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Rapid modeling: Implications for business planning

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ABSTRACT

The ability to quickly model the production implications of a product for the marketing, sales, finance, or engineering functions of the enterprise, takes the manufacturing function into a strategic planning role. Rapid modeling can play a significant role in the selection of a manufacturing strategy. This discussion will show the capability and potential of rapid modeling in assisting planners and analysts examine various manufacturing alternatives. The proposed modeling technique can be used to examine manufacturing variables of interest to the marketing, engineering, production and finance components of the business entity. The model provides a focal point for the organization's decision support system by providing insight into the major aspects of production planning, scheduling and economic justification.

I. INTRODUCTION

The process by which products are coming to market is becoming shorter thus necessitating integration of the engineering, marketing and production components of the business enterprise [8]. The manufacturing component of the enterprise can make or break an effort based on the selected manufacturing strategy. A manufacturing planning and analysis method that works within the framework of the product design cycle and keeps pace with design [10] can make manufacturing a major driving force. Thus, manufacturing can become an active rather than reactive force in the process [14].

II. A MANUFACTURING SYSTEM MODEL

An example of a high level model that illustrates the rapid modeling technique is shown in Figures II-1. This is a model of an advanced wafer fabrication process used to manufacture custom and semi-custom VLSI circuits [5]. The model includes a description of the information flow as well as the material flow. Figure II-1 illustrates the equipment involved in the process. Table II-1 and 2 contains an equipment description and the process information that accompanies a typical product made in the system.

The performance parameters most manufacturing managers are interested in are:

- Production rate
- Throughput
- Work-in process (WIP) and inventory cost
- Equipment utilization

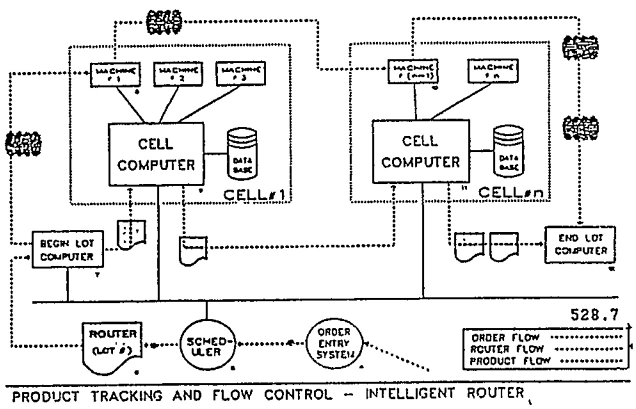

Figure II-1: Equipment Configuration for a Wafer Fabrication Process

1. Results for WAFERA Production

Table II-3 is a listing of the results of the analysis using the rapid modeling tool MANUPLAN.

Table II-1: Equipment Specifications for Wafer Fabrication

* equip * name *	no.in group	reliability-(min) Mean Time to Fail (mttf)	to repair (mttr)
OES	1	1000	10
SCHED	1	1000	10
ROUTER	1	1000	10
BEGINCOM	2	1000	10
MACH1	1	1000	10
CELLCOM1	1	1000	10
MACHN	1	1000	10
CELLCOMN	1	1000	10
ENDCOM	1	1000	10

*

*Part name/num *	demand per day	lot size	demand factor
ORDER	100	1	1
WAFERA	100	1	1
DONE			

Table II-2: Process Routing Sheet

* OPERATION ASSIGNMENT FOR PART ORDER

*

Opern name *	Equip Name	time/lot (setup)	time/pc (run)
OES	OES	1	5
SCHED	SCHED	1	4
ROUTER	ROUTER	1	5
BEGINCOM	BEGINCOM	1	3
MACH1	MACHN	3	7
MACHN	MACHN	2	4
ENDCOM	ENCOM	1	3
DONE			

* Routing for Item (Part) ORDER

* From * Opern *	To Opern	Proportion
DOCK	OES	1
OES	SCHED	1
SCHED	ROUTER	1
ROUTER	BEGINCOM	1
BEGINCOM	MACH1	1
MACH1	MACHN	1
MACHN	ENDCOM	1
ENDCOM	STOK	1

