The Production Information and Control System

IBM

Data Processing Application

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PREFACE

This manual, by defining the applications that make up a production information and control system, paves the way for a manufacturing company to convert to mechanized production control.

The application studies begin with a basic ingredient — the information requirements and relationships of production data. An attempt is made to answer the questions "What is necessary for a total production system?" and "How is it created?"

Several factors permit solutions to the problem of mechanization in this area: (1) the IBM bill of material processor program, which organizes disk files and maintains the record data, (2) the enhanced speed, flexibility, and capacity of IBM's direct access storage devices on its System/360 computer, and (3) the IBM operating system program concepts with the ability to maintain continuity between jobs.

The production information and control system is a logical and orderly growth plan for a manufacturing organization to do a better job of managing men, machines, materials, and money. The goals are clear:

- Increased productivity
- Increased profitability
- Improved management

This publication enables the reader to visualize the management of a company as a total system. But, in addition, it provides new knowledge of subjects seldom discussed before:

- Value of common data files
- Flow and interaction of manufacturing applications
- Workings and use of transaction entries
- Techniques for disk file organization
- Use of symbolic labels to define DATA BASE records

The introduction discusses the fabrication and assembly types of manufacturing for which this production information system is designed. It also explains the problems and needs confronting the industry today.

Chapter 1 provides an overview of the system. Each of the eight application subsystems is defined. They bear the following titles:

- Engineering Data Control
- Inventory Control
- Sales Forecasting
- Requirements Planning
- Capacity Planning
- Operation Scheduling
- Shop Floor Control
- Purchasing

Chapter 2 provides an in-depth analysis of the data requirements and methods of file organization. Transaction entries are shown, applicable to each subsystem, together with functional flowcharts and sample output formats.

The DATA BASE appears in the appendix of the manual. It is the start toward a framework for a production information system. It is also a planning tool for continued growth and implementation.

Third Edition (Reprinted December 1969)

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INTRODUCTION

THE ENVIRONMENT

TYPES OF COMPANIES

Manufacturing industries are classified into (1) basic producer, (2) converter, and (3) fabricator. The basic producer uses natural resources to produce raw materials for other manufacturers. An illustration is a steel company processing iron ore to produce steel ingots. The converter, on the other hand, uses the products of the basic producer and changes them into a variety of industrial and consumer products. He takes the steel ingot, for example, and changes it to bar stock, tubing, or plate. Finally, the fabricator takes the product of the converter and transforms it into a variety of products. The bar stock becomes nuts, bolts, or twist drills. Or, to produce an automobile, the fabricator assembles body, chassis, frames, wheels, engines, and other parts.

METHODS OF PRODUCTION

The fabrication industries further break out their operations into the job shop, the assembly (or product) line, or a combination of the two.

The job shop is the intermittent type of operation. Department or work centers are organized about particular types of multipurpose machines to perform a specific function. Individual work centers exist for drilling operations, milling, facing, etc. Because of the profusion of centers, control of work in process becomes a burden. Order expediting, scheduling, and machine setups further complicate the job shop operation. Such an environment inevitably calls for heavy paperwork in order to control closely its costs and productive capacities.

The assembly line is described as the continuous type of operation. A uniform flow exists within a physically contiguous area. Although paperwork is less burdensome, the line is very sensitive to disruption from breakdown.

The third or combination process calls for departments to be laid out in an operational sequence on the basis of product specialization. As a result, a single direction of flow exists from one department to another.

TYPES OF PLANNING

Orders are separated into "make" or "buy" items. To-buy material falls in the domain of the purchasing department. To-make orders are scheduled into the fabrication shops and the assembly line. These may be further categorized as make-to-stock or make-to-order. Finished stock orders are directed to the warehouse as standard or stock items. They may also become slightly modified by the addition of certain options or features. Make-to-order material is custom-built or custom-assembled and bears the earmark of an individual customer's requirements.

Examples of the kinds of fabrication and assembly companies that fit the general environment just described appear as in Figure 1.

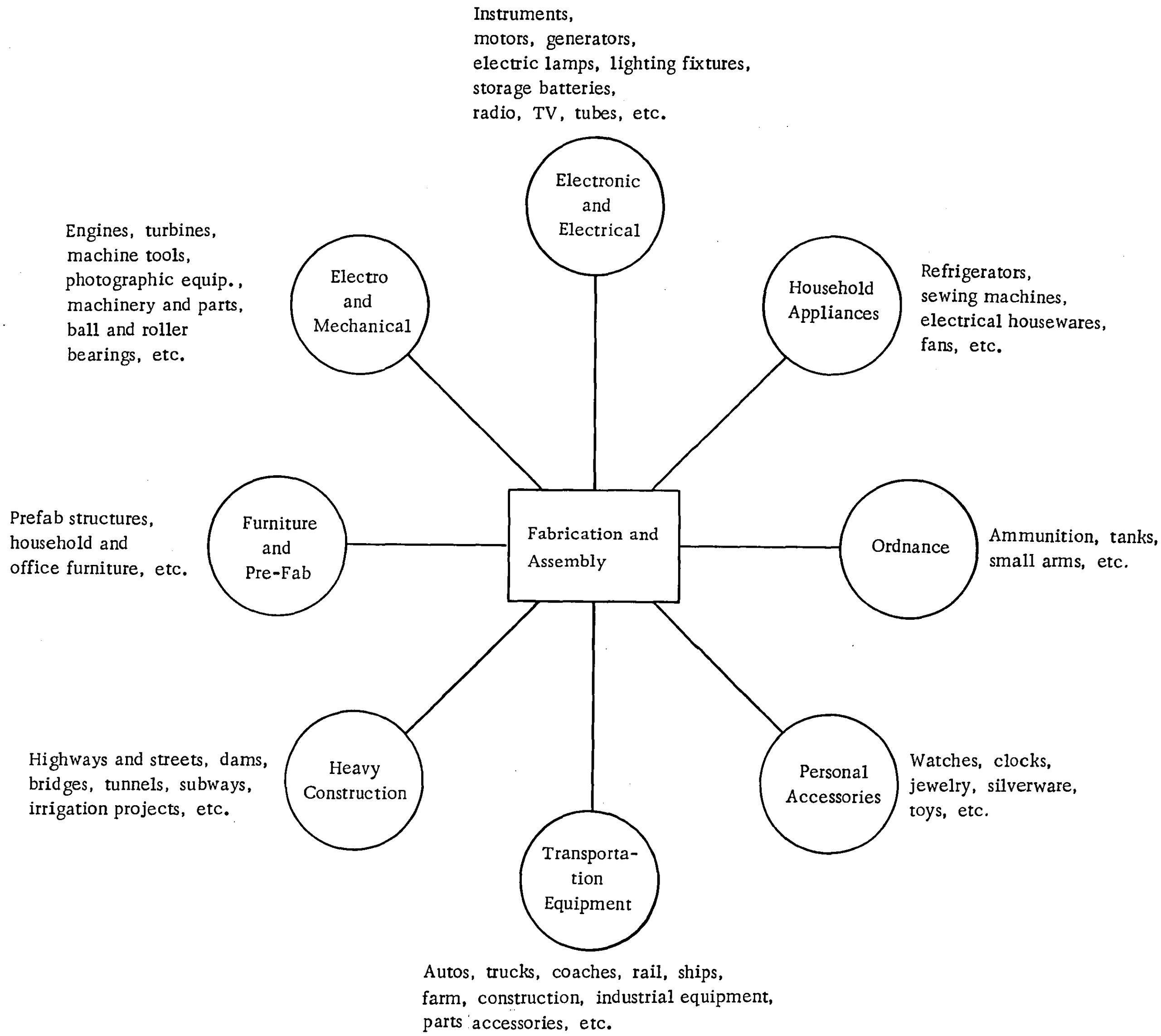

Figure 1. General classification of fabrication and assembly companies

THE MANUFACTURING ORGANIZATION-- ITS PROBLEMS

The manufacturing organization is plagued with a combination of problems that differentiates it from all other industries. It is a costly business; its product is complex; the company undergoes heavy competition; and it operates in an ever changing environment. Added to these external burdens are its internal conflicts--decentralized planning and excessive record data.

A COSTLY BUSINESS

Materials, machines, and manpower add up to burgeoning costs. Under materials, the expectation is for lower investment in inventory. Included in the cost of inventory are handling and storage costs, taxes, and obsolescence. The standard range for inventory carrying costs is 20-25% of inventory value. In the area of machines, management seeks to utilize its equipment more properly. Under manpower, higher efficiency is sought. Investment is spread between direct factory labor and indirect clerical employees. The ratio of clerical workers to production workers continues to rise. There is no end in sight to the volume of clerical operations performed in plants today. Even so, one out of four of the productive workers themselves is handling paperwork. And still the overall problems remain unsolved.

A COMPLEX AND CHANGING PRODUCT

Manufacturing companies produce and assemble a complicated product. The manufacture of delicate surgical instruments, intricate jet-powered engines, machine tools, or TV tubes illustrates this complexity.

The product is also subject to considerable change. It is constantly being redesigned because of new technology or other reasons; different raw material is used, or new features are added. Engineering changes must then be processed and controlled to update bills of material.

A COMPETITIVE BUSINESS

Most companies usually operate under the tremendous pressure that is applied by competition. This pressure tends to limit the amount of time available for planning, execution of plans, or revision of plans. A manufacturer by no means has unlimited time to plan and execute. If he takes too long, his competitors will be there first and will capture the market. The pressure of competition forces fast decisions and faster action.

How does a company meet its competition? By offering a good product at reasonable cost and by keeping a customer satisfied. This can be accomplished by providing prompt answers to questions concerning a multitude of matters, such as order status, scheduled shipment date, etc.

A CHANGING ENVIRONMENT

The manufacturing environment expands and contracts with great frequency. A new product line might require additional capital outlays for new plant and warehouse sites, the hiring of more skilled workers, or the relocation of new or old machines. These are the growth pains. Lowered demand might entail periods of contraction. Layoffs are the end result. Management is therefore faced with the need to plan and schedule material, men, and machines for its changing environs.

DECENTRALIZED PRODUCTION PLANNING

Departmental conflicts may persist in the organization when attempting to reconcile the requirements of sales, production, and the financial interests. Departments tend to recognize only some of the costs and information important to them. They fail to recognize those outside their usual field of activity. The sales department is well aware of customer service and the need for substantial inventories. The production department is concerned with utilization of resources--the operating levels and costs of employment, overhead, and facilities. Finance, on the other hand, watches over excessive inventory and carrying costs, fearful of cash drains and their effect on the profit picture.

Although these departments have varying needs of the same data, they usually end up providing and maintaining their own conventional record files. However, production problems must be solved from the viewpoint of the company as a whole.

AN INFORMATION EXPLOSION

The gathering and dissemination of information usually is the manufacturing company's most difficult problem. Information is voluminous, scattered, and often difficult to obtain. Five types of dissemination exist: (1) replies to inquiries, (2) standard routine reports, (3) exception printouts, (4) shop paper, and (5) special reports.

Managers (and their assistants) embroiled in paper have no time for evaluation, planning, or decision making. Their workday is fraught with searching for information to handle the various crises that arise in addition to the normal workflow. How can they possibly digest all of the extraneous detail in a dynamic organization?

THE MANUFACTURING ORGANIZATION-- ITS NEEDS

Experience has shown that manufacturing has need for (1) a central information system, and (2) a framework to facilitate mechanization.

A CENTRAL INFORMATION SYSTEM

The accumulation of information must be concentrated in a production information center where, literally, one set of books is maintained. This takes the form of records stored on computer disk files, readily accessible to all interested parties at a moment's inquiry. These records should be designed to contain as much data as is deemed important to management. Accurate records are also an essential requirement of the system. Because only one set of archives will now be put to use, it will be easier to maintain this accuracy.

A FRAMEWORK FOR MECHANIZATION

A start in the design of a manufacturing framework was made by IBM in 1960 with its management operating system (MOS).* Its philosophy was built around the ability to update records by random processing (versus batch processing) and to inquire immediately, through a console typewriter, into the status of any part number. The development of IBM RAMAC ® disk storage files made MOS an immensely popular and effective approach.

However, it has been a difficult task to convert and maintain the record information. As a result, implementation of additional MOS applications has been generally postponed. Announcement of the IBM bill of material processor program has served to alleviate the problem by providing a technique to organize and maintain the basic file records.

The production information and control system now becomes another breakthrough, a detailed framework for integrating eight applications into a DATA BASE composed of master, engineering, and open order status records (see Figure 2).

A DATA BASE generally covers all the operational record information needed to handle a company's business. It is stored on disk files and is therefore directly online to a computer. Because of this, summary and detail information can be accessed, updated, and retrieved from multiple entry points. Data is stored one way through reference to symbolic record field labels and can be printed in various output formats.

Each of the system records is linked in a particular manner. For example, a part number accessed from the item master record may lead to a product structure, a standard routing, an open purchase order status, or to an open job order summary or detail record. In the latter instance, the specific work center in which the job is being performed may even be pinpointed.

But a DATA BASE provides further advantages that may not be too apparent,. such as the following:

- Reduces computer process time
- Reduces number of programs to be written
- Reduces sorting of records
- Encourages standardization of transaction entries
- Encourages use of multiple entry points

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*See MOS for Manufacturing Industries (E20-8041)

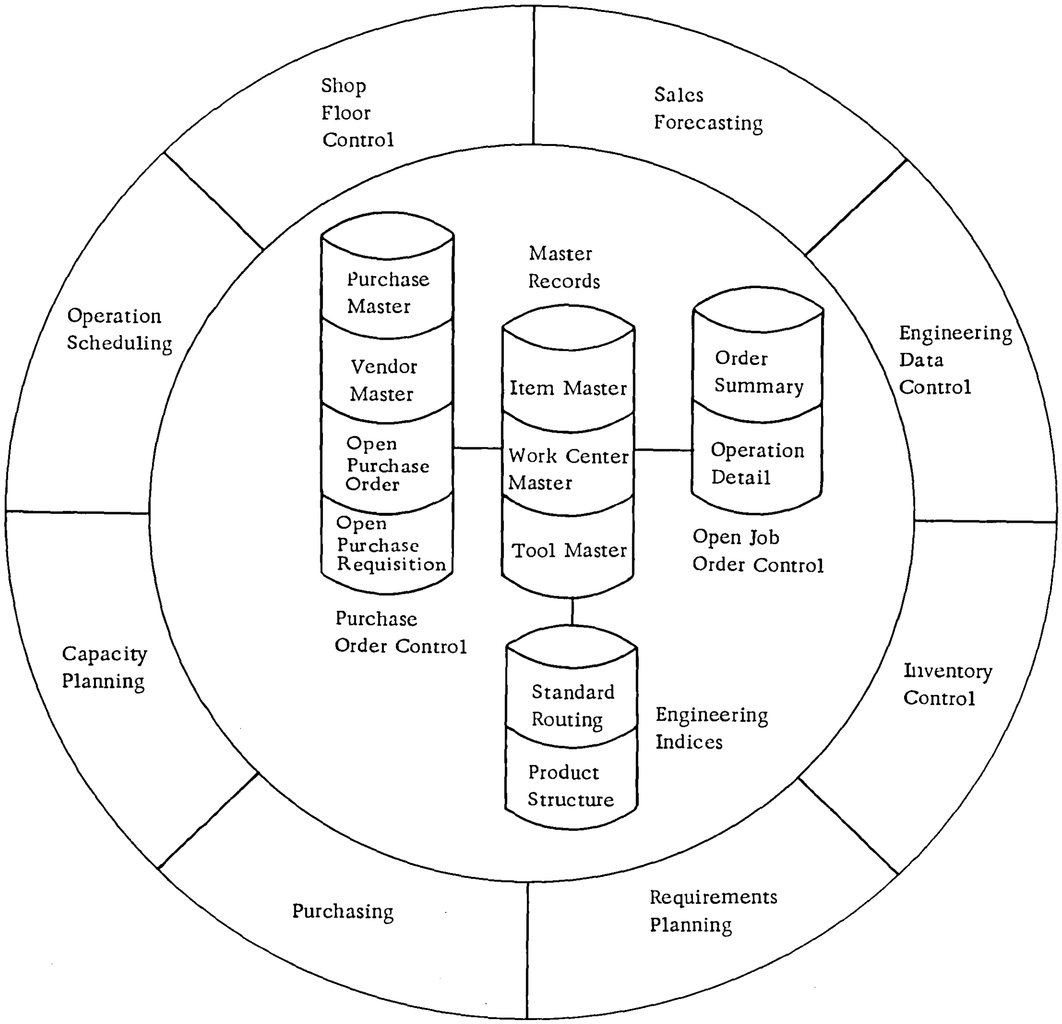


Figure 2. The integrated system

DATA FLOW IN A MANUFACTURING ORGANIZATION

Figure 3 shows the interactions of these events grouped within seven major areas:

1. Sales analysis
2. Engineering
3. Inventory control and production scheduling
4. Manufacturing facilities
5. Purchasing
6. Finance
7. Sales/distribution

While the DATA BASE is designed to process segments of all these areas, it does not contain the additional detail records needed to handle sales analysis, finance, and sales/distribution.

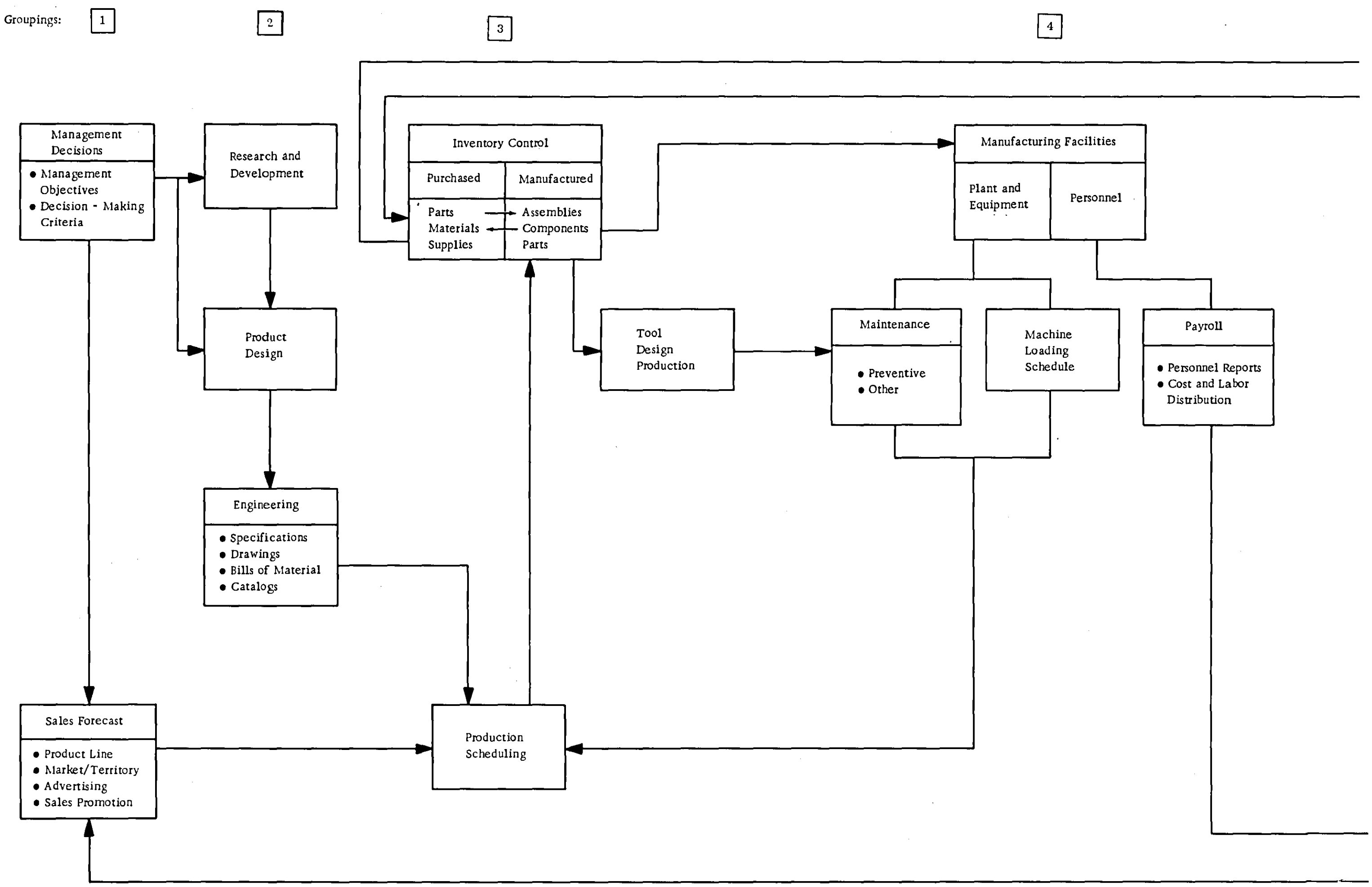
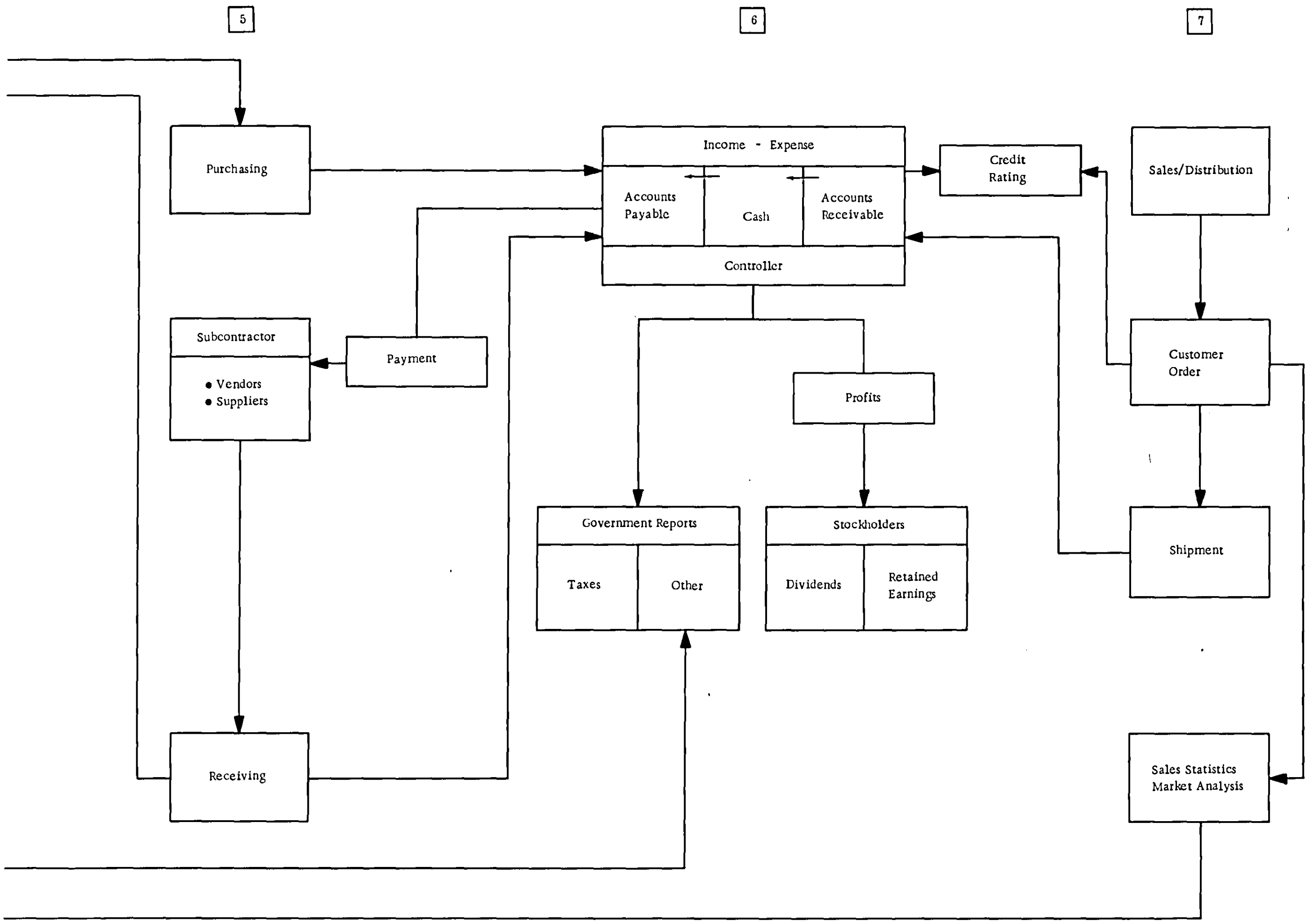


Figure 3. Data flow in a manufacturing organization


5
6
7
Purchasing
Income - Expense
Accounts Payable
Cash
Accounts Receivable
Controller
Credit Rating
Sales/Distribution
Subcontractor
• Vendors
• Suppliers
Payment
Customer Order
Profits
Government Reports
Taxes
Other
Stockholders
Dividends
Retained Earnings
Shipment
Receiving
Sales Statistics
Market Analysis

PRIMARY FLOW

Figure 4 is a general pattern for a production model. The flow leads from an initial input of customer orders and statistical sales background data to the final shipment of an order. This generalized model is divided into a planning phase and an execution phase.

Planning

Planning begins with the preparation and projection of order forecasts. Stock availability and on-order status are screened across product inventory records. But component family characteristics of the product line must also be recognized. Product structure or bills of material enter into these decisions.

After a determination of net requirements, an order quantity analysis takes place to ascertain lot sizes and lead times for both purchased and manufactured items.

To-buy items are routed to the upper level of the chart (shown as PURCHASING), where the items are placed on a purchase requisition. At this point a selection of vendor is made, price and delivery are negotiated, and purchase order is released. Receipt cards and/or a scheduled receipt document may be prepared simultaneously with the purchase order and

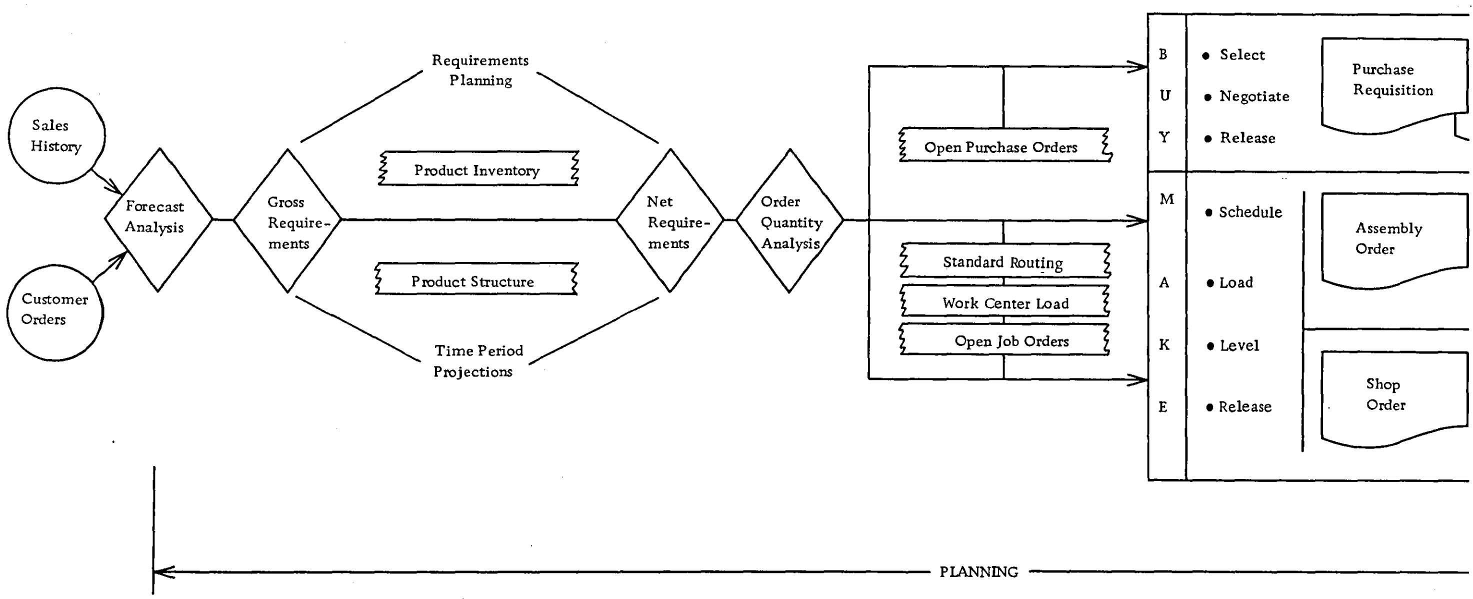


Figure 4. The production model -- primary flow

forwarded to the inspection-receiving area of the warehouse. An open purchase order record is now initiated for follow-up.

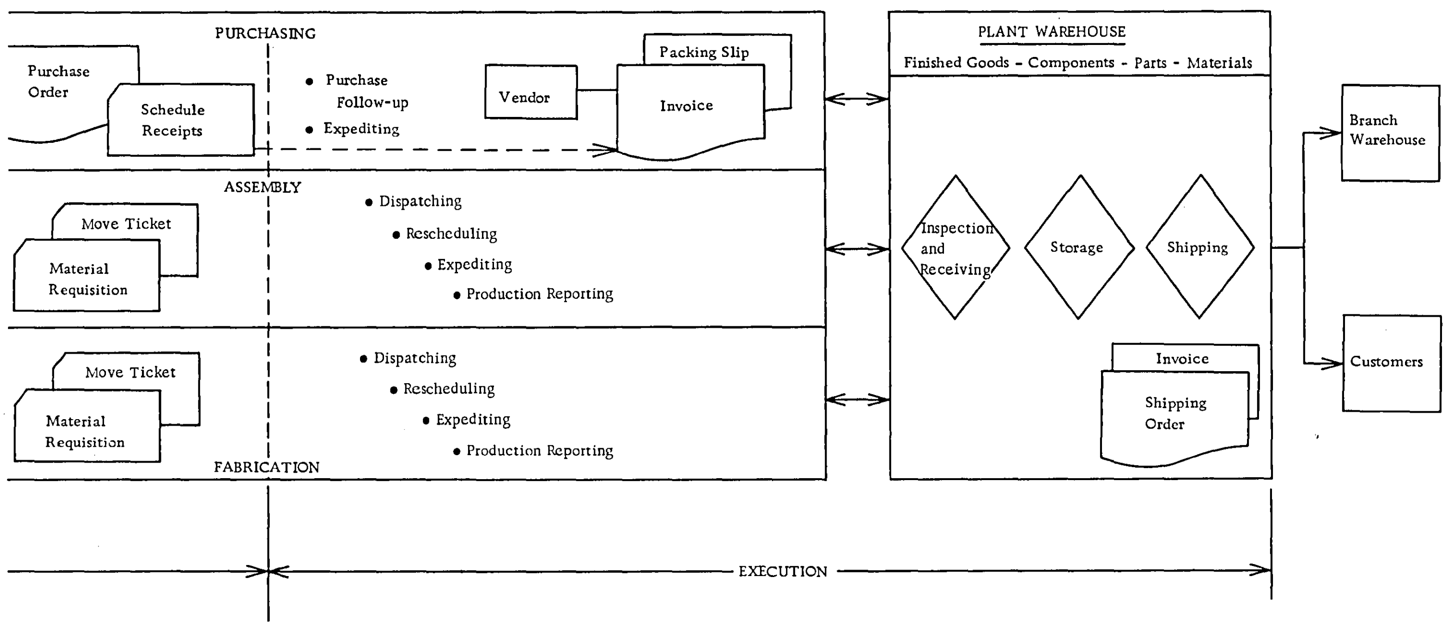
To-make items are routed to production planning for assembly and fabrication. Some similarity exists in these two levels. An assembly order is generated for the assembly area, a shop order for the fabrication area. Material requisition and move tickets accompany both documents. Three basic types of records (standard routing, work center load, and open job order) permit assembly and fabrication to schedule, to load and to level the line or the shop, and to release the order paperwork.

Execution

Execution begins at the purchasing level with the need for order follow-up and vendor expediting. The vendor ships material to the plant warehouse, accompanying his shipment with packing lists and an invoice.

Varied execution functions are performed at the assembly and fabrication levels. Orders are dispatched, rescheduled, and expedited between work centers. In the meantime, current production reporting updates work center and open job order records.

Finished goods and components move from the assembly and fabrication areas to the inspection and receiving area. The final cycle in the production model is a shipment authorization requesting the warehouse to pack and ship to a branch warehouse or to the customer.



SYSTEM FLOW

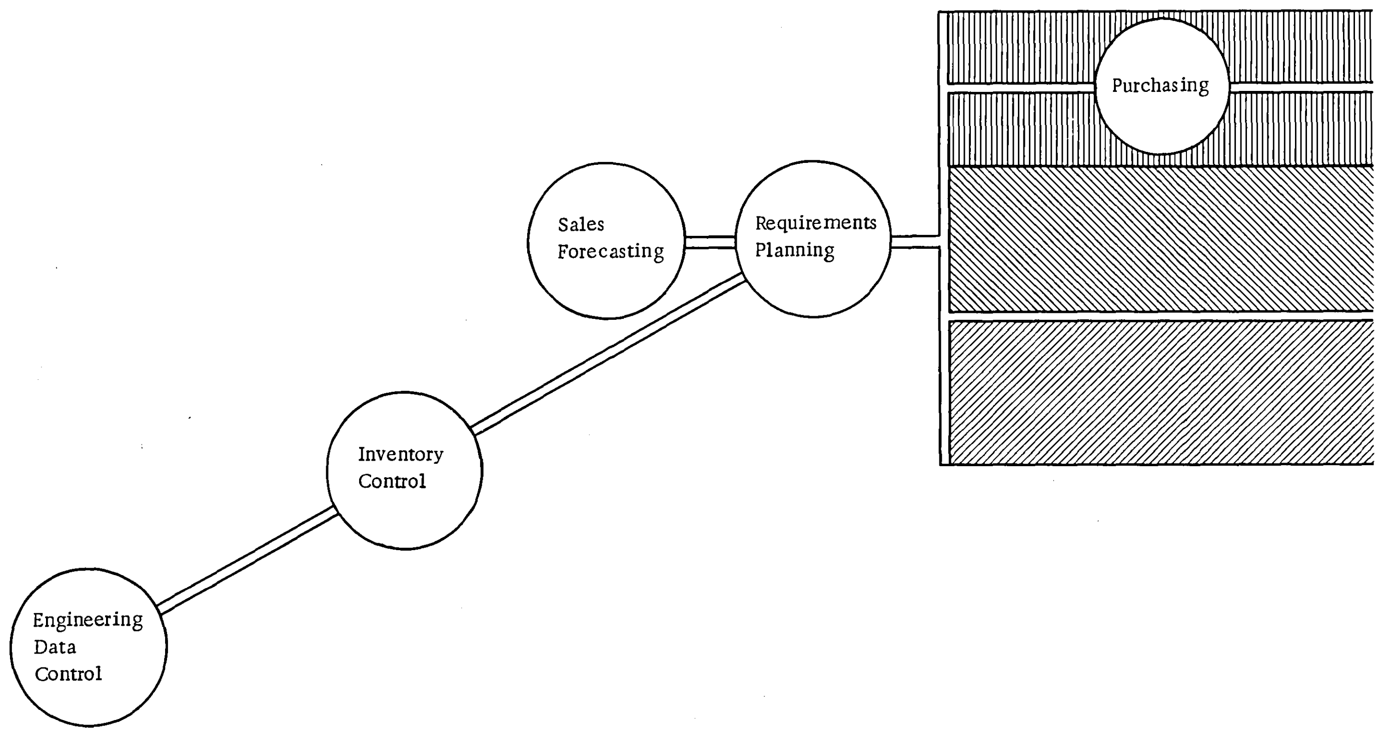
The subsystems have been designed to fit the production model. Figure 5 may be considered to be an overlay to coincide with the three-level information flowchart discussed in Figure 4.

Information flow begins from two directions. The first path moves from engineering data control to inventory control to requirements planning. The mission of engineering data control is to organize and maintain the basic records, that is, the item master, product structure, standard routing, and work center master. As already noted, it accomplishes this by means of the IBM System/360 Bill of Material Processor program. This subsystem has the added capability of retrieving information from the DATA BASE. Six retrieval functions are performed -- three in assembly sequence, and three in parts usage format.

An inventory control subsystem follows organization of the basic records. On-hand inventory, usage history, and on-order fields are utilized in the item master so that a stock status report can be generated. Thus, a major objective of this application area is record maintenance and the updating of inventory. With accessibility to such data, "when to order" and "how much to order" decisions can be made. Since the already-activated item master and product structure records are now available to it, a requirements planning subsystem is prepared to work in conjunction with inventory control.

A second flow line moves from sales forecasting to requirements planning. The sales forecasting subsystem analyzes historical demand data, which may be stored on the item master, to provide requirements planning with a gross finished product forecast plan. To accomplish this, a forecast model must be selected, which, in turn, arrives at new trends and forecast error deviations.

The merger of requirements planning with inventory control now makes it possible to determine net requirements, projected into time periods and scheduled due dates. Product structure records are used at this point to allow the breakdown of finished



ENGINEERING DATA CONTROL	INVENTORY CONTROL	SALES FORECASTING	REQUIREMENTS PLANNING	PURCHASING
Item Master, Product Structure, Standard Routing, Work Center Master } Organization of basic records Open Job Order - Order Summary	Item Master	Item Master	Item Master Product Structure	Item Master Purchase Master Vendor Master Open Purchase Order

Figure 5. The production model -- system flow and DATA BASE records

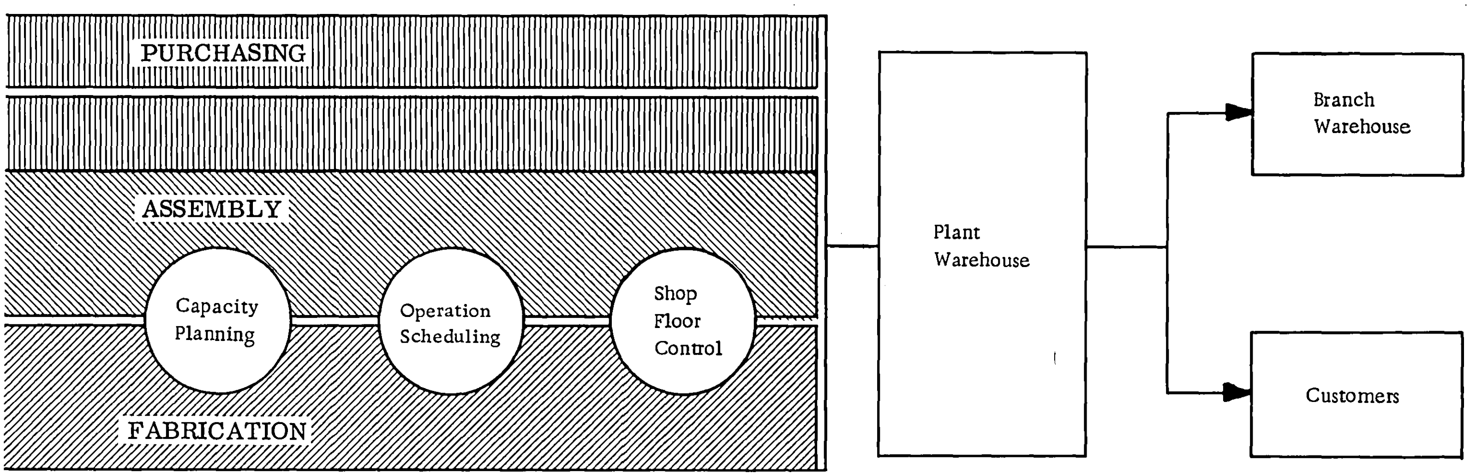
product items into individual components. These are similarly netted and projected into time periods. All this results in planned orders, destined to each of the three links -- purchasing, assembly, and fabrication.

Planned orders to purchasing follow the pattern observed in the primary flow of Figure 4. Requisitions are prepared. Through the use of purchase master and vendor master records, a vendor may be selected and a purchase order with receiving cards initiated. An open purchase order record is created so that purchase follow-up can become the next sequence of events.

Planned orders also flow into the assembly and fabrication areas, where the capacity planning subsystem, or long-range scheduler, looks at an entire planning horizon. Its purpose is to identify overloads far enough into the future to allow for both facility and manpower planning. After order start date calculations are performed (utilizing standard routing records), consideration is given to plant capacity. The work center master record is used for this purpose. Available techniques are then used to level the loads. A work center load report, projected by time period, is one of the key output documents.

Operation scheduling accepts orders which have gone through a releasing cycle from capacity planning and schedules the work center within its short-range time span. Dispatching sequences are prepared and analyses made of the loads. Priority rules are set and order completion dates determined. To the short-range scheduling phase of this subsystem has been added the control of tools. A tool master record is designed for this function.

Shop floor control is the final subsystem in the flowline. It prepares the shop packets and other factory documentation. It also constructs the open job order summary and operation detail records so that progress of the work through each center can be reported. Feedback is one of its more important functions so that the system can respond to change. The three levels shown on the chart converge at the plant warehouse to complete the information flow.



CAPACITY PLANNING	OPERATION SCHEDULING	SHOP FLOOR CONTROL
Item Master	Standard Routing	Item Master
Standard Routing	Work Center Master	Product Structure
Work Center Master	Open Job Order	Standard Routing
	- Order Summary	Open Job Order
	- Operation Detail	- Order Summary
	Tool Master	- Operation Detail

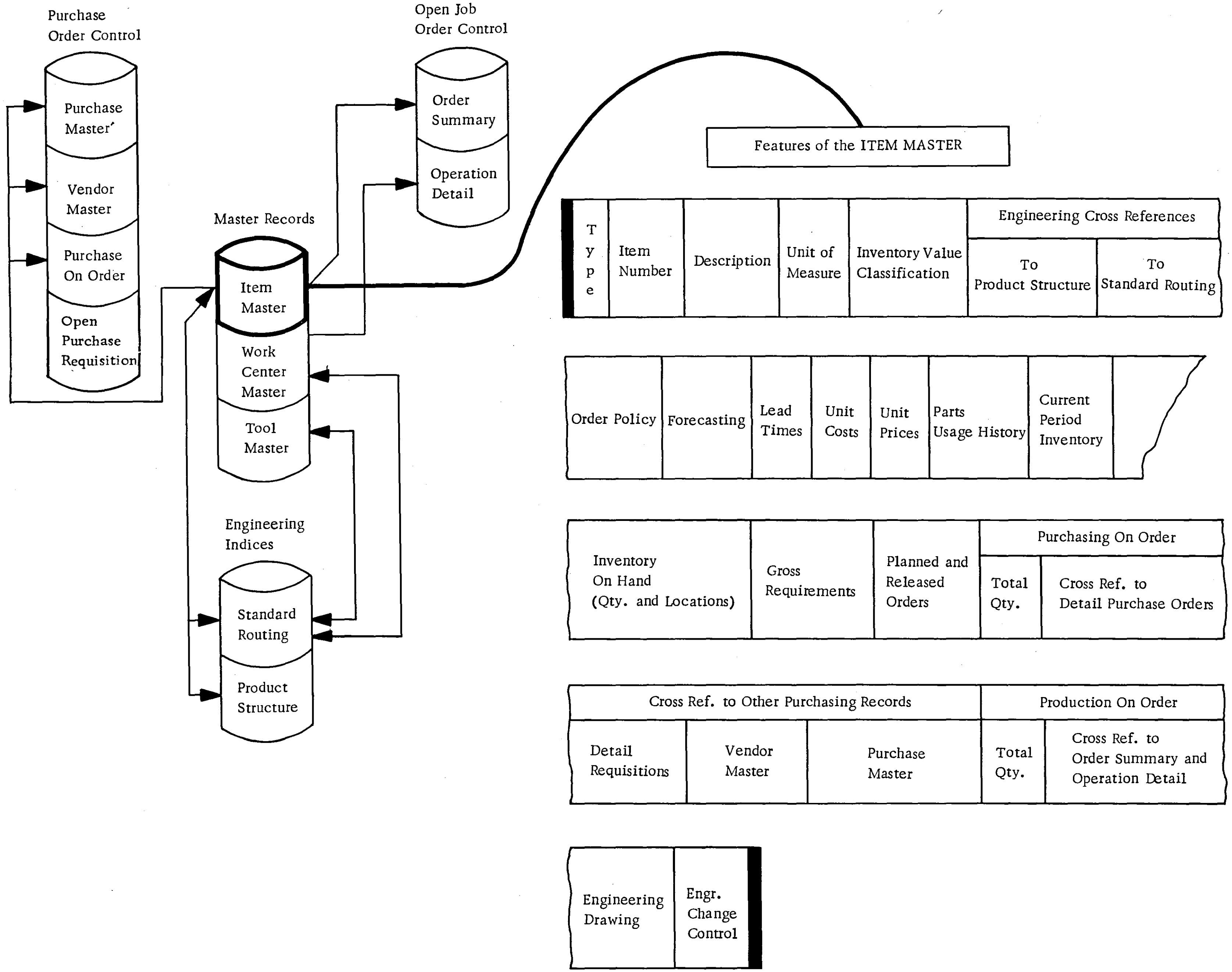


Figure 6. Standardized records

STANDARDIZED RECORDS

A set of standardized record layouts has been designed as a base to mechanize the application areas leading toward the total integrated production information and control system. These records contain fields that are considered necessary to enable the majority of users to realize their production output requirements. Each field is described in detail in the appendix. Their respective lengths, however, are left to the discretion of the user.

The record design is shown in Figure 6.

TRANSACTION ENTRIES

The production information and control system also suggests use of a standard group of transaction entries from a matrix checklist. In essence, a transaction is input to a system, which alters several fields of several records. This is best illustrated in Figure 7 by citing the interactions of a vendor receipt coded "RR" opposite "Receiving Report". A quantity of units arrives at the inspection and receiving dock. Record updating takes place. The on-hand inventory and current receipts fields of the item master are increased; the total quantity on-order purchasing field is decreased. Meanwhile, if purchasing detail records are also maintained, their fields are similarly updated.

Transaction	Code	Item Master					Open Order Files		
		On Hand	Current Receipts	Total Quantity On Order Purchasing	Total Quantity On Order Production	Available	Open Purchase Orders (Detail)	Open Job Order -Order Summary	Open Job Order - Operation Detail
Symbolic Labels →		MOHTQ	MCSRE	MPUPQ	MPRPQ	MAVAL	PONUM	OSONO	ODORN
Work Order	WO				+	+		+	+
Work Order Adjustment Down	WD				-	-		-	-
Purchase Order	PO			+		+	+		
Receiving Report (Vendor)	RR	+	+	-			-		
Receipt (Interplant)	RC	+	+		-			-	-

Figure 7. Sample transaction entries

The production information and control system defines how modular programs and routines are created so that they can be linked together into a total production system.

One type of modularity is the linkage of application subsystems into a production information system. The essential features of these subsystems are shown in Figure 8; they are discussed at further length in Chapter 2.

