SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

October 1980
NSRP 0007

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 12: Application of Modular Software to Establish a "Closed Loop" System for Shipyard Production Control

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
OCT 1980	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
The National Shipbuilding Research Program Proceedings of the REAPS Technical Symposium Paper No. 12: Application of Modular Software to Establish a "Closed Loop" System for Shipyard Production Control	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**SAR**	**23**	

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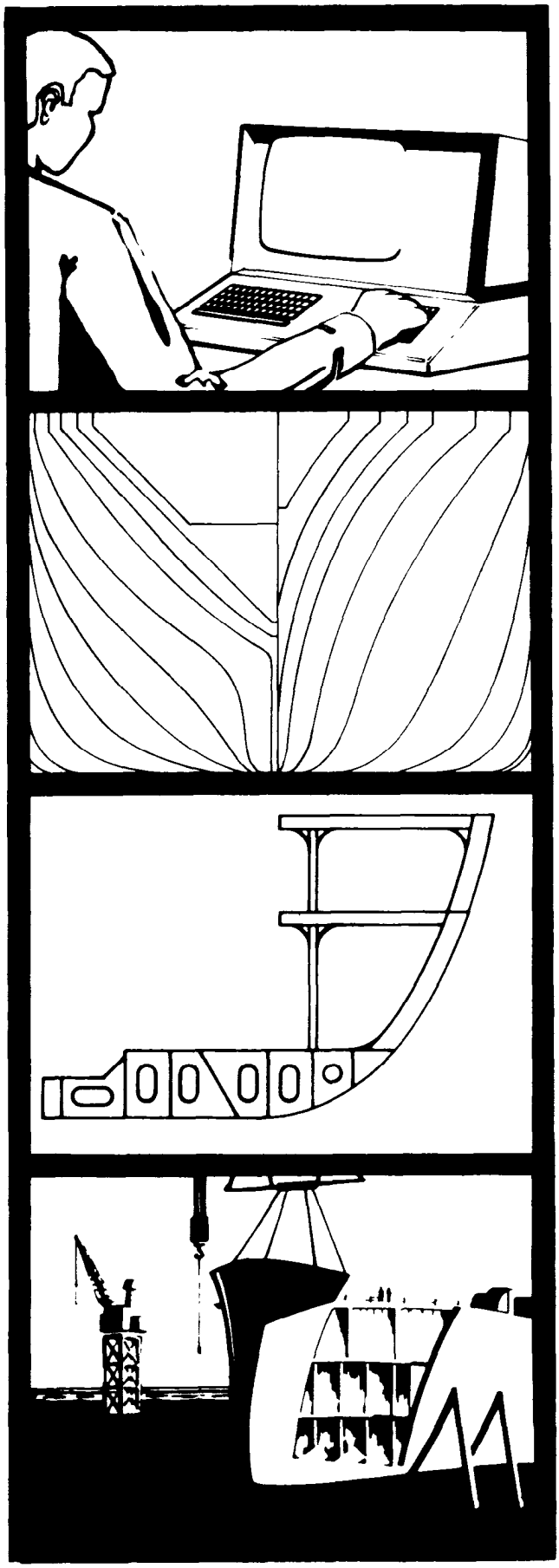

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IN
S HIPBUILDING

Proceedings of the
REAPS Technical Symposium
October 14-16, 1980
Philadelphia, Pennsylvania

APPLICATION OF MODULAR SOFTWARE TO ESTABLISH A "CLOSED LOOP" SYSTEM FOR SHIPYARD PRODUCTION CONTROL

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ABSTRACT

This paper addresses the key functions of a closed-loop production and inventory, and planning control system generally applicable to the shipbuilding industry. A key feature of the shipbuilding closed-loop system is the application of made-to-order concepts not generally used in production and inventory planning, and control systems for other industries. The use of modular packaged software to make the system operational on a timely step-by-step basis are explored. Special considerations for tailoring the software to satisfy general shipbuilding requirements are reviewed. A summary of the potential benefits of a closed-loop system (i.e., "what if" planning) is also included.