*

Table II-3: Manuplan Results for WAFERA

EQUIPMENT UTILIZATION(%)

	Setup	Run	Repair
OES	13.9	69.4	0.8
SCHED	13.9	55.6	0.7
ROUTER	13.9	69.4	0.8
BEGINCOM	6.9	20.8	0.3
MACH1	20.8	48.6	0.7
CELLCOM1	20.8	48.6	0.7
MACHN	13.9	27.8	0.4
CELLCOMN	13.9	27.8	0.4
ENDCOM	6.9	41.7	0.5

Work in Process by equipment-WAFERA

* * * *	Desired production can be Good Prodn	Scrap Prodn	WORK IN PROCESS
LOT	100	0	4.3
ROUTE	100	0	4.3
DONE			
	TOTAL PIECES:		8.6

*

* OPERATIONS FOR PARTS

*	WORK IN PROCESS (pieces)	TIME spent /visit	TOTAL FLOW TIME spent /good piece
OES	0.8	10.8	10.8
SCHED	0.5	6.6	6.6
ROUTER	0.3	4.1	4.1
MACH1	1.3	18.2	18.2
MACHN	0.5	7.1	7.1
ENDCOM	0.4	5.5	5.5

III. REQUIREMENTS FOR RAPID MODELS

The major benefit derived from rapid modeling is the ability to quickly describe and analyze various manufacturing alternatives. The need for rapid modeling with the underlying premises are described in [14].

1. Features of Rapid Modeling

The following features are essential to a rapid modeling capability:

- Ease of entry of production and process data into the model and ease of making changes to that information.
- The input data should be minimal and the results should be complete enough to assist the user during the decision process.
- Output information must be in a form easily comprehended by the user.
- The tool should be interactive with short execution time.
- The input and output results should be integrated with other analysis tools like spreadsheets and simulation.
- To be useful, the model and analysis must be complete and rigorous.

2. Advantages of the modeling Approach

Unlike simulation the rapid modeling approach does not require the user to know the underlying statistical distribution for the input data. Traditional simulation usually requires data and other information that is usually unavailable at the beginning of an analysis. Access to an analysis tool that lets the user do a quick "what-if" analysis without the tedium and skill requirements inherent in simulation, is overcome by the rapid modeling approach described here.

3. Spreadsheet

Spread sheets such as Lotus 1-2-3 have most of the features of speed, ease of use, etcetera, but do not have a simple model that is directly useful for the questions of interest. A more complete model within a spreadsheet would be equivalent to a rapid modeling approach but the programming time would be lengthy, the customization would be complex and consistency would be questionable.

4. Lead Time Estimates for The MRP System

A Manufacturing Resource Planning (MRP) system theoretically can do "what-if" analysis however, in practice it is never interactive. Also, MRP systems require lead time as an input. Since lead time usually varies directly with the manufacturing systems loading, reliability parameters, lot size, setup and run times the resulting lead times estimates from rapid modeling can be used in the MRP system. This makes it an effective stand alone planning tool that can be used with the MRP system.

IV. RAPID MODELING EXAMPLES

The power and potential of rapid modeling using MANUPLAN and SIMAN and its value to the decision makers in the organization is illustrated in the following examples.

1. Manufacturing Process Design or Change

One of the most traditional industrial engineering functions is manufacturing process design [1] and design changes to existing facilities. The rapid modeling approach allows a manufacturing engineer or planner to be more progressive; a product designer can also use the rapid modeling tool to help design for manufacturability. Answers to the following questions are facilitated by using a rapid modeling approach.

- How to design the product knowing what machines are available?
- How does the design use the available machines ?
- How to justify the new technology to be used in the product?

