A PRODUCTION ANALYSIS SIMULATION SYSTEM (PASS)

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ABSTRACT

The Production Analysis Simulation System, PASS, is a computer-based simulation system designed to represent the key elements of electronics, electro-mechanical or mechanical assembly oriented manufacturing operations. PASS provides management with a precise mechanism:

- To evaluate the efficiency and/or capacity of these operations
- To generate estimates of the impact of a wide variety of strategic and tactical changes in the production system

The PASS simulation produces a set of detailed measurements of each alternative manufacturing strategy and tactic. These measurements enable the manufacturing manager to assess the trade-offs between these alternatives. The following standard measurements are generated by PASS:

- Finished goods and work-in-process inventory levels
- Manpower utilization and costs
- Stockout levels including
  - a record of the percentage of late deliveries for each assembly, subassembly, accessory, etc.
  - for all late orders, a distribution describing the number of days late.
- A detailed record of the manufacturing and manpower planning process is also represented.

In summary, PASS is a simulation system that provides answers to "WHAT IF....?" questions about alternative manufacturing operating strategies such as changes in product flow, cycle times, production to order versus production to inventory, etc. These answers are produced in the form of detailed, quantitative reports which provide top management with a precise dollars and cents, hours and minutes report of the impact of each alternative manufacturing strategy and tactic under evaluation.

I. OBJECTIVES OF THE PRODUCTION ANALYSIS SIMULATION SYSTEM (PASS)

The PASS simulation is designed to provide answers to a number of key questions related to the manufacturing process. This includes:

- "WHAT IF my manufacturing operations performed according to present specification?"

In order to set a base line for comparing alternative manufacturing strategies and tactics, PASS is first run to measure how the manufacturing system would operate if all standard current operating procedures were followed. PASS represents the current manufacturing strategies and tactics in terms of the flow of materials, work, and information as they are supposed to operate according to current procedures and standards. By testing the results of PASS in comparison with actual historical manufacturing records, an audit of current manufacturing operations is obtained. In particular,

- Actual inventory levels are checked against levels that would have resulted if all procedures had been followed
- Actual stockouts can be compared with stockouts that would have resulted under the current set of manufacturing strategies and tactics
- Actual manpower levels and utilization rates can be compared with the results of the PASS run

The initial PASS run can go a long way towards identifying weaknesses in the structure of manufacturing operations. Manufacturing bottlenecks, inefficient manpower utilization, and order response problems can be pinpointed using PASS to audit your operations.

A. EFFECTS OF IMPROVED DEMAND FORECASTING

An inaccurate order forecasting system can seriously impair many of the key elements of manufacturing operations. High inventory levels, high stockouts, high idle time, and excessive overtime can sometimes be accounted for by the order forecasting mechanisms alone. In these situations, simply replacing the current order forecasting mechanism with an improved one can result in savings of significant magnitudes. PASS will compare the current forecasting procedures with "ideal" procedures. Specific alternative forecasting mechanisms can first be tested using PASS, and then can be directly implemented in the manufacturing system.

B. EFFECTS OF IMPROVED CROSS-TRAINING PROGRAMS AND MORE FLEXIBILITY TO MOVE WORKERS FROM ONE DEPARTMENT TO ANOTHER

Manpower smoothing can frequently be accomplished through a comprehensive cross-training program. However, cross-training programs can be expensive and time-consuming. PASS precisely identifies the potential savings in cross-training. These savings can be then compared with the costs of a program, and a rational decision can be made on the cross-training issue.

C. WHAT ARE THE EFFECTS OF CHANGING PRODUCTION CYCLE TIMES

The length of a production period is frequently set up by the accounting department with little understanding of the impact of cycle times on production efficiency. A change from four weeks to one week cycle time, for example, has resulted in reducing average inventory levels by over 50 percent. PASS provides a precise identification of the savings from alternative cycle times.

D. WHAT ARE THE EFFECTS OF CHANGING RAW MATERIAL STOCKING LEVEL POLICIES

The cost of stocking and maintaining extensive inventories of raw materials can be quite high. The cost of raw material shortages can also be high. PASS assesses the trade-off between raw material inventories and stockout levels, and the impact of low-cost solutions to the problem. In particular, an improvement in the raw material inventory investment can sometimes be very effective in reducing overall average inventory levels. PASS identifies the impact of raw material inventories on entire manufacturing operations and total inventory investment.