Background

The shipbuilding industry presents challenges to its management that are nearly unequaled in other industries. The dimensions of delivered ships exceed the size of comparable end products. Shipyard engineering must define and control several hundred thousand parts for each design. Much of the equipment used in outfitting ships is advanced state-of-the-art technology. To deliver the ships to budget and schedule, extensive efforts are expended to plan and control the required resources. In most cases, ships are built one-at-a-time and, while not always visible, no two ships of a class/contract are exactly the same. Systems to support shipyard management have generally satisfied single management functions (i.e. master planning, engineering, accounting) and relied on analysts, planners, and expediters to link the functional elements together. In yards with advanced technology shipbuildinq programs (typically associated with a high level of contract specification changes), the efforts required to maintain the functional system links expand quickly.

Despite the intense attention of shipyard management to assure the systems support the various building programs, many situations develop in which material or other resources are not available to satisfy the contract/schedule requirements and schedules/budgets are missed.

Evolution of Closed Loop System

Generally, the complications of planning and controlling shipyard efforts parallels the manufacturing industry with the exception of contract focus, technical specification requirements and traceability. In coping with their system requirements, the manufacturing industry promoted the development of a system concept that became viable as computer applications software technology advanced. Originally, this concept was known as MRP (Material Requirements Planning). With field experience, MRP advocates converted this acronym to mean manufacturing resources planning, since not just material had to be planned and controlled to make production goals. Successful MRP systems captured the imagination of top management and the opportunity to integrate the planning and control process from top to bottom via closed loop concepts (feedback communication and data integration) became reality.

Make-To-Order

Interest on the part of manufacturers who make products for the government led to the refinement of Make To-Order concepts and software which address many of the contract and technical requirements of shipbuilding. The

opportunity now exists to apply 'Closed Loop' concepts in shipyards to support management in planning and controlling resources, priorities, and performance to deliver ships on schedule, at planned costs, at the right ROI, and correctly configured.

Because of the size, complexity, inertia of work-in-process, and overall employee reluctance to change, shipyards cannot expect to install a Closed Loop system overnight. Extensive design, planning, and education efforts are required for all levels of the shipyard organization. A practical approach can be adopted to install the Closed Loop system in modules so shock is minimized and experience builds a strong foundation for success. Overall success of the system will be determined by: 1) constant evaluation and response to the feedback mechanisms and 2) a program to continually monitor key system performance factors.

The following schedules explain in more detail the closed loop system, associated Make-To-Order features, what modular software can be used to build the closed loop system and a strategy for installing the modules:

- Make-To-Order (MTO) Features:
  (Schedule #l)
- Closed loop concept for shipyard production control.
  (Schedule #2)
  - Basic Data
  - Top Management planning
  - Operations management planning
  - Operations execution

- Matrix analysis of shipyard closed loop elements to available software modules.
  (Schedule X3)

- Installation strategy
  (Schedule #4)

SCHEDULE 1
Page 1 of 1

Key features of M-T-O (make-to-order) include:

- Order pegging to control component parts for a given order or contract.

- Allocation of Inventory to specific contracts or orders. (Inventory balances may be optionally maintained by receipt or expiration date, user determined cost, vendor or lot data.)

- Component availability analysis by order or contract.

- Mass rescheduling or order cancellation by order or contract.

- Tracking of material issues by order or contract for actual cost purposes (issues from stock in optional data sequence, such as FIFO).

- Maintain bill-of-material user comments for special purposes such as additional engineering change revision information.

- Material lot control through reference identification on inventory transactions by order or contract.

- Order or contract configuration history by reporting the pegged structure, component revision level and actual quantities for closed orders.

"CLOSED LOOP" CONCEPT FOR SHIPYARD PRODUCTION CONTROL

BASIC DATA

BASIC ELEMENTS	FUNCTION	INPUT TO
BILLS OF MATERIAL DATA	Maintain part specifications Define each product on level **by level basis** - for **all** functions Maintain product configuration (Hull effectivity)	. Construction Planning/Master Scheduling . Key Event/System Scheduling . Requirements Planning . Inventory Planning . Product Costing . Product Design . CAD/CAM
INVENTORY DATA	Maintain inventory balances and order **status** data **by** part and contract	. Requirements Planning . Inventory Control . Purchasing . Performance Accounting . CAD/CAM
ROUTINGS	Maintain specifications for manufacturing process of a part	. Construction Planning . Master Scheduling . Shop Floor Control . CAD/CAM . Product Costing . Performance Accounting

