Simulations Games And Experiential Learning in Action, Volume 2, 1975

OMSIM: AN OPERATIONS MANAGEMENT GAME

George A. Johnson
Idaho State University

Thomas E. Hendrick
University of Colorado

INTRODUCTION

This paper describes a new game oriented towards a production/ operations management environment called OMSIM [4] (Operations Management SIMulation). The authors have been developing and refining OMSIM for the past three years and are currently subjecting it to extensive classroom testing on over 400 students in nine course sections taught by four different instructors at the University of Colorado. The early responses from students are gratifying; most say that it is challenging, realistic, properly frustrating, and provides an integrating decision making experience.

Our stimulus to build OMSIM was not caused by the absence of several excellent games which emphasize production/operations decisions; pedagogical simulators in this area have been commercially available for about six years. PROSIM [3] and The Decision Making Game [2] both appeared in 1969. A year later JOBLOT [1] was published, with PROSIM V [5] following in 1971. Having utilized [2], or attempted to utilize, [1], two of these games at the University of Colorado and reviewing the structure of the other two, we would characterize The Decision Making Game and PROSIM as games of beginning to moderate complexity, with JOBLOT and PROSIM V being classified as complex.

GENERAL CHARACTERISTICS OF OMSIM

OMSIM has been designed to fit between these two groups of games along with the flexibility to structure a specific game environment which ranges from moderately complex to complex. This variable structuring is easily facilitated through the use of an auxiliary program (PARAMGEN) which automatically generates unique game parameter decks for use in OMSIM based on the desired complexity as specified by the game administrator. Further, the parameter deck produced by PARAMGEN is used as input to DEMHIST, another auxiliary program, which produces a printout of 36 months of daily demand histories for each of the products manufactured. These histories contain trend, seasonal, and other time series information for the game participants.

All three programs (OMSIM, PARAMGEN, and DEMHIST) are written in Fortran IV and require a medium sized system with a card reader, card punch, and a line printer. Central processing time for a single OMSIM run of a seven product environment (fairly complex) made up of 10 teams with multiple copy output typically is about 1 minute with a cost of about $12.00 on

Colorado's CDC 6400.

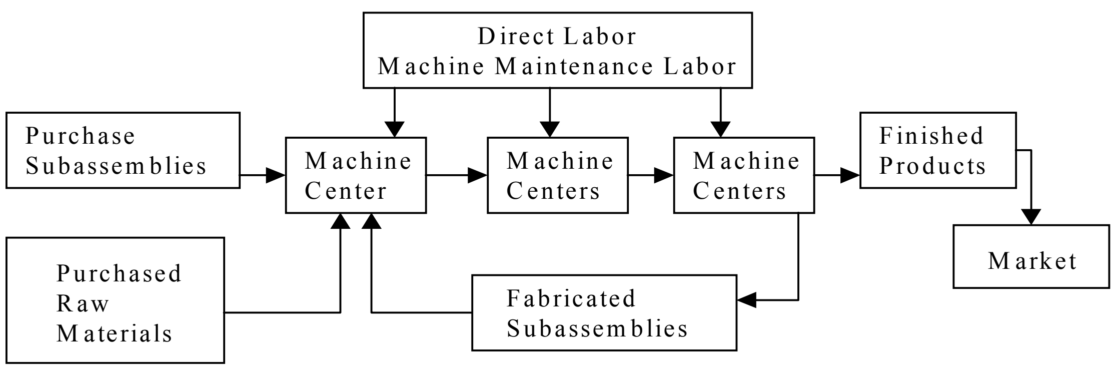
SPECIFIC CHARACTERISTICS OF OMSIM

Overview

OMSIM emulates a typical manufacturing environment which transforms raw materials and subassemblies (either manufactured internally or purchased) into standard finished products with direct labor and machine operations. The manufacturing specifications for each product, as well as the number of different products are determined by the game administrator according to the desired level of complexity. Typically, each round of play simulates and reports on production activities for each of 20 days;

Figure 1 provides a diagram of the production flow of OMSIM. Each step has unique requirements for labor, machines, materials, subassemblies, and routing. The general objective is to design, implement, and control an efficient production system which can produce finished products at a minimum cost and sell them at a price which produces maximum return on investment.

FIGURE 1



Pricing and Demand

The basic market environment is determined through a set of demand functions generated by PARAMGEN and the prices charged by each team. Price competition is optional in the game. If pricing is used, the demand for each team is dependent on each team's price in relation to all other teams and to a basic market price. If price competition is not allowed, then each team faces the same demand for finished products; there is no interaction between teams. Demand is generated for each day according to trend, season, cyclic, and random effects specified by the administrator. Leading and coincident economic indicators are also included for use in forecasting demand.

A unique feature of <u>OMSIM</u> is the provision of a program that utilizes the demand functions planned for the game and generates a three year history of daily sales that immediately precedes the first period of game play. This provides an abundance of Pricing and Demand material for use of forecasting models for time series analysis.