E. WHAT ARE THE EFFECTS OF CHANGES IN CUSTOMER SERVICE LEVEL PERFORMANCE OBJECTIVES

The impact of order response time policies on the manufacturing system can be enormous in terms of inventory levels and market share. One of the most critical strategic errors in the manufacturing system is the establishment of customer service levels which are either too high or too low. Sometimes, the marketing division will urge the establishment of a 100 percent customer service level (no back orders). If manufacturing goes along with this policy without examining the alternatives, tremendous unnecessary costs may result. In many environments, a 90 or 95 percent service level is satisfactory to customers, and can lead to enormous reductions in inventory, overtime, and capacity requirements. In other environments, a low customer service level may result in the deterioration of sales. Using PASS, the marginal costs of upgrading customer service levels can be measured against the marginal benefits of improved customer relationships. PASS enables the manufacturing management to test the precise effects of each alternative service level on the entire population system.

F. WHAT ARE THE EFFECTS OF MODIFYING THE PATTERN OF WORK FLOW ON THE PRODUCTION FLOOR?

Changing the flow of work on the production floor can be a hazardous undertaking. Managers frequently follow the rule of thumb, "Don't change things unless there are obvious problems!", for good reason. The impact of changes in the flow of work on a complex production system can be serious. PASS provides a tool for evaluating the complex effects of changes in work flow without disrupting current operations. This allows many alternatives to be tested and those with negative impacts to be rejected.

G. WHAT ARE THE EFFECTS OF MODIFYING INVENTORY POLICIES FOR FINISHED GOODS OR INTERMEDIATE PRODUCTS?

Perhaps more study over the past 20 years has gone into the question of establishing optimal inventory policies than into any other aspect of business. Despite the fact that so much is known in this area, inventory policies are rarely given a thorough review in practice. In many of today's most progressive corporations, outdated inventory policies persist. This is sometimes explained by the fact that inventory policies are deeply imbedded into the structure of the corporate computer software and cannot be accessed easily by manufacturing management. PASS provides a unique opportunity to review inventory policies by permitting manufacturing management to literally "plug in" alternative policies to test their impact on productivity.

H. WHAT ARE THE EFFECTS OF MANUFACTURING PART OF THE PRODUCT LINE "TO ORDER" RATHER THAN "TO INVENTORY"?

Production-to-order for selected items can lead to significant reductions in inventory levels, warehouse capacity requirements and shrinkage. However, production-to-order is not always a feasible route due to order response time requirements. PASS provides a mechanism for the manufacturing manager to evaluate the feasibility of "to order" production for selected items in the line. Without the use of PASS, these opportunities are frequently overlooked.

I. WHAT ARE THE EFFECTS OF USING DIFFERENT SCHEDULING, SEQUENCING, OR ROUTING POLICIES?

Problems with scheduling, sequencing, and routing procedures are frequently at the heart of manufacturing problems. The complexity of these policies makes them difficult to evaluate using a paper and pencil approach. PASS provides an excellent mechanism for testing the impact of alternative scheduling, sequencing, and routing policies on manufacturing productivity.

In summary, the PASS simulation provides the ability to simulate current operations and compare the effects of specific changes against present manufacturing operations.

II. PASS SYSTEM DESIGN

A. GENERAL SYSTEM STRUCTURE

PASS is a computer simulation model written in SIMSCRIPT II.5. It has been set up to fully represent the discrete activities of a manufacturing system. It represents the system in terms of a series of more than 30 different components which model manufacturing planning activities, assembly operations, quality assurance operations, inventory and order activities. A simplified overview of the structure of PASS is shown in Figure II-1.

1. Inputs to PASS

This figure shows two types of inputs required to run PASS.

- Fixed inputs are items which do not change each time PASS is run. They include historical order forecasts, actual demand histories, product structures, cost factors, assembly and Q.A. times. Some of the fixed input represents historical data which will be used to compare alternative strategies
- Parametric inputs are those items which are changed to answer different "WHAT IF...?" questions. Parametric inputs can include the number of different types of personnel, period lengths, idle time policies, production protocols, and forecasting procedures.

2. PASS Logic Overview

The logical structure of PASS is actually a series of computer programs which represent different activities and events in your production system.