"CLOSED LOOP" CONCEPT FOR SHIPYAIRD PRODUCTION CONTROL

TOP MANAGEMENT PLANNING

Closed Loop Element	Function	Input to	Feedback
BUSINESS PLANNING - Objectives -	Set overall objectives of company and manage to support those objectives	Production Planning Sales Planning	Bottom line
SALES PLANNING	Plans sales to **meet** objectives	Production Planning	Market Success
PRODUCTION PLANNING - Resources -	Determine rates and allocate the resources required to meet the company's business objectives and satisfy contract/construction demands.	Mdster Scheduling . what to schedule · Schedule Adjustments Inventory Plan	Business Planning **.Evaluate and adjust** the plan
MASTER SCHEDULING - Product -	States production demands in terms of "what", "How **Much"** and "When". Provides **key** facility **load** analysis (Rough **cut** capacity plan). Interface with **master construction/key event/** system schedules.	Materials Requirements Planning . What . How much . When	Production Planning . Realism . Adjust the plan . Adjust the resourses

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Closed Loop Element	Function	Input to	Feedback
MATERIAL REQUIREMENTS PLANNING - Priority -	Calculates requirements, plans orders and maintains priorities (time phased) using master schedule, bills of material and inventory status.	Inventory Control . Detail Requirements . Planned orders	Master Scheduling . Master Schedule Input
INVENTORY CONTROL - Availability - - Contract Operations Management -	VANILLA Maintains part balance and order status data MTO Explodes order requirements at all levels to support construction schedules Maintains contract and common stock part balance and pegged contract order status Maintains lot control/contract location Maintains contract allocations Drives contract accounting	Capacity Requirements Planning . Detail Order Data for Load Analysis Purchasing .Purchasing Requirements Performance Accounting . Planned/Actual Data	Production Planning . Inventory Status Master Scheduling . Inventory Status . Relieves Master Schedule Material Requirements Planning . Covered Requirements
CAPACITY REQUIREMENTS PLANNING -Ship/Shop/Floor Capacity-	Assists in determination of the most efficient production schedule based on projected facility load.	Production Planning . Load analysis Master Scheduling . Load analysis	Operations Execution Function . Detail Planning for resource check

"CLOSED LOOP" CONCEPT FOR SHIPYARD PRODUCTION CONTROL

OPERATIONS EXECUTION

Closed Loop Element	Function	Input to	Feedback
SHOP FLOOR CONTROL - Schedule Performance -	Executes the plan by controlling Ship/Shop capacity and priorities, reporting contract order status and maintaining delivery, quality and productivity performance.	Performance Accounting	Adjustments for: Master Scheduling Material Requirements Planning Inventory Control Capacity Planning
PURCHASING - Schedule Performance -	Executes the plan by controlling vendor capacity and priorities, reporting purchase order status and maintaining delivery, quality and and cost performance.	Performance Accounting	Adjustments Master Scheduliny Material Requirements Planning Inventory Control Capacity Planning
PERFORMANCE ACCOUNTING (Cost and Inventory Accounting) - Accountability - - Progress - - Cost at Complete -	Status, maintains and reports key cost, rate and other variance data. Drives progress accounting and cost at complete analysis	All	Master Scheduling Material Requirements Planniny Inventory Control Capacity Planning Bill of Material (Design Engineering) Routing data Overall Business Planning

MATRIX ANALYSIS OF SHIPYARD CLOSED LOOP ELEMENTS

TO AVAILABLE SOFTWARE MODULES

CLOSED LOOP ELEMENT	GENERALLY APPLICABLE MODULE	SYSTEM INSTALLATION CONSIDERATIONS
BUSINESS PLANNING	MODELING SYSTEM	NO CHANGES EXPECTED BUT MUST CONTAIN STRATEGIES AND INTEGRATE TO PRODUCTION PLAN
PRODUCTION PLANNING (Contract/Construction Planning)	COST SCHEDULE CONTROL SYSTEM Generally home grown but packages are available	KEY EVENT/SYSTEM SCHEDULING WORK BREAKDOWN STRUCTURE ACTUAL COST AND PROGRESS DATA INTERFACE SCHEDULE MAINTENANCE EXPLOSION/ CAPABILITY