A second type of modularity utilizes the buildup of individual routines within a subsystem. A number of different variations might exist, for example, to arrive at an order policy in an inventory control subsystem. A selection of one or more of these

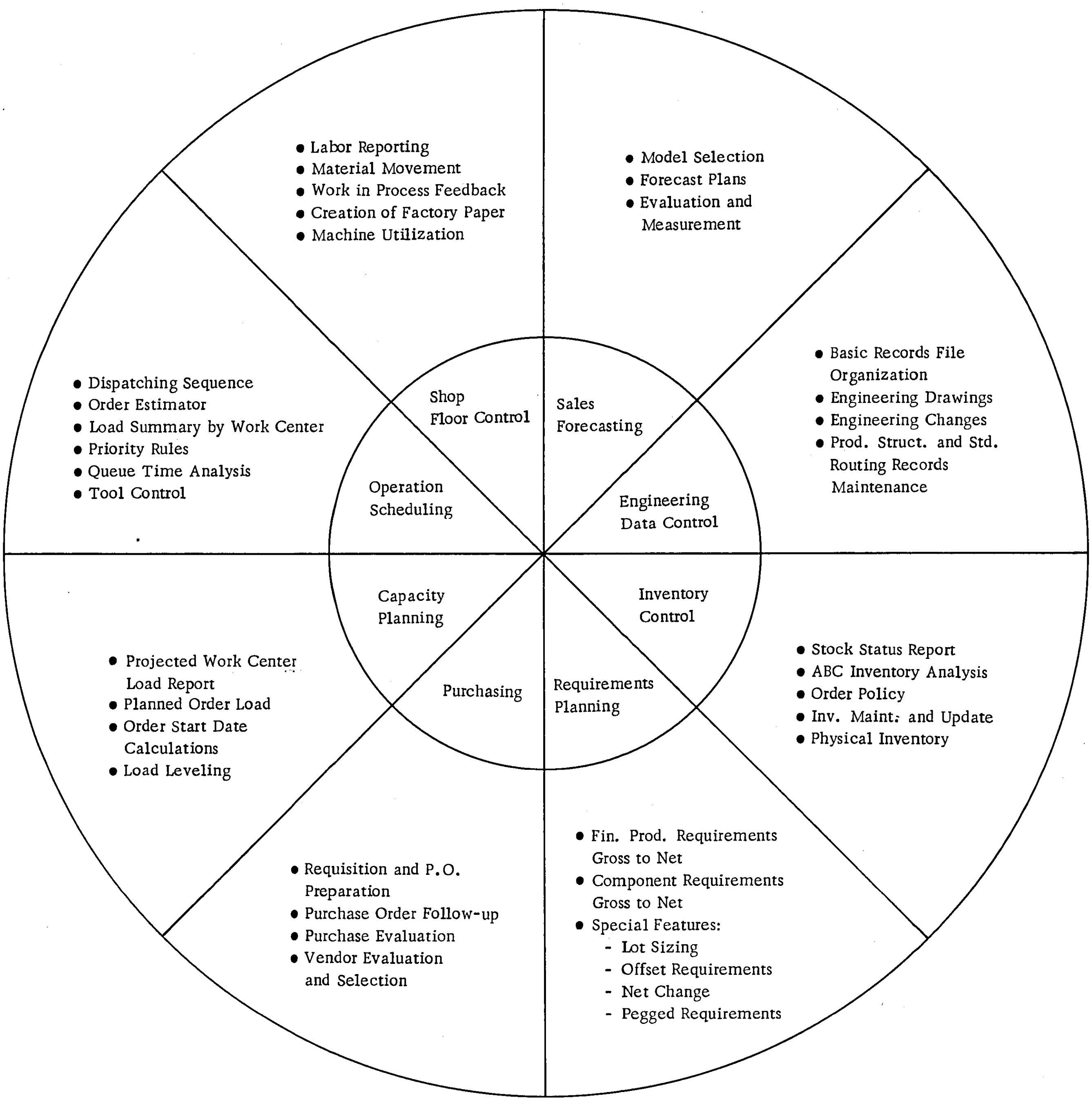


Figure 8. Features of the subsystems

variations would become part of a final program (Figure 9a).

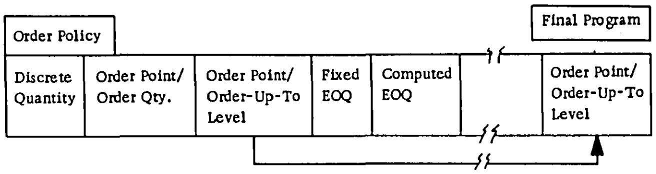


Figure 9a.

In the example of requirements planning, (Figure 9b), all five routines might be used.

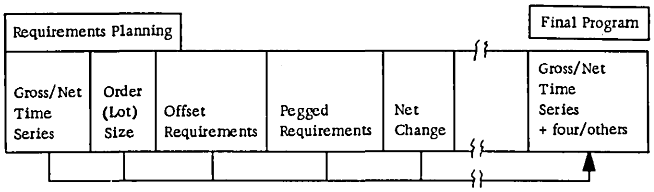


Figure 9b.

A third type of modularity is the linkage of the presently available IBM programming products. These consist of the System/360 Bill of Material Processor program, which organizes the following basic records: the item master, product structure, standard routing, and work center master. Another set of programs is the System/360 Disk Operating System, which maintains continuity between jobs by scheduling and queuing I/O operations on the System/360, and which checks and handles both error conditions and I/O interruptions.

BENEFITS OF THE SYSTEM

A PLAN FOR GROWTH

A plan can be developed to begin implementing each of the application areas leading to the integrated production system. The system can grow as the user grows. And the user will obtain tangible results long before the total system is installed.

STANDARDIZATION

Information is common to all -- it is known and called by one description. One set of records makes this possible. The manufacturing company finds it easier to plan for standard procedural systems.

A DEVELOPED FRAMEWORK

Extensive DATA BASE

The production information and control system is an excellent tool to determine the data requirements of each subsystem. It defines the input and the purpose of each record field.

The record base has two important features -- accessibility and accuracy. Information is accessible through inquiry to multiple points; detail is available through chaining to all related records. No longer is it necessary to spend hours or days searching file drawers or ledger cards. Also, information is more accurate; it is updated in only one place. Standard transaction entries processed within each subsystem assure complete record maintenance.

Method for Improved File Organization

File organization programs are designed to use minimum record storage space. At the same time, updating of record fields is speeded.

Modular Program Design

The bill of material processor efficiently organizes the basic records. The disk operating system maintains continuity of programs. There is minimum system change; new techniques can be incorporated without the necessity for changing the entire system.

A CLEARINGHOUSE FOR PRODUCTION INFORMATION

All production information is now directed into a single channel. Levels of operating and management personnel are made more aware.

CLOSER CONTROL OVER MATERIALS, MACHINES, MANPOWER, AND MONEY

- The key to cost reduction. Costs can be more closely controlled, with better surveillance over overtime hours, inventory, and machines.
- The key to efficient planning.
- More time available to react to changes.
- Less waste, reduced information costs, more profits.

GENERAL DESCRIPTION

Each application subsystem is discussed in this chapter as outlined below:

- Introduction
- Objectives
- Subsystem flow
- Module description
- Summary

The subsystems are described in the following sequence:

- Engineering data control
- Inventory control
- Sales forecasting
- Requirements planning
- Capacity planning
- Operation scheduling
- Shop floor control
- Purchasing

This sequence was selected because the subsystems are closely related to and dependent upon particular records within the DATA BASE. Figure 10 indicates that four of the subsystems (engineering data control, inventory control, sales forecasting, and requirements planning) use information provided in the item master, product structure, standard routing, and work center master files. The figure also shows that the techniques for creating and maintaining these files are provided by the IBM System/360 Bill of Material Processor program. * Many techniques of the bill of material are summarized in the engineering data control section.

A comprehensive subsystem summary chart appears at the end of each subsystem writeup summarizing the module names, input, processing routines, DATA BASE record fields applicable to each module, and nature of the output. For added convenience, similar information is also included at the end of each module description.

Additional files are required for the other four subsystems -- capacity planning, operation scheduling, shop floor control, and purchasing. When implemented, these files complete the DATA BASE.

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*See IBM System/360 Bill of Material Processor -Application Description (H20-0197)

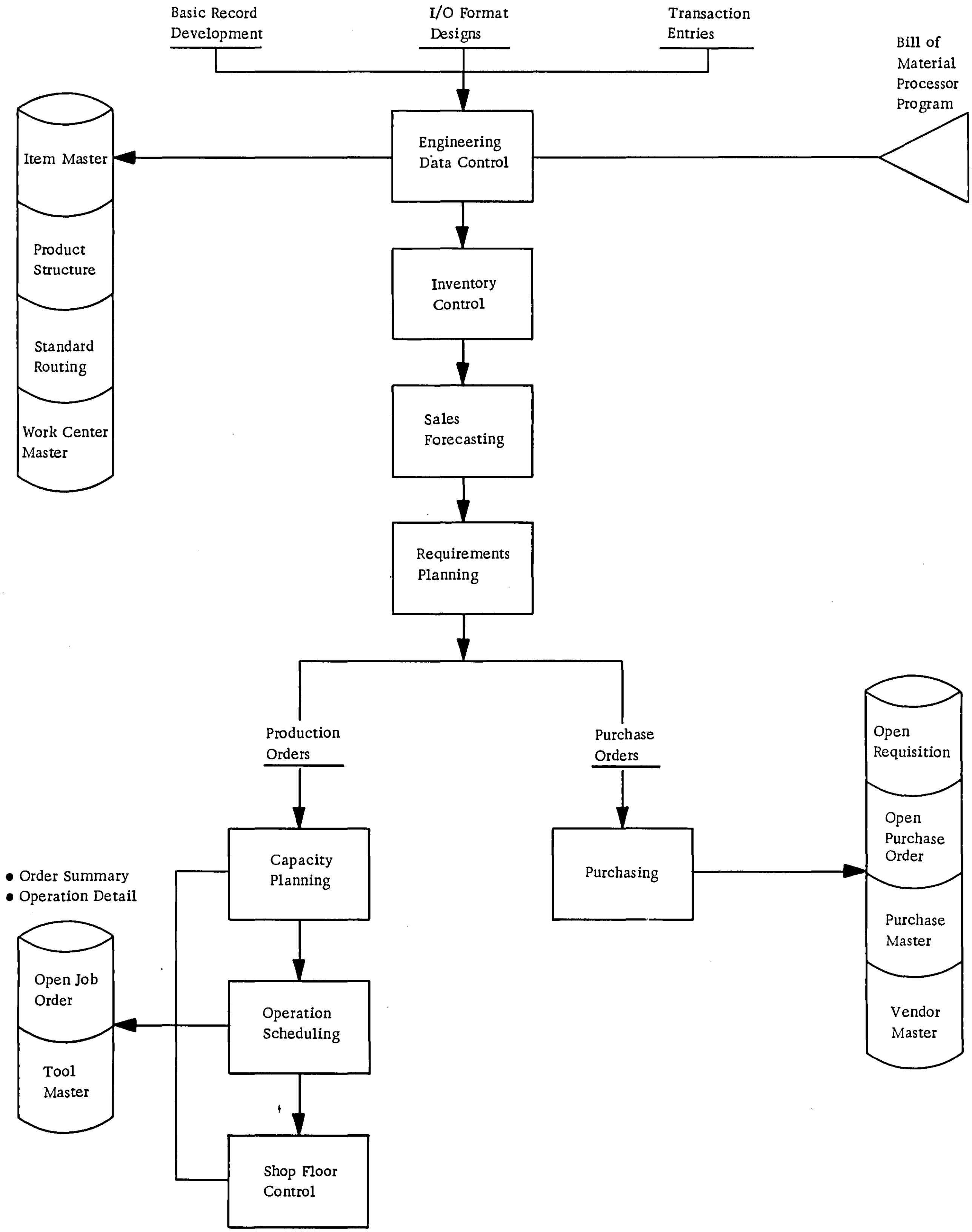

Figure 10. System flow and interaction

INTRODUCTION

The manufacturing organization must be able to maintain and retrieve accurate, up-to-date engineering information. This usually involves large volumes of records that describe the structure or makeup of its products and the production specifications for fabrication and assembly. These records are vital in the planning and execution of the manufacturing process.

Within a typical manufacturing organization this information is resequenced, reformatted, or summarized to suit individual requirements of various departments. Frequently, separate files are used. This requires duplication of file maintenance effort and almost inherently involves working with data that contains differences and inaccuracies.

One of the more essential maintenance functions is engineering change. The engineering design function makes changes to a product by altering individual assemblies and subassemblies that constitute a finished unit, and/or the production specifications for assembly or fabrication. These changes must be reflected in the records that describe the products, assemblies, and the routing for items.

In addition to the increased recordkeeping resulting from engineering changes, many questions must be answered before the decision to make the changes. These include: What parts should be changed, and how? Are any of these parts currently being changed for other purposes? If so, what is the status of the change, and who is responsible? Where is this item used? What is the effectivity date? Will the sequence of effectivity affect this change? Is the current inventory usable, reworkable, or scrap, or should it be stocked out on specific usages? Are there any changes in routing and the standards? What are the tool requirements? When is the best time for this change to become effective?

Accurate information is of prime importance for judgments regarding these questions and for use by other functional areas within a company.

OBJECTIVES

The major objective of this subsystem is to provide for (1) maintenance of timely data and (2) retrieval of information from the files.

The file load and maintenance functions for four of the records described in this manual are provided by the IBM bill of material processor.* The records are:

- Item master
- Product structure
- Standard routing
- Work center master

The relationship among these records is illustrated in Figure 11.

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*See Bill of Material Processor - a Maintenance and Retrieval System (E20-0114)

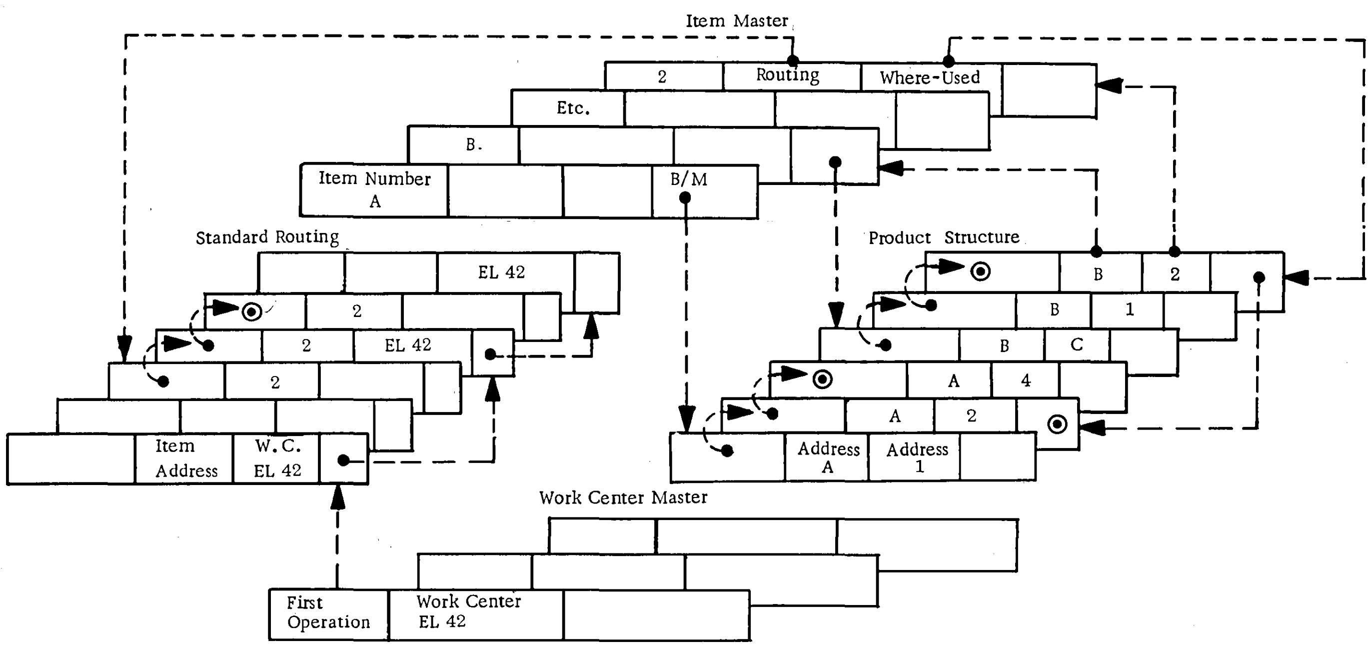


Figure 11. File relationship--bill of material processor

The item master contains the disk addresses of where the product structure (first component address and first where-used address) and the standard routing have been stored. Product structure records indicate the next records within the product structure file that are associated with the item for both the bill of material and the where-used lists. Note that in the example (Figure 11), part 2 is a component for assemblies A and B (the second product structure record for A, and the third record for B). The same product structure records provide the where-used information. The where-used chain for item 2 can be traced for all uses of this part (in this example, where-used consists of assemblies A and B).

The address of the first operation of the standard routing file is also recorded in the item master file. Each operation record has the address of the next operation record in the standard routing file peculiar to the item. Each record in the standard routing file can also be "chained" to the master record for the work center in which it usually is performed. This is accomplished by placing the address of the first operation for a work center on the work center master, and the address of each following record on the individual records within the standard routing file.

Product structure data that has been organized and maintained as described, forms the basis for retrieving information in many ways. The disk file effectively contains product structure records in two sequences: (1) assembly sequence (that is, grouping the components of an assembly) and (2) where-used sequence (that is, grouping direct usages of a part number on higher-level assemblies). Both of these sequences are used in data retrieval for preparing reference documents and for applications that require product structure data as a framework for processing.

Using basic retrieval programs, the computer can produce a variety of formats from the information in the master files. Figure 12 illustrates the most common basic formats and some of their uses.

Product specifications (standard routing file) are stored within the subsystem and are used in several functions (for example, order release, capacity planning). A routing sheet and labor reporting cards are illustrated in the shop floor control section.

Another significant aspect of the bill of material processor file technique, when expanded to include other records (such as the open job order file, discussed under "Operation Scheduling" and "Shop Floor Control," is the ability of production management to analyze, before establishing an effective date or phase-out quantity, the status of a part or assembly subject to engineering change. A request for information regarding a particular assembly can provide the complete on-hand, on-order status for the assembly and its components, as well as the status of all assemblies on which it is used. The item master record points to a series of open shop orders that furnish the current order location, hours to completion, and the material, labor, and burden costs to date. Figure 13 illustrates the data and the source within the system for an engineering change trial fit. *

---

*See Management Operating System - Engineering Detail (E20-0028)

Assembly Sequence Format

Assembly Part Number—20136818 Assembly Description—Pump Assembly		
Part No.	**Description**	**Quantity per Assy.**
53167	Screw	6
531690	Washer	5
728419	Screw	5
1431473	Seal	2
3519794	Motor	1
3572133	Spring	2
20136130	Pump shaft assembly	1
	Set collar	

Single level bill of material

Shows all components and quantities per required to make an assembly.

Applications

- Assembly orders, requisitions
- Level by level net requirements planning

Assembly Part Number—144-20 Assembly Description—Series 20 Service Pump			
Levels	**Part No.**	**Description**	**Quantity per Assy.**
1	20136186	Pumping Assy.	1
.2	7365963	Service Box	1
.2	20136812	Adaptor	2
.2	20136813	Adaptor Gasket	2
.2	20136818	Pump Assy.	1
..3	531674	Screw	6
..3	531690	Washer	5
..3	728419	Screw	5
..3	1431478	Seal	2
		Motor	

Indented parts list

Traces product structure downward through all assembly levels of a product or major assembly.

Applications

- Service parts catalogs
- Product assembly planning

Assembly Part Number—144-20 Assembly Description—Series 20 Service Pump		
Part No.	**Description**	**Total Qty. per Assy.**
231285	Pin	3
356736	Pin	1
481278	Nut	9
496830	Screw	10
498052	Bolt	9
517370	Washer	9
531674	Screw	18
531690	Washer	5
728419	Screw	5
1431478	Seal	2
3519794	Motor	1

Summarized parts list

Each component is listed once with total quantity used on a given product or major assembly.

Applications

- Gross material requirements
- Product costing

Parts Usage Format

Part Number—44601 Part Description—Bushing		
Next Assy. Part No.	**Description**	**Quantity per Assy.**
C2841	Collar	1
C2841-2	Collar	1
D1458	Adaptor	1
406209	Adaptor Plate	1
406210	Adaptor Plate	1
406210-1	Adaptor Plate	2

Next assembly where-used

Indicates part number usage on next higher level assemblies.

Applications

- Component allocation
- Engineering change analysis

Part Number—44601 Part Description—Bushing			
Levels	**Assembly Part No.**	**Assembly Description**	**Quantity per Assy.**
X	C2841	Collar	1
. X	B3055	Drive Shaft	2
. . X	A1054	Pump Connector	2
. X	E2828	Stand Pipe	1
X	D1458	Adaptor	1
. X	A1054	Pump Connector	1
X	C2841-2	Collar	1
. X	B3056	Drive Shaft	1
. . X		Pump Conn...	

Indented where-used

Traces all direct and indirect part number usages upward through all assembly levels.

Applications

- Value analysis—where-used trace
- Contract specifications

Part Number—44601 Part Description—Bushing		
Assembly Part No.	**Assembly Description**	**Total Qty. per Assy.**
A1054	Pump Connector	3
A1055	Pump Connector	3
A1058	Pump Connector	1
A1060	Pump Connector	5
E2828	Stand Pipe	1
E2828A	Stand Pipe	1
E2828B	Stand Pipe	1
		2

Summarized part usage

Shows the total quantity of part usage per on all end products.

Applications—End Products

- Cost change effect on product cost (actual or anticipated)
- Component shortage impact on product schedules

Figure 12. Product structure formats

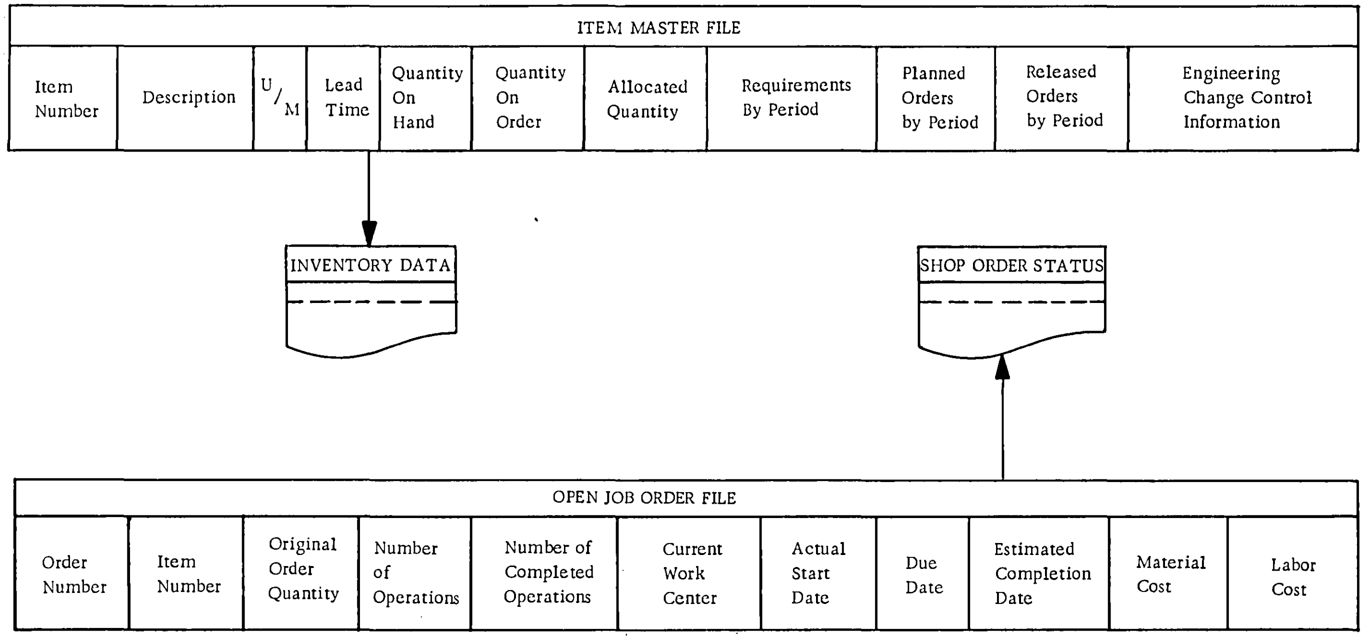


Figure 13. Engineering change trial fit

SUBSYSTEM FLOW

Engineering data control is designed around two modules: (1) file load and maintenance and (2) retrieval. Figure 14 illustrates the relationship and the information flow. Input to the file load and maintenance module consists of the data to construct (and later, when necessary, to change) the item master, product structure, standard routing, and work center master files.

Output from this module includes audit lists that serve two functions. First, they provide a record of information that may be used in reconstruction of certain records. Second, they serve as everyday working documents. The latter case is especially true of the listing available from the organization and maintenance of the product structure file.

This listing should contain the entire bill of material for an assembly with a notation of the maintenance performed. It can be used as a master bill of materials and also as a check to see that the information in the file has been updated correctly.

The retrieval module uses the files to locate and assemble data for requests. Input consists of identifying information that specifies the type of request and the records to be used.

Output from the retrieval module includes parts usage and assembly sequence information. This can be used for printing reports (for example, single-level bill of material, indented parts lists) or other functions, such as requirements planning.

Another report illustrated on the chart and related to engineering is the trial fit. This report combines inventory information (item master) and production order status (open job order file). The open job order file is included in the diagram to illustrate that information from any file can be used by the retrieval module. The creation of the open job order file is discussed under "Shop Floor Control."

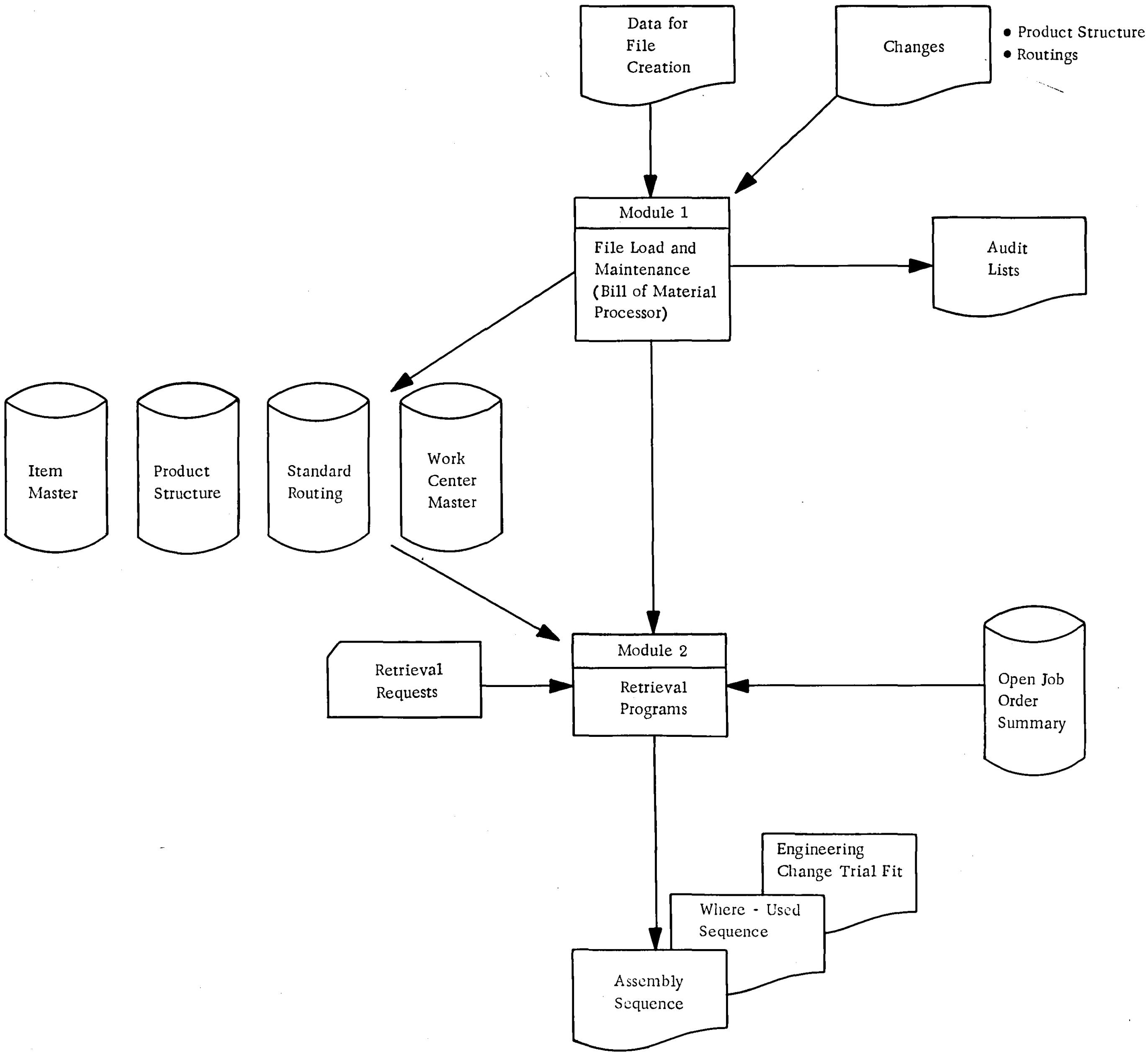


Figure 14. Engineering data control subsystem flow

MODULE DESCRIPTION

File Load and Maintenance

File load and maintenance routines are provided by the bill of material processor.* While these routines are discussed in detail in the manuals that describe this program, some of the main features are listed below:

1. The bill of material processor uses direct access capability to make the same product structure information available in either of the following:
   a. Assembly or bill of material sequence, thereby linking the components of an assembly in any desired sequence. The assembly component sequence is specified by the user; the product structure

*See IBM System/360 Bill of Material Processor-Application Description (H20-0197) and 1440/1311 Bill of Material Processor, 1440 - ME-02X - Application Description (H20-0079)

   records are initially loaded and later maintained in this sequence through the use of direct access file chaining techniques.
   b. Where-used sequence, thereby associating item number usages on higher-level assemblies. This eliminates the need for maintaining a separate file to indicate where each part is used or for periodically sorting the bill of material file into where-used sequence.

2. The bill of material processor uses the same direct access capability to make the standard routing records available in either of the following:
   a. Routing sequence, which specifies the logical sequence of operations during the manufacturing process.
   b. Work center where-used sequence, which enables the customer to retrieve information relative to all work performed by any work center.

3. The structure of an assembly is recorded only once regardless of the number of times it is used on higher-level assemblies or end products. The structure records are loaded and maintained in the form of a series of single-level assemblies.

4. Low-level coding is maintained automatically. This code indicates the lowest level usage of the item with respect to all assemblies of which it is a component.

The bill of material processor programs have been widely accepted by manufacturing companies. In addition, the programs provide the framework for entry to a wide variety of applications -- requirements planning, capacity planning, and operation scheduling.

The maintenance section keeps data current. Transactions describing the changes must be made available to the system. Five types of transactions are described below.

Item Structure Change

If the change alters the product structure by adding or removing assembly components, or alters the quantity used in the assembly, this information is reflected in the product structure file. Maintenance routines are provided that accomplish these changes to the file, and that update the chains for where-used and product structure. Automatic maintenance of low-level codes is also provided.

New Item Specifications

In instances where the engineering change requires a new item to be either purchased or fabricated, it is necessary that the system be furnished with the new item data. If the item is an assembly, the system accepts the relevant product structure data, and maintains it in usable form.

Delete Item Notice

This is the inverse of adding items to the file, namely, the determination that an item is obsolete and no longer required. This determination should be made periodically, so that file sizes, reorganization, etc., do not become unwieldy and time-consuming. The system is informed of the item to be deleted, at which time the master record and the structure record are updated. A record containing the data, reason, and authorization for deletion is created on a deleted items file.

Production Specification Changes

Routing information stored in the standard routing file is changed to reflect the latest engineering level. The standard routing for an item is located from the information on the item master record.

Engineering Change Effectivity

Some engineering changes are considered mandatory and are effected almost immediately. Others are made effective contingent on in-process and stock inventory, model changeover, specific end item serial numbers, etc. The criteria for making the change effective are known as the effectivity. Varying effectivities create a condition where the engineering department has released bills of material showing the latest version, but the manufacturing department is still producing the product in the original or former configuration. Figure 15a displays the original assembly B. Figure 15 shows part number 1 removed and part number 4 added to assembly B. There may be a requirement to retrieve either the original assembly or the new version at some time: (1) between engineering change release time and manufacturing effectivity, or (2) after manufacturing effectivity (for cost, repair, or other purposes). This can be accomplished with a minimum of recordkeeping by maintaining component records that note the differences between the two versions of the assembly (Figure 15). In the example, the computer program can call out assembly B, consisting of its original components (C, 1, and 2), or its revised components (C, 2, and 4), by adding effectivity to each component record.

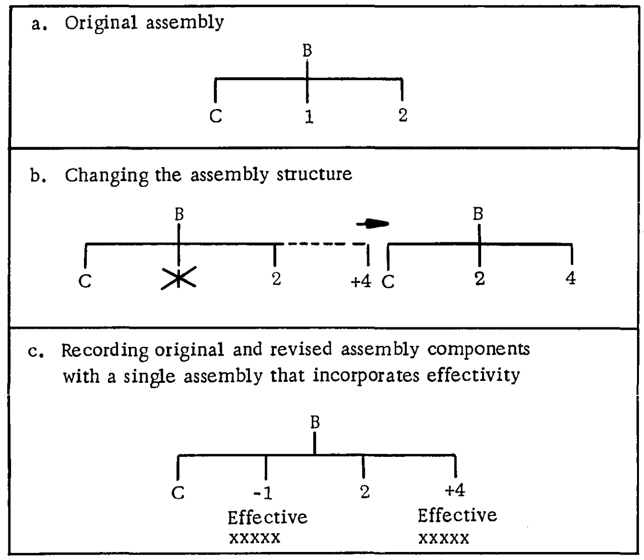


Figure 15. Recognizing original and revised assembly components

SUBSYSTEM: Engineering Data Control

			DATA BASE		
MODULE NAME	INPUT	PROCESSING ROUTINES	RECORD TITLE	RECORD FIELDS	OUTPUT
File Load & Maintenance (B/M Processor)	• Data for: Item Master Product Structure Standard Routing Work Center Master • Changes to Files	• Original File Load • Maintenance Routines	Item Master	• Item Number • Address of First Assembly Component • Address of First Assembly Where-Used • Record Count • Low-Level Code • Address of First Routing Operation • Run Activity Control No. • Overflow Chain Address for Sequential Additions • Engineering Drawing Number Date • Last Previous Engineering Change Number Reason for Change Disposition Effectivity Date • Current Engineering Change Number Reason for Change Disposition Effectivity Qty. Effectivity Date	Audit Lists Part No. Master Bills of Material Standard Routing Work Center Master
			Product Structure	• Address of Component Item Master Record • Compare Portion of Item Number • Address of Next Assembly Component • Address of Parent Item No. Master Record • Compare Portion of Parent Item Number • Address of Next Where-Used This Item • Address of Previous Where-Used This Item • Quantity Per Assembly • Current Engr. Change No.	

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
			Standard Routing	• Item Master Address • Compare Portion of Item No. • Routing Sequence No. • Address of Next Sequential Operation • Address of Previous Operation • Work Center Identification • Address of Work Center Master Record • Work-Center Where-Used Chain - Next • Work-Center Where-Used Chain - Previous • Current Engr. Change No.	
			Work Center Master	Work Center Identification • Address of First Operation in Where-Used Chain • Work Center Where-Used Chain Record Count • Overflow Chain Address for Sequential Additions	

Retrieval Programs*

The file organization technique provides a large variety of retrievals. The item master file is used in conjunction with the product structure file to obtain assembly sequence and parts usage information. For assembly sequence, the item master record has the address of the product structure information for each assembly. These records are accessed using sequence chains, which are created during initial loading, and which link all the components of an assembly together. The item master records for the component parts are accessed to obtain information for each component of the assembly. This is easily accomplished as each product structure record has the address of where the component's item master record is stored.

The same product structure records provide parts usage information. Each item master record has the location of a product structure record wherein the part is used in a higher-level assembly. The product structure records have a second set of chains created during initial loading that link all direct usages for a part number together. To illustrate the type of processing that is performed, several retrieval functions are discussed.

The single-level bill of material is discussed for assembly sequence. Assume that the files have been loaded and a request relating to assembly A has been entered into the system. Assembly A (illustrated in Figure 11) consists of parts 1, 2, and 4. The item master for assembly A is read to obtain the description and other information for printing, in addition to the address of the product structure file. As each product structure record is processed, the address of the item master record of the component is used to obtain the data peculiar to each part. The sequence of processing is (1) read the product structure record, (2) use it to locate the component item master record, (3) extract the information and print, and (4) if there is another component, repeat the sequence.

Parts usage retrieval is discussed for next assembly where-used. In Figure 11, part number 2 was used on assemblies A and B. When a request of this type is processed, the item master record for part 2 is located. This record has the address of the first of a series of product structure records where part 2 has been identified as a component of a higher-level assembly. In the example, the address locates the product structure for assembly B, which, in turn, has the address of the product structure record of assembly A, part 2. Each product structure record has the address of the item master record for the assembly; therefore, the descriptive information can be located and printed.

The sequence of processing is (1) read the product structure for where-used, (2) use it to

*See System/360 Product Structure Retrieval Program Application Description (H20-0329) locate the assembly item master record, (3) extract the information and print, and (4) if there is another usage indicated, repeat these steps.

The last retrieval to be discussed is combining inventory information with production order status. The request would identify the item number(s) that is used to locate the master record. Information stored on this record is assembled for output.

The production on-order quantity is backed up by one or more records in the open job order file. The location of the first record is determined from the item master record. If more than one order exists for a part, each later record is located by the reference in the open job order file. As each open-order record is read, the data is extracted for reports.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Retrieval Programs	Request Identification	Retrieval Programs	Open Job Order Summary In addition to the records above: • Item Master • Product Structure • Standard Routing • Work Center Master	• Item Number • Order Number • Quantity Complete-Previous Operation • Scheduled Due Date • Status Code • Current Operation Work Center Quantity to Complete Quantity Completed • Current Engineering Change No.	• Single Level Bill of Material • Indented Parts List • Summarized Parts List • Next Assembly Where Used • Indented Where Used • Summarized Parts Usage • Engineering Change Trial Fit Inventory Information Order Status Assembly Part

SUBSYSTEM SUMMARY

A summary chart for the engineering data control subsystem appears as Figure 16.

SUBSYSTEM: Engineering Data Control

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
File Load & Maintenance (B/M Processor)	• Data for: Item Master Product Structure Standard Routing Work Center Master • Changes to Files	• Original File Load • Maintenance Routines	Item Master	• Item Number • Address of First Assembly Component • Address of First Assembly Where-Used • Record Count • Low-Level Code • Address of First Routing Operation • Run Activity Control No. • Overflow Chain Address for Sequential Additions • Engineering Drawing Number Date • Last Previous Engineering Change Number Reason for Change Disposition Effectivity Date	Audit Lists Part No. Master Bills of Material Standard Routing Work Center Master

Figure 16. Engineering data control subsystem summary chart (Sheet 1)

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE RECORD TITLE	DATA BASE RECORD FIELDS	OUTPUT
				• Current Engineering Change Number Reason for Change Disposition Effectivity Qty. Effectivity Date	
			Product Structure	• Address of Component Item Master Record • Compare Portion of Item Number • Address of Next Assembly Component • Address of Parent Item No. Master Record • Compare Portion of Parent Item Number • Address of Next Where-Used This Item • Address of Previous Where-Used This Item • Quantity Per Assembly • Current Engr. Change No.	
			Standard Routing	• Item Master Address • Compare Portion of Item No. • Routing Sequence No. • Address of Next Sequential Operation • Address of Previous Operation • Work Center Identification • Address of Work Center Master Record • Work-Center Where-Used Chain - Next • Work-Center Where-Used Chain - Previous • Current Engr. Change No.	
			Work Center Master	Work Center Identification • Address of First Operation in Where-Used Chain • Work Center Where-Used Chain Record Count • Overflow Chain Address for Sequential Additions	
Retrieval Programs	Request Identification	Retrieval Programs	Open Job Order Summary In addition to the records above: • Item Master • Product Structure • Standard Routing • Work Center Master	• Item Number • Order Number • Quantity Complete-Previous Operation • Scheduled Due Date • Status Code • Current Operation Work Center Quantity to Complete Quantity Completed • Current Engineering Change No.	• Single Level Bill of Material • Indented Parts List • Summarized Parts List • Next Assembly Where Used • Indented Where Used • Summarized Parts Usage • Engineering Change Trial Fit Inventory Information Order Status Assembly Part

Figure 16. Engineering data control subsystem summary chart (Sheet 2)

INVENTORY CONTROL

INTRODUCTION

An inventory control system must establish the optimum levels at which inventory should be maintained.* This goal is not easily achieved. In the manufacturing company, conflicting interests must be satisfied. The sales department is interested in keeping customer service at the highest possible level to meet quotas and stave off competition; this tends to raise inventory levels. The financial department is concerned with working capital and, because of this, attempts to keep inventory levels low. If inventory levels can be kept low, the working capital can be kept available for use. The production department strives to level production to stabilize employment and keep operating efficiency high; it thereby creates inventory at times and uses it up at other times. The inventory policy that is established is a key factor in determining how well a company will operate. For this reason, the inventory control subsystem holds a vital spot in the operation of an effective production information and control system.

*See Management Operating System — Forecasting, Materials Planning and Inventory Management—General (E20-0031)

OBJECTIVES

The inventory control subsystem has the dual function of planning and execution. The system must determine:

1. When to order
2. How much to order

The planning phase of the inventory control subsystem must provide the operating rules for the execution phase to carry out.

Inventory in manufacturing companies may be broken down into categories based on usage and value. The method of categorizing inventory is known as the ABC control method. An inventory control subsystem must have the ability to perform the analyses necessary to break inventory into categories. On the basis of these categories, the emphasis that must be placed on control of the inventory for each item can be established. The varying degree of control of inventory occurs as a result of the order point, order quantity, and safety stock level, which are established from the categorization that results from inventory analysis. This analysis may be carried out on the basis of various criteria.

Figure 17 shows two methods of analysis; the first ranks items by the investment in inventory they represent, the second by return on investment.

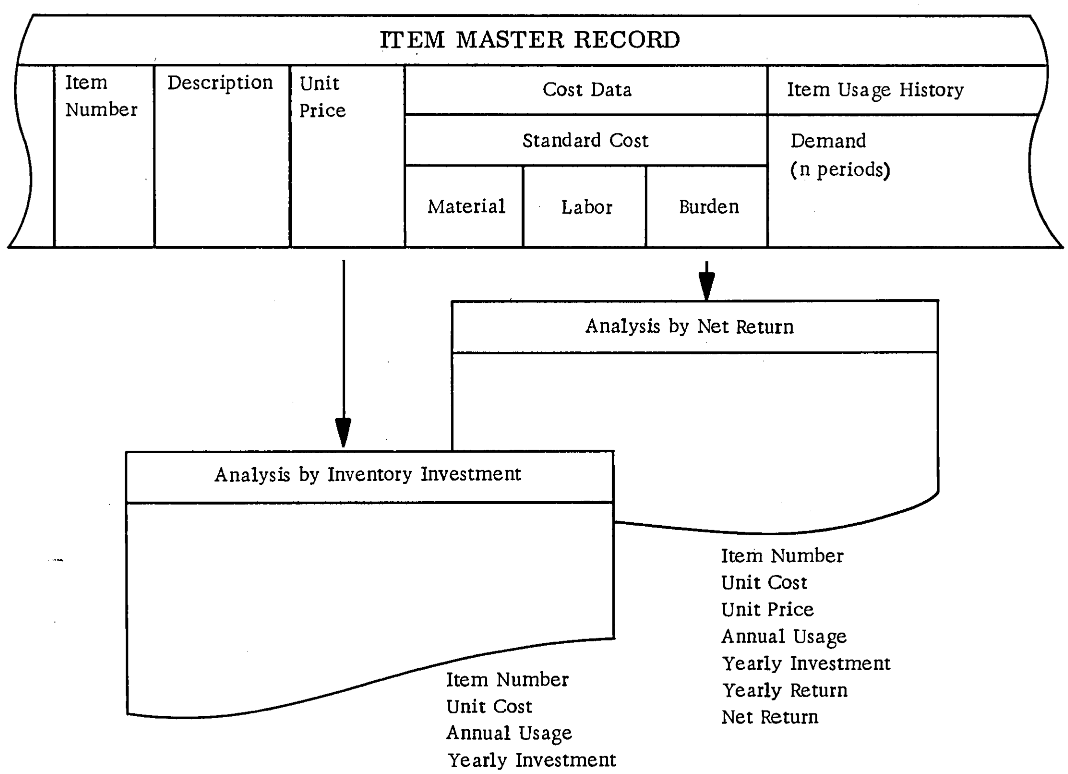


Figure 17. Inventory analysis

At the completion of an analysis of inventory, a determination of the order policy for each inventory item is made. It is at this point that safety stock level, order point, and order quantity must be determined. It is the function of the safety stock maintained for an item to ensure that the possibility of stockouts is kept to a minimum.* This safety level must be a function of several factors. A good inventory control subsystem must have the ability to determine safety stock in one of two ways. First, it must be able to take the average usage of an item and, with a factor expressing safety stock in terms of time, determine the quantity that should be maintained. The time factor must be determined by the implementer and be supplied to the system. Second, if a forecasting method (such as exponential smoothing) is used, safety stock can be determined as a function of the variation in the demand for the item over the replenishment lead time.

Once the safety stock level is known, the next step in inventory control is to compute the order point. Order point is simply the inventory level at which an order should be initiated to ensure against an out-of-stock condition. Order point is determined from the replenishment lead time for the item, the interval at which inventory and the safety stock level are reviewed.

Having determined when to order, the quantity to be ordered must now be ascertained.

On the basis of either the history of usage or the forecast of usage of an item, an order quantity can be determined that reduces total cost by balancing order cost and inventory carrying cost. This quantity is commonly called the EOQ (economic order quantity). The EOQ can be determined in several ways to best reflect management's views concerning inventory. Provision should be made for the EOQ computations to be made in various ways in an inventory control subsystem.

The execution phase must accept the daily transactions that affect inventory, such as stock issues, receipts, transfers, and adjustments. It must update inventory records and furnish reports concerning error conditions and inventory status. (Figure 18 shows some typical stock status reports that can be prepared by an inventory control subsystem.) In addition, the phase must issue order notices for items that fall below inventory order point; also, the phase has the task of initiating and recording physical inventory figures.

*See IMPACT — Inventory Management and Control Techniques (E20-8105)

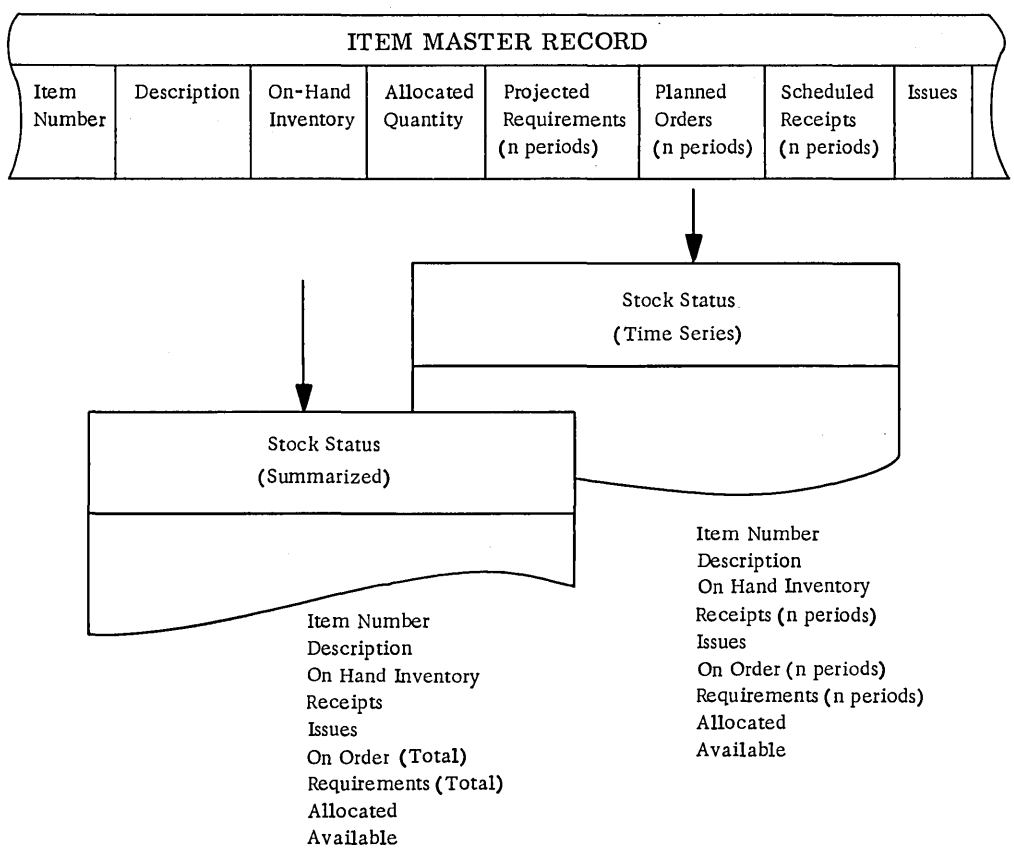


Figure 18. Stock status reporting

SUBSYSTEM FLOW

The planning phase of the inventory control subsystem accepts information concerning the usage of each item and the degree to which protection against stockout is required (see Figure 19). The system operates on this data to produce reports that analyze inventory, inform management on order quantities, and project the safety stock level for each item. At the same time it inserts this information in the appropriate place in the item master record.