- A master schedule is created based on either current planning and scheduling procedures or alternative procedures being tested.
- Work orders are created from a master schedule and work is assigned (to men or machines) according to current or alternative principles.
- The manufacturing operations take place according to standard times (one of the fixed inputs). Completed work goes to quality assurance and then into inventory (or directly to the customer in the case of "production-to-order").
- At the same time, as manufacturing operations occur, the PASS system represents orders arriving at the factory or warehouse. These are filled, where possible; back order queues are created, and inventories are adjusted as appropriate.

3. PASS Output Reports

As all of this activity occurs within the computer, information is accumulated on the efficiency and effectiveness of manufacturing operations. The data accumulated during each run of PASS is provided to the user in a series of output reports. These reports include detailed information on

- Inventory Levels. The "history" of inventory information is maintained at the levels of detail of interest to the user. These generally include work-in-process inventories, final inventories, and subassembly inventories.
- Stockouts. A detailed record of stockouts is provided, including data on the number of occurrences by product and the length of time before stockouts were filled.
- Manpower Utilization. Data on manpower is kept in terms of the number of workers (by type), cumulative busy time, and cumulative idle time.
- Cost. All key costs are accumulated and reported by PASS including inventory costs, manpower costs, and total costs.

B. PASS LOGIC STRUCTURE

A detailed representation of the logic structure of PASS is provided in Figure II-2.

1. Initiating a Production Period in PASS

- PLAN represents the current manufacturing production planning activities.
- HOUR calculates man-hours required for the next production periods based on standard hours.
- BROAD creates a broadload to represent upcoming manpower requirements.
- MANPLAN builds a manpower planning schedule and schedules hirings and firings based on manufacturing requirements.
- GROSS builds a gross schedule based on planning requirements.
- MASTER converts the gross schedule to a master schedule.

2. Simulating a Production Period

Following these planning steps, a production period is initiated (BEGIN PERIOD). During each period, the computer represents the beginning of each day (SDAY) and the end of each day (EDAY). PASS provides a representation of the production system as follows:

- ORDER. This event generates streams of orders for products based on historical (or projected) order patterns.
- STASS. Assembly operations are initiated in this "start assembly" event.
- ENASS. An assembly operation is completed, according to standard times, and the "end assembly" event determines whether to pass the product on to quality assurance or to file it in inventory.
- STQA and ENQA. These events, "start quality assurance" and "end quality assurance" perform similar functions to the start assembly and end assembly events.
- TIME converts standard time required for operations to real time.
- INVENTORY performs a number of functions. When orders arrive, they are filled out of inventory, using this routine. ("Production-to-order" operates differently). Inventory also keeps track of inventory levels and stockouts.
- KILL destroys a work order once it has been filled and maintains a record of the inventory activity.

3. Concluding a PASS Run

Output reports can be generated for each production period being simulated as well as for the entire simulation.

Output reports from a PASS run include:

- The general input data used for the run
- Data describing the manpower configuration and product input data
- The product structure and substructure (or subassembly) relationships
- Actual sales data used for the run. This sales data is used for generating streams of orders for the simulation. Forecast data is also shown in this figure. These can be historical forecasts or the results of improved forecasting techniques.
- The master schedule generated for each period.
- At the end of each period, a detailed report on product planning for that period is generated. The production planning reports will differ according to the planning mechanism used in each application.
- A manpower planning report is also produced. The manpower planning accounts for borrowing and releasing men from other departments as well as hiring and firing according to corporate policies.
- At the end of each period, and at the end of the entire simulation, a manpower activity report is generated. The effectiveness of each alternative can be measured, in part, by the amount and cost of busy labor under the alternative. Clearly, if "manpower" was busy only 70 percent, then the number of actual men can be reduced to minimize manufacturing costs.
- A PASS inventory report is also generated. This reports both levels and dollars of inventory.

Additional reports can be generated, depending on the particular requirements of the user of PASS. Likewise, only those reports desired by the user need be generated. Any of the reports described above can be skipped with a simple user instruction.

The most powerful feature of PASS is its ability to compare alternative manufacturing strategies and to measure the impact of these alternatives in a clear, precise way. For each alternative which is tested using PASS, a detailed set of reports such as those discussed above are automatically generated. The "bottom line" for each alternative is represented by a series of three summary report.

- A detailed inventory report summary for the total simulation
- A detailed stockout report for the total simulation
- A detailed manpower activity report for the total simulation

Examples of these reports are shown in Figures III-1, 2, 3 and 4.