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP ELEMENT	GENERALLY APPLICABLE MODULE	SYSTEM INSTALLATION CONSIDERATIONS
MASTER SCHEDULING	MASTER SCHEDULING	TECHNIQUE TO INTERFACE WITH PRODUCTION PLANNING (WORK PACKAGE) CONTROL SYSTEM HOW TO MAINTAIN PLANNING BILLS FOR LONG LEAD MATERIAL HOW TO PLAN/FORECAST SERVICE REQUIREMENTS - SHOPS - MOLDS, SPECIAL EQUIPMENT, JIGS, FIXTURES - SPARES - OTHER PRODUCTS ROUGH CUT LOAD ANALYSIS LEVEL FOR LABOR/MACHINE/FACILITY HOW TO FORMALLY KEEP OFF HULL WORK PACED TO ON HULL WORK (TIME FENCES) - POLICIES MUST BE STRICT TO MAINTAIN MOMENTUM BUT PRACTICAL TO GET MAXIMUM FROM EQUIPMENT, MANPOWER AND MATERIAL

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP -- ELEMENT	GENERALLY APPLICABLE MODULE	SYSTEM INSTALLATION CONSIDERATIONS
BILLS OF MATERIAL PART SPECIFICATION	DESIGN ENGINEERING	HULL EFFECTIVITY?. PLANNING/BID BILLS CONTRACT CHANGES WORK BREAKDOWN STRUCTURE ORDER/WORK PACKAGE CONCEPTS INTERFACES TO CAD/CAM PART SPECIFICATION
INVENTORY DATA AND INVENTORY CONTROL	INVENTORY CONTROL (MTO CAPABILITIES)	ORDER PEGGING AND RELATED NETWORK REQUIREMENTS (MTO Requirements) ORDER LAUNCH AND CONTROL LOT CONTROL/TRACEABILITY CONTRACT ALLOCATIONS INTERFACES TO CAD/CAM STOP WORK NOTIFICATION AND CONTROLS CLOSE OUT MECHANISM

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP ELEMENT	GENERALLY APPLICABLE MODULE	SYSTEM INSTALLATION CONSIDERATIONS
ROUTINGS	MANUFACTURING ENGINEERING	INTERFACES TO GROUP TECHNOLOGY? HULL APPLICABILITY? QUALITY REQUIREMENTS
MATERIAL REQUIREMENTS	MATERIAL REQUIREMENTS PLANNING	ALLOCATE TO CONTRACTS AND DETERMINE NET REQUIREMENTS BY CONTRACT MTO/RP INTERFACE
CAPACITY REQUIREMENTS PLANNING	CAPACITY PLANNING	NONE SPECIAL AT INDUSTRY LEVEL
SHOP FLOOR CONTROL	SHOP FLOOR CONTROL	NONE SPECIAL AT INDUSTRY LEVEL
PURCHASING	PURCHASING	GENERALLY HOME GROWN SHOULD ADDRESS BID PROCESS, VENDOR QUALIFICATIONS AND RELIABILITY, AND SPECIAL REPORTING

CLOSED LOOP ELEMENTS TO SOFTWARE MODULES

CLOSED LOOP ELEMENT	GENERALLY APPLICABLE MODULE	SYSTEM INSTALLATION CONSIDERATIONS
PERFORMANCE ACCOUNTING	INVENTORY ACCOUNTING	HOW TO MAINTAIN "BID BILL" BY CONTRACT AND MEASURE - ENGINEERING TAKEOFF VARIANCES - ACTUAL USAGE VARIANCES INTEGRATION WITH CONTRACT CHANGE - FOLLOWUP COST ANAYSIS CONTRACT ACCOUNTING
	PRODUCTION COSTING	USING THE VARIANCES IN MANUFACTURING TO EVALUATE BID/ESTIMATES - ESTIMATE - BID - PURCHASING - MATERIAL - MANUFACTURING (Labor) MAINTAIN FULL ABSORBTION OF COST IN PRICED OUT BILLS - UNIT COST EFFECTIVITY?

CLOSED LOOP SYSTEM FOR SHIPYARD PRODUCTION PLANNING AND CONTROL

INSTALLATION STRATEGY

Step	Modules Addressed	Benefits Anticipatecl
1	Design Engineering	Accurate and timely product engineering information - Bills and routings - Product specitication control
	Manufacturing Engineering	Hull effective engineering change tracking and control
	Manufacturing Engineering	Work package preparation, dispatch and control Minimize manufacturing lead times and related costs by facility usage control
2	Inventory Control/Make To Order	Accurate part balance/contract order status Contract order network control Work packages generation and control Visability of order/construction status Support schedule definition Contract material location control Historical data maintenance by contract Long lead item control Improved contract change evaluation and control capabilities
3	Master Scheduling Material Requirements Planning	Rough cut validation of construction plan Order planning Control of common manufactured parts Interface with MTO for full BOM control
4	Shop Floor Control	Coordination of schedules at lower level Improved shop scneduling for addressing alternative manufacturing strategies Detail status of manufacturing work - Permits input/output control Ship/Shop - QC/NQC interface
5	Capacity Planning	Efficient facility loading Minimize production delays
6	Inventory accounting (Product costing	Variance analysis for improved bids and contract Change support Effective support of progressing and CAC analysis Integrated contract accounting Ties performance to business planning Closes the loop