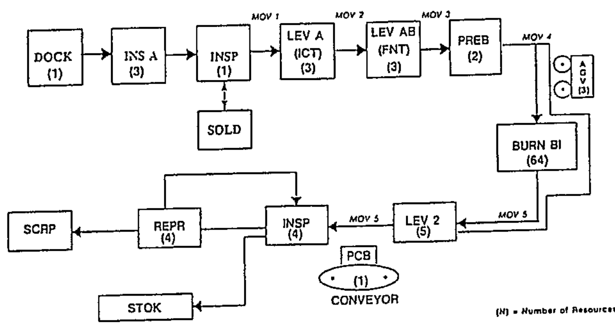

Figure IV-1: Model for a PCB Mfg Process

For example, in the PCB Assembly and Test model describe in Figure IV-1 and Table IV-1 , the designers may wish to reduce the possibility of rework by improving the process or part quality before the INSPT step. The analysis of the required changes would be forced on the manufacturing department with the designer usually not getting a quick answer. With a rapid modeling approach the manufacturing department could respond quickly or the product designer could model the changes interactively to see how the design changes would affect the manufacturing system

Table IV-1: Equipment Utilization Before and After Process Improvements

*

* EQUIPMENT UTILIZATION SUMMARY

DEMAND 30,000 LOT SIZE=1

* equip * name	no. in group	TOTAL UTIL(%) BEFORE	TOTAL UTIL(%) AFTER
INSA	2	52.6	52.6
INS	4	45.3	45.3
IP	2	49.7	49.7
SOLD	-1	1.2	1.2
ICT	6	77.3	69.7(*)
FNT	2	42.3	42.3
PREB	2	41.7	41.7
BI	-1	10	10
LEV2	5	21.9	16.8(*)
INSP1	4	77.3	66.1
REPR	4	25.5	2.2(*)
CRAN	2	93.6	62.6(*)
AGVS	6	67.6	63.3(*)
CONV	-1	0.2	0.2

performance parameters.

The manufacturing departments solutions could be a reduction of a minute in setup time at an operation or a machine, an increase in the number of machines or an improvement in the process. These all may be cost effective solutions. These would all lead to a decrease in the utilization of the REPR resource, as expected. The Flow Time and WIP levels would also decrease due to the process improvement. Table IV-1 shows the results of improving the process quality from 50% to 95% and the change in equipment utilization that results when there is the are fewer boards to be tested and rerouted back to the testers by the material handling system.

2. Impact on Marketing

The interaction between design and marketing is facilitated by the rapid modeling approach [12]. If marketing and sales have a wide range of potential projects, volumes and product mixes, the resultant range of possible options in design and manufacturing sector are even greater. An ability to look at many scenarios quickly is the only method that will insure a consistent and meaningful analysis of the options.

Consider a system with two potential volumes as shown in Table IV-2 and how that effects the manufacturing processes and equipment. At different volumes the equipment and production methods one chooses could be significantly different. The rapid

Table IV-2: Equipment Utilization Summary --Lot Size=1

Operation on 2 Shifts (16 hrs/day)

DEMAND	30,000		60,000	
equip name	no. in group	TOTAL Util(%)	no. in group	TOTAL Util(%)
Quality Level		50%		50%
INSA	2	52.6	3	70.1
INSB	4	45.3	4	90.6
INSP	2	49.7	3	66.2
SOLD	-1	1.2	-1	1.2
ICT	6	77.3	10	92.7
FNT	2	42.3	2	84.7
PREB	2	41.7	2	83.3
BI	-1	10	-1	10
LEV2	5	21.9	5	43.7
INSP1	4	77.3	7	88.3
REPR	4	25.5	4	51.1
CRAN	2	93.6	4	93.6
AGVS	6	67.6	9	90.1
CONV	-1	0.2	-1	0.2

modeling approach lets the manufacturing decision maker plot out a complete long term (2, 3, 5 year) manufacturing strategy for various evolving system configurations as the volume grows from year to year. The financial implications can also be analyzed using as a basis the results obtain from the model. The analysis method used make manufacturing the active rather than reactive force of the company.