In the execution phase, the daily transactions that affect inventory are processed, and the file is updated. In addition, the system prepares a register of these transactions. The inventory control subsystem also reports on stock status, physical inventory, and detected errors. This phase also pinpoints items that have fallen below the inventory order point and should therefore be reordered.

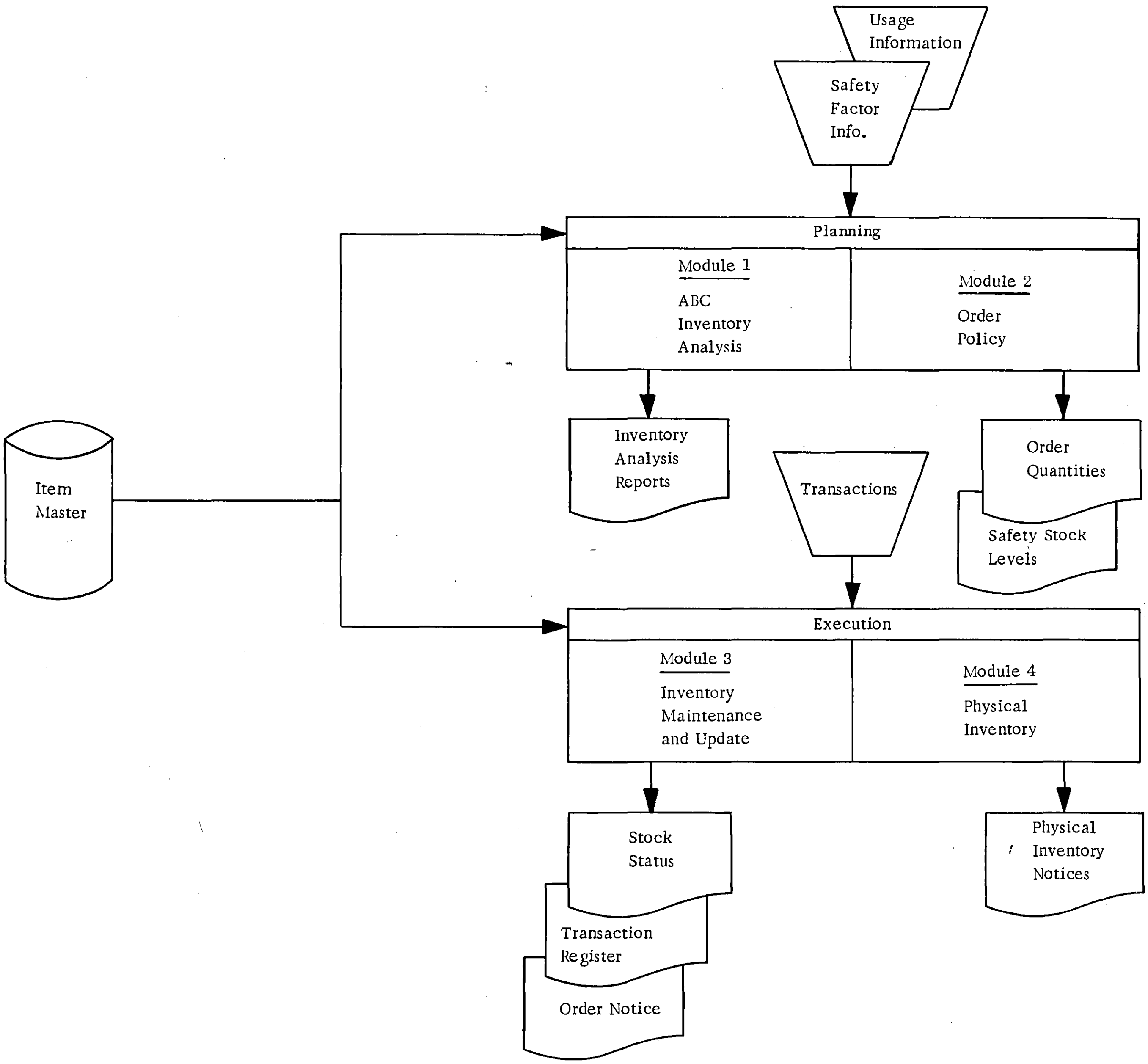


Figure 19. Inventory control subsystem flow

MODULE DESCRIPTIONS

ABC Inventory Analysis

Inventory analysis is generally one of the first steps toward organizing an inventory control system.* It helps answer the questions "What do we control?" and "How do we control it ?" Items are classified into groupings, which are determined by the implementer. These groupings are generally based on a measure of dollar value and annual usage. The investment in inventory that an item represents is determined by the cost of producing or buying that item and the annual quantity produced or used. If these factors are extended for each item in an inventory, the items can be ranked in sequence by annual investment. A typical breakdown of inventory might show:

Class	Annual Investment	Percentage of Items
A	65 %	15 %
B	20 %	35 %
C	15 %	50 %

An ABC grouping of this nature simplifies the method of order quantity determination, since the same method can be used for all items in a group. The percentages shown above indicate one way in which inventory can be classified. Breakpoints could be used with similar benefit, and more categories could also be decided on. It is not unusual to break inventory into six or eight classes.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
A-B-C Inventory Analysis	• Parameter Specifications	A-B-C Analysis	Item Master	• Item Number • Parts Usage History • Unit Cost • Unit Price	• Analysis by Investment • Analysis by Net Return

Order Policy

After inventory is classified and decisions are made about the order policy to be used to control each category, the next step is to determine the order point and order quantity for each item. The first factor to be determined for an item is the "safety stock". This safety stock is provided to ensure against the possibility of being out of stock at any point during the reorder cycle for an item. The safety stock can be determined in several ways. If this can be expressed in terms of time (for example, two weeks' supply or a percentage of lead time), the system can compute the quantity that might reasonably be used during this time. This quantity would represent the safety stock. Another method of computing safety stock is on the basis of statistics. This method is based on the average deviation of the actual usage from an average or forecast of usage. This deviation is called the mean absolute deviation (MAD). Also on the basis of statistics the degree of safety can be expressed as a multiple of this deviation, which is called the "safety factor". A "percentage of service" can be calculated that will indicate the degree of safety against stockouts that can be expected. Service can be converted to units by multiplying the MAD by a safety factor. Providing for safety stock equal to the value of MAD (that is, a safety factor of one) means that 78% of the time there is protection against stockouts. Doubling the MAD (safety factor of two) increases the stockout protection to 94%. Various levels of safety factor and the related percentage of service are shown below:

Safety Factor	% of Order Cycles with No Stockout
0.00	50.00
1.00	78.81
1.25	84.13
2.0	94.52
2.5	97.72
3.0	99.18
3.75	99.87

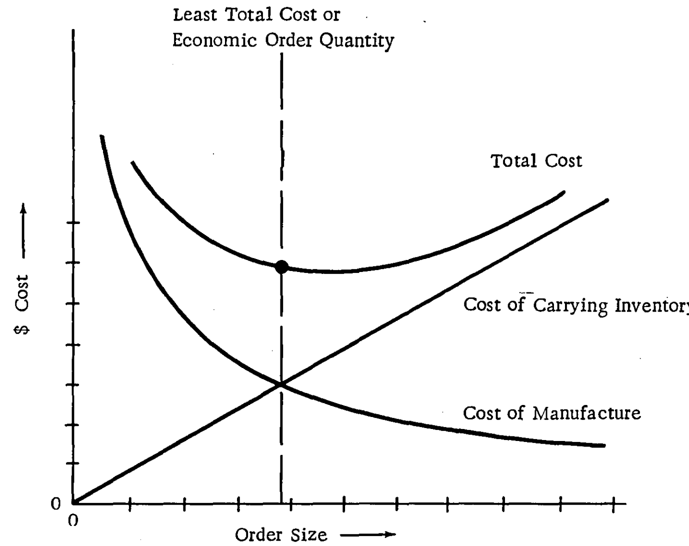
Safety factors for service levels using MAD (service based on frequency of stockout)

*See System/360 Inventory Control (H20-0471)

A company using the inventory control subsystem would be required to supply the safety factor or the service level desired, and the safety stock level would be computed.

Having computed the safety stock required, the system determines the order point by computing the average usage during the replenishment lead time and adding this to the safety stock level.

The question of how much to order is now the last remaining item of order policy to be determined. The system accepts an order quantity provided in the item master and uses this amount. This is called a fixed order quantity. The system also is able to determine the quantity required to return inventory to some customer specified level, commonly called order-up-to quantity, or it computes the economic order quantity. The standard or classical EOQ formula attempts to derive the order quantity that offers the least total cost for producing an item. Figure 20 illustrates graphically how this technique arrives at a quantity. The point at which the two lower curves cross is the lowest total cost and, therefore, the most economic order quantity. It has been established that, in general, the total cost curve is very flat in the area of the minimum. This fact allows some flexibility in the rounding of order quantities to more convenient numbers. The inventory control subsystem should have the ability to determine an order quantity on the basis of the EOQ calculation, and also to consider a user supplied rounding technique. This technique can be called the min-max multiple.



"Standard" or "classical" EOQ formula

$$Q = \sqrt{\frac{2AS}{IC}}$$

Q = order quantity
A = annual sales or usage
S = setup or order cost
I = item unit cost
C = inventory carrying rate

Figure 20. Economic order quantity

Another method for computing order quantity is on the basis of a technique for obtaining minimum unit cost. This approach considers making orders on the basis of the actual requirements and not on the basis of an average, as is the case in the classical approach. Figure 21 demonstrates this least unit cost run size technique.

Line 1	Period	1	2	3	4	5	. . . . . n
Line 2	Requirement	50	60	70	70	80	. . . .
Line 3	Possible run quantity and associated unit cost	50 .12	60	70	70	80	. . . .
Line 4		50+60 .065	0	70	70	80	. . . .
Line 5		50+60+70 .055	0	0	70	80	. . . .
Line 6		50+60+70+70 .056	0	0	0	80	. . . .

Inventory Carrying Rate = .02 (2%) per period, and the unit cost is $1.00

Possibility 1: Line 3 illustrates the possibility of running each requirement as a separate run. The unit cost of running 50 in period 1 is computed as follows:

$$\text{Unit Cost} = \frac{\text{Setup Cost + Carrying Cost}}{\text{Quantity}} = \frac{\$6.00+\$0}{50} = \$.12$$

The next solution to this problem is combining other requirements with the 50 of period 1 to determine whether anything can be saved.

Possibility 2: If period 2 (60) is combined with period 1 (50) to yield a run of 110 (line 4), the unit cost drops:

$$\text{Unit Cost} = \frac{\text{Setup + Carrying Cost}}{\text{Quantity}} = \frac{6.00 + 60 \times 1.00 \times .02 \times 1 \text{ period}}{110} = \$.065$$

Possibility 3: If this procedure is repeated, it is found (line 5) that a run of 180 in period 1 costs $.055 each.

$$\text{Unit Cost} = \frac{\text{Setup + Carrying Cost}}{\text{Quantity}} = \frac{6.00 + 60 \times 1.00 \times .02 \times 1 + 70 \times 1.00 \times .02 \times 2}{180}$$

$$= \$.055$$

Possibility 4: Running 250 (line 6) in period 1 costs $.056 each.

Conclusion: The most economic quantity to be run in period 1 is 180.

The same problem is restated below assuming this run of 180 in period 1.

Period	1	2	3	4	5 . . . .n
Requirement	180 (run)			70	80
Possible run quantity and associated unit cost				70 .086	80
				70+80 .051	0

The procedure would be repeated using period 4 as the base in an attempt to find its best run size.

Figure 21. Least unit cost run size

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Order Policy	• Percent Carrying Cost • Order Cost	Calculations: (1) Order Pt. /Order Up-to-Qty. (2) EOQ (3) Safety Stock	Item Master	• Order Policy Order Code Order Point Order Qty. or Order-Up to Level Safety Stock Minimum Maximum Multiple • Parts Usage History • Unit Costs-Std.	• Order Point - Order Quantity

Inventory Maintenance and Update

The execution phase of the inventory control subsystem is concerned with the maintenance of the item inventory records. Inventory can be divided into several different types:

1. Stock that is physically on the shelf in the stockroom. This is called on-hand inventory.
2. Stock that is not yet physically in the stockroom because it is in the process of being manufactured. This is called in-process inventory.
3. Stock that is neither on-hand nor in process but, rather, planned for inventory in the form of unstarted orders. This is called on-order inventory.

In addition to the necessity of maintaining these general categories of inventory, there also exists the necessity to verify the actual quantities that are incorporated in the records. This area is called physical inventory. The function of the inventory control subsystem is to perform the necessary maintenance on the sections of the item master record that are connected with inventory. An integral part of this maintenance procedure must, of necessity, be the normal report generation that takes place in substantial volume and, usually, on a regular cycle. The second and perhaps more important type of reporting is the exception reporting. This takes the form of short, concise statements of unusual conditions.

In-Stores Inventory

The limits of responsibility of this phase are defined as beginning at the time of physical receipt into a stockkeeping area and continuing until the item is physically issued from that area. If partially completed items are returned to the stockroom to await further work, they again become the responsibility of this phase.

The items in the in-stores inventory (on hand in stockrooms) can be divided into two major categories, depending on whether orders may or may not be initiated by the inventory control subsystem. Orders should not be initiated by this module for items that are ordered by the requirements planning subsystem—namely, items that are discretely ordered to meet needs, or items that are ordered on the basis of some economic lot size. On the other hand, this subsystem is in an excellent position to perform the ordering necessary for items whose inventory is maintained on an order point/order quantity basis. This method of inventory keeping has at times been called a minimum/maximum or two-bin system. Certain transaction processing must take place for both kinds of items. Figure 22 is an attempt to show the way in which a few typical transactions might affect various record fields.

For items that are considered on an order point/order quantity basis, it is the responsibility of this phase to review the status of inventory with each incoming transaction and to inform the proper ordering function (either purchasing or manufacturing) of the need for stock replenishment. This information can take the form of a printed report, punched cards, or both. If there is not enough inventory in stores to satisfy a requirement, a back-order transaction is entered for the item, and it becomes part of the transaction chain. This type of transaction is not removed from the file until enough stock is received to cover the requirement.

Inventory status reporting is a responsibility of this phase of the inventory control subsystem. Status reports are prepared in a format and on a cycle determined by the implementer.

In the past, the inventory recordkeeping has taken place in the stockroom or other locations, such as raw material storage areas and shop floor areas reserved either for assembly line component storage,

Transaction		On-Hand Inventory	Allocated Quantity	Purchasing On-Order	Production On-Order
Planned Receipt	Purchase	+		-	
	Production	+			-
(Transfer) Unplanned Receipt		+			
Planned Issue		-	-		
(Transfer) Unplanned Issue		-			
(Return) Credit Issue		+			
Purchase On-Order				+	
Production On-Order					+
Inventory Adjustment (+)		+			
Inventory Adjustment (-)		-			
Canceled Order	Purchasing			-	
	Production				-
Inventory Allocation			+		

Figure 22. Inventory transactions and their effect on the item master

for supplies, or for any other inventory that might be stored. The inventory recordkeeping usually has been accomplished by means of a clerk making an entry in an inventory ledger. The method of entering information into a computer-based recordkeeping system must take the form of a transaction record. Whenever a new supply of nuts and bolts arrives, for example, a transaction is initiated to inform the system that the on-hand inventory for the item has been increased by a specific, verified quantity. When a withdrawal of material is made, information is provided to reduce the on-hand quantity. These transactions may take several forms, such as a punched card or a typewriter entry.

The input to the in-stores inventory maintenance phase comes from any of the various locations where stock is kept, and is in a form that is acceptable to the computer. A basic assumption about validity and accuracy of the transaction is made even though further checking is performed by the programs involved.

The transactions affecting this phase of inventory maintenance are concerned primarily with the on-hand inventory quantity. Two types of transactions must be processed—incoming stock and outgoing stock.

Incoming stock transactions represent receipts or adjustments that increase on-hand inventory. The incoming quantity must first be added to the on-hand inventory. This having been done, a check must be made to determine whether a back order exists for this item. A back order represents a previous requirement for the item that could not be filled because of a lack of inventory. If a back order exists, a notice of the present availability of stock must be issued so that this requirement can be filled, either completely or partially. The transactions entering the system (receipt to stock, for example) are entered in the transaction log, as are the transactions generated by the system.

An outgoing stock transaction (issue, for example) first determines whether a previous back order exists for this item, and whether this transaction is destined for that use. If this is the case, the on-hand inventory is reduced, and the back order is removed either partially or completely. On the other hand, if the outgoing transaction is not for the outstanding back order, a notice of this apparent conflict is issued. If there are no outstanding back orders, the on-hand inventory is reduced, or a back order is created for the stock that cannot be supplied. In any of these cases, the incoming transactions, as well as the system-generated transactions, are logged.

The on-hand inventory fields of the item master are designed to facilitate centralized control of stock. In the illustration (Figure 22a), all of the stock locations appear in one record for part number 275617. This includes stockroom locations on the plant floor, in the central finished goods warehouse, or at a remote branch warehouse location.

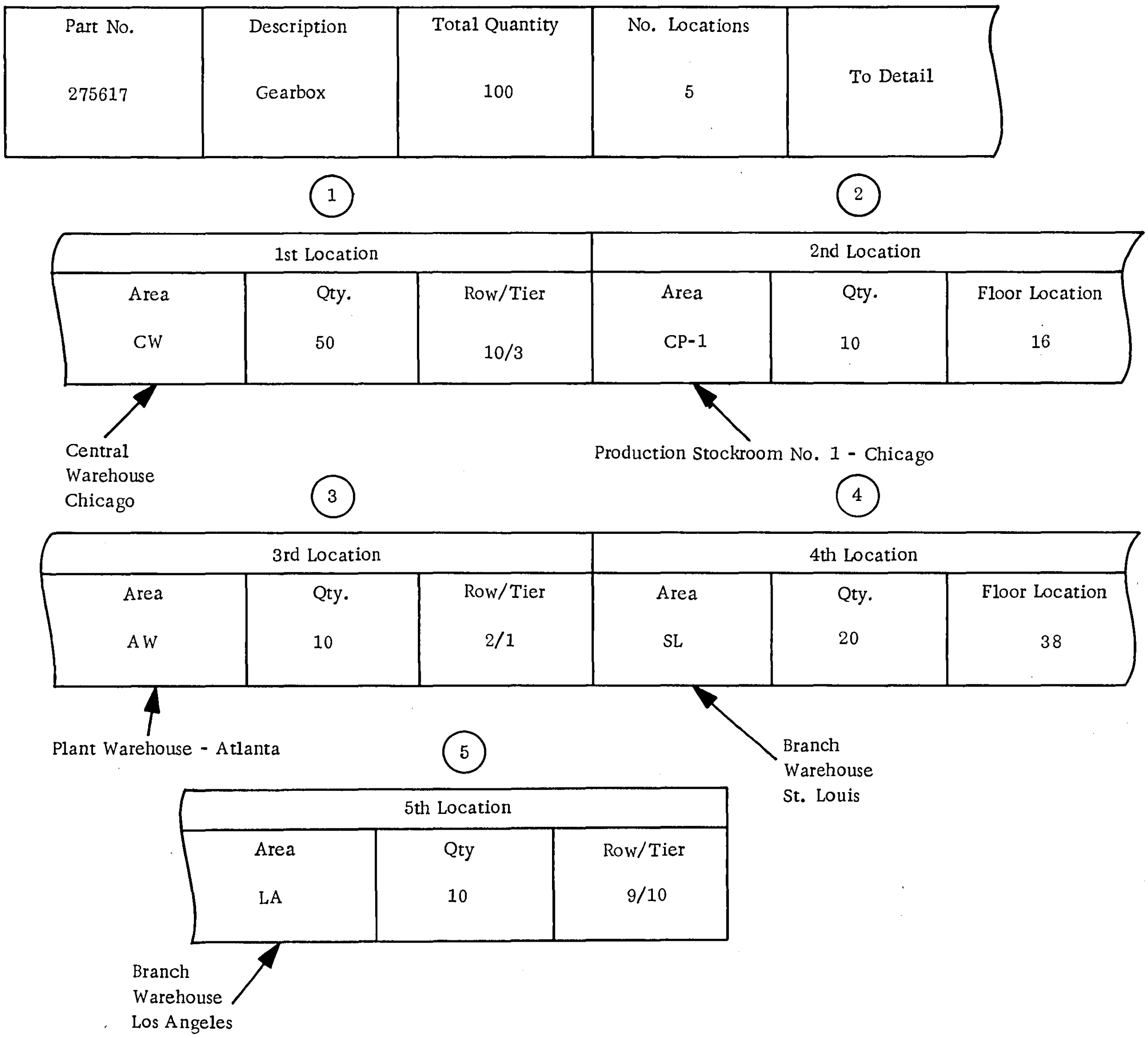


Figure 22a. On-hand inventory fields in the item master

In-Process Inventory

In-process inventory maintenance is concerned with the recordkeeping that must take place from the time an item is withdrawn from stock until that item reenters the stockroom or has lost its identity. An item loses its identity by being incorporated into a larger assembly. The item may, however, reenter stock after having certain operations performed on it that do not change its identity. This partially finished item again becomes the responsibility of the in-stores inventory maintenance phase.

The maintenance of the in-process inventory takes place in the detail record, which is established for each released shop order. A discussion of the in-process inventory maintenance function may be found in the section of this manual dealing with the shop floor control subsystem. This subsystem is required to keep a check on each released shop order to determine whether the quantity ordered and the quantity actually being produced are within acceptable tolerance. Reporting on the status of in-process orders is performed by this subsystem in the same general way that in-stores reporting is accomplished.

On-Order Inventory

The responsibilities of this phase are very similar to those of in-process inventory maintenance. The maintenance is concerned only with those records related to either open shop orders that are not yet released to production or open purchase orders.

In the area of purchase orders, the detail records are checked each time a receipt from a vendor is reported to determine whether the quantity received is within the stated tolerance with the original order quantity. If there is agreement, responsibility transfers to the in-stores phase to record the receipt to stock. If there is no agreement, reporting takes place to inform management of the exception. Status reporting is again the function of this phase.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Inventory Maintenance and Update	• Issues • Receipts • On Order • Cancellations • Adjustments ± • Transfers ± • Scrap ±	Inventory Update	Item Master	• Inventory On Hand Total Qty. Area Qty. • Allocated Qty. • Back Orders Qty. • Current Period Beginning Inventory Transfers & Adjusts. Receipts Issues Demand • On Order-Purchasing/ Production • Requirements-Gross	• Stock Status Summary • Transaction Logs • Order Notice for Order Point Items

Physical Inventory Count

This module checks the physical inventory fields in the item master record on a cyclical basis and prepares the necessary documents to initiate physical stock counting when necessary. From this point, the phase ensures that the count is taken and the records adjusted for any discrepancy between actual and record quantities. All the necessary reporting related to physical stocktaking is generated by this phase.

Input is primarily the reports of physical counts that are made. These reports come to this phase from whatever group is responsible for taking the actual count in the stockroom. Additional input comes in the form of instructional transactions indicating adjustments to be made to the inventory records.

The inventory record for each item is checked on a regular basis to determine whether a physical count should be taken. If the time to take a count has arrived, a notice is generated to initiate the count. When the count is completed, the phase compares the actual count to the book count and notifies management if they are not in acceptable agreement. Physical inventory reports are generated by the system to inform management of the results of a physical stock count. Exception reports are produced to emphasize unusual conditions.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Physical Inventory Count	• Inventory Count • Physical Inventory Adj. ±	(1) Physical Inventory Notification (2) Physical Inventory Validation	Item Master	• Physical Inventory Type Qty. Count Checker No. Date last count Date of next count • Inventory On Hand Total Qty. Area Qty.	• Inventory Discrepancy List • Inventory Adjustment Report

SUBSYSTEM SUMMARY

The modules of the inventory control subsystem are summarized in Figure 23.

SUBSYSTEM: Inventory Control

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
A-B-C Inventory Analysis	• Parameter Specifications	A-B-C Analysis	Item Master	• Item Number • Parts Usage History • Unit Costs • Unit Price	• Analysis by Investment • Analysis by Net Return
Order Policy	• Percent Carrying Cost • Order Cost	Calculations: (1) Order Pt. /Order Up-to-Qty. (2) EOQ	Item Master	• Order Policy Order Code Order Point Order Qty. or Order-Up to Level Safety Stock Minimum Maximum Multiple • Parts Usage History • Unit Costs-Std.	• Order Point - Order Quantity
Inventory Maintenance and Update	• Issues • Receipts • On Order • Cancellations • Adjustments ± • Transfers ± • Scrap ±	Inventory Update	Item Master	• Inventory On Hand Total Qty. Area Qty. • Allocated Qty. • Back Orders Qty. • Current Period Beginning Inventory Transfers & Adjusts. Receipts Issues Demand • On Order-Purchasing/ Production • Requirements-Gross	• Stock Status Summary • Transaction Logs • Order Notice for Order Point Items
Physical Inventory Count	• Inventory Count • Physical Inventory Adj. ±	(1) Physical Inventory Notification (2) Physical Inventory Validation	Item Master	• Physical Inventory Type Qty. Count Checker No. Date last count Date of next count • Inventory On Hand Total Qty. Area Qty.	• Inventory Discrepancy List • Inventory Adjustment Report

Figure 23. Inventory control subsystem summary chart

FORECASTING

INTRODUCTION

The role of the sales forecasting subsystem is to analyze historical data about the demand process and generate a forecast for a desired planning horizon (for example, a season or a year).

Output of the subsystem, which is based upon analysis of past data patterns, can be blended with the additional information available to the planner, such as economic trends, competition, market trends, etc., to yield a solid foundation for the plan.

While a computer forecast, by itself, may not suffice for planning purposes, the man-machine cooperation achieved by such an approach exploits the advantages inherent in both the planner and the computer. No machine can replace the judgment capability and experience of the human planner. The machine, however, can generate forecasts more efficiently when many forecasts are involved.

The term "projection" is often used instead of "forecasting" when historical usage information is the principal basis for estimating future demand. This distinguishes the forecasting technique described in the manual from other techniques that use extrinsic factors, such as housing starts and gross national product, for correlation to estimate future demand.

This subsystem is designed to furnish management with an easy-to-work-with tool in order to perform accurate, long-range planning. Information will flow to requirements planning.

The first consideration in forecasting is the type of forecasting model that is to be used.* Some of these models are:

1. Constant
2. Trend
3. Cyclical or seasonal

Figure 24 shows a plot of demand for an item over a twelve-month period. By observation, the data seems to fluctuate around a constant value of 100 units/month. The forecast model, or general representation of the demand pattern, can be expressed as $X = 100$, where X is the demand function.

A representation of data showing linear trends is indicated in Figure 25. Although the average value is a straight line by inspection, it does possess a positive slope. The model that best represents this pattern of demand data is a straight line or linear pattern. The model is, therefore, represented by the expression $Y = AX + B$, where A and B are constants, X is the period value, and Y is the demand.

*See System/360 Inventory Control (H20-0471), IMPACT (Wholesale) (E20-8105), and Retail IMPACT (E20-0188)

Similarly, Figure 26 reflects a picture of demand that is increasing at an increasing rate. This type of pattern is expressed by the function $Y = AX^2 + BX + C$, where C is an additional constant.

Finally, Figure 27 shows an indication of the type of pattern that can result from seasonal demand. This is best described by a sine function of the form $Y = A + B \text{ sine } X$.

Basically, most histories of demand data fall into one of these patterns. The determination as to which model best fits the history is made by using a technique of fitting a curve or function to the data. This is known as regression analysis. Inherent in the least-squares procedure used in regression analysis is the fact that many periods of data must be maintained on the file for each item to be forecasted, if it is to be used as a continuing technique of forecasting.

The answer to the problem is the use of a technique known as exponential smoothing. Stated simply, smoothing is a technique comparable to finding an average of historical data and, as the data for each new period becomes available, developing a new average of the old and new data. The old average and the new period data are weighted in such a manner as to give more or less importance to the old average, depending on the desires of the individual. The formal expression used is New Average = Old Average $+\alpha$ (new demand - old average), where α (the alpha factor) is the weight assigned to the new data. The factor determines the relative weight to be given to old and new data. The conventional moving average technique requires that several periods of the most recent data should always be maintained on the file. The smoothing approach requires only that the old average should be carried forward each period. The term exponential smoothing derives from the fact that the new piece of data, when averaged with the old average, has less effect on the overall calculation as time progresses. If the effect that a piece of data has on the new average over a period were plotted, it would follow an exponential curve.*

The expression for the new average is known as a single smoothed expression and is used for estimating constant models, as in Figure 24. The expression tells us nothing about trend, as would be required for the linear model in Figure 25. The exponential and cyclic models have not only trends but trends that are changing. The terms "double

*See Management Operating System-Forecasting, Materials Planning and Inventory Management-General (E20-0031)

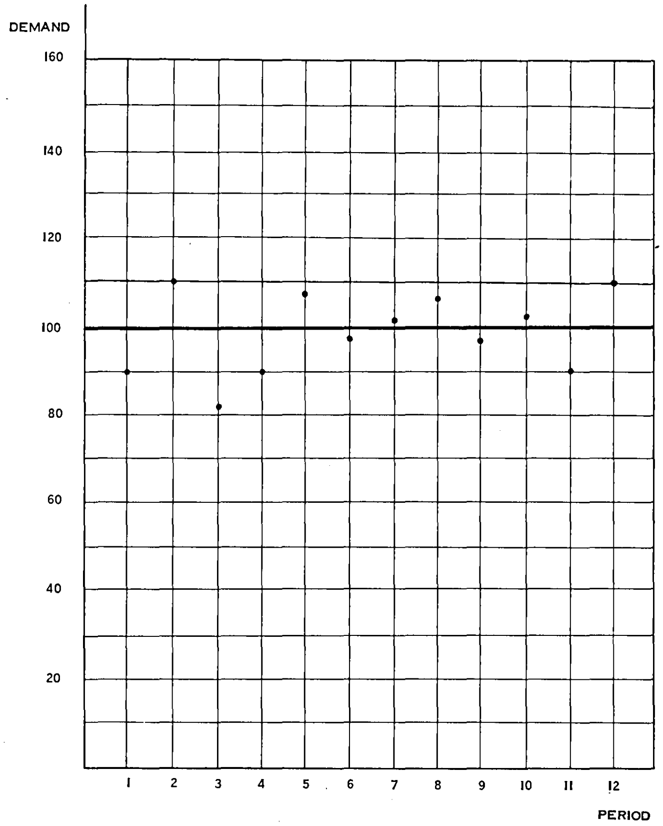


Figure 24. Constant demand pattern

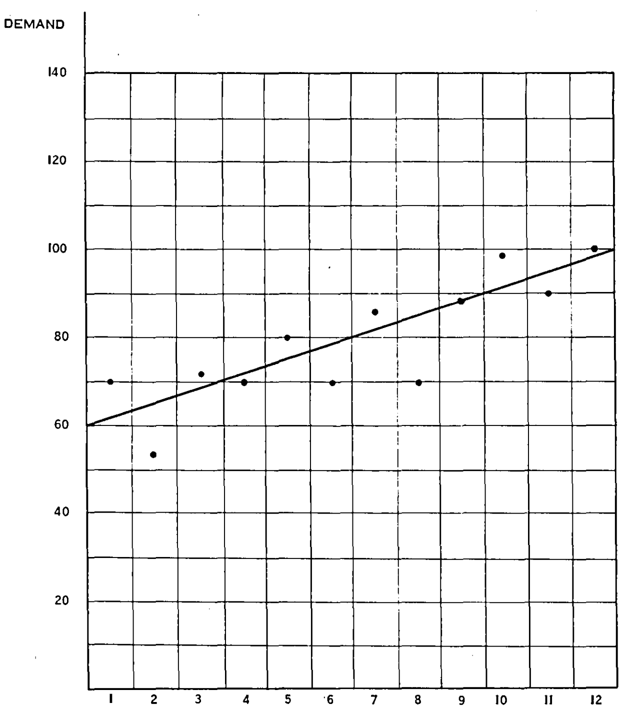


Figure 25. Linear demand model

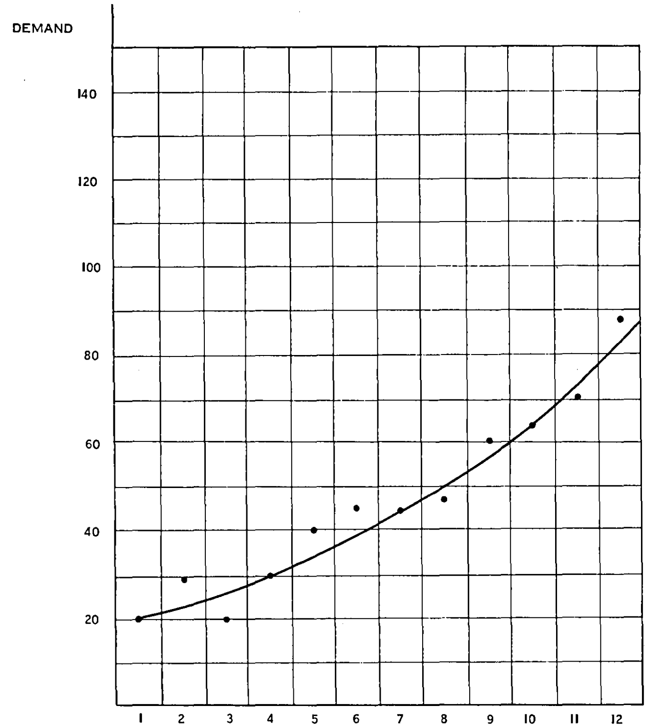


Figure 26. Increasing demand

smoothing" and "triple smoothing" are applied to a model depending upon whether two or three unknown factors are to be determined.

It is important to understand that exponential smoothing is a different technique from the least squares regression technique used for curve fitting. It can be shown, however, that after initial selection, exponential smoothing provides almost identical results without the data requirements imposed by regression analysis. In case of a constant model,

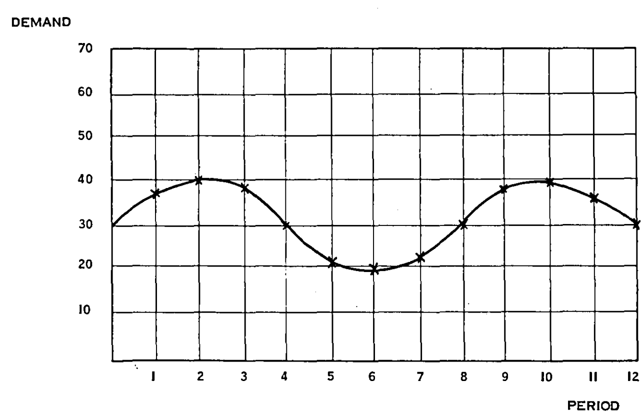


Figure 27. Seasonal demand

as in Figure 24, the current average is equivalent to the forecast for the next period or periods.

In addition to being informed of new averages and trend, and projecting the trend into the future, one would like to have some indication as to the reliability of this forecast. Certainly, large expenditures of money are made on the basis of such forecasts. The problem of "By how much can we expect to miss the forecast?" is known as the forecast deviation or, conventionally, the mean absolute deviation (MAD). It is the average of all the differences between the actual sales or demand and the average demand. If, for example, the forecast of new demand were 100 and the MAD were 10, then the probability that demand in the next period would not be greater than:

100 is 50%	(Forecast)
110 is 78.8%	(Forecast+1 MAD)
120 is 94.5%	(Forecast+2 MAD)
130 is 99.2%	(Forecast+3 MAD)

OBJECTIVES

The planning for implementation of forecasting subsystems in the manufacturing industries has not yet reached widespread acceptance. The reasons for this are twofold.

First, the characteristics of some businesses are such that analysis by inspection of data yields results that are good enough. Namely, one looks at past demand and feels that his demand for the past year has been 100 a month; therefore, it remains 100 a month for the future. Even if trends exist or seasonal patterns appear, the forecast-by-inspection route appears "good enough". The fallacy here, however, is that since the forecast is based somewhat on intuition and "feel", safety allowances are increased to allow for any error in judgment. The additional inventory is no small matter if this gross approach is followed on several hundred items.

Second, the tools generally furnished in a forecasting subsystem appear to be formidable. Manuals and descriptions of the subject imply an extremely sophisticated background of statistical and graphical analysis. The only requirement, insofar as one is concerned, is an understanding of what a subsystem of this type will furnish, not necessarily a thorough understanding of the statistical techniques employed.

Several items are to be considered in selecting a sales forecasting plan for an organization:

1. Type of smoothing or model. This can be based on the feel for the type of model, calculated manually from actual data or past data which can be analyzed automatically by the system available to aid in the selection of a plan.

2. Length of forecast. This is a subjective consideration; some of the factors would be lead time of the item, plus considerations regarding long-range planning.

3. Forecast period. This is the time between iterations or revisions in the forecast. Revisions should be made periodically, since the further into the future the forecast is made, the less reliable the results.

4. The smoothing constant (α). In the expression New Average = Old Average + α (new demand + old average), an initial value must be assigned to alpha. A small value of alpha means that more importance is being assigned to the old average than to the difference of (new demand - old average). The value of alpha ranges between 0 and 1.0. A high value of alpha produces a highly responsive forecasting plan, which adapts itself to new sales situations, but it also has a higher degree of forecast error.

5. The initialized model. Once the plan has been decided upon, initial averages and trend must be determined. If data is available, they can be calculated or estimated; if data is not available, the averages are estimated, and the trend is set to zero.

6. Items selected. Although forecasting can be performed on any part or subassembly, it is anticipated that the forecasting system will be more appropriate for end item assemblies and service parts.

SUBSYSTEM FLOW

The forecasting subsystem is composed of two modules — model select, and update and project (see Figure 28). The first is used to select the model and calculate initial values for each item. This is done when the system is initially set up, then periodically (perhaps yearly) or as required to meet changing conditions. Input to this module is historical demand, and the principal output is the updated item master record.

The update and project module is used to keep the item master file current (that is, reflecting the most recent demand) and to project future demand. Input to this module is the demand for the current period, which is used to update the values calculated by the model select module. Output consists of a printed report and a projection record for use by the requirements planning function.

Figure 29 is a representation of several periods of historical data, along with the projection for periods 30 through 36. The solid line going through the data is the trend line, and is represented by two numbers or points (first average and second average). On the basis of the historical demand (analyzed and summarized by model select), the use of

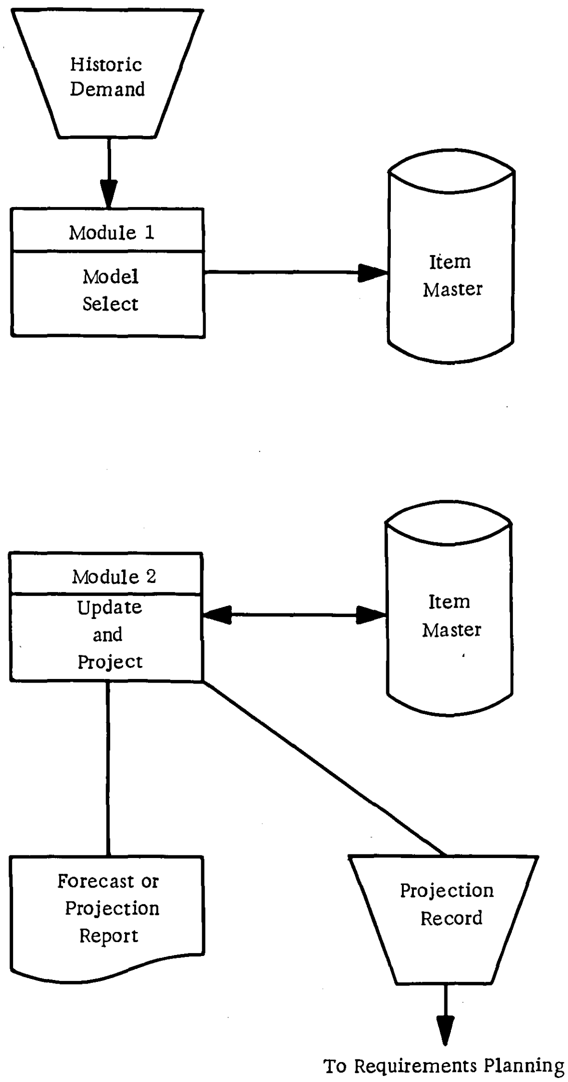


Figure 28. Forecasting subsystem flow

an alpha factor, and the most recent demand, it is possible to project demand for future periods (indicated by the broken line). Several important points are to be made from the illustration:

1. Data for historical periods is not retained in the file. Only the current averages of the data are required.
2. A trend model was selected for the historical data, and it was determined by model select some time in the past.
3. The effect of the most recent demand is part of the latest projection.
4. When the update and project program is run again after the next period, new projection information is made available for periods 30 through 36 on the basis of actual demand for period 29.

The calculations used for period 29 follow:

New First Average = Old First Average + α (Current Demand - Old First Average)

= 319.0 + .05(349 - 319.0)

= 320.5

New Second Average = Old Second Average + α (New First Average - Old Second Average)

= 300.0 + .05(320.5 - 300.0)

= 301.0

Trend

$$= \frac{\text{First Average - Second Average}}{\frac{1-\alpha}{\alpha}}$$

$$= \frac{320.5 - 301.0}{19}$$

= 1.0

Average Demand = 2 x First Average - Second Average

= 2 x 320.5 - 301.0

= 340

For the periods beyond 30, the trend (1.0 in this example) is added to the previous period's projection to obtain the projection for each subsequent period.

The projection report is illustrated in Figure 30. For each item, the report lists the old and the new values for average demand, first average, second average, trend, MAD, and sum of the deviations. The values shown on the first line are the old values; those on the second line are the new values. The model type code, the alpha factor, and the current demand are also indicated. The projections for this trend item are extrapolated for twelve time periods in this example.

The output of this subsystem, therefore, provides projections of future requirements for end item assemblies. This data then provides the necessary input for the requirements planning subsystem. Detail part and subassembly requirements are calculated on the basis of the output furnished by the forecasting subsystem.

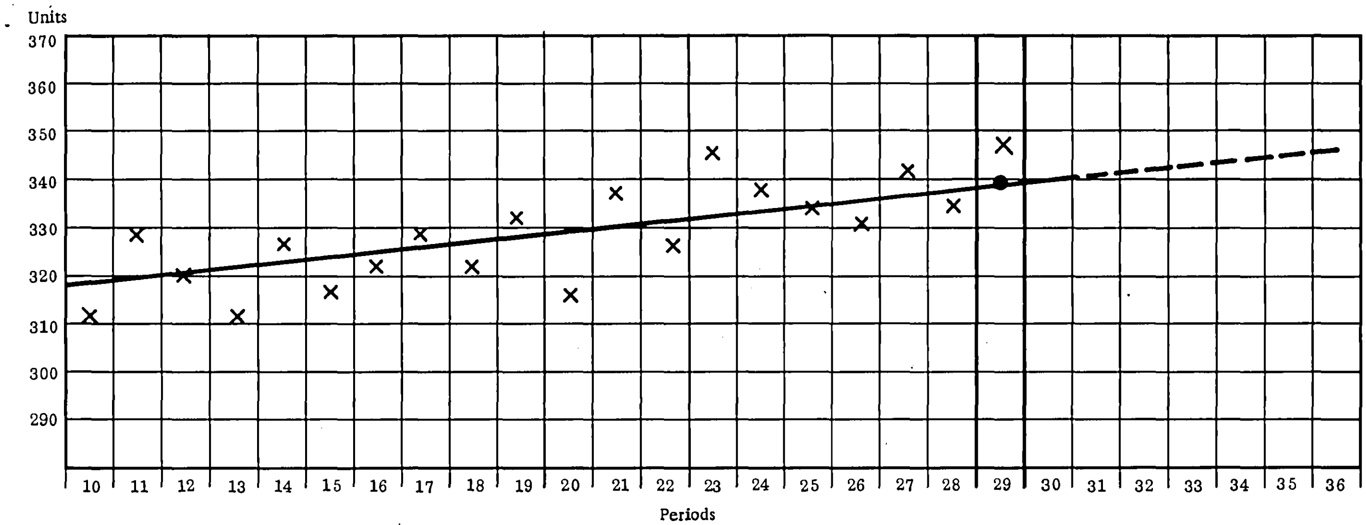


Figure 29. Smoothing with trend

ITEM NUMBER	DESCRIPTION	MODEL ALPHA	CURRENT DEMAND	AVERAGE DEMAND	FIRST AVERAGE	SECOND AVERAGE	TREND	MAD	SUM OF DEVIATIONS
A-1476843	ADAPTER UNIT	T	349	338.0	319.0	300.0	1.0	21.0	50.1-
		.05		340.0	320.5	301.0	1.0	20.5	39.1-

PROJECTION	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-
12 PERIODS	341	342	343	344	345	346	347	348	349	350	351	352

Figure 30. Forecast or projection report

MODEL DESCRIPTIONS

Model Select

Past demand data by period are accumulated for analysis. All items that are to be included in the forecast subsystem should first be examined by the model select phase. This run examines past demand and ascertains the best model to assign the item. For items that appear to be seasonal in nature, two years of data are usually required. The base indices are calculated for each period of the seasonal items and retained on the file for future use by the update and project program.

For items that do not have past demand data, and that are not seasonal, an arbitrary model selection can be made on the basis of past experience. The control cards indicate the item number, the model type selected, the estimate of past averages, and for all items, the value of alpha.

Output of the model select run is data indicating the model type, averages, trend, and base indices. This appears on the item master record for use by the update and project run.

			DATA BASE		
MODULE NAME	INPUT	PROCESSING ROUTINES	RECORD TITLE	RECORD FIELDS	OUTPUT
Model Select	• Historic Demand • Parameter Cards	• Edit • Determine Model (Regression Analysis) • Compute Averages • Determine Trend • Calculate Base Indices • Initial Update of Item Master	Item Master	• Model Type • First Average • Second Average • Trend • Average Demand • Mean Absolute Deviation (MAD) • Alpha • Base Indices	• Updated Item Master • Model Select Listing

Update and Project

Input to the update and project run consists of current period demand, parameter cards, and output from the model select run, or the updated item master from the previous update and project run. Parameter cards indicate any overriding factors, extent of the projection, and various expressions to be used in the smoothing formulas.

The module determines the type of smoothing required from the code appearing in the master record. The module provides for first and second order linear trend or seasonal trend capabilities. Depending upon the model, it calculates new averages and trend, and if extrapolation of the data is requested, it projects demand into the future on the basis of the run limits.

The projection, averages, trend, etc., are furnished in report form. In addition, a machine-readable record is prepared for input to requirements planning.

The sum of the forecast errors provides an indication of how well the forecast is anticipating actual demand. As soon as these deviations exceed a predetermined amount, the item is highlighted for examination.

			DATA BASE		
MODULE NAME	INPUT	PROCESSING ROUTINES	RECORD TITLE	RECORD FIELDS	OUTPUT
Update and Project	• Current Period's Demand	• Calculate New Averages • Revise Trend • Adjust Base Indices • Compute Mean Absolute Deviation • Tracking Signal • Project Demand	Item Master	• Model Type • First Average • Second Average • Trend • Average Demand • Mean Absolute Deviation (MAD) • Sum of Deviations • Alpha • Base Indices	• Forecast or Projection Report • Updated Item Master • Projection Record for Requirements Planning

SUBSYSTEM SUMMARY

Figure 31 summarizes the function of each of the modules in the sales forecasting subsystem.

The first module, model select, is concerned with analyzing past data for items not considered previously by the forecasting system. Once a forecast model is determined, the system proceeds to module two, to keep the values up to date and to project future demand.

Output includes the projection report, updated item master record, and a projection record for Requirements Planning.

SUBSYSTEM: Forecasting

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Model Select	• Historic Demand • Parameter Cards	• Edit • Determine Model (Regression Analysis) • Compute Averages • Determine Trend • Calculate Base Indices • Initial Update of Item Master	Item Master	• Model Type • First Average • Second Average • Trend • Average Demand • Mean Absolute Deviation (MAD) • Alpha • Base Indices	• Updated Item Master • Model Select Listing
Update and Project	• Current Period's Demand	• Calculate New Averages • Revise Trend • Adjust Base Indices • Compute Mean Absolute Deviation • Tracking Signal • Project Demand	Item Master	• Model Type • First Average • Second Average • Trend • Average Demand • Mean Absolute Deviation (MAD) • Sum of Deviations • Alpha • Base Indices	• Forecast or Projection Report • Updated Item Master • Projection Record for Requirements Planning

Figure 31. Forecasting subsystem summary chart

INTRODUCTION

The problems involved in exercising control over a manufacturing process are to a great extent determined by the complexities of the finished products involved. One problem in controlling the total efficiency of a complex manufacturing process is that of detailed requirements planning.* This is a matter of establishing the type and quantity of component parts and assemblies necessary in future production calendar periods. An equally important and related problem is ensuring that these original component parts and assemblies are planned to be available as needed. Insofar as requirements planning is concerned, this entails the examination of current inventory conditions and the issuance of the necessary make or buy notifications.

