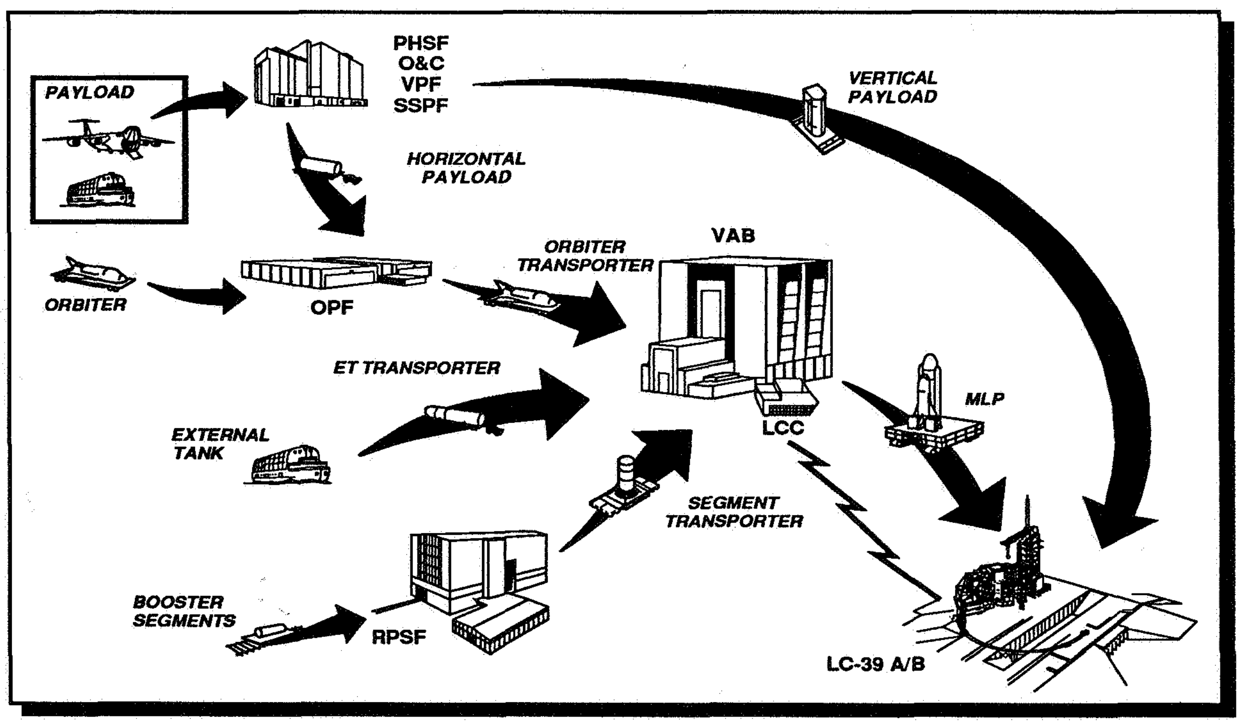

Figure 2. STS Processing Flow

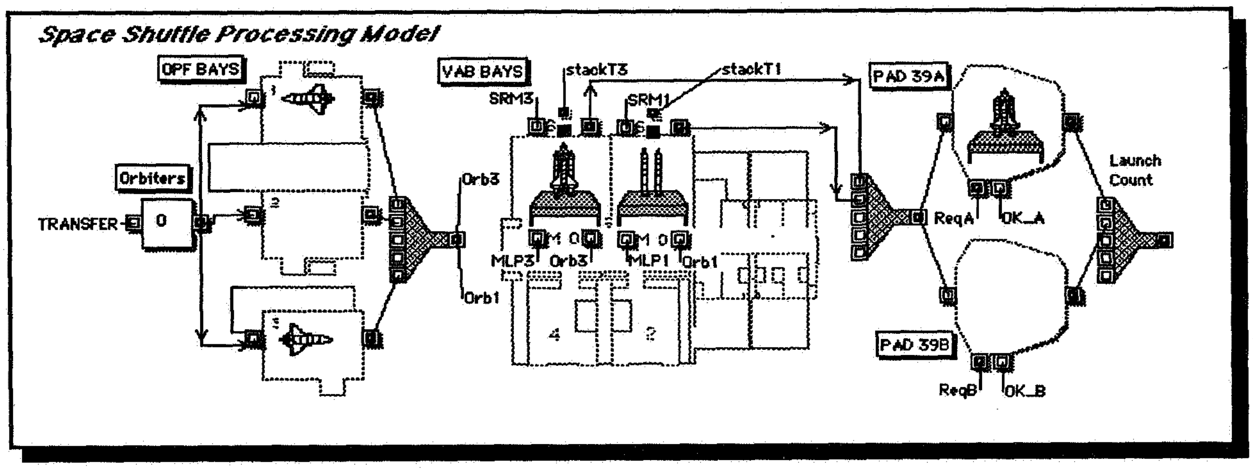

Figure 3. STS Processing Model-Overview

The STS Processing Model was developed through the use of the simulation software *Extend + Manufacturing*™ available from Imagine That, Inc., San Jose, Ca. *Extend* is hybrid, library based, iconic-block (graphical element) commercial-off-the-shelf (COTS) simulation software package. The Model operates in a discrete event mode, where events are orbiter movements or other status changes. Event times are driven by orbiter process durations and the resolution of resource conflicts. An orbiter's process duration is selected from a statistical distribution of achieved processing durations or a default constant. As can be seen in Figure 3, the simulation model of the launch site is very intuitive as the OPF, VAB, and launch pad footprints are used as part of the Model. The process flow on the screen is the same as the orbiter movement toward the launch pad. Additionally, icons of the shuttle, solid rocket boosters, and external tank provide visual clues as to the status of the integrated flow.

Through the use of an input/output screen, called the Notebook, assets such as orbiters or mobile launcher platforms (MLPs) can be added or deleted in order to perform "what-if" analyses. These type of changes take about 10 seconds to make, and it takes about 5 minutes to model a years worth of processing to determine the effects on the launch site. Processing times that the Model pulls from the statistical database, such as for the OPF, VAB, or pads, are also shown in the Notebook input screen (Figure 4) as the Model is running.