Another unique feature is that all teams, except for price effects, face the same demand. This minimizes the "grumbling" about being the victim of chance, and makes it easy, where it may be necessary, to rerun the decisions of an individual team because of errors. In other words, a single team may be rerun without rerunning all other teams.

Capital Investment

The first set of decisions each team faces involves capacity planning and purchasing capital equipment. This requires the translation of demand forecasts into capital facility requirements. These capital facility requirements are then translated into two types of decisions. First, the team is confronted with a number of choices of machines which can do one particular job. Figure two presents an example of choices that might be available.

FIGURE 2
MACHINE DATA

Machine Center	Cost	Per Period Depreciation	Operating Cost/hour	Machine Factor	Labor Factor	Setup Factor	Machine Type
1	$16,200	$270	$1.68	100	100	100	1
1	43,600	720	16.74	67	78	93	2
1	82,600	1370	20.15	42	40	32	3
2	15,400	250	1.00	100	100	100	1
2	44,000	730	10.03	79	71	120	2
2	60,600	1010	17.70	64	67	78	3
3	20,400	340	5.30	100	100	100	1
3	44,200	730	12.73	69	82	121	2
3	14,300	230	4.75	105	101	120	3
4	15,600	260	5.12	100	100	100	1
4	31,800	530	5.22	92	95	99	2
4	51,800	860	5.18	86	52	64	3

The alternatives range from expensive automatic machines requiring high set-up costs and low labor requirements and machine time to cheaper machines that require small set-up times but substantial amounts of labor and machine time. The machine factor, labor factor, and set-up factor determines a machine's efficiency. For example, a machine factor of 67 means that that machine will take 67% of the standard time to produce a product. As a machine is used these factors increase each period to simulate machine deterioration. Machines also vary in their operating costs, and their reliability. Further, expensive machines are generally considered more complex and less reliable, and new machines are subject to infant mortality of breakdown. A game player in considering capital investment can increase his capacity by scheduling a second shift or overtime.

Second, capital facilities' costs are dependent on the number of machines purchased. For every four machines added the firm must add $50,000 in fixed plant assets. Capital investment in plant and machines can be minimized by scheduling overtime or a second shift if extra capacity is required.

All capital investments are depreciated on a straight line basis and may be financed through debt or equity. The manner of financing can be controlled by the game administrator.

The administrator is free to design his own machine choices; however, since this can be a time consuming task he can utilize the auxiliary program PARAMGEN to generate all the machine choices with a handful of basic parameters. This feature makes it easy to change the structure of the game from term to term.

Maintenance

A decision clearly related to the selection of machines are the maintenance policies of a firm. Maintenance policies are translated into the computation of a probability of breakdown for each individual machine. This probability is utilized in a Monte Carlo process each day to determine machine breakdowns. Three decisions constitute a firm's maintenance policies. First, the type of machine selected sets a basic breakdown factor or probability of breakdown for a machine. Second, the probability of breakdown is affected by the number of maintenance persons scheduled each period. Last, preventative maintenance can be scheduled for each machine for specific days. As machines are used, their probability of breakdown continues to increase. The only way this probability can be decreased is through preventative maintenance or if the machine fails and is repaired. Repair does not have as great an effect as preventative maintenance in reducing the new probability of breakdown after repair.

Operational Decisions

After the team has established its capital facilities, it faces the task of managing its day to day operations. The basic areas involved here are scheduling of labor, scheduling of machines, material management, and cash management. In making these decisions the team works from a set of production requirements. A simple example is given in Figure 3. The times specified represent the standard times which may be modified by the type of machine used. Note that product three is a subassembly which is used in the production of products 1 and 2 as raw material 4.

Labor

Labor may be scheduled for regular time, overtime, and for one or two shifts for each day. In addition, hours must be allocated to specific machines and shop orders for each day. This requires detailed scheduling by the game player.

FIGURE 3

PRODUCTION REQUIREMENTS

PRODUCTION REQUIREMENTS FOR PRODUCT 1

	MACHINE CENTER			
	1	2	3	4
Routing Order	4	1	3	2
Machine Hrs.	.004	.06	.031	.014
Setup Time (Hrs)	5.20	8.00	.50	1.30
Labor Hours	.02	.18	.73	.05
Raw Material				
1	5	0	0	0
2	0	0	0	5
3	0	8	0	0
4	0	0	0	4

PRODUCTION REQUIREMENTS FOR PRODUCT 2

	MACHINE CENTER			
	1	2	3	4
Routing Order		1		
Machine Hrs	0	.107	0	0
Setup Time (Hrs)	0	8.40	0	0
Labor Hours	0	.01	0	0
Raw Material				
1	0	0	0	0
2	0	8	0	0
3	0	0	0	0
4	0	1	0	0

PRODUCTION REQUIREMENTS FOR PRODUCT 3

	MACHINE CENTER			
	1	2	3	4
Routing Order	2	3	1	4
Machine Hrs	.053	.010	.240	.001
Setup Time (Hrs)	3.60	2.00	14.00	.70
Labor Hours	.02	.02	.40	.01
Raw Material				
1	0	0	0	0
2	0	8	0	0
3	0	0	0	0
4	0	0	0	0

Note: Product 3 is produced only as a subassembly and becomes raw material 4. It is never sold as a finished product. Raw material 4 may be purchased rather than produced.