APPLICATION OF MODULAR SOFTWARE TO ESTABLISH A "CLOSED LOOP" SYSTEM FOR SHIPYARD PRODUCTION CONTROL

SHIPBUILDING ENVIRONMENT

- LEADERS IN ADVANCED TECHNOLOGY PROCESSES
- ENVIRONMENTAL AND SAFETY FACTORS EMPHASIZED
- MORE OFF HULL WORK
- VERTICAL INTEGRATION EXPANDING
  - MORE OPPORTUNITIES FOR PROFIT
  - TOLERANCES DIFFICULT TO MEET
  - HIGH LEVEL OF EXPEDITING
- COMPETITIVENESS
- MAKE-TO-ORDER FOCUS

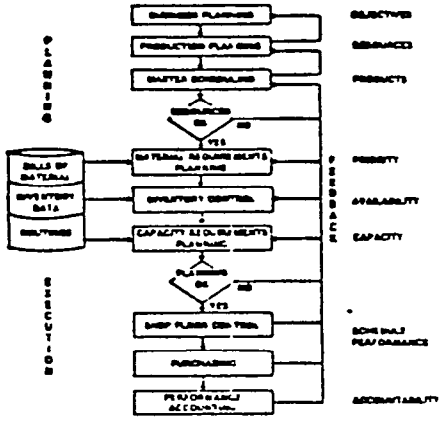
IN A SHIPYARD, WHAT IS A CLOSED LOOP SYSTEM?

IT IS AN INFORMATION SYSTEM FOR PLANNING AND CONTROLLING RESOURCES, PRIORITIES, AND PERFORMANCE TO DELIVER SHIPS.

- ON SCHEDULE
- AT PLANNED COST
- AT THE RIGHT ROI
- CORRECTLY CONFIGURED

SHIPYARD PLANNING AND CONTROL

CLOSED LOOP MANUFACTURING SYSTEM



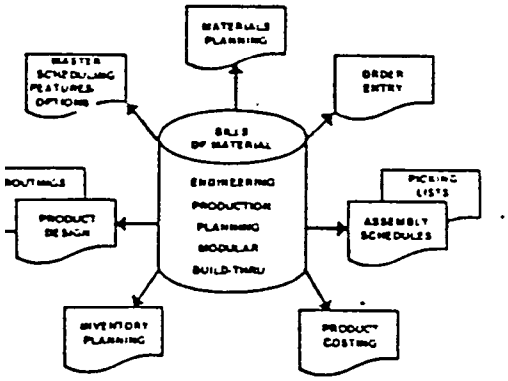
MASTER ROUTING

PART NO	DESCRIPTION	UNIT MEAS	TYPE CODE	COMM CODE	ENG REF NO	ENG REV	SHOP NO
AA 01	DOUBLE DOOR SET	EA	MFG	ENG	12345	01	AA 01

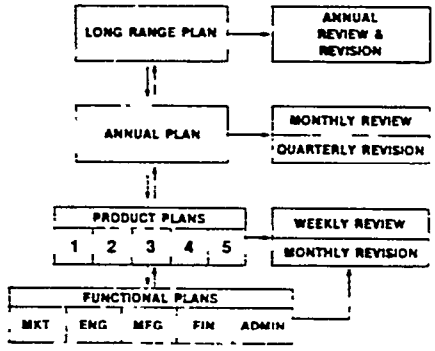
OPER NO	DESCRIPTION	DEPT NO	W/C NO	MACH NO	TOOL NO	SETUP HRS	LABOR HRS/PC	RATE CODE
AA 01	BOTCH LOCATIONS FOR HINGES PER	600	351	61284	60160	.2	.350	9
010 01	PRINT & TOTAL	600	351					
020 01	ATTACH HINGES TO DOORS	600	351		30160	.5	.350	9
030 01	SCREW CENTER POST TO LEFT DOOR	600	351		30160	.2	.350	9
040 01	INSPECT	600	350			.5	.100	1
050 01	PACK FOR SHIPPING	600	351		P0001	.5	.350	1
					TOTAL HRS/MFG	.2	1.350	