III. EXAMPLE OF THE USE OF THE PASS SYSTEM

The results of testing four alternatives for a sample product are shown in Figures III-1 through III-4. The four alternatives tested for this product were:

- ° Four-week cycle time, multi-stage production strategy (Figure III-1)
- ° Four-week cycle time, single-stage strategy (Figure III-2)
- ° One-week cycle time, multi-stage strategy (Figure III-3)
- ° One-week cycle time, single-stage strategy (Figure III-4)

The issue of cycle times and production stages was critical for the products in the example. In other manufacturing environments, different alternatives will apply. However, the detailed PASS output reports and the ability to compare one alternative with the next are the same, regardless of what particular alternative is being tested. Each of the four alternatives is compared in Figure III-5, showing dramatic improvement possible by switching from the four-week, multi-stage strategy (the actual strategy used by the manufacturer before PASS was implemented) to a one-week, single-stage strategy. The savings indicates the kind of dramatic success which Decision Sciences has had in applying the PASS system to various corporate manufacturing environments.

IV. USE OF THE PASS SYSTEM

Approximately two man years have gone into the development of PASS. It can be run on any machine which supports a SIMSCRIPT II.5 compiler. Run time will vary according to the complexity of product hierarchies, the number of job centers and employees, and the number of days being represented for a given run. As indicated above, a highly flexible series of output options provides the user with easy access to any level of detail or summary of the results of each simulation.

Surprisingly little effort is required to run PASS. The system is designed to rely on standard types of data available in every manufacturing environment. (For example, standard costs, standard assembly times, and standard product explosions).

The initial PASS runs will be made by the analysis group and presented to manufacturing management. At this point, the alternative "WHAT IF...?" strategies can be tested with relative ease, depending on the strategy to be tested. Some alternatives require extremely minor modifications in the input parameters.. For example, the changes from one-week to four-week cycle times, and from single-stage to multi-stage strategy are "built in" functions and require no additional effort. Other changes, such as modifications in work flow, require slightly more effort to create an exact representation of the alternative being tested. In general, however, once the " "base line" has been established, very little marginal effort is required to test most alternatives.

PASS can either be run by Decision Sciences Corporation or can be leased for ongoing use. System set-up usually takes on the order or 60 days elapsed time and about 90-100 man days of effort for input, scenario construction and analysis. Typical projects have generated a 20:1 return or greater.

In summary, PASS is an excellent demonstration of the applicability of simulation as a useful tool in support of a particular, vital class of day-to-day business issues; manufacturing strategy and tactical planning, scheduling, and assignment.