OBJECTIVES

The function of a requirements planning subsystem is to determine the raw materials, fabricated parts, purchased parts, subassemblies, and assemblies needed to meet the finished products plan that was generated by a forecasting subsystem or its substitute. The term finished product is used to include service or repair parts, as well as prime products. The objective is to determine requirements as quickly and as accurately as possible, as well as to react quickly to change in forecast, order cancellation, and plant rescheduling.

To be generally effective the subsystem should have the capability to accomplish the following:

1. Determine net finished product requirements.
2. Determine gross and net component requirements.
3. Determine lot size requirements.
4. Determine offset component requirements on the basis of manufacturing or procurement lead time.
5. React to revisions to orders or forecasts on a "requirements alteration" basis.
6. Review and adjust planned orders by "conversational planning".

The subsystem should be modular in design to permit the ability of either including or excluding, for example, the offsetting of component requirements.

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*See Management Operating System for Manufacturing Industries (E20-8041)

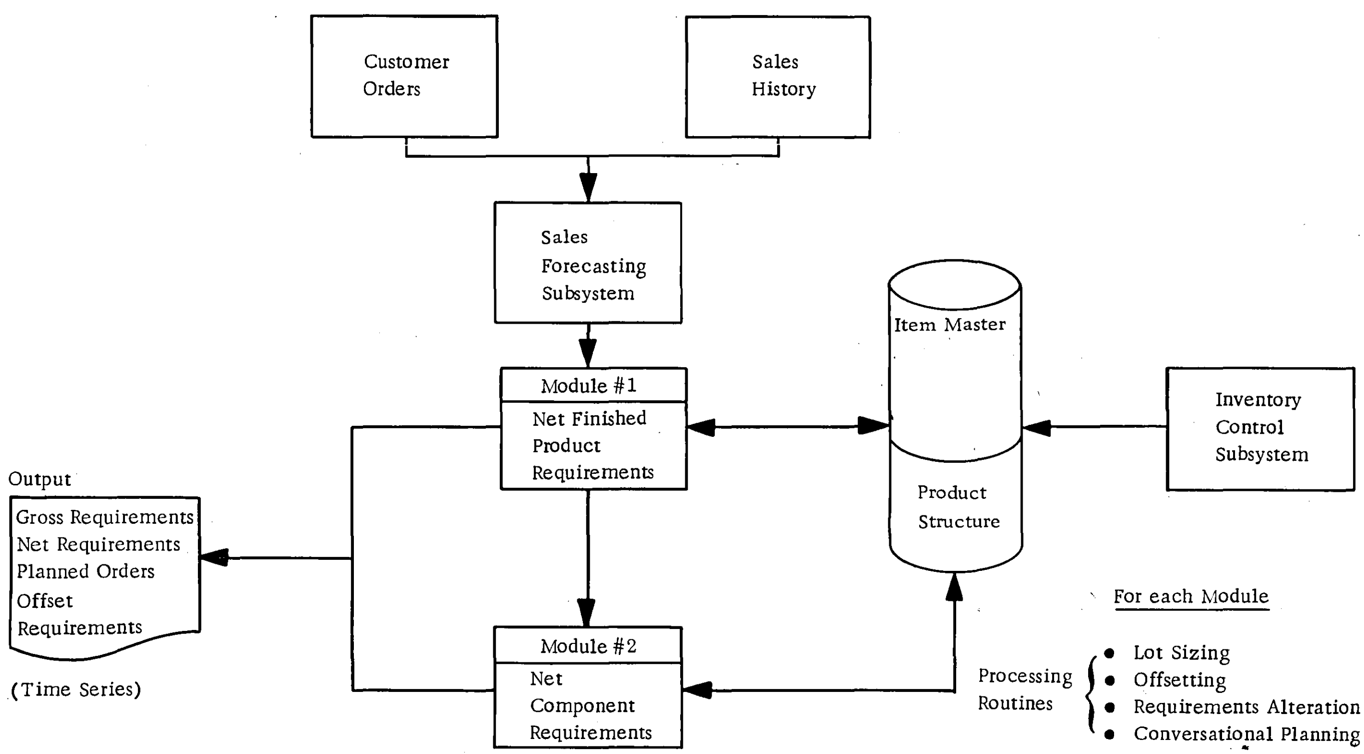

Figure 32. Requirements planning subsystem flow (general)

SUBSYSTEM FLOW

Figure 32 shows the requirements planning subsystem flow. The input is in the form of a forecast or customer orders to the first module, which determines the net finished product requirements. These provide input to the second module, which determines the gross and net component part requirements. The output from both modules can be reports showing the requirements by time period for finished products and component parts. Exception notices can also be generated for purchasing and manufacturing showing items requiring attention, and the quantities involved.

Requirements planning is accomplished by translating product specifications into raw material, part, subassembly, assembly, and packaging requirements, by accessing bills of material. The component requirements are distributed over the proper time intervals of a production calendar by the level offset or manufacturing and procurement lead times.

The accumulated requirements per item are checked against the available stock on hand, and on order, to determine net requirements. If requirements are not adjusted by existing inventories, this process results in a gross requirement. Planned orders emerge from the system as an immediate response to shifts in demand. A sudden increase in requirements, which causes negative availability, generates instant order action. Conversely, a sudden decrease in demand may cause excessive inventory. The system has the ability to cancel planned orders and forestall the building of surplus inventory.

TIME SERIES LEVEL-BY-LEVEL ANALYSIS

One of the most advanced analysis techniques, and most exacting in planned requirements is the time series level-by-level analysis approach. It is applicable, in particular, where a product has multilevels of production, high cost components, a long lead time, stocking of semifinished components, and/or multiused assemblies and parts. The requirements planning subsystem employs this level-by-level time series approach.

Levels are associated directly with manufacturing lead time. The point at which a product is completely assembled is the highest or zero level of a product structure. The components that make up this stage are called level 1 items.

Level 2 is the preceding stage in the manufacturing process, and the level numbers keep rising until the most basic component is made. The number of levels is dependent on the complexity of the end product; the higher the level number, the earlier the component is needed in the manufacturing process.

Order action for any component is suspended until its lowest-level requirement is exploded. A part or subassembly is at its lowest-level when it is no longer a component at a lower level in any other assembly or for any other end product. When the lowest level of usage is reached, the total requirements are checked for inventory availability, and any necessary orders are signaled.

Use of the low-level code implies that each item (part number) has been coded to identify the lowest level of its usage in connection with any of the finished products in the line. This low-level code is contained in the item master record and is used primarily during explosion to indicate when netting is to be performed.

Gross requirements are posted directly to the item master record as they are developed (level by level). The low-level code is examined each time a gross requirement is posted, and netting is performed when the lowest level of usage has been reached. This procedure is accomplished through the use of the level action chain described in a previous MOS manual.*

Figure 33 shows an example of two end products, X and Y, and their associated assemblies, subassemblies, and parts, with the appropriate low-level codes. It also depicts the lead times or offset between levels in the manufacturing process. Note that "1" is used on both products X and Y, and although it appears in levels 1, 2, and 4 of product X, and in level 1 of product Y, its low-level code remains "4".

*See MOS Inventory Management and Materials Planning - Detail (E20-0050) p. 97

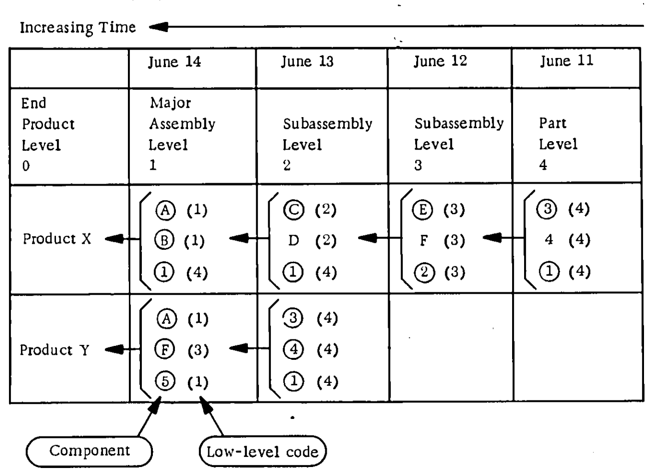

Figure 33. Low-level control code

The following characteristics (not every characteristic need be present) are indicative for justifying this approach:

1. The finished product is complex — multi-manufacturing levels.
2. The finished product is expensive — strict control desirable.
3. There are multiple uses of components and subassemblies with significant value attached to each.
4. Consolidation of order requirements is necessary to reduce purchase and manufacturing order costs.
5. The finished product manufacturing cycle is relatively long.
6. Raw material or semifinished components are stocked.
7. Component and raw material lead time is relatively long.

The time series level-by-level approach, on equipment other than a data processing system, is impractical, because of the excessive process and manual handling time required. Advantages of this method,* as implemented by an IBM data processing system with direct access storage, are:

1. The initial coding and file maintenance for the low-level control code is automatic, fast, accurate, and eliminates intermediate handling.
2. Bills of material are chained to the inventory control and are randomly accessed. Only one bill of material per assembly is required.
3. One continuous run eliminates output of level-by-level requirements, except for the components subject to management review.
4. Engineering change file maintenance is simplified, facilitating up-to-date and accurate bills of material for planning.
5. Requirements are generated rapidly, thereby greatly reducing the overall materials planning cycle. Furthermore, the time series level-by-level approach provides for the generation of requirements more frequently on the basis of forecasts or rescheduling, thereby increasing inventory savings.
6. An extended bill of materials is prepared rapidly and automatically, providing a complete list of materials and requisition cards per item.
7. Parts and assembly requirements are consolidated before netting against inventory. This means that the netting procedure for any part takes place only once during a planning cycle.
8. Order sequence is easily maintained through the use of the start and completion dates provided for each order, on the basis of higher assembly level start date.
9. Complete stock status reports are not required on a daily basis. Exception reporting provides management with critical stock positions as the condition arises.
10. Tight control is maintained over material allocated for assembly or part order, with shortage reports automatically prepared using a chaining technique.

*See Management Operating System - Inventory Management and Materials Planning - Detail (E20-0050)

MODULE DESCRIPTIONS

Net Finished Product Requirements

As shown in Figure 32, the first module of the requirements planning subsystem determines the net finished product requirements. As was stated earlier, the term "finished product" is used to include service or repair parts, as well as prime or end products.

The input to this module comes from the forecasting subsystem, or its substitute, and consists of the gross finished product requirements for the planning periods involved. The input data involved is item number, quantity, date required, and the customer or shop order number, if one exists.

These gross requirements are compared to the available inventory, and calculations are made to determine the net finished product requirements. The gross requirements are stored in the item master record. If desired, both the gross and net requirements can be printed as shown in Figure 34.

The requirements determined in this module provide the input for the next module, which develops component requirements.

	Requirements by Time Periods											
Item	Behind Schedule	1	2	3	4	5	6	7	8	9	10	→ 11-20
A		8	7	5	0	10	6	4	10	8		Gross Requirements
						5	6	4	10	8		Net Requirements
						20			20			Planned Orders
					20			20				Off Set

Figure 34. Projected requirements by time periods

Net Component Requirements

Again, referring to Figure 32, the second module of the requirements planning subsystem (net component requirements) has the function of exploding the net finished product requirements as determined in the first module and developing the net component requirements. The input, of course, is the net finished product requirements by item number, quantity, and due date. These net finished product items are exploded level by level. The top-level explosion generates the net requirements, which are the gross requirements for the next level, and which are compared to available inventory to develop net requirements. The net requirements just developed are then exploded to the next level to develop gross requirements, which are netted, and the process continues until all levels have been exploded and netted. Any items based on order codes B or C are ignored by the netting process (see item master record).

During this process, the gross requirements are stored; if desired, a report can be printed showing by item the gross and net requirement quantities (Figure 34).

PROCESSING ROUTINES

Associated with each of these two modules (gross-to-net finished products and gross-to-net component requirements) are the following routines that may be called into use:

1. Plan orders (lot sizing)
2. Offsetting
3. Requirements alteration
4. Conversational planning

These routines are modular in design and independent of one another. Therefore, any or all may be called into use within either module. A general description of these four routines follows.

Plan Orders

Another important function that can be handled in the requirements planning subsystem is that of planning orders — that is, combining net requirements that have been generated into lot sizes which satisfy the order policy for the item.

At the first point in time where a net requirement has been generated, a quantity determined from the order policy is established as a planned order and is placed in the item master. If the first net requirement is larger than the quantity determined from the order policy, multiple planned orders are developed. The first and later net requirements are added sequentially into the future, and comparisons are made to the planned order until the remaining quantity for the planned order has been reduced to zero, at which time another planned order is developed, and the procedure is continued for all net requirements. Exception notices to purchasing and manufacturing are made on all items requiring attention; a report may be obtained showing the planned lot sizes (Figure 34).

Offsetting

This routine provides the capability to offset net requirements or planned lot size requirements to establish the start date of the requirements. This means that each level's requirements are offset by the appropriate amount of manufacturing or purchasing lead time. For example, assume the product structure shown in Figure 35 contains three levels.

Assume also that a one-month lead time between levels is required. It takes one month to procure items 1 and 2, and one month to assemble B and C to make item A. Therefore, on the basis of this assumption, if item A were due in month 1, items B and C would be due in month 5, and items 1 and 2 would be due in month 4.

The amount of time required to procure or to produce an item (lead time) is maintained in the item master record, and is referenced during the explosion process to establish the proper offset. Concurrent with the offsetting of requirements, the item's lead time is checked to determine whether the lead time offset planned start date occurs in the current planning period, or whether the current period has already passed the planned start date. Exception notices are printed for all items falling into those categories for appropriate management action. If lot sizing has been employed, the offsetting is done for the lot sizes generated (see Figure 34).

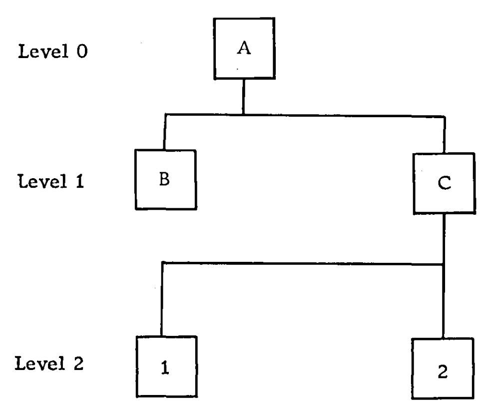

Figure 35. Three-level product structure

Requirements Alteration

A capability that is desirable in requirements planning is that of reacting to forecast or customer order changes by introducing only the amount of change that has occurred as opposed to a complete regeneration of requirements planning. A forecast may be revised upward or downward, for example, by ten percent. Instead of having to regenerate the entire plan, it is desirable to be able to deal only with the quantity that has caused the alteration. This capability is made possible through the use of direct access storage devices.

The input, therefore, is in the form of a transaction denoting the item number, quantity changed customer or shop order number, and date required. This information is processed in the same manner as other requirements.

Comparisons to both planned and on-order quantities are made; in the case of planned orders, appropriate revisions are made. Insofar as released orders are concerned, exception notices are prepared with advice to cancel, increase, or reschedule purchase or work orders. In addition, the item master record is updated as required to reflect the result of the alteration.

Conversational Planning

Another capability that is desirable in a mechanized requirements planning subsystem is the ability to review and adjust planned orders that have been developed by the system. This can best be accomplished by reviewing the planned orders that have been developed for a level and make adjustments before proceeding to the next level. The "conversational planning" type of processing provides a method by which planned order quantities and required dates can be adjusted and reentered into the system so that correct component requirements are established.

PROCESSING DETAIL

Figure 36 shows the interrelationship of the modules and routines to each other, certain files, and the various points where exception notices or reports can be generated. It will prove helpful to refer to this flowchart as the following processing is discussed.

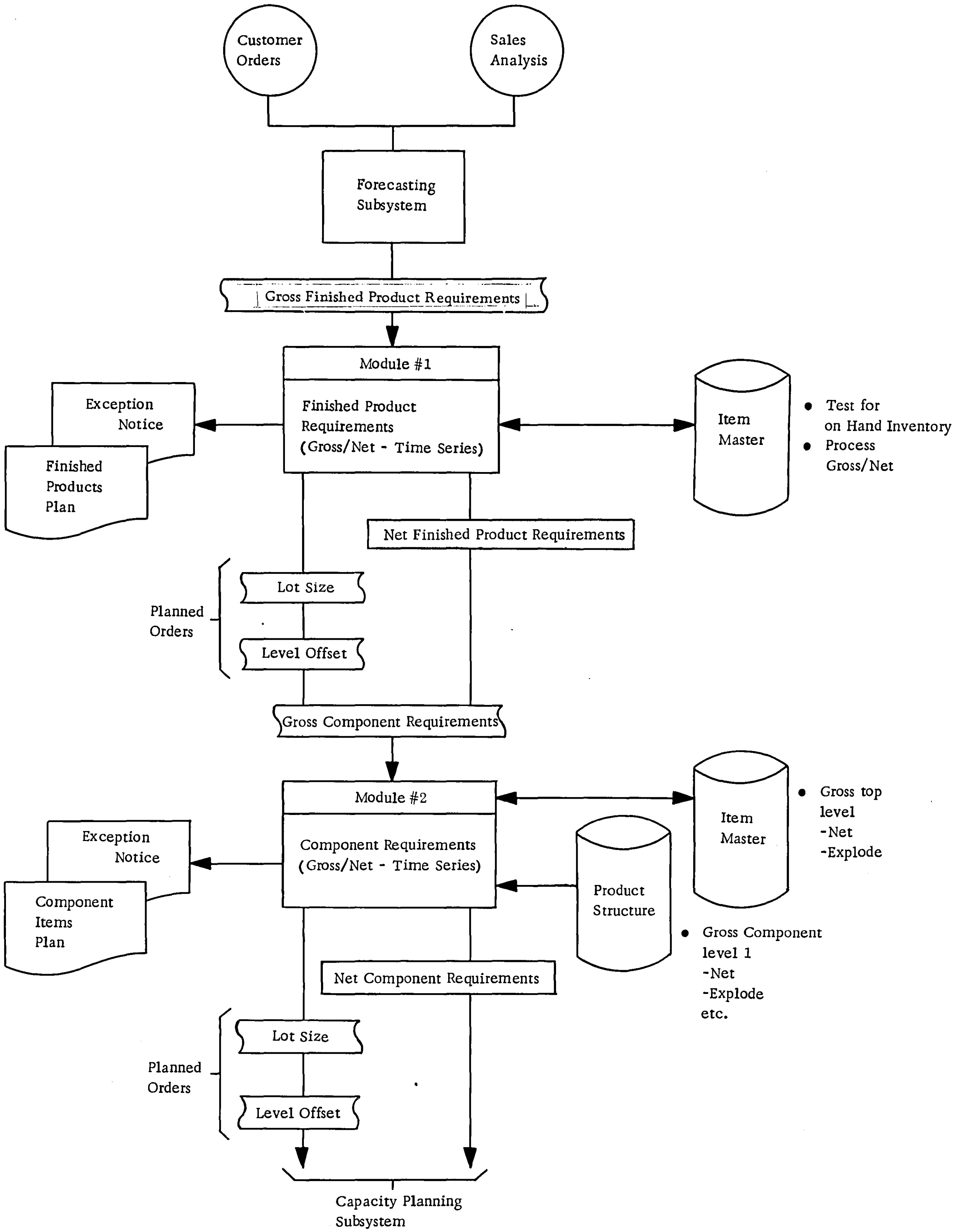

Figure 36. Requirements planning subsystem flow (processing detail)

Net Finished Product Requirements

This phase of the gross-to-net module determines from the forecast or its substitute the net finished product requirements. These top-level net requirements become the input for the next phase of this module — net component requirements, with the option for lot sizing and/or time period offset.

The input consists of forecast requirements containing the top-level item number, gross quantity required, and the due date, all of which is stored in the item master record. This phase of the gross-to-net module takes the following steps:

1. Access the item master file, and locate the items for which requirements exist.
2. Compare the gross requirements quantities to the available inventory, and when the available inventory is reduced to zero, determine the net requirement and store it for further processing. Before reducing the gross requirements against the released orders, the gross requirements may be temporarily increased by a shrinkage factor. This satisfies a dual purpose: temporarily adjusting the gross requirement before reducing it by a released order that includes a shrinkage consideration, and providing a resulting net requirement to include anticipated shrinkage.
3. Review the released orders in relation to the time series gross requirements in order to provide exception notices that can be used to expedite, cancel, or alter released orders.
4. If no further processing is desired, the output from this phase is a report to purchasing or manufacturing, showing the net requirements, quantities required, and scheduled due dates for the items requiring attention.
5. If further processing is desired, the net top-level requirements, quantities, and due dates provide the input to the next phase of the module, that is, the determination of the net requirements for the component items that go into the top-level items.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Net Finished Product Requirements	• Finished Product Forecast, or Orders obtained from Forecasting Subsystem (as Gross Finished Product Reqs. - Module 2 of Forecasting, or its substitute)	• Gross to Net Order (lot) sizing Offset Reqs. • Req. Alteration • Conversational Planning	Item Master	• Item No./Description • Gross Requirements • Low-Level Code • Planned Orders • Order Policy Order Code • Safety Stock • Shrinkage Factor • Inventory On Hand • Allocated Qty. • Modifier Code • Number Days Supply • Maximum Quantity • Minimum-Maximum-Multiple Quantity • Cutoff Date • On Order-Purchasing/Production • Lead Time Purchasing Production • Unit of Measure	• Finished Products Plan Report Gross Requirements Net Requirements Planned Orders with Lot Size Planned Orders with Offset • Exception Notice • Planned Orders

Net Component Requirements

The net top-level requirements, as generated in the first module, are input to this module. To determine the net component requirements, the following steps are taken.

1. The item master record is retrieved, and these items are presented to the product structure file for level-by-level explosion through the use of the IBM bill of material processor* and utility programs.

2. The top-level explosion determines the gross requirements for the next level, and these requirements are stored in the item master record.

3. As was done for the top-level items, the gross component requirements are compared against the available inventory, and the net component requirements are determined

4. The net requirements just generated are exploded to the next level, creating component gross requirements, which are stored in the item master record for further explosions.

5. The process continues until all levels have been exploded and netted.

6. If no further processing is contemplated, the output of this phase is a report showing net requirements by item number, quantity, and due date for the component items.

*See Bill of Material Processor - A Maintenance and Retrieval System (E20-0114) and IBM System/360 Bill of Material Processor - Application Description (H20-0197)

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE RECORD TITLE	DATA BASE RECORD FIELDS	OUTPUT
Net Component Requirements	• Net Projected Finished Products (From Module 1) • Adjustments	• Gross to Net • Explode to Next Level Order (lot) Sizing Offset Reqs. • Req. Alteration • Conversational Planning	Item Master	• Type of Item • Item No. /Description • First Assembly Component Address • Low-Level Code • Next Item in Activity Chain • Run Activity Control No. • Gross Requirements • Shrinkage Factor • Planned Orders • Order Policy Order Code • Modifier Code • Number Days Supply • Maximum Quantity • Minimum-Maximum-Multiple Quantity • Cutoff Date • Inventory On Hand • Allocated Qty. • Safety Stock • On Order-Purchasing/Production • Lead Time Purchasing Production • Unit of Measure	• Component Items Plan Report Gross Requirements Net Requirements Planned Orders with Lot Size Planned Orders with Offset • Exception Notice • Component Gross Requirements • Planned Orders
			Product Structure	• Component Item No. Master Addr. and Compare Portion • Qty. per Assembly • Next Component Address • Product Structure Scrap Factor • Lead Time Adjustment	

Plan Orders

If desired, the netted requirements that have been generated may be lot-sized. The item master record contains the order policy that is pertinent to that item and upon which quantity decisions are based. Lot sizing of netted requirements is accomplished as follows:

1. The net requirements, by period, are compared to the item's order policy.

2. The first period containing a net requirement establishes that a planned order, on the basis of the type of ordering policy involved, must be initiated.

3. If the order policy is a fixed quantity, the order is planned and is then reduced by the net requirements by time period until the planned order quantity has been reduced to zero (at which point a new planned order is generated) or until all net requirements have been satisfied by the planned order.

If the order policy is a calculated order quantity, the net requirements are accumulated by time period, and the lot size is determined by comparing fixed costs (setup costs) with variable costs (accumulated unit carrying costs). The size of the order quantity is established when the variable costs exceed the fixed costs. This procedure is repeated until all net requirements have been satisfied by the planned orders.

In many cases, the order policy does not satisfy the complete restrictions that should be applied to lot sizing. To further define other considerations when lot sizing, modifiers are applied to the order policy. These can include number-days-of-supply to restrict the number of days that an individual order quantity should cover, minimum-maximum-multiple quantities to achieve upper and lower limits as well as rounding an order quantity, and cutoff date to restrict the number of time periods of the total order policy. Both order policies and modifiers are unique to an item.

4. Lot sizing is done level by level, and the lot sizes from a higher level become the input for exploding and netting of later levels.

5. The output from this phase consists of a report showing the item numbers, quantity, and due date for the lots required to be ordered.

Offsetting

This phase of the subsystem offsets the lot-sized net requirements in time, level by level, to establish the proper time relationships between the scheduled due dates of top-level items and their components.

Offsetting is accomplished in the following manner:

1. After the top level is netted and lot-sized, the lot size quantity (planned order) is offset by considering the lead time for the item. This is accomplished before posting the offset planned order to its components. The offset planned order is then stored in the item master.

2. The offset plan orders become the gross requirements of the next level by extending the plan orders by the usage located in the product structure record for each component. The component gross requirements may be adjusted by a product structure scrap factor that is applicable only for a specific component when assembled to a specific parent item. In addition, a product structure offset adjustment can adjust the lead time of a component gross requirement to more accurately relate the required date that the component must be available in order to be assembled to a specific parent item. This level is then netted, the lot size is determined, and the correct offset is applied before posting the requirements to the following level. The offset planned order (lot size) is stored in the item master.

3. This processing continues until all levels have been completed.

4. Each item is checked to determine whether the required lead time (offset) falls into the current period. If it does, an exception notice is prepared.

5. The output consists of a report to manufacturing and/or purchasing, showing item number, quantities, and due dates for the items requiring attention; all planned orders are stored in the item master.

Requirements Alteration

The purpose of this phase of the module is to update the requirements, because of changes in forecasts or customer orders, without necessitating a complete regeneration of requirements.

The input to this phase is a revised forecast or a change to a customer or shop order that has previously been introduced to the system. The input consists of item number, quantity, due date, and (if applicable) customer or shop order number.

If a forecast is changed, either plus or minus, the new forecast for the period involved is compared to the previous forecast quantity for the period. As a result of this comparison, the difference between the two is used to update requirements planning.

Requirements alteration to a forecast is introduced via a transaction card containing the transaction code, item number, quantity, and due date. Code "RF", for example, may indicate that a revised forecast is replacing a previous forecast.

Any requirement change that affects planned orders (not released orders) updates the planned order record contained in the item master.

Depending upon the type of change involved, the new gross requirements are placed in the item master record, and the altered quantity is processed through the netting, lot sizing, and offset routines.

Requirements alterations can be introduced at any level; however, if increases in item requirements are being introduced, they are normally started at the top level. The differences between the original forecast or planned orders requirements and the newly calculated requirements are reflected (plus or minus) as changes to the next-lower level's requirements.

Any requirement alteration that affects a released order already entered on the item master record causes an exception notice with a "reschedule order" comment.

An example of these exception notices is shown in Figure 37.

Item #	Trans-action	Quan-tity	Due Period	Order No.	Date	Approved
A	CW	100	6/17	75	5/12	JS

Transaction Codes

WO = Work Order
CW = Cancel Work Order
PO = Purchase Order
CP = Cancel Purchase Order
RF = Revised Forecast

Figure 37. Exception notice -- cancel work order

Conversational Planning

The purpose of this method of processing is to allow "interruption" of the requirements planning subsystem after each level of planned orders has been developed. The planned orders may be reviewed for possible adjustment. Only the adjustments are "reentered" into the system. The proper planned orders stored in the item master record are changed before all previously planned orders are extended and posted to their components.

Conversational planning facilitates ease of review of the planned orders that have been developed according to their order policy and modifiers. Planned orders must be stored to use this method of processing.

A report is prepared for each planned order that has been adjusted showing all the planned orders for an item after the adjustments have been made.

Conversational planning and requirements alterations can be used together. When a requirements alteration affects an item's planned order that has been adjusted by conversational planning, the planned orders are not changed. This is done because the system has no way of knowing what order policies were applied outside the system. In this situation, to facilitate review, a report is produced showing the planned orders that have been adjusted by conversational planning and the planned orders calculated by the system as a result of the requirements alteration.

Pegged Requirements

In many situations, it is important that information be available from the system to show on which item the component is immediately used, as well as on which top-level item it is used.

Pegged file information can prove valuable in determining which subassemblies, assemblies, and finished products (with related customer orders) will be affected because of a shortage of a pegged item. The rapid retrieval of this information enables management to make decisions regarding purchasing, expediting, or informing customers in advance of delays. Figure 37a shows how gross requirements of item number 24567 can be pegged to three detail records.

The pegged requirements file is an extremely volatile file and is updated any time there is a change to a gross requirement — in quantity, dates, change in customer usage, deletions, or new additions to gross requirements.

Since the pegged requirements file can be large and must be maintained, it is important to determine when the pegged file should be created in a production information and control system. In many cases, this decision is dictated by the ultimate use of the pegged file. The creation of the pegged file is discussed in the requirements planning subsystem to illustrate how the pegging can be performed.

Pegging can be accomplished in the following manner:

As gross requirements are developed, and as each level is exploded, a pegged requirements file is generated. The gross requirements that are not associated with a customer or shop order number can be carried as pegged requirements, with no customer or shop order number assigned; however, all other information associated in the record is carried — that is, immediate use item number, quantity, due date, ultimate use item number, quantity, and due date. In place of the customer or shop order number, an appropriate identification is used to relate it back to its forecast source. As firm customer or shop order numbers are generated, they are input to the system as transactions containing the following:

- Item number (top level)
- Quantity
- Due date
- Customer or shop order number

These items are then compared by item number and due date to the due date of the forecast gross requirement item. Then, the customer or shop order number is inserted in the record, and a new forecast pegged requirements record is generated containing a quantity that has been reduced by the amount of the firm order.

The output from this routine is a pegged requirements file that can be accessed from the item master record.

A customer may not wish to keep pegged requirements on all parts, but rather, only on those that are critical to his operation or on those items that have a high cost value. Therefore, options are provided to use time buckets on other items and, in some cases (nuts and bolts), just a single total bucket in the item master record.

SUBSYSTEM SUMMARY

The requirements planning subsystem consists of two basic modules:

1. Gross to net — finished products
2. Gross to net — component requirements

And four routines:

1. Plan orders (lot sizing)
2. Offsetting
3. Requirements alteration
4. Conversational planning

The basic inputs are time period forecasts or customer order, inventory balances, and ordering factors. In addition, the bill of materials file is required to provide for the necessary explosions.

ITEM MASTER				
Item No.	Gross Requirements			
24567	Date 200	Qty. (100)	Address to Pegged Requirements	etc. →

Detail

Pegged Requirements										
Part No. Requirement			Immediate Use			Finished Product Use				
This Part No.	Qty.	Sched. Due Date	Part No.	Qty.	Sched. Due Date	Part No.	Qty.	Sched. Due Date	Cust. Order No.	Prod. Order No.
24567	(20)	200	10116	10	250	23208	10	270	456	4723
24567	(50)	200	47970	25	260	93066	25	275	654	5125
24567	(30)	200	12234	30	280	77002	15	300	110	5517

Figure 37a. Pegged requirements recordkeeping

The processing of these modules has certain options. A customer may wish to determine only net finished products, or he may wish to determine, in addition, the gross and net component requirements. He may or may not wish to provide for lot sizing, level offset, requirements alteration, or conversational planning.

The modules are summarized in Figure 37b.

SUBSYSTEM: Requirements Planning

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Net Finished Product Requirements	• Finished Product Forecast, or Orders obtained from Forecasting Subsystem (as Gross Finished Product Reqs. - Module 2 of Forecasting, or its substitute)	• Gross to Net Order (lot) sizing Offset Reqs. • Requirements Alteration • Conversational Planning	Item Master	• Item No./Description • Gross Requirements • Pegged Requirements (a) Part No. Requirement This Part No. Quantity Sched. Due Date (b) Immediate Use This Part No. Quantity Sched. Due Date (c) Finished Product Use Part No. Quantity Sched. Due Date Customer Order No. Production Order No. • Low-Level Code • Planned Orders • Order Policy Order Code • Modifier Code • Number Days Supply • Maximum Quantity • Minimum-Maximum-Multiple Quantity • Cutoff Date • Inventory On Hand • Allocated Qty. • Safety Stock • On Order-Purchasing/Production • Lead Time Purchasing Production • Unit of Measure • Shrinkage Factor	• Finished Products Plan Report Gross Requirements Net Requirements Planned Orders with Lot Size Planned Orders with Offset • Exception Notice • Pegged Requirements Listing • Planned Orders
Net Component Requirements	• Net Projected Finished Products (From Module 1) • Adjustments	• Gross to Net • Explode to Next Level Order (lot) Sizing Offset Reqs. • Requirements Alteration • Conversational Planning	Item Master	• Type of Item • Item No./Description • First Assembly Component Address • Low-Level Code • Next Item in Activity Chain • Run Activity Control No. • Gross Requirements • Planned Orders • Order Policy Order Code • Modifier Code • Number Days Supply • Maximum Quantity	• Component Items Plan Report Gross Requirements Net Requirements Planned Orders with Lot Size Planned Orders with Offset • Exception Notice • Pegged Requirements Listings • Planned Orders • Component Gross Requirements

Figure 37b. Requirements planning subsystem summary chart (Sheet 1)

SUBSYSTEM: Requirements Planning

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
			Item Master	• Minimum-Maximum-Multiple Quantity • Cutoff Date • Inventory On Hand • Allocated Qty. • Safety Stock • On Order-Purchasing/Production • Lead Time Purchasing Production • Unit of Measure • Pegged Requirements (a) Part No. Requirement This Part No. Quantity Sched. Due Date (b) Immediate Use This Part No. Quantity Sched. Due Date (c) Finished Product Use Part No. Quantity Sched. Due Date Customer Order No. Production Order No.	
			Product Structure	• Component Item No. Master Addr. and Compare Portion • Qty. per Assembly • Next Component Address • Product Structure Scrap Factor • Product Structure Offset Adjustment	

Figure 37b. Requirements planning subsystem summary chart (Sheet 2)

INTRODUCTION

Capacity planning forms the base from which a plant's detailed operational schedules can be developed. In essence, it performs the job of long-range planning, that is, taking the load of jobs to be run, placing the jobs against the available men and machines within the required time period, and developing start dates in order to establish a leveled load pattern. Capacity planning provides information far enough into the future to permit judgments to be made regarding the shifting of loads. Also, ample time is thereby made available for corrective action, such as adding extra shifts, subcontracting work, purchasing rather than manufacturing, adjusting manpower requirements, etc.

A capacity planner may also be used to simulate plant operations. In successive iterations, using different work center capacities (perhaps representing the addition or removal of machine tools or different sales forecasts or product mixes, priorities, etc.), the effect of changes on staffing, overtime, and adding shifts may be examined. Similarly, with an initial body of firm orders, information about the effect of one or more proposed additional orders may be obtained. The capacity required and/or the cost of producing a pending order at several alternative due dates may also be investigated.

The capacity planner receives as its input the item numbers, quantities required, and due dates from a requirements planning subsystem and provides as output the leveled workload (planned orders) required by the operations scheduling subsystem.

The differences between scheduling programs and a capacity planning program fall into three categories:

1. Long-range planning. The capacity planner concerns itself with long-range planning of plant capacity. It does not furnish information regarding the dating of operations, but rather the anticipated load hours that will be imposed on the work center some six, twelve, or more months into the future. Basically, it addresses itself for use by plant managers who ask, "What can I build, and when can I expect to have it shipped?" An operation scheduling system addresses itself for use by shop foremen who ask, "On which parts and operations should I work today, and what are their relative priorities?"

2. Orders can be moved. Since capacity planning is resolving load conflicts a number of months into the planning horizon, judgments may be made today regarding which orders can be shifted to provide plant operating personnel with leveled workloads.

3. Gross loading techniques. Since capacity planning is not concerned primarily with the creation of a daily designated list, the techniques may be of a more gross nature. For example, if the planning period is one month, the question to be resolved is not the determination of individual operation start dates, but rather how much of the total machine or labor load hours will fall within the monthly periods. The determination of individual operation start dates (as opposed to order start dates) has less significance in long-range planning. Consequently, it may be totally unnecessary from a system standpoint to design a capacity planner to use a simulation approach. Simulation techniques furnish very exact results, but are not realistic for capacity planning, for several reasons:

- Planned orders are subject to change. Placing a clock time of 10:30 a.m. on an operation six months into the future is not meaningful.
- A simulator would require considerably more data for its use than a capacity planner. A capacity planner needs information regarding total available labor or machine hours by work center by period. An operations scheduler, using a simulation technique, needs data regarding number of machines, number of shifts, contention rules, overlaying and lot-splitting algorithms, etc., and builds a model "to duplicate this situation by the system".
- In view of the span of time over which a planner is concerned, it is essential that the detail that does not contribute significantly to the quality of the results should not be explicitly considered. For example, Q analysis would be a typical operation scheduling output. Overload analysis by work center would be a typical capacity planner output with no information as to the number of jobs in queues or the length of such queues.

INFINITE LOADING

Working back from the completion date and using estimated setup, process, move, and wait times for each operation, the requirements planning subsystem calculates an order start date without regard to capacity. The start date is next used to load the order into each department and work center. Underload and overload conditions are determined as work center loads are accumulated.

Corrective action, such as extra shift, subcontracting, procurement rather than manufacture, alternate routings, etc., may be taken. The fact that other means are used to relieve the overload (rather than rescheduling) has lead to calling this practice "loading to infinite capacity".

The utility value of an infinite loader serves several important functions:

1. It provides valuable information by which a discipline can be established for releasing work to the shop floor.

2. It provides information to a user regarding action to be taken for long-range planning of facilities and manpower. A finite planner levels workloads, and thereby may move orders late if capacity is not available. The unleveled or "raw" picture of true plant conditions is therefore destroyed.

3. It furnishes a vehicle by which the user can control the manner in which the workload profile is leveled.

4. It provides a logical first step in implementing a total production control system. Data requirements — such as a master routing file — are established, and file interrelationships are solidified.

Figure 38 illustrates the relative time spans for both the capacity planning and operation scheduling subsystems.

The projected load profile (dotted line) is somewhat unpredictable and can be subject to constant movement either earlier or later. Capacity planning considers only planned orders, as opposed to released or committed orders. The load for released orders extends a short period into the future and at some point begins to fall off. The operation scheduling subsystem moves orders from a planned category to a released category. Shop floor control, on the other hand, has the responsibility of creating shop packets and other documentation.

OBJECTIVES

The implementation of a capacity planning subsystem can solve many of the problems continually facing production control managers. Chief among these problems are excessive work in process, queues that are too long, large volumes of work that are behind schedule, and excessive lead times. It is not uncommon for 80 percent of the overall lead time of a manufactured item to consist of wait and move times, with only 20 percent consisting of processing time.

It is often reasoned, since a plant's capacity is relatively fixed, that if a sufficiently long lead time were attached to an item, it would get through the shop on time. The effect of this reasoning is diametrically opposed to two of the basic objectives of a good production control system. First, by starting work earlier than necessary, work-in-process inventory is increased; and second, lead times are considerably longer than they should be, thereby compounding the scheduling problem and causing inventory safety stock to be unnecessarily high.

A point is soon reached where the volume of work committed exceeds the shop's ability to perform. The problem is further complicated by the uncontrolled flow of the workload through the plant. Late orders become later, and on-time orders become late. It is incumbent upon production control managers to control the input of orders committed to the shop. To do this, they must be equipped with the knowledge of the long-range effects of orders on the available facilities.

The capacity planning subsystem is the necessary tool to solve these problems. This subsystem:

1. Determines feasible order start dates. This function determines the time periods in which the order is scheduled to be started; however, if overloads are encountered, shifts are made to start the order in an earlier time period.

2. Maintains workload summaries. As resource requirements for orders are loaded into their respective work centers, the load hours imposed are accumulated. At the completion of the run, a report can be furnished that indicates the expected load hours for each work center by time period.

3. Relieves overload conditions. This function exercises control as to where to move loads most advantageously when overload periods are encountered. Orders that can be shifted are placed in the time periods that are least overloaded and that have the best ability to absorb the load.

4. Substitutes work centers. This function exercises control as to where to place loads when substitute work centers can be employed. As is the case in many plants, alternate work centers exist that can be put to use; they provide a greater advantage than incurring overtime or adding additional shifts to existing centers.

The output of a capacity planning subsystem consists of output reports, as well as updated files.

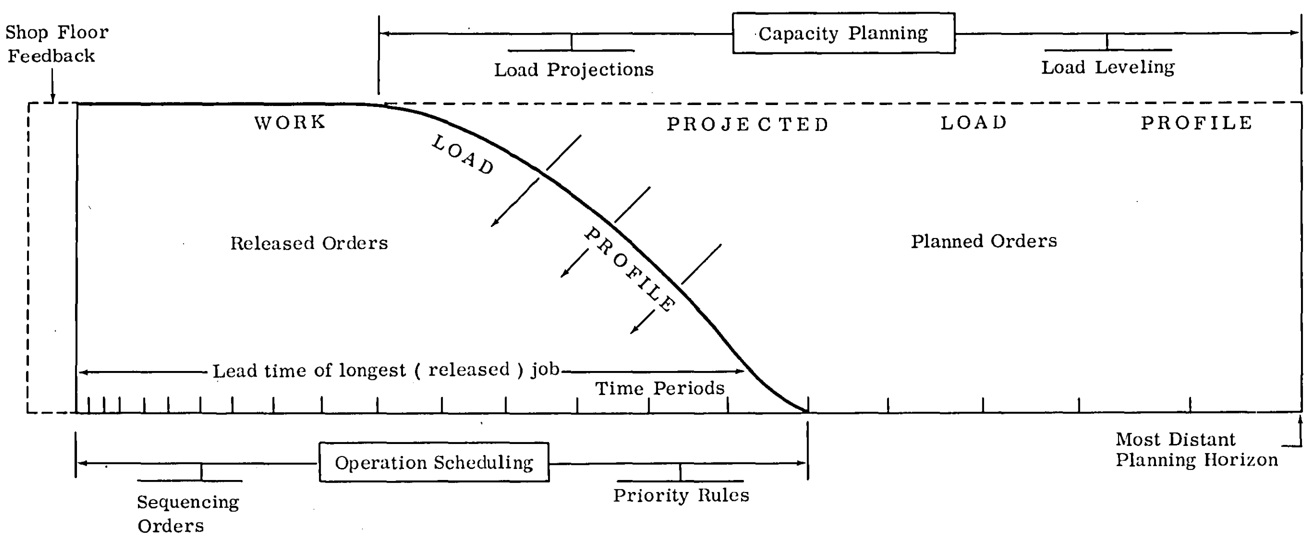

Figure 38. Range of production planning

The example in Figure 39 shows a planned order schedule with part number, part description, order number, scheduled shop start and completion dates, and the quantity associated with the order.

The planned orders that are scheduled to start before the next planning run, when approved, can be entered into the release cycle (see "Shop Floor Control"). This provides the necessary input for the operation scheduling subsystem.

Figure 40 is an example of a work center load report. The load hours represent a summary of all orders that are affecting work center number 234. This report may be used for labor and facilities planning, and as the basis for making judgments for shifting work to other time periods or work centers.

The second column indicates the period start, as well as the number of working days in the period. Capacity hours are broken down between desired capacity (40 hours per week per machine) and maximum capacity (extra shifts and overtime). Load hours are broken down between released orders and planned orders; in addition, an indication is shown of the amount of idleness in a period. The percent of load relates to the desired capacity, and a pictorial "load-to-capacity" ratio is shown for rapid visual scanning of the report.

Date

Planned Order Schedule

Component Part/Assembly Number	Description	Order Number	Scheduled Start Date	Scheduled Completion Date	Order Quantity
4683 PN	CONSOLE HOUSING	A976	650	672	25
4794 XL	CHASSIS COVER	4720	641	651	50
5269 RL	CHASSIS BASE	5775	657	667	50

Figure 39. Planned order schedule

WORK CENTER LOAD REPORT Date:

Work Center No. 234 Dept. 347 Plant No. 3

Period	Days		No.	Capacity		Load					Load-to-Capacity Ratio
1	First	No.	Mach	Present	Maximum	Released	Planned	Total	Idle	Percent	0 100
1	210	5	2	80	100	70		70	10	88	xxxxxxxxx •
2	215	5	2	80	100	20	60	80		100	xxxoooooooo
3	220	5	2	80	100		70	70	10	88	ooooooooo •
4	225	5	2	80	100		60	60	20	75	oooooooo •
5	230	20	2	320	400		250	250	70	80	oooooooo •
6	250	20	2	320	400		400	400		100	oooooooooooo
7	270	20	2	320	400		200	200	120	62	oooooo •
8	290	60	2	1440			1000	1000	440	71	ooooooo •

Figure 40. Work center load report

SUBSYSTEM FLOW

The capacity planning subsystem consists of four modules, two that assemble and edit input, one that prepares reports, and one that contains the logic for the capacity planning functions (see Figure 41).

Module 1 (construct planned order file) uses the results of the requirements planning subsystem, which are stored in the item master record. The module locates each master and extracts the planning order quantity and due date, in addition to item indentification and other descriptive data. This information is combined with and/or extended by other data (for example, time standards, setup, work center identification, etc.) obtained from the standard routing file. It is used to construct the planned order file for the scheduling and loading module.

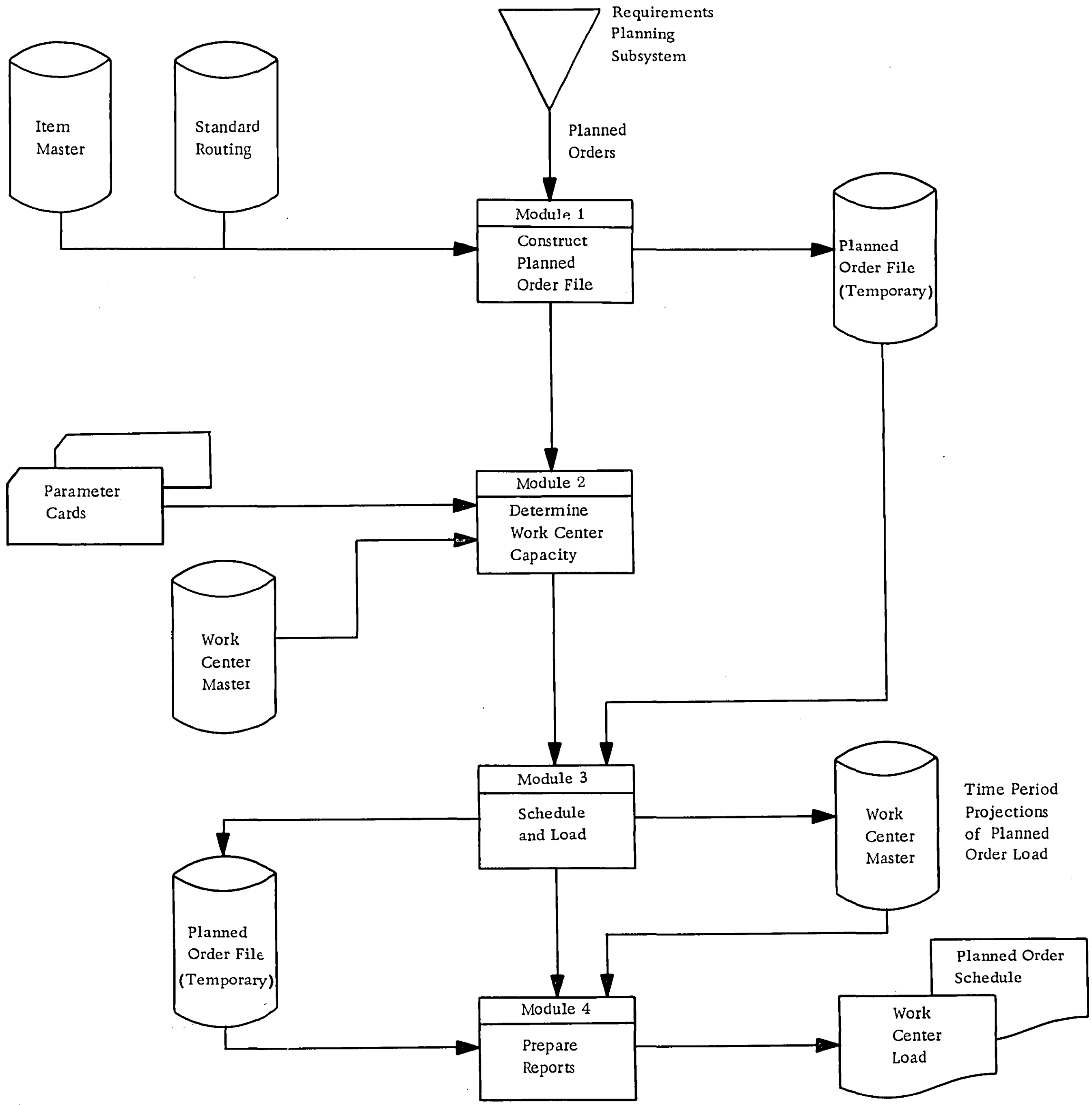

Figure 41. Capacity planning subsystem flow

Module 2 (determine work center capacity) provides the other major input to scheduling and loading. It locates each work center master record and determines the capacity available for planning. This is accomplished by subtracting the load of released orders from the capacity levels of the time periods to be planned. The load imposed on the shop by released orders is summarized in the work center master record by other subsystems (that is, operation scheduling and shop floor control).