▲ OPERATIONS REQUIRED TO MAKE PART

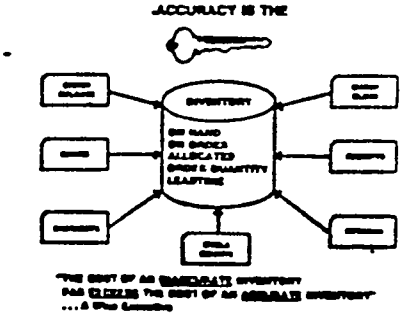
BILL OF MATERIAL USES



BUSINESS PLANNING CYCLE



INVENTORY TRANSACTION CONTROL

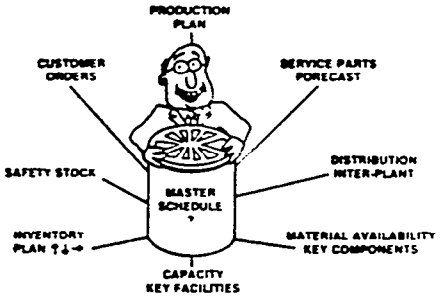


PRODUCTION PLANNING OVERVIEW

ALLOCATE COMPANY RESOURCES TO CAPITALIZE ON THE "BEST" MARKETPLACE OPPORTUNITIES

SHIPYARD PLANNING AND CONTROL

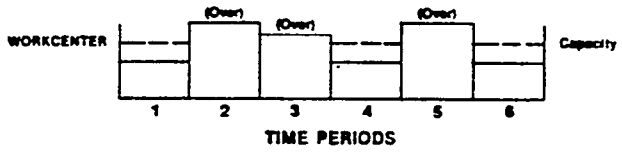
MASTER SCHEDULE INPUT



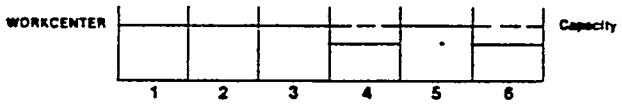
IS MASTER SCHEDULING A BIG JOB? YES!
IT IS THE DRIVER FOR MRP

LOADING METHODS

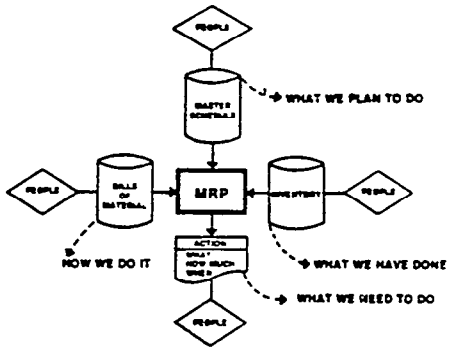
INFINITE - Without Regard For Capacity



FINITE - Not To Exceed Capacity

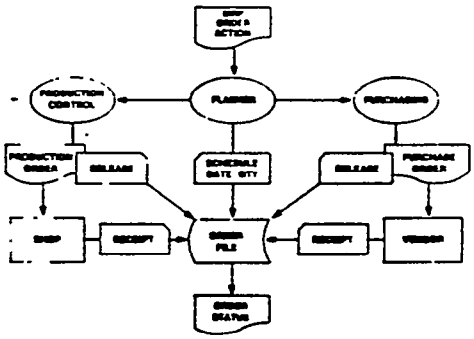


MRP SYSTEM OVERVIEW



"A PLAN THAT EXCEEDS CAPACITY WILL NOT GET PRODUCED AND WILL BUILD INVENTORY"

PRODUCTION & PURCHASE ORDER CONTROL



PRIORITY DISPATCH LIST

WORK CENTER	PART NO	ORDER NO	OPER NO	QUANTITY ORDER	QUANTITY COMPLETE	QUANTITY BALANCE	QUANTITY ROUND	SCHEDULE START	SCHEDULE OUT
102	*AA02	12333	010	10	0	10	5	6-27-X	6-27 X
	AA10	12444	020	25	0	25	5	6-30-X	6-30-X
	*AA01	12345	020	100	50	50	50	7-01-X	7-07 X