The output of the Model is shown in Figure 5. The output shows the achieved launch rate, yearly launch rate, facility utilization for each of the facility processing bays and launch pads, and MLP and orbiter availability. A spreadsheet within the Notebook also captures the as-run data for each processing flow so that comparisons and statistical analyses can be made to determine the results of each "what-if" run. Additional data elements can be added to the Notebook as desired.

Each of the facilities represented consist of a hierarchical block. A hierarchical block is composed of a series of logic blocks that represent the logic and events that occur within the facility. Through the use of hierarchical blocks, it is very easy to add or delete facilities to determine the effect on the processing flow, launch rate, or facility utilization. After a hierarchical block is created, it can be added to a library, such as the STS Processing Library, and used to add the facility in the processing flow as desired. It is also easy to delete a facility, simply by selecting and deleting it, to determine the subsequent effect on the processing flow. Either change,

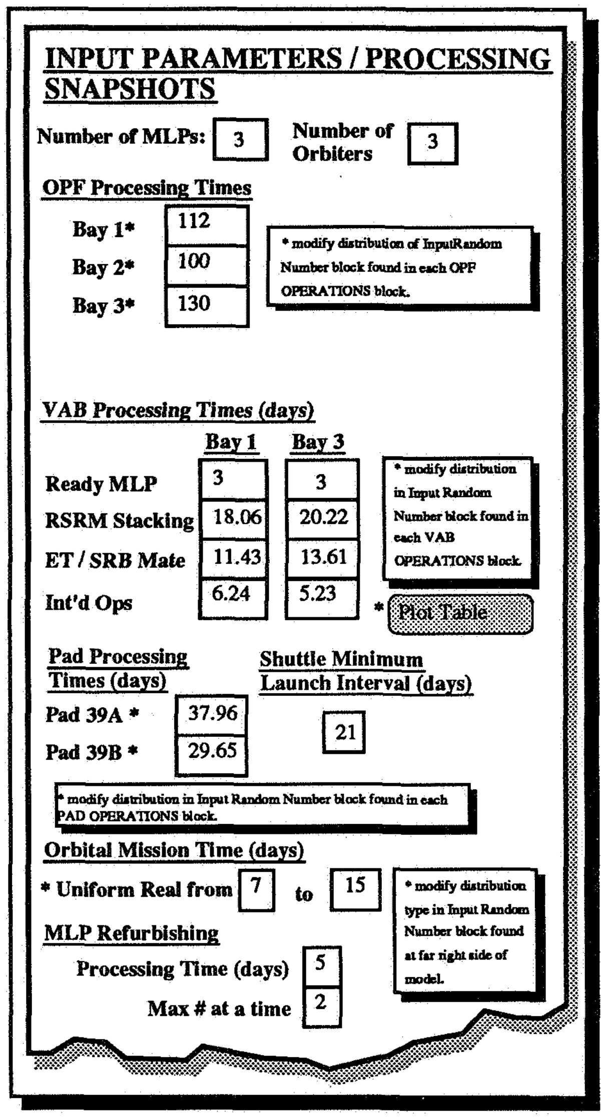

Figure 4. STS Processing Model NotebookInput Screen

whether adding or deleting a facility, takes less than 15 seconds to implement.

Due to its nature as a hybrid simulation package/language, *Extend* enables people with a wide range of ability to change the Model at many levels of detail. The user can double-click on block icons and change dialog parameters. From libraries supplied, the user can get new blocks, connect them, and enter parameters. The simpler groundrules are represented in Equation blocks, so the user can change these or add new blocks to modify groundrules. For the most flexibility, the user can create new primitive blocks by using *Extend*'s built-in C compiler and dialog/icon editors to either modify a pre-existing block or build one from scratch. Most blocks needed are already pre-built. In fact, all but one of the blocks used to build the Model are pre-built.