In addition, efficiency and capacity reservation factors (for service or unplanned work) can be used to modify the hours of available capacity for each time period.

Module 3 (schedule and load) uses the planned orders and work center capacity to assign start dates for orders and to summarize the load for the work centers. Capacity information can be used to level loads by adjusting start dates of certain orders and/or using substitute work centers, where appropriate. The results of this run are placed in the work center file and in the planned order file.

Module 4 (prepare reports) uses the information produced by module 3 that has been placed in the work center master file and the planned order file to prepare work center load, planned order schedule, and other reports.

These reports are analyzed to determine whether changes are necessary. Except under unusual conditions, it is anticipated that most changes would be for other than the most recent time periods. Ideally, the extreme fluctuation of load for the most recent periods would have been reduced gradually through corrective action over the span of several previous planning cycles. The planned orders that are scheduled to start before the next planning run are placed in the release cycle when the plan is approved.

MODULE DESCRIPTIONS

The modules of the subsystem are discussed separately. They are:

1. Construct planned order file
2. Determine work center capacity
3. Schedule and load
4. Prepare reports

<u>Construct Planned Order File</u>

The principal function of this module is to prepare planned order information. This is accomplished by examining each item master record to determine whether an order quantity has been posted as a result of the last requirements planning run. When an item master record is encountered that has one or more planned orders, this module writes a record in the planned order file. One record is generated for each planned order.

The additional information necessary to describe the order is obtained from the standard routing file (which is located from the address stored on the item master record). Work center identification and sequence, setup, and run standards (stored in the standard routing file) are used to calculate and assemble the record for the planned order.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Construct Planned Order File	• Planned Orders (from Requirements Planning Subsystem)	• Determine Qty. and Data Requirements • Extend Routings on the Basis of Lot Sizes Required • Determine Work Centers Required • Retain Work Center Hours Required • Sort Orders by Priority	Item Master	• Item No. • Planned Qty. • Planned Date • Order No. • Std. Routing-1st Oper. Address	• Planned Order File (Work File used by this Subsystem only)
			Standard Routing	• Oper. No. • Time Stds. -Set Up, Labor, Machine • Work Center Where-Used Chains • Address to Next Oper. • Move Time	

The quantity of the planned order is multiplied by the time standards for the operations. The setup time can be added to determine the total hours of load for the work center. It may be advantageous to calculate load figures for men and machines, and allow the loading function to accumulate two classes of totals for each work center.

The lead time for the order is also placed in the output file. This factor can be obtained from the item master or the standard routing file, and reflects what has been experienced in the shop on previous orders for this item based on average Q-times recorded for each work center, plus setup and run time. It can also be the best available estimate, or it can be calculated using a formula that arrives at a value the manufacturer feels is realistic and desirable.

Another important function of this module is to determine a priority value for each order. This value is used to arrange the planned order file in sequence when scheduling and loading to finite capacity: It ensures that the orders with highest priority are processed first, thereby having the best chance to utilize the available capacity.

Priority is important if the scheduling and loading module is designed to adjust order start dates relative to available capacity. It can be a combination of several factors, such as total cost, ratio of material cost to labor cost, or the fact that it is a part for a particular product or customer, etc. However, the probability is that a significant portion of priority is determined by the degree of flexibility that exists for order start date. In this way, orders that can be moved to earlier periods are identified so that they can be shifted when overloads develop.

The module combines the information from the item master and the standard routing records to prepare the planned order file, which is used as input to the schedule and load module.

Determine Work Center Capacity

This module uses the work center master records and parameter cards to provide capacity information for the schedule and load module. The information includes work center identification and the available capacity in hours for the time periods to be planned (supplied by parameter cards). Other parameters include the length and shop dates for each period, plus an indication of any holidays, etc.

The work center capacity is expressed as two values — maximum and desired. Maximum capacity can indicate a total reflecting a three-shift operation, seven days a week (or any other practical limitation); while desired capacity is a lesser amount indicating a normal or a preferred level of operation.

The capacity available for planning is determined by reducing these amounts by the load that exists in the work centers at the present time. This represents the load for released orders, that is, those that are no longer to be considered for capacity planning and that have been placed under the control of the operation scheduling subsystem. The load of the released orders is available from two other subsystems — operation scheduling and shop floor control. It is used to reduce the capacity for the time periods covered by this load.

In addition, further reductions of capacity may be specified to allow for unplanned work (for example, service orders), and to reflect the efficiency of the work center. These calculations are performed by this module to produce the net hours available during each time period for each work center. A record is produced that is used by the next module.

Schedule and Load

This module uses the work center capacity and order description records, and provides the output

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TIME	DATA BASE: RECORD FIELDS	OUTPUT
Determine Work Center Capacity	• Parameter Cards • Work Center Master File • Option Specs	• Set Up Internal Option Table • Set Up Work Center Load Availability Table • Set Up Work Area • Set Up Definition-of-Period-Size Table	Work Center Master	• Work Ctr. Identification • Available Hrs. by Period-Capacity/Labor/Machine • Wrk. Ctr. Projections-Planned Order Load	

for preparing schedule and load reports. Orders are assigned start dates on the basis of due date, lead time, and the ability of the work center to accommodate the load.

The module performs various initializing functions, one of which is to construct a table of available resources. This is accomplished by reading the work center capacity records (produced by module 2) and retaining selected information within the computer. Provision is made for the accumulation of load hours for each work center and time period. In addition, a shop date and duration is associated with each time period.

The next step is to process the planned order file. The module reads the order record, determines the start date using due date and lead time, and relates this to the resource capacity table. The load hours are added to the totals by time period for each work center specified on the order. The accumulation of load is compared to the available capacity for the work centers. If no overload occurs, the order is dated and placed in the file for writing reports.

When overloads occur, the processing can be modified to include several additional functions. Orders that have flexibility with regard to start date can be shifted to earlier time periods. Each time the load is adjusted to reflect the change in date. If the overload were eliminated, the order would be dated and placed in the report file. In some cases, the overload cannot be eliminated, and the order must be placed in time periods that exceed capacity.

Another function within the module can evaluate and select the start date for the order that causes the least amount of overload. This date is recommended even though capacity is exceeded.

There are two capacity levels — desired and maximum. Therefore, moderate overloads related to desired capacity may still be within an acceptable range. Adjustments to capacity (for example an additional operator) can be considered as long as there is enough time to plan; or perhaps some of the work may be subcontracted. The module can weight overloads that approach maximum capacity higher than those for desired capacity, thereby attempting to keep the load as close as possible to desired capacity.

The module can also provide for the possibility of shifting the load to substitute work centers. These work centers are identified to the module, which is able to determine whether capacity is available in the substitute work centers when overloads occur. The logic can be so designed that substitution is selected before shifting the load to different time periods. The output is coded so that the reports can indicate the action taken.

When all the orders have been processed, the load information for the work centers is placed in the output file for preparing reports. In addition, the total load data can be maintained on the work center master file to provide a net change capability. Changes to the planned schedule are processed by the module by adjusting the load stored within the file. Additional reports can be prepared that reflect the effect of the changes.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Schedule and Load	• Planned Order File (Module 1)	• Determine Work Center Load Hrs. Available • Load Work Center by Machine or Man-Hour Load Requirements • Substitute Load • Reverse Load Hrs. (if "Net Change" desired)	Work Center Master	Planned Order Load	• Updated Work Center Master File • Generalized Report File

Prepare Reports

This module uses the output of the schedule and load module and the work center master records to prepare reports. Many variations can be produced, depending upon the requirements of each company. Two of these output reports and their uses have been discussed under "Objectives".

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Prepare Reports	• Generalized Report File (from Module 3) • Report Types Desired	• Format Output • Extract Load Data by Work Center • Extract Schedule Data • Extract Optional Data	—	—	• Work Center Load Report by Period • Planned Order Schedule Report

SUBSYSTEM SUMMARY

The capacity planning subsystem was designed as a tool for long-range planning. In some cases, the subsystem executes management's policy with regard to the selection of start dates, load leveling, shifting of orders, and work center substitution; and it suggests a plan for approval. In other instances, it highlights conditions for judgments outside the computer. The significant point is that the subsystem provides enough information and time for corrective action. The modules are summarized in Figure 42.

SUBSYSTEM: Capacity Planning (Long-Range)

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Construct Planned Order File	• Planned Order (from Requirements Planning Subsystem)	• Determine Qty. and Data Requirements • Extend Routings on the Basis of Lot Sizes Required • Determine Work Centers Required • Retain Work Center Hours Required • Sort Orders by Priority	Item Master Standard Routing	• Item No. • Planned Qty. • Planned Date • Order No. • Std. Routine-1st Oper. Address Address • Oper. No. • Time Stds. -Set Up, Labor, Machine • Work Center Where-Used Chains Address to Next Oper. Move Time	• Planned Order File (Work File used by this Subsystem only)
Determine Work Center Capacity	• Parameter Cards • Work Center Master File • Option Specs	• Set Up Internal Option Table • Set Up Work Center Load Availability Table • Set Up Work Area • Set Up Definition-of-Period-Size Table	Work Center Master	• Work Ctr. Identification • Available Hrs. by Period-Capacity/Labor/Machine • Wrk. Ctr. Projections-Planned Order Load	
Schedule and Load	• Planned Order File (Module 1)	• Determine Work Center Load Hrs. Available • Load Work Center by Machine or Man-Hour Load Requirements • Substitute Load • Reverse Load Hrs. (if "Net Change" desired)	Work Center Master	Planned Order Load	• Updated Work Center Master File • Generalized Report File
Prepare Reports	• Generalized Report File (from Module 3) • Report Types Desired	• Format Report Output • Extract Load Data by Work Center • Extract Schedule Data • Extract Optional Data			• Work Center Load Report by Period • Planned Order Schedule Report

Figure 42. Capacity planning subsystem summary chart

INTRODUCTION

Scheduling involves assigning dates on which a job is expected to start and finish. This procedure becomes complex because these start and finish dates must be established for thousands of orders moving through a plant at the same time, each contending for limited production facilities, each dependent upon prior and subsequent processing, and each having a priority assigned but subject to change.

In addition, many things occur in a shop that constantly affect the sequence in which work is performed. These occurrences influence the schedule. What appears to be a desirable sequence of operations today may be inefficient at a later date.

The schedule, and its execution, determine whether orders are to be completed on time, the amount of idle time for men and machines, and the dollars tied up for work in process. Therefore, the key factor in this area is the development of realistic schedules, plus a method for efficient execution.

OBJECTIVES

The principal function of an operation scheduling subsystem is to provide information for various levels of management, thereby assisting them in maintaining an economic balance among the following major objectives:

1. Meet the due date for orders.
2. Increase utilization of resources.
3. Minimize in-process inventory.

Specifically, the information must provide answers for questions similar to the following:

What jobs should be worked next?
When will the work be in this department?
What is the relative priority of the jobs?
What tools should be assembled?
What is the load for the work centers?
How much setup is required?
What is the current status of the jobs in the shop?
Should we plan for overtime tomorrow?--the weekend?

To accomplish these overall objectives and provide useful information, the subsystem performs the following:

1. For some short period in the immediate future, it provides a list of jobs to be done at each work center. For example, the list may be prepared daily, extending three days into the future. This list specifies a preferred sequence, arrived at by the use of a dispatching or sequencing rule, while specifically considering the capacity available at each work center. *

2. For the period covered by the dispatching list discussed above, and for a somewhat longer period, it indicates the load that is expected to arrive in the work centers. For some work centers the expected workload may be greater than what can be done using the present capacity, in which case this information is useful for decisions regarding the use of substitute work centers, alternate routing, or the use of overtime.

3. It provides a means to estimate the completion time of each order.

4. It highlights late orders.

5. It provides an analysis of late orders indicating a ranking of work centers relative to the number of late jobs in queue and the amount of time these orders may have to wait in queue if adjustments are not made.

The system accepts information describing the sequence of operations on each job or order, the order's release date and due date, the operations already completed, and the standard time for each operation. In addition, shop capacity information is supplied describing the number of machines or work stations available in each work center in the shop, by day and shift.

SUBSYSTEM FLOW

The operation scheduling subsystem consists of three modules: (1) sequencer, (2) completion time estimator, and (3) tool control (Figure 43). The tool control module is discussed separately for ease of explanation.

Data that describes the jobs to be done (open job order file) and the capacity of the work centers (work center master file), along with the program specifications, are entered into the sequencer phase. Here, the contentions among jobs at the work centers are resolved for a specified amount of time into the future. The time period may be a number of days (for example, ten), and is one of the program specifications for this module.

A general discussion of the sequencer logic is presented in the processing summary section. Output consists of a dispatch list, showing the order in which jobs should be assigned at the work centers. The frequency of preparing the list and the length of time covered by it depend upon each manufacturer's requirements. For example, a list produced daily may contain information regarding the

*See Shop Floor Control with IBM System/360 (E20-0173)

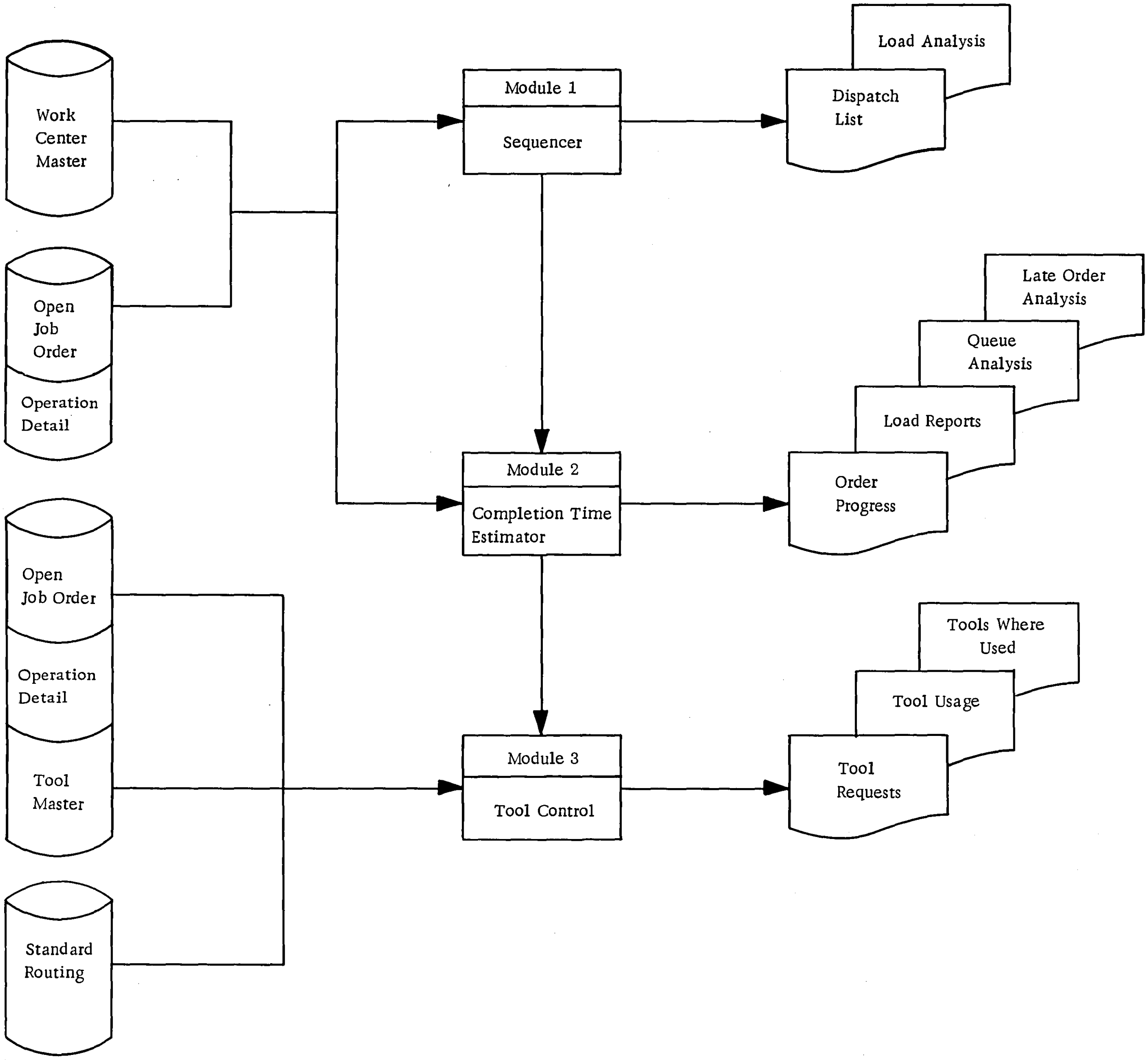

Figure 43. Operation scheduling subsystem flow

next three days. The requirements are not necessarily consistent from run to run; therefore, information of this type must be a program specification.

Another output of the sequencer module is the analysis of load for the various work centers. This is included on the individual dispatch lists and can be consolidated and summarized by department for levels of management. The reports include the number of jobs, the setup hours, and the process hours for increments of time into the future, for example, the next five days. The load figures are subdivided into the amount in queue at the start, the amount predicted to arrive, and the amount expected to be completed during each period.

The completion time estimator module provides information on a less frequent basis, for example, weekly. It provides order status information with an estimated completion date for orders, longer-range load reports, and analysis of queue times and late orders. This information extends into the future through the length of all orders in the file. The reports are illustrated and discussed in the output section. The basic information used for these reports is available as a result of the processing performed by the estimator, which determines an arrival time, a start time, and a completion time for each operation not used in the sequencer module.

The tool control module is designed to overcome such problems as (1) insufficient types of tools, (2) insufficient storage facilities, (3) poor records, and (4) jobs scheduled without regard for tool requirements. This module discusses the organization of the tool master record. It also elaborates on tool requests, tool reporting, usage recording, and tool scheduling.

MODULE DESCRIPTIONS

Sequencer

Before specifying input needs, the manner in which jobs traverse the shop is discussed briefly. Each job is required to spend a certain amount of time at each of a series of work centers in specified sequence in order to accomplish its operations. When a job arrives at a work center, it may or may not have to wait its turn before it can be processed, depending on its relative priority among the list of jobs waiting at the center. After it is processed, it is moved to its next work center. This move usually takes a significant amount of time. The minimum input requirements, then, are a description of the routing for each job, the method of determining priority, the availability of work stations and staff within work centers, and information regarding transit times between work centers. This section describes these requirements.

Another factor that is usually required as input for scheduling is an estimate of queue delay, that is, the amount of time a job spends waiting in queue before being performed at a work center. As stated previously, the value of this factor depends upon the load at the work center when the job arrives and its relative priority within the queue. The technique to be used in the operation scheduling subsystem eliminates this input requirement. Instead, the queue times are determined within the computer for each job at each work center on the basis of the number (and work content) of jobs to be performed, their priority, and the capacity of the work center.*

The input data can be divided into three categories:

1. Order description
2. Work center description
3. General program information

Order Description

Each order is described by the following information:

- Order identification
- Scheduled start date
- Due date
- Priority value
- List of operations in order of occurrence

Each operation must be described by the following information:

- Operation identification
- Status -- code indicating status (that is, complete, run started, etc.)
- Transit time to next operation (optional)
- Setup time
- Run time
- Number of pieces
- Special action on this operation
  a. Overlap with next operation
  b. Assign more than one work station
  c. Process at a substitute work center if overloads occur

The special actions are optional, and the methods for implementing them are discussed in a later section.

It is important that the job or order information be up to date. For scheduling to be efficient, the system must be given accurate information concerning the current status of each operation on each job. The shop floor control subsystem discusses the techniques for recording the latest status from the shop floor.

Work Center Description

A work center is made up of one or more work stations. If a work center consists of more than one work station, any work station is considered capable of performing the tasks assigned to the work center. The person who makes the assignment in the shop makes the final judgment regarding individual job requirements and machine capabilities.

In most situations the terms "work station" and "machine" are synonymous. A work station may require one or more workers to perform its tasks.

The following information must be supplied to describe each work center:

- Total number of work stations
- Number of work stations operating for each shift
- Amount of overtime scheduled for each work station in each period
- Average transit or move time from this work center to any other in the shop (whenever the operation data contains a transit time, this time is ignored)
- Efficiency--a percentage factor used to adjust the amount of work assigned to the work center *

*See Improved Job Shop Management through Data Processing (E20-6071)

*See MOS-Dispatching, and Job and Cost Reporting - Detail (E20-0062)

General Program Information

The most important general information is the "priority rule", which is used by the sequencer to resolve conflicts at work centers. Each operation for each job can be assigned a priority number, which may be a function of many factors, such as:

- Time remaining to due date of job
- Number of operations
- Process time for the operation
- Value of the order
- An importance ranking (perhaps for orders for a particular product group or a particular customer)

An example of a priority rule that can be used is "slack per remaining operation". The difference between the due date and today's date (or the start date) is reduced by the processing time (setup and run) for all remaining operations. This figure (slack) is divided by the number of operations to obtain slack per remaining operation.

$$\text{Priority} = \frac{(\text{Due Date - Today's Date}) - \text{Processing Time}}{\text{Number of Remaining Operations}}$$

In the formula above, the difference between due date and today's date can be converted to hours before subtracting the processing time.

A significant point is that once a rule is specified, the sequencer can recalculate the priority value for each operation on the basis of the latest information, and rank the operations at each queue automatically as they become available.

Other program specifications include the choice of runs to be performed at each iteration and the length of time to be covered by them.

An input specification that is closely related to the choice of runs is the choice of output reports. The types of reports that can be provided are discussed in the following pages.

Processing Summary

The sequencer has access to the files that contain the latest information regarding the status of the orders and the capacity of the work centers. This data, along with various program specifications, provides the input for this module.

The program imitates or simulates the operation of the plant for some time into the future. This is accomplished by constructing tables within the computer that represent the facilities on which the operations are to be loaded. This may be thought of as a model of the plant. Operation records are used to obtain information regarding the work to be done by the model.

The program also records the passing of simulated time by using an accumulator or "clock", which is set to zero initially and incremented as events occur within the program. This enables the program to assign arrival, start, and completion times for operations as they are processed.

Basically, the procedure is as follows:

1. After various initializing functions have been performed, the program sets aside three areas to retain information regarding the work centers, the work stations, and the jobs to be done. The work center area allows the capacity by shift to be retained; the work station area allows for recording the current assignment and the completion time of each operation; the third area (jobs to be done) informs the computer about the priority and availability of jobs at the work centers.

2. Initial assignments for work stations are made by loading the operation currently being worked in the shop or selecting the job of highest priority from the queue (determined by feedback). The operation identification, start time, and anticipated completion time are recorded for each work station that is assigned.

3. The work center with the earliest expected completion time for a currently assigned operation is examined, and the clock is incremented to coincide with the completion time. If other jobs are in queue for this work center, the one with the highest priority is assigned to the available work station. This assignment information replaces that of the previous assignment for this work station. Arrival time, start time, and completion time for each operation are recorded in the file so that the information can be used later for reports.

4. The job whose operation was just completed is assigned a move time to its next work center. A specific move time may be indicated for the completed operation. If not, one may be indicated for the work center where the operation was completed. If neither is specified, an overall move time is used, as given in the general program data.

5. The job is entered in the work center queue for its next operation; its arrival time is determined by:

$$\text{Arrival Time} = \text{Completion Time of Previous Operation} + \text{Move Time}$$

6. The next time at which something is expected to occur is determined (for example, a job arrives at a work center, or an operation is completed), and the process described in steps 3 through 6 is repeated until the end of the planning horizon is reached. As periods are crossed (that is, at the end of each shift), each work center's availability list is updated to reflect the number of work stations to be manned on the new shift.

The above procedure must be amended at times to account for special actions. Three such actions are described: (1) lap phasing, (2) assigning extra work stations, and (3) substitution. The rules for applying each are given below:

1. Lap phasing. This involves moving some of the pieces of a lot to the next work center before all pieces have been processed at a given operation. The operation record specifies the maximum number of sublots into which the lot can be broken for this purpose. Each sublot requires a separate move. The program can suggest a number of moves and start times for the operations, considering move time, setup and run times at both work centers, and the availability of work stations at the next work center. The dispatching lists for both work centers would reflect these recommendations.

2. Assigning extra work stations. Operation input includes a multiple-machine code. The system interprets this to mean that additional machines are to be used for this operation as they become available. The dispatching list would indicate the action that was performed within the system.

3. Substitution. This involves routing a job to a work center other than the normal one for a given operation. Three modes can be used: (a) it is specified on input that this job is to use the substitute group, (b) the logic is to consider the priorities of all jobs at the substitute work center, (c) the program is to substitute only to prevent a work station from becoming idle. The substitution is recommended only if it results in getting the job to its next work center earlier.

The primary results from the sequencer are a list of operations to be performed at each work center, and a projection of the load that is expected to arrive at the work centers within the immediate future.

The principal output from the sequencer is a dispatching list (see Figure 44), which indicates the

WORK CENTER 22045 — DISPATCHING LIST — SHOP DATE 611

ORDER NUMBER	PART NUMBER	OPERATION NUMBER	PRIORITY	SETUP HOURS	RUN HOURS	LOT SIZE	PREVIOUS OP. NO.	PREVIOUS WORK CENTER	NEXT OP. NO.	NEXT WORK CENTER	START TIME	ARRIVAL TIME	CODES
50964	128765	020	172	2.5	11.0	50	010	14046	030	33047	8.0	AVAIL	
50722	124888	040	184	1.7	5.6	30	030	08047	050	14046	8.0	AVAIL	
50611	124111	060	196	.5	3.0	100	052	08049	070	33047	8.0	AVAIL	
50612	125001	040	204	1.8	5.9	75	030	10075	050	14048	8.0	AVAIL	
50511	123321	040	162	1.5	4.0	50	020	12062	050	08047	11.5	10.2	

WORK CENTER 22045 — WORK CENTER LOAD ANALYSIS

SHOP DAY	IN QUEUE OPS	IN QUEUE SETUP	IN QUEUE RUN	ARRIVALS OPS	ARRIVALS SETUP	ARRIVALS RUN	SCHEDULED OPS	SCHEDULED SETUP	SCHEDULED RUN
611	25	48.6	180.7	17	18.6	67.9	11	15.2	57.4
612	31	52.0	191.2	8	9.0	42.5	15	14.2	59.4
613	24	45.8	174.3	12	13.1	53.0	14	17.1	56.0
614	22	41.8	171.3	10	14.0	67.9	9	11.9	62.3
615	23	43.9	176.9	16	10.4	72.6	12	16.4	64.0

Figure 44. Dispatching list with load analysis

order in which jobs should be assigned at the work center. Each operation is described by order identification, operation number, priority, setup and run time, and lot size. Additional information includes the previous work center, next work center, and a start time that is used to sequence the list. Some operations are available for assignment at the start of the run, others are scheduled to arrive when the previous operation is completed. The scheduled arrival time, along with the transaction entry (for example; expedite the move to the next work center), is also printed for the appropriate operations.

For each work center, the load hours divided into setup and run are summarized for five working days into the future. For each day, there are listed the load that is in queue at the start of the day, what is expected to arrive, and what has been scheduled to be worked.

A summary report, perhaps for each department, can be prepared that would include the load information for the work centers within each department. Totals by department would be included, in addition to the data listed on the bottom of the dispatching list. Capacity information, indicating the number of work stations in each center, and the number of men by shift that are available, can also be printed.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Sequencer	• Release Orders (Open Job Order File) • Parameters Length of Run Special Functions • Capacity Data (Work Center Master)	• Initialization • Original Assignment • Job Assignment • Job Completion & Transit • Arrival Time • Determine Next Event • Special Actions	Open Job Order Summary	• Order Number • Scheduled Start Date • Due Date • Job Priority	• Dispatching List Sequence of Operation Load Analysis by Work Center • Summary by Department
			Open Job Operation Detail	• Operation Number • Work Center No. • Next Operation No. • Status Code • Move Time • Standard Hrs. - Setup • Standard Hrs. - Labor/Machine • Special Action Codes • Work Center Identification • Manned Machines by Shift • Work Center Efficiency • Move Time	

Completion Time Estimator

Because the sequencer uses only the operations that are expected to be in the work centers within a specified time (for example, the next ten days), many jobs would not be fully scheduled. Therefore, the principal function of the completion time estimator is to predict the completion dates of these jobs without considering the detailed contentions. This is accomplished by calculating average queue times for each work center and combining these with the processing time and move time for each remaining operation of the job. The sum of move, queue, and processing times is used to estimate a completion date for each operation, and for the order (last operation).

The procedure is as follows:

1. For each work center, determine the priority rating for all operations below which 25% of the operations are contained. Similarly, determine the priority rating corresponding to 50%, 75%, and 100%. These four ratings determine the end points of a set of four priority categories. Every operation is assigned to a category.

2. Summarize the queue times of the jobs at each work center by priority category, and compute the average queue time for each category. This is done for all operations processed by the sequencer. Queue time is the difference between arrival time and start time (these were determined by the sequencer module).

The queue times from previous runs can be retained and used to influence the times developed during the latest iteration. Various techniques, such as weighted average or exponential smoothing, can be used for this purpose.

3. For each unscheduled operation, assign a queue time for the work center involved on the basis of the averages computed in step 2 above and the priority (category 1, 2, 3, or 4) of the operation.

4. Estimate and record an arrival, start, and completion time for each operation. The completion

time of the last operation is the completion time for the order.

The information is available for analysis and the preparation of reports.

The output of the estimator includes reports that relate to order status, work center load, and analysis of queue time and late orders. Several of these reports are illustrated in Figure 45.

The order status report contains a line of information for each order in the file. The order is identified by number and the item being produced. The order quantity, scheduled start date, actual start date, and the current and next work centers are listed to indicate the current status of the order. The remaining information describes what has to be done and how the time between the report date and the completion date will be utilized. The number of operations to be done, standard hours remaining, move time, and queue time are used to estimate the completion date, which, when compared to the due date, provides the number of days each order is early or late.

A detail listing, called a job progress report, can include a line for each operation of every order, or for late orders only. Such a list can consist of a description of the operations, an estimated start date, and an indication of the load hours, move time, and queue time for each. For completed operations, the actual start and/or completion date would be available.

The work center load report illustrated in Figure 45 can specify capacity information, along with the expected load. For each work center, the number of work stations, the staff by shift, and the hours of capacity are listed. The accumulation of the setup and run time for jobs that have an estimated arrival date within each period is printed and compared against the capacity for each period. The last column is the available capacity (plus or minus) for the work center.

This report can be prepared in several versions using different techniques for arriving at load accumulations. For example, one report can list the load on the basis of order completion dates as provided by the estimator. Another report can be prepared that accumulates the load on the basis of changing the operation dates for orders that were estimated to be late. This can be accomplished by removing the estimated queue and move times (or portions thereof) to get these orders back on schedule. The variation in load can be examined to determine the effect that expedite action for these orders would have at the various work centers. This information can give an indication of capacity adjustment (that is, overtime) that may be necessary to meet the due dates.

ORDER STATUS REPORT

SHOP DAY 610

ORDER NUMBER	ITEM NUMBER	ORDER QUANTITY	START DATE SCHED.	START DATE ACTUAL	CURRENT W. C. NO.	CURRENT W. C. QNT.	NEXT WORK CENTER	NUMBER OF OPERATIONS TOTAL	NUMBER OF OPERATIONS COMP.	NUMBER OF OPERATIONS REM.	STD. HOURS REMAINING	MOVE HOURS	QUEUE HOURS	EST. COMP. DATE	DUE DATE	DAYS EARLY
50964	128765	50	606	608	22045	0	33047	5	1	4	28	16	92	617	620	3

WORK CENTER LOAD REPORT

SHOP DAY 610

WORK CENTER NUMBER	NUMBER OF WORK STATIONS	STAFF BY SHIFT	HOURS PER WEEK	CAPACITY ADJUSTMENT (EFFICIENCY)	HOURS CAPACITY WEEK	PERIOD NUMBER	SHOP DAY OF PERIOD START	LENGTH OF PERIOD IN WEEKS	LOAD HOURS SCHEDULED TO ARRIVE SETUP	RUN	TOTAL	PERIOD CAPACITY	LOAD TO CAPACITY	AVAILABLE CAPACITY (HOURS)
14 046	4	4 4 2	400	80.0	320	1	610	1	70	290	360	320	1.12	40-
						2	615	1	58	252	310	320	.97	10

QUEUE TIME ANALYSIS REPORT SHOP DATE 610

WORK CENTER	PREVIOUS ITERATIONS 1	2	3	4	CURRENT SEQUENCER RUN 1	2	3	4	ADJUSTED FOR ESTIMATOR 1	2	3	4
08 046	17.5	26.4	32.7	42.8	15.4	25.2	30.6	41.8	16.8	26.0	32.0	42.1

Figure 45. Examples of estimator reports

The queue time analysis provides estimates of the number of hours that operations are waiting in queue. For each work center, figures are listed for four categories of priority. This is accomplished by arranging the operations in priority sequence and assigning number one to the first 25%, number two to the second 25%, etc. The difference between arrival time and start time is the queue time for the operation. The average queue time for each group is calculated and printed on the report. The results of the previous runs and the current run can be used to provide adjusted wait times, which are used by the estimator.

Another output is the late order analysis report. The operations for these orders can be isolated and processed to provide the number of operations and the total queue time for the late orders at each work center. An average queue time per operation is calculated. In addition, for each work center, the number of late jobs and the queue time can be grouped with respect to periods of allowable overtime (specified as input). The days and the shift on which overtime can be worked are entered into the module. This information is used to subdivide the operations into these time periods on the basis of the estimated start time of each. This provides an indication of the number of jobs and their queues that can be influenced by the use of overtime at each period.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Completion Time Estimator	o Open Job Order File (Includes result of last sequences run)	• Determine Priority Ranking • Summarize Queue Time • Assign Dates • Order Status Reporting • Load Reports • Late Order Analysis	Open Job Operation Detail Work Center Master	• Operation Number • Work Center No. • Next Operation No. • Status Code • Move Time • Standard Hrs. -Setup • Standard Hrs. -Labor/Machine • Special Action Codes • Move Time • Manned Machines by Shift	• Order Status Report • Order Progress Report • Queue Time Analysis • Load Reports • Late Order Analysis

Tool Control

Module Flow

The routines for this module are illustrated in Figure 46.

Requests to the tool crib for tools for specific operations are triggered by the output of the operation scheduling subsystem. This may be the dispatching list or other documents that are used for locating tools in the crib and reporting back to the system the action performed relative to the request. The reporting may be done on an exception basis, that is, reporting only when tools are not available or when more than one tool exists of a particular number and usage and/or location is recorded within the system.

On a cycle basis or in response to specific requests, complete where-used information for tools can be provided. The where-used information would specify all operations within the standard routing file for which a tool is used, or it could be restricted to the where-used within the open job order file, which provides the specific usage of tools in the immediate future.

Reports highlighting unavailability of tools and delay of operations can be summarized to assist in determining the need for additional tools.

Maintenance codes, in conjunction with usage information accumulated on the tool record, can provide recommendations for tool maintenance that do not conflict with imminent tool usage.

Organization of Records

Tool information is concerned primarily with the tool master, the standard routing, and the open job order files. Each series of operations in the standard routing file is related to an item master. Figure 47 illustrates the relationship among the tool master, the standard routing, and the open job order files. The standard routing has the identification of the tools that are used in conjunction with the operations. This provides complete tool usage information, as every operation in the standard routing file carries this information, whether an order is active or not. Conversely, each tool master has access to complete where-used information via the standard routing file. This is provided by a

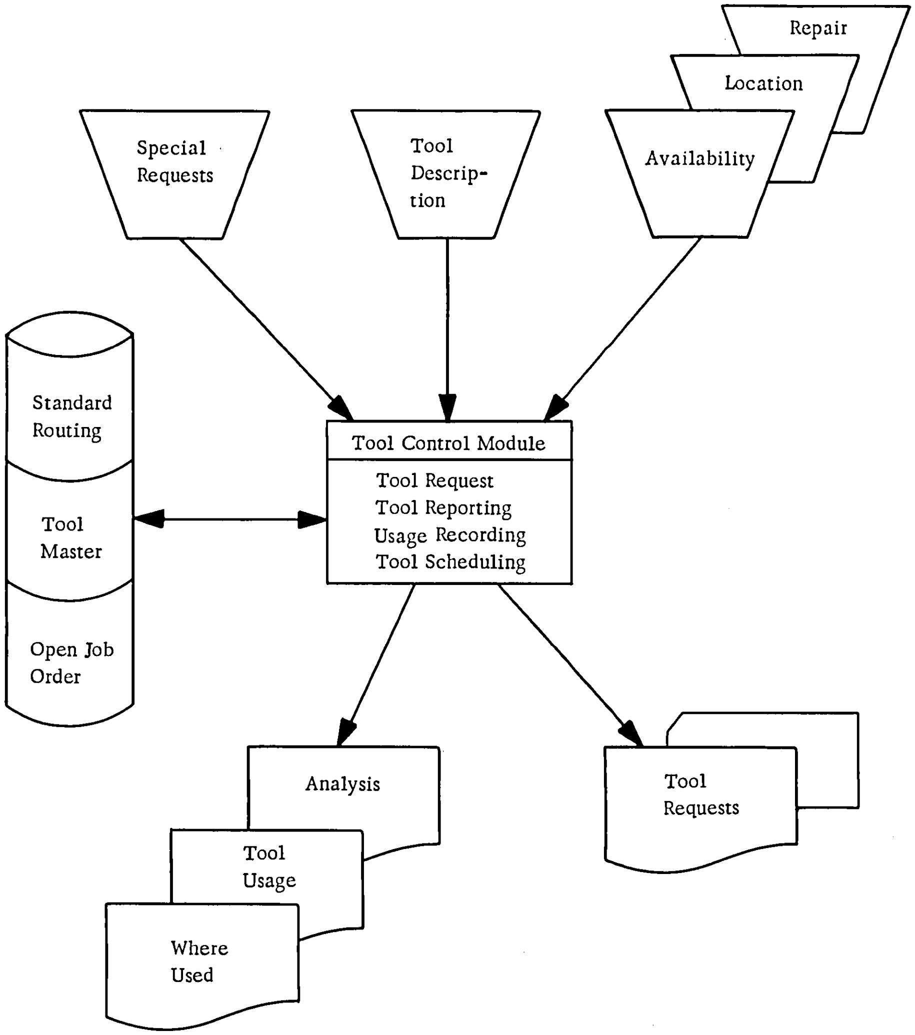

Figure 46. Tool module flow

series of references, starting with each tool master and identifying each operation that uses the tool.

When orders are released, the information in the standard routing file is modified and appended to reflect the specific order number, due date, quantity, etc., and placed in the open job order file. The tool relationships are preserved, thereby providing current tool usage and where-used information for open orders.

Processing Routines

Tool request. As jobs become available or are scheduled to arrive at a work center, a request for tools is made. The method employed to request tools from the tool crib(s) depends upon the amount of tool information stored within the system and the degree of control the user would like the module to exercise.

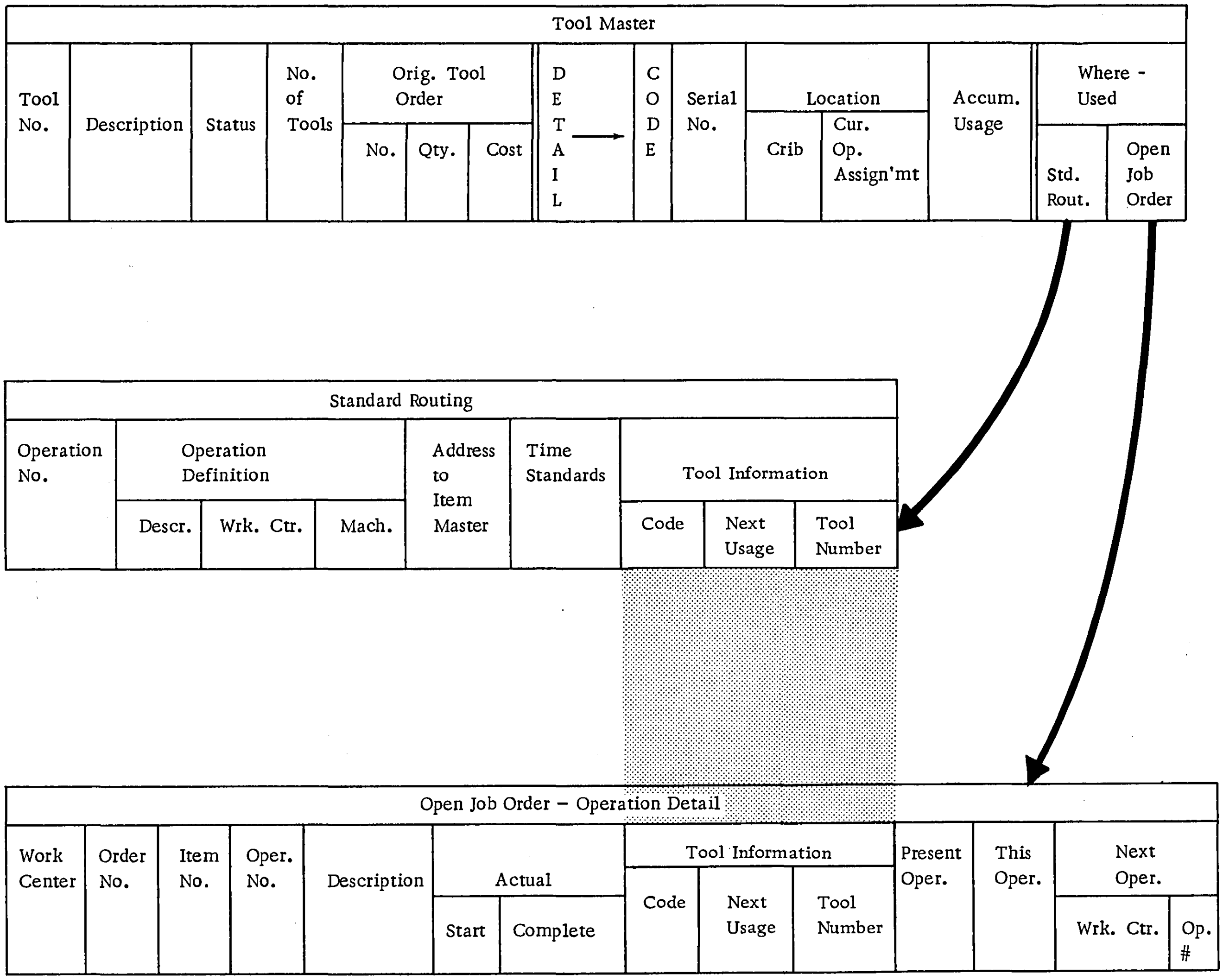

Figure 47. Relationship of tool records

One type of tool request could be the dispatching list furnished by the operation scheduler, which could be modified to include tool requirement codes (Figure 48). Tool crib personnel would assemble the tools and report the availability (or unavailability) of tools to the system. Tools could be assembled from lists maintained outside the computer, e.g., the tool crib.

When tool information is added to the standard routing file, the tool request can include more information. When orders are released, the records in the standard routing file are used to construct the open job order file. This file has access to the same tool information. Thus, as a job is scheduled to start, a request for tools can be prepared. The request contains order and operation identification, work center number, and a list of the tools required to perform the operation

The dispatching sequence furnished by the operation scheduler is scanned to determine the jobs that require tools and that are due to start in the near future. A document is prepared for the tool crib to assist in locating the tools and to provide a means for reporting back to the system.

A special list (or a series of forms, or punched cards) can be prepared that is based upon the dispatching sequence and that consolidates the tool requests in a more useful sequence for crib personnel (see Figures 48 and 49). If the location of the tool has been recorded and maintained by the system, the location also is listed. The individual forms and cards constitute a working document for

WORK CENTER 22045			DISPATCHING LIST							SHOP DATE 611		T – TOOLS REQUIRED A – TOOLS ASSEMBLED
ORDER NUMBER	PART NUMBER	OPERATION NUMBER	PRIORITY	SETUP HOURS	RUN HOURS	LOT SIZE	PREVIOUS OP. NO.	PREVIOUS W. C.	NEXT OP. NO.	NEXT W. C.	START TIME	ARRIVAL TIME	CODES
50964	128765	020	172	2.5	11.0	50	010	14046	030	33047	8.0	AVAIL	T A
50722	124888	040	184	1.7	5.6	30	030	08047	050	14046	8.0	AVAIL	T A
50611	124111	060	196	.5	3.0	100	052	08049	030	33047	8.0	AVAIL	T A
50612	125001	040	204	1.8	5.9	75	030	10075	050	14048	8.0	AVAIL	T
50511	123321	040	162	1.5	4.0	50	020	12062	050	08047	11.5	10.2	T A
50												AVAIL	T
51												8.9	

TOOL REQUEST									
ORDER NUMBER	PART NUMBER	OP. NO.	DEPT.	WORK CENTER	TOOL IDENTIFICATION	LOCATION	✓	NEW LOCATION	DATE
3125	237784	2	1400	1000	1862377	15 09			611
RECEIVED			DATE						
RETURNED									
TOOL CRIB COPY									

Figure 48. Request for tools

tool assembly, that is, they can be used as a pulling list and for control over the return of tools to the crib when the job is complete. The individual card has the added utility of being a turnaround document for reporting back to the system.

The operation record in the open job order file is coded to indicate that a tool request has been issued, thus ensuring that multiple requests are not prepared.

In a plant where remote terminals are used for two-way communication between a central computer and the tool crib(s), these documents can be pre-

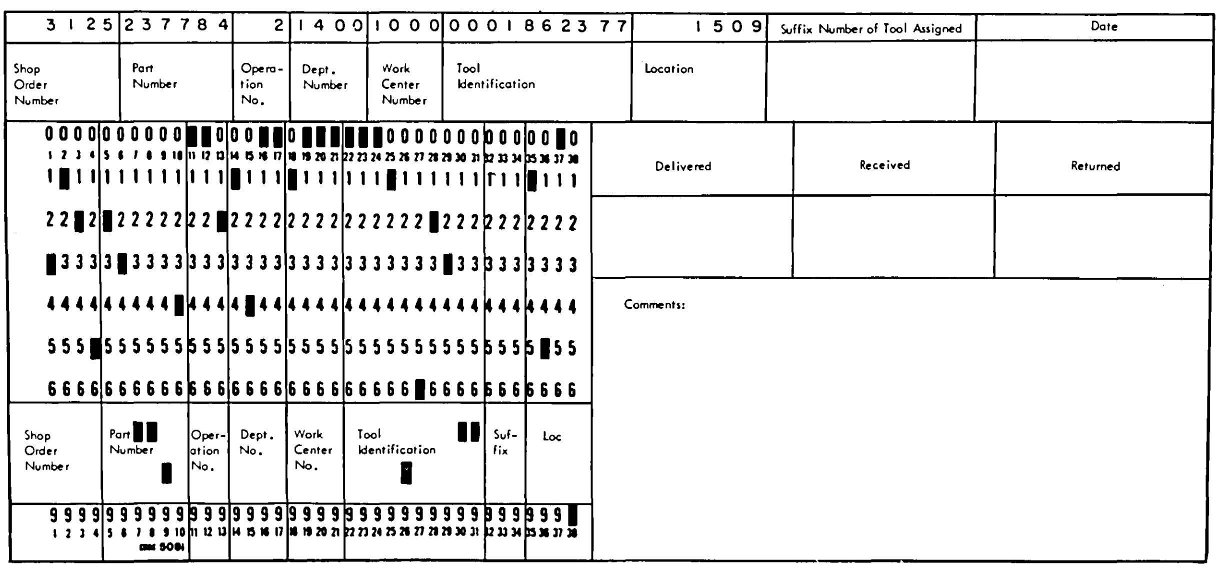

Figure 49. Tool request card

pared as needed at the crib. In addition, the terminal provides the means to report tool activity back to the system on a more timely basis.