FIGURE II-1 OVERVIEW OF PASS STRUCTURE

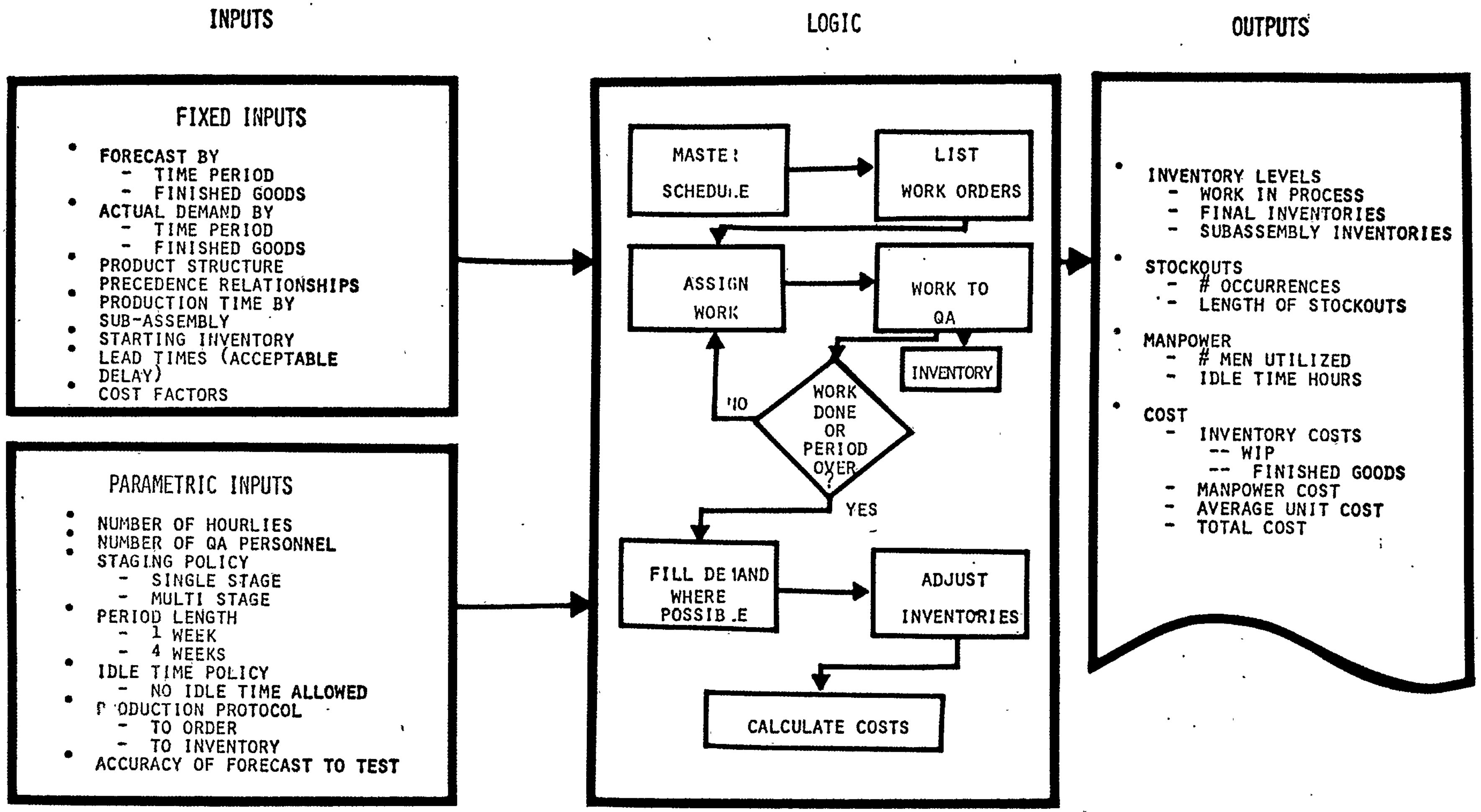
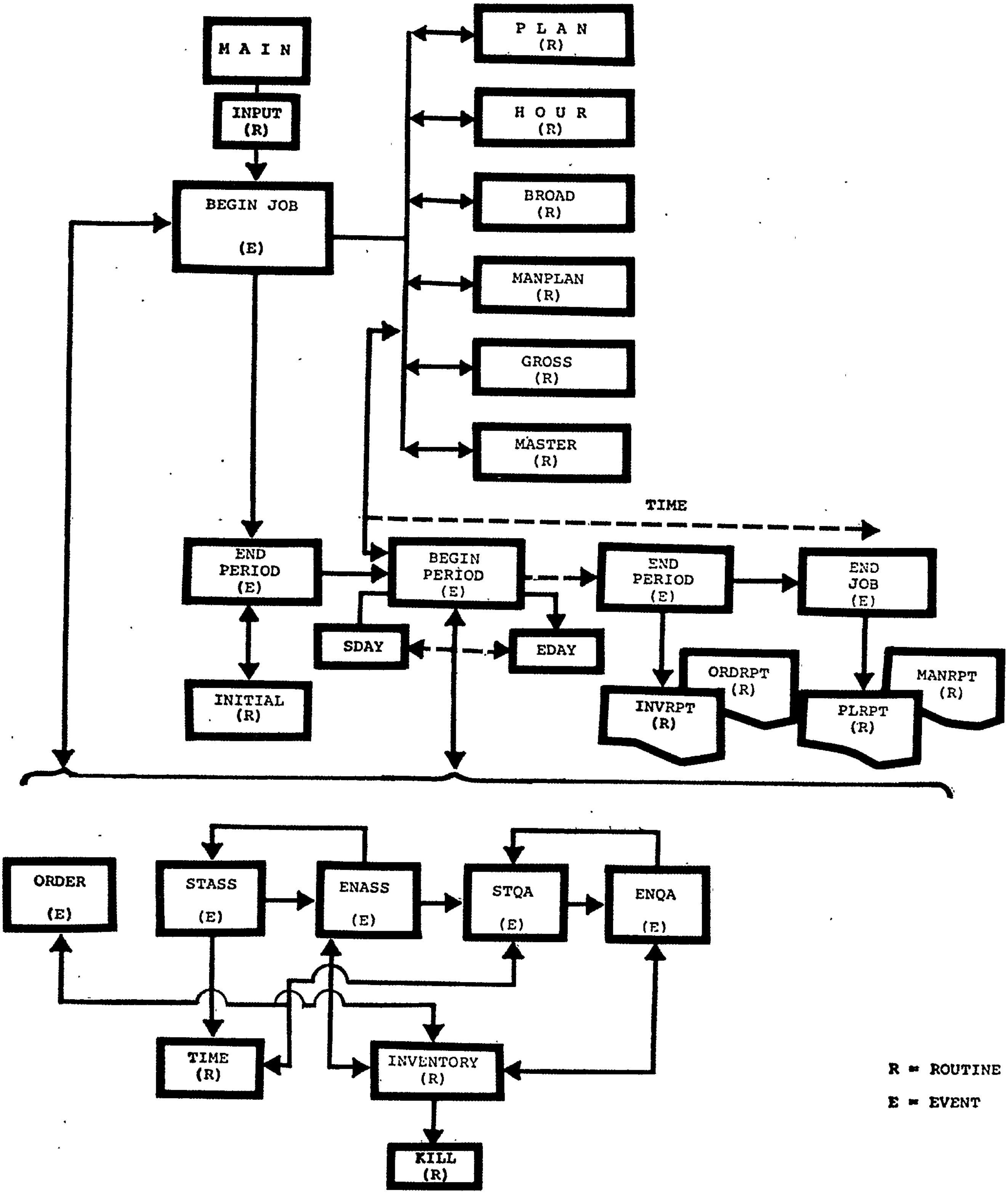