3. Impact on Product Design

Early in the life cycle of a project, one focuses on the questions of design and manufacture to cost. There are many new technologies that can be exploited and the decision makers need to sort out the effects of the various possible alternatives. Rapid modeling techniques are useful in bringing all the operating units in the enterprise together early in the design cycle to examine and trade off the many alternatives that can lead to product enhancements and an optimum manufacturing strategy.

The value of the rapid modeling approach is most clear when the enterprise is attempting to produce the product at the lowest possible cost or at a cost that is lower than the competition. Both approaches are valid but the manufacturing and business implications are enormous. A company would need to consider all aspects of engineering, sales, and production to make some decisions. A rapid modeling tool is necessary because it provides the speed and flexibility to aide in the analysis of all of the options and include the important factors.

4. Impact within Manufacturing

The rapid modeling approach can also take a more short term view of manufacturing [12]. A user can run a schedule for each quarter or month and make various manufacturing decisions based on the results. For example, the manager could decide to off-load certain parts or operations to other departments or vendors, make decisions about the levels of overtime or suggest schedules more in line with the plant's capabilities. The analyst can model each quarter and have different production plans and strategies for different quarters as illustrated in Table IV-3. The rapid modeling tool lets the analyst or planner change the production levels, product mix, staffing, etc. and make decisions based on the results obtained from the tool.

Table IV-3: PCB Demand by Period

DEMAND FOR	PART NAME/NUMBER PCB149	PCB259
QRTR 1 88	4500	5400
QRTR 2 88	4000	4400
QRTR 3 88	5500	6400
QRTR 4 88	3500	5000
QRTR 1 89	4500	5400
QRTR 2 89	4200	4600
QRTR 3 89	5800	6600
QRTR 4 89	3800	5400

V. INTEGRATION WITH OTHER TOOLS

The interdisciplinary nature of the business enterprise requires integration of the decision support tools. The spreadsheet is a common tool used throughout most enterprises for the basis of analyzing and communicating. In addition to the parameters identified thus far from rapid modeling, the analyst may include within a spreadsheet an analysis with cells and equations that directly relate to the manufacturing cost.

1. Analytic Modeling and Simulation

The analyst can now more easily link analytic modeling with simulation. SIMSTARTER (SIMSTARTER and MANUPLAN are trademarks of Network Dynamics Inc., Cambridge, MA.) is a tool that generate a fully debugged and functioning model and experiment input files for SIMAN , from the input data for MANUPLAN [2]. SIMSTARTER improves simulation model building productivity and shifts most of the analyst's effort from simulation model creation to the creation of the CINEMA (CINEMA and SIMAN are trademarks of Systems Modeling Corp. Sewickely, PA.) [13] animation layout of the entire system. In some cases certain relationships inherent in the actual system being modeled might not be definable in the MANUPLAN model, and the SIMSTARTER-generated SIMAN model may need some changes. Often such changes can be made in one area of the model code, leaving most of the SIMSTARTER-generated model untouched. By starting with a complete simulation, thereby avoiding the usual step-by-step coding of the more routine events in the simulation, one's efforts can be focused on the enhancements that make the simulation a more valuable tool. In the end, the extra time spent on making the simulation more realistic through the addition of details and on developing an easily understood animation, can help in the training and orientation of the decisions makers based on the conclusions derived from the system simulation.

The ability to show behavior of the system dynamically and optimize it using computer graphics after performing a spread sheet analysis enhances the decision making process [3].

VI. EXPERIENCE WITH RAPID MODELING

Based on the consulting and understanding of numerous manufacturing systems, production in the US has been the "step child" to the engineering, finance and marketing components in many enterprises. The ability to rapidly model the manufacturing process allows it to become the driving force in the strategic planning of a firm. The ability to show the manufacturing and financial implications of decisions with a dynamic graphic illustration of a system puts product manufacturing planners in a pro-active mode comparable to the product designer. The design, manufacturing and marketing components become a management team that responds quicker and more efficiently in the short design and manufacturing cycles brought about by the emerging technologies of the 1990s.

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