Tool reporting. There are several points where tool activity is reported to keep the files up to date. The module provides for tool availability (or unavailability), maintenance and repair, and location reporting.

Tool availability reporting relates to the request to the crib for tools used on a specific operation. This may simply be a positive or a negative response for scheduling and tool usage recording. If negative, an indication of the specific tool number and the time it will be available is included.

If usage information is being recorded for measuring tool life, and more than one tool exists, the specific number of the tool assigned is necessary to update the correct tool record. The reporting can be accomplished on an exception basis in conjunction with tool scheduling, which assigns the specific tool number. Crib personnel report only when they are unable to use the tool requested.

Reporting of tool availability provides the system with the data to update usage, highlight the tools causing delays, and assist in scheduling operations.

Availability reports from the shop floor are used to locate the specific operation record in the open job order file, and the specific tool record for the operation. The operation record is coded for tool availability, or it is placed in a hold state if the tool is not available. The tool record is updated to reflect the job on which it is being used or the reason it is not available. For unavailability reports, the date the tool will be available and the location should be included. The routines check for and report discrepancies; for example, a tool is reported in use on a completed operation, or a tool that is coded for repair is reported in use. These exceptions are listed on a report for verification.

Another point of reporting tool activity occurs when tools are sent out for maintenance and repair. A date for the expected return, the new location, and a code are recorded on the specific tool record. When the system is informed of the tool failure, it can examine the current where-used information (open job order - operation detail) and list the jobs that require the tools. This information is available to the operation scheduler for preparing the dispatching list. It does not schedule the job to start until the tool is available.

When the system is informed of repair or maintenance of tools, it places this information in the tool master file. The new location, status code, and expected return date are recorded for the tool specified. A list of operations from the open job order file can be prepared to determine the effects on the schedule.

Location reporting enables the module to record and retrieve this information for operating personnel. Tool requests can indicate where the tool is stored or the work center at which it is being used.

If tools are returned to the same place in the crib, location is reported only when the tool must be stored elsewhere. Location is provided as input when the tool master is added to the file, and it is not changed until a new location is supplied by the tool crib. When the tool is in use, its location is the work center in which the job is being performed.

Usage recording. Some tools require usage information to determine their status relative to expected tool life (time between tool resharpenings or tool replacements). There are several methods of recording usage, and a company may employ one or more of these within a plant, for example, elapsed time, actual cutting time, etc. Therefore, the tool control module provides for an accumulation of usage and a code to identify the method. Each operation that requires the use of this tool may also have a factor and code to complete the reconciliation and updating. For illustration, assume the tool life is measured in hours of actual cutting time. This would be coded and stored on the tool master. In addition, each operation would have an indication as to how pieces, elapsed run time, etc., can be converted to the unit of measure on the tool master. For example, the code may indicate an amount per 100 pieces, which would be used by the program, in conjunction with pieces reported, to determine the number of hours to accumulate in the usage field.

The accumulated usage information is checked against the tool life to determine whether the tool should be highlighted for action.

There may be several tools of a specific number. Therefore, usage information is recorded for each tool. This requires that reports to the system identify the unique tool used, or that the tool number assignment be made by the system at the time of tool request. The people in the tool crib must use the exact tool specified (or report back on an exception basis the number of the tool selected).

Analysis and exception reports regarding tool usage and tool failures reported from the shop floor can be prepared when tool usage reporting is a part of the module.

Tool scheduling. When tool records are maintained and updated, and they contain the current location of the tool, a determination of availability can be made before a request for tools. Jobs can be scheduled to minimize tool conflicts. This is accomplished in conjunction with the operation scheduling subsystem and the tool master records. The operation detail records in the open job order file contain the tool number (or pointer to a list of tools) needed for each operation.

One level of control is to highlight tool conflicts (that is, use of the same tool for different operations), using the computer to arrange all multiple usages of tools by date. The list contains the identification of the jobs that are causing the conflict. Shop personnel can use this list for scheduling purposes, assembling the tools for the job that best solve the conflict. This may be done on the basis of the priority of the jobs, or the processing time of the jobs, etc. The final decision regarding where the tools should be used rests with the people on the shop floor.

The report identifies areas that require action. Some jobs may be rescheduled, or it may be enough to expedite the return of tools currently in use on the shop floor. If additional information is needed, a current where-used inquiry can be made. The response would indicate all jobs in the open job order file on which the tool is used.

Another procedure permits the operation schedules to make recommendations regarding the sequence in which jobs should be processed on the basis of tool information in the file. Two jobs that require the same tool for the same time are not scheduled. The tool request lists the priority of tool assembly and flags jobs on which tools are needed elsewhere in the near future. This helps to ensure the prompt return of tools. To assist tool crib personnel, the request can specify the job on which the tool is needed next.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Tool Control	• Tool Availability • Maintenance & Repair • Usage • Location	• File Load and where used • Tool Request • Tool Reporting • Usage Recording • Tool Scheduling	Tool Master	• Tool Number • Status • Number of Tools • Where-Used Standard Routing Open Job Order • Location Crib Current Operation Assignment • Accumulated Usage • Tool Life Estimate • Date Last Inspected	• Tool Requests • Maintenance Recommendations • Analysis of Tool Usage • Where-Used Complete Current
			Open Job Operation Detail	• Tool Information Code Number or Address	
			Standard Routing	• Tool Information Code Number or Address	

SUBSYSTEM SUMMARY

The operation scheduling subsystem provides the type of information and working documents that help manufacturing companies control production more effectively. The input, output, and data requirements for the modules are summarized in Figure 50.

SUBSYSTEM: Operation Scheduling

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE RECORD TITLE	 RECORD FIELDS	OUTPUT
Sequencer	• Released Orders (Open Job Order File) • Parameters Length of Run Special Functions • Capacity Data (Work Center Master)	• Initialization • Original Assignment • Job Assignment • Job Completion & Transit • Arrival Time • Determine Next Event • Special Actions	Open Job Order Summary	• Order Number • Scheduled Start Date • Due Date • Job Priority	• Dispatching List Sequence of Operation Load Analysis by Work Center • Summary by Department
			Open Job Operation Detail	• Operation Number • Work Center No. • Next Operation No. • Status Code • Move Time • Standard Hrs. - Setup • Standard Hrs. - Labor/Machine • Special Action Codes	
			Work Center Master	• Work Center Identification • Manned Machines by Shift • Work Center Efficiency • Move Time	
Completion Time Estimator	• Open Job Order File (Includes result of last sequences run)	• Determine Priority Ranking • Summarize Queue Time • Assign Dates • Order Status Reporting • Load Reports • Late Order Analysis	Open Job Operation Detail	• Operation Number • Work Center No. • Next Operation No. • Status Code • Move Time • Standard Hrs. -Setup • Standard Hrs. -Labor/Machine • Special Action Codes	• Order Status Report • Order Progress Report • Queue Time Analysis • Load Reports • Late Order Analysis
			Work Center Master	• Move Time • Manned Machines by Shift	
Tool Control	• Tool Availability • Maintenance & Repair • Usage • Location	• File Load and where used • Tool Request • Tool Reporting • Usage Recording • Tool Scheduling	Tool Master	• Tool Number • Status • Number of Tools • Where-Used Standard Routing Open Job Order • Location Crib Current Operation Assignment • Accumulated Usage • Tool Life Estimate • Date Last Inspected	• Tool Requests • Maintenance Recommendations • Analysis of Tool Usage • Where-Used Complete Current
			Open Job Operation Detail	• Tool Information Code Number or Address	
			Standard Routing	• Tool Information Code Number or Address	

Figure 50. Operation scheduling subsystem summary chart

INTRODUCTION

Some of the major problems of production control are caused by the lack of timely information regarding the status of production orders. It is important to know the orders that are on time, the orders that are behind schedule, where the jobs are at the present time, and the work centers in which they have to be processed. In addition, exceptional conditions (for example, excessive order costs and unusual delays) should be highlighted for management action.

Many companies have thousands of orders at various stages of production. It is almost impossible to keep accurate, up-to-date records for these orders using a manual system. The major difficulties are (1) the great volume of information that must be considered, and (2) the comparatively small amount of time available before a decision is necessary. Data processing systems are capable of storing and processing the vast amount of data required to maintain control of work in the shop. The use of data collection equipment reduces the time lag between an event and its recognition to the point where the information and control system can be as dynamic as the shop itself.

OBJECTIVES

The principal objective of the shop floor control subsystem is to provide current information and thereby assist management in its efforts to control production effectively.

To accomplish this overall objective, the subsystem provides the documents necessary to identify the jobs and to report the progress of the work on the floor. This includes the creation and maintenance of data processing records on which the status is recorded within the system.

These functions can be divided into two areas--release of new orders, and order progress reporting.

With regard to the former area (release of new orders), the processing that is done before the release of an order to the shop includes the creation of the open job order file and the preparation of reporting documents. Material requisitions, labor reporting tickets, and move tickets are prepared in addition to the routing sheet.*

With regard to the latter area (order progress reporting), the transactions that affect the status of the open job order file are processed and recorded within the system. Both areas are discussed in more detail in the following sections.

*See Aerospace Information and Control Systems - Shop Control (E20-8121)

SUBSYSTEM FLOW

The information flow for shop floor control is illustrated in Figure 51. Released order information is made available to an order release module to create the open job order file and prepare the output documents. The item number on the input enables the system to locate the item master and the standard routing files. The input information, combined with the data in the files, is used to produce the output documents that accompany the material when the job is released to the shop.*

As the work progresses through its stages of production, reports are made available to the system. This information is used to update the open job order file, thereby providing the current status for management and the other subsystems, for example, operation scheduling. Audit listings and exception reports can be produced to verify the transactions and to identify possible errors and/or trouble spots, for example, insufficient quantity reported complete. The method and frequency of collecting data in the shop can range from gathering prepunched cards (marked with variable data) at the end of the shift to the use of IBM data collection equipment connected directly to a central computer. The selection of the method and frequency of data collection is an economic judgment to be made on the basis of the requirements of each company. This section places emphasis on transactions and their relationship with the files rather than on the method of data collection.

The subsystem flowchart in Figure 51 indicates the general relationship among the files. Before discussing input, output, and processing for shop floor control, the file relationship is presented in more detail. Figure 52 illustrates some of the fields within the item master, standard routing, work center master, and the two sections of the open job order file--order summary and operation records.

The item master file contains the address where the standard routing information has been stored. This is used wherever it is necessary to locate the routing information for a particular item, as in the case of order release.

The on-order quantity in the item master is supported by one or more open job order records. The

*See Shop Floor Control with IBM System/360 (E20-0173)

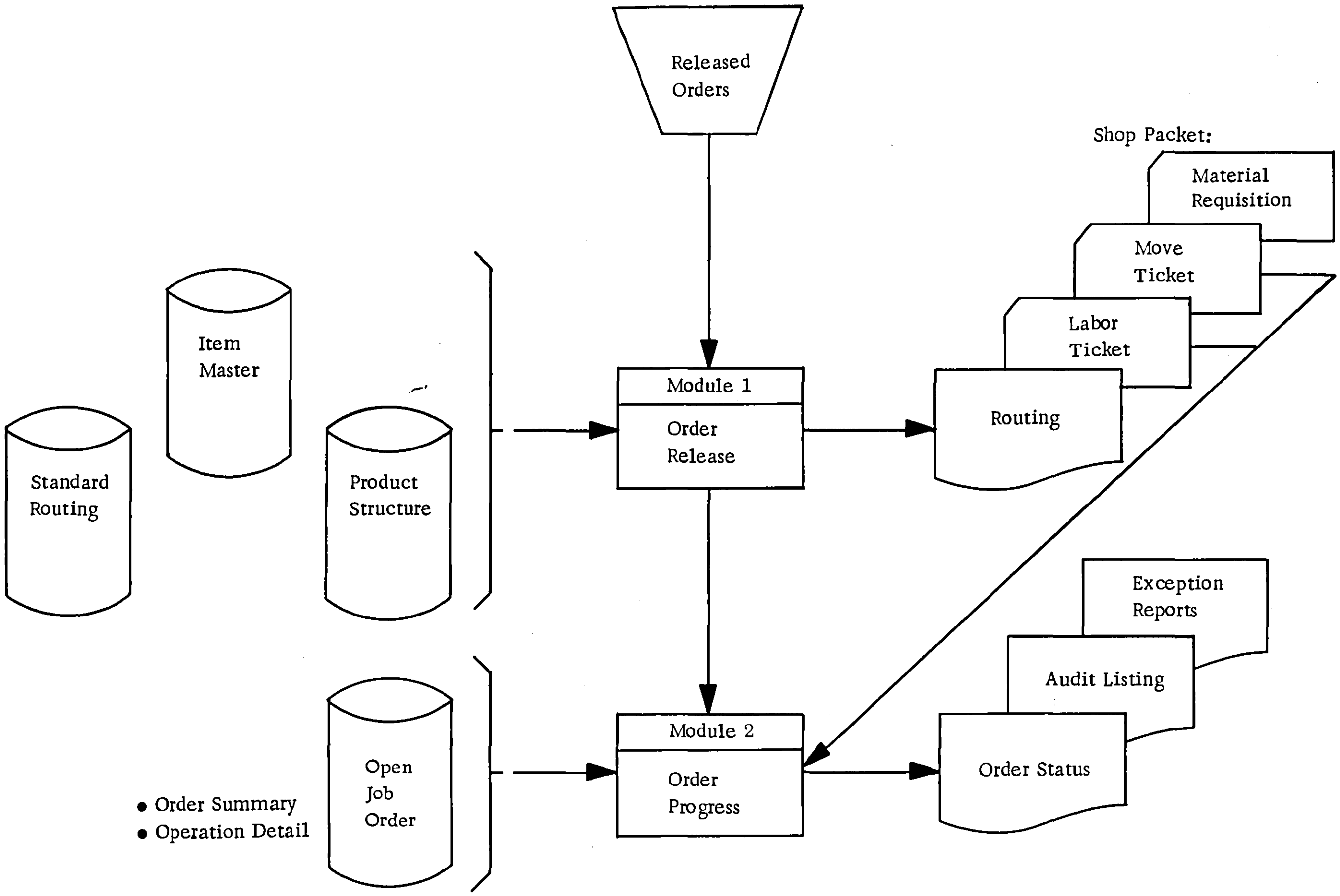

Figure 51. Shop floor control subsystem flow

item master record has the order number of the record in the open job order file (order summary) that relates to this item. If more than one order exists for an item, each order summary record has the number of the next order for the item. In this way, the record for every order for an item can be located. Conversely, each item master record can be located using the item number stored in the open job order file.

The open job order file has two sections--order summary, and operation detail. The order summary section has information that enables the system to locate the operation record for the current work center. Each operation detail record, in turn, specifies the location in the next work center, thus providing the ability to locate every operation detail record for each order summary. In addition, the operation records can be stored in sequence by order number and can be located from input transactions that specify work center, order number, and operation number.

Finally, the work center master file contains the location of the first of a series of records in the standard routing file. The standard routing records contain the location of the next record for this work center. In this way, all records in the standard routing file are chained to a work center master. Similarly, all operation records of the open job order file are referenced to the master record for the work center in which they will be performed.

These relationships make it possible for the system to locate the appropriate record as the input transactions are processed.

MODULE DESCRIPTIONS

The modules of the shop floor control subsystem are described by discussing the input requirements, followed by a summary of the processing that is done within the computer.

When the decision regarding the release of an order has been made, the subsystem requires the following information:

- Item number
- Quantity of the order
- Due date and start date of the order

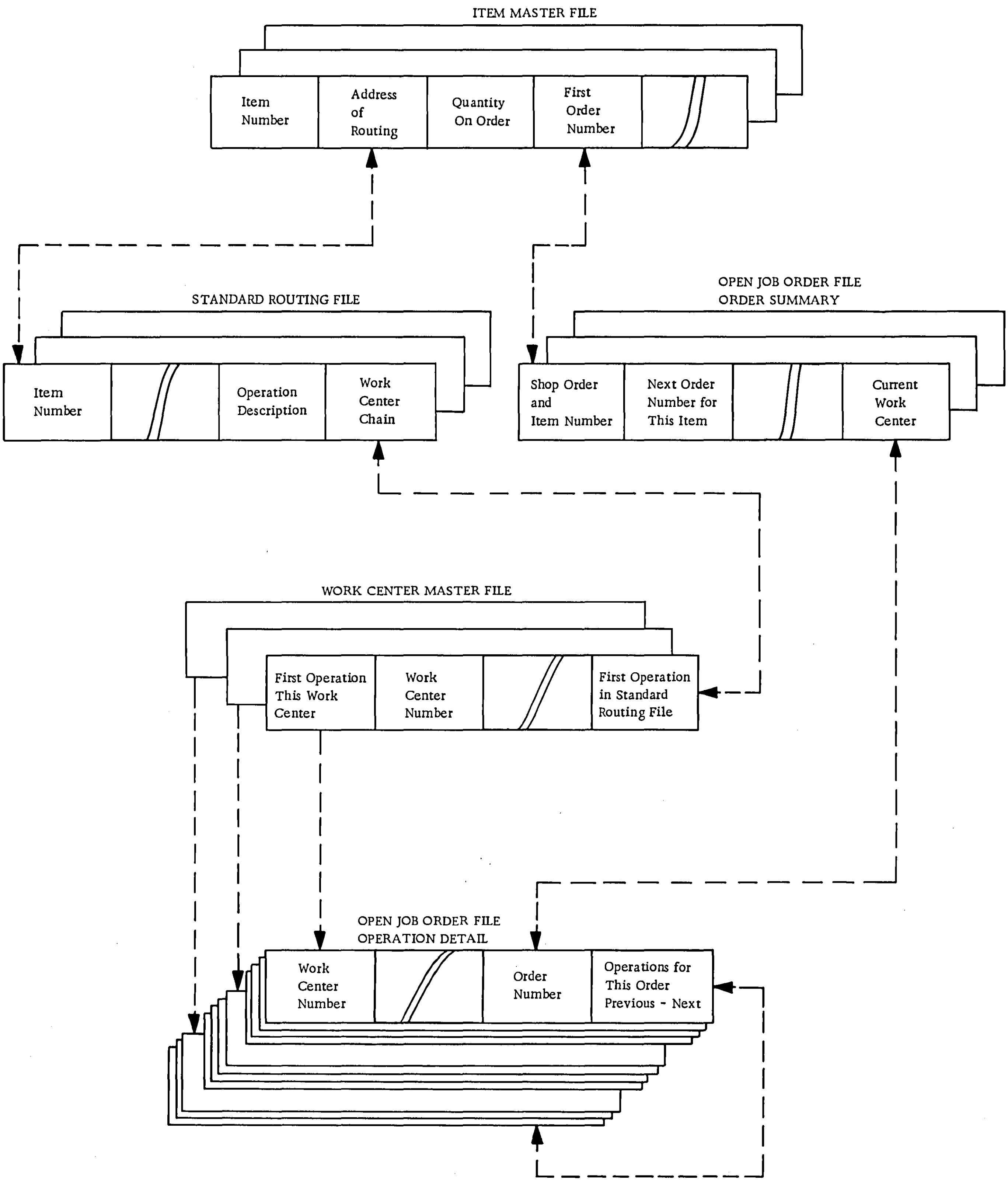

Figure 52. File relationship

This information is available from the output provided by the requirements planning and capacity planning subsystems, and can be used as input to shop floor control after approval or modifications.

To report order progress, the following information is necessary:

- Order number
- Operation number
- Work center number
- Transaction code
- Transaction information

The requirements for transaction information depend upon the code and the type of reporting specified by each company when the system is designed. For example, if the code indicates the transaction is a labor report for the completion of an operation, the additional fields may be employee number and quantity. Another company may wish to include machine number, start time, and completion time.

Fields of information that may be included on a labor report are quantity, hours, start time, completion time, employee number, and machine number. These are in addition to the fields required to identify and locate the records, that is, order identification, operation number, and work center number.

A move report may include, in addition to order information, the work center from which the material has been moved, the work center where it is now, and an identification of the employee reporting the move.

Scrap reporting may include an authorization code or number, in addition to the quantity. Any special transactions involving the delay of work may include codes for identification of the type of delay (for example, tool unavailability or repair) and a date when the condition is expected to be relieved. *

Order Release

The routing sheet and the reporting documents are prepared a certain number of days (ten is used in this example) before release of the order to the production control department or the shop floor. This provides time to determine material and tool shortages and allow the information to be entered in the open shop order file for use by the operation scheduling subsystem.

Using the input that describes the order, the subsystem can locate the item master record and the particular series of operation records in the standard routing file. For assembly orders, the product structure file is available to prepare a parts list, in addition to the operation data. The output summary section includes examples of documents that are prepared.

The output reports and the information for the open job order file can be classified as heading (order summary) and detail (operation detail). The system, having read the item master and the first record in the standard routing file, assembles the information for the heading portion of the routing sheet and the order summary portion of the open job order file. Each operation record in the standard routing file is used for preparing the detail on the routing sheet and the entry to the operation record section of the open job order file.

The records for entry into the two sections of the open job order file are processed to insert the records in their proper position in the file and to ensure that all cross-references are established.

The order quantity specified as input is used in conjunction with the time standards and shrinkage factor on the standard routing to determine the load hours for the operations. This information is stored in the open job order file.

The cards to be included in the shop packet are punched at this time. The number of cards required depends upon the method of data collection used in the shop. If IBM data collection equipment is installed, an order identification card can be used over and over at every point of reporting. Variable information, such as quantity, is entered at the terminal, combined with the card data, and transmitted to a central recording area.*

If cards are collected as part of the reporting method, operation identification cards are produced. Using this approach, cards can be punched as follows:

- Job cards--adequate number to report the labor for each operation
- Move ticket--one per move
- Issue card--one per type of material to be issued.
- Receipt--one per shop order

Allocation of material and recognition of shortages may be done at the time the shop order is being prepared for release to the plant. Some companies may desire to allocate when the order is still considered to be a planned order. Provision can also be made to incorporate the allocation procedure as part of the capacity planning subsystem. In this way, a somewhat longer time period would be available for corrective action.

Basically, the processing for material allocation is as follows:

The raw material item master record (or the item master records for all parts of an assembly, as

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*See Management Operating System - Dispatching and Job and Cost Reporting - Detail (E20-0062)

*See IBM Data Collection in the Factory (E20-8076) determined by the product structure file) must be checked for availability, and the requirements must be added to the allocated field. If there is insufficient quantity, an output record is produced that can be used to prepare shortage lists for the inventory control department and/or the production control department.

Management must decide upon the procedure to be followed for shortages; for example, assembly orders may be released regardless of the shortage of certain items, while orders for fabricated parts are held for action. If raw material is not available in sufficient quantity, the order may be split or rescheduled, or other orders using the raw material may be modified on the basis of the quantity of new material available and the receipt date of any outstanding purchase order.

The system can retain the shortage information with a reference to the shop order that is being delayed. Receipts to stock, as a result of purchasing or fabrication, would be used to identify the orders automatically on which the shortages have been eliminated.

The master records for the items on which shop orders were released are changed to reflect the on-order status. The quantity (of the released order) recorded as planned in the record is eliminated. Each item master with quantity on order has a reference to the open job order file. If more than one outstanding order exists for an item, the records in the open job order file are chained.

The work center master is modified to reflect the addition of the operation records for the newly released orders. The files are available to record the status of the work in process.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATE BASE RECORD TITLE	 RECORD FIELDS	OUTPUT
Order Release	• Order Release Data (From Capacity Planning) Item Number Quantity Due Date Start Date • Changes to Orders	• Item No. Master Update • Extension of Standard Routing • Construct Open Job Order File • Prepare Shop Order Allocation	Standard Routing	• Item Master Address • Operation Number • Work Center No. • Time Standards-Setup Hours • Time Standards-Labor/Machine • Special Action Codes • Tool Information Code Number or Address	• Shop Packet: Routing Sheet Labor Reporting Cards Material Requisition Move Tickets Receipt to Stock Parts List for Assembly Orders
			Item Master	• Item Number • Planned Orders • On Order-Production Total Quantity Address to Detail • Allocated Quantity • Standard Routing-First Operation Address • First Assembly Component Address • Current Engineering Change Number	
			Product Structure	• Component Item Master File Address • Compare Portion of Component Item Master • Next Component Address • Quantity per Assembly • Current Engineering Change Number	

Order Progress

The reporting of order progress is summarized in the open job order file. Such transactions as labor reports, move tickets, etc., are entered into the subsystem as input. The order number, operation number, and work center number provide the means to locate the record to be updated. Depending upon the transaction code and the fields of data that are included on input, one or more fields in the file may be changed. In addition, various edits can be performed to ensure that the information is reasonable relative to what is expected; for example, the quantity reported for an operation can be checked against the quantity of the previous operation. Transactions that do not pass the edit tests can be highlighted for verification.

As an example of the processing, assume that an operation card was marked with the quantity completed by the employee, collected, and keypunched for entry in the computer.

When the card information is read by the computer, the open job order file is referenced. Both the order summary and the operation record for this order can be located and read by the system.

The quantity on the input transaction is added to the quantity completed for this operation. The total is compared against the quantity reported on the previous operation to ensure that the second operation quantity is not greater than that of the first. If this report is coded for operation completion, the module can also ensure that the second operation quantity is not less than the first by more than the shrinkage or scrap allowance for the current operation. The status code is updated, and the operation record is returned to the file.

The information from the operation record is recorded on the order summary and returned to the file. The current operation and quantity fields are changed to reflect the latest transaction. If the operation is complete, the next operation number and work center number are inserted on the order summary. In this way, the order summary contains the latest information and is referenced to the record that describes the operation currently being processed in the shop.

If start and completion time were included on the input, this would be posted in the operation record. Cost information can also be accumulated in a similar manner.

In addition to the file updating, a record of the transaction can be produced. This would be processed for preparing audit listing and exception reports. It would also provide an automatic entry for other application areas not discussed specifically in this manual, for example, payroll.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Order Progress	• Labor Reports • Material Moves • Scrap Reports • Exception Notice (held for tool no. drawing, etc.)	• Locate Open Job Order • Update Operation Record • Update Order Summary • Edit Transaction • Prepare Output	Open Job Order Summary	• Item Number • Order Number • Number of Operations This Order • No. Completed Operations • Address to Operation Detail • Qty. Completed-Present Operation • Qty. Completed-Current Operation • Scheduled Start Date • Engineering Change No. • Current Work Center • Scrap Reported • Shrinkage Factor • Standard Material Costs • Labor Costs-Standard To Date • Job Priority	• Exception Report • Audit Listings • Order Status
			Open Job Operation Detail	• Work Center No. • Operation No. • Move Time • Scheduled Start Date • Actual Start Date • Qty. Complete-Previous Operation • Qty. Complete-This Operation • Qty. Scrapped • Status Code • Tool Information • Labor Costs Standard/Actual	

Output

The output at the time of order release is the shop order and cards for reporting progress. The shop order or routing sheet states what must be done on a product, assembly, or part, as well as where and how it will be done. It specifies the quantity to be produced and the material that is used. In addition, the path, sequence, and timing of the operations to be performed and the machines required to accomplish these operations, are identified.

Shop orders are prepared for both assembly and fabrication manufacturing. The assembly order consists of bill of material listings, as well as an operation routing. Illustrations of the route sheet and the cards that are punched are included in

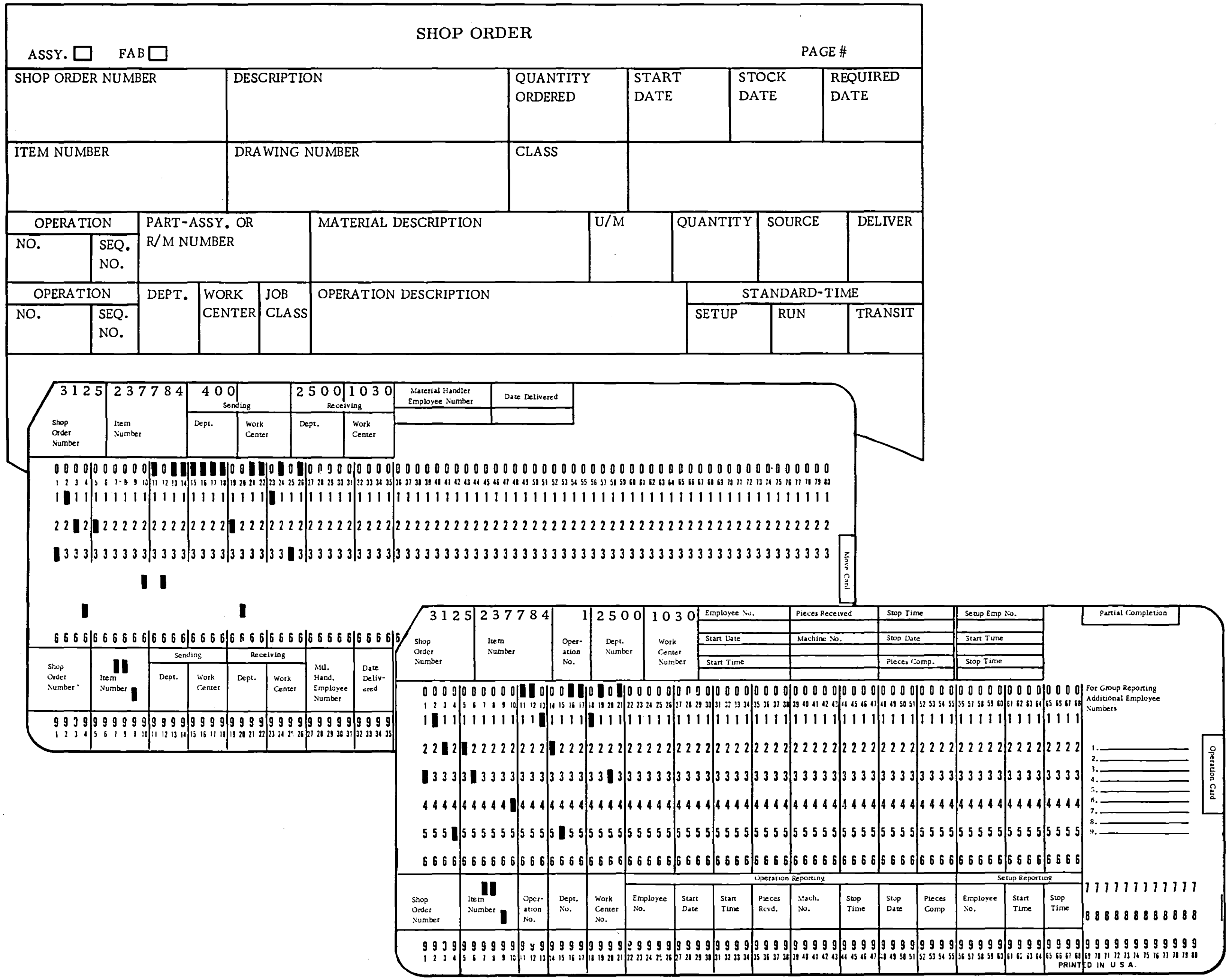


Figure 53. Shop order and reporting cards

Figure 53. Note that all the cards contain the order identification and the work center number where the activity is to be performed.

In addition to the operation card and move tickets, material requisition and stock receipt cards can be prepared. *

As a result of order progress reporting, the latest status of each open job order is stored in the file. Detail status reports can be produced as discussed in the section that describes the operation scheduling module, or for particular orders, on an inquiry or selective basis.

Output from the day-to-day reporting can include audit listings for verification and control on the shop floor.

The audit listing for labor reporting can be arranged in department sequence by employee number to permit each employee to ensure that his reports are recorded properly. Work center and department listings with summary information can also be provided. Exceptions (for example, an operation that has been reported moved to the next work center without a labor report from the previous department) can be highlighted by appropriate codes.

Each transaction that is processed and the fields of information in the file are available to the system and can be combined to produce output records. These can be selected and arranged in many different sequences to prepare a wide variety of reports.

SUBSYSTEM SUMMARY

The shop floor control subsystem is summarized in Figure 54. The chart indicates the input, output, and file information used by the modules.

*See Dynamic Shop Control (E20-0104-1)

SUBSYSTEM: Shop Floor Control

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Order Release	• Order Release Data (From Capacity Planning) Item Number Quantity Due Date Start Date • Changes to Orders	• Item No. Master Update • Extension of Standard Routing • Construct Open Job Order File • Prepare Shop Order Allocation	Standard Routing	• Item Master Address • Operation Number • Work Center No. • Time Standards-Setup Hours • Time Standards-Labor/Machine • Special Action Codes • Tool Information Code Number or Address	• Shop Packet: Routing Sheet Labor Reporting Cards Material Requisition Move Tickets Receipt to Stock Parts List for Assembly Orders
			Item Master	• Item Number • Planned Orders • On Order-Production Total Quantity Address to Detail • Allocated Quantity • Standard Routing-First Operation Address • First Assembly Component Address • Current Engineering Change Number	
			Product Structure	• Component Item Master File Address • Compare Portion of Component Item Master • Next Component Address • Quantity per Assembly • Current Engineering Change Number	
Order Progress	• Labor Reports • Material Moves • Scrap Reports • Exception Notice (held for tool no. drawing, etc.)	• Locate Open Job Order • Update Operation Record • Update Order Summary • Edit Transaction • Prepare Output	Open Job Order Summary	• Item Number • Order Number • Number of Operations This Order • No. Completed Operations • Address to Operation Detail • Qty. Completed-Present Operation • Qty. Completed-Current Operation • Scheduled Start Date • Engineering Change No. • Current Work Center • Scrap Reported • Shrinkage Factor • Standard Material Costs • Labor Costs-Standard To Date • Job Priority	• Exception Report • Audit Listings • Order Status
			Open Job Operation Detail	• Work Center No. • Operation No. • Move Time • Scheduled Start Date • Actual Start Date • Qty. Complete-Previous Operation • Qty Complete-This Operation • Qty. Scrapped • Status Code • Tool Information • Labor Costs Standard/Actual	

Figure 54. Shop floor control subsystem summary chart

PURCHASING

INTRODUCTION

The purchasing subsystem is responsible for the availability of stock to satisfy requirements for raw materials, purchased parts, and supplies. It must be scheduled to meet the overall manufacturing plan. In carrying out its job, the purchasing subsystem makes the necessary judgments regarding quality, vendor, price, and delivery.*

The area involves four major groupings:

- Requisition and purchase order preparation
- Purchase maintenance and update
- Purchase order follow-up
- Purchase evaluation

Order preparation is a two-stage procedure. Purchase requisitions are first prepared and directed to the proper buyers. Next, vendor quotations are obtained and analyzed. Recent purchase and vendor history is reviewed to determine the nature of previous "buys", as well as vendor delivery and quality ratings. Upon acceptance or modification of the requisition, the authorized order is processed in the second stage to produce a purchase order for the vendor.

Purchase Maintenance and update, the second grouping, is concerned with the maintenance and organization of the purchasing records and the processing of transaction entries.

The function of purchase order follow-up is to keep track of order progress by reviewing orders periodically and creating the necessary highlight and exception reports.

Finally, purchase evaluation rates a vendor on the basis of delivery and quality and, in addition, reviews buyers' ordering performance.

An efficient purchasing system provides management with information regarding deviations from the purchasing plan, thereby enabling the organization to concentrate on areas where additional economies are feasible.

*See Management Operating System - Industrial Purchasing - General (E20-0070)

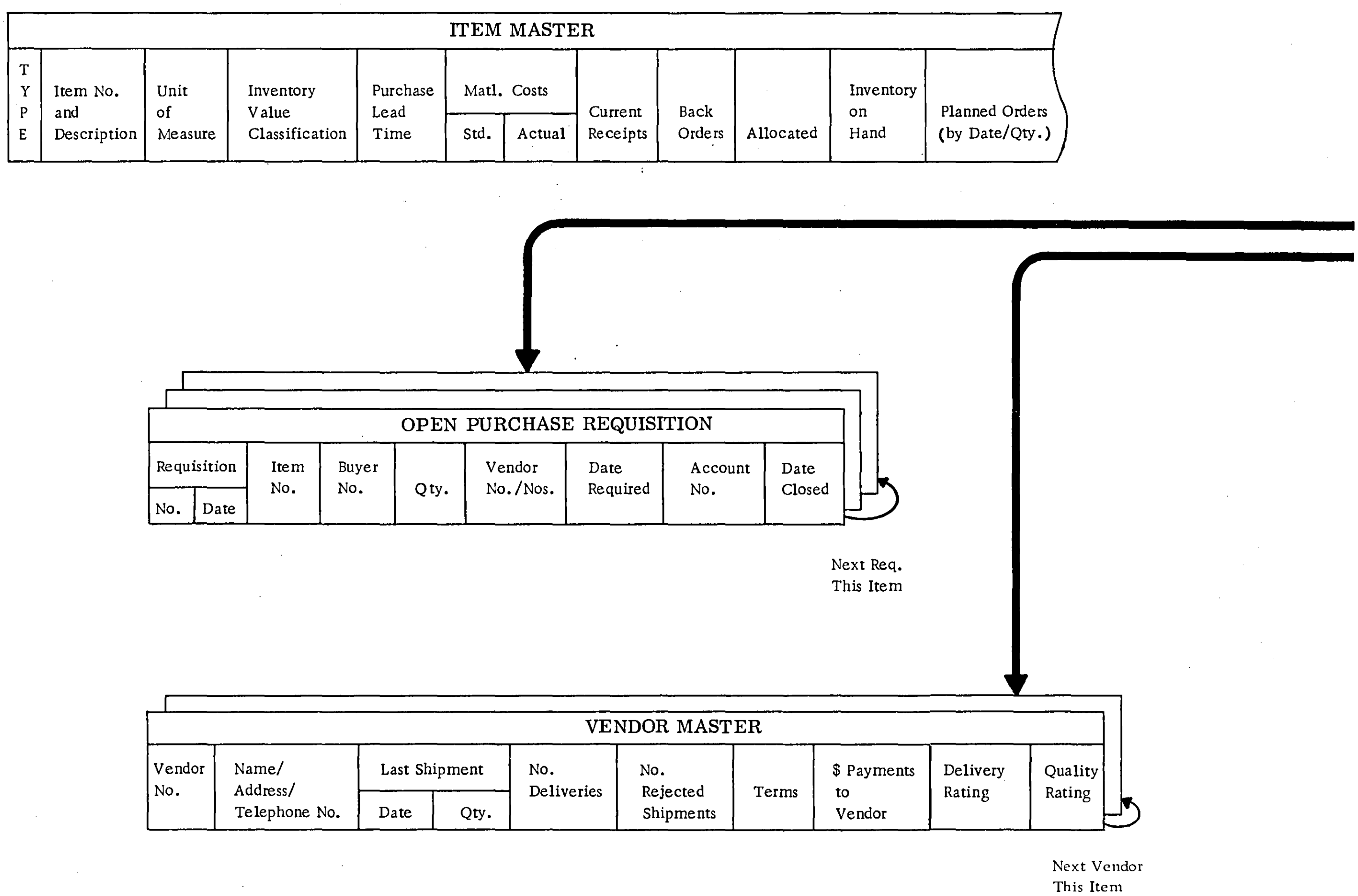


Figure 55. Relationship of purchasing records (see Appendix A for additional record data)

OBJECTIVES

A good purchasing subsystem aims to:

- Reduce the routine paperwork by automatically issuing purchase requisitions, purchase orders, follow-ups, requests for quotes, and pertinent management and operational reports. This will separate professional purchasing duties from clerical duties. A buyer can plan for more effective use of his time; more of his effort, for example, might be spent negotiating with vendors.
- Develop a total information system that contains all the information needed, not just the basic requirements. To illustrate, open requisition, vendor, and purchase master records have all the pertinent data so that the buyer does not have to spend time looking up this information.
- Provide the buyer with answers to questions regarding the suppliers of a particular item, the quantity of material ordered from each supplier, price comparisons, delivery ratings, and standards of quality. The buyer can obtain immediate access to this information by inquiry to the central records.
- Reduce the cost of materials going into the products through more favorable price negotiations, long-term contracts (where practical), and family-of-parts contracts with high-volume suppliers.
- Eliminate duplicate archives by creating and maintaining accurate purchasing records.
- React faster to change. This means becoming more aware of receipts in process, current vendor quotations, order closeouts, or order shipment status.

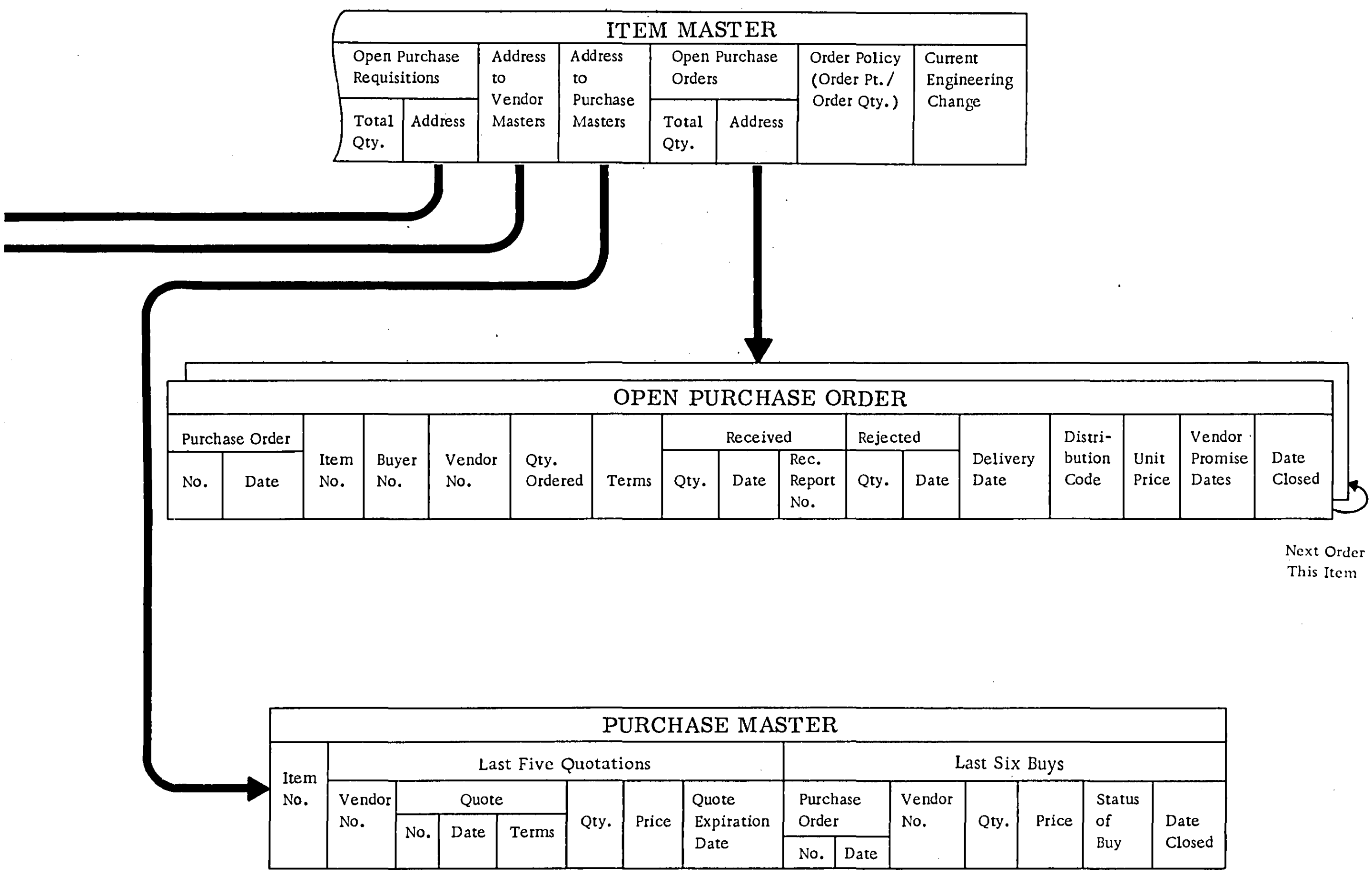
DESCRIPTION OF RECORDS

The system records* are shown in Figure 55. They begin with the item master and link to the open purchase requisition, open purchase order, vendor master, and purchase master.

Item Master

Item master records identify both raw material and purchased parts. Lead time, costs, receipts, on-hand stock, ordering policy, and planned purchases

*See Management Operating System - Industrial Purchasing - Detail (E20-0074)



for future time periods are some of the basic fields to be used by purchasing. In addition, two fields contain addresses that point to vendor master and purchase master records. Total on-order quantities of both open requisitions and purchase orders are available in summary fields appearing on the item master. Their detail is obtained by addresses pointing to each requisition and order stored on the disk file.

Open Purchase Requisition

Requisition records contain the buyer code, quantity, a list of vendor numbers that supply the particular item, date the item is required, and closing date of the requisition. (Closed requisitions remain on the file for one month, after which time they can be placed on magnetic tape for future retention.)

Open Purchase Order

Purchase order records contain the buyer code, a vendor identification, quantity ordered, date due-in, price, and closing date of the order. In addition, areas are set aside to record vendor promise dates, receipts, and rejects.

Vendor Master

Vendor records contain the vendor code, name, address, and telephone contact, the last shipment made by this vendor, his price breaks, terms, a summary of deliveries, rejected shipments, and the dollar amount of business transacted over the last twelve months. Vendor delivery and quality ratings are provided to assist the buyer in vendor selection, and for reporting purposes. A delivery index compares lateness of current shipments with those of a prior base period; a quality index shows the trend in rejections.

Purchase Master

This record is an extension of the item master. It contains a history of the last five vendor quotations of the purchased part (with price and terms) and the last six buys of the item (providing order number, vendor, quantity, date, and price).

SUBSYSTEM FLOW

The procurement cycle begins with either the inventory control subsystem or the requirements planning subsystem providing a future purchase requirement on a purchase action or an order notice. (Inventory control order items are based on usage; requirements planning items are planned for in advance.) The information flow is shown in Figure 56.

MODULE DESCRIPTIONS

Requisition and Purchase Order Preparation

All five purchasing records are utilized in processing requisitions and orders.

Purchase requisitions are printed or displayed for the buyer. With the historical quotes and buys information appearing in the purchase master record, and by further reference to ratings and price breaks from the vendor master, a vendor is selected, a purchase order record is created in the file, and the order form is printed.

At the same time the order is prepared, an order acknowledgment card is prepared with receipt/ inspection cards. The latter are forwarded to the receiving department, where they are retained while awaiting receipt of the goods from the vendor.