WORKCENTER/START DATE SEQUENCE

*AVAILABLE AT WORK CENTER

SHIPYARD PLANNING AND CONTROL

INPUT-OUTPUT CONTROL

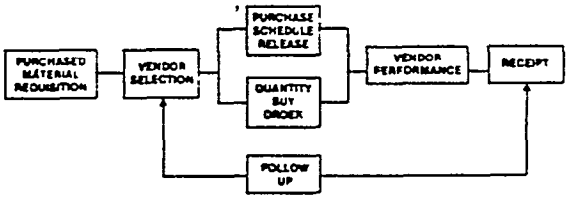
		WEEK			
		1	2	3	4
INPUT CRP	PLANNED	260	260	260	260
	ACTUAL	260	255	260	
	CUMM DEVIATION	0	−5	−5	
OUTPUT SFC	PLANNED	290	290	290	290
	ACTUAL	295	250	270	
	CUMM DEVIATION	+5	−35	−55	
BACKLOG STATUS	PLAN 300	270	240	210	180
	ACTUAL	265	270	260	

"A PLAN THAT EXCEEDS CAPACITY WILL NOT GET PRODUCED"

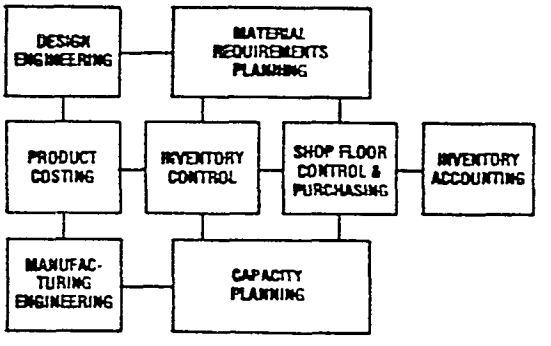
PERFORMANCE MEASUREMENT

PERFORMANCE AREA	RESPONSIBILITY	
BILL OF MATERIAL	ENGINEERING	
PERFORMANCE CRITERIA	PERFORMANCE MEASUREMENT	MEASUREMENT METHOD
PRODUCT STRUCTURE	PARTS, QUANTITIES, LEVEL BY LEVEL FOR ASSEMBLY	PULL PARTS AND ASSEMBLE
ENGINEERING CHANGE CONTROL	PLANNED AND ACTUAL EFFECTIVITY DATES	WEEKLY ECN EFFECTIVITY STATUS REPORT
OBSOLETE INVENTORY	OBSOLETE INVENTORY MUST 5% OF TOTAL INVENTORY	QUARTERLY OBSOLETE INVENTORY ANALYSIS REPORT

PURCHASING FLOW



MAC-PAC
MANUFACTURING PLANNING AND CONTROL SYSTEM



PERFORMANCE QUESTIONS

- WHAT IS THE PERFORMANCE?
- WHAT SHOULD IT BE?
- WHAT IS PERFORMING?
- WHAT IS NOT?
- WHAT ACTION IS REQUIRED?
- WHO IS RESPONSIBLE?
- WHEN WILL IT BE DONE?
- WHAT IS THE FOLLOW-UP?

CLASS A, B, C, D USERS

SYSTEM CLASSIFICATION	SYSTEM PERFORMANCE	SYSTEM CHARACTERISTICS
A	95%	COMPLETE CLOSED LOOP SYSTEM. TOP MANAGEMENT USES THE FORMAL SYSTEM TO RUN THE BUSINESS. ALL ELEMENTS AVERAGE 90% TO 100%.
B	85%	FORMAL SYSTEM IN PLACE BUT ALL ELEMENTS ARE NOT WORKING EFFECTIVELY. TOP MANAGEMENT APPROVES BUT DOES NOT PARTICIPATE. ELEMENTS AVERAGE 80% TO 89%.
C	70%	SHOP IS ORDER LAUNCHING RATHER THAN PLANNING PRIORITIES. FORMAL AND INFORMAL SYSTEM ELEMENTS ARE NOT TIED TOGETHER. SOME SUB-SYSTEMS NOT IN PLACE. ELEMENTS AVERAGE 60% TO 75%.
D	50%	FORMAL SYSTEM NOT WORKING, OR NOT IN PLACE. POOR DATA INTEGRITY. LITTLE MANAGEMENT INVOLVEMENT. LITTLE USER CONFIDENCE IN SYSTEM. ELEMENTS ARE 50% OR BELOW.