FIGURE II-2

PASS STRUCTURAL DESIGN

INTERACTIONS BETWEEN EVENTS AND ROUTINES



R = ROUTINE

E = EVENT

FIGURE III-1

STANDARD ELECTRODE: 4 WEEK, MULTI-STAGE

DETAILED INVENTORY REPORT
FOR TOTAL SIMULATION

PART NUMBER AND DESCRIPTION	FINAL LEVEL (UNITS)	FINAL LEVEL (DOLLARS)	AVE INV LEVEL (UNITS)	AVE INV LEVEL (DOLLARS)	CARRYING COST (30 %)
476-022-000 ELECTRODE TR	3137	$ 14869.38	1474.	$ 6989.13	$ 160.85
221-150-000 COMP GLASS S	394	$ 1667.56	306.	$ 1450.44	$ 33.38
221-330-000 COMP GLASS S	519	$ 2122.71	302.	$ 1235.33	$ 28.43
221-140-000 INNER GLASS	1592	$ 2610.88	415.	$ 681.19	$ 15.68
221-010-000 OUTER GLASS	757	$ 787.28	303.	$ 314.82	$ 7.25
223-175-000 TUBE 1 IN CU	15	$ 7.95	264.	$ 139.86	$ 3.22
221-090-000 OUTER TAPER	850	$ 501.50	347.	$ 204.86	$ 4.71
TOTAL		$ 22767.25		$ 11015.61	$ 253.51

PASS
DETAILED STOCKOUT REPORT
FOR TOTAL SIMULATION OF 13 PERIODS

LEAD TIME = 7 DAYS

PART NUMBER AND DESCRIPTION	NO. ON TIME	NO. PAST LEAD	PER CENT LATE	......LATENESS REPORT(DAYS PAST LEAD TIME...... 0-5 DAYS NO.	0-5 DAYS %	6-10 DAYS NO.	6-10 DAYS %	11-15DAYS NO.	11-15DAYS %	16-20DAYS NO.	16-20DAYS %	20+ DAYS NO.	20+ DAYS %
476-022-000 ELECTRODE TR	9843	580	6%	330	57%	250	43%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-150-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-330-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-140-000 INNER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-010-000 OUTER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
223-175-000 TUBE 1 IN CU	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-090-000 OUTER TAPER	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

PASS
ACTIVITY
REPORT
FOR TOTAL SIMULATION

MANPOWER ACTIVITY

TYPE OF MANPOWER	AVE. NO. OF PEOPLE	TOTAL NO. HRS. BUSY	TOTAL NO. HRS. IDLE	PER CENT BUSY	COST OF BUSY LABOR
ASSEMBLY	4.	4601.	2997.	61 %	98912.91
Q.A.	2.	2051.	2374.	46 %	44104.76
TOTAL	6.	6652.	5372.	55 %	143017.59

