# AN INTERACTIVE SIMULATOR FOR TEACHING PRODUCTION PLANNING AND CONTROL

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Abstract

In this paper, an interactive production simulator is described which can be used to teach modern production planning and control techniques. Using this system the student can experience many of the complexities of a manufacturing environment. Master production scheduling and materials requirements planning capabilities are included in the simulator.

## INTRODUCTION

Production planning and control is not a new topic in industrial engineering education. Virtually all industrial engineering colleges address the subject in one or more courses. Recently, many articles have been published regarding the renewed emphasis on production planning and control and its significant effect on productivity. Due to the complexities of a production environment teaching this subject to inexperienced students has been difficult. The goal of this project was the development of an interactive production simulator as an aid to educators. This project was funded by the National Sciences Foundation.

Simulation has proven to be a valuable teaching aid. In the late 1960's, a production simulator (PROSIM V) was developed at Auburn University (1). The simulator provided students the opportunity to experience the complexities of a manufacturing environment. Though the production process simulated was relatively uncomplicated, many planning and control techniques were demonstrated, such as forecasting, lot sizing, scheduling, and inventory and manpower resource control. However, as with most educational simulators, developments of new planning and control techniques, such as material requirements planning (MRP), and new simulation methodologies have reduced its effectiveness.

The primary objective of this project was the development of an interactive production simulator similar to PROSIM, but incorporating modern techniques and methodologies. Computer planning models for Master Production Scheduling (MPS), Material Requirements Planning (MRP), and Capacity Planning (CP) were included. A thorough understanding of how to employ these planning concepts is essential to today's graduates. Formulating the simulator as an interactive next-event simulation, and using a modular structure resulted in a more efficient and flexible system. The resulting package should be a valuable aid to engineering educators.

## THE SIMULATED MANUFACTURING ENVIRONMENT

Simulation of a broad range of manufactured products and production facilities is possible using the production simulator. In general, one or more end products are produced to satisfy randomly distributed demand. Each end product consists of subassemblies and parts which are either purchased or fabricated. The manufacturing facility consists of a series of work stations each of which performs a separate process. Parts, subassemblies, and end products are kept in a limited storage warehouse.

In addition to the variable demand for end products, other uncertainties are simulated. Purchasing lead times and work station processing times vary. Material losses occur in varying amounts during shipping and processing. Machine breakdowns occur, and the repair times are randomly distributed.

The student is cast in the role of production supervisor, and is responsible for purchase and production order releases, production activity scheduling, and inventory control. The work force may be varied by scheduling overtime, or by adding second and third work shifts. The costs normally associated with manufacturing activities (ordering, holding, stock-out, expediting, labor, overhead, etc.) are incurred, and may be used as a performance measure.

## THE SIMULATION CYCLE

The simulator allows the instructor to interactively design the manufacturing environment, or employ one which is provided. The problem parameters and certain simulator features are easily modified. Once the system is initialized, weekly production

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cycles begin.

The student or team is provided with essential background information, such as bill of materials, production routing, demand history, current inventory, work-in-process, and cost data. Also, each student is provided with a set of data files containing parameters for the planning modules. These files are structured similarly to those normally encountered in industry and are easily modified. The Bill of Material (BOM) file is created, but the student must input appropriate data.

After examining the demand history, the student forecasts end item demand. The forecast along with current inventory and planned receipts are input to the MPS model. The model displays planned inventory status, allowing the student to iteratively develop a schedule for production of end items.

Once an acceptable schedule is developed, the MRP model is used to explode end item requirements. The student is responsible for insuring the accuracy of the lead times contained in the planning files. Also, an erroneous BOM file will, naturally, produce erroneous results. The output from this regenerative model will guide expediting and order release decisions.

The next step in the cycle is Capacity Planning. Using the CP model, the student can determine if over or under loading is anticipated. Adding a shift, scheduling overtime or expediting a work order may then be employed to rectify the problem. The costs associated with these actions must be weighed carefully.

Production simulation now begins. The student releases production and purchase orders, and allocates labor hours. A critical ratio is calculated for each production order using the due date and planned lead time. This determines job priority. Processing and transfer lot sizes may also be modified by the student to control job flow through work centers.

As the simulation progresses, messages are output when significant events occur. In addition, the instructor has the option of allowing some decision making either at specified time intervals or upon occurence of selected events.

Upon completion of the simulation performance, files for the instructor and the student are updated, and the event calendar and system status are saved for the next cycle. Performance report programs are available for both instructor and student. These present information on inventory status, production costs, forecast accuracy, and demand satisfaction.

## THE PRODUCTION SIMULATOR

The production simulator was developed on a Hewlett-Packard 3000 using the FORTRAN language. A next-event simulation methodology was used employing a filing system similar that used in GASP. System initialization, feature selection, model execution, and data input are all accomplished interactively. Data and program files are maintained on disk. A modular structure was used for ease in transportation and modification.

A relatively simple manufacturing environment is included as a sample problem. This was taken from the PROSIM V (2) manual and has many virtures as a classroom model. Modification or replacement of this example is a relatively straight forward task.

## CONCLUSION

Renewed emphasis on production planning and control in industry is evident from the many articles on the subject recently published. Consequently, it is imperative that today's graduates of Industrial Engineering have a firm grasp of modern techniques of planning and control. However, educational institutions have historically had difficulty teaching production courses so that an inexperienced student will have an understanding of the production environment. The interactive production planning and control simulator provides educators with an instructional aid in demonstrating the difficulties of planning and controlling a manufacturing environment. Effective techniques can be presented and their application demonstrated. Furthermore, the flexible nature of the simulator allows for new techniques to be incorporated and a broad new range of manufacturing environments to be studied.

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