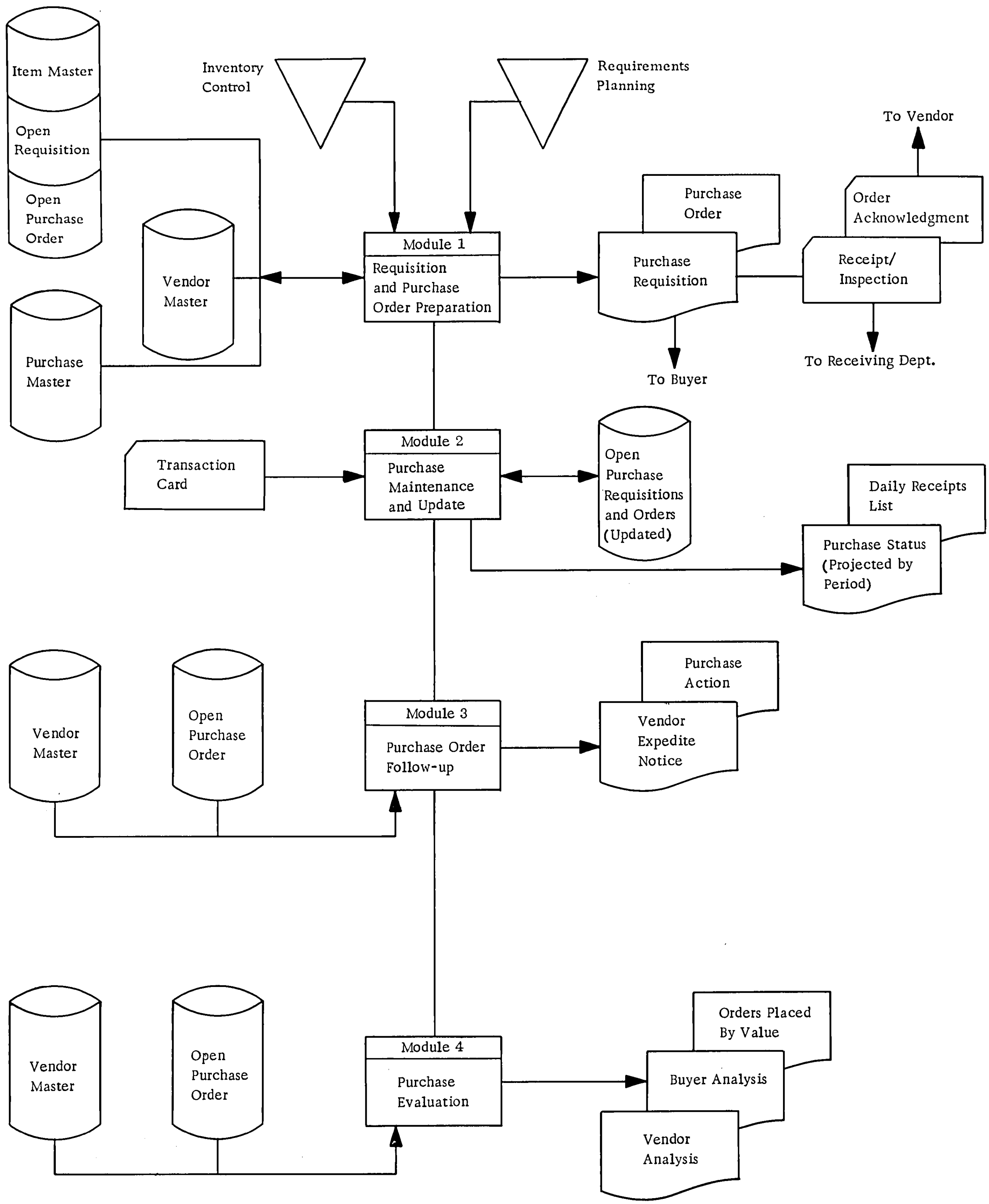


Figure 56. Purchasing subsystem flow

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Requisition and Purchase Order Preparation	• Purchase Requirements (From Inventory Control and Requirements Planning Subsystems)	• Purchase Requisition Preparation • Vendor Determination • Order Writing	Open Purchase Requisition	• Req. No. /Date • Item No. • Vendor No. /Nos. • Quantity • Date Required • A/C No. • Buyer No. • Date Closed	• Purchase Requisition • Purchase Order • Order Acknowledgment Card • Inspection/ Receipt Cards
			Open Purchase Order	• P. O. No. /Date • Item No. • Vendor No. • Buyer No. • Quantity • Delivery Date • Distribution Code • Terms • Unit Price • Vendor Promise Dates	
			Purchase Master	Last 5 Quotations Last 6 Buys	
			Vendor Master	Vendor No. Name/Address/Telephone Last Shipment Delivery Rating Quality Rating	

Purchase Maintenance and Update

New requisitions and purchase orders are input to the system to create open purchase requisition and open purchase order records. Total on-order quantity fields for requisitions and purchase orders are updated on the item master. Transaction entries (for example, vendor receipts, item rejects, overages, order acknowledgments, and alterations) update the open purchase order files. The system can be designed so that parts can be rejected easily in such locations as receiving, inspection, or parts storage. A rejection report is completed showing the reason for rejection. Codes are used to authorize scrap, rework in plant, return to vendor, or use as is. Thus, a properly coded reject transaction can alter any number of record fields to satisfy the information needs of many departments. Output may consist of a daily receipts list, which informs both purchasing and production control that the order is now at inspection, or a purchase status report (itemized by week, to cover, for example, a 24-week forward period) showing items on order, scheduled due dates, and current status. Essentially, the report permits the buyer to ascertain where the next price break might be after considering anticipated future requirements.

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Purchase Maintenance and Update	Purchasing transactions	• Transaction updating: Overage, Reject, Acknowledgment, New Requisition, New Purchase Order, Alteration, Vendor Receipt	• Item Master • Open Purchase Order • Open Purchase Requisition • Vendor Master • Purchase Master	(For Record Fields see Figure 55)	• Purchase Status • Daily Receipts List • Updated Open Purchase Requisitions and Orders

Purchase Order Follow-Up

Vendor master and open purchase order files are used in this module to provide automatic follow-up at key points in the purchasing cycle. This assures the availability of the right quantities and quality at the right time and place. Several types of output may be prepared. One of these, the purchase action report, appears as Figure 57. The remarks column of that format spells out "shipment past due", or some other pertinent exception statement. In this manner, quick follow-up becomes possible on every delayed purchase order receipt, inspection problem, or situation involving laxity in forwarding an order acknowledgment.

The vendor expedite notice is another helpful output document from this module. It is a reminder, automatically generated, which can be mailed out to each vendor to confirm his overdue or shortly-due commitments and delivery dates.

Purchase Action Report — Date: 4/20/--

Buyer	Vendor	Item No.	Order No.	Quantity Received	Total Quantity	Remarks
93	A Co.	226353	B 632	0	0	No acknowledgment
93	B Co.	297463	B 095	50	100	Shipment past due

Purchase Action Report — Date: 4/20/--

Buyer	Vendor	Item No.	Order No.	Quantity Received	Total Quantity	Remarks
97	A Co.	971425	D 032	0	0	No shipment confirmation
97	Z Co.	832658	X 001	100	500	Inspection failure

Figure 57. Purchase action report

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE RECORD TITLE	 RECORD FIELDS	OUTPUT
Purchase Follow-Up	• Vendor Master • Open Purchase Orders	• Purchase Action Report Preparation • Vendor Expedite Notice Preparation	Open Purchase Order	• P. O. Number/Date • Item Number • Buyer Number • Vendor Number • Order Status • Qty. Ordered • Qty. Rec'd/Rejected • Vendor Promise Dates • Terms • Amount Paid • Delivery Date	• Purchase Action Report • Vendor Expedite Notice
			Vendor Master	• Vendor No. • Name/Address	

Purchase Evaluation

Module four provides periodic evaluations of vendor and buyer performances on the basis of factors of quality and delivery. As a result of information stored in the vendor master, a vendor analysis report can be printed showing monthly dollar payments to each of the suppliers, number of rejected shipments, and number of deliveries.

Vendor rating reports * can be designed to include:

1. Delivery rating (for example, days late) showing average current rating, current month, one month previous, two months previous, etc.
2. Quality rating (for example, rejects) showing similar monthly data. Deliveries that are late have a weight factor calculation:

Days Late		Factor
1-10	x	1
11-20	x	2
21-30	x	3
over 30	x	4

To have up-to-date information, an average monthly rating can be computed each month.

Vendor formula:

$$100 - \frac{\text{(days late x weight factor)}}{\text{Number of deliveries made}} = \text{Rating}$$

$$\frac{\text{Rating} + \text{last month rating} + \text{2 months prev. rating}}{3} = \text{Aver. monthly rating}$$

A delivery rating of from 100 - 85 is considered excellent; 84 - 70 is average; and 69 or less is below average.

Purchasing must also analyze the performance of its own department. The buyer analysis report shows the requisitions received, processed, and backlogged. It can also provide a buyer delivery rating using the vendor formula shown above.

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*See COMPASS (Computer-Oriented Management Planning and Scheduling System) at IBM Poughkeepsie (E20-0200)

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE RECORD TITLE	 RECORD FIELDS	OUTPUT
Purchase Evaluation	• Vendor Master • Open Purchase Orders	• Calculate Delivery Rating • Calculate Quality Rating	Vendor Master	• Vendor Number • Delivery Rating • Quality Rating	• Vendor Analysis • Buyer Analysis • Orders Placed by Value
			Open Purchase Order	• No. Deliveries • No. Rejected Shipments • P. O. No. /Date • Buyer No. • Unit Price • Qty. Received/Date	

SUBSYSTEM SUMMARY

The modules are summarized in Figure 58.

SUSBSYSTEM: Purchasing

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE		OUTPUT
			RECORD TITLE	RECORD FIELDS	
Requisition and Purchase Order Preparation	• Purchase Requirements (From Inventory Control and Requirements Planning Subsystems)	• Purchase Requisition Preparation • Vendor Determination • Order Writing	Open Purchase Requisition	• Req. No. /Date • Item No. • Vendor No. /Nos. • Quantity • Date Required • A/C No. • Buyer No. • Date Closed	• Purchase Requisition • Purchase Order • Order Acknowledgment Card • Inspection/Receipt Cards
			Open Purchase Order	• P. O. No. /Date • Item No. • Vendor No. • Buyer No. • Quantity • Delivery Date • Distribution Code • Terms • Unit Price • Vendor Promise Dates	
			Purchase Master	Last 5 Quotations Last 6 Buys	
			Vendor Master	Vendor No. Name/Address/Telephone Last Shipment Delivery Rating Quality Rating	
Purchase Maintenance and Update	Purchasing transactions	• Transaction updating: Overage Reject Acknowledgment New Requisition New Purchase Order Alteration Vendor Receipt	• Item Master • Open Purchase Order • Open Purchase Requisition • Vendor Master • Purchase Master	(For Record Fields see Figure 55)	• Purchase Status • Daily Receipts List • Updated Open Purchase Requisitions and Orders

Figure 58. Purchasing subsystem summary chart (Sheet 1)

SUBSYSTEM: Purchasing

MODULE NAME	INPUT	PROCESSING ROUTINES	DATA BASE: RECORD TITLE	DATA BASE: RECORD FIELDS	OUTPUT
Purchase Order Follow-Up	• Vendor Master • Open Purchase Order	• Purchase Action Report Preparation • Vendor Expedite Notice Preparation	Open Purchase Order	• P. O. Number/Date • Item Number • Buyer Number • Vendor Number • Order Status • Qty. Ordered • Qty. Rec'd/Rejected • Vendor Promise Dates • Terms • Amount Paid • Delivery Date	• Purchase Action Report • Vendor Expedite Notice
			Vendor Master	• Vendor No. • Name/Address	
Purchase Evaluation	• Vendor Master • Open Purchase Orders	• Calculate Delivery Rating • Calculate Quality Rating	Vendor Master	• Vendor Number • Delivery Rating • Quality Rating • No. Deliveries • No. Rejected Shipments • P. O. No. /Date • Buyer No. • Unit Price • Qty. Received/Date	• Vendor Analysis • Buyer Analysis • Orders Placed by Value

Figure 58. Purchasing subsystem summary chart (Sheet 2)

CHAPTER 3: Implementation Guide and Expanded Usage

MODULE AND SYSTEM GROWTH

Each functional area has been described as a self-contained subsystem. It is organized in this manner so that a large degree of freedom is allowed during implementation. The subsystems chosen and the sequence in which they are implemented are left to the discretion of the user. The goal to be achieved is the primary guide in deciding which subsystems to implement. Of course, available manpower and financial resources do guide a company in deciding the sequence and timing of its implementation. Although the modular subsystem approach goes a long way to easing application implementation, several areas still remain that must be considered, such as preparing and editing existing data for completeness, accuracy and format, planning for pilot or parallel operation, and coordinating conversion activities. Each application must therefore be surveyed for conversion problems, and specific procedures must be developed to overcome the problem areas.

It must be made clear that before a successful production information and control system can be implemented, a comprehensive plan of action must be developed. This plan should be designed in such a way that major revisions to the DATA BASE records and programs established early in the life of the system can be avoided during later expansion.

Where to Start

An early step in the installation of any computer-oriented system is screening and organizing the data to be used. This is especially important in the implementation of the system, since the same basic files serve many different functional areas. Each individual installer should consider such questions as:

- What interrelationships of data files exist?
- Which existing records can be used or modified?
- How will new data be gathered?
- How will both existing and new information be verified?
- In what sequence will the files be organized?

The System/360 Bill of Material Processor program will serve many of these early implementation needs. Its generalized programs can be modified to perform various functions during the creation and maintenance of the basic files. Having organized the data to be used by the system and having created the necessary files, the implementation effort must now be turned toward the remaining task. To ensure that the system will be operating on a timely basis, the next consideration must be the maintenance and updating of information in the files. The primary source of information in the DATA BASE is the item master, which is maintained by the inventory control subsystem. It is envisioned, therefore, that a company would first wish to include the inventory control subsystem. This subsystem is selected first simply because the maintenance of inventory records directly affects almost all other areas of operation and provides the basis for additional subsystems.

Figure 59 shows a representation of the modular concepts followed. The file usage legend indicates the flow of file information. The solid outline indicates that the file is created (and used) by the applicable subsystem; the dotted outline indicates that the file is required by the subsystem. Any file that is shown as required must have been created in a previously integrated subsystem.

The chart indicates that the inventory control subsystem uses as its basic file system the file organization and file structure created and maintained by the System/360 Bill of Material Processor program.

From the inventory control subsystem, note that the path can lead to any of the following:

- Requirements planning
- Engineering data control
- Purchasing
- Sales forecasting

The requirements planning subsystem creates time series requirements on the item master as well as the pegged requirements file. This, then, is the precedence path required if one wishes to implement operation scheduling or shop floor control.

Each of the five possible routes from the inventory control subsystem uses the item master file. The open purchase requisition/purchase order, the purchase master, and the vendor master files required in the purchasing subsystem are created and maintained within that area of responsibility. If the sales forecasting subsystem is implemented before a requirements planning subsystem, future planning can use a forecast based on past history regarding usage of end items.

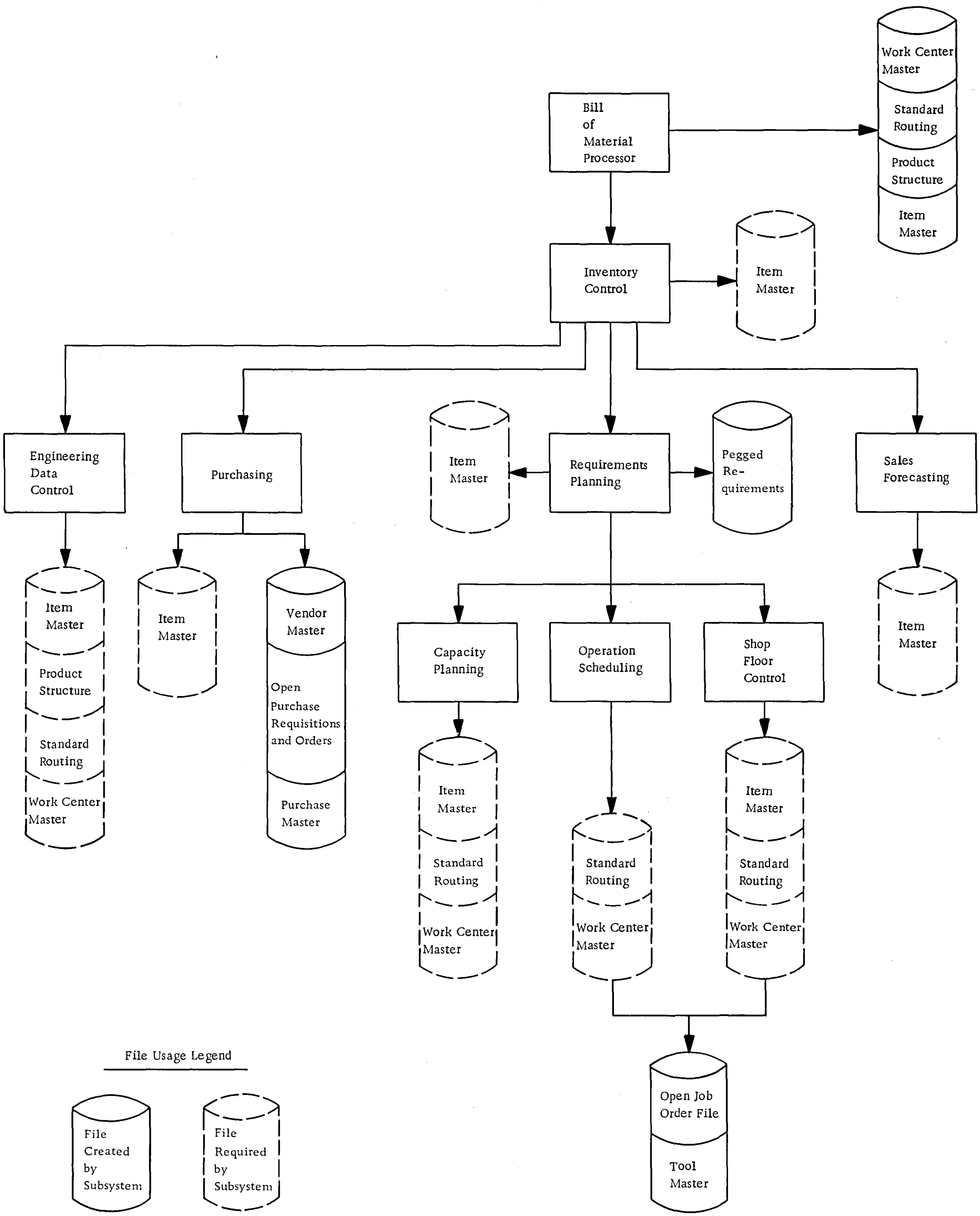


Figure 59. System growth

The capacity planning, operation scheduling, and shop floor control subsystems necessarily follow the requirements planner. The shop floor control subsystem, however, need not be implemented following any form of scheduling program but may actually precede scheduling programs with the prime intention of perhaps aiding in evaluating and determining accurate time standards and move times. The open job order file is shown as a file being created by either the operation scheduling or the shop floor control subsystem, depending upon which is created first. Both require the use of an open job order file. A capacity planning subsystem need not be implemented before an operation schedule. The latter can provide some form of load analysis that extends into the future, in addition to the operation sequencing capability.

The production information and control system, then, is virtually any series of functions that a company would like it to be. The design of the system is so flexible that subsystems need not be added in any prescribed serial manner. The company, in designing its system, chooses only those functions which are more urgent or which provide the greatest number of benefits.

Subsystem Modularity

Modularity within each subsystem affords the following advantages:

- Record size. A customer need incorporate into a record only those fields which reflect the functions now being performed. Also, fields can be added to the records as information becomes available.
- Function growth. Each subsystem contains a series of different functions. One or two may be incorporated initially, and as experience and confidence are built up, more complex functions may be added in the future.

The implementation of a subsystem does not require the implementation of all aspects of that subsystem but only the ones that are considered desirable at the time, and at a rate of inclusion that is best for the specific needs of the installation.

PROGRAMMING CONSIDERATIONS

Under the production information and control system, it is possible to tailor the many different phases into a daily operating tool and at some future date to upgrade capabilities as the need arises.

To accomplish this, however, a user must be familiar with some of the following:

- Customizing file organization routines
- Specifying work areas and I/O sizes
- Specifying field sizes and mnemonic descriptions
- Incorporating user-written routines
- Linkage editor and library considerations

Customizing File Organization Routines

The system contains several logical files, each performing certain functions, and each connected to another directly or indirectly. Under supervision of the various operating systems specifications must be furnished to the system that indicate such items as the name of a file, labels given to an I/O area, record size, blocking factor, and many other variables that reflect the manner in which the files are to be handled. These specifications are macros that generate the appropriate coding for the files to be handled in the manner desired.

Figure 60 illustrates sample DOS/360 coding for specifying an index sequential DTF entry. The symbolic file name is MASTFIL. The type of processing for the file is to be both random and sequential. The record size is 200 bytes; the records are to be fixed unblocked; the key length is ten bytes; the I/O area label is RECARA. Records are to be written back to the file after updating; the label of the customer's routine for wrong-length record processing is EROUT. These parameters for the file named MASTFIL will generate the appropriate coding to handle the file exactly as desired and set up the appropriate points to link to such routines as

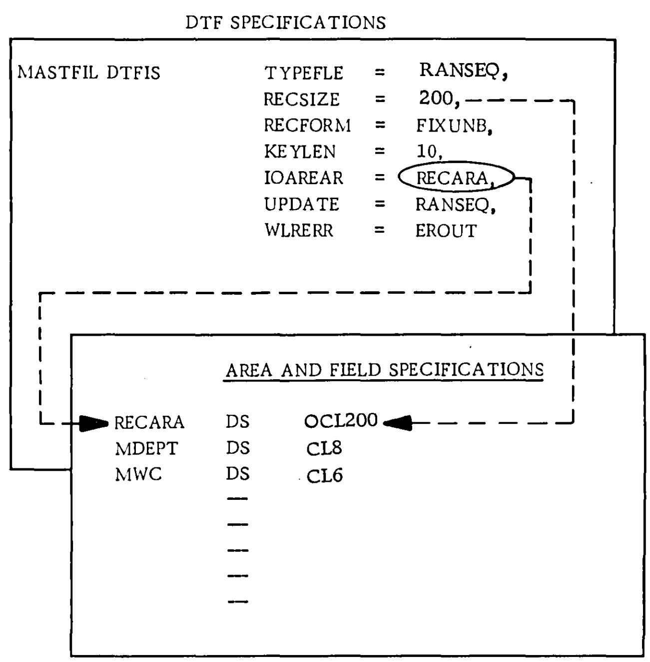


Figure 60. User specifications

EROUT, should it be necessary. A programmer, therefore, has total flexibility as to the name of the files, size, blocking factors, linkages to other routines, and many other variables. The user must consider the types of files desired as well as the type of disk functions he wishes to include.

Specifying Work Areas and I/O Areas

The I/O area specified in Figure 60 contains a label called RECARA. When a record is read into core, the coding generated by the DTF reads the record into the location RECARA. For the system to make the necessary error checks, the customer must also specify the characteristics of the I/O area. The core storage for RECARA is set aside with a DS statement. The operand shown in Figure 60 for the first DS statement of OCL200 means that the program should consider that 200 bytes are set aside (CL means that it is to be character information with a length of 200). The zero in the first position indicates that field definitions within the 200-byte area will be defined later. The bill of material customizing procedure provides the necessary macros and parameter cards to facilitate specifying this kind of information.

Specifying Field Sizes and Mnemonics

The specifications in Figure 60 for the area defined as RECARA indicate that 200 bytes are to be considered to be set aside. If the user wishes to refer to a specific location within the area called RECARA, according to one procedure, the data can be referenced by address modification; for example, if it is known that the information for the work center is in positions 25 to 30 relative to the start of RECARA, the data can be accessed by referring to location RECARA + 24. This procedure entails an awareness of where every piece of data is relative to the start of the I/O or work area. In addition, making a change to a field size entails modifying all the code in the program that makes references to other data fields. A more direct procedure is to attach a label to all the fields within the record.

When using the information, all that is required is furnishing the appropriate label name. The relative position within the work area is not a matter of concern. Figure 60 illustrates two field names, MDEPT and MWC. The former has a size of eight bytes, the latter six. Accessing of the data within those areas is by label name or mnemonic code. The bill of material program contains labels for certain fixed data, such as chain address fields. The user, of course, will add fields of his own choosing to the records already created. He must, therefore, furnish the size of each field desired, as well as the mnemonic label desired to refer to the field. The arrows in Figure 60 show the relationship required between the information specified in the DTF section and that specified in the area and field specifications.

Incorporating User-Written Routines

Normally, at key points in mainline programs, exits are provided that contain fixed labels that are used as the subroutine name. The subroutine differs from the macro in that the subroutine is placed in core in only one specific area; other routines can branch to it as desired and as necessary. A macro is a special form of subroutine. Each time a programmer calls the macro, the assembler program places all of the macro code at the point where the operator issued the call in the mainline program. If a given macro is called ten times in a program, the coding is generated at the ten different points at which the calls were issued. Each time the macro is called, parameter information passed with the macro tailors the coding to the specific task. For example, a move macro is coded as MOVE SAU, MWC where data is moved from a field called MWC to another field called SAU. However, the next time the macro is issued, it can be written as MOVE REPORT, MDEPT where the field called MDEPT is moved to an area called REPORT. A subroutine, on the other hand, is fixed in its functions and fixed as to the data it accesses each time.

Figure 61 shows the relationship between a subroutine called USRRTN and the mainline program.

Linkage Considerations

The operating systems provide for maintenance of three library types: macro, relocatable, and core image. The macro library contains the routines that will be inserted into the main routine when these macros are called during the assembly run. These macros are in source language format. The relocatable library contains assembled object modules that still contain unresolved location and external linkages. These programs cannot be executed before examination by linkage editor. The core image library contains routines that are in machine-executable form.

machine-executable form.

The customizing procedure requires functions that are included in the relocatable and macro libraries, in addition to the use of the linkage editor program and the assembler.

Figure 61 shows the DTF, mainline, and user modules. These various sections will be contained on one of the three libraries. Each can be assembled separately and linked together at the time that a running system is desired. (The programmer's manual for the bill of material processor contains detailed specifications on the customizing of these various sections, as well as an illustrative example of the procedure to be followed.)

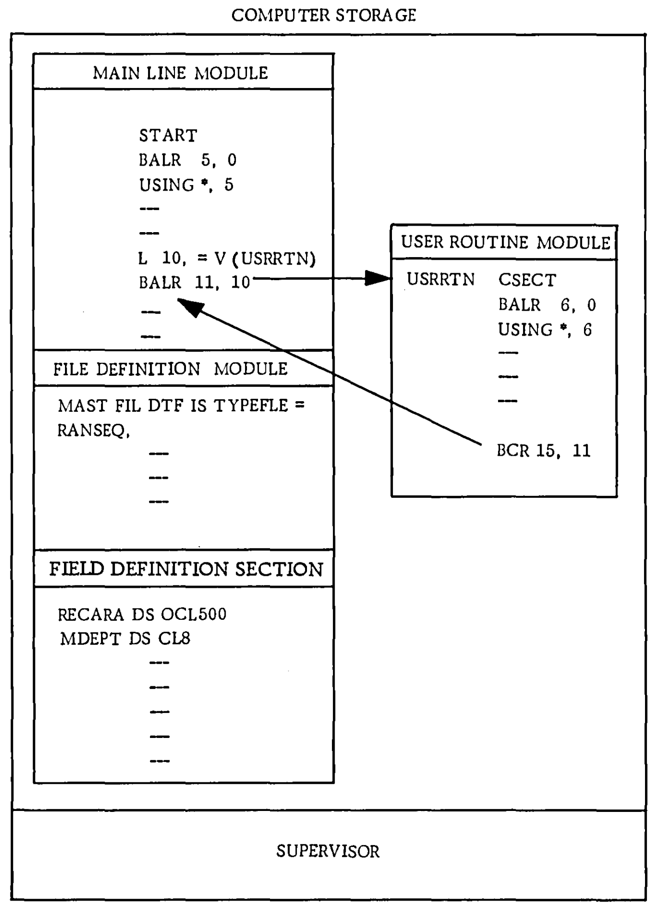


Figure 61. User-written sections and mainline program

INQUIRY CONCEPTS

A centralized management information system offers an important communication link between the various manufacturing phases. Today, effective management requires a responsive control system to highlight all kinds of information.

The production information and control system permits direct communication with its numerous master, engineering, and order status records at any time and from any remote location. Data is readily available for all questions asked of the system.

Data can be transmitted by telecommunication networks to eliminate much of the delay now inherent in many systems (Figure 62). A terminal in a customer's office can transmit his order directly to the home office or plant site. After the order has been entered, scheduled, and production dates established, an acknowledgment can be transmitted back for customer information. A shorter turnaround cycle results in better customer service, hence, better customer relations.

Inquiry into the DATA BASE can be performed in a number of different ways. Present technology permits inquiries to be printed and typed, viewed by an IBM cathode ray tube display station, or transmitted audibly by telephone. In the latter instance, an IBM audio response unit receives an inquiry, consisting of a series of coded characters, from its inquiry terminal. It transmits the message via the channel to the processor, character by character, under program control. The processing unit processes the input message and composes a response, selecting the desired words in proper sequence from a vocabulary stored in direct access storage as digitally-coded voice. This is converted to "spoken" language and transmitted to the originating terminal.

The real-time approach emphasizes processing the transaction as it occurs, and updating all records immediately. As a result of the processing, exception notices and status reports are produced. Corrective management action may be taken and fed back into the system. The real-time system offers not only management by exception, but management by exception as the exception occurs. To implement a system of this type, random access storage and remote terminals are required. Once installed, the following general advantages will result:

- Exception reporting of situations requiring management action
- Up-to-date information on which to base decisions
- Periodic summary reports of significant areas not received at the present time
- Reduction of the manufacturing time span
- Routine decision making performed by the system
- Reduction of in-process inventory
- Better use of men and machines
- Checks by the system to assure the reporting of key transactions
- Lower material investment required
- Access to common files by all activities
- Accurate data collection through editing of input information at the source
- Immediate inquiry into status of all items, lots, orders, etc.

Additional specific advantages accuring in the major areas of activity follow.

Receiving and Receiving Inspection

Goods, when received by the receiving department, can be counted and immediately reported to the system. They can be identified by association with an item on an open purchase order, and quantities received can be checked against the outstanding amount. The computer can audit the information and update the purchase order file for date, quantity, and number of shipments. The stock inventory record can thus also be updated to reflect the amount in the receiving department, and a further check can be made to determine whether expedite of material is required. If so, the system can so inform the receiving department.

Also, the system can initiate a report to the inspection department as to the lots to inspect as well as the sampling criteria to use. Communication back to the system from the inspection department can indicate any rejected lots; this, in turn, can trigger notification to a material analyst of a rejected lot so that a judgment can be made regarding its disposition.

In addition, receipts delivered to the wrong plant may be accepted or quickly redirected, thereby saving time. This is possible because all purchase order information is available to all receiving areas through a centralized data base.

Purchasing

Routine items can be ordered automatically. These include high-volume standard items that represent a high percentage of the purchase orders but a relatively low portion of the dollar commitment. This allows the purchasing personnel to concentrate on items requiring more attention.

Also, purchase information can be prepared for the analyst's decision. Information as to vendor experience and quotations, plus the order history regarding the purchase item, can thus be made available to him. The analyst is now in a better position to make an intelligent, informed appraisal, as well as the ultimate decision for the order.

There can also be automatic purchase order follow-up. Those orders requiring acknowledgment, confirmation of shipping dates, etc., can be automatically identified and processed. Clerical intervention may not be required.

In addition, periodic vendor and order analysis can be made. The vendor's performance in relation to quality and timeliness of goods received can be evaluated against predetermined criteria. Order analysis can be efficiently accomplished to determine such data as product group usage and a breakdown of the number of purchase orders in relation to their dollar value.

Material Control

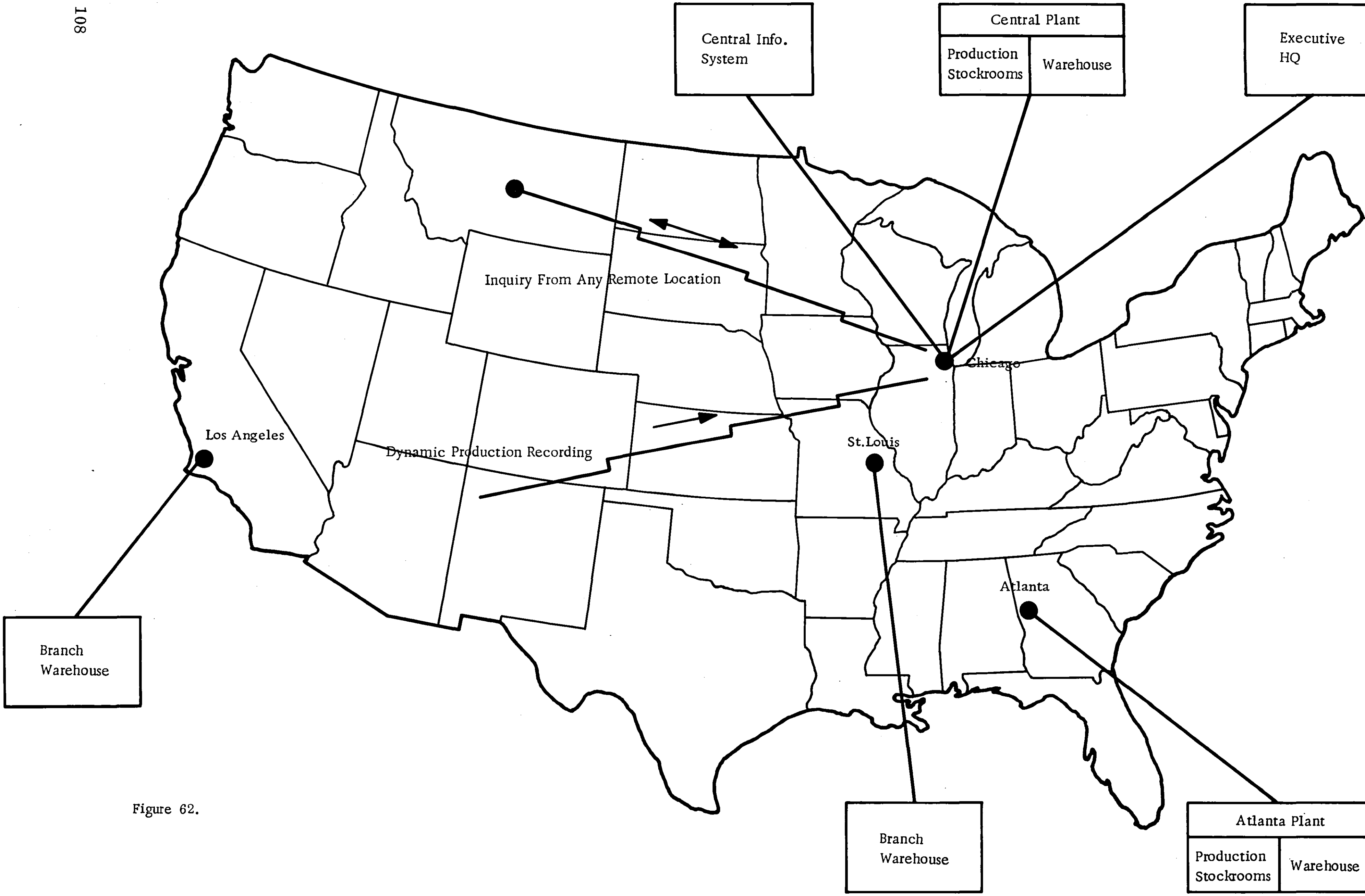
Material control can generate documents necessary to assure the availability of stock for efficient functioning of the departments. It can control the transactions pertaining to material after the material is moved from the receiving or the inspection department; for example, recording the progress of material from the stockroom, through the fabrication process, and into the assembly departments.

The association of the requirements and inventory records with the manufacturing operations is a prime function of this area. The system can control the issue of material from the stockroom to the factory floor. Tighter control over surplus can be applied by requiring reports of issues and returns within a specific period.

Stockroom transactions for the supplies and maintenance items can be processed and reflected in the files. The inventory analysis routines can initiate a requirement message for the purchasing function when necessary.

Thus, among other functions, the system can accomplish the following:

- Determine the avaliability of stock for released operations
- Issue and control the material released
- Prepare cut instructions when necessary
- Update the inventory file
- Control surplus material issued to the floor



Central Info. System
Central Plant
Production Stockrooms
Warehouse
Executive HQ
Inquiry From Any Remote Location
Chicago
Los Angeles
St.Louis
Dynamic Production Recording
Atlanta
Branch Warehouse
Branch Warehouse
Atlanta Plant
Production Stockrooms
Warehouse

Figure 62.

DYNAMIC PRODUCTION RECORDING AND EDITING

The direct access capability of the files and data collection equipment used with System/360 provide the means to develop a dynamic production recording and editing system. The lag between the time an event occurs and the time it is recorded in the files is reduced substantially when terminals in the production department are connected directly to the computer. In essence, the computing potential and the production status information of the system are available to each department.

The transactions from each department can be edited when they are reported. Discrepancies and unusual reports can be highlighted at a time when it is most advantageous for corrective action. For example, a labor report can be flagged on the third operation of an order that included a quantity greater than that reported complete on the second operation, so that the count can be verified. A variety of actions can be included in the computer logic.

Transactions that do not pass particular edit tests can be rejected, or they can be accepted while a notice is sent to the foreman or stockroom for verification. Some transactions may highlight the need for additional reporting; for example, a move reported complete in one department can signal that the labor transaction (job completion) from the previous department has not been reported.

Figure 63 illustrates the use of a remote printer in a department where labor transactions have been reported. Edit messages are prepared within the computer and transmitted to the printer. Several examples of edit messages are included in the illustration.

In addition to the editing capability, the use of direct communication to a computer increases the timeliness of the information. An inquiry would elicit an immediate response reflecting the current status of the operation.

Information of this type can assist management in its effort to control the work on the shop floor, with management not having to react to status information that reflects what happened yesterday or, in some cases, days before. The dispatching of work in the shop is an excellent example of a control or discipline that can improve with up-to-date information.

In most plants, the dispatching function is controlled at a work center or department. Once the order leaves, control is transferred to another dispatcher. The sequence in which jobs are run in one department is selected without knowledge of its

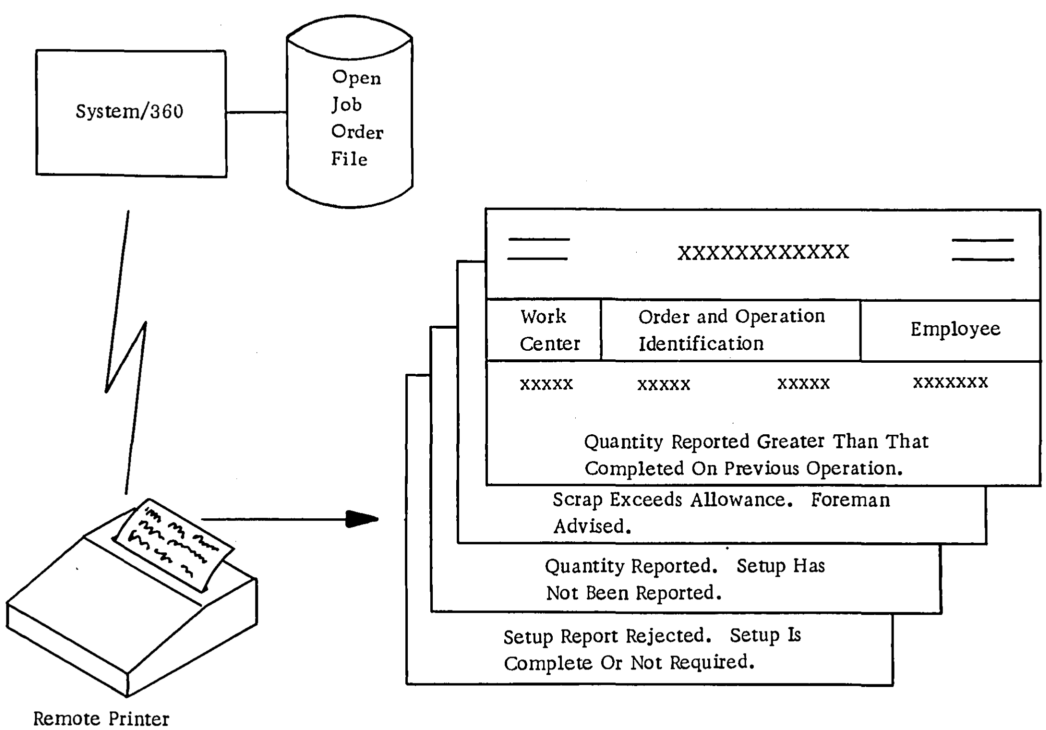


Figure 63. Edit messages

effect on other departments. With central files, up-to-date status information, and remote terminals, many levels or degrees of control are possible. For example, the dispatching function could remain at the local level. However, more efficient tools (for example, dispatching lists and exception notices) would be at the dispatcher's disposal. Or the dispatching function could be centrally located, with relatively few specialized people communicating with the shop floor. Assignments would be made by a central dispatcher who has access to the latest information stored within the system. Judgments would be made regarding assignments that best conform to the overall plan for controlling the flow of work.

Finally, the logic for job assignment can be placed within a computer, with each worker receiving his assignment via the remote printer in the department. This can be thought of as a dispatching list that is printed one line at a time. It has an advantage over the list in that the line does not have to be printed until it is needed and can therefore reflect the latest information.

There are many variations of the methods discussed above. For example, in the computer-dispatched system, a suggested plan (sequence of jobs) can be prepared that is approved or modified by key individuals in the shop. This plan can then be executed by the computer as assignments are requested.

Other areas of control that can be improved with two-way communication between the computer and the shop floor include tool control and material movement. Tool requests to the tool crib can be prepared on the basis of the latest sequence of jobs. The number of requests can be screened to ensure that tools being assembled are for jobs that will be worked in the near future. In addition, if a particular tool is needed for a high-priority job and it is currently in use, the computer can signal the crib when the tool becomes available, determining this on the basis of the labor report for the job currently using the tool.

The moving of material from department to department (or work centers) can be better controlled by informing the material handlers of the jobs of highest priority. A message can be produced when a high-priority job is reported complete in a particular department, thereby helping the material handlers to execute the overall plan more efficiently.

Obviously, all aspects of expanded usage of the DATA BASE could not be discussed; nor will all those that have been discussed necessarily be implemented by each manufacturer. The important point is that the DATA BASE, in conjunction with the System/360, provides for many expanded uses. The files and subsystems (or portions thereof) enable each manufacturing concern to develop an information and control system consistent with its individual needs.

APPENDIX: THE DATA BASE

Implementation of a production information and control system begins with the specification of the data base. The data base covers all the operational record information needed to facilitate the maintenance and flow of data within and between the applications described in this manual. A set of standardized record layouts has been designed as a base to mechanize the application areas. These records contain fields that are considered necessary to enable the majority of users to tailor their own data base requirements.

The data base detailed here is designed to be operational using the IBM System/360 Bill of Material Processor program. The data base is composed of eleven basic records. Each master data set contains a basic record, and is chained to related data records to compose the integrated data base illustrated in Figure 64.

Formats for each record are followed by a detailed description of each field in the record.

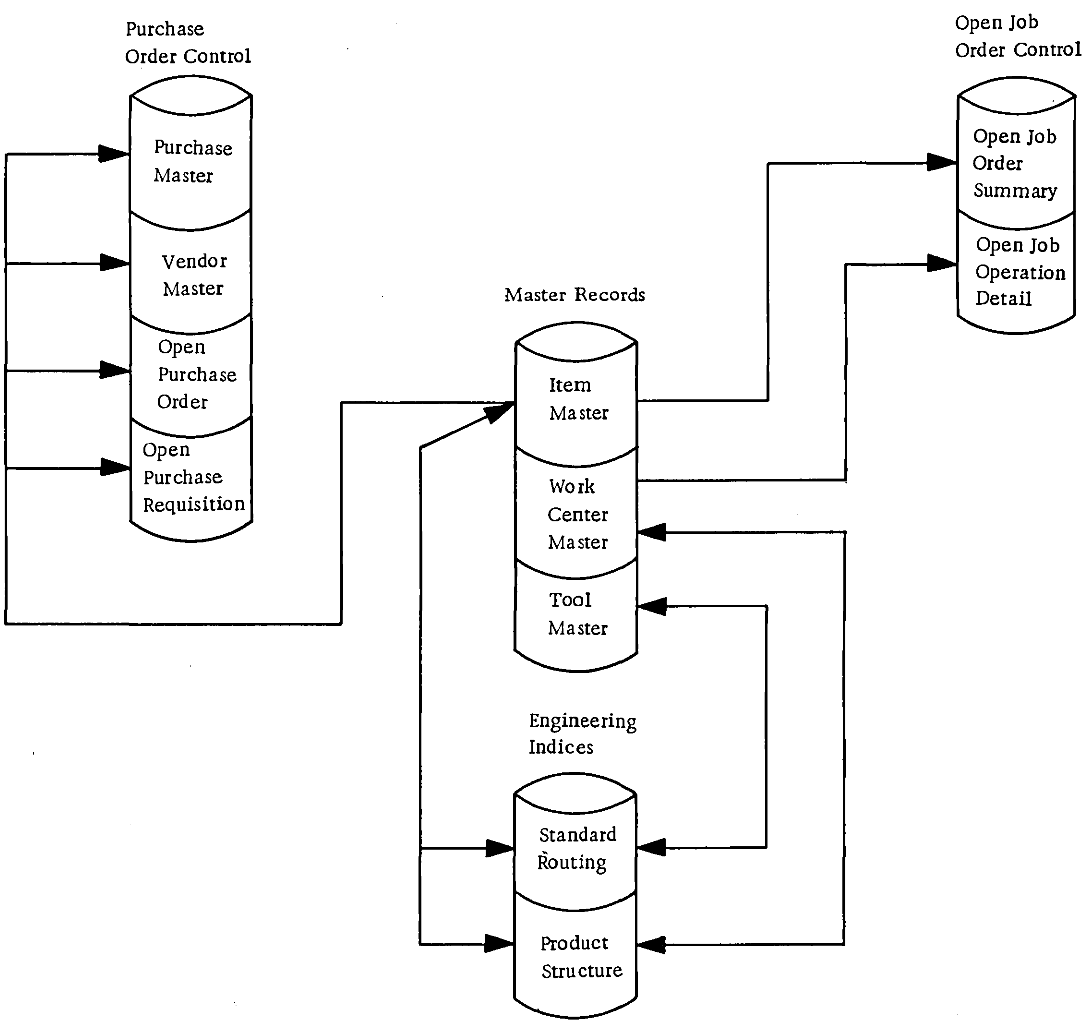


Figure 64. The data base

RECORD LAYOUTS, FIELD DESCRIPTIONS, AND SYMBOLIC LABELS

Method for Assignment of Labels

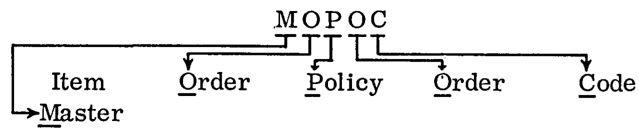
Symbolic labels appear opposite each name shown in this section. In their order of discussion, the record titles and basic prefixes are shown below.

Record Title	Basic Prefix
Item Master	M
Open Purchase Requisition	PR
Open Purchase Order	PO
Vendor Master	PV
Purchase Master	PM
Open Job Order Summary	OS
Product Structure	S
Standard Routing	R
Work Center Master	W
Open Job Operation Detail	OD
Tool Master	T

Five letters identify the label, as follows:

1st letters	identify the basic record (M for item master, PR for open purchase requisition)
2nd letter	Used to identify either basic record, or letters 3-5
3rd letter 4th letter 5th letter	Letters of the next words in the field name are used so that as much meaning is conveyed as is possible

Example: A field of the item master is called "Order Policy--Order Code". This is coded as:



Some variations may be noted, such as:

MFCBI -- Item Master (= M)
"Forecasting (= FC)
- Base Indices" (= BI)

RSACO -- Standard Routing Record (= R)
"Special Action Code" (= SACO)

SECTION A: ITEM MASTER

Item			Flags		Unit of Measure	Inventory Value Classification	Product Structure	
Type	Number	Description	Forecasting	Requirements Planning			First Assembly Component	
							Address	Record Count
	*						*	*
1	2	3	4	5	6	7	8	9

Product Structure							Standard Routing		
First Assembly Where-Used		Low-Level Code	Next Item in Activity Chain		Run Activity Control Number	Overflow Chain Address (Sequential Additions)	First Operation Address	Last Operation Address	Record Count
Address	Record Count		Item Master Address	Compare Portion of Item Master					
*	*	*	*	*	*	*	*	*	*
10	11	12	13	14	15	16	17	18	19

Order Policy												
Order Code	Order Point	Order Quantity or Order-Up-To	Safety Stock	Minimum	Maximum	Multiple	Modifier to Order Policy	Modifier Code	Modifier Cutoff Date	Total Unit Cost	Total Setup Cost	Carrying Rate
20	21	22	23	24	25	26	27	28	29	30	31	32

Forecasting												
										Base Series		
Model Type	First Average	Second Average	Trend	Safety Factor	Average Demand	Mean Absolute Deviation (MAD)	Sum of Deviations	Alpha	Number Forecast Periods	1	→	n
33	34	35	36	37	38	39	40	41	42	43		

Shrinkage Factor	Lead Time				Raw Material	
		Production				
	Purchasing	Set Up	Run	Queue/Move	Number	Unit Quantity per this part
44	45	46			47	48

Unit Cost						Unit Price			Parts Usage History			
Standard Costs			Actual Costs			List	Net	Discount Codes	Demand		Issues	
Material	Labor	Burden	Material	Labor	Burden				Number Periods	Quantity	Number Periods	Quantity
49	50	51	52	53	54	55	56	57	58	59	60	61

Current Period					Inventory on Hand						Allocated Quantity
							Primary Location				
Beginning Inventory	Transfers and Adjust-ments	Receipts	Issues	Demand	Total Quantity	Number Locations	Area Code	Quantity	Stock Location	Address to Multiple Locations	
62	63	64	65	66	67	68	69	70	71	72	73

Back Orders Quantity	Project Gross Indicator	Project Gross Factor	Physical Inventory					Projected Order Requirements			
								Gross Requirements		Planned Orders	Released Orders
			Type Inventory	Quantity Count	Checker Number	Date of last Count	Date of next Count	Date/Quantity →	Address to Pegged	Date/Quantity →	Date/Quantity →
74	75	76	77	78	79	80	81	82	83	84	85

Pegged Requirements											
Part Number Requirement			Immediate Use			Finished Product Use					Address to Next Requirement
This Part Number	Quantity	Scheduled Due Date	Part Number	Quantity	Scheduled Due Date	Part Number	Quantity	Scheduled Due Date	Customer Order Number	Production Order Number	
86	87	88	89	90	91	92	93	94	95	96	97

On Order	On Order - Purchasing				Address to Purchase Master	Address to Vendor Master	On Order - Production		Engineering Drawing	
	Open Purchase Requisition		Open Purchase Order							
Grand Total	Total Quantity	Address to Detail	Total Quantity	Address to Detail			Total Quantity	Address to Detail or First Job Order Summary	Drawing Number	Date
98	99	100	101	102	103	104	105	106	107	108
		(See open purchase requisition.)		(See open purchase order.)	(See purchase master.)	(See vendor master.)		(See open job order summary.)		