OTHER USES OF SIMULATION

In addition to the STS Processing Model, *Extend* and simulation have been used in a wide variety of instances where it was important to

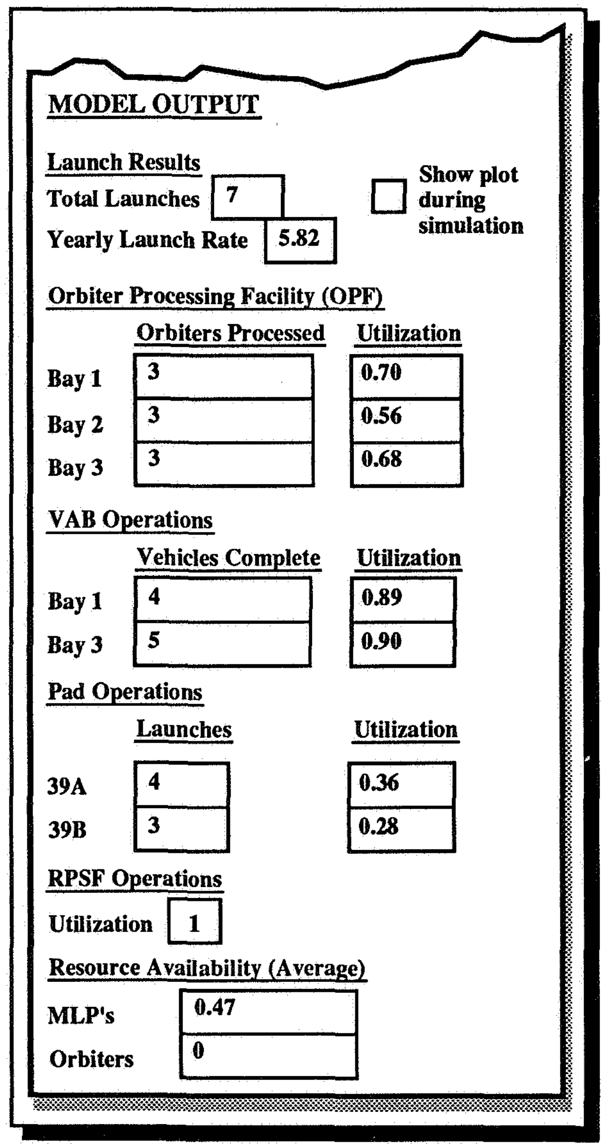

Figure 5. STS Processing Model Notebook Output

see the impact of changes before they were implemented. Lennon Associates, an architectural firm, uses simulation as part of the design and specification process. They modeled the emergency room requirements for Grossmont Hospital in preparation for construction of a new emergency room. Using data compiled from the hospital's records, Lennon found that there were nearly 400 different outcomes that could happen to a patient upon entering the emergency room door. By simulating the actual emergency room requirements, bed requirements were determined to be lower than what the hospital thought they needed, lowering construction and operating costs. Although the emergency room has not yet been built, it is estimated that the simulation will save the hospital $1 million in construction costs and $300,000 per year in operating costs.

BDM International used *Extend* to verify the engineering design of equipment for a military contract, saving $10-15 million. The *Extend* simulation reduced the need for testing and simplified the analysis of the project. It also reduced the size and number of reports required. The main savings occurred because the project team used *Extend* to develop a hardware design that was less expensive than what was currently available, and used simulation as a proof of concept.

Gentek, Inc, a company that specializes in engineering and financial modeling, used *Extend* for an expansion project undertaken by Ben and Jerry's Ice Cream Co. The simulation modeled their 10-year requirements for electricity and the effects and trade-offs (including operation costs) of using alternative sources of energy such as thermal storage. The co-generation plant they selected allowed Ben & Jerry's to expand without forcing the utility companies to increase their capacity.

CONCLUSION

Until recently, the use of computer simulation was limited to those entities with the large amount of resources required to take advantage of the technology. However, due to the recent advances made in hardware and software technology, computer simulation is a tool that is available to anyone desiring to take a peek into the future.

BIOGRAPHIES

Michael Sham (407-383-2200 ext. 2427) is a member of the Advanced Programs Study Team for Lockheed Space Operations Company at Kennedy Space Center. Mr. Sham's current responsibilities include the analysis and evaluation of new space launch systems in terms of their impact to the existing launch infrastructure. He received his BS in Marketing and Management from Oklahoma State University and a MBA with an emphasis in statistics from the Florida Institute of Technology.

Andrew Siprelle (615-982-7046) is President of Siprelle Associates, a firm which provides simulation consulting, training, and custom models. Mr. Siprelle's industry experience includes creation and analysis of deterministic and stochastic models for strategic planning, application of Experimental Design for process improvement, and training employees in industrial statistics. He has used *Extend* to help numerous companies analyze operations and increase productivity. Mr. Siprelle specializes in statistical analysis of simulation output and simulation experiments. He received his BS in Industrial Engineering and Operations Research from Virginia Polytechnic Institute and State University.