FIGURE III-2

STANDARD ELECTRODE: 4 WEEK, SINGLE STAGE

DETAILED INVENTORY REPORT
FOR TOTAL SIMULATION

PART NUMBER AND DESCRIPTION	FINAL LEVEL (UNITS)	FINAL LEVEL (DOLLARS)	AVE INV LEVEL (UNITS)	AVE INV LEVEL (DOLLARS)	CARRYING COST (30 %)
476-022-000 ELECTRODE TR	2082	$ 9868.68	692.	$ 3281.77	$ 75.53
221-150-000 COMP GLASS S	0	$ 0.	248.	$ 1176.37	$ 27.07
221-330-000 COMP GLASS S	168	$ 687.12	116.	$ 472.98	$ 10.89
221-140-000 INNER GLASS	50	$ 82.00	197.	$ 323.02	$ 7.43
221-010-000 OUTER GLASS	50	$ 52.00	177.	$ 184.49	$ 4.25
223-175-000 TUBE 1 IN CU	291	$ 154.23	100.	$ 53.00	$ 1.22
221-090-000 OUTER TAPER	291	$ 171.69	101.	$ 59.67	$ 1.37
TOTAL		$ 11015.70		$ 5551.29	$ 127.76

PASS
DETAILED STOCKOUT REPORT
FOR TOTAL SIMULATION OF 13 PERIODS

LEAD TIME = 7 DAYS

PART NUMBER AND DESCRIPTION	NO. ON TIME	NO. PAST LEAD	PER CENT LATE	0-5 DAYS NO.	0-5 DAYS %	6-10 DAYS NO.	6-10 DAYS %	11-15 DAYS NO.	11-15 DAYS %	16-20 DAYS NO.	16-20 DAYS %	20+ DAYS NO.	20+ DAYS %
			......LATENESS REPORT (DAYS PAST LEAD TIME......										
476-022-000 ELECTRODE TR	9576	765	7%	154	20%	108	14%	112	15%	222	29%	169	22%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-150-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-330-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-140-000 INNER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-010-000 OUTER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
223-175-000 TUBE 1 IN CU	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-090-000 OUTER TAPER	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

PASS
ACTIVITY
REPORT
FOR TOTAL SIMULATION

MANPOWER ACTIVITY

TYPE OF MANPOWER	AVE. NO. OF PEOPLE	TOTAL NO. HRS. BUSY	TOTAL NO. HRS. IDLE	PER CENT BUSY	COST OF BUSY LABOR
ASSEMBLY	4.	3571.	3914.	48 %	76779.08
Q.A.	2.	1672.	2614.	39 %	35951.22
TOTAL	6.	5243.	6528.	45 %	112730.25

PASS ... Continued

FIGURE III-3

STANDARD ELECTRODE: 1 WEEK, MULTI-STAGE

DETAILED INVENTORY REPORT
FOR TOTAL SIMULATION

PART NUMBER AND DESCRIPTION	FINAL LEVEL (UNITS)	FINAL LEVEL (DOLLARS)	AVE INV LEVEL (UNITS)	AVE INV LEVEL (DOLLARS)	CARRYING COST (30 %)
476-022-000 ELECTRODE TR	914	$ 4332.36	667.	$ 3162.93	$ 18.20
221-150-000 COMP GLASS S	213	$ 1009.62	93.	$ 442.17	$ 2.54
221-330-000 COMP GLASS S	344	$ 1406.96	264.	$ 1080.93	$ 6.22
221-140-000 INNER GLASS	244	$ 400.16	180.	$ 294.97	$ 1.70
221-010-000 OUTER GLASS	232	$ 241.28	177.	$ 184.08	$ 1.06
223-175-000 TUBE 1 IN CU	260	$ 137.80	227.	$ 120.39	$ .69
221-090-000 OUTER TAPER	429	$ 253.11	244.	$ 143.79	$ .83
TOTAL		$ 7781.27		$ 5429.25	$ 31.24

PASS
DETAILED STOCKOUT REPORT
FOR TOTAL SIMULATION OF 52 PERIODS

LEAD TIME = 7 DAYS

PART NUMBER AND DESCRIPTION	NO. ON TIME	NO. PAST LEAD	PER CENT LATE	0-5 DAYS NO.	0-5 DAYS %	6-10 DAYS NO.	6-10 DAYS %	11-15 DAYS NO.	11-15 DAYS %	16-20 DAYS NO.	16-20 DAYS %	20+ DAYS NO.	20+ DAYS %
476-022-000 ELECTRODE TR	10540	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-150-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-330-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-140-000 INNER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-010-000 OUTER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
223-175-000 TUBE 1 IN CU	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-090-000 OUTER TAPER	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

