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THE UNIVERSITY OF ALBERTA

A MICROCOMPUTER-BASED MATERIAL REQUIREMENTS PLANNING SYSTEM FOR SMALL MANUFACTURERS

by

STEPHEN KAM-SAI CHENG

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A MICROCOMPUTER-BASED MATERIAL REQUIREMENTS PLANNING SYSTEM FOR SMALL MANUFACTURERS submitted by STEPHEN KAM-SAI CHENG in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in MECHANICAL ENGINEERING (ENGINEERING MANAGEMENT).

Supervisors

Date July 20, 1987

ABSTRACT

Manufacturing companies in the eighties are turning more and more towards the use of computer-based production and inventory management systems. These systems provide for a better control of the work-in-process inventories, capacity requirements, and order tracking in a manufacturing environment. These systems also aid in developing reports for upper management and provide for a more logical coordination of the day-to-day production and manufacturing activities.

Recent advances in the microcomputer technology have made these systems available and affordable to small manufacturers. In this study, a microcomputer-based material requirements planning (MRP) system for small manufacturers was developed and tested with an actual implementation at Argo Materials Handling Systems Limited. The result is an improvement in the accuracy and reliability of the bill of materials and inventory record data. The application and implementation of the system were also investigated and the report concluded with some recommendations for future development.

The computer program is written in the BASIC language and is easily adaptable to any small company. A user's manual is included and a sample problem is used to demonstrate the operation and capability of the system.

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Thanks are also extended to Mr. N. Loblick and the staff at Argo Materials Handling Systems Limited where the system was implemented. Their cooperation and support are very much appreciated.

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1. INTRODUCTION

During the past two decades, new methods and tools for production requirements have had a dramatic impact on the manufacturing process. One good example is the introduction of numerical controlled machines onto the factory floor. While all this has been going on, production and inventory management have remained very much the same, as an order-launching and expediting process.

Material Requirements Planning (MRP) is a relatively new tool for inventory management in a manufacturing environment. It differs from the traditional inventory management methods in the way it handles stock item requirements. MRP treats the inventory items as if their requirements are *dependent* on each other and from this it *calculates* their future demands. In a traditional approach, these calculations are based on some kind of forecasting or statistical computations.

A material requirements planning system will plan and schedule the inventory item to arrive *at the time* of need, not *before* or *after* it is required. It is totally responsive to fluctuating demands during production and will make adjustments accordingly. A manufacturer with a MRP system only carries inventory items that are *needed* rather than replenishing the stock level with large safety stocks in order to absorb unforeseeable requirements in the future. Companies that have been using such a system have

reported that they have reduced their inventory investment level from 20 to 35%[27]. In addition, there is a reduction in the production and purchasing costs, also an improvement in customer service in terms of meeting the delivery deadlines.

1.1 Purpose

The main objective of this study is to design and develop a microcomputer-based material requirements planning (MRP) system and test it with an actual implementation. The system is being implemented in a small manufacturing company located in northwest Edmonton - Argo Materials Handling Systems Limited.

It is important to realize that a MRP system includes,

- An inventory classification & identification module
- A forecasting module
- A master production schedule module
- An inventory control module
- An order processing module

All the above modules are necessary and responsible for processing information in the MRP data base. They have been developed and integrated to form what is being referred to as a MRP system throughout this thesis.

This study also serves as the first part of a two-part research project towards the development of a complete production and inventory planning and control (PIPC)

system. A schematic diagram of such a system is shown in Figure 1.1. Capacity requirements planning is a technique used to determine what personnel and machine resources are needed to meet the production objectives generated in the material requirements plan. Together, material and capacity requirements planning establish specifically *what*, *when*, and *where* materials and capacities are needed.

In addition to the academic aspect of the study, this model can be used as a teaching guide for people that are involved in the material and production management area.

1.2 Background Information

Manufacturers in the eighties are faced with a formidable challenge. In order to compete with other manufacturers, they have to come up with products which have more variety and improved quality. This means that their product line will be increased both in size and complexity. A clerical system can no longer cope with the increasing production problems encountered in a manufacturing environment. Thus, a more sophisticated inventory and production control method is required.

In a manufacturing environment, every item passes through multiple stages of transformation from raw materials to finished products. A company must plan to have the necessary parts ready on time in order to assemble them into finished products. The reasoning and assumptions used behind traditional inventory management methods are

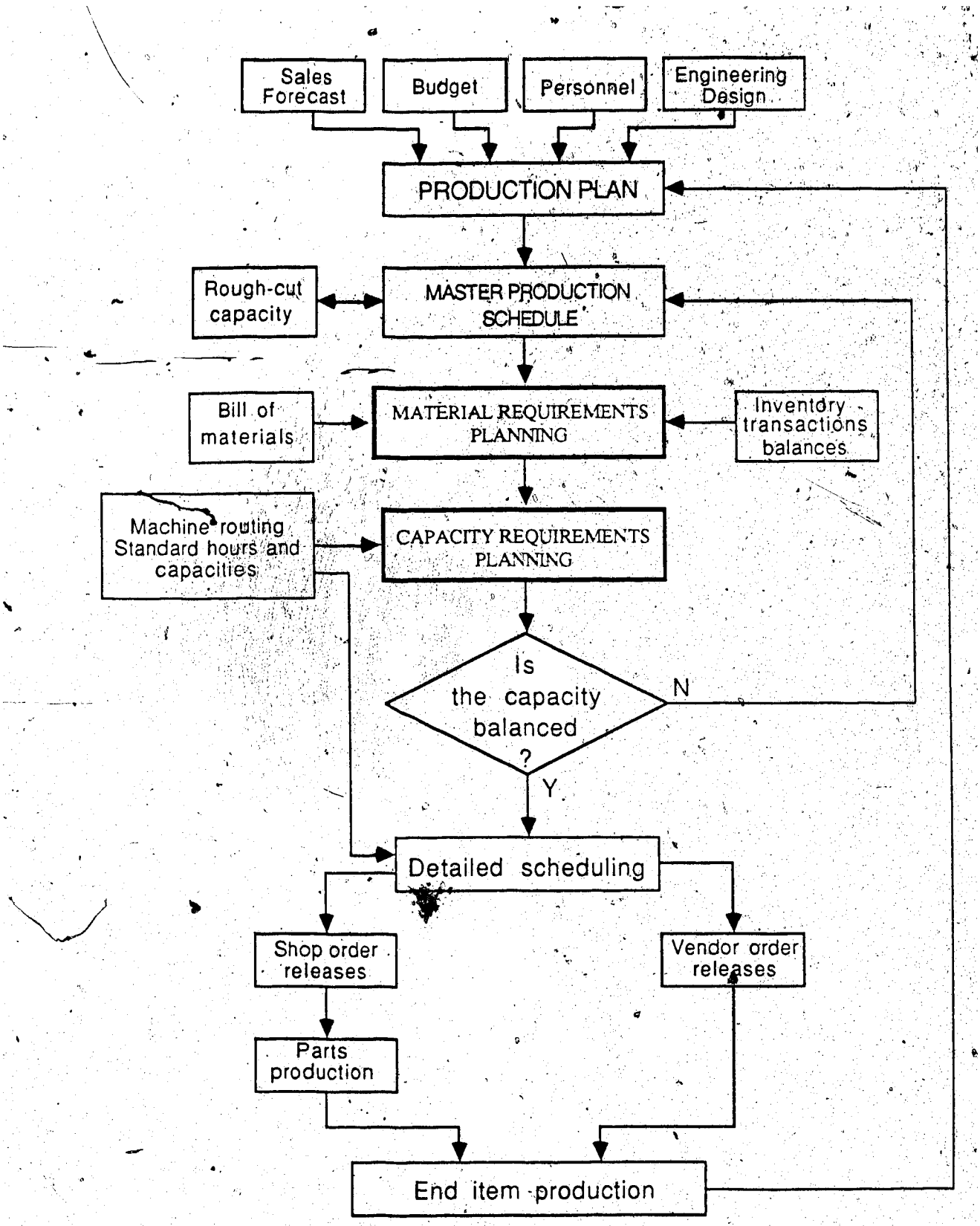

Figure 1.1 A Complete PIPC System Flowchart

not applicable to the manufacturing inventories. For example, in the reorder point approach, the service level and safety stock form the basis for determining the order quantity. Both of the above criteria are statistically determined and are applicable only to items whose demand cannot be calculated otherwise. With the economic order quantity method, the calculation is based on the assumption that inventory is consumed at a steady, or continuous rate. This again disregards the lumpy demand nature of manufacturing inventories. These methods also suffer from a lack of sensitivity in response to the actual or discrete demand fluctuations which may arise during production.

The material requirements planning technique uses a different approach from the reorder point or economic order quantity inventory models. It relates the master production schedule to the appropriate product structure records and determines *what* and *when* parts or materials are to be ordered or fabricated. In a manufacturing setting, there are far more dependent-demand items (parts and materials) than there are independent ones (finished products and service parts). This makes the MRP method particularly suitable for managing inventory in this environment.

One of the main reasons for companies to use the traditional methods is that it requires much less in terms of calculations and system discipline than the MRP method. This is understandable because when these methods were

developed, most companies still relied heavily on clerical calculations for their daily inventory transactions, order processing, and other bookkeeping routines. However, with a *manual* system, it is usually too late to make appropriate production adjustments as unpredictable demands and delays occur. This fails the primary objective of production and inventory management.

The growth of MRP has paralleled developments in computer technology in the sixties. With more powerful and affordable computers, it has become possible to unify forecasting, order processing, and other inventory control functions under an umbrella approach. The advantage and effectiveness of the MRP method has become more apparent.

Successful MRP installations enjoy a reduction in inventory carrying costs, better customer service, and improved productivity. However, not all MRP implementations are successful.

A switch from an existing inventory control system to a MRP system can be both an agonizing and demanding process. If this transition is not done carefully, it can be disastrous to the company instead of being helpful. It has been reported that successful MRP implementations only range from a high of 50% to lows of 20%[31]. Many reasons have been offered for this low success ratio, most of which centre around an eager manager jumping into a MRP installation unprepared and expecting too much during the transition period. Other reasons range from the lack of

commitment from top management to inexperienced personnel managing and monitoring the system after installation. Companies that have been using some kind of a computerized inventory control system have shown that they are usually better prepared for a MRP installation. The average time spent in implementation varies with different companies, but would be about one year to one year and a half, depending on the complexity of the inventory system. This includes a thorough preliminary study, conversion of the bill of materials and production flowcharts into the MRP data base, a parallel or test run, and finally, a complete computerized inventory and production control system.

1.3 Overview of MRP in a Manufacturing Environment

In a manufacturing environment, little of the production time is spent in producing the end or finished products. This is because all finished products are made up of parts and assemblies, which have to be either fabricated within the plant or purchased from outside suppliers. An automobile, for example, has close to 20,000 parts, even a simple typewriter, has over 1,000 different parts. All these parts have to be available with the *right* quantity at the *proper* time and place so that they can be assembled into finished products. In a reorder point system, stock levels are established on the basis of demand over lead time which assumes a gradual depletion of inventory. Replenishment orders are always placed when

stock levels reach the order point. It does not take into consideration whether or not the stock is actually needed in the *near* future. In a MRP environment, however, orders are only placed for inventory items that are *actually needed* in the planned periods and adjustments can be made to the particular period when unforeseeable changes occur during production.

The main driving force behind a MRP system is the master production schedule, which contains demand from customer orders for inventory item in each time period. After these quantity requirements are established, the MRP program works parallel with the bill of materials and the stock master files. By considering *when* various components and materials of the finished product are scheduled to be produced and their lead times for supply, it *time phases* replenishment orders so that parts arrive when they are needed. Ideally, replenishments would arrive at the work station exactly at the time when they are required, thus minimizing the amount of work-in-process inventory. Since this goal is rarely attainable because of delayed shipments, cancelled orders, etc., the system re-examines the master production schedule, on a continuous or periodic basis, to identify schedule disruptions and make changes or adjustments accordingly.

It is important to realize that MRP alone is not a complete solution for inventory and production management, it *does not* do aggregate planning and scheduling. This is

the job of capacity requirements planning, which requires the work centre and machine routing informations. A MRP system is also cost-insensitive, i.e. the output from the system only determines *how much* and *when* to order. Inventory level and replenishment size must still be established on the basis of the economic criteria. This economic consideration, together with material and capacity requirements planning, form a complete production and inventory planning and control system.

1.4 Scope and Methodology

This thesis is divided into four sections. The first section consists of background information and a discussion of the MRP method. Next an inventory classification and identification system is included. This is a prerequisite to any computerized inventory control system and the proposed ICI scheme is implemented together with the MRP application software at Argo Materials Handling Systems Limited. The third part of the thesis gives a detailed description of each computer model used in the system. A sample problem is included in chapter eight to demonstrate the operation of the system. The last part of the thesis is devoted to the testing and implementation of the system plus some recommendations for future development.

In order to form a complete production and inventory planning and control system, a capacity requirements planning (CRP) model must be included. This is currently

being developed by fellow graduate student, Gopalakrishnan. The CRP program takes the output from the MRP system and calculates the machine and manpower requirements. It then compares this with the existing capacities and makes appropriate changes in the proposed master production schedule. The final result is a manufacturing schedule that shows the detailed production timetable for parts and components.

1.5 Software Considerations

The MRP system software was developed on the IBM Personal Computer using the programming language BASIC (Beginner's All-purpose Symbolic Instruction Code). Although BASIC is not a very versatile language, it does offer the following advantages,

i) Minimum hardware requirements. Only 64K of RAM memory is needed to run the BASIC program. Although a two diskette drive system is recommended, the program can be run with one single drive.

ii) No additional software investment. The BASIC programming language is readily available. An interpreter version of the language is always included on the DOS system disk.

iii) Availability of subroutines. Because BASIC is the first language that was developed for the microcomputer, many ready-to-run subroutines

have been written and tested. These algorithms can be easily incorporated into one's application program.

iv) BASIC is simple and easy to learn. Most people know BASIC. This means programmers who are proficient in the language are easy to obtain.

The MRP system is divided into three distinct modules with several subprograms within each module,

(I) Inventory Processing Module :

1. Stock Creation & Maintenance
2. Input Stock Parent/Son Relationship
3. Amend Bill of Materials Structure Quantity
4. Delete Relationship & Replacement of Stock
5. Stock Status Enquiry
6. Stock Listing
7. Bill of Materials Report
8. Where-used (Pegging) Report

(II) Order Processing Module :

1. Customer Order Entry
2. Customer Order Enquiry
3. Customer Order Cancellation
4. Customer Order Delivery
5. Stock Qty. Re-allocation
6. Purchase Order Entry
7. Purchase Order Enquiry
8. Purchase Order Cancellation

9. Purchase Order Receipt

(III) System Processing Module

1. MRP Matrix Regeneration
2. MRP Single Stock Display
3. MRP Matrix Printing
4. Sales History Enquiry
5. Sales Forecast
6. Month-end Processing
7. Initial System Data Files Setup
8. Reorganization of Data Files
9. Chain to Other Programs

The MRP system is menu-driven. The user can go from one program to another by selecting the corresponding number from the displayed menu. The program itself is very user-friendly and will prompt the user for confirmation before any action is taken. There are a total of thirty-four BASIC programs and eleven data files in the system.

As different companies have different requirements in their inventory structure, slight modifications to the programs are inevitable during implementation. The source code of the programs is available and a listing of the data record formats is included in the Appendix B. Together, they provide sufficient information for program modifications or future enhancements to the system.

2. THE MRP METHOD

2.1 Perspective

Inventory planning and control people find that in managing their inventory, often more that one method is needed. This is primarily due to the diversified nature of the inventory items under consideration.

According to J.A. Orlicky[27], inventory can broadly be divided into two distinct categories, distribution and manufacturing inventory.

The main function of the distribution inventory is to satisfy customer demand. This demand is both irregular and unpredictable. The inventory level is dictated by current market conditions and the service part requirements.

On the other hand, the purpose of manufacturing inventory is to satisfy production requirements. The master production schedule, which is derived from the company's production plan, is the sole source of demand that governs manufacturing inventory policy. Another important consideration for this type of inventory items is that it is not restorable. This means that once the conversion into work-in-process inventory is started, the process cannot be terminated without realizing substantial penalties such as scrap or reworking of the part.

Failure to distinguish the characteristics between distribution and manufacturing inventory will lead to the erroneous application of inventory control techniques. In

manufacturing, where the required quantity of materials and parts is dependent on the demand for the assemblies in which they are used, the material requirements planning (MRP) method is particularly suited for planning and controlling inventory of this nature. MRP can also respond faster to the customers' needs, reduce inventory investment, and improve productivity. This chapter is devoted to examine the elements that make up the MRP method, also its planning and rescheduling functions in a production environment.

2.1.1 Prerequisites and Assumptions

The first prerequisite of any MRP system is the existence of a master production schedule, which serves as the main input to the system. A master production schedule is a detailed production plan of *what* and *how much* to produce for each future time period in order to meet the customer and production requirements.

Manufactured products are made up of assemblies and components, which can be stated in terms of a bill of materials list. A bill of materials record defines the sequence in which component parts or subassemblies are put together. A MRP system presumes that this is possible with every assembled product.

Since MRP is a computer-based control system, the only language that it understands is symbols. In order to identify each part unambiguously, every inventory item must

be assigned an unique part number. This again is a prerequisite to the system. The numbering scheme must be made flexible enough to accommodate future coding requirements.

For planning purposes, all assembled products are broken down to their component levels and the MRP program time phases them to generate their respective order releases. This *assumes* that a lead time can be given to every item and the sum of the lead times of all the components in a finished product does not exceed the MRP planning horizon.

The last assumption in a MRP system is that all component materials can be discretely disbursed. For example, if ten units of a component are required for a given assembly, MRP expects that exactly ten units can be disbursed and consumed. This is sometimes not practical with some raw material items and therefore, requires that standard inventory handling procedures be modified to accommodate such complications.

2.1.2 System Inputs and Outputs

The main input to the MRP system is the master production schedule, which is shown in Figure 2.1. It is made up of demands from the sales forecasts, customer orders, and service parts requirements. The master production schedule is said to "drive" the entire MRP system and therefore, information in the master schedule

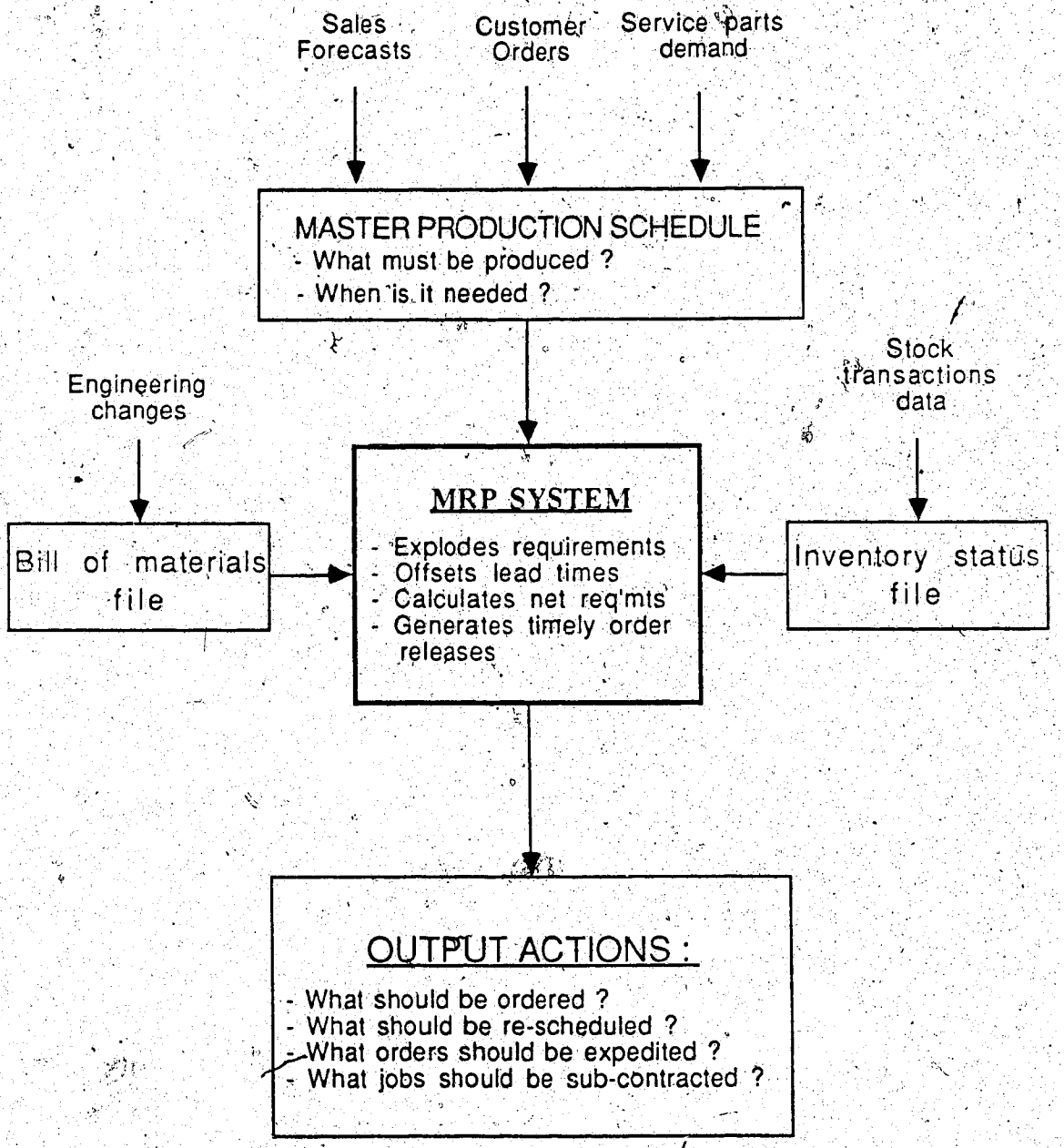

Figure 2.1 Inputs and Outputs of a MRP System

file must be entered as accurate as possible.

The inventory status file, also known as the item master file, contains information such as the on-hand balance, on-ordered quantity, lead time, and safety stock of each individual stock item. This file is kept up-to-date by the posting of the day-to-day inventory transactions through the order processing program.

The bill of materials file defines the structural relationship of the assembled products and its components. All assembly items contain the storage address (called a pointer) to the respective bill of materials structure record. The inventory and bill of materials files are thus cross referenced to each other. Detailed information on how this is accomplished can be found in the respective data record formats in the Appendix B.

All of the above informations is input into the system and MRP calculates the quantity requirements needed to satisfy the *proposed* master production schedule. It also determines when orders for parts and materials need to be *released* to the shop or to vendors.

Outputs from the system consist of reports that can assist the production manager in deciding when to order, what to expedite and other related inventory policies. The system output can also be used as the input to a capacity requirements planning program for detailed scheduling of machines and manpower.

2.2 Elements of a MRP System

In order to understand how the MRP method works, one has to first get acquainted with the terminology used. Since MRP is a production and inventory management technique, a large part of its vocabulary represents terms from the production/operations management area.

2.2.1 Independent versus Dependent Demand

The request for finished products stored on the shelves or parts carried in inventory for the sole purpose of service requirements can be classified as "independent-demand". The term "independent" indicates that *no relationship* exists between the demand of an item and any other items. The main source of this demand comes from the requirements in the customer order.

In a manufacturing environment, finished products are assembled products which are in turn, made up of subassemblies and parts. One generally refers to them as "components". The demand for these components *depends* on the demand for the assemblies in which they are used. MRP calls this the "dependent-demand". They are the results of the demand for a higher-level item, specifically the finished product.

This independent-dependent-demand concept suggests that when items have demands that are independent, it is necessary to forecast their requirements using techniques such as moving average or exponential smoothing. When the

demand is dependent, the requirement should *not* be forecasted but rather should be *calculated* through a bill of materials explosion. This indicates that finished-goods items and service parts should use the reorder point technique or the economic order quantity approach to determine their inventory policies. As for the component items, it is more appropriate to employ the material requirements planning technique.

2.2.2 Bill of Materials Record

A bill of materials record in its simplest form is nothing more than a parts list - a listing of each component required to make one unit of the product. Part numbers and assembled quantities are the minimum information required on the list. Sometimes, bill of materials records are referred to as "product structure" records, the two terms being synonymous.

The bill of materials information is required by virtually every company that manufactures an assembled product. Figure 2.2 shows the product structure of a simple assembly, A1054. It lists the components, as well as the quantity needed to produce one unit of the assembly.

The most common way to display a bill of materials is the indented format, as shown in Figure 2.3. Here the components of the product assembly are shown indented one space to the right. An asterisk placed beside the quantity indicates that it is an assembly. This quantity is used as

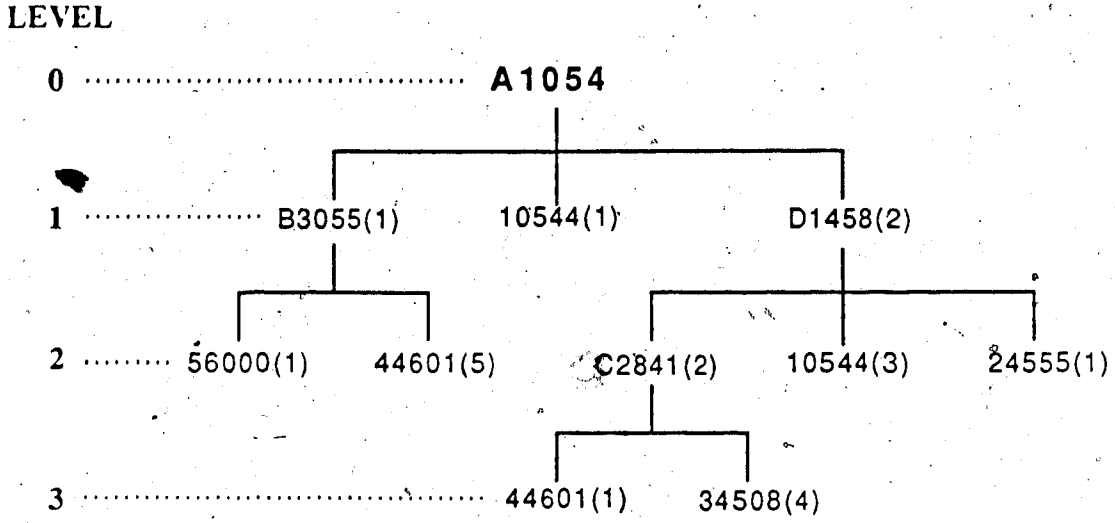

Figure 2.2 Product Structure for an Assembly

Product A1054

Part no.	Description	Quantity
1)B3055	----------	1*
56000	----------	1
44601	----------	5
2)10544	----------	1
3)D1458	----------	2*
C2841	----------	2*
44601	----------	1
34508	----------	4
10544	----------	3
24555	----------	1

Figure 2.3 Indented Bill of Materials Format

a multiplier to compute its component quantity requirements.