Changes in the aggregate level of labor incurs hiring and layoff costs. Further, effective labor hours scheduled are subject to a labor efficiency, which accounts for personal time and breaks. To add a further touch of realism, this efficiency is lower on Mondays and Fridays and higher in the middle of the week. If a second shift is scheduled, labor efficiency is also reduced.

Labor negotiations are easily facilitated with OMSIM for game administrators who wish to include it. The game provides the facility to set individual labor rates for each firm and to shut down a firm's production if it is struck for any part of a period.

Scheduling

The requirements to produce a product are specified according to the example in Figure 3. Each product requires a certain number of processing steps. Typically, this varies from 1-5 machine center steps. At each step there are specified requirements for machine set-up time, machine time, labor time, and raw material requirements. As a product is produced, it is transferred from one step to another until completion, after which it goes to finished goods inventory.

In scheduling production, the team may schedule each machine every day. Scheduling requires that one specify the day or days scheduled, product to be worked on, quantity to be produced, labor allocated, and the machine on which the production is to take place. This is undoubtedly the most laborious task in the game. Skillful scheduling however has a significant impact on game performance. Complete scheduling flexibility allows the student to experiment with different scheduling strategies which range from dedicated machines producing a level rate to variable rates requiring frequent machine changeovers from one product to another.

Materials Management

The firm must purchase raw materials for use in production. Subassemblies may either be produced or purchased, thus creating a make or buy decision. Purchased materials may be ordered through the use of reorder point and order quantity policies, or, alternatively, orders for specific quantities on a specific due date may be placed. This later option provides the opportunity to demonstrate Material Requirements Planning (NRP). An optional mechanism is provided for expediting emergency orders of raw materials at increased prices. This simulates the action of an expeditor and overcomes the problem of a plant being shut-down for a long period awaiting a raw material. Delivery lead time can be estimated, but is subject to random variation. Quantity discounts are also allowed for each raw material as are different raw material prices for each team.

We believe OMSIM is very strong in the area of material requirements planning. The approach of other games is to have raw material orders placed at the beginning of each period for delivery at the end of the period. A few games allow automatic ordering based on reorder points, however we know of none that allows the player to specify different order sizes and different delivery dates. For other games, this precludes the illustration of Material Requirements Planning as an alternative to EOQ, ROP policies. Many other games do not provide for any variation in lead time nor do they allow expediting raw materials where shortages exist.

Another useful attribute of OMSIM is the inclusion of sub- assemblies. The game can be structured so that subassemblies, at an extreme, require other subassemblies and/or each other. This allows the illustration of complex product trees, and bill of materials explosion.

Cash Management

The major factor in controlling cash is the facility for adding or paying off debt or investments. There are penalties for poor cash management in the game as well as an exponentially increasing interest rate for teams that become overburdened with debt. For cash rich companies there are outlets for various types of investments. Finally, delays occur in receiving accounts receivable and in payment of accounts payable.

Game Output

Each period the game player is provided a detailed report of the firm’s operations. This report provides daily information on scheduled labor and actual labor available; each order scheduled and units produced; machine down time; messages indicating the reason production was less than scheduled if that occurred; raw material orders placed and received; sales information; and raw material, in process, and finished goods inventory information. The team also receives a balance sheet, income statement, a summary of information on sales, production, inventory, and machine status, and an industry report which provides information on the performance of each team.

AVAILABILITY OF OMSIM

Presently, OMSIM is being tested in nine classes at the University of Colorado. It is largely debugged and will be available through the University of Colorado’s Business Research Division at a nominal price until a commercial publishing arrangement can be completed. Those interested in its use should contact the authors.

REFERENCES

1. Churchill, Geoffrey, JOBLOT, (Toronto: The Macmillan Company, 1970)

2. Darden, Bill R. and William H. Lucas, The Decision Making Game, (New York: Appleton-Century-Crofts, 1969)

3. Greenlaw, Paul S. and Michael P. Hottenstein, PROSIM, (Scranton: International Textbook Company, 1969)

4. Johnson, George A. and Thomas E. Hendrick, OMSIM, (Boulder: Business Research Division, University of Colorado, to appear in 1975) Telephone (303) 492-8227

5. Mize, Joe H., Bruce E. Herring, Clifford L. Cook, Myung S. Chung, and Charles R. White, Production System Simulator (PROSIM V), (Englewood Cliffs: Prentice-Hall Inc., 1971)