PASS
ACTIVITY
REPORT
FOR TOTAL SIMULATION

MANPOWER ACTIVITY

TYPE OF MANPOWER	AVE. NO. OF PEOPLE	TOTAL NO. HRS. BUSY	TOTAL NO. HRS. IDLE	PER CENT BUSY	COST OF BUSY LABOR
ASSEMBLY	2.	3696.	1616.	70 %	79468.91
Q.A.	2.	1560.	2883.	35 %	33537.91
TOTAL	4.	5256.	4499.	54 %	113006.81

FIGURE III-4

STANDARD ELECTRODE: 1 WEEK, SINGLE STAGE

DETAILED INVENTORY REPORT FOR TOTAL SIMULATION

PART NUMBER AND DESCRIPTION	FINAL LEVEL (UNITS)	FINAL LEVEL (DOLLARS)	AVE INV LEVEL (UNITS)	AVE INV LEVEL (DOLLARS)	CARRYING COST (30 %)
476-022-000 ELECTRODE TR	428	$ 2028.72	308.	$ 1461.27	$ 8.41
221-150-000 COMP GLASS S	6	$ 28.44	44.	$ 210.59	$ 1.21
221-330-000 COMP GLASS S	0	$ 0.	22.	$ 88.81	$ .51
221-140-000 INNER GLASS	225	$ 369.00	92.	$ 150.65	$ .87
221-010-000 OUTER GLASS	0	$ 0.	64.	$ 66.56	$ .38
223-175-000 TUBE 1 IN CU	0	$ 0.	25.	$ 13.33	$ .08
221-090-000 OUTER TAPER	0	$ 0.	42.	$ 24.78	$ .14
TOTAL		$ 2426.16		$ 2015.99	$ 11.60

PASS

DETAILED STOCKOUT REPORT FOR TOTAL SIMULATION OF 52 PERIODS

LEAD TIME = 7 DAYS

PART NUMBER AND DESCRIPTION	NO. ON TIME	NO. PAST LEAD	PER CENT LATE	......LATENESS REPORT(DAYS PAST LEAD TIME...... 0-5 DAYS NO.	0-5 DAYS %	6-10 DAYS NO.	6-10 DAYS %	11-15DAYS NO.	11-15DAYS %	16-20DAYS NO.	16-20DAYS %	20+ DAYS NO.	20+ DAYS %
476-022-000 ELECTRODE TR	10470	70	1%	70	100%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-150-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-330-000 COMP GLASS S	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-140-000 INNER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-010-000 OUTER GLASS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
223-175-000 TUBE 1 IN CU	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
221-090-000 OUTER TAPER	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
BACKORDERS	0	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%

PASS

ACTIVITY REPORT FOR TOTAL SIMULATION

MANPOWER ACTIVITY

TYPE OF MANPOWER	AVE. NO. OF PEOPLE	TOTAL NO. HRS. BUSY	TOTAL NO. HRS. IDLE	PER CENT BUSY	COST OF BUSY LABOR
ASSEMBLY	3.	3474.	3395.	51 %	74690.76
Q.A.	2.	1492.	3101.	32 %	32082.35
TOTAL	5.	4966.	6497.	43 %	106723.09

PASS ... Continued

FIGURE III-5

MANUFACTURING STRATEGY

IMPACT ANALYSIS

STANDARD ELECTRODE

TIME PERIOD	STRATEGY	AVERAGE INVENTORY $	INVENTORY COST/YEAR	MAN HOURS PER YEAR			STOCKOUT % ON TIME
				ASSEMBLY	Q.A.	TOTAL	
4 WEEKS	M.S	11,015.61	3295.63	4601	2051	6652	94 %
4 WEEKS	S.S	5,551.29	1660.88	3571	1672	5243	93 %
1 WEEK	M.S.	5,429.25	1624.48	3696	1560	5256	100 %
1 WEEK	S.S.	2,015.99	603.20	3474	1492	4966	99 %
DIFFERENCE 4W/MS vs 1W/SS		8,999.62	2692.43	1127	559	1686	5 %
% IMPROVEMENT OF 1W/SS OVER 4W/MS		81.69	81.69	24.50	27.25	25.35	5.3 %