The bill of materials record is the direct result from the design people in the engineering department. They must, however, work in collaboration with manufacturing to determine the production feasibility of the design.

2.2.3 Lead Time

Lead time is defined as the time required to complete an operation. In a MRP data base, there are two kinds of lead times that need to be considered.

Manufacturing lead time is defined as the duration between the release of a work order to its completion. This includes the time it takes to prepare the necessary job shop papers, the time required for the machine setup, plus the waiting or "queue" time between machines and the actual time for the operation.

For parts and materials originated externally, one is concerned with the purchasing lead time, which is the time between placement of the order to the arrival of goods. This includes the vendor's lead time to prepare the ordered items and the time needed for delivery.

Since lead time dictates when orders (work or vendor) should be released, therefore, it must be determined as accurately as possible. Unfortunately, this is rarely attainable because of frequent and unforeseeable changes in a production environment. For example, in manufacturing,

production capacity depends on the supply-demand relationship in the facility. If requirements exceed capacity, lead time increases and all jobs take longer to complete. On the other hand, when there is an excess of capacity, waiting time decreases and some machine centres may become idle. In all situations, management actions are needed to adjust capacity so that a relatively constant lead time is maintained.

2.2.4 Low Level Coding

In a product structure record, every part or subassembly that goes into a product is assigned a level number that indicates its relative position in the assembly sequence. The final assembly or finished product, by convention, is assigned a number zero and is referred to as the zero level. Level one is reserved for assemblies or components that go *directly* into the finished products. The other levels follow in order as indicated in Figure 2.2. The level code indicates where to explode and calculate the requirements in a MRP regeneration.

However, for components that are used on different assemblies, it is possible that they may result in having more than one level code. An example of such can be found in component 44601. In Figure 2.2, the component is used on assembly B3055 as well as C2841 and has a level code of 2 and 3 respectively. A similar situation occurred to component 10544.

In the MRP processing logic, all items are exploded on a level-by-level basis, this means that each item will only be examined once during the process. For this to be done by the computer, it requires the necessity of an unique level code for each item. In order to remedy the above multi-level problem, an unique level code that identifies each item's lowest level of usage is assigned to the part. For example, component 44601 has a level code of 2 and 3 respectively when it is used on different assemblies. Since level three is its lowest level of usage, it will therefore be assigned the low-level code number 3 in its product structure record. In the future, if it is used on an assembly that places it in level four of the product structure, the level code will be reassigned as 4 and so on. Fortunately, this low-level coding is taken care of automatically by the application program. The revised product structure of assembly A1054 is shown in Figure 2.4, with the utilization of low-level coding.

2.2.5 The MRP Matrix

Since the MRP method is time related, a way of showing its "time-dependent" ev[illegible] to be adopted. The accepted format for this is a series of planning periods or time "buckets", requirements are then aggregated into the buckets, which can either be days, weeks, months, or years. Generally, the smaller the time period for planning, the more precise is the projection. However,

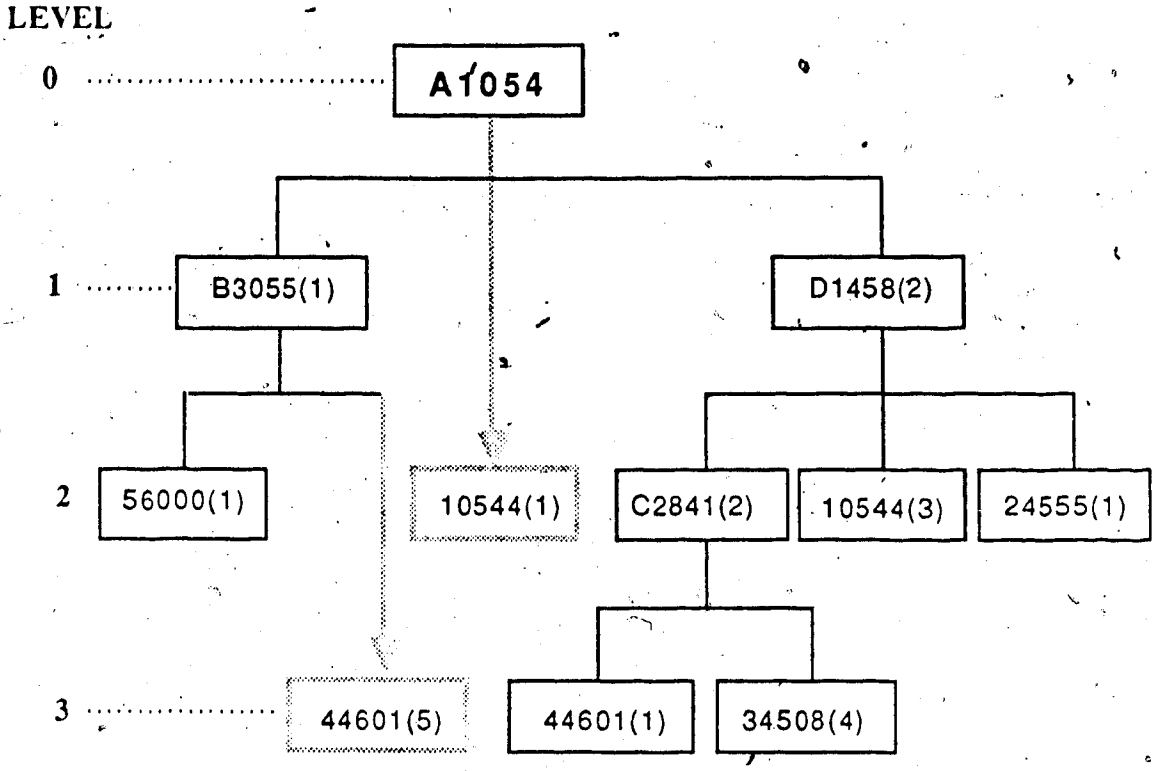

Figure 2.4 Low-level Coding for Assembly A1054

Part # : A1054	Desc.: Dining Table, 5'x7'							
Safety Stock : 5 Starting Bal.: 10	Week number							
	1	2	3	4	5	6	7	8
Gross Requirements								
Scheduled Receipts								
Projected Available								
Net Requirements								
Planned Order Releases								

Figure 2.5 Elements in a MRP Output Matrix

in data processing consideration, large time buckets require less disk storage space. In this particular MRP system that was developed, a one-week planning period was used, which is the most commonly adapted by manufacturers.

The fundamental MRP report, also known as the "MRP matrix" is shown in Figure 2.5. The following is a description of each of the terms in the matrix.

Gross Requirements : the total anticipated demand of the item during each time period. For finished products, this quantity is obtained from the master production schedule; for components or materials, this demand is accumulated from the "planned order releases" from its parent assemblies.

Scheduled Receipts : materials or components that are expected to arrive on open shop or purchase orders.

Projected Available : the anticipated quantity of an item at the end of the period. This value is computed from the on-hand, gross requirements, and scheduled receipts quantity.

Net Requirements : this represents the quantity that must be supplied to the manufacturing facility in order to satisfy the customer or production requirements (either to be acquired externally or fabricated internally).

Planned Order Releases : by offsetting the lead time, this indicates when orders (purchase or shop) must be released so that the materials or components will be available or arrive on time for production.

2.3 Mechanics of MRP

A good inventory control system should be able to provide timely information for determining requirements of parts and materials. Many times, however, inventory systems often order replenishment too *soon* or too *late*. They rely heavily on "expediters" to *rush* the most needed items through production or from vendors. A material requirements planning system will generate requirements in precise time periods, so that it can provide correct coverage to get components through production as required.

The calculations involved in the MRP technique are nothing more than simple arithmetical computations, but the amount of data manipulation is massive and the computations are extensive. Fortunately, this is done with the help of the computer, which is excellent in doing repetitive computations. This section gives an overview of the operation of the MRP technique.

2.3.1 MRP Processing Logic

MRP starts with a master production schedule that contains the demand from the customer orders and sales

forecasts. This forms the gross requirements of the end items. By working together with the bill of materials file, it explodes these top-level requirements down the product structure tree one level at a time to determine the component or material requirements. The explosion identifies *what* components, as well as *how much*, are required to produce a given quantity of the end items. At this point, safety stock (if any) are either subtracted from the on-hand balance or added to the gross requirements. The net requirements are then computed by taking the on-hand balance and scheduled receipts information from the inventory status file, subtracting them from the gross requirements quantity.

This net requirements can be thought of as an indication of possible shortages. MRP detects this insufficiency well in advance and plans their coverages by offsetting the lead time for each component to generate the necessary planned orders. The planned orders *specify* the quantity and time period where work orders are to be released to the shop or purchase orders to be placed with vendors. If the exploded item is an assembly, then this planned order release forms the gross requirements of lower level component products. The timing of the planned order releases is of course, derived from the timing of the net requirements. Most MRP systems however, will not automatically release an order, it only suggests a release date to the planner. This is where the system calls for

some kind of human intervention and judgement, since it involves a number of decisions that should *not* be made by the computer. When the planner releases the order, it turns into an open order and becomes a scheduled receipt.

This exploding and netting process is repeated for each level in the product structure tree until the lowest level is reached. Here, MRP has answered the question of *what*, *how much*, and *when* to order parts and materials to satisfy the production requirements during the planned periods.

An example of a detailed MRP calculation is included in chapter eight of the thesis. Readers are encouraged to consult this example in order to pursue further understanding of the MRP technique.

2.3.2 Use of Safety Stock

Generally speaking, there is no need for safety stock in a MRP environment because most demands are calculated rather than forecasted. Its use is prudent only when the *supply* is erratic and uncontrollable. This may be due to delays in shipping beyond the control of the vendor or a high possibility of defective parts in the incoming shipment.

Safety stock disrupts the timely planning of the MRP method by overstating the requirements. Overstated requirements causes confusion, unnecessary expenses, and often, a loss of confidence in the system. Rather than

augmenting the inventory level with excessive safety stock, management should therefore, concentrate on improving stock room accuracy and on determining realistic manufacturing and purchasing lead times. This will help the system to determine accurately when orders should be released so that parts and materials can arrive at the time when they are needed.

2.3.3 Planning and Rescheduling

It is normal to find that manufacturing and purchasing schedules in a production environment start changing the moment they are established. Alterations to the master production schedule are common. Some possible reasons can be: a delay in shipment, an emergency order for an important customer, engineering changes, labor disputes, machine breakdowns, and absenteeism. This is not an exaggeration of the problem, but rather a fact of life in manufacturing.

One of the prime objectives of an effective production and inventory management system is its ability to respond quickly to changes in production demand, right down to the component level. This is precisely what a MRP system can do in terms of its planning and rescheduling capabilities. The planning function of the MRP technique performs an important duty in calculating lower level component requirements. As this requirement changes, MRP will reschedule the planned orders automatically so as to

provide a workable schedule for meeting the revised production requirements.

There are basically two ways to accomplish this planning and rescheduling function in a MRP system. The following section presents a detailed discussion of the two methods involved.

2.3.4 Regenerative versus Net Change MRP Systems

There are two major types of MRP systems in use today. They are the *regenerative* and the *net change* processing systems.

With a regenerative system, at the end of each planning period (usually one week), previous planned requirements are completely erased. The entire bill of materials explosion and netting process is repeated for every item - both for those which have had changes or revisions and those whose status has not changed at all from the previous regeneration. Depending on the size of the data files and the type of data processing equipment used, this computation can be a lengthy process.

In a net change system, it recognizes that not every item's status has been changed during the planning period and therefore, only those product structures which are affected by the change will be exploded. Since requirements are replanned or orders are rescheduled only for those parts that are affected, net change calculation requires considerably less time than regenerative.

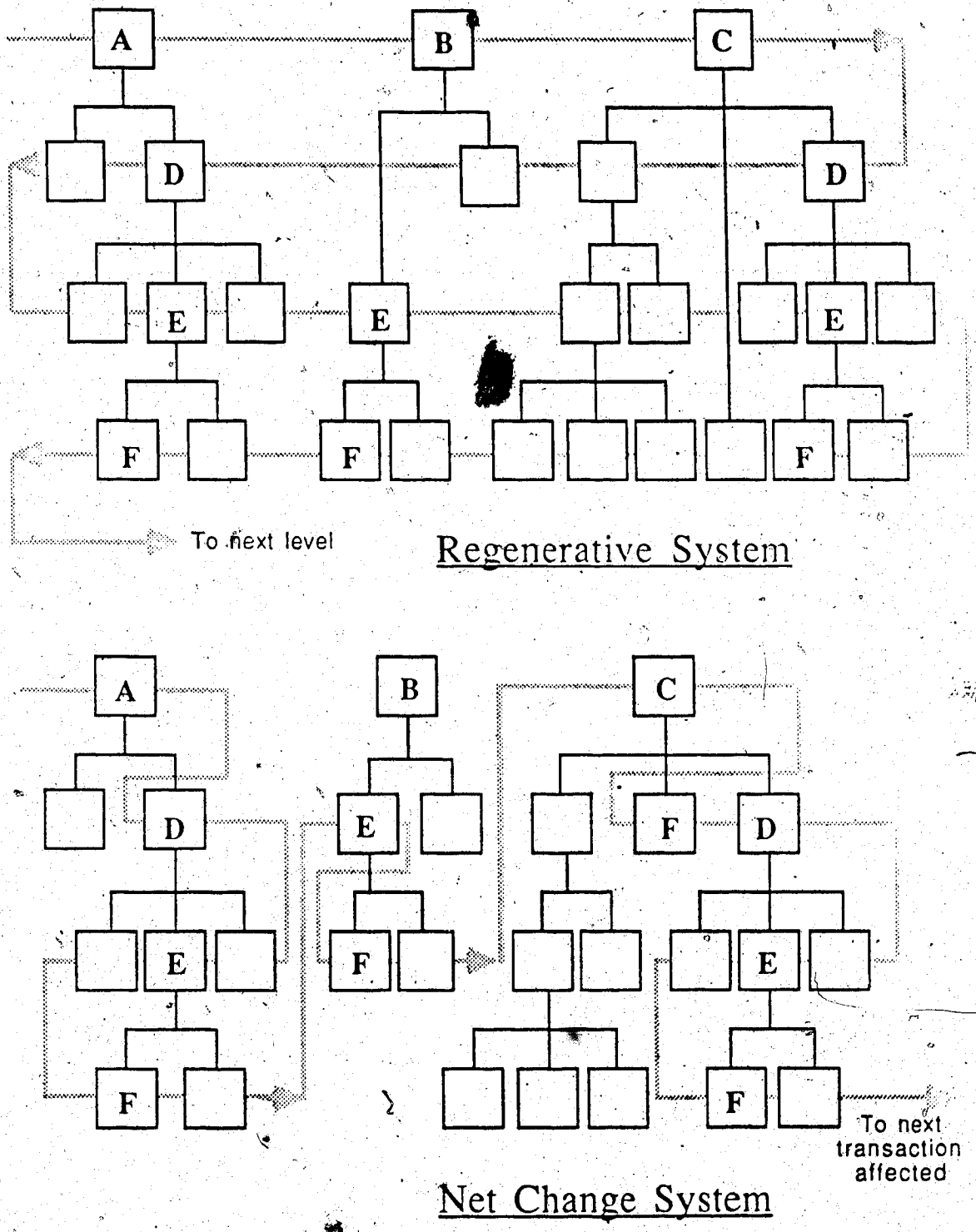

Figure 2.6 Regenerative Versus Net Change MRP Systems

Figure 2.6 shows the processing algorithms for both the regenerative and net change calculations. In this example, the demand for assembly D is changed due to a quantity amendment in the customer order. It can be seen that in the regenerative mode, the product structure trees are exploded level-by-level and item-by-item regardless of the changes involved. In a net change processing, however, only those components which were affected by the change (assembly D) are exploded.

The choice of either a regenerative or a net change system depends on the nature of the production facility and the frequency of replanning. A net change system has the benefit of more timely information on which to plan its manufacturing and purchasing activities. One drawback to this method is its "nervousness" - it may overreact, causing more *new* requirements and schedules to be generated than are *necessary*. One particular advantage of the regenerative system worth mentioning is its ability to *purge* the errors which may have crept in during the planning periods by net change updating. Most of the MRP application software today can operate either in a regenerative or net change mode. It is recommended that one does the daily transactions updating with the net change method, and regenerates the total system on a weekly or fortnightly basis.

3. AN INVENTORY CLASSIFICATION AND IDENTIFICATION SYSTEM

The basic structure of the inventory classification and identification (ICI) system was designed by fellow graduate student Evan Hu. This system was adapted for use with modifications to suit Argo Materials Handling's inventory requirements.

3.1 Introduction

The importance of a well conceived inventory classification and identification system is often overlooked as an area of concern to manufacturing companies. Inventory storage, manufacturing processes, engineering changes, product services requirements and utility needs must be understood and addressed. The implementation of a computerized production and inventory planning and control (PIPC) system, which more companies are considering, requires an ICI system.

A well conceived and implemented ICI system can confer benefits in addition to being a requirement of a computerized PIPC system. The process of eliminating unnecessary diversity which frequently exists in the various stages from design to manufacture defines the concept of standardization - the control of necessary variety. An ICI system in itself cannot directly accomplish standardization, but can offer a framework for encouraging standardization.

3.2 Criteria for Developing an ICI System

Several criteria must be addressed before the implementation of an ICI system. An ICI system should be [1][13] :

1) Expandable : The code must provide space for additional entries within each classification for new items. There must also be capacity to expand existing classifications and add new ones to take care of future changes.
2) Precise : The code structure must be such that only one code may be correctly applied to a given item.
3) Concise : The code should require the least possible number of digits to adequately describe each item.
4) Convenient : The code must be easily understood by each user and simple to apply, whether encoding or decoding.
5) Meaningful : If possible, the code itself should indicate some of the characteristics of the items.
6) Operable : The code should be adequate for the present and anticipated data processing machine methods, as well as for manual reference.

3.3 Classification Systems

A plan of classification is necessary before determin-

ing the actual coding method. The grouping of like items should be accomplished in a manner which is logical and best suits the needs of the business. As many major classifications and subdivisions necessary to meet the business requirements should be devised[13].

For most manufacturing concerns, inventory is composed of three basic classes[13] :

1) Raw Materials : Raw materials are often broken into two subclasses,
   i) Materials purchased and stored for future processing. These materials may be purchased from outside the concern or from an internal division.
   ii) Components or assemblies purchased from outside the concern.
2) Work-in-progress : Raw materials that have had value added to them in the form of labor and overhead by the concern and await additional processing into finished goods.
3) Finished Goods : Completed products that await delivery to prospective customers.

The manufacturing concept of Group Technology (GT), popular in Europe in the machine building areas, incorporates the development of a classification system for work pieces, working operations, and manufacturing equipments as one of its basic tenants. GT can be defined

as a production method that involves machining of parts in "families", i.e. groups of related parts[11]. GT systems are entirely dependent on a part classification. Two approaches are used, the overall or macro approach and the specific or micro approach[36]. The macro approach has been relatively popular in Europe. Several "Universal Component Classification Systems" have been developed as a result of studies of statistics of the components most commonly found in certain industries. Most methods classify on an item design basis using geometry, material and process operation. The Opitz[15] and Vuoso[36] are popular "design" oriented systems based on six and four digit codes respectively.

An analysis of existing macro systems, however shows that due to their "universal" nature with an orientation to the machine component industry, are of limited value for many applications. The variation in the statistics of a particular class of components is often substantial from industry to industry[1]. The micro approach which is designed based on the particular needs of an individual company, may offer a more suitable solution to company standardization in a computerized PIPC environment of machine parts.

3.4 Coding Methods

Coding formats fall into three broad categories :

1) Non-significant alpha-numeric

2) Significant alpha-numeric

3) Mixed format significant-sequential alpha-numeric

The non-significant format consists of sequential numbers assigned to items with no provision for classifying groups of like items. It has the advantage of being simple and relatively error free in implementation, and has the ability to code an unlimited number of items by using the fewest possible characters. Sequential formats require the use of a directory as no information is encoded within the digits. This method is practical when operated in a business with a computerized PIPC system. The computer is able to cross reference relatively easily and quickly the code of an item to an abbreviated description contained in the item master file. Also from a data processing standpoint, the non-significant format is more computationally efficient due to its compactness. The sequential non-significant format is popular especially in the wholesale-retail inventory control area with companies that have computerized PIPC systems.

Significant systems are those which convey information to a knowledgeable user directly upon reading. Various schemes are available[13][26] :

1) Block codes

2) Group codes

3) Significant digit codes

4) Final digit codes

5) Decimal codes

6) Mnemonic codes

7) Numeric-alphabetic codes

8) Consonant codes

9) Indent codes

Purely significant codes are rare in practice, usually a combination of significant and non-significant codes is used. The first digits of the code are significant and the remaining digits are non-significant, requiring an index. For many companies this format incorporates the advantages of both and retains a degree of flexibility[26].

3.5 Argo's Inventory Classification & Identification System

Argo Materials Handling Systems Limited is a small manufacturing company with three main product lines. The previous ICI system at Argo was basically sequential, with intermittent, conscious attempts to build some significance into the system. Standardization and classification were not fully addressed and the system was not orderly applied. As well, the system was constrained by a physical limit, it had literally run out of numbers. A new approach was necessary to remedy the situation and in order to implement a computer-based manufacturing resource planning (MRP II) system. Argo was in need of a system tailored to their business - a limited product line with numerous permutations of style, capacity, size, color, etc., built

in small batch quantities.

A degree of significance in the ICI was considered to be important from a user convenience standpoint which ruled out implementation of a sequential system. Data-processing computation requirements were considered secondary as the main product trees were relatively small, five main product lines totalling less than 400 unique finished products.

An eight character code, with significant and non-significant digits, was selected as satisfying Argo's need for a degree of identification and has more than sufficient capacity for growth. A shorter code would not be able to convey clearly the necessary information and lacked sufficient capacity to meet possible future requirements. A longer code was felt to be unnecessary.

The new system designed, is based on a hierarchical, monocode structure with a mixed format code. The hierarchy is based on MRP levelling, uses a pseudo indent code[2], and mnemonic codes. For example, Figure 3.1 shows a part number for a finished product.

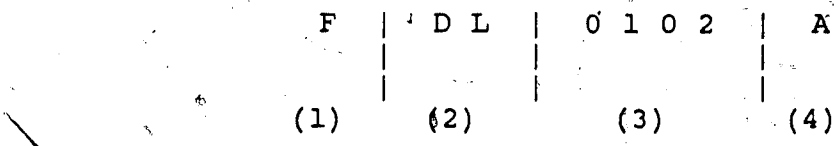

Figure 3.1 Argo's Inventory Classification and Identification Coding Example

The first character (the production process code) is an indent code that classifies the identification of the part into its place in the production process (e.g. F-for a finished product). The next two characters are called the description code and consist of mnemonic codes to classify the item (e.g. DL-for dock levellers). A different code meaning is assigned, depending on the production process code branch. The classification is "design" oriented and consists of items that are similar in shape and design purpose. The next four characters are non-significant, are assigned sequentially and are used to differentiate specific products within a particular description code branch. The final character is used as a revision code. One additional character was considered as a check digit but due to the added complexity in assigning the four non-significant characters, it was excluded.

A check digit can be used for detecting data entry errors. Most check digits are computed from the code characters preceding the check digit. For example, the last number of the code 1236 is "6" and is calculated from the sum of the three preceding numbers 1 + 2 + 3 = 6. When an ICI code is entered, the check digit is calculated from the keyed in code. If the calculated check digit and the keyed in check digit do not agree, then an entry error has occurred. Check digits however increase the system complexity and cause the inclusion of an additional digit which has no direct significance.

