Proceedings of the 1987 Winter Simulation Conference
A. Thesen, H. Grant, W. David Kelton (eds.)

USING ANALYTICAL AND SIMULATION MODELING FOR EARLY FACTORY PROTOTYPING

JEANETTE G. NYMON
ALCOA INTER CON-X
SAN DIEGO, CALIFORNIA

ABSTRACT

Simulation and modeling needs became apparent early in the design of a greenfield manufacturing facility, especially in the areas of factory floor design support and in factory floor scheduling. Simulation packages were introduced to this project earlier than normal to help drive the design, rather than waiting for the facility design to drive the system development. Time constraint was another reason for the early development of the prototypes; the models and scheduling systems will be tailored while the factory is brought on line.

1. INTRODUCTION

With Alcoa's decision to enter the electronic ceramic packages market the planning for a manufacturing facility began in 1986. This facility was planned from the beginning to showcase automation and integrated manufacture and the integration and automation team was born.

The CIM team was involved in this project very early in its growth, joining the project in April, 1986. The business plan was evolving and continued to evolve over several months. Marketing strategies were put together and revised over the same period, with the decision to produce electronic cofired ceramic packages, a product that is usually custom built for each customer. The need for modeling and simulation for the facility soon became apparent. The overall process was defined early; process steps included discrete as well as continuous. The manufacturing philosophies to be used are still evolving, however. With this mix of processing steps many questions had to be answered, and some are still being answered.

Simulation and modeling needs were identified by the summer of 1986. The objectives identified were to:

- support the development of manufacturing equipment requirements,
- drive the evolution of users' needs for the systems design,
- support factory and materials handling design and automation,
- facilitate the development of the manufacturing philosophy with respect to work-in-process, lot size, just-in-time, yields, quality and rework,
- identify factory floor scheduling requirements and build a scheduling tool,
- design and build an early prototype of the system that overlays the process equipment and control,
- evolve the prototype system into the actual factory operating system by simulating factory operation,
- find and correct bugs,
- identify and resolve any overlooked areas in the factory systems,
- build a model to train new production employees.

The objectives above were used to identify the specific software packages that would be used for the facility design. These objectives were grouped into the basic needs of quick rough-cut factory floor modeling, factory floor schedule simulation model prototyping, and simulation with animation. The packages chosen to fill these needs were Manuplan, Factor and Siman with Cinema, respectively. A schematic of how these packages fit together and the resulting information flow is shown in Figure 1.

The team is still in the mode of building the prototype models. They built several "rough cut" models of the factory floor with Manuplan, evolving the models as the business plans changed and as more details of the factory floor operation became apparent. The first cut prototype simulation model for factory floor scheduling was built from data input to and produced by the rough cut models, and the data requirements for integrating the scheduling tool with other systems were identified. The rough cut models are being evolved into simulation models that will be used to