Engineering Change Control								
Last Engineering Change				Current Engineering Change				
							Effectivity	
Number	Reason For Change	Disposi-tion	Effectivity Date	Number	Reason For Change	Disposi-tion	Date	Quantity
109	110	111	112	113	114	115	116	117

ITEM MASTER (M)

Field No.	Symbol	Field Name	Description
1	MTYPN	Item Type	Codes used to define an item, for example: 1. Assembly and subassembly 2. Fabricated parts 3. Raw material 4. Purchased part 5. Customer option
2	*	Item Number	The number that identifies the item.
3	MPDSC	Item Description	The item name can range from a short noun abbreviation to a more descriptive wording.
4	MPJCD	Projection Code	Codes for use in forecasting (or projection) subsystem to indicate whether this item is to be projected (1 = yes, 2 = no).
5	MRPF	Reqs. Planning Flag	Codes for use in requirements planning subsystem (-1 = pegged reqs., 2 = time series, 3 = other).
6	MUTMS	Unit of Measure	A code that describes the measurements by which parts and materials are purchased, used, priced, and sold (gallons, pieces, feet, pounds, yards, etc.).
7	MVACL	Inventory Value Classification	A code indicating the category of inventory for this item. Stratification of inventory is accomplished by correlating annual demand, investment, and net profit.
8	*	First Assembly Component Address	The address of the product structure record representing the first component of the assembly whose part number is specified by the item number field. Starting with the first assembly component address, all components in the assembly are linked together in an assembly component chain.
9	*	Record Count	Provided for audit and control; it is a count of product structure records that represent the components of this part number.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

Field No.	Symbol	Field Name	Description
10	*	First Assembly Where-Used Address	The address of the product structure record representing a usage of this part number on a higher-level assembly. Starting with this address, all direct usages of this part on higher-level assemblies are linked together in a part number where-used chain.
11	*	Record Count	Provided for audit and control; it is a count of product structure records in a where-used chain for this part number.
12	*	Low-Level Code	A number indicating the lowest tier or level at which a particular part number is found in all product structure trees. These codes are used in the processing of summarized explosion and implosion retrieval programs and in checking assembly-to-subassembly continuity.
13	*	Next Item in Activity Chain Item Master Address	The address of the next item master record in an activity chain. Activity chains link together all active item master records with a common low-level code. Each of the chains is anchored in a segment of a core storage level table that corresponds to the low-level code of the item master. The chain is also used in summarized explosions and implosions.
14	*	Compare Portion of Item Number	The compare portion of the next part number in the activity chain used to check continuity.
15	*	Run Activity Control Number	An aid to reconstruction and restart procedures, and to specialized retrieval functions. At the beginning of any application program run, the program accesses this field, updates it by one, and displays the run number on the operations log.
16	*	Overflow Chain Address for Sequential Additions	The link field by which additions to the file, though located physically in a different part of the file, may nevertheless be treated as in logical part number sequence.
17	*	Address of First Routing Operation	Beginning with this address, all operations required to manufacture a part or an assembly are linked together in a forward routing chain. This chain is maintained in ascending sequence specified by the user.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

Field No.	Symbol	Field Name	Description
18	*	Address of Last Routing Operation	Beginning with this address, all operations in a fabrication or an assembly routing are linked together in a backward chain maintained in descending sequence by operation number. The use of a backward chain may speed date calculation for scheduling purposes. It may also speed maintenance for the routing file.
19	*	Record Count for Standard Routings	The total number of operations in a fabrication or an assembly. It is used as a test on the number of accesses in a forward or backward routing chain.
		Order Policy	
20	MOPOC	Order Code	Codes are organized to select specific ordering plans:
		Code	
		A — Discrete Quantity	The items covered by this code are ordered to meet requirements with minimum or no protective stock.
		B — Order Point/Order Quantity	Ordering under this policy is of a fixed order quantity ordered at some predetermined level of inventory.
		C — Order Point/Order-Up-to Level	This method orders enough to return inventory to a user specified level.
		D — Fixed EOQ	Each time an order is placed the quantity has been predetermined by the amount shown in this field. The quantity is recomputed periodically.
		E — Dynamically computed EOQ	The quantity ordered varies to reflect future demand, which, in turn, varies from period to period. Each order placed is for a newly computed quantity.
21	MOPOP	Order Point	The quantity expected to be consumed during the replenishment lead time plus a reserve. It is average demand multiplied by lead time plus safety stock.
22	MOPOQ	Order Quantity or Order-Up-to Level	Order quantity is the amount to be ordered when the order point is reached. It is also used by requirements planning if fixed EOQ is used. If item coded order-up-to level (C in MOPOC), this field has the level instead of order quantity.
23	MOPSS	Safety Stock	The amount of stock to protect against uncertainty in demand and in the length of the replenishment lead time.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

Field No.	Symbol	Field Name	Description
24	MOPMN	Minimum	Customer-specified minimum allowable order quantity.
25	MOPMX	Maximum	Customer-specified maximum allowable order quantity.
26	MOPMU	Multiple	The number to be used in rounding of order quantity (for example, even 100s or multiples of 10, etc.).
27	MOPOR	Modifier to Order Policy	Used to contain either number-days-supply or maximum quantity modifier to an order policy
28	MOPRC	Modifier Code	Used to determine whether MOPOR contains number-days supply or maximum quantity modifier
29	MOPCD	Modifier-Cutoff Date	Used to restrict number of days to be considered in an order policy for this item.
30	MUCTL	Total Unit Cost	Total unit cost for this item
31	MUCSU	Total Setup Cost	Total setup cost for this item
32	MOPCR	Carrying Rate	Carrying rate per period for this item
33	MFCMT	Forecasting or Projection Model Type	Models may be classified into four types: constant, trend, seasonal, and trend-seasonal.
34	MFCFA	First Average	Field contains the average demand to be used with 1st and 2nd order smoothing.
35	MFCSA	Second Average	Field used in 2nd order smoothing to smooth the 1st average.
36	MFCTM	Trend	The result of the trend calculations performed during the update and project run.
37	MFCSF	Safety Factor	A number used for computation of safety stock. If statistical methods are used, this factor is multiplied by MAD (adjusted for lead time) to determine safety stock. The safety factor may be time or a percentage of lead time which is used with average demand to calculate safety stock.
38	MFCAD	Average Demand	The average demand as computed during the update and project run.
39	MFCMD	Mean Absolute Deviation (MAD)	The average of the differences between actual demand and average demand for an item, as determined each time average demand is calculated (e.g., every two weeks). All differences are considered positive.
40	MFCSD	Sum of Deviations	Sum of deviations between actual demand and estimated demand; used to determine the accuracy of the forecast.

Field No.	Symbol	Field Name	Description
41	MFCAL	Alpha	Smoothing constant. The weighting factor to be assigned to current data and past demand. The higher the factor, the greater weight given to recent demand.
42	MFCFP	Number Forecast Periods	Number of periods to extend or to project demand.
43	MFCBI	Base Indices	A series of factors used to adjust the averages for cyclic demand patterns.
44	MSHRF	Shrinkage Factor	The factor of percentage by which an order may be expected to change in quantity during manufacture because of losses from scrap, deterioration, pilferage, etc.
45	MLTPU	Lead Time - Purchasing	The time it takes to receive an order for a purchased item from a vendor; includes internal purchasing cycle and vendor lead time.
46	MLTPR MLTSU MLTRN MLTQM	Lead Time - Production Set-Up Time Run Time Queue/Move Time	The total time required to produce an order; includes set-up, run, and Queue/Move time.
47	MRMNO	Raw Material Number	Identification of the raw material to produce this item.
48	MRMUQ	Raw Material Unit Quantity per This Part	Amount of raw material required for this item; not needed if raw material is part of the product structure.
		Unit Cost	
49	MUCSM	Standard Material Cost	Standard material cost applied to this item number.
50	MUCSL	Standard Labor Cost	Standard labor cost applied to this item number.
51	MUCSB	Standard Burden Cost	Standard burden cost applied to this item number.
52	MUCAM	Actual Material Cost	Actual material cost for this item number.
53	MUCAL	Actual Labor Cost	Actual labor cost for this item number.
54	MUCAB	Actual Burden Cost	Actual burden cost applied to this item number.
		Unit Price	
55	MUPLP	List Price	List price for sale of item.
56	MUPNP	Net Price	Net price for sale of item.
57	MUPDC	Discount Codes	Price code for pricing structure (for example, discount from list or net, applicable in sale to jobber, dealer, etc.).

Field No.	Symbol	Field Name	Description
		Parts Usage History	
58	MPUPD	Number Periods Demand	Cumulative periods of demand (for example, past six months, past year).
59	MPUQD	Demand Quantity	Total demand during past number of periods.
60	MPUPI	Number Periods Issues	Cumulative periods of issues or disbursements (for example, past six months, past year).
61	MPUQI	Issues Quantity	Total disbursements during past number of periods.
		Current Period	
62	MCSBI	Beginning Inventory	The amount in inventory at the beginning of the current time period.
63	MCSTA	Transfers and Adjustments	Running sum of the transfers and adjustments made to the inventory of an item during the current time period. Starts over at zero at the beginning of the next time period.
64	MCSRE	Receipts	Running sum of the inventory receipts made during the current time period. Starts over at zero at the beginning of the next time period.
65	MCSIS	Issues	Running sum of the inventory disbursements made during the current time period. Starts over at zero at the beginning of the next time period.
66	MSSDE	Demand	Running sum of the actual demand for an item (whether satisfied or not) during the current time period. Starts over at zero at the beginning of the next time period.
		Inventory On Hand	
67	MOHTQ	Total Quantity	Grand total units on hand at all stock locations.
68	MOHNL	Number locations	Total number of stock locations.
69	MOHPA	Primary Location - Area Code	An area code to identify (a) warehouse number, (b) building number, (c) department number, or (d) stockroom number, (Primary location fields represent the first material location area. Multiple locations are chained to this record field.)

Field No.	Symbol	Field Name	Description
70	MOHPQ	Primary Location - Quantity	Quantity of stock on hand at this location.
71	MOHML	Primary Location - Stock Location	Location of stock on hand. Material might be stored by (a) row/tier, (b) aisle number, or (c) floor location.
72	MOHML	Address to Multiple locations	Linkages to all additional stock locations. These fields correspond to primary location layout.
73	MALQT	Allocated Quantity	A quantity of stock on hand or on order earmarked to cover requirements.
74	MBOQT	Back Orders Quantity	Requirements that have been received but that have not been fulfilled because of a lack of materials or parts.
75	MPJSW	Project Gross Indicator	Indicator used to determine whether this item is to have its gross requirements projected by determining the number of periods known requirements and projecting an average of this demand for the periods with no known requirements.
76	MPJFT	Project Gross Factor	Used to adjust, up or down, the average of the known requirements when projecting gross requirements.
77	MPITI	Physical Inventory Type Inventory	Code denoting category of physical inventory-taking (for example, annual audit, rotating count, periodic).
78	MPIQC	Quantity Count	Quantity or wieght count taken on individual items during physical inventory.
79	MPICN	Checker Number	Man number identifying stockman counting the inventory.
80	MPIDL	Date of Last Count	Date inventory was taken for this item.
81	MPIDN	Date of Next Count	Date of next inventory-taking, as generated by the computer.
82	MPRGR	Projected Order Requirements Gross Requirements	Total requirements accumulated by time periods before consideration of available inventory.
83	MPRPA	Address to Pegged Requirements	Direct access device address to pegged requirements file.

Field No.	Symbol	Field Name	Description
84	MPRPM	Planned Orders	Net quantity planned to be purchased or to be shop-produced by time period.
85	MPRPE	Released Orders	Sum of all the quantities of orders that have been placed in the release cycle by time period.
		Pegged Requirements	
		Part Number Requirement	
86	MPRTN	This Part Number	A part number designation for this item that is pegged.
87	MPRTQ	Quantity	The gross required quantity for this item.
88	MPRTD	Scheduled Due Date	The date this item is required.
		Immediate Use	
89	MPRIN	Part Number	A part number designation for this item.
90	MPRIQ	Quantity	The gross required quantity for this item.
91	MPRID	Scheduled Due Date	The date this item is required.
		Finished Product Use	
92	MPRFN	Part Number	A part number designation for this item.
93	MPRFQ	Quantity	The gross required quantity for this item.
94	MPRFD	Scheduled Due Date	The date this item is required.
95	MPRFC	Customer Order Number	Customer order number associated with this item number and due date.
96	MPRFP	Production Order Number	Production order number associated with this item number and due date.
97	MPRNA	Address to Next Requirement	Address of next pegged requirement.
98	MTOOQ	Grand Total On-Order Quantity	Grand total on-order quantity of this item as a result of adding (a) total purchase requisitions, (b) total purchase orders, and (c) total production in process.
		On Order - Purchasing	
99	MPURQ	Total Requisition Quantity	Total quantity on order from purchase requisitions.
100	MPURA	Address Requisition Detail	Chain address to open purchase requisition detail records (quantity in each requisition should balance to total quantity above).

Field No.	Symbol	Field Name	Description
101	MPUPQ	Total Purchase Order Quantity	Total quantity on order from purchase orders.
102	MPUPA	Address Purchase Order Detail	Chain address to open purchase order detail records (quantity in each purchase order should balance to total quantity above).
103	MPUPM	Address to Purchase Masters	Chain address to purchase master file.
104	MPUVM	Address to Vendor Masters	Chain address to vendor master file.
105	MPRPQ	Total On-Order Production Quantity	Total quantity in production for this item.
106	MPRPA	Address to On-Order Production Detail	Chain address to open job order summary records (quantity in each record should balance to total quantity above).
107	MEDNO	Engineering Drawing Number	The number that identifies the drawing for this item.
108	MEDDT	Engineering Drawing Date	The date of the engineering drawing.
109	MECPN	Engineering Change Control Last Change Number	The number of the engineering change that was issued before the current change number.
110	MECPR	Reason for Change	A code to denote why the change was made. Examples include: 1. Safety 2. Emergency 3. Field trouble 4. Cost reduction 5. Product improvement 6. Correction 7. Sales request 8. Factory service 9. Suggestion 10. Standardization 11. Special customer options 12. New product planning
111	MECPP	Disposition	Code to indicate the action to be taken; for example: 1. Use all parts 2. Rework all parts 3. Scrap all parts when new parts are available 4. Use to minimum quantity 5. Mandatory changes (stops activity immediately)

Field No.	Symbol	Field Name	Description
112	MECPD	Effectivity Date	The date the engineering change was effective.
113	MECCN	Current Change Number	The number for the most recent change.
114	MECCR	Reason for Change	Code to indicate why the change is being made. See field number 103 for example.
115	MECCP	Disposition	Code to identify the action required relative to the change. See Field number 104 for example.
116	MECCD	Effectivity Date	Estimated or planned date when the change will be effected.
117	MECCQ	Effectivity Quantity	On-hand inventory quantity for the part which when reached, signals that all future production be made at the design level indicated by this engineering change number.

SECTION B: OPEN PURCHASE REQUISITION

Purchase Requisition		Item Number	Buyer Number	Requisition Quantity	Date Required	Vendor Number or Numbers	Account Number	Date Closed	Address to next requisition this Item
Number	Date								
1	2	3	4	5	6	7	8	9	10

OPEN PURCHASE REQUISITION (PR)

Field No.	Symbol	Field Name	Description
1	PRNUM	Purchase Requisition Number	Identification numbers serially assigned to each requisition. This is the detail record that supports the total quantity open requisitions field of the item master.
2	PRDAT	Purchase Requisition Date	Date of the requisition.
3	PRITN	Item Number	This number is also recorded in the item master. The item is classified as an assembled part, component part, raw material, or purchased part.
4	PRBUY	Buyer Number	Buyer to whom requisition is directed.
5	PRQTY	Requisition Quantity	Quantity of parts or material required.
6	PRDTR	Date Required	Month/day/year that purchased part or material is to be received.
7	PRVNO	Vendor Number or Numbers	Identification number(s) assigned to each vendor or vendors.
8	PRACN	Account Number	Accounts payable charge number.
9	PRDTC	Date Closed	Requisition closeout or completion.
10	PRNRA	Address to Next Requisition This Item	Linkage to next requisition number for this item.

SECTION C: OPEN PURCHASE ORDER

Purchase Order		Item Number	Buyer Number	Vendor Number	Vendor Terms	Order Status	Requisition		Ship Date	Delivery Date	Stock Date	Distribution Code	Vendor Promise Date	
Number	Date						Number	Date					First	Latest
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

Quantity Ordered	Received			Rejected		Unit Price	Other Charges	Total Amount Paid	Account Number	Date last Payment	Date Closed	Address to next Open Purchase Order this Item
	Quantity	Date	Receiving Report Number	Quantity	Date							
26	27	28	29	30	31	32	33	34	35	36	37	38

OPEN PURCHASE ORDER (PO)

Field No.	Symbol	Field Name	Description
11	PONUM	Purchase Order Number	Identification number serially assigned to each purchase order. This is the detail record that supports the total quantity open purchase orders field of the item master.
12	PODAT	Purchase Order Date	Month/day/year that the purchase order was prepared.
13	POITN	Item Number	This number is also recorded in the item master record. The item is classified as an assembled part, component part, raw material, or purchased part.

Field No.	Symbol	Field Name	Description
14	POBNO	Buyer Number	Code identification of the buyer who processed the purchase order.
15	POVNO	Vendor Number	Identification code assigned to each vendor.
16	POVTR	Vendor Terms	Payment discount terms.
17	POSTA	Order Status	Code indicating that order is (a) completed, (b) pending arrival of a rush shipment, etc.
18	PORQN	Requisition Number	Number of original requisition against which this order has been prepared.
19	PORQD	Requisition Date	Month/day/year that the requisition for parts or material was prepared.
20	POSHD	Ship Date	Month/day/year that shipment is to be sent by vendor.
21	PODED	Delivery Date	Month/day/year that shipment is to be received.
22	POSTD	Stock Date	Month/day/year that parts or material is to be entered into inventory.
23	PODCD	Distribution Code	Department or area earmarked to receive material from this order.
24	POVPF	Vendor Promise Date First	Month/day/year that the shipment was originally to be received from vendor.
25	POVPL	Latest	Month/day/year that the latest promised delivery date was revised by the vendor.
26	POQTY	Quantity Ordered	Quantity of parts or material purchased.
27	POQRE	Quantity Received	Quantity of parts or material received.
28	PODRE	Date Received	Date material is received.
29	PORRN	Receiving Report Number	Number of receipts document for incoming vendor material.
30	POQRJ	Quantity Rejected	Quantity of parts or material rejected by inspection department.
31	PODRJ	Date Rejected	Date inspection department rejected material.
32	POUNP	Unit Price	Cost of parts or material for an established unit of measure.

Field No.	Symbol	Field Name	Description
33	POOTC	Other Charges	Costs in addition to the purchase of parts or material. This involves miscellaneous freight, insurance, handling, crating, etc.
34	POTAP	Total Amount Paid	Total dollars paid to vendor to date.
35	POACN	Account Number	Accounts Payable charge number.
36	PODLP	Date Last Payment	Month/day/year of most recent payment to vendor.
37	PODTC	Date Closed	Purchase order closeout or completion.
38	PONIA	Address to Next Open Order This Item	Address of next purchase order for the same item.

SECTION D: VENDOR MASTER

Vendor Number	Name and Address/ Telephone No.	Terms	Ship Via	FOB Point	Major Commodities	Vendor Contact	Buyer Number	Number Shipments Inspected	Number Deliveries
1	2	3	4	5	6	7	8	9	10

Number Rejected Shipments	Delivery Rating	Quality Rating	Last Shipment	Total Payments to Vendor	
			Date	Current Month	YTD
11	12	13	14	15	16

VENDOR MASTER (PV)

Field No.	Symbol	Field Name	Description
1	PVVNO	Vendor Number	Identification code assigned to each vendor.
2	PVNAT	Name and Address/Telephone No.	Vendor name, street number, city, state, and telephone contact.
3	PVTER	Terms	Payment discount terms.
4	PVROU	Ship Via	Method of shipping purchased material.
5	PVFOB	FOB Point	Number code representing delivery destination point.
6	PVMAC	Major Commodities	Most important products sold by the vendor.
7	PVVEC	Vendor Contact	The individual employed by a vendor who can be contacted regarding status of orders, shipments, schedules, etc.
8	PVCOB	Buyer Number	Top buyer contact.
9	PVNSI	Number Shipments Inspected	That portion of a vendor's shipments inspected when received.
10	PVNOD	Number Deliveries	Number of deliveries from a vendor to date.

Field No.	Symbol	Field Name	Description
11	PVNRS	Number Rejected Shipments	Number of shipments from a vendor rejected to date.
12	PVDRA	Delivery Rating	Average monthly rating, computed each month, of days late.
13	PVQRA	Quality Rating	Average monthly rating, computed each month, of rejects.
14	PVLSD	Last Shipment Date	Date vendor made most recent shipment.
15	PVTPC	Total Payments Current Month	Total payments made to vendor this month or period.
16	PVTPY	Year to Date	Total payments made to vendor year to date.

SECTION E: PURCHASE MASTER

Item Number	Blanket Purchase Order No.	Number Purchase Orders		Last Five Quotations							
		YTD	Previous Year	Vendor Number	Quote			Quantity	Unit Price	Other Charges	Minimum Lot Quantity
					Number	Date	Terms				
1	2	3	4	5	6	7	8	9	10	11	12

Last Five Quotations		Price Breaks →	Last Six Buys						
Minimum Lot Price	Quote Expiration Date		Purchase Order		Vendor Number	Quantity	Unit Price	Status of Buy	Date Closed →
			Number	Date					
13	14	15	16	17	18	19	20	21	22

PURCHASE MASTER (PM)

Field No.	Symbol	Field Name	Description
1	PMITN	Item Number	Purchased part number, identifiable by the item master record.
2	PMBPO	Blanket Purchase Order Number	Single purchase order number applicable to innumerable purchases.
3	PMNOY	Number Orders Year to Date	Number of orders to a particular vendor or for particular parts or materials year to date.
4	PMNOP	Number Orders Previous Year	Same as preceding, but for the previous year.
		Last Five Quotations	
5	PMQVN	Vendor Number	A number assigned to identify each vendor against which a quotation has been placed.
6	PMNOQ	Quote Number	A number assigned to quotations from selected vendor for a particular part or material.

Field No.	Symbol	Field Name	Description
7	PMQQD	Quote Date	Month/day/year that a vendor submitted a quotation.
8	PMQTE	Quote Terms	Payment discount terms for this quotation
9	PMQQT	Quote Quantity	The quantity of parts or material quoted by a vendor.
10	PMQPR	Quote Unit Price	The price of a part or material quoted by the vendor.
11	PMQOC	Other Charges	Costs in addition to the purchase price, such as freight, special handling, etc.
12	PMQMQ	Minimum Lot Quantity	The minimum batch quantity of an item that must be purchased.
13	PMQMP	Minimum Lot Price	The lowest amount that is paid for a specified batch quantity of an item.
14	PMQED	Quote Expiration Date	The date that a price quotation is no longer valid.
15	PMPBR	Price Breaks	Vendor prices based on lot quantities
		Last Six Buys	
16	PMRPO	Purchase Order Number	The number of the recent purchase order for a part or material.
17	PMPPD	Purchase Order Date	The month/day/year that the recent purchase order was written.
18	PMRVN	Vendor Number	A number identifying the recent supplier of a part of material.
19	PMRQT	Quantity	The quantity of the recent purchase order.
20	PMRUP	Unit Price	The price per unit of a part of material quoted recently.
21	PMRSB	Status of Buy	Status code representing recent buy--for example, awaiting receipt, awaiting invoice, etc.
22	PMRDC	Date Closed	Date that final shipment arrives and is paid for.

SECTION F: OPEN JOB ORDER SUMMARY

Order Number	Item Number	Number Operations this Order	Original Order Quantity	Number Completed Operations	Address to Operations Detail	Quantity Completed Previous Operation	Scheduled		Actual	
							Start	Due Date	Start	Complete
1	2	3	4	5	6	7	8	9	10	11

Lead Time	Job Priority	Engineering Change Number	Status Code	Current Operation				Shrink-age Factor	Scrap Report-ed	Standard Material Costs
				Work Center	Operation Number	Quantity to Complete	Quantity Completed			
12	13	14	15	16	17	18	19	20	21	22

Labor Costs			Date last activity	Address to next Order Number
Standard	Standard to Date	Actual to Date		
23	24	25	26	27

OPEN JOB ORDER SUMMARY (OS)

Field No.	Symbol	Field Name	Description
1	OSONO	Order Number	The number assigned to the shop order for identification.
2	OSITO	Item Number	The number of the item for which the order was issued.
3	OSNOT	Number Operations This Order	The number of operations that must be performed to produce the item.
4	OSOOQ	Original Order Quantity	The quantity that was ordered.
5	OSNCO	Number Completed Operations	The number of operations that have been reported complete.
6	OSODA	Address to Operations Detail	The address to the detail operations records. It is the address of the operation that is currently being processed.
7	OSQCP	Quantity Completed Previous Operation	The quantity that was reported at the end of the last operation.
8	OSSSD	Scheduled Start Date	The date this order was originally scheduled to start in the shop.
9	OSSDD	Scheduled Due Date	The date on which the order was scheduled to be completed.
10	OSASD	Actual Start Date	The date the order was started in the shop, as determined by feedback.
11	OSACD	Actual Completion Date	The shop date the order was reported to be complete.
12	OSLDT	Lead Time	The estimate of time required to do the work in the shop.
13	OSJOP	Job Priority	A value calculated to enable a scheduling system to rank this order relative to all others; for example, this can be the result of average slack per remaining operation calculations (see "Operation Scheduling")
14	OSECN	Engineering Change Number	The number that identifies the change level under which this order is to be produced.
15	OSSTC	Status Code	A code to summarize the status of the order, for example, on time, late, expedite, etc. It can be used to influence the priority value.

Field No.	Symbol	Field Name	Description
16	OSCOW	Current Operation Work Center	The number of the work center where the work is currently being performed.
17	OSCOO	Operation Number	The number of the operation currently being worked.
18	OSCOQ	Quantity to Complete	The number of pieces that have not been reported complete.
19	OSCOC	Quantity Completed	The quantity reported completed for the current operation.
20	OSSHF	Shrinkage Factor	The quantity or scrap factor associated with the order.
21	OSSCR	Scrap Reported	The quantity of scrap that has been recorded to date.
22	OSSMC	Standard Material Costs	The standard costs for the material used for the order.
23	OSLCS	Labor Costs Standard	The standard labor costs for the order.
24	OSLCD	Standard to Date	The accumulation of the standard costs that have been reported to date. It is the sum of the standard costs of completed operations.
25	OSLCA	Actual to Date	The actual labor costs that were reported for the completed operations.
26	OSDLA	Date Last Activity	The date this shop order record was last changed.
27	OSNOA	Address to Next Order Number	The address where the next order (for this same item number) is stored in the file.

Record Status Code	Component Item Number Master		Parent Item Number Master		Quantity per Assembly	Next Component Address	Where-Used Chain Address this Item		Current Engineering Change Number	Scrap Factor	Offset Adjust-ment
	File Address	Compare Portion of Item Number	File Address	Compare Portion of Item Number			Next	Previous			
	*	*	*	*	*	*	*	*			
1	2	3	4	5	6	7	8	9	10	11	12

PRODUCT STRUCTURE (S)

Field No.	Symbol	Field Name	Description
1	SRSCO	Record Status Code	Code to indicate the present status of this product structure record, for example: 1. Engineering Add: This record is part of the product structure but is not to be used in retrieval runs pending the effectivity of the latest engineering change. When the change is made, the record code is changed to (3) Build. 2. Engineering Delete: This record is still active in the product structure and is used in retrieval runs until the latest engineering change effectivity causes it to be put in (4) Inactive status. 3. Build: This record is in the product structure at a given design level (indicated by the engineering change number) and is to be used in all retrieval runs. 4. Inactive: This record is awaiting physical removal from the file because it has been superseded.
2	*	Component Item Master File Address	The direct access device address of the component item number master record.
3	*	Compare Portion of Component Item Master	The portion of the component item number used for checking purposes.
4	*	Parent Item Master File Address	The address of the parent item number master record.
5	*	Compare Portion of Parent Item Master	The portion of the parent item number used for checking purposes.

Field No.	Symbol	Field Name	Description
6	*	Quantity per Assembly	The quantity of this component used in the parent assembly.
7	*	Next Component Address	Address of the product structure record representing the next component of the parent assembly.
8	*	Address of Next Where-Used This Item	Address of the product structure record representing another usage of this item number in another assembly.
9	*	Address of Previous Where-Used This Item	Address of the product structure record representing another (previous) usage of this item number in another assembly.
10	SCECN	Current Engineering Change Number	Current engineering change number that applies to this usage of this item.
11	SPSSF	Scrap Factor	Used to increase a component's gross requirements to reflect a scrap loss when assembled to a specific parent item.
12	SPSOA	Offset Adjustment	Used to adjust the required date of a component's gross requirements to more accurately reflect the date required in assembly to a specific parent item.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

SECTION H: STANDARD ROUTING

Operation Number	Sequence Number this Routing	File Addresses						Special Action Codes	Alternate Operations Address	WORK CENTER	
		Item Master	Compare Portion of Item Master	Next Operation this Routing	Previous Operation this Routing	Work Center Where-Used Chain				Master Address	Compare Portion
						Next	Previous				
*	*	*	*	*	*	*	*			*	
1	2	3	4	5	6	7	8	9	10	11	12

Operation Classification	Operation Definition			Tool Information			Time Standards				Move Time	Shrinkage Factor	Current Engineering Change Number
	Description	Work Center (Department Group)	Machine Number	Code	Next Usage	Tool Number	Set-up Code	Set-up Hours	Labor Hours	Machine Hours			
13	14	15	16	17	18	19	20	21	22	23	24	25	26

STANDARD ROUTING (R)

Field No.	Symbol	Field Name	Description
1	ROPNO	Operation Number	Number assigned to this manufacturing or assembly operation.
2	*	Sequence Number This Routing	Number indicating the position of this operation in this routing.
		File Addresses	
3	*	Item Master Address	Address at which the item master record for the item is to be found.
4	*	Compare Portion of Item Master	Portion of the item number used for checking purposes.
5	*	Next Operation This Routing	Address of the operation routing record for the next sequential operation in this routing.
6	*	Previous Operation This Routing	Address of the operation routing record for the sequentially previous operation in this routing.
7	*	Work Center Where-Used Chain — Next	(†) Address of the operation routing record representing next usage of this work center.
8	*	Work Center Where-Used Chain — Previous	(†) Address of the operation routing record representing previous usage of this work center.
9	RSACO	Special Action Codes	Codes to designate (1) lap phasing, (2) multiple machines, or (3) alternate work centers.
10	RAOPA	Alternate Operations Address	The address where alternate routing for the item can be found.
11	*	Work Center Master Address	The location where the master record for the work center can be found.
12	*	Compare Portion of Work Center Number	Portion of work center number used for checking purposes.
13	ROPCL	Operations Classification	Code to indicate the type of operation, for example: 1. Primary — most desirable method of production 2. Alternate — less desirable but acceptable method of production; etc.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

(†) These addresses are required to maintain bidirectional chaining of all the uses of a work center.

Field No.	Symbol	Field Name	Description
		Operation Definition	
14	ROPDE	Description	Short description of the operation, for example, drill, mill, bore, etc.
15	RWCND	Work Center or Department Number or Group Number	Work center may be classified as department number or machine group number in which work is to be performed.
16	ROPMN	Machine Number	Actual machine on which the work is to be performed, if this is a requirement.
		Tool Information	
17	RTOCO	Code	A code specifying the number of tools required for this operation. It is also used to determine the contents of the next two fields.
18	RTONV	Next Usage	This field contains the location of the next usage for a particular tool when one tool is required on the operation. If more than one tool is used, it is the address where the information for multiple tool usage is stored.
19	RTONO	Tool Number	The identification number of the tool required for this operation. If more than one tool is required, this field is blank. The tool numbers are stored in the multiple usage area.
		Time Standards	
20	RTSUC	Setup Code	Code to specify if setup is applicable to man, machine, or both, or setup pool.
21	RTSSH	Setup Hours	The established standard for the amount of time required to set up the equipment to perform this operation.
22	RTSLH	Labor Hours	The established standard for the amount of direct labor required to perform this operation.
23	RTSMH	Machine Hours	The established standard for the number of machine hours required to perform this operation.
24	RMOVE	Move Time	An estimate of the time required to move the order to the next work center.
25	RSHRF	Shrinkage Factor	Factor used to compute scrap that relates to this operation.
26	RCECN	Current Engineering Change Number	This number identifies the design level (of the item) with which this operation is associated.

SECTION I: WORK CENTER MASTER

Work Center Identification		First Operation in Where-Used Chain		Overflow Chain Address For Sequential Additions	Number Machines in this Machine Group	Address to Detail of Machines in this Group	Work Center Efficiency	Move Time
Department Number	Machine Group Number	Address	Record Count					
*		*	*	*				
1	2	3	4	5	6	7	13	14

No. Shifts	Hrs. Per Shift	Daily Capacity (Maximum)			Daily Capacity (Desired)		
		SU	Machine	Labor	SU	Machine	Labor
15	16	17	18	19	20	21	22

Machine Detail				
Machine Number	Description	Machine Capacity	Make and Model	Maintenance Data
8	9	10	11	12

Work Center Projections									Jobs in Center	
Available Labor (Hours)	Current Period	Period 1 →	Available Machine (Hours)	Current Period	Period 1 →	Planned Order Load	Current Period	Period 1 →	Total Load Hours	Address of First Operation in Work Center (See operation detail.)
23			24			25			26	27

Manned Machines by Shift		Hours Completed this Center this Period				
Weekday (Shifts 1-3)	Weekend (Shifts 1-3)	Total Actual Hours		Total Standard Hours		Address to Completed Operations this Work Center
		Machine	Labor	Machine	Labor	
28	29	30	31	32	33	34

WORK CENTER MASTER (W)

Field No.	Symbol	Field Name	Description
		Work Center Identification	
1	*	Department Number	Identification of a physical unit within a manufacturing facility, which may be further subdivided into smaller classifications of like machines or work centers.
2	WMAGR	Machine Group Number	Identification of a single machine or work station or of a group of like machines or work stations within a department.
3	*	First Operation in Where-Used Chain Address	Address of the first operation routing record for the first operation in a chain of operations performed by this department — machine group.
4	*	Record Count for Work Center Where-Used Chain	A count of operation routing records present in the where-used chain for this department — machine group. It is provided for audit and control.
5	*	Overflow Chain Address for Sequential Additions	Address to additions to the file that are located physically in a different part of the file and that may be treated logically as if in department — machine group identification number sequence.
6	WNMTG	Number of Machines in This Machine Group	Physical count of like machines or work stations assigned to this department — machine group.
7	WADMG	Address to Detail of Machines in This Machine Group	Address to machine detail file.
		Machine Detail	
8	WMDMN	Machine Number	Number of the machine.
9	WMDDE	Description	Denotes machine category, for example, vertical mill, horizontal lathe, etc.
10	WMDMC	Machine Capacity	Denotes pertinent machine information, for example, tonnage, stroke, etc.
11	WMDMM	Make and Model	Shows manufacturer and model number.
12	WMDMD	Maintenance Data	Denotes due date for scheduled preventive maintenance or date last maintenance was performed.

*Indicates fields and labels required by the IBM System/360 Bill of Material Processor program (360-ME-06X). See programmer's manual (H20-0246).

Field No.	Symbol	Field Name	Description
13	WEFIC	Work Center Efficiency	As defined for use with the operation scheduling subsystem, this factor is a ratio of standard hours to actual hours. It reflects historic data and is used to estimate how much work (in standard hours) should be scheduled relative to the capacity.
14	WMOVE	Move Time	For use with operation scheduling. An estimate of the average amount of time required to move work from this work center.
15	WNOSH	Number of Shifts	Number of shifts generally worked by this center.
16	WHRSH	Hours per Shift	Number of hours normally worked by shift for the work center.
17	WMCSU	Maximum Setup Hours	Maximum number of setup hours that can feasibly be worked in a day (extra shifts or overtime).
18	WMCMC	Maximum Machine Hours	Maximum number of machine hours that can feasibly be worked in a day.
19	WMCLA	Maximum Labor Hours	Maximum number of labor hours that can feasibly be worked in a day.
20	WDCSU	Desired Setup Hours	The current or desired level of operation for setup porposes.
21	WDCMC	Desired Machine Hours	The current or desired level of operation for machine hours per day.
22	WDCLA	Desired Labor Hours	The current or desired level of operation for labor hours per day.
		Work Center Projections	
23	WPALH	Available Labor (Hours)	The capacity (expressed in labor hours) that is available for planning. It reflects the number of men expected to be available at the work center by time period.
24	WPAMH	Available Machine Hours	Same as labor hours, except that it reflects available machine hours.
25	WPPLO	Planned Order Load	The load hours that were summarized in the capacity planning subsystem as a result of processing planned orders. It may be subdivided into labor and machine hours.

Field No.	Symbol	Field Name	Description
		Jobs in Center	
26	WCTLH	Total Load Hours	The total load at this work center that reflects the remaining time of operations being performed or waiting to be processed, as determined by shop floor control.
27	WCFOA	Address of First Operation in Work Center	The operations in the open job order file are chained to the work center master. This is the address of the first operation.
		Manned Machines by Shift	
28	WMMWD	Weekday	Three numbers that indicate the staff for this work center by shift for Monday through Friday.
29	WMMWE	Weekend	Three numbers that indicate the staff for weekends.
		Hours Completed This Center This Period	
30	WHCAM	Total Actual Machine Hours	Total machine hours reported on completed job — period to date.
31	WHCAL	Total Actual Labor Hours	Total labor hours reported on completed jobs — period to date.
32	WHCSM	Total Standard Machine Hours	Total standard machine hours earned for completed operations this period to date.
33	WHCSL	Total Standard Labor Hours	Total standard labor hours earned for completed operations this period to date.
34	WHCOA	Address to Completed Operations this Center	A chain of all completed operations for this work center. This is the address of the first operation in a series. Each operation record has the address of the next record for this work center.

SECTION J: OPEN JOB OPERATION DETAIL

Work Center Number	Order Number	Item Number	Operation Number	Sequence Number	Operation Description	Must Run Machine Number	Special Action Code	Tool Information		
								Code	Next Usage	Tool Number
1	2	3	4	5	6	7	8	9	10	11

Move Time	Scheduled Start	Actual		Previous Work Center	Previous Operation		This Operation			Next	
		Start	Completion		Operation Number	Quantity Completed	Quantity Completed	Quantity Scrapped	Shrink-age Factor	Work Center	Operation Number
12	13	14	15	16	17	18	19	20	21	22	23

Status Code	Standard Hours this Order Quantity			Actual Hours		Labor Costs		Date Last Activity
	Setup	Labor	Machine	Labor	Machine	Standard	Actual	
24	25	26	27	28	29	30	31	32

OPEN JOB OPERATION DETAIL (OD)

Field No.	Symbol	Field Name	Description
1	ODWKC	Work Center	The location where the work is to be performed.
2	ODORN	Order Number	Identification number for a shop order.
3	ODITN	Item Number	The number of the part for this order.
4	ODOPN	Operation Number	The number assigned to this manufacturing or assembly operation.
5	ODSEN	Sequence Number	A number indicating the position of this operation into the routing for this order.
6	ODOPD	Operation Description	A short description of the operation to be performed.
7	ODMRM	Must Run Machine No.	The number of a specific machine in the work center on which this operation must run; a blank if any machine.
8	ODSAC	Special Action Code	Code to designate (1) lap phasing, (2) multiple machines, or (3) alternate work centers.
9	ODTIC	Tool Information Code	A code to indicate the number of tools required for this operation.
10	ODTNU	Next Usage	For operations that require one tool it is the location of the next operation on which this tool is required. If more than one tool is required, it is the address of where the multiple usage data is stored.
11	ODTNO	Tool Number or Address	The number of the tool required for this operation. This field is blank if multiple tools are required. Tool numbers are stored in the multiple usage area.
12	ODMOT	Move Time	The usual amount of time required to move this lot to the next work center.
13	ODSES	Scheduled Start Date	The date furnished by the last run of the operation scheduling subsystem.
14	ODASD	Actual Start Date	The date this operation was started.
15	ODACD	Actual Completion Date	The date this operation was completed.

Field No.	Symbol	Field Name	Description
16	ODPWC	Previous Work Center	The number of the work center for the previous operation.
		Previous Operation	
17	ODPON	Operation Number	The number of the previous operation.
18	ODPQC	Quantity Completed	The quantity completed for the previous operation.
		This Operation	
19	ODTQC	Quantity Completed	The quantity completed for this operation.
20	QDTQS	Quantity Scrapped	The quantity scrapped for this operation.
21	ODTSF	Shrinkage Factor	Losses resulting from scrap, deterioration, pilferage, and other factors.
22	ODNWC	Next Work Center	The work center where the next operation is to be performed.
23	ODNON	Next Operation Number	The number of the next operation to be performed.
24	ODSTC	Status Code	Indicates current status of this operation: 0-complete, 1-run started, 2-setup complete, 3-setup started, 4-waiting.
		Standard Hours This Order Quantity	
25	ODSHS	Set Up	The standard amount of time required to set up this job.
26	ODSHL	Labor	The established standard for the direct labor hours to perform this operation.
27	ODSHM	Machine	The established standard for the number of machine hours required to perform this operation.
28	ODALH	Actual Labor Hours	The accumulation of direct labor hours reported for this operation.
29	ODAMH	Actual Machine Hours	The accumulation of machine hours reported for this operation.
30	ODSLC	Standard Labor Costs	The standard labor costs for this operation.
31	ODALC	Actual Labor Costs	The accumulation of direct labor costs reported for this operation.
32	ODDLA	Date Last Activity	The last date this record was changed.

SECTION K: TOOL MASTER

Tool Number	Description	Status	Number of Tools	Original Tool Order			Where-Used		DETAIL CODE	Serial Number	Location		
				Number	Quantity	Cost	Standard Routing	Open Job Order			Crib	Current Operation Assignment	
												Work Center	Order Number
1	2	3	4	5	6	7	8	9	10	11	12	13	14

Codes			Accumulated Usage	Estimated Tool Life	Date Last Inspection	In Process Repair Flag		Address to Overflow
Inspection	Maintenance	Usage				Code	Location	
15	16	17	18	19	20	21	22	23

TOOL MASTER (T)

Field No.	Symbol	Field Name	Description
1	TNUMB	Tool Number	A unique number to identify the tool.
2	TDESC	Description	A name or series of descriptive codes to further describe the tool.
3	TSTAT	Status	A code denoting the current status, for example, in use, ready to be assigned, out for repair.
4	TNTOO	Number of Tools	The quantity or number of tools that exist and that are identified by the unique tool number.
		Original Tool Order	
5	TOTON	Number	The order number under which this tool was originally produced.
6	TOTOQ	Quantity	The number of tools that were produced under the original tool order.
7	TOTOC	Cost	The cost of producing the tools on the original order.
		Where-Used	
8	TWUSR	Standard Routing	The address of the first operation in the standard routing file on which this tool is used. A chaining technique is used, and this is the first link of the chain. The records in the standard routing file indicate later uses.
9	TWUOJ	Open Job Order	The base of the where-used chain through the open job order file. Each record in that file points to the next usage to identify the operations on which this tool is to be used.

Field No.	Symbol	Field Name	Description
10	TCONO	Code Number	A general classification code for tool categories.
11	TSENO	Serial Number	For multiple tools; a suffix number to identify each tool specifically. This is necessary if usage information is to be maintained.
12	TLOCR	Location Crib	The area identification where this tool is normally located.
13	TCOWC	Current Operation Assignment Work Center	If the tool is assigned to an operation, this field contains the work center number.
14	TCOON	Order Number	The order number for which this tool is currently being used.
15	TINSC	Codes Inspection	A code denoting the inspection procedure for this tool, for example, after each use.
16	TMACO	Maintenance	If a maintenance function must be performed, this code indicates the procedure to be followed, for example, when usage is equal to tool life, after each use.
17	TUSCO	Usage	A code used to identify the type of information in the accumulated usage field, for example, hours of use, hours of actual cutting time, number of pieces.
18	TACUS	Accumulated Usage	A total that reflects the usage of this tool. If is the sum of hours or pieces, etc., indicated by the usage code.
19	TETLF	Estimated Tool Life	A value that specifies when the tool is normally ready for maintenance. It is stated in the same terms as accumulated usage.
20	TDLIN	Date Last Inspection	The shop date on which this tool was last inspected.
21	TIPRC	In-Process Repair Flag Code	Code indicating that the tool is out for repair or maintenance.
22	TIPLC	Location	Code indicating where the repair or maintenance is being performed.
23	TATOF	Address to Overflow	The address of the next record for this tool number. This is used when multiple tools exist and usage and/or location information is being recorded for each unique tool.

BIBLIOGRAPHY: Additional References

The references below are in addition to those appearing in the footnotes within the manual.

INFORMATION SYSTEMS

Product Definition in the Aerospace Industry (E20-0235)

Telephone Information System - Study Guide (E20-0158)

Telephone Information System - Customer Service (E20-0151)

Customer Information File for Banks - Design Guide (E20-0234)

ENGINEERING

Engineering Data Processing for Manufacturing Industries (E20-8106)

Engineering Data Processing - Automated Design Engineering (E20-8151)

Engineering Design Data Processing at IBM (E20-8155)

Automated Manufacturing Planning (E20-0146)

Methods and Standards Automation (E20-0144)

Information Storage and Retrieval Program for Engineering Parts and Drawings (E20-0132)

Introduction to Automatic Data Processing for Numerical Control of Machine Tools (E50-0022)

FORECASTING

Aerospace Information and Control Systems - Forecasting (E20-8125)

OPERATION SCHEDULING

Aerospace Information and Control Systems - Planning and Tooling (E20-8119)

Plant Maintenance Management System (E20-0124)

SHOP FLOOR CONTROL

Machine Shop Downtime Analysis and Control (E20-0130)

MOS - Quality Assurance for Manufacturing Industries (E20-8081)

Industrial Testing - Data Analysis and Control (E20-0021)

PURCHASING

IBM Management Operating System - Industrial Purchasing (E20-8054)

The following IBM publications provide general related information:

System/360 Inventory Control Application Description (H20-0471)

System/360 Product Structure Retrieval Program Application Description (H20-0329)

System/360 Bill of Material Processor Application Description (H20-0197)

Bill of Material Processor - A Maintenance and Retrieval System (E20-0114)

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