Stock Coding

"ABF5678A" ------>

A	B F	5 6 7 8	A
(1)	(2)	(3)	(4)
Stock / Production Type	Generalized description of Group	Part Identifier (uniqueness no.)	Revision Code

1. STOCK / PRODUCTION TYPE (one alphabetic character)

A: .. Assembly
C: .. Component, plant fabricated
F: .. Finished product
P: .. Purchased component
S: .. Sub-assembly
U: .. Unprocessed raw material

2. GENERALIZED DESCRIPTION OF GROUP (two alphabetic characters)

AN: .. ANgle
BF: .. Base Frame weldment
BR: .. BRacket
BS: .. BuShing
BT: .. BolT
CA: .. CAsting
CH: .. CHannel
CR: .. CRank
CS: .. Circular Section
CU: .. CUp
DH: .. Dock leveller - Hydraulic
DL: .. Dock Leveller - standard
DS: .. Dock Seal / Shelter
DW: .. Deck Weldment
EB: .. Eye Bolt
EG: .. Electrical Gadget
EM: .. Edge (of dock) Mount
EW: .. Electric Wirestock
FB: .. Flat Bar
GA: .. General Assembly parts
HC: .. Hold down/Hydraulic Cylinder
HT: .. Hinge Tube
HW: .. Handle Weldment
LA: .. Link Assembly
LB: .. Lip Booster
LD: .. direct,Lift elevating Dock
LF: .. LiFt arm
LG: .. LuG
LN: .. Lock Nut
LR: .. Lip operatoR
LW: .. Leg Weldment (S/Assy.)
LW: .. Lip Weldment (Assy.)
MD: .. triangle arM elevating Dock
MP: .. Mounting Plate
NA: .. iNner Arm
NT: .. NuT
OE: .. Office Equipment
OS: .. Office Supply
PL: .. PLate
PN: .. PiN
RD: .. thReaDed RoD
RS: .. Rectangular Section
SA: .. Spring Anchor
SC: .. SCrew
SH: .. Spring Hanger
SL: .. Safety Leg (S/Assy.)
SL: .. System Lift (Assy.)
SP: .. SPring
SR: .. Seal or "O"-Ring
SS: .. Square Section
TA: .. ouTer Arm
TR: .. TRiangle arm assy.
TS: .. Tubular Section
WS: .. WaSher
XX: .. MISCELLANEOUS items

Figure 3.2 Argo's Inventory Classification and Identification System

Figure 3.2 shows a comprehensive representation of the inventory classification and identification system used by Argo Materials Handling Systems Limited.

3.6 Conclusion

An inventory classification and identification system should be designed to meet specific company needs. Macro classification and coding systems, particularly the Opitz system, are relatively popular and useful if they in fact do satisfy the requirements of a specific organization. However, the features of a particular class of components are likely to vary according to the type of industry concerned and the needs of specific companies within that industry. Therefore, the micro approach which concentrates on the particular requirements and characteristics of an individual company is often necessary.

The system designed for Argo Materials Handling Systems Limited meets the basic requirements of being expandable, precise, concise, convenient, meaningful, and operable. The system is an integral part of the manufacturing resource planning system being implemented at Argo and fully satisfies all requirements of this system.

The importance of initially designing a specific and workable inventory classification system should not be overlooked, as implementing a replacement system to rectify the shortcomings of an inadequate system can be time consuming and expensive.

4. FORECASTING MODEL

This model uses a stock item's past twelve months' sales data and generates a sales forecast for any number of future periods specified by the user. The output from the program forms part of the input to the master production schedule for long term planning of manufacturing resources.

4.1 Data Requirements and Methodology

The module contains six forecasting models: three based on the moving average method and three on the exponential smoothing method. At the beginning of each program, the user specifies the number of periods of past data to be used in the computation. The forecasted result is tabulated as well as plotted on the screen.

The forecast is generated for any number of future periods specified by the user. In general, the further ahead the forecast, the lower the accuracy that can be expected. The unit of time is the month and the data file SALHIST.DAT can store a total of 13 months' sales records for each inventory item (i.e. the current month's plus the past 12 months'). This record is created in addition to the master production schedule (MPSCHED.DAT) and the material requirements planning (MRP.DAT) records in the stock creation program.

Three parameters are calculated to measure the effectiveness of the forecast. They are the mean square

error (MSE), the mean absolute deviation (MAD), and the mean absolute percentage error (MAPE). Since different data characteristics require different forecasting techniques, the user should experiment with various models to find the one that is best suited for the particular application.

4.2 Moving Average Models

This method is the simplest of all the forecasting techniques. The fundamental concept in the moving average method[4][25] is that the most recent observations will dictate the value to be forecasted. At any time t, the average of the n most recent observations (t-1, t-2, . . . ,t-n) is computed, this is referred to as the moving average at time period t.

In all the moving average models, the user specifies the number of most recent observations n, to be included in the computations. In general, the larger the value of n, the slower the model will respond to changes in the data. On the other hand, with a small value of n, the model will respond to fluctuations in the data more rapidly, but effects of the earliest observations will be nullified. To help the user to determine a suitable value for n, the program will calculate the forecasting errors corresponding to a range of n values specified by the user. The most appropriate value is the one that yields the smallest error.

The inputs for all the moving average models include the data points (which are read in automatically by the program), the number of terms to be included in the computation, and the number of future periods forecast desired. The outputs include the forecasted values, the errors, and the model accuracy measurements. The parameters MSE, MAD, MAPE are used to determine how well the model fits a particular data set.

4.2.1 Simple Moving Average

This model will usually provide a good fit to data that exhibits a *constant process*. In the simple moving average, one calculates the arithmetic average of the past data for a specific number of periods. As new sales figures become available, the earliest data is dropped and the new value is included in the computation.

Figure 4.1 shows the output of a simple moving average forecast for stock item CABS0002. It uses a two term moving average and forecasts two periods into the future. One drawback of this method is that the forecast contains a lag. This effect is more pronounced when the data fluctuates rapidly, as is exhibited in Figure 4.1.

4.2.2 Weighted Moving Average

If the data exhibits a cyclical pattern around a *constant trend*, a weighted moving average model should be considered. In the simple moving average technique, it

SIMPLE MOVING AVERAGE

for product CABS0002

PERIOD	DEMAND	MOV.AVG.	FORECAST	ERROR
1	23			
2	26	24.5		
3	22	24		
4	21	21.5	24.5	-3.5
5	21	21	24	-3
6	22	21.5	21.5	0.5
7	25	23.5	21	4
8	28	26.5	21.5	6.5
9	26	27	23.5	2.5
10	26	26	26.5	-0.5
11	25	25.5	27	-2
12	24	24.5	26	-2
13			25.5	
14			24.5	

Accuracy measures for a 2 term forecast

Mean squared error (MSE) = 9.425
Mean absolute deviation (MAD) = 2.45
Mean absolute % error (MAPE) = 10.031

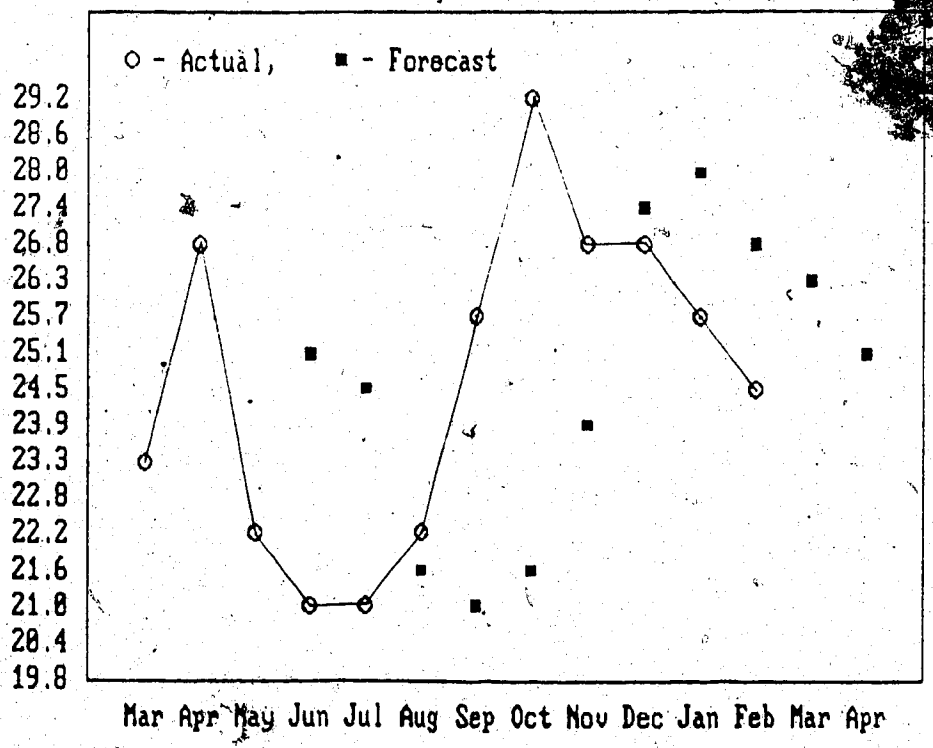

Figure 4.8 Outputs from the Simple Moving Average Model

gives equal weight to each unit of data, which means that what was developed several time periods ago has the same impact on the forecast as the most recent data. This is not always true because data from recent periods often provide more accurate information, and therefore should be given more emphasis.

The weighted moving average model allows the user to assign weights to the n most recent observations. The weight given to each data should be in proportion to the data's importance to the forecast. With the proper weights assigned, this model will provide an accurate forecast for data that displays a constant trend.

The additional input requirement for this model is the value for each weight, the sum of the weights adds up to one. The output is essentially the same as the simple moving average model.

4.2.3 Double Moving Average

While the simple and weighted moving averages are suggested for a constant process, the double moving average model is recommended for data with a *linear* or *nonlinear trend*. It provides a better fit for data that fluctuates rapidly than the previous two methods. The model will respond more rapidly in the valleys but may tend to overshoot the peaks.

The input and output of this model are basically the same as that for the simple moving average model.

4.3 Exponential Smoothing Models

In the computation for the moving average, each term in the averaging period is given a specific weight, while all the other terms outside the period are given a value of zero. In the exponential smoothing technique[25], the weights assigned to the past observations decrease exponentially as they become less recent. The exponential smoothing forecasted value is thus a weighted average of all the previous observed data.

To start the forecasting process, the user has to supply an initial value. This value can also be computed by the program automatically if the user chooses the initialization option and specifies the number of data points to be included in the computation. These initial values are only used to initiate the process, and will be taken over by the actual data once the process is going.

The smoothing constant alpha, determines the level of smoothing and the speed to which the model responds to fluctuation in the data. Small variations in the data indicate that a small alpha might be appropriate, while large fluctuations call for a larger value for alpha. The role of alpha in exponential smoothing is analogous to the number of averaging terms in moving average.

4.3.1 Simple Exponential Smoothing

The simple exponential smoothing model is recommended when the data exhibits a *constant process*, with or without cyclical tendencies.

SIMPLE EXPONENTIAL SMOOTHING

for product CABS0001

PERIOD T	DEMAND D(T)	SMOOTH ST. F(T+1)	FORECAST F(T)	ERROR D(T)-F(T)
1	53			
2	44			
3	54	53.5		
4	58	57.5	48.5	9.5
5	50	50.8	53.5	-3.5
6	48	48.3	57.5	-9.5
7	56	55.2	50.8	5.2
8	56	55.9	48.3	7.7
9	54	54.2	55.2	-1.2
10	65	63.9	55.9	9.1
11	51	52.3	54.2	-3.2
12	58	57.4	63.9	-5.9
13			52.3	
14			57.4	

Forecast using a 2 term initialization & alpha = 0.9

Mean Squared Error (MSE) = 51.19681
Mean Absolute Deviation (MAD) = 6.860168
Mean Absolute % Error (MAPE) = 12.37859

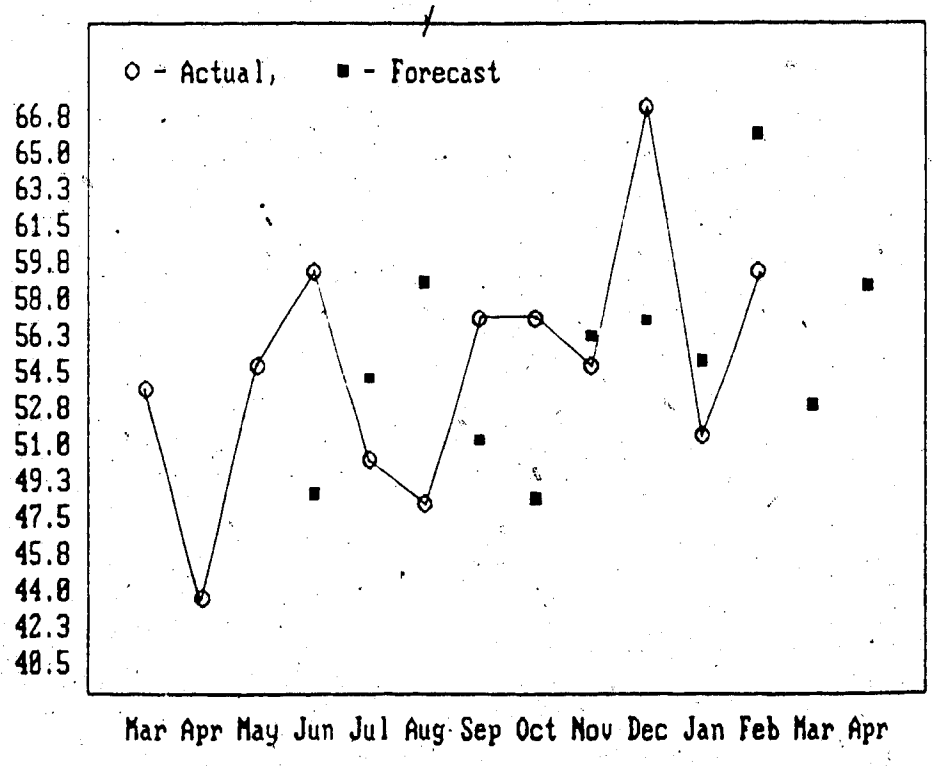

Figure 4.2 Outputs from the Simple Exponential Smoothing Model

One advantage of this model is that only three pieces of data are needed to be carried from period to period in order to generate the forecast. They are the most recent forecast, the actual demand, and the smoothing constant.

The output forecasted result for product CABS0001 is shown in Figure 4.2. An alpha value of 0.9 was used and the initial value was averaged using the actual data from the first two periods. The plot does indicate that a trend exists and a double exponential smoothing model may be better suited for this particular application.

The input requirements for this model are the initial value to start the forecast, the value for alpha, and the desired number of future periods to be forecasted. The outputs include the solution and a plot of both the actual and forecasted data. In addition, the user is given the option to change the value of alpha and recompute the solution without having to rerun the program.

4.3.2 Double Exponential Smoothing

This model provides a better fit than the simple exponential smoothing model when the data displays a *linear trend*. Initial values for both the slope and the intercept are required from the user. Alternately, the program could generate these values using simple linear regression with the number of terms specified by the user.

The double exponential smoothing model reacts much faster to changes than the simple smoothing model, but it

may overreact to random variations in the data. Large values of alpha enhance the model's sensitivity, but it has been shown that when alpha values greater than 0.30 are used[25], this model cannot represent the true characteristics of the data adequately. A search for a more appropriate model is needed.

The required inputs and resulting outputs for this model are basically the same as those for the simple exponential smoothing model.

4.3.3 Triple Exponential Smoothing

This model is recommended for data that exhibits *nonlinear trend*. In general, for any polynomial process of order k, one should use an exponential smoothing model of order (k+1).

Since this model uses a third order smoothing algorithm, the value of alpha is very critical in determining the model's performance and accuracy. Special care should be exercised in selecting this value, otherwise unpredictable results may occur.

The initial values are computed by the program rather than input from the user as they are more difficult to estimate. The outputs are the same as the previous two models.

4.4 Forecasting Errors

Quantitative measures of accuracy are useful not only

in calculating the forecasting errors, but also in the evaluation of a particular model's appropriateness to the input data. Three methods are included in the model, they can be used together or separately to determine the performance of a specific model.

The mean squared error (MSE)[3][23], is simply the sum of the *squared* forecast errors, divided by the number of periods in the forecast.

$$MSE = \sum_{t=1}^{T} [D(t) - F(t)]^2 / T,$$ where D(t)=actual demand, F(t)=forecasted ''

Although the MSE is probably the most widely used, it suffers from the possibility of over-emphasizing the error due to the squared term.

The mean absolute deviation (MAD)[3][23] represents the sum of the *absolute* forecasting errors, divided by the number of periods. It eliminates the exaggerated effect of the previous method.

$$MAD = \sum_{t=1}^{T} |D(t) - F(t)| / T,$$ where D(t)=actual demand, F(t)=forecasted ''

When the data exhibits large fluctuations, the mean absolute *percentage* error (MAPE)[3] is a better measurement of forecast accuracy. It relates the size of

the error to the actual observation. Mathematically, it is calculated by taking the mean absolute deviation and dividing by the actual demand for that particular period.

$$MAPE = \sum_{t=1}^{T} | [D(t)-F(t)] / D(t) | \times 100 / T$$

where D(t)=actual demand
F(t)=forecasted ''

Theoretically, the best model is the one that gives the smallest error for all the above three criteria. However, this may not always be possible and the forecaster must decide which error criterion is more important for the individual data set.

5. MASTER PRODUCTION SCHEDULE MODEL

5.1 Purpose

The master production schedule is the main driving force behind a material requirements planning system. In most manufacturing companies, the production plan is based on the current year's sales forecast. The master production schedule can be thought of as a "production forecast". It translates the production plan into more specific detailed requirements so that it can be used in the material and capacity planning calculations.

Figure 5.1 shows the function of the master production schedule in a production environment. The material requirements quantity of each item in the master production schedule model is read into the MRP matrix each week during the regeneration process. The master production schedule thus can be said to "drive" the MRP system, and consequently, the entire production control system.

5.2 The Data Record Structure

The main function of the master production schedule is to transform the backordered quantities from the customer order into gross requirement quantities in the planned periods. The resulting schedule expresses the overall production plan which shows what *quantity* of each item are needed in *each* planned period. The file that contains the data for the master production schedule information is

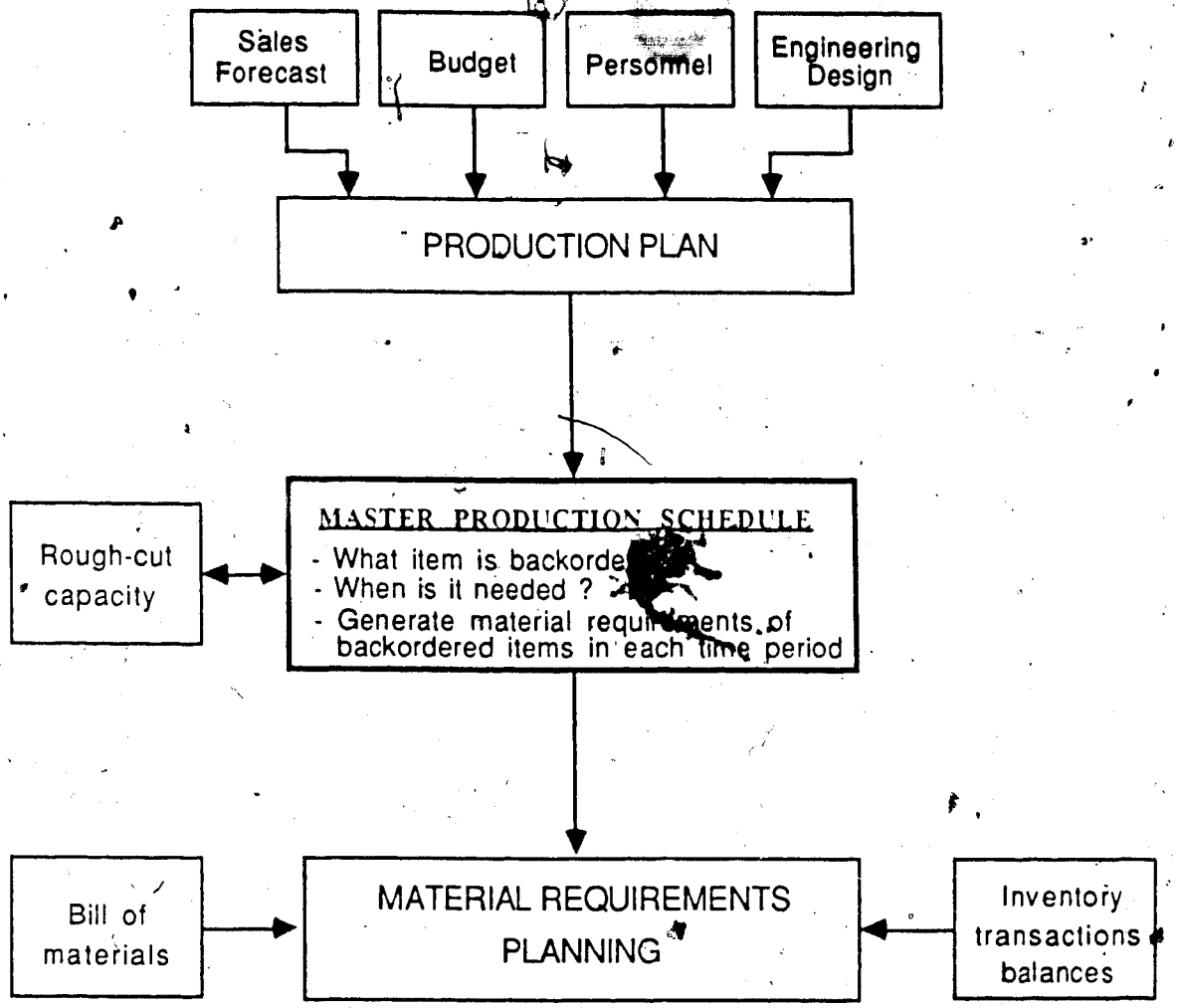

Figure 5.1 Function of the Master Production Schedule

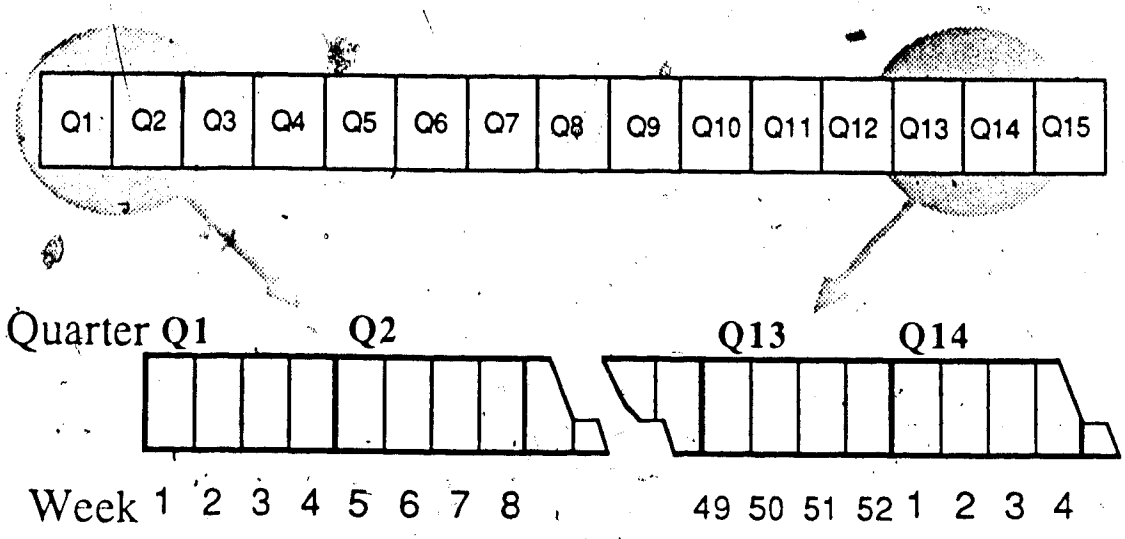

Figure 5.2 Data Structure of a MPS Record

called MPSCHED.DAT and its data record format details are listed in the Appendix B. Figure 5.2 shows the structure of one master production schedule (MPS) record. It has a length of one hundred and twenty bytes and contains fifteen data field areas (quarters) of length eight bytes each. Each area stores four consecutive weeks' quantity requirements. For example, the first area stores the requirements for week number one to four, the second area for week number five to eight, and so on. With a total of fifty-two weeks in a year, one may expect that thirteen data areas will be sufficient to keep one year's requirements. However, towards the end of the year, quantity requirements will possibly be generated from customer orders that are to be delivered in the early part of next year, thus will not be accounted for with a fifty-two-week record. Therefore, in this computer model,

there are two additional data areas (namely, the fourteenth and the fifteenth quarters), to accommodate the quantity requirements from week number one to eight of the following year.

One master production schedule record is generated for every new stock item created. The size of the MPSCHED.DAT file is equal to 120 x (number of stock items + 1) and it is the largest file in the MRP data base.

5.3 The Data Processing Algorithm

At the time when a stock item is created, a master production schedule record is also created in the MPSCHED.DAT file, and placed at the same file location as the stock record in the master file. Initially, the quantity requirements in all the sixty-week data areas is set to zero by the program. When a customer order is entered, existing on-hand inventory will be allocated on a first-come-first-serve basis. Any stock that is not available at the time of the order will be backordered. The backlog of these customer orders forms the new demand and will be added to the quantity requirements in the corresponding time period (week).

For example, customer order #1 is to be delivered on 20th Aug., 1987. It requires 100 units of part A and 60 units of part B, currently there are 80 units of part A and none of part B in stock. Therefore, we have to backorder 20 units of part A and 60 units of part B for this

particular order. These quantities will be added to the 34th week's quantity requirements data areas for part A and part B in the master production schedule. If an order is amended or cancelled, the total required quantity will be updated by the program automatically.

The master production schedule file, along with the other stock related files will be rebuilt during the data reorganization program. The main function of this program is to erase all the unwanted records, rebuild the stock master records sequentially, and generate a new stock index key. It was mentioned earlier that each master production schedule record could accommodate a total of sixty (52 for the current year and 8 for the next year) weeks' requirements. Therefore, when a year has elapsed, it should reflect this change in the file record as well. This is being done during the month-end processing. If the program finds that the current month is December (last month of the year), current year's quantity requirements (week number 1 to 52) will all be reset to zeros and next year's requirements (week 53 to 60) will be copied to the first two field areas to reflect the year change. The program also resets the system date to the 1st of January of next year before exiting to the main menu.

6. ORDER PROCESSING MODEL

6.1 Function of the Order Processing Programs

The [redacted] from the master production schedule, the material requirements planning matrix, and the order files are all pertinent and related to each other in a MRP system. The order processing module acts as a "link" between these data files; it takes the information from the customer and purchase orders as input, processes them and updates them to the output data files. Figure 6.1 shows a schematic diagram of the process and names of the output data files.

There are altogether nine different programs in the module, five of them are used for processing the customer orders and the other four for the purchase orders. Since this module's input and output involve almost all the files in the MRP data base, it is very important that its processing logic and data flow within be fully understood. The user is urged to consult the particular sections on order processing in the user's manual in order to familiarize oneself with the programs in the module.

6.2 Data Record Structure of the Order Files

The customer order records in the CUSTODR.DAT file are stored in the sequence in which they are entered. The structure of the data record is shown in Figure 6.2. Each item is tied to the next by the use of the next record

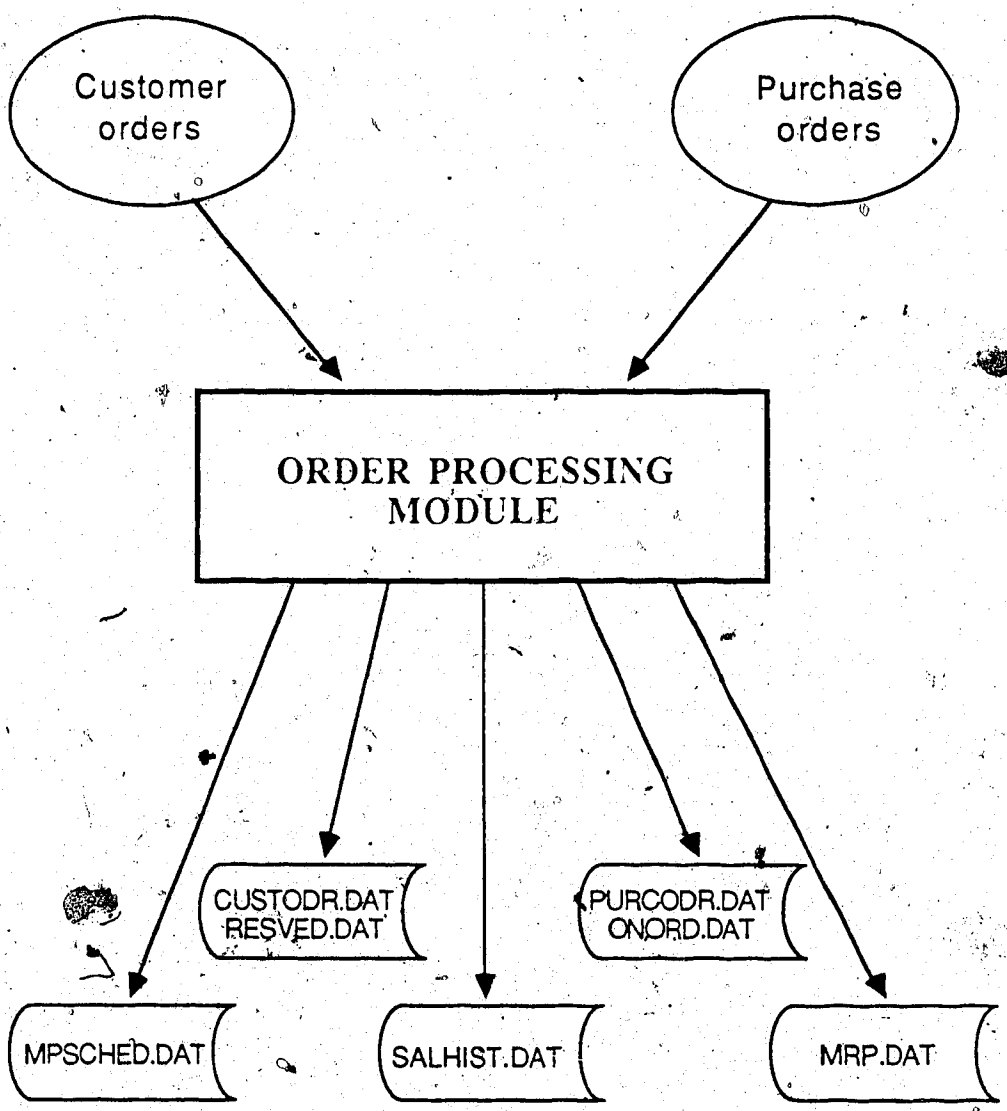

Figure 6.1 Inputs and Outputs of the Order Processing Module

pointer (NXTREC$)[1]. There are certain flags that are used to indicate the status of the record. A zero means the end of the list of items in the order. For example, in Figure 6.2, the first item in customer order INV001 is 90 pieces of CABS0002, follows by 15 pieces of DRWR0001. With item DRWR0001, a zero is found in the NXTREC$ field, which indicates that it is the last item in the particular customer order. A similar record arrangement has been made for customer order INV002 and INV003.

During the customer enquiry processing, items in the order might be amended or deleted. A flag of "-1" is used to denote that the record has been deleted from the order. This applies also to the cancelled orders, to which all the NXTREC$ value will be set to "-1".

When an item is delivered, the last character in the customer name (CUSNAM$) is replaced by the symbol "¦" to indicate the transaction. The allocated quantity field variable (ALCQTY$) is reset to zero to signify that the reserved stock related to this ordered item has been delivered.

The same record structure is used in the reserved stock (RESVED.DAT) file. In Figure 6.2, five units of CABS0002 have been reserved for three different customers - 1 unit for Argo Materials Hdlng, 2 units for the Univ. of

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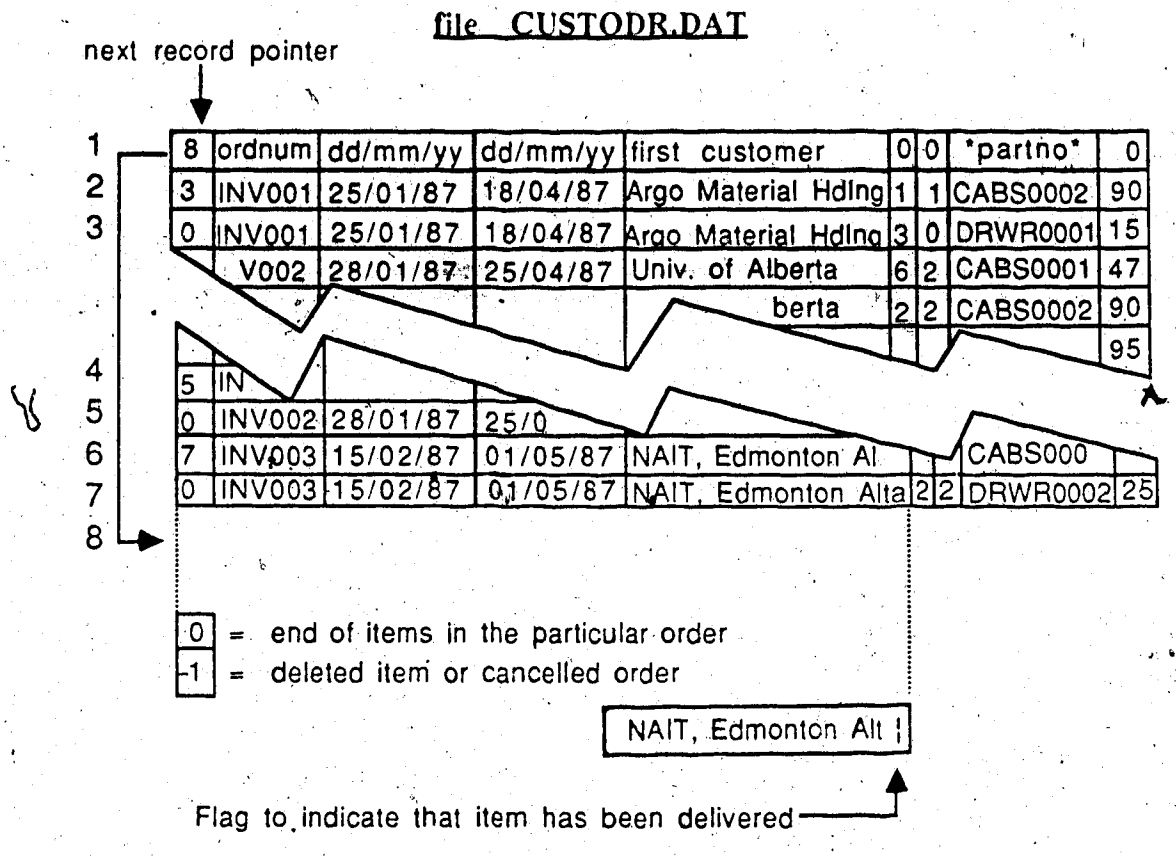
[1]This is the name of the field variable used in the data file. See the data record formats (Appendix B) for more details.



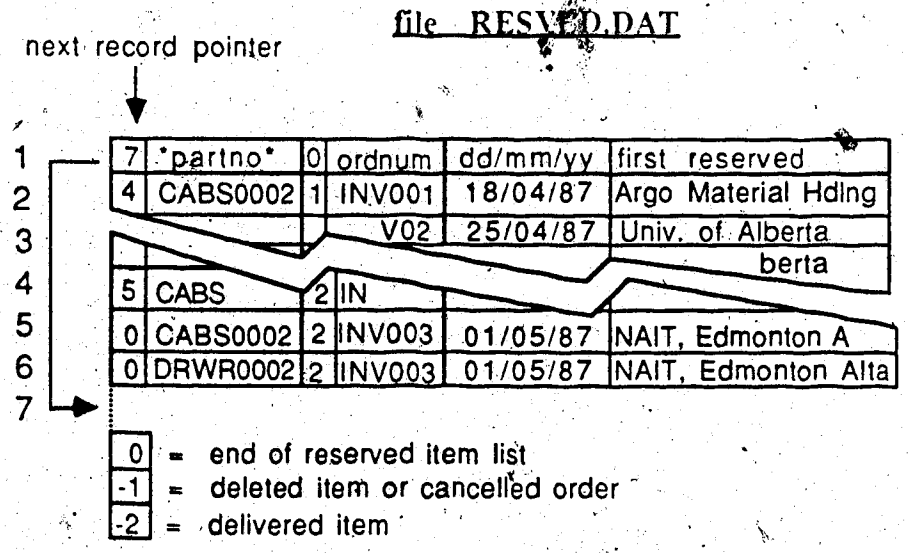


Figure 6.2 Data Record Structure of the Order Files

Alberta, and 2 units for NAIT, Edmonton. However, a different flag is used to denote the stock delivery, a "-2" in the NXTRES$ field.

Since the sample data in chapter eight only have three customer orders entered, Figure 6.2 shows only the details for the above records. However, a similar data structure is adapted for the purchase order (PURCODR.DAT) and on-ordered stock (ONORD.DAT) records.

6.3 Data Flow Within the Module

Figure 6.3 shows the steps involved in processing a customer order from its entry to its delivery. It also indicates the flow of data between the different programs and their interaction with each other.

When a customer order is entered, the on-hand inventory is used to fill the ordered quantities on a first-come-first-serve basis. However, not all quantity requirements can be satisfied at once and this forms the item backlogs that have to be ordered from suppliers or to be manufactured in the plant. This backordered quantity becomes the gross requirements in the master production schedule when the customer order is updated. This process is shown as the Customer Order Entry in Figure 6.3. During order entries, the on-hand and reserved inventory quantity in the stock master file is subtracted or added with the ordered item quantity. At the same time, new records are being written to the CUSTODR.DAT and RESVED.DAT files.

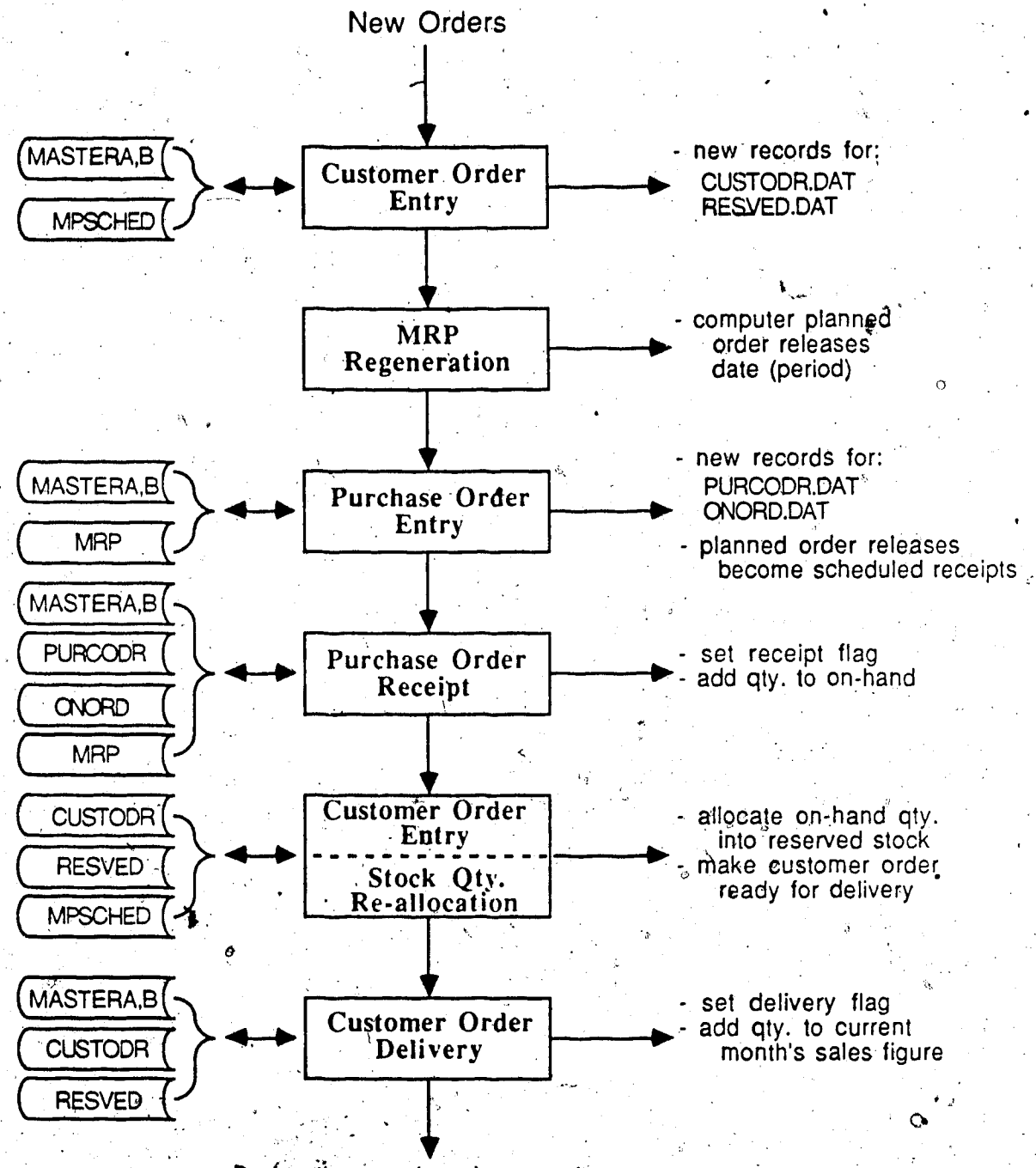


Figure 6.3 Flow of Data r Processing Module

Next, the MRP Regeneration program (either partial or total regeneration) is run to calculate the planned order releases, if any, that resulted from the backordered quantities in the customer order. After the date (period) for the planned order releases have been determined, the purchase order for the parts or raw materials is placed with the vendor at the proper time. This step is very important because the vendor's lead time for delivery have been taken into consideration in computing the period for the order releases so that parts can arrive in time to be assembled into finished products. During the Purchase Order Entry, the requisition quantity will be added to the stock on-ordered quantity in the master file. The released order becomes the scheduled receipt record in the MRP matrix file.

When the item from the purchase order arrives, the stock is received and added to the on-hand inventory using the Purchase Order Receipt program. When there is sufficient quantity in inventory, the user can reserve stock for a particular customer order using the Customer Order Enquiry or the Stock Qty. Re-allocation program. A reserved stock record will be written for each new allocation and it becomes part of the reserved item list.

After stock quantities have been allocated, the customer order is now ready for delivery. In the Customer Order Delivery program, the ordered quantity is subtracted from the reserved stock list and added to the current

month's sales history record. Note that when a record in the order files is delivered or received, it is not erased from the data file, but rather a flag is set to indicate its status. At the end of the month, all ordered items that have been delivered or received will not be rebuilt. This is done in order to keep the size of the order files as small as possible and to improve the data access time. If a record of the past sales orders is desired, one should make a backup copy of the files before running the month-end processing program.

7. MATERIAL REQUIREMENTS PLANNING MODEL

7.1 The Objective

The main objective of the material requirements planning (MRP) program is to convert the quantity requirements from the master production schedule into net requirements. This is done by using data from the bill of materials and stock master file to calculate the net requirement for each inventory item and *time phase* them to determine their *proper* coverage. The output consists of information regarding planned orders so that correct inventory action can be taken, i.e. the *timely* release of the purchase or work orders.

The material requirements planning model is *capacity-insensitive*, i.e. it will call for the production of items for which the needed capacity (machine or labor), may not be sufficient. Therefore, if a capacity requirements planning (CRP) module is available, outputs from the MRP model should be used as inputs to the CRP module to generate *realistic* production planning actions. Otherwise, a rough-cut capacity should be used as a guide during the making of the master production schedule. Presently, the CRP model is being developed by fellow graduate student Gopalakrishnan.

The position of the MRP model relative to other inventory and production control functions is shown in Figure 7.1. The relationship depicted in this chart exists

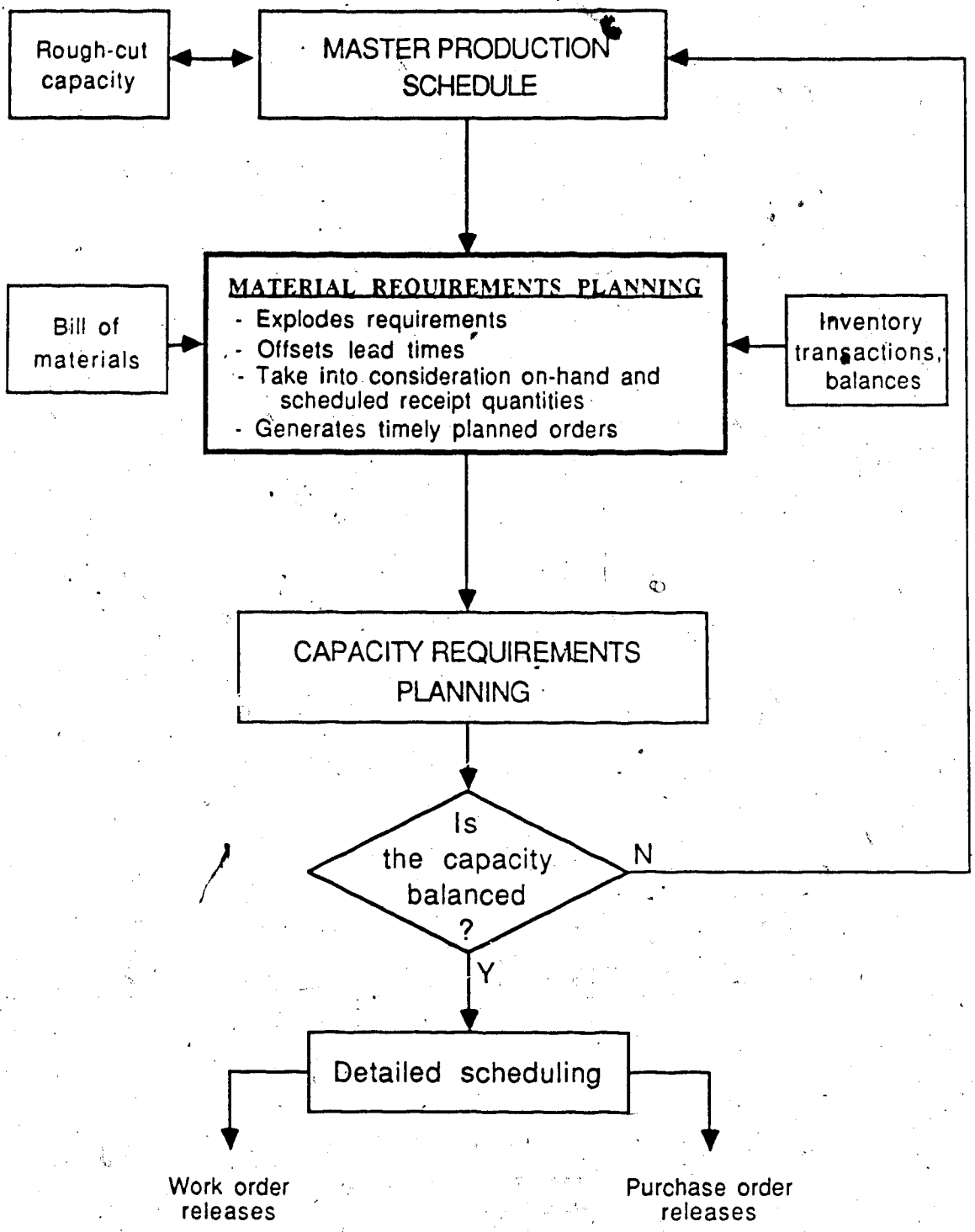


Figure 7.1 Position of MRP in a Production Environment

in any manufacturing company. The capacity requirement planning module can be omitted if a rough-cut capacity consideration is included in the making of the master production schedule.

7.2 The Computer Model

In a similar manner to the master production schedule, one MRP matrix record is created for every new stock item entered. The data format is as shown in Figure 7.2, which is the same for all inventory items and has a length of eighty bytes.

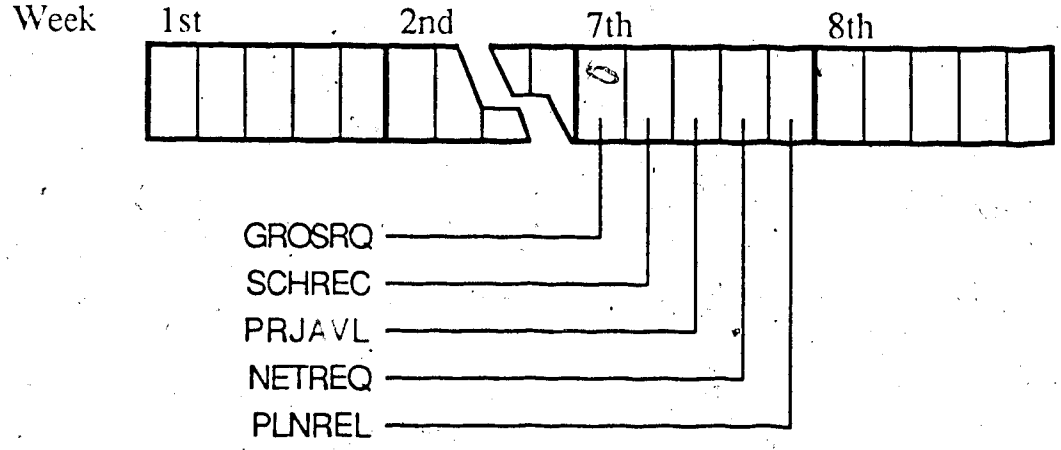


Figure 7.2 Data Structure of a MRP Record

The planning horizon in this model is an eight week period span, which should adequately cover the cumulative procurement and manufacturing lead times for components for a small manufacturer.

The model treats all items as if they are *dependent*

and *calculates* their future demands. This computation is based on a valid master production schedule and therefore, uncertainty (if any) exists only at the master production schedule level. A powerful feature that has been built into the model is its rescheduling capability. It can reschedule changes in two different ways, net change versus regenerative.

Net change only recalculates net requirements for those components that were affected by the change. In a regenerative approach, however, the entire bill of materials file is exploded, level by level, to recalculate the net requirements based on the latest master production schedule. A flowchart diagram for the regeneration process is shown in Figure 7.3.

7.3 The Processing Algorithm

Table 7.1 shows the order releases schedule for a cabinet (part no. CABS0002). Details of the customer order transactions is documented in chapter eight of the thesis.

In this scenario, 5 units of the cabinet are required by the customer and are to be delivered on 01/05/87. At the time of placing the order, only 2 units were available and hence 3 units have to be backordered. This backlog quantity is entered into the master production schedule during the order updating process. When a MRP regeneration is initiated, the latest master production schedule's quantity requirements will be read in as the gross

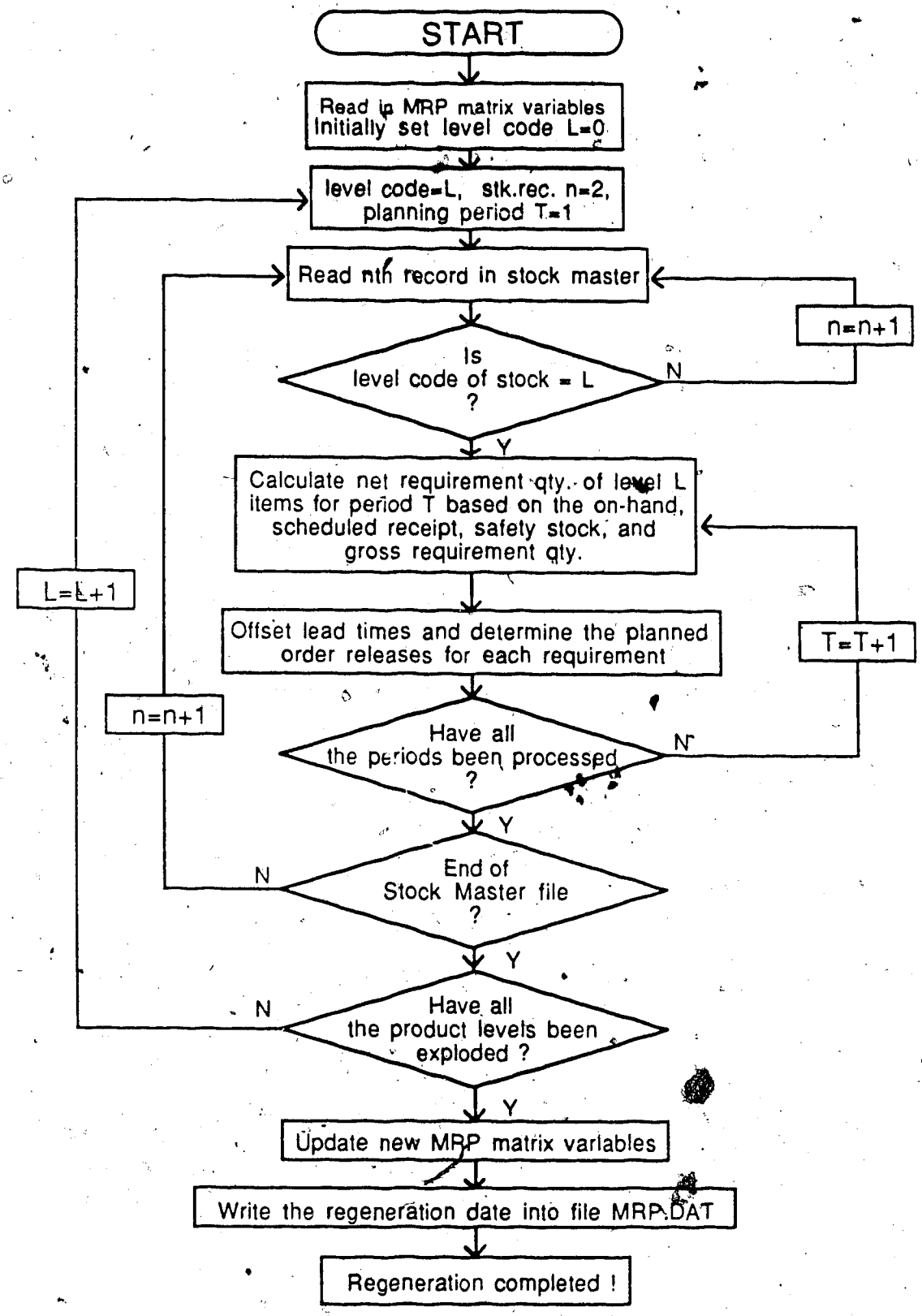


Figure 7.3 MRP Regeneration Flow Chart

PART NO.: CABS0002	DESC.: Cabinet with drawers							LEAD TIME : 2
SAFETY STK.: 0	@12/03/87			PERIOD (WEEK)				
STARTING BAL.: 0	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	0	0	0	3
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	0	0	0	0	0	0	0	-3
NET REQUIREMENTS	0	0	0	0	0	0	0	3
PLANNED ORDER RELEASES	0	0	0	0	0	3	0	0

PART NO.: FRAM0001	DESC.: Cabinet Frame,2W x 3.5H x 1.5D							LEAD TIME : 1
SAFETY STK.: 0	@12/03/87			PERIOD (WEEK)				
STARTING BAL.: 1	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	0	3	0	0
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	1	1	1	1	1	-2	-2	-2
NET REQUIREMENTS	0	0	0	0	0	2	0	0
PLANNED ORDER RELEASES	0	0	0	0	2	0	0	0

PART NO.: HORZ0001	DESC.: Horizontal panel, 2W x 1.5L							LEAD TIME : 2
SAFETY STK.: 0	@12/03/87			PERIOD (WEEK)				
STARTING BAL.: 10	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	0	6	0	0
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	10	10	10	10	10	4	4	4
NET REQUIREMENTS	0	0	0	0	0	0	0	0
PLANNED ORDER RELEASES	0	0	0	0	0	0	0	0

Table 7.1 Order Releases Schedule for the Cabinet

requirement in the MRP matrix. This is being shown as a requirement of 3 units in week number eighteen (01/05/87) in the first schedule of Table 7.1.

The projected available and net requirement quantities are calculated using the following formulas,

$$\text{Projected available} = \text{On-hand quantity} + \text{Scheduled receipts} - \text{Gross requirement}$$

$$\text{Net requirement} = \text{Safety stock} - \text{Projected available}$$

In our example, we have a net requirement of 3 units of the cabinet in week 18. Since the manufacturing lead time for the cabinet is two week, a planned work order must be released in the 16th week in order to have the cabinet ready by week 18.

In a MRP system, planned order releases at one level generate requirements at the lower levels. One unit of the cabinet frame (FRAM0001) and two units of the horizontal panel (HORZ0001) are needed to assemble one cabinet. This is being shown as the gross requirements of 3 units and 6 units for the frame and panel respectively, plus any other requirements from week 16 in the master production schedule. There is a net requirement of 2 units for the cabinet frame because we only have an on-hand quantity of 1 unit at the time of the regeneration. In order to have 3 units of the cabinet frame ready to be assembled into the finished product on week 16, we must place an order in week 15 after considering its lead time. However, we do not require any horizontal panels because we have 10 units to start with, which can satisfy the 6 unit requirement in week number 16. Note that the horizontal panel is at the lowest (component) level of the bill of materials structure and it will not generate any further "dependent-demand" requirements. A vendor or shop order has to be released depending on whether the part is purchased from outside or manufactured in the plant.

Batch sizing techniques have not been incorporated

into this model. One of the reasons being that in a production environment, there are some important decisions that *should not* be made *automatically* by the computer, but rather should be made by the people involved. This order sizing decision is one of the areas that has to be looked at more closely on an individual basis.

8. MRP DEMONSTRATION PROGRAM

8.1 Data Files Setup

The demonstration data files are stored on the same diskette as the program files. In order not to change or destroy any of the original demonstration data, it is highly recommended that one copy all the data onto another diskette before running the demonstration program. This can be done easily by placing the MRP system diskette in drive A and insert a formatted diskette in drive B. Enter the following at the DOS prompt,

```
A> copy *.dat b:
```

A total of eleven files with extension .DAT will be copied onto the diskette placed in drive B. To start running this demonstration program, one must follow the steps described in the User's Manual (Appendix A) to load and run the MRP application software. Be sure to make drive A the default drive and place the newly copied data diskette in drive B.

In the demonstration data, the MRP planning horizon is from week 11 to 18, therefore, one should set the system date to between 12/03/1987 and 18/03/1987 before running the system.

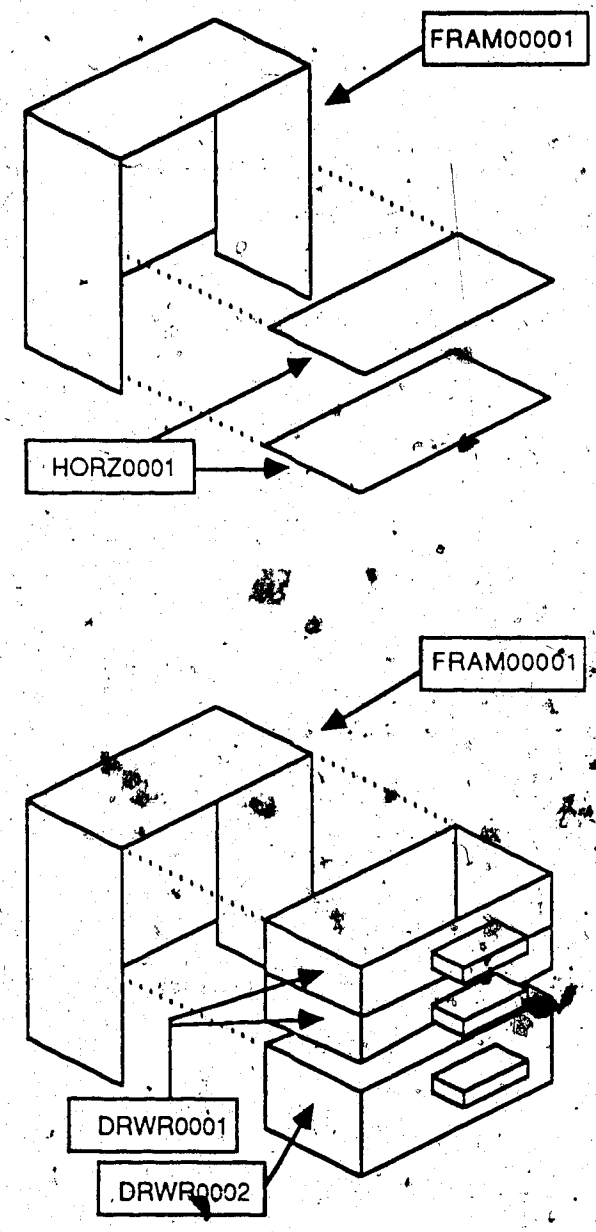


Figure 8.1 Cabinet Assemblies w/Shelves and w/Drawers

8.2 Description of the Problem

Company Woodworks Ltd. manufactures two kinds of cabinets, one with shelves and the other with drawers. The cabinet assemblies are shown in Figure 8.1.

The bill of materials specifies the relationship that shows how the cabinet is put together. A schematic representation is shown in Figure 8.2. It identifies each component and the quantity required per unit for the completed assembly.

A cabinet with shelves (CABS0001) is made up of :
- 1 unit of item FRAM0001 (cabinet frame)
- 2 units of item HORZ0001 (horiz. panel)

The cabinet with drawers (CABS0002) is made up of :
- 1 unit of item FRAM0001 (cabinet frame)
- 2 units of item DRAW0001 (drawer, 7")
- 1 unit of item DRAW0002 (drawer, 18")

The cabinet frame (FRAM0001) in turn, is made up of :
- 2 units of item SIDE0001 (side panel)
- 1 unit of item HORZ0001 (horiz. panel)
- 1 unit of item BACK0001 (back panel)

The 7" drawer (DRWR0001) in turn, is made up of :
- 1 unit of item DBOX0001 (7" box)
- 1 unit of item HDLE0001 (handle)

The 18" drawer (DRWR0002) in turn, is made up of :
- 1 unit of item DBOX0002 (18" box)
- 1 unit of item HDLE0001 (handle)

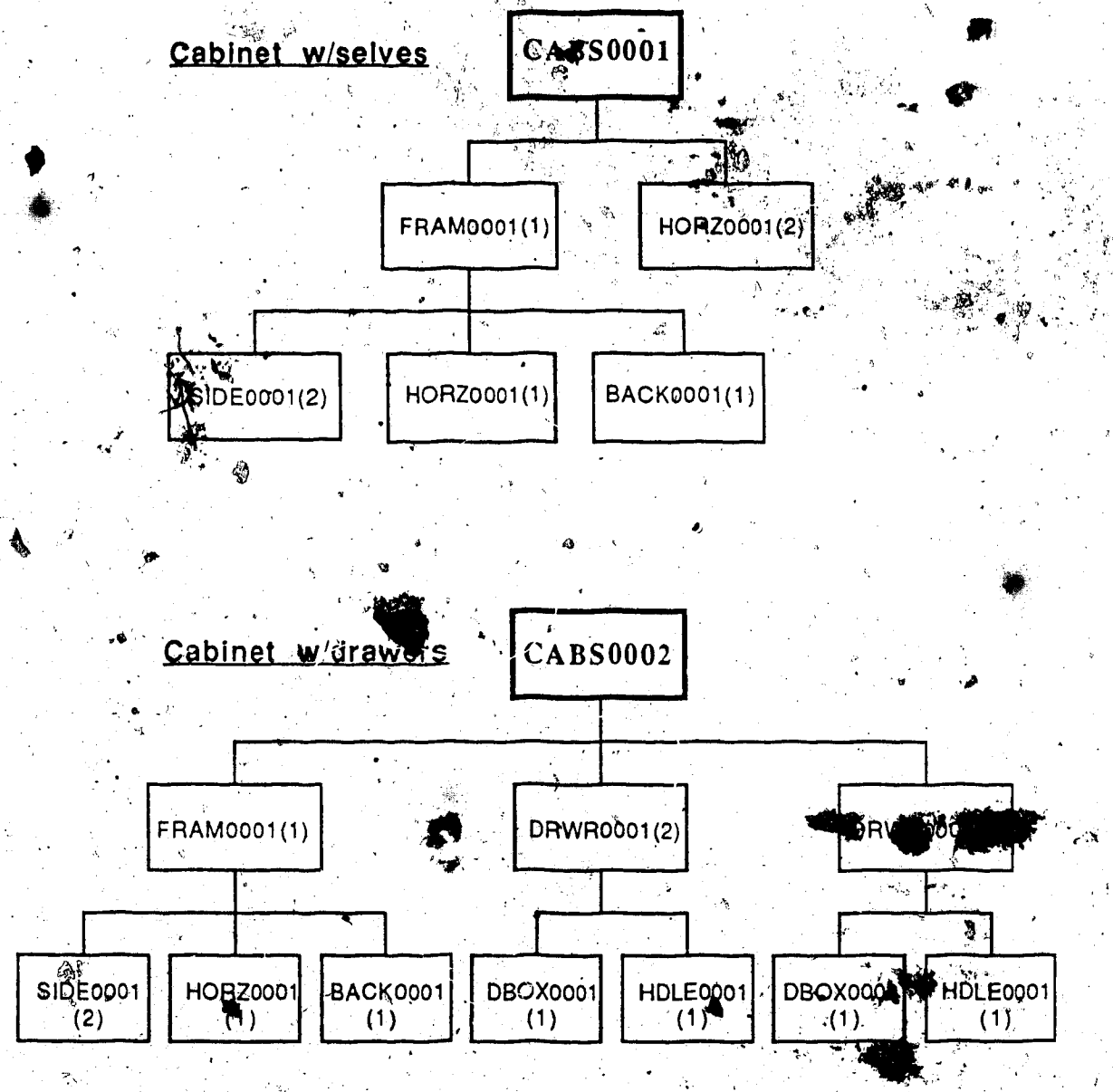


Figure 8.2 Bill of Materials Structures for the Cabinets

ORDER NO.: INV001 ORDER DATE : 25/01/87 DELVRY DATE : 18/04/87
CUSTOMER : Arss Materials Hdlng

PART NO.	DESCRIPTION	LDTIME	UNIT	ORD.QTY	U.PRICE	ALC.QTY	BACKORD
1)CABS0002	Cabinet with drawers	2	unt	1	90.00	1	0
2)DRWR0001	Drawer, 7" depth	2	set	3	15.00	0	3
					135.00		

ORDER NO.: INV002 ORDER DATE : 28/01/87 DELVRY DATE : 25/04/87
CUSTOMER : Univ. of Alberta

PART NO.	DESCRIPTION	LDTIME	UNIT	ORD.QTY	U.PRICE	ALC.QTY	BACKORD
1)CABS0001	Cabinet with shelves	1	unt	6	47.00	2	4
2)CABS0002	Cabinet with drawers	2	unt	2	90.00	2	0
					462.00		

ORDER NO.: INV003 ORDER DATE : 15/02/87 DELVRY DATE : 01/05/87
CUSTOMER : NAIT, Edmonton Alta.

PART NO.	DESCRIPTION	LDTIME	UNIT	ORD.QTY	U.PRICE	ALC.QTY	BACKORD
1)CABS0002	Cabinet with drawers	2	unt	5	95.00	2	3
2)DRWR0002	Deep drawer, 18" depth	3	set	2	25.00	2	0
					525.00		

Table 8.1 Customer Orders in the Sample Problem

The orders in Table 8.1 were placed by customers and the currently on-hand inventory is as follows,

BACK0001 - 10 units
CABS0001 - 2 ''
CABS0002 - 5 ''
DBOX0001 - 10 ''
DBOX0002 - 10 ''
DRWR0001 - 0 ''
DRWR0002 - 2 ''
FRAM0001 - 1 ''
HDLE0001 - 50 ''
HORZ0001 - 10 ''
SIDE0001 - 10 ''

8.3 Sample Data Computations

Customer order INV001 requires 1 unit of CABS0002 and 3 units of DRWR0001 in week 16. Initially, we have 5 units of CABS0002 and none of DRWR0001 on-hand. Therefore, we have to backorder all the 3 units of the 7" drawer while 1 unit of the cabinet is reserved for this order. One can look at the stock information with the Stock Enquiry Program and verify that this is true.

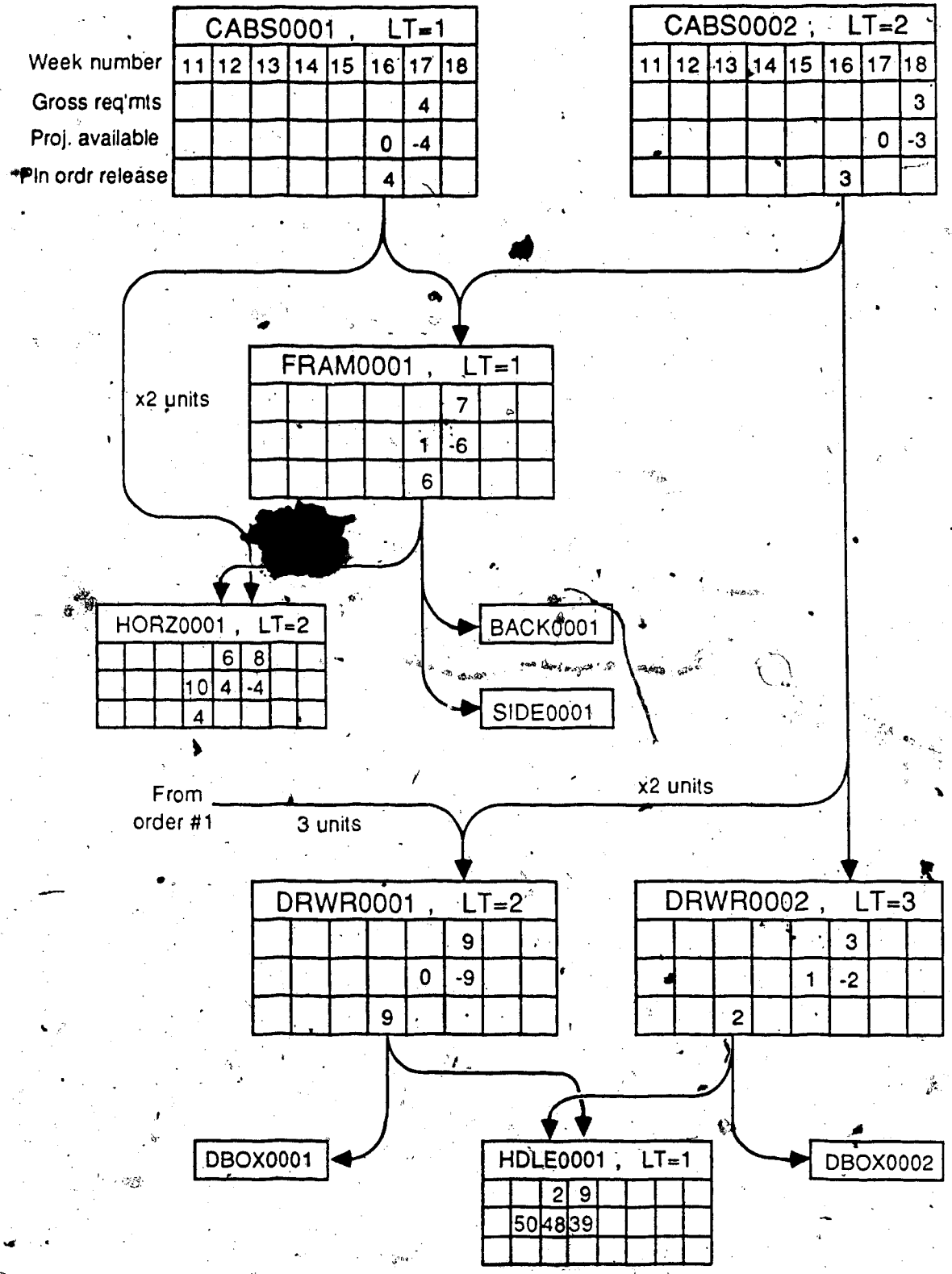
In the second order (INV002 to be delivered in week 17), the quantity of item CABS0001 on-hand is not sufficient to meet the requirement while the demand for the other cabinet (CABS0002) can be satisfied with the existing inventory. Therefore, 4 units of CABS0001 are backordered and 2 units of the second cabinet will be reserved for customer "Univ. of Alberta".

The backordered quantity for item CABS0001 in the above order will generate component requirements at the lower levels of the bill of materials structure. Lead time for item CABS0001 is 1 week, therefore one must start to assemble it in week 16. In that week, one must have on-hand 4 units of item FRAM0001 and 8 units of part HORZ0001. If we look at the on-hand inventory, we only have 1 units of FRAM0001, we will need 3 additional units in week 16 for the cabinet.

In the third order (INV003), we have a backorder of 3 units for CABS0002. The manufacturing lead time for this cabinet is 2 weeks. When this is translated into lower

level requirements we will have a demand for 3 units of the assembly FRAM0001 in week 16. One can see as the number of orders increase or as the bill of materials structures become more complex, working out the planned order releases by relying on manual calculations will be both time consuming and inefficient, not to mention the possibility of computation errors.

Figure 8.3 shows the material requirements planning (MRP) matrix computations for some of the items. The calculations are based on the customer order requirements in Table 8.1. Note that the gross requirement for 9 units of DRWR0001 in week 16 results from both the independent (order INV001) and dependent ("parent" item CABS0002) demand. The reader is advised to examine each of the matrices carefully in order to understand the computation logic.



Figuire 8.3 MRP Matrix Computations for the Cabinets

9. IMPLEMENTATION OF THE SYSTEM

This project involves the development and implementation of a complete computerized production and inventory control system at Argo Materials Handling Systems Limited. This study is the first of a two-part research project which involves the design of a material and capacity requirements planning total system.

The first part of this chapter gives a general discussion on computer system implementation. The second part is devoted to the implementation specifically at Argo.

9.1 Implementation Factors

Although there are many factors that contribute to a successful implementation, the following discussion can serve as a guide to future installations.

9.1.1 Management Support

The first requirement for any successful implementation is to have the full *support* and active *commitment* from top management. In most organizations, the main obstacle to a successful system lies not in the technical areas (hardware and software), but in the people involved - their attitudes, interests, and commitment towards the system.

It is well known that seeking top management approval and support is a time-consuming task. Often this means endless presentations, studies and meetings, but this is an

inevitable and vital step to a successful implementation because of the following reasons,

i) A properly designed and [illegible] computerized production and inventory control system will change the entire operation of the organization. It may result in a redistribution of powers within the organization. Most people do not like to lose the controls that they have acquired over the years and conflicts of interest might occur.

ii) Implementation of a new system is costly. In additional to the hardware and software costs, other expenses such as re-hiring, training, and consultancy are required. Figure 9.1 shows a normal breakdown of the implementation cost[14] excluding the hardware expense. It can be seen that in addition to the software outlay, the other expenses account for more than fifty percent of the total expenditure.

iii) The time needed for installation is lengthy. Typical requirement for an average installation ranges from one and a half to two years. During this time span, a successful implementation requires continual support and commitment from everybody in the company.

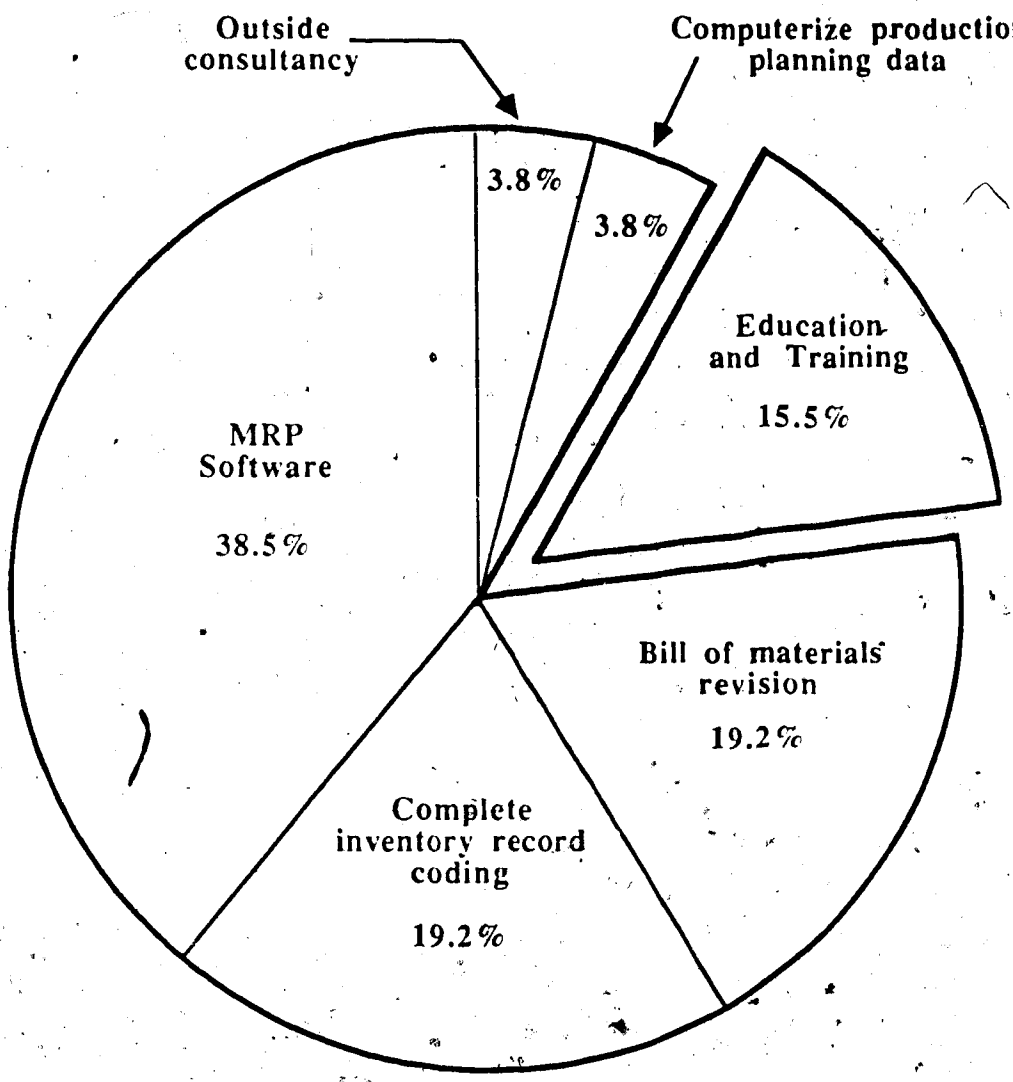


Figure 9.1 MRP Implementation Cost Breakdowns

9.1.2 Data Acquisition

During implementation, the most demanding and time-consuming tasks is establishing the accuracy and integrity of the inventory records.

Inaccurate and obsolete bill of materials records can hinder the computerization process greatly. When this happens, one cannot rely solely on information on the engineering drawings. A large amount of time will have to be spent in gathering information from knowledgeable people in the organization.

9.1.3 Education and Training

Before and after the implementation, the company has to provide an essential education and training program to all its staff. The key people that will benefit most from such a program are those who rely heavily on the system's operation and output.

There are basically four areas to be covered in an education program. They are,

- Why does the company need such a new system ?
- How will the new system affect every employee's day-to-day activities ?
- Why is the support from all personnel so critical to the success of the system ?
- The system is here to help, and is not a threat to anyone's job.

One important aspect about this program is that it involves everyone in the company, from the top executives to the stockroom dispenser. In practice, not everybody needs to go through the program with the same level of sophistication. The courses must be carefully structured for maximum benefits to the organization.

As with most new installations, certain new skills are required in running the system. This means retraining for some of the existing staff and sometimes recruitment of new employees. The existing organization structure may also have to be changed to accommodate this new system and often conflicts of interest occur between different departments. Management must monitor this change closely and see that the transition goes as smoothly as possible.

9.1.4 Personnel Turnover

One of the most common factors contributing to the failure of the system is the high turnover of employees, especially those involved in the data processing areas. Often the same people that designed and installed the computer system initially will no longer be there when it starts to function productively, typically one and a half years after the initial "go ahead" decision from the management.

Personnel turnover is something that is not fully controllable by the management, however, certain degree of influence can be exercised over the timing of the turnover.

When an employee's departure is affirmed, the company must act quickly to find a suitable replacement, either by re-hiring or reshuffling some of the remaining staff. If this is done swiftly, the new employee will have adequate time to follow up the duties and responsibilities of the "would be" ex-employee before he or she departs.

9.2 Implementation at Argo

Argo Materials Handling Systems Limited is a small manufacturing company located in the northwest industrial area of Edmonton. The company specializes in the design and manufacture of a number of materials handling equipments such as dock levellers, elevating docks, lift tables, and door seals.

An inventory classification and identification (ICI) system was used in Argo's inventory control department. Details of the coding scheme can be found in chapter three of the thesis.

9.2.1 Part Numbering

It was decided by Argo's management that the products that were first to be computerized are the dock levellers and elevating docks. One of the main reasons being that these two products account for a large proportion of the company's operating revenues.

Dock levellers are manufactured in various sizes and capacities. The deck sizes range from 5'x5' to 7'x10' and

loading capacity from 11,000 to 75,000 pounds. A block numbering scheme was utilized in the non-significant digits position to ensure that dock levellers of similar sizes are grouped together. A similar arrangement has been made for the elevating docks. The resulting code for the the dock levellers is shown in Table 9.1.

As for the numbering of subassemblies and components, the non-significant digits were assigned arbitrarily. Care has been taken to leave enough room between successive numbers so that new parts in the future can be accommodated. For example, circular bar stock of diameters 1-3/4" and 2" have been assigned part number of CCS83000 and CCS84000 respectively. In the future, if a 1-7/8" diameter bar is used, it will be assigned a part number between CCS83000 and CCS84000.

9.2.2 Bill of Materials Record

In the computerization of the product structure records, first each finished product was broken down into their immediate components, which is referred to as the assembly level. From there, they were further subdivided into the subassemblies and down the product structure tree to the component level.

For a dock leveller, there are six main assemblies that make up the finished product. They are the deck weldment, the lip weldment, the base frame, the spring lift arrangement, the lip operator, and the lip booster. All

Size (sq.ft.)	Capacity (lbs.)	ICI Coding
5 x 5	25,000	F DL 14050
5 x 6	25,000	14100
5 x 8	25,000	14200
6 x 5	25,000	14400
6 x 6	25,000	14600
6 x 8	11,000	15200
6 x 8	25,000	15400
6 x 8	25,000 ,23"	15500
6 x 8	30,000	15600
6 x 8	35,000	15800
6 x 8	40,000	16000
6 x 8	50,000	16200
6 x 8	60,000	16400
6 x 8	75,000	16600
6 x 10	25,000	17000
6 x 10	30,000	17100
6 x 10	35,000	17200
6 x 10	40,000	17300
6 x 10	50,000	17400
6 x 10	60,000	17600
6 x 10	75,000	17800
7 x 6	25,000	18400
7 x 6	30,000	18500
7 x 6	35,000	18600
7 x 6	40,000	18800
7 x 6	50,000	19000
7 x 6	60,000	19100
7 x 6	75,000	19200
7 x 8	25,000	19400
7 x 8	30,000	19500
7 x 8	35,000	19600
7 x 8	40,000	19800
7 x 8	50,000	19900
7 x 8	60,000	20000
7 x 8	75,000	20100
7 x 10	25,000	20300
7 x 10	30,000	20400
7 x 10	35,000	20500
7 x 10	40,000	20600
7 x 10	50,000	20700
7 x 10	60,000	20900
7 x 10	75,000	21000

Table 9.1 Block Numbering of the Non-Significant Digits for the Dock Levellers

the assemblies are different for different models except the lip operator and the lip booster, which are common to all. To cover all model requirements, there are many possible combinations for the bill of materials. Determining these combinations and developing the bill of materials represent the most time-consuming task during the implementation.

9.2.3 Analysis of Implementation Problems

Argo Materials Handling Systems Limited is a relatively small manufacturing firm. Many problems can be found during system implementation in small companies and some of them have been encountered at Argo.

Most small companies can only afford the minimum number of staff. Management support and commitment during implementation are not easy to obtain as each employee is occupied with his or her own duties. As a result, the implementation is often given secondary importance and does not justify the hiring of full time data processing personnel. Existing staff is frequently overloaded with works emanating from the implementation process and this may lead to an indifferent attitude towards the system.

Because of limited staff, management is reluctant to change existing practices as extra efforts are needed to reorganize duties among employees. This means most of the software application will have to be "tailor-made" to accommodate present inventory management procedures.

In a small company, most of the responsibilities lie with a few individuals. When such an individual leaves the company, a substantial amount of time is lost in following up and redirecting some of his/her duties and workloads.

Proper system documentation is a practice not commonly found in small companies because it is an expensive and time-consuming job. However, this documentation is very important if changes are to be made to the system in the future. It is unfortunate that this is often done hastily and inaccurately, which leads to later problems such as added expenses, maintenance chaos and eventually, system failure.

9.2.4 Future Tasks

Figure 9.2 shows an implementation flowchart of the system at Argo. The items that are in bold print indicate that these processes have been completed, the rest are future steps that remain to be done.

At present there are close to 2,000 different part numbers in the MRP data base. Most of the product structure records for the dock levellers and elevating docks have been entered. All the inventory processing programs have been fully tested and running. In the capacity requirements planning area, the company is at the stage of gathering manufacturing process data and inputting them into the model. The capacity requirements planning program and data are yet to be tested and verified.

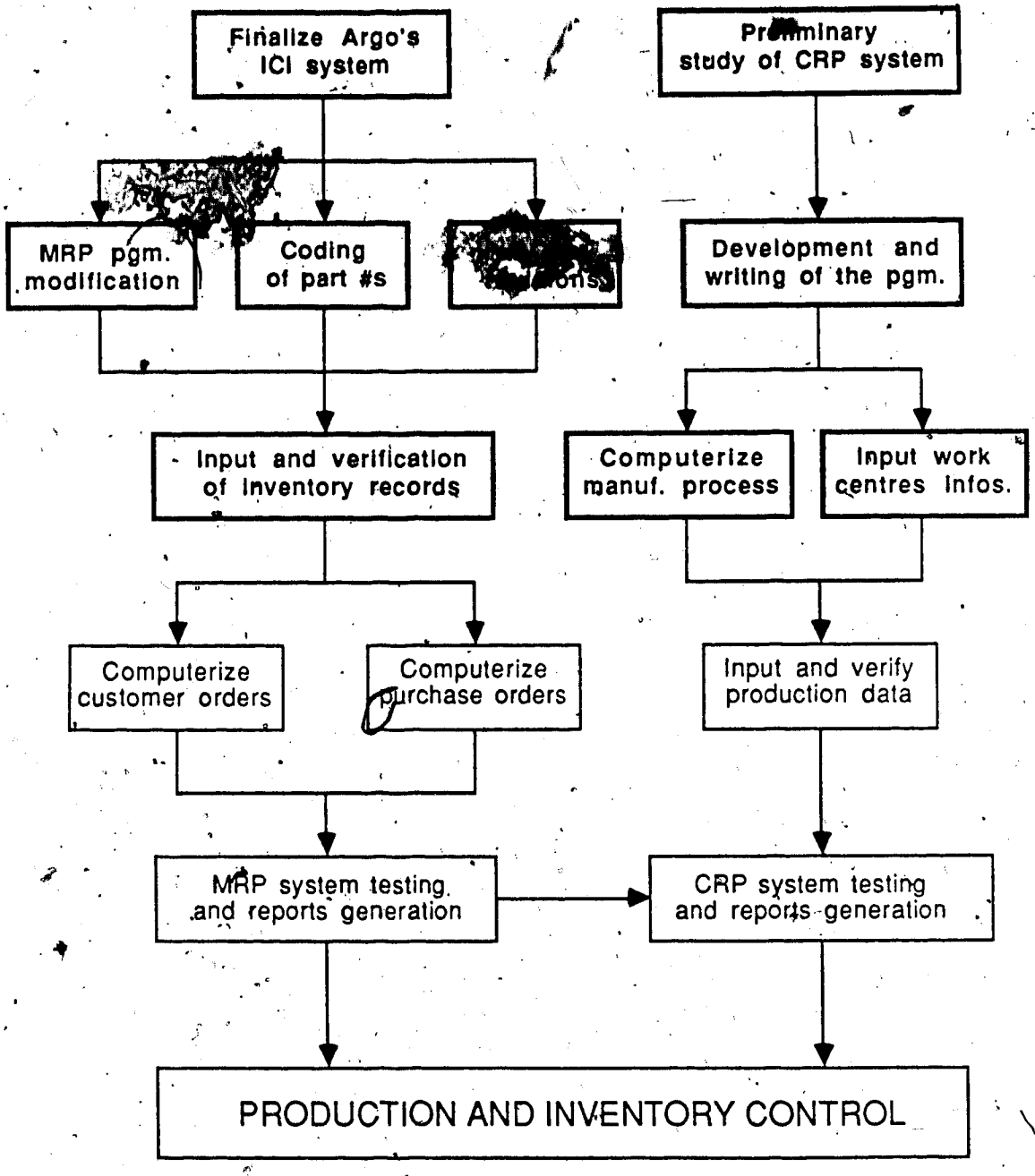


Figure 9.2 Implementation Flowchart at Argo

Future work includes the computerization of the present manual ordering system and parallel run with the actual data. The result can be monitored and checked in the MRP system output in terms of reports and inventory status records. The output requirements from the MRP system will be used as input to the capacity requirements planning program for calculating machine and manpower requirements. When the capacity requirements planning module is fully tested, it will be interfaced with the MRP system to form a complete computerized production and inventory control system.

10. CONCLUSION AND RECOMMENDATIONS

A microcomputer-based material requirements planning (MRP) system for small manufacturers has been developed and tested with an actual implementation at Argo Materials Handling Systems Limited. The result is an improvement in the accuracy and reliability of the inventory data records. At present the company is in the process of computerizing the rest of the manufacturing functions into the system.

The MRP application software was developed on the IBM Personal Computer using the computer language BASIC. The program source code and data file record formats are available for making modifications or future enhancements to the system.

A demonstration program is included in chapter eight of the thesis. Together with the user's manual, it provides an introduction to the operation of the system for first-time users.

Argo Materials Handling Systems Limited is an example of many small manufacturers, who are in a position to computerize their existing inventory control method but lack the preparation and expertise for a large system. This MRP system that was developed would be useful and adequate for small companies that are computerizing for the first time and have relatively simple inventory records.

Computer system implementation is both a frustrating and time-consuming process. During this process, there have been many difficulties encountered. Following is a list of recommendations for future implementation,

1. Program speed. The MRP application software is written in the IBM interpreter BASIC language. Execution of the programs is both slow and is limited by the memory size restriction of the language, which is only 64K. With the release of Microsoft's QuickBASIC compiler version 2.0, the programs can be compiled with minimum modifications.
2. Storage medium. The amount of data that can be stored on one double sided, doubled density diskette is approximately 1000 inventory items. A hard disk is highly recommended to be used for data storage. In addition to its massive capacity, a hard disk also improves the record access time greatly over the diskette system.
3. Capacity requirements planning module. A MRP system will only generate quantity requirements for parts and components. It will not take the production capacity and batch sizing into consideration. In order to have a complete inventory and production control system, a capacity requirements planning module must be added to the system.

4. Auto-generation of part numbers. The most demanding and time-consuming task during system implementation was the numbering of the non-significant digits. Tremendous amount of time can be saved if this can be done automatically by the program.

5. Programming language consideration. BASIC is not a very versatile programing language. When there is a need for changes in the data record structure, most of the existing programs will have to be rewritten. A higher level language such as PASCAL, C, or dBASE III should be employed so that modifications can be made with minimum effort.

6. Multiuser environment. The present MRP application software can only be run in single-user's mode. This means that only one person can use the system at a time. At the time of this writing, IBM has released its new microcomputer system, Personal System/2, which can run multiple applications concurrently. It is recommended that the MRP system be converted to run in this environment.

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APPENDIX A

USER'S MANUAL FOR RUNNING THE MATERIAL REQUIREMENTS PLANNING SYSTEM

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I. SYSTEM REQUIREMENTS AND PROGRAM LOADING INSTRUCTIONS

This is a Material Requirements Planning System that runs on the IBM Personal Computer (PC). The minimum hardware requirements is an IBM PC with dual disk drives of 360K each; 64K of RAM memory, and a printer for hardcopy outputs and reports.

The amount of inventory that can be stored on a double sided, double density diskette is approximately 1,000 stock items. Manufacturers having more inventory items and more complex bill of materials structures should use a hard disk for data storage.

To start using the system, you will need the MRP program disk and a formatted diskette for data storage. Consult the DOS manual on how to format a new diskette.

There are a total of thirty-four BASIC program files with extension .BAS on the diskette. In additions, there are eleven data files (.DAT), one batch files (MRP.BAT), and one system file (CONFIG.SYS). A copy of IBM's BASIC language interpreter version 3.0 is also included on the diskette. Note that if you are using a machine other than IBM's, make sure you replace this version of BASIC with the one for your machine before running the programs.

Due to the limited amount of disk storage space on one diskette, the system files that are needed to boot up the computer cannot be placed on the same diskette with the program files. You will need a separate DOS system disk to start up the computer.

If you do not have a CONFIG.SYS file on your DOS system disk, copy the one from the MRP program diskette onto your DOS diskette and reboot the computer. This is necessary because in the MRP system, some of the programs open as many as eight input/output files simultaneously. In order to accomplish this requirement, you will have to include the command FILES=12 in the CONFIG.SYS file. More instructions on this can be found in the DOS manual.

After the computer is turned on and the DOS prompt appears, insert the MRP diskette into drive A (the one on the left or at the top), and type "MRP" at the DOS prompt (without the double quotes). You will then be asked to enter the current date and time.

You may enter the date (May 15,1987) in any of the following formats: 5/15/87, 5/15/1987, 5-15-87, or 5-15-1987 (remember to use the numeric keys above the letters). If you do not wish to change the date displayed, simply press the <RETURN> key. However, it is important that the system has the correct date every time the MRP application software is run, this is because in the Order Processing Module, the program uses this date to calculate the number of weeks into the current year.

After you have entered the current date or pressed <RETURN>, the time that has been set when DOS is first loaded will be displayed. If you want to change the time, enter the numbers for the hour, minute, and second (if desired) separated by colons, i.e. HH:MM:SS. Use the 24-hour military time, 4 p.m. for example, will be entered as 16:00:00. If you do not wish to change the time displayed, press <RETURN> to continue.

After the date and time have been entered, you should hear a whirring noise and see a red light on the front of drive A. The computer is in the process of reading and loading the program into the memory, do not open the drive door when the light is on, this could damage the diskette, the disk drive, or both.

The first message you see on the screen is shown in Figure A.1. You should enter the letter "D" if you have a dual disk drive, "H" if you have a hard disk for data storage. The program will then instruct you to enter the letter of the diskette drive or the name of the hard disk directory respectively.

Programs in the MRP application software are menu-driven. The main menu is shown in Figure A.2. It consists of three processing modules, each having their own individual subprograms for processing the corresponding data.

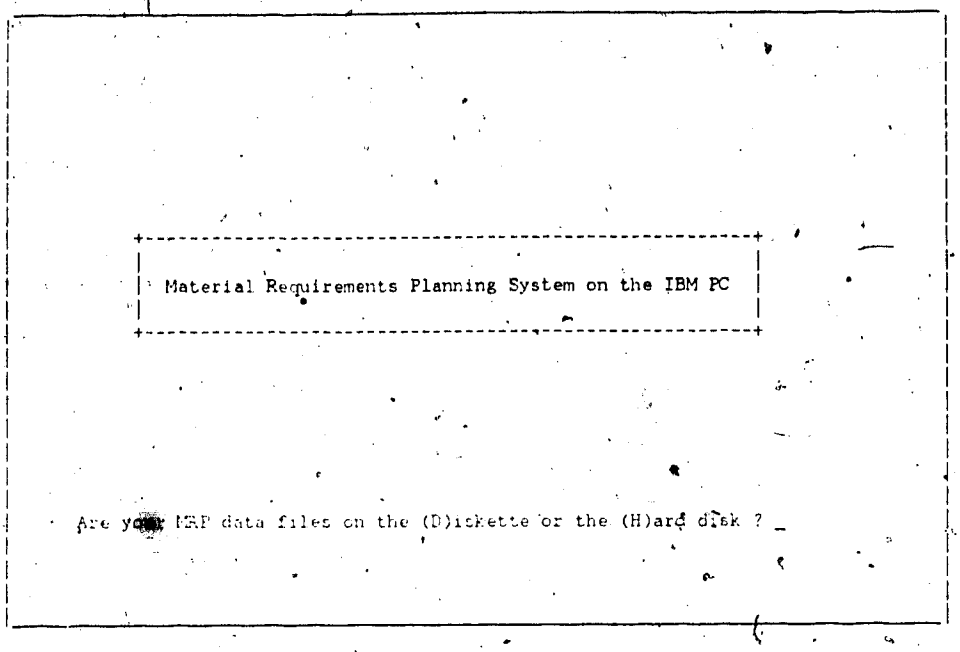


Figure A.1 MRP System Startup Menu

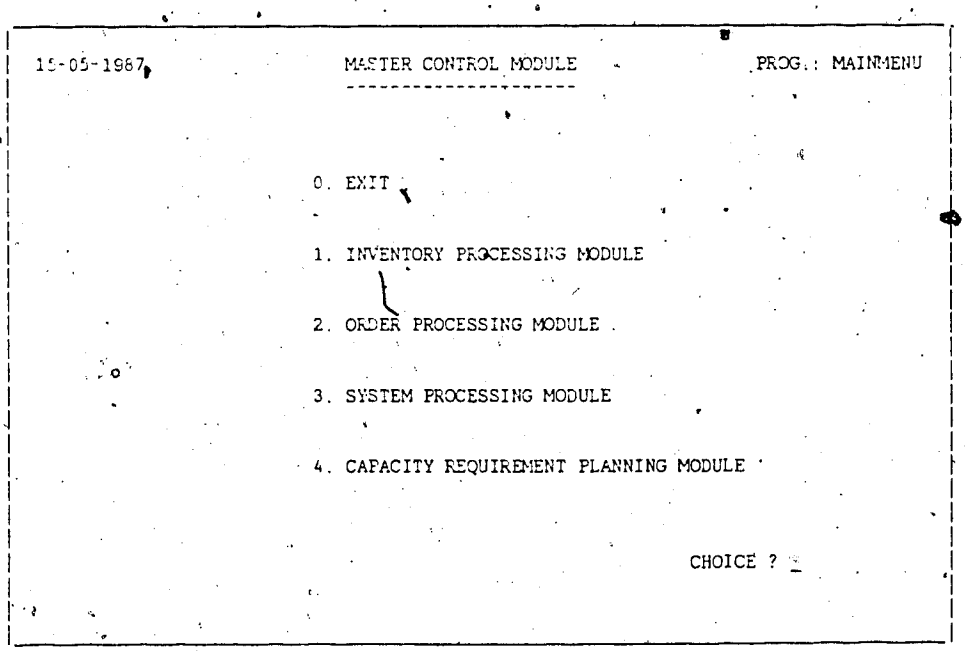


Figure A.2 Main Menu of the MRP System

If you are using the system for the first time or you are entering new data for a different company, you should go to the system processing module and run program #7 to create the initial data files on your storage diskette before running any other programs. There will be a total of eleven data files with extension .DAT after the initialization.

Turn to the following pages for a detailed description and usage of each of the subprograms.

II. INVENTORY PROCESSING MODULE

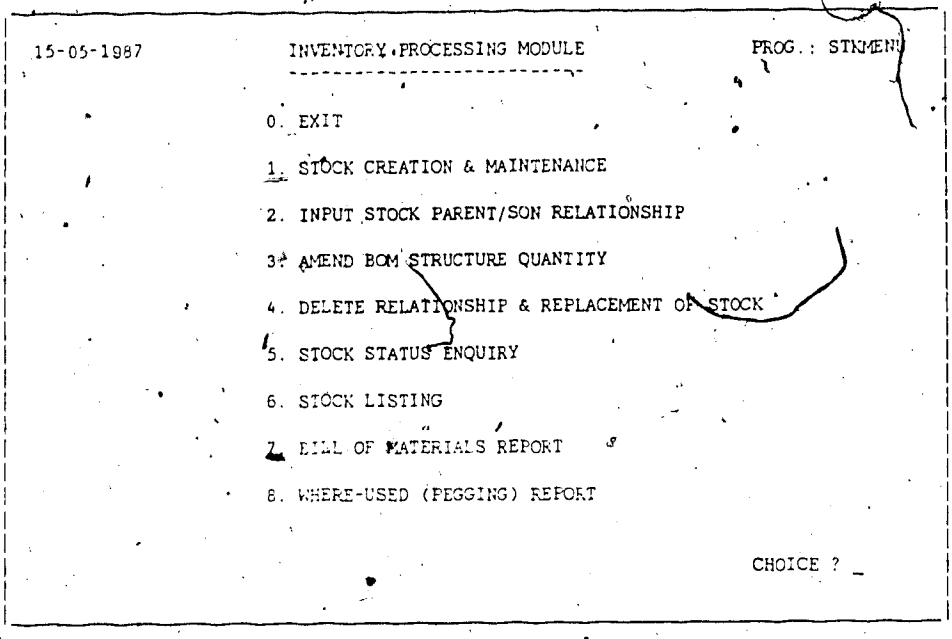


Figure A.3 Inventory Processing Menu

. Stock Creation & Maintenance - create a new stock item, amend the details, and delete existing stock numbers.

. Input Stock Parent/Son Relationship - create the BOM structure of the product.

. Amend BOM Structure Quantity - amend the quantity required per higher level item in the BOM structure.

. Delete Relationship & Replacement of Stock - delete an incorrect BOM structure or replace an existing stock in the BOM structure with a new part.

. Stock Status Enquiry - display all the stock details on the screen plus any outstanding orders relating to the particular stock.

. Stock Listing - display the stock details on the screen or print it out on the printer.

7. Bill of Materials Report - display or print the BOM structure of a product or an assembly.

8. Where-Used (Pegging) Report - report which shows where the part will be used in the next level of assembly.

1. STOCK CREATION & MAINTENANCE

This program is used to create new stock items, amend stock details, and delete an existing stock number from the inventory file. A new record will be written for each newly created stock to the files MASTERA.DAT, MASTERB.DAT, MPSCHED.DAT, MRP.DAT, and SALHIST.DAT. There are twelve fields that the user has to enter to create a new stock.

```
15-05-198[illegible]            STOCK MAINTENANCE                  PROG.: STKMAINT
                                -----------------

1.    PART NUMBER : NEW00000        * - EXIT
                    --------                 7.  SAFETY STOCK :
2.    DESC. :
             ------------------------------  8.  QTY. ON-HAND :
3 UNIT OF MEASURE :
                    ---                      9.  QTY RESERVED :
4.   UNIT COST($) :
                                             10. QTY ON-ORDER :
5.  LEAD TIME(WK) :
                                             11.  Y-T-D REC'D :
6,  REORDER LEVEL :
                                             12.  DRAWING NO. :
                                                                --------

                                             New Stock (Y/N) ? _

->ZEROS should be entered for RESERVED & ON-ORDER Qty for newly created stock.
```

Figure A.4 Stock Maintenance Menu (new stock)

(1) PART NUMBER : enter any character string of length 8, the program will check the MASTERA.DAT file to determine if it is a new stock item. If it is, the program will prompt,

New Stock (Y/N) ?

The user at this point should check to see if the stock number just entered is correct, type "Y" if it is a new stock, otherwise "N" to

clear the entry and enter another stock number.

If the stock number entered already exist, the program will ask,

(A mend/D elete/N ext) ?

go to the section on "Changes, Amendment & Deletion" for seperate instructions,

(2) DESCRIPTION : enter the description of the stock item, maximum permissible length is 30 characters, use abbreviations if necessary.

(3) UNIT OF MEASURE : enter any character string up to 3 characters in length (e.g. pcs, lbs, ft., etc.).

(4) UNIT COST($) : enter the unit cost of the stock item, use any real number.

(5) LEAD TIME(WK) : enter the lead time for the stock item in number of weeks (round off to the nearest integer).

(6) REORDER LEVEL : enter the reorder level quantity (integer).

(7) SAFETY STOCK : enter the safety stock quantity (integer).

(8) QTY. ON-HAND : enter the current on-hand quantity. The company should do an inventory count before inputting this value (integer).

(9) QTY RESERVED : enter a zero ("0") for a newly created stock.

(10) QTY ON-ORDER : enter a zero ("0") for a newly created stock.

(11) Y-T-D REC'D : enter the Y-T-D purchased quantity for the stock item if this information is available (integer).

(12) DRAWING NO. : enter a string up to 8 characters long, e.g. SDL-063.

After inputting the last field (#12), you will be asked if there are any changes to the information just entered.

Any Changes (Y/N) ?

Enter "N" the program will prompt with,

(U)pdate (I)gnore ?

"U" will instruct the program to create the new stock item with the displayed details into the corresponding MRP data files, you will see a red light on the front of drive "B" and hear some disk access noises indicating the process of writing the new record onto the diskette. After the stock record is successfully written, there will be a beep and the following message will be displayed,

New Stock Created !

To confirm that the writing of the new stock record to the MRP data files is completed, press the <ENTER> key. This will clear the stock details on the screen and let you enter another stock number.

If an "I" is entered instead, the stock information just entered will be ignored and cleared from the screen, the user will then be able to enter a new stock number.

Changes, Amendment & Deletion

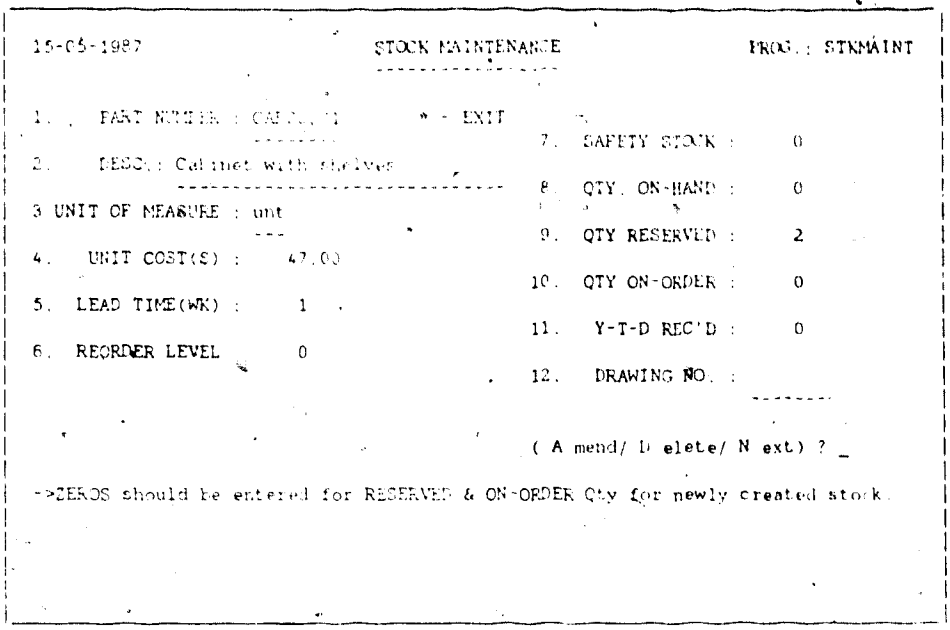


Figure A.5 Stock Maintenance Menu (existing stock)

If you have entered an existing stock number, the program will ask,

(A mend/D elete/N ext) ?

Type in "N" (for [N]ext stock) if you do not want to amend or delete this stock item. This will clear the stock details so that you can enter another stock number.

You can change, amend the fields of the stock item in the MASTERB.DAT file. (C)hange is used for correcting the fields before the item is created, (A)mend is used for correction after the stock record had been written.

When you are in the (C)hange or (A)mend mode, you will be prompted to enter the field number (2 to 11) to which you want to make changes. Field #1 is the stock number, it must be unique in the master file, therefore it cannot be changed or amended. If you have created an incorrect part number, the only way to correct it is to

delete the stock number and recreate it with the right number.

You can exit from the (C)hange or (A)mend mode by typing in a zero ("0") or simply hit the <ENTER> key when you are at the "Change/Amend Line No. ?" prompt. Messages will be displayed to indicate that the stock details have been changed or amended.

If you choose to enter "D" for deletion, the program will first check to see that the reserved quantity and on-ordered quantity is equal to zero. If it is not, a message will be displayed asking you to check the order files. This is because the reserved and on-ordered quantity of the stock item is equal to the sum of the individual ordered item from the customer and purchase orders respectively. Therefore, before you can delete a particular stock item, you must first delete its corresponding reserved or ordered quantity in the customer or purchase orders.

If the reserved and on-ordered quantity of the stock you want to delete is zero, the program will then check to see if this stock item is used in any existing bill of materials (BOM) structure. If it is, you will first have to delete the BOM relationships. The program will then ask you one more time to confirm the deletion,

```
Are you sure you want
    to delete this stock (Y/N) ?
```

Answer "Y" will instruct the program to delete the stock item from the stock master and all other related files, answer "N" to clear the screen details and enter another stock number.

2. INPUT STOCK PARENT/SON RELATIONSHIP

After you have input all the stock numbers and have it printed out and checked, you are ready to enter the Bill of Materials (BOM) structure for each assembly or subassemblies. Although the program will only allow you to enter one assembly (parent) and five subassemblies (sons) at any one screen input, there is no limitation on the number of subassemblies that you can enter to make one unit of the final assembly. For example, if there are nine parts (A1 to A9) that are required to make one final product B, you will have to enter the BOM structure twice. The first time with parent "B" and sons "A1" to "A5" and the second time with sons "A6" to "A9".

```
15-05-1987                PARENT/SON RELATIONSHIPS                PROG.: RELATION

                Part no.  Desc.                              Dwg no.  Unit
    PARENT  :   CABS0002  Cabinet with drawers
                --------
    1st SON :   FRAM0001  Cabinet Frame,2W x 3.5H x 1.5D                . . . (1S)
        QTY :   1                                                         (1Q)

    2nd SON :   DRWR0001  Drawer, 7" depth                              . . . (2S)
        QTY :   2                                                         (2Q)

    3rd SON :   DRWR0002  Deep drawer, 18" depth                        . . . (3S)
        QTY :   1                                                         (3Q)

    4th SON :   *                                                       . . . (4S)
        QTY :                                                             (4Q)

    5th SON :                                                           . . . (5S)
        QTY :                                                             (5Q)

                                                  Are All Entries Correct (Y/N) ? _

To exit program, type in (PARENT/SON : *) or (QTY : 0)
```

Figure A.6 BOM Relationship Program Menu

When you first enter the stock number of the parent part, there will be a check to see if the part number exists, the description and drawing number of the stock will be displayed beside its part number. Type an "*" in this field to exit the program.

Enter the stock number for the first son, followed by the quantity that is required to assemble into one part of the parent product. Repeat and enter the information for the next son and so on. Up to five intermediate lower level items can be entered at any one screen input. If you have less than five "son" to enter, type an "*" in the next non-exist "son" part number (e.g. if the "parent" product has only three parts, type in an "*" in part number for the "4th son" after you have entered the first three), this will allow you to exit from the input mode. If there is no obvious errors in the relationship (e.g. parent part number input as one of the sons), the program will prompt you with,

Are All Entries Correct (Y/N) ?

You should check the BOM structure just entered to see that you have entered all the part numbers and quantities correctly, otherwise type "N" to make changes.

You can make changes to each "son"'s part number and quantity by specifying the corresponding fields 1S/Q to 5S/Q. After you have made the necessary changes, hit the <ENTER> key to get back to the above prompt.

Typing "Y" will instruct the program to build or insert the new BOM structure into the files MASTERA.DAT & BOM.DAT. The program will check for more subtle invalid relationships (e.g. one of the sons has already been entered as a higher level item of the parent part), and will beep and display error messages where appropriate.

If no more errors are detected in the proposed BOM relationship, the program will ask you once more to confirm the creation of the BOM structure,

(U)pdate (I)gnore ?

Enter "U" will instruct the program to go on with the new BOM structure creation, otherwise, "I" will clear the screen and let you start entering a new relationship.

The time required to create a new structure into the

bill of materials file depends on how complex the existing file is and at which level in the structure you are inserting the relationship. Typically it will take about 1/2-minute for a 4-level bill of materials structure,

Parent/Son Relation Created !

A beep and the above message will be displayed after the new BOM structure is successfully created.

3. AMEND BOM STRUCTURE QUANTITY

If you discover that the component quantity required to make one assembled product is incorrect after you had already entered its BOM structure, you could correct the mistake in two ways. The first method is to delete the particular incorrect BOM structure and reenter it with the right one. However, this requires extra work and may prove to be a nuisance with the frequent engineering design changes that affect only the quantity requirements in the BOM structure.

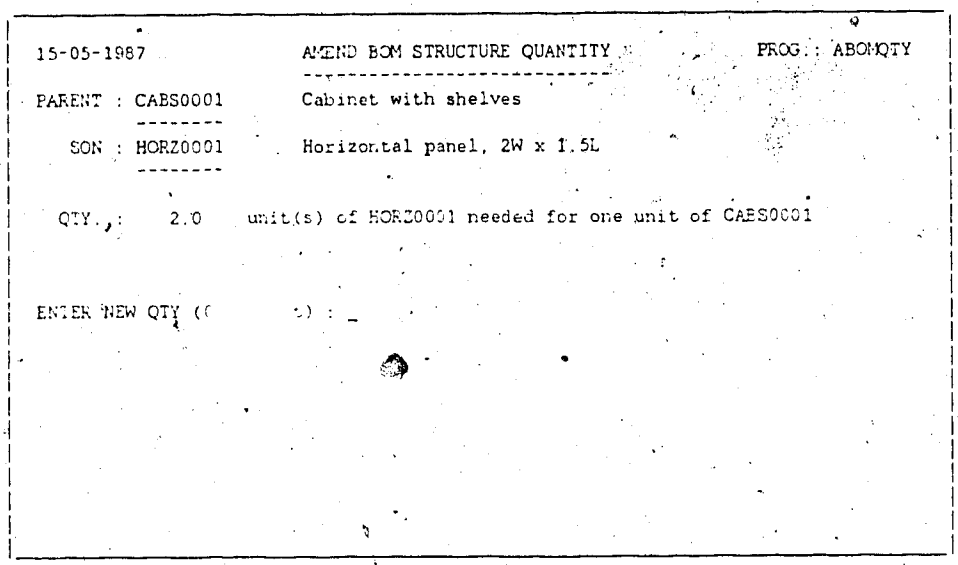


Figure A.7 BOM Quantity Amendment Menu

This program is specifically written to do the above correction quickly and easily. You enter the part number for the particular parent-son BOM structure that you want to amend, the program will then display the number of unit(s) that are needed for one unit of the parent part. Enter the new quantity requirement and the changes will be updated into the BOM file. Changes are confirmed with the message,

New BOM qty. has been updated,
hit <ENTER> to continue . . .

If you do not wish to make any changes, just enter a zero or hit the <ENTER> key, the program will clear the screen and let you enter another part number.

4. DELETE RELATIONSHIP & REPLACEMENT OF STOCK

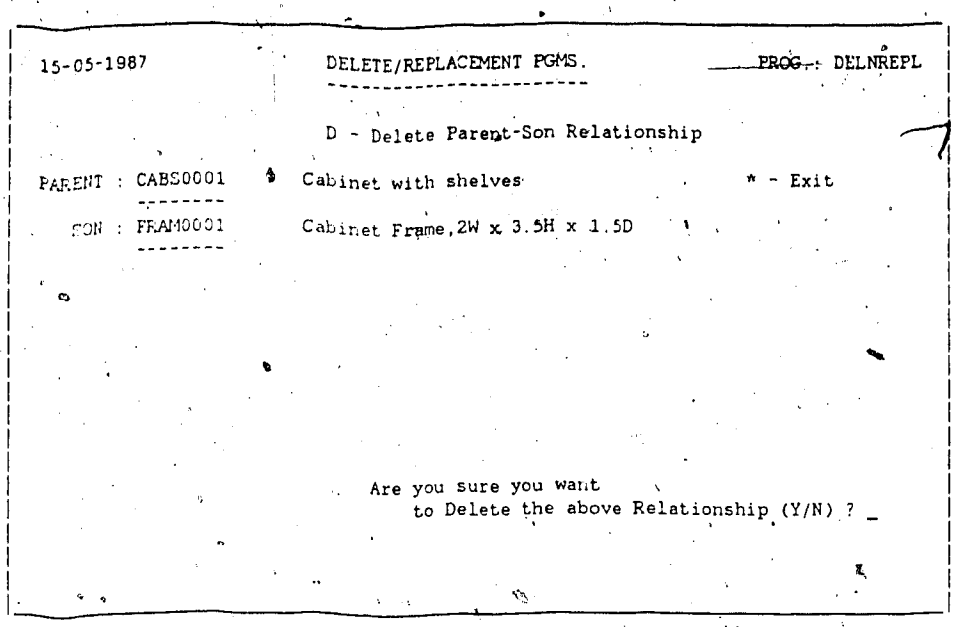
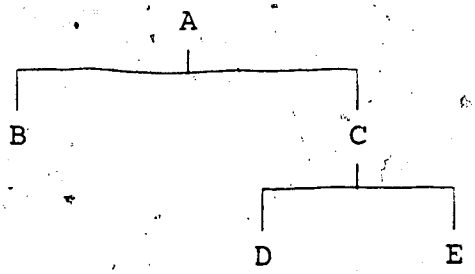


Figure A.8 BOM Deletion Program Menu

DELETION :

If you discover you have made a mistake in entering the BOM structure for a product, do not panic, you do not have to reenter everything from scratch. However, the only way to correct the mistake is to delete the incorrect structure, and recreate the right one. This program provides you with the instructions to delete one parent-son relationship at one time.

e.g. we have the following BOM structure entered,



You can delete parent-son relationships A-B, A-C, C-D, or C-E. However, you cannot delete relationship A-E directly, as it affects intermediate member C. In order to do this, you will have to first delete relationship C-E and then A-C.

i) PARENT : enter the part number for the assembly or finished product.
ii) SON : enter the part number for the component.

The program will check to see if the relationship exists and prompt with the message,

Are you sure you want
to Delete the above Relationship (Y/N) ?

Answer "Y" will instruct the program to carry on the deletion and confirm with the message,

Above Relationship Deleted !

Otherwise, "N" will clear the screen and let you input another relationship.

REPLACEMENT :

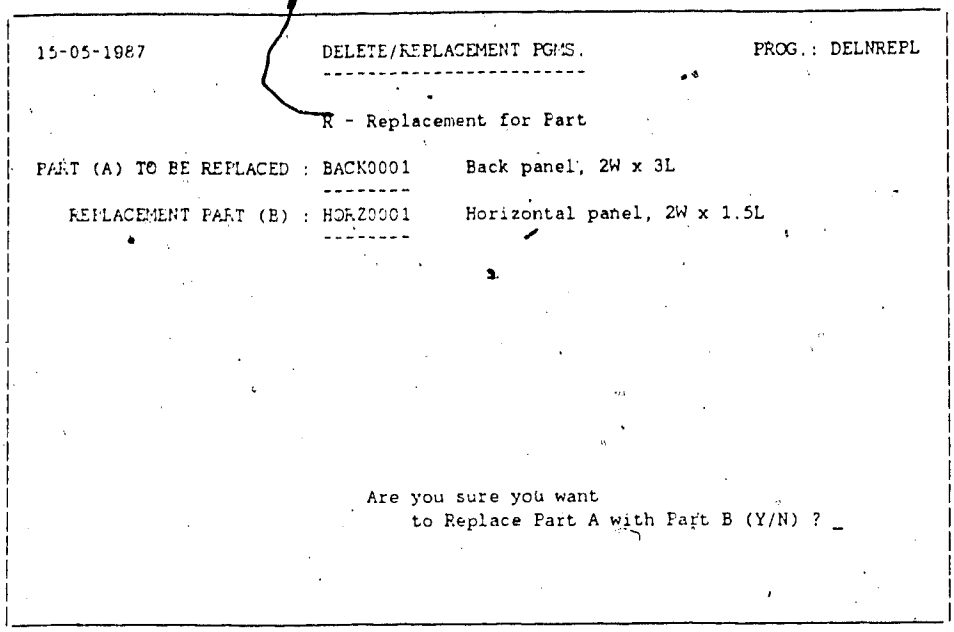


Figure A.9 Part Replacement Program Menu

Many times, a vendor will choose to discontinue supplying a particular part or component. However, it is usually substituted by a new part that is interchangeable with the old one. This is particularly true in the automobile industry. The second part of this program, provides you with the option to replace an existing part number in the BOM structure with another one. This saves the tedious effort of deleting and recreating the product structure in all the BOM records that uses the obsolete part.

PART (A) TO BE REPLACED : enter the part number for the obsolete part to be replaced.

REPLACEMENT PART (B) : enter the new part number to replace part A.

The program will then check for subtle illegal relationships (e.g. replacement part B is the parent, son

of A, etc.) and display error messages if there are any. Otherwise you will be prompted with the message,

Are you sure you want
to Replace Part A with Part B (Y/N) ?

Answer "Y" will replace part A with part B in every occurrence in the BOM file. The time required for the processing will depend on how large the BOM file is and how often does part A appear in the structure. A beep and the message,

Part B replaced Part A !

will be displayed to confirm successful replacement.

Answer "N" will clear the screen and let you input another set of part numbers for replacement.

5. STOCK STATUS ENQUIRY

```
15-05-1987                    STOCK STATUS ENQUIRY              PROG.: STKENQRY

PART NUMBER : CABS0002   DESCRIPTION : Cabinet with drawers
              --------
  UNIT COST :    90.00     LEAD TIME :  2   UNIT : unt   LEVEL CODE :  0

ON-HAND QTY :     0    ROL :     0    SAFETY STK :    0   DRAWING NO.:

YTD PURCHASE:     0        LAST PURCHASE ORDER PLACED :  DD/MM/YY

RESERVED QTY:     5                   ON-ORDER QTY :     0

REQUIRED ORDER  QTY  CUSTOMER NAME      DELIVERY ORDER  QTY  SUPPLIER NAME
--DATE-- -NO.-  ---  -------------      --DATE-- -NO.-  ---  -------------

18/04/87 INV001   1 Argo Materials Hdlng
25/04/87 INV002   2 Univ. of Alberta
01/05/87 INV003   2 NAIT, Edmonton Alta.


Tap <ENTER> after reading details !
```

Figure A.10 Stock Status Enquiry Menu

Enter the part number of the item you wish to look at and all its stock details will be displayed on the screen. Note that the reserved quantity should be equal to the sum of the allocated quantity from each individual customer order. This is true also with the on-order quantity and the corresponding purchase orders. If this is not the case, it means that some of the data have been mistakenly written and you should notify the programmer or the system analyst about the error.

Type in an "*" in the part number field to exit the program.

6. STOCK LISTING

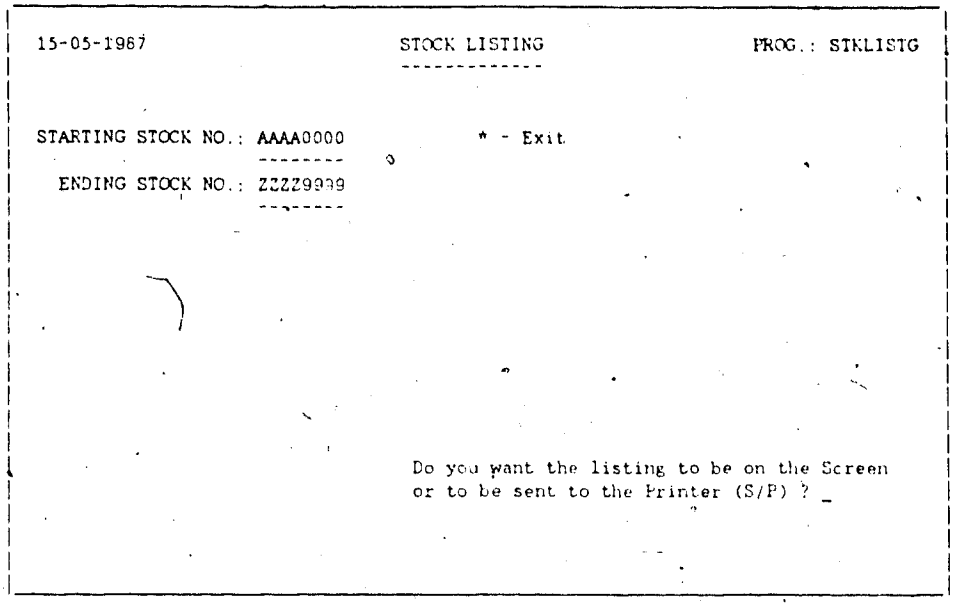


Figure A.11 Stock Listing Menu

Enter the range of the stock numbers to be listed (starting and ending stock number). The program will then prompt you to choose the output device,

> Do you want the listing to be on the Screen
> or to be sent to the Printer (S/P) ?

Enter "S" will instruct the program to display the stock listing on the terminal with 20 items per screen. Otherwise, "P" will produce a hardcopy listing on 8-1/2 x 11" paper in compressed print with 50 items per page.

Part no.	Desc.	Unit	Drawing	Lvl	Ltme	U.Price
1)BACK0001	Back panel, 2W x 3L	pcs		2	1	8.00
2)CABS0001	Cabinet with shelves	unt		0	1	47.00
3)CABS0002	Cabinet with drawers	unt		0	2	90.00
4)DBOX0001	Box for 7" depth drawer	pcs		2	1	12.00
5)DBOX0002	Box for 18" depth drawer	pcs		2	1	22.00
6)DRWR0001	Drawer, 7" depth	set		1	2	15.00
7)DRWR0002	Deep Drawer, 18" depth	set		1	3	25.00
8)FRAM0001	Cabinet Frame,2W x 3.5H x 1.5D	unt		1	1	35.00
9)HDLE0001	Handle for drawer	pcs		2	1	5.00
10)HORZ0001	Horizontal panel, 2W x 1.5L	pcs		2	2	6.00
11)SIDE0001	Side panel, 1.5W x 3.5L	pcs		2	1	12.00

. . . . . End of Listing . . . . . .

hit <Enter> after reading . . .

Figure A.12 Stock Listing on the Screen

15-05-1987 STOCK LIST PRINTING Page no.: 1

PART NO.	DESCRIPTION	DWG NO.	UNIT	LVL	U.COST	LT	ROL	S.Stk	On-Ha	Resvd	On-Or	YTD-R
BACK0001	Back panel, 2W x 3L		pcs	2	8.00	1	0	0	20	0	0	0
CAES0001	Cabinet with shelves		unt	0	47.00	1	0	0	0	2	0	0
CABS0002	Cabinet with drawers		unt	0	90.00	2	0	0	0	5	0	0
DBOX0001	Box for 7" depth drawer		pcs	2	12.00	1	0	0	10	0	0	0
DBOX0002	Box for 18" depth drawer		pcs	2	22.00	1	0	0	10	0	0	0
DRWR0001	Drawer, 7" depth		set	1	15.00	2	0	0	0	0	0	0
DRWR0002	Deep Drawer, 18" depth		set	1	25.00	3	0	0	1	2	0	0
FRAM0001	Cabinet Frame,2W x 3.5H x 1.5D		unt	1	35.00	1	0	0	1	0	0	0
HDLE0001	Handle for drawer		pcs	2	5.00	1	0	0	50	0	0	0
HORZ0001	Horizontal panel, 2W x 1.5L		pcs	2	6.00	2	0	0	10	0	0	0
SIDE0001	Side panel, 1.5W x 3.5L		pcs	2	12.00	1	0	0	10	0	0	0

Figure A.13 Stock Listing on the Printer

7. BILL OF MATERIALS REPORT

```
15-05-1987                  BILL OF MATERIAL REPORT                  PROG. : BOMRPORT

PART NUMBER : CABS0002   DESCRIPTION : Cabinet with drawers
              --------
  UNIT COST :    90.00    LEAD TIME :   2   UNIT : unt    LEVEL CODE :  0

Do you want a (C)omplete listing or just the (F)irst level components ? C
                                                                  QTY/ QTY/  TTL
===COMPONENT DESCRIPTION==========DWG NO.==LEVEL  1 2 3 4 5 6 7=LVL=ASY==$/ASSY

 1)Cabinet Frame,2W x 3.5H x 1.5D        FRAM0001*          1
   Side panel, 1.5W x 3.5L                 SIDE0001         2   2   24.00
   Horizontal panel, 2W x 1.5L             HORZ0001         1   1    6.00
   Back Panel, 2W x 3L                     BACK0001         1   1    8.00
 2)Drawer, 7" depth                      DRWR0001*          2
   Box for 7" depth drawer                 DBOX0001         1   2   24.00
   Handle for drawer                       HDLE0001         1   2   10.00
 3)Deep drawer, 18" depth                DRWR0002*          1
   Box for 18" depth drawer                DBOX0002         1   1   22.00
   Handle for drawer                       HDLE0001         1   1    5.00
                                                                    --------
                                                                      99.00
hit <ENTER> after reading the details !
```

Figure A.14 BOM Report Program Menu

The report uses an indented Bill of Materials format. It is printed on 8-1/2 x 11" paper in compressed print. Due to the size of the display screen, only seven levels of BOM structure can be shown at a time (level 1 to 7 or level 8 to 14). However, in the hardcopied output, all the fourteen levels will be printed.

A complete listing will list the BOM structure down to the lowest level (usually the raw materials). But at times, this could be lengthy (a complete BOM listing for a complete finished product with 150-200 components will take several minutes to print) and is often unnecessary. By specifying (F)irst level before printing, only the intermediate components of the product will be printed. This is considerable faster than the (C)omplete listing.

Enter an "*" in the part number field to exit the program.

15-05-1987 / BILL OF MATERIAL \
\ REPORT /

PART NUMBER : CABS0001 (LEVEL 0) DWG NO.:
DESCRIPTION : Cabinet with shelves
LEAD TIME : 1
UNIT COST : 47.00

	PARTS DESCRIPTION	DWG NO.	LEVEL 1 2 3 4 5 6 7 8	Raw Matl	QTY/ NLVL	QTY/ ASSY	COST/ ASSY.
1)	Horizontal panel, 2W x 1.5L		. HORZ0001		2	2	12.00
2)	Cabinet Frame,2W x 3.5H x 1.5D		FRAM0001*		1		
	Side panel, 1.5W x 3.5L		. SIDE0001		2	2	24.00
	Horizontal panel, 2W x 1.5L		. HORZ0001		1	1	6.00
	Back panel, 2W x 3L		. BACK0001		1	1	8.00
							---
*-An Assembly			TOTAL COST PER UNIT OF PART (CABS0001) :			$	50.00

15-05-1987 / BILL OF MATERIAL \
\ REPORT /

PART NUMBER : CABS0002 (LEVEL 0) DWG NO.:
DESCRIPTION : Cabinet with drawers
LEAD TIME : 2
UNIT COST : 90.00

	PARTS DESCRIPTION	DWG NO.	LEVEL 1 2 3 4 5 6 7 8	Raw Matl	QTY/ NLVL	QTY/ ASSY	COST/ ASSY.
1)	Cabinet Frame,2W x 3.5H x 1.5D		FRAM0001*		1		
	Side panel, 1.5W x 3.5L		. SIDE0001		2	2	24.00
	Horizontal panel, 2W x 1.5L		. HORZ0001		1	1	6.00
	Back panel, 2W x 3L		. BACK0001		1	1	8.00
2)	Drawer, 7" depth		DRWR0001*		2		
	Box for 7" depth drawer		. DBOX0001		1	2	24.00
	Handle for drawer		. HDLE0001		1	2	10.00
3)	Deep Drawer, 18" depth		DRWR0002*		1		
	Box for 18" depth drawer		. DBOX0002		1	1	22.00
	Handle for drawer		. HDLE0001		1	1	5.00
							---
*-An Assembly			TOTAL COST PER UNIT OF PART (CABS0002) :			$	99.00

Figure A.15 Sample BOM Listing Printout

8. WHERE-USED (PEGGING) REPORT

```
15-05-1987              WHERE-USED (PEGGING) REPORT          PROG. : PEGRPORT

PART NUMBER : HORZ0001
              --------
DESCRIPTION : Horizontal panel, 2W x 1.5L

                                        Is the printer ready (Y/N) ? _
```

Figure A.16 Pegging Report Printing Menu

This report shows where the component is used in the assembly. It prints the intermediate assemblies (parents) of the entered stock number. This is useful in tracing the assembly or finished product that uses a particular component or raw material.

```
15-05-1987                  < WHERE-USED (PEGGING) REPORT >

PART NUMBER : HORZ0001 (LEVEL 2 )
DESCRIPTION : Horizontal panel, 2W x 1.5L
  LEAD TIME :  2
  UNIT COST :     6.00

USED IN PART NO.          DESCRIPTION                        QTY PER ASSY.
----------------          -----------                        -------------
CABS0001 (LEVEL 0 )       Cabinet with shelves                       2
FRAM0001 (LEVEL 1 )       Cabinet Frame,2W x 3.5H x 1.5D             1
```

Figure A.17 Sample Pegging Report

III. ORDER PROCESSING MODULE

```
15-05-1987          ORDER PROCESSING MODULE          PROG.: ORDMENU
                    ----------------------

                    0. EXIT
                    1. CUSTOMER ORDER ENTRY
                    2.    ''    ''   ENQUIRY
                    3.    ''    ''   CANCELLATION
                    4.    ''    ''   DELIVERY
                    5. STOCK QTY. RE-ALLOCATION
                    6. PURCHASE ORDER ENTRY
                    7.    ''    ''   ENQUIRY
                    8.    ''    ''   CANCELLATION
                    9.    ''    ''   RECEIPT

                                                  CHOICE ? _
```

Figure A.18 Order Processing Menu

1. Customer Order Entry - this program allows you to enter a new customer order. The stock master and master production schedule files will be updated accordingly.

2. Customer Order Enquiry - displays any existing customer order on the screen as well as produces hardcopies on the printer. It also allows you to amend or delete any ordered stock item.

3. Customer Order Cancellation - cancels the entire customer order and updates the corresponding data files.

4. Customer Order Delivery - delivers the ordered stock item and add this quantity to the current month's sales count in the sales history file.

5. Stock Qty. Re-Allocation - this program allows you to re-allocate stock between the on-hand and reserved quantity.

6. Purchase Order Entry - this program allows you to enter a new purchase order. The stock master and MRP matrix files will be updated accordingly.

7. Purchase Order Enquiry - displays the details of any existing purchase order on the screen as well as produces hardcopies on the printer.

8. Purchase Order Cancellation - cancels the entire purchase order and updates the corresponding data files.

9. Purchase Order Receipt - transforms the ordered stock quantity into receipt stock and updates the stock on-hand quantity accordingly.

In the order entry, order enquiry, order cancellation, and stock qty. re-allocation programs, if changes are made to the ordered items, the program will prompt,

Do you want to do a Partial Regeneration for the net changes (Y/N) ?

Answer "Y" if you want to reflect the changes in the MRP matrix immediately, otherwise "N" to clear the message and enter another order number.

Note: see the related sections on regeneration versus net change processing in the MRP method - chapter two of the thesis.

1. CUSTOMER ORDER ENTRY

This program is used for creating new customer orders. A new record will be written to the customer order file for each ordered stock item. The order number, order date, delivery date, and customer's name is referred to as the header informations. They can be amended in the customer order enquiry program except for the order number, which must be unique.

```
15-05-1987                  CUSTOMER ORDER ENTRY                  PROG.: CUSTORDR
                            -------------------

ORDER NO.:[INV001]    ORDER DATE : 25/01/87    DELVRY DATE : 18/04/87
CUSTOMER :[Argo Materials Hdlng]

                                                          SELLING
  PART NO. DESCRIPTION          LDTIME  UNIT  ORD.QTY     PRICE    ALC.QTY BACKORD
  -------- -----------          ------  ----  -------     -------  ------- -------
1)CABS0002 Cabinet with drawers    2     unt       1      90.00        1       0
2)DRWR0001 Drawer, 7" depth        2     set       3      15.00        0       3
3)*

(A)mend      (D)elete      (I)gnore      (M)ore      (U)pdate ? _
```

Figure A.19 Customer Order Entry Menu

Header Information :

Order no. - enter a 6 character string for this number. The program will first check to see whether this number exists in the customer order file. If it does, an error message will be displayed and the program will prompt you to enter another number.

Order date - enter the date in the format DD/MM/YY, otherwise an error message will be displayed and you

will have to reenter it in the proper format.

Delivery date - also to be entered in the format DD/MM/YY. It is extremely important to have the correct date because the program uses this date to calculate the week number that the gross requirements quantity from this order will be added to. If the delivery date entered is less than or equal to the order date, an error message will be displayed and you will be required to enter the date again.

Customer - enter the name of the customer. A maximum length of 20 characters can be used for the name.

Order Details :

Part no. - enter an 8 character stock number, the lead time (weeks) and unit of measure will be displayed.

Order Qty. - enter the quantity ordered by the customer for the stock item (integer).

Selling Price - enter the selling price of the stock item. Do not enter the dollar($) sign as part of the entry.

Allocated & Back-ordered Qty. - these two quantities are calculated by the program itself. The available on-hand quantity of the stock item is assigned to the customer orders on a first-come-first-serve basis. If the ordered quantity cannot be filled from the on-hand inventory, the amount short will be shown as the back-ordered quantity. This will be added to the gross requirements in the master production schedule.

Enter an "*" in the part no. field to exit to the command line.

Command Line :

(A)mend (D)elete (I)gnore (M)ore (U)pdate ?

Type in the first letter of each function to execute the command.

(A) - after the command is activated, you will be prompted to enter the line number to which you want to amend. Type in the stock number, ordered quantity or selling price that you want to change. You can retain the original value of each field by hitting the <ENTER> key without typing in anything. After all the necessary adjustments, hit the <ENTER> key to return to the command line.

(D) - you will be prompted to enter the line number that you want to delete. The word "*** Deleted ! ***" will be displayed on the line to indicate that it has been deleted. Hit the <ENTER> key to return to the command line.

(I) - if you have discovered that most of the stock items that you have already entered is incorrect, it may be easier to reenter the entire order than to correct them one by one. You can do this by executing this command to ignore everything that you have typed in so far for this order. The screen will be cleared and you will be prompted to enter a new order number.

(M) - executing this command will let you continue to enter the rest of the stock items in the order.

(U) - you must thoroughly check the information you have entered for this order before executing this command. The on-hand quantity in the stock master file and the gross requirement quantity in the master production schedule file will be updated when this command is executed. A new record will be written to the customer order file for each ordered item and to the reserved stock file if necessary. The red light on the front of the data drive will come on to indicate writing to disk is in process. After all the records have been successfully written and updated, a confirmation message will appear,

Customer order written to disk file !

Hit the <ENTER> key to clear the screen and you will be prompted to enter a new order number.

Enter an "*" in the customer order number field to exit the program.

2. CUSTOMER ORDER ENQUIRY

```
15-05-1987                CUSTOMER ORDER ENQUIRY              PROG.: CUSTENQY
                          ----------------------

ORDER NO.:[INV002]      ORDER DATE : 28/01/87    DELVRY DATE : 25/04/87
CUSTOMER :[Univ. of Alberta     ]

                                                          SELLING
  PART NO. DESCRIPTION          LDTIME  UNIT  ORD.QTY     PRICE    ALC.QTY BACKORD
  -------  -----------          ------  ----  -------     -------  ------- -------


        Enter field to be changed : (O)rder date
                                    (D)elivery date
                                    (C)ustomer name
                                    (U)pdate changes
                                    (I)gnore   ''

                                CHOICE ? _
```

Figure A.20 Customer Order Header Amendment Menu

Enter an existing customer order number and the program will first ask,

Do you want to change the header informations (Y/N) ?

If a "Y" is entered, the program will display the screen as shown in Figure A.20. This allows you to change the order date, the delivery date, and the customer's name. If you choose to enter "N", the rest of the order will be displayed on the screen and you will be prompted with the command line,

(A)mend (D)elete (H)ardcopy (M)ore (E)nd ?

(A) - enter the line number you want to amend. Type in the stock number, ordered quantity or selling price that you want to change. You can retain the original

```
15-05-1987                  CUSTOMER ORDER ENQUIRY                  PROG.: CUSTENQY

ORDER NO.:[INV002]      ORDER DATE : 28/01/87    DELVRY DATE : 25/04/87
CUSTOMER :[Univ. of Alberta    ]

                                                    SELLING
   PART NO. DESCRIPTION          LDTIME  UNIT ORD.QTY  PRICE   ALC.QTY BACKORD
   -------- -----------          ------  ---- -------  -------  ------- -------
 1)CABS0001 Cabinet with shelves    1     unt      6    47.00        2       4
 2)CABS0002 Cabinet with drawers    2     unt      2    90.00        2       0

(A)mend      (D)elete      (H)ardcopy      (M)ore      (E)nd ? _
```

Figure A.21 Customer Order Enquiry Menu

value for any of the above by hitting the <ENTER> key. The changes will be updated immediately to the inventory and master production schedule files. This method can also be used to reserve on-hand quantity as allocated after new stock has arrived.

(D) - enter the line number that you want to delete. The ordered quantity will be subtracted from the gross requirements quantity in the master production schedule. If there is a stock allocation, it will be added back to the on-hand quantity in the stock master file.

(H) - executing this command will produce a copy of the order on the printer. Before hitting the <ENTER> key, make sure that the printer is turned on. Otherwise the program will hang up and give you a "device time out" error.

(M) - due to the size of the screen, the program can only display fourteen lines of order item on the screen at one time. Typing in this command will clear the current lines and continue to display the rest of the order on the screen.

(E) - clears the screen and allows you to enter another customer order number.

3. CUSTOMER ORDER CANCELLATION

```
15-05-1987              CUSTOMER ORDER CANCELLATION              PROG.: CUSTCANC

ORDER NO.:[INV003]      ORDER DATE : 15/02/87    DELVRY DATE : 01/05/87
CUSTOMER :[NAIT, Edmonton Alta.]

                                                    SELLING
  PART NO. DESCRIPTION          LDTIME  UNIT ORD.QTY  PRICE   ALC.QTY BACKORD
  ------- -----------           ------  ---- -------  -------  ------- -------
 1)CABS0002 Cabinet with drawers   2    unit      5    95.00       2       3
 2)DRWR0002 Deep drawer, 18" depth 3    set       2    25.00       2       0
                                                    --------
                                TOTAL ORDER AMOUNT $ :      525.00

Are you sure you want to cancel this order (Y/N) ? _
```

Figure A.22 Customer Order Cancellation Menu

Instead of using the customer order enquiry program to delete the ordered items one by one, this program allows you to cancel the entire order.

This is especially useful if you discover that the order number is incorrect after it has already been entered. You will have to use this program to cancel the entire order and reenter it using the correct order number.

Enter an "*" in the customer order number field to exit the program.

4. CUSTOMER ORDER DELIVERY

```
15-05-1987                CUSTOMER ORDER DELIVERY                PROG.: CUSTDLVY
                          ----------------------

ORDER NO.:[INV001]      ORDER DATE : 25/01/87    DELVRY DATE : 18/04/87
CUSTOMER :[Argo Materials Hdlng]

                                                  SELLING
   PART NO. DESCRIPTION          LT UNIT OR.QTY    PRICE   ALC.QTY BKORD  STATUS
   -------- -----------          -- ---- ------   -------  ------- -----  ------
 1)CABS0002 Cabinet with drawers  2  unt      1     90.00        0     0  Delivrd
 2)DRWR0001 Drawer, 7" depth      2  set      3     15.00        0     3   *O/S*

(A)ll       (H)ardcopy      (M)ore      (P)art of      (End) ? _
```

Figure A.23 Customer Order Delivery Menu

After the customer order quantity is filled using the on-hand quantity from the inventory, it is now ready for delivery. Only items with a back-ordered quantity equal to zero can be delivered as partial shipment of the quantity is not allowed. The status field shows whether the stock item had been delivered or is still outstanding.

When a stock item is delivered, a flag ("-2") will be set in the customer order record to indicate the delivery. The allocated quantity will be added to this month's sales count in the sales history file.

(A)ll (H)ardcopy (M)ore (P)art of (End) ?

(A) - enter this command only if you want the entire order to be delivered immediately. The program will first check to see if all the back-ordered quantity in the

order is zero and all the status is outstanding. If it is not, an error message will be displayed informing you that an "(A)ll deliver" command cannot be executed and you should use the "P" command instead to deliver individual ordered items.

(H) - executing this command will produce a copy of the customer order on the printer. It will show the status (outstanding or delivered) of the item in addition to the order details.

(M) - due to the size of the screen, the program can only display fourteen lines of order item on the screen at one time. Typing in this command will clear the current lines and continue to display the rest of the order on the screen.

(P) - if the entire order cannot be delivered immediately using the command "All", you will have to use this command to deliver "Part of" the order. Type in the line number of the item to be delivered, make sure its back-ordered quantity is zero, otherwise an error message will be displayed and you will be asked to reenter the line number. After each successful delivery, the status field of the item will be shown as "Delivrd".

(E) - clears the screen details and allows you to enter another customer order number.

Enter an "*" in the customer order number field to exit the program.

5. STOCK QTY. RE-ALLOCATION

Although the on-hand stock quantity is allocated on a first-come-first-serve basis during customer order entries, the user can use this program to override the particular allocation. This program can also be used to reserve on-hand quantity for a certain customer after new stock has arrived.

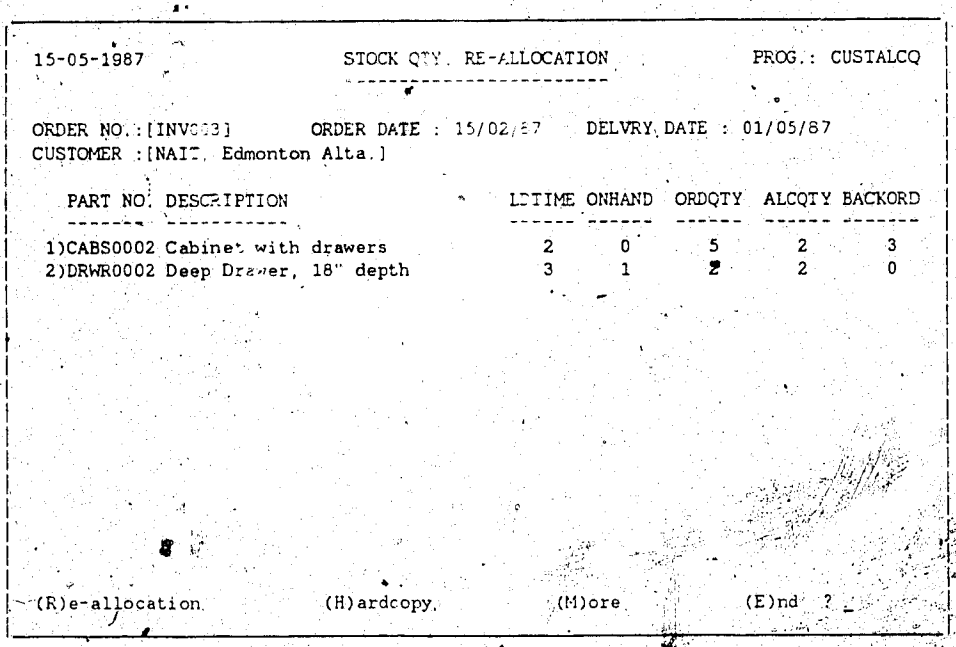


Figure A.24 Stock Re-Allocation Menu

(R) - enter the line number to re-allocate the on-hand quantity. If there is no previous allocation, a new reserved quantity record will be written to the file RESVED.DAT, otherwise the program will update the existing reserved and master production schedule records.

(H) - execute this command to produce a printed output, make sure the printer is on when executing this command.

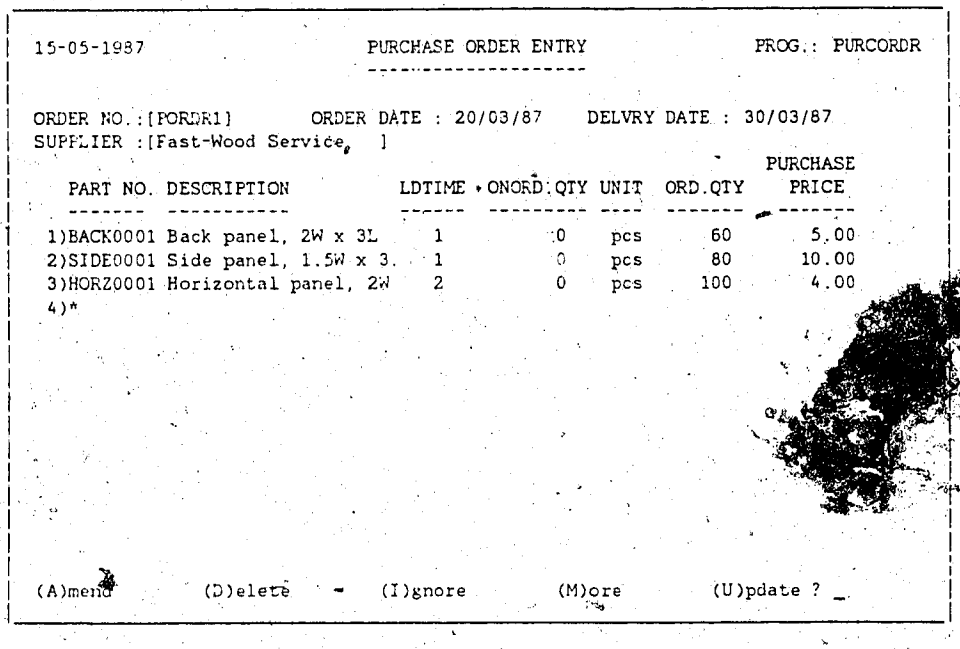
(M) - due to the size of the screen, the program can only display fourteen lines of order item on the screen at one time. Typing in this command will clear the current lines and continue to display the rest of the order on the screen.

(E) - execute this command to clear the screen and enter another customer order number.

Enter an "*" in the customer order number field to exit the program.

6. PURCHASE ORDER ENTRY

This program is used for creating new purchase orders. A new record will be written to the purchase order file for each on-ordered stock item. The order number, order date, delivery date, and supplier's name is referred to as the header information. They can be amended in the purchase order enquiry program except for the order number, which must be unique.



```
15-05-1987                  PURCHASE ORDER ENTRY                  PROG.: PURCORDR

ORDER NO.:[PORDR1]      ORDER DATE : 20/03/87    DELVRY DATE : 30/03/87
SUPPLIER :[Fast-Wood Service,  ]

                                                                    PURCHASE
   PART NO. DESCRIPTION          LDTIME  ONORD.QTY UNIT  ORD.QTY     PRICE
   -------  -----------          ------  --------- ----  -------  --------
 1)BACK0001 Back panel, 2W x 3L      1          0   pcs       60      5.00
 2)SIDE0001 Side panel, 1.5W x 3.    1          0   pcs       80     10.00
 3)HORZ0001 Horizontal panel, 2W     2          0   pcs      100      4.00
 4)*

(A)mend      (D)elete     (I)gnore      (M)ore      (U)pdate ? _
```

Figure A.25 Purchase Order Entry Menu

Header Information :

Order no. - enter a 6 character string for this number. The program will first check to see if this number exists in the purchase order file. If it is an existing purchase order number, an error message will be displayed and the program will ask you to enter another number.

Order date - enter the date in the format DD/MM/YY,

otherwise an error message will be displayed and you will have to reenter it in the proper format.

Delivery date - also to be entered in the format DD/MM/YY. It is extremely important to have the correct date because the program uses this date to calculate the week number that this order will be received in the MRP matrix as a scheduled receipt. If the delivery date entered is less than or equal to the order date, an error message will be displayed and you will be required to reenter the date.

Supplier - enter the name of the supplier. A maximum length of 20 characters can be used for the name.

Order Details :

Part no. - enter an 8 character stock number, the lead time (weeks), current on-ordered quantity and unit of measure will be displayed.

Order Qty. - enter the quantity ordered from the supplier for the stock item (integer).

Purchase Price - enter the purchase price of the stock item. Do not enter the dollar($) sign as part of the entry.

Enter an "*" in the part no. field to exit to the command line.

Command Line :

(A)mend (D)elete (I)gnore (M)ore (U)pdate ?

Type in the first letter of each function to execute the command.

(A) - after the command is activated, you will be prompted to enter the line number you want to amend. Type in the stock number, ordered quantity, or purchase price

that you want to change. You can retain the original value of each field by hitting the <ENTER> key without typing in anything. After all the necessary adjustments, hit the <ENTER> key to return to the command line.

(D) - you will be prompted to enter the line number that you want to delete. The word "*** Deleted ! ***" will be displayed on the line to indicate that it has been deleted. Hit the <ENTER> key to return to the command line.

(I) - if you have discovered that most of the stock items that you have entered to this point are incorrect, it may be easier to reenter the entire order than to correct them one by one. You can do this by executing this command to ignore everything that you have typed in so far for this order. The screen will be cleared and you will be prompted again to enter a new order number.

(M) - executing this command will let you continue to enter the rest of the stock items in the order.

(U) - you must thoroughly check the information you have entered for this order before executing this command. The on-ordered quantity in the stock master file forms the scheduled receipts quantity in the material requirements planning matrix when this command is executed. A new record will be written to the purchase order file as well as the on-ordered stock file for each ordered item. The red light on the front of the data drive will come on to indicate writing to disk is in process. After all the records have been successfully written and updated, a confirmation message will appear,

Purchase order written to disk file !

Hit the <ENTER> key to clear the screen and you will be prompted to enter another order number.

Enter an "*" in the purchase order number field to exit the program.

7. PURCHASE ORDER ENQUIRY

```
15-05-1987                PURCHASE ORDER ENQUIRY                PROG.: PURCENQY
                          ----------------------

ORDER NO.:[PORDR1]      ORDER DATE : 20/03/87    DELVRY DATE : 30/03/87
SUPPLIER :[Fast-Wood Service    ]

                                                                  PURCHASE
   PART NO. DESCRIPTION          LDTIME  ONORD.QTY UNIT  ORD.QTY    PRICE
   ------- -----------          ------  --------- ----  -------  -------


        Enter field to be changed : (O)rder date
                                    (D)elivery date
                                    (S)ustomer name
                                    (U)pdate changes
                                    (I)gnore   ''

                          CHOICE ? _
```

Figure A.26 Purchase Order Header Amendment Menu

Enter an existing purchase order number and the program will first ask,

Do you want to change the header informations (Y/N) ?

If a "Y" is entered, the program will display the screen as shown in Figure A.26. This allows you to change the order date, the delivery date, and the supplier's name. If you choose to enter "N", the rest of the order will be displayed on the screen and you will be prompted with the command line,

(A)mend (D)elete (H)ardcopy (M)ore (E)nd ?

(A) - enter the line number you want to amend. Type in the stock number, ordered quantity or purchase price that you want to change. You can retain the original

```
15-05-1987                PURCHASE ORDER ENQUIRY                PROG