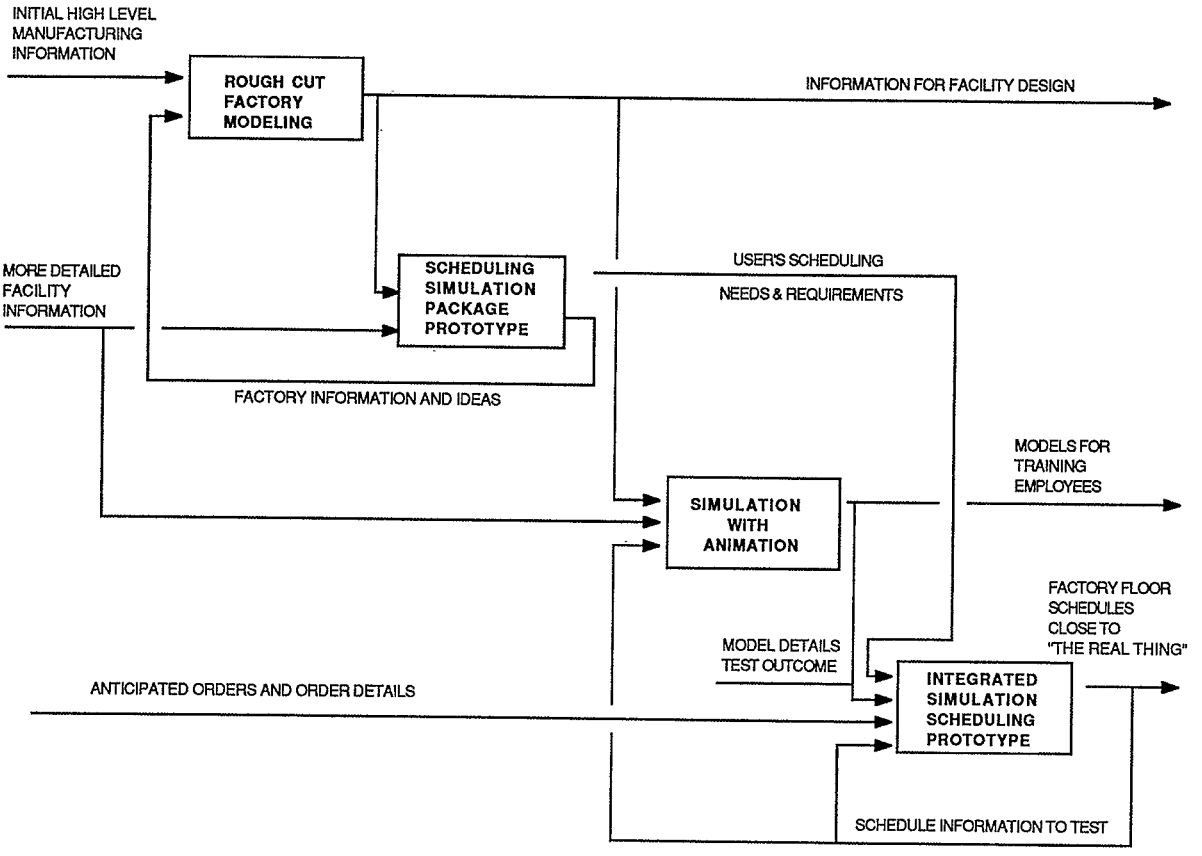

FIGURE #1 SIMULATION AND MODELING INFORMATION FLOW FOR PROTOTYPE DEVELOPMENT

test and validate the prototypes as well as to train new employees as the design details come into focus and new factory employees are hired.

2. Development of the Rough Cut Models

The need for Manuplan's input information drove the thinking of some issues such as planned shift schedules, specific yields at different processes, process flow rates, setup times, lot sizes (material handling issues), inspection issues, and machine failure issues. The timing of this modeling was perfect since Manuplan accepted and dealt with data on a macroscopic level. Each iteration of the business and production plan was modeled with results being fed back to the people responsible for the facility layout. Manuplan helped the team to understand the specific process flow that they were designing as the final production plan emerged. Some of the questions and issues that it forced included:

- are our expected yields at each process step realistic?
- what shifts do we need to run to make production?
- where are the process "bottlenecks" and what are we going to do about them?
- what areas of the process need redesigning?
- what lot sizes make the most sense in our process?
- where should the inspection points be in the process and what percentage of the parts should be inspected?
- will our initial year's factory layout fit strategically into our five-year design?

The more important of Manuplan's outputs were equipment utilization (Are enough pieces of equipment for the production volume being planned?), flow times and work-in-process. The outputs basically showed whether or not the designs would allow production goals to be met. Even more basic, the outputs showed that the information gathered from

the people familiar with the process was correct or close to it. Specifically, the information that Manuplan gave, on a rough cut basis, included:

- equipment utilization (including the percentage as repair time),
- work-in-process, overall as well as at each process point,
- total scrap quantities,
- average flow times through the system, overall as well as at each process point.

The iterations followed through Manuplan gave enough information about the facility design to begin laying out a first cut at the support system, especially in terms of a factory floor scheduler.

3. Scheduling System Prototype Model Development

The Factor scheduling package uses as its basis a high level discrete event simulation model of the factory floor combined with scheduling heuristics embedded in the model. This simulation model is more specific than Manuplan in that it requires more detail on the materials required and on the machine groupings as well as on the routings. The input information required include:

- shop orders and their respective release and due dates,
- a bill of materials for each order,
- the specific routings associated with each order,
- the work centers that need to be scheduled,
- machine buffer size limits.

The interesting aspect of this modeling is that it was initiated early in the design of the facility, before the design was firm and equipment orders were placed.

The prototype model of the facility was built in early 1987 to provide an idea of what the scheduling tool would and would not do, and detail what was needed to integrate it into the system architecture. The team was able to drive out users' needs and requirements early in the design of the system, before they were locked into a system final design. They were also able to develop a specific data structure definition for integration and drive the MRP II data structures. The primary advantage of this prototype system was that they were able to show the users a sample of what they would have in their system, rather than just a written document. They were much clearer on what the system would look like and the team was much clearer on their needs. This prototype further drove and defined the manufacturing philosophies with respect to scheduling rules, lot sizing and buffer sizes.

4. Further Plans for Prototype Development

As the specific product designs come into focus an imaginary database will be put together that will support both the MRP II system as well as feed the scheduling prototype for testing. The results of the prototype will be compared with another simulation model being built to support the facility design. Projected marketing data will be used to put together various order combinations to "stress the system." The prototype will then be further evolved into the actual system as the facility takes form.

5. RESULTS AND CONCLUSIONS

At this point the rough cut modeling is finished, using Manuplan in areas where new ideas needed to be quickly tested. The first prototype of the scheduler with Factor has been completed and the integrated design prototype is still evolving. The facility operating philosophy is still evolving and will in the months to come. The prototype system will help to facilitate that. The tedious part may be yet to come, evolving the prototype into a system that supports the factory due to begin production in 1988. Many system details will be revisited between now and then.

As the systems design and integration plan unfolded, it has been seen that quick prototyping is a useful method of identifying user requirements and software weaknesses within the real time constraint of factory design. The strength of this method is that the users can actually see and touch a version of what they will have for their facility, making it much easier to put together what is really wanted than if the system were only laid out on paper. It is an approach that can be used when time is at a premium. It is effective in driving out system and software issues before the system is due to be placed on line, reducing the time required to tailor and debug the systems.

AUTHOR'S BIOGRAPHY

JEANETTE G. NYMON is a Senior Systems Engineer for Alcoa, assigned to the Alcoa Inter Con-X project in San Diego, California. She was employed by Alcoa for 9 years, 7 years in a process engineering capacity. On the Inter Con-X project, she is responsible for all simulation and modeling as it relates to the integrated factory floor. She received her B.S. degree in Chemical Engineering from Washington State University and is a senior member of IIE.

Jeanette G. Nymon
Alcoa Inter Con-X
16885 West Bernardo Drive
San Diego, CA 92127
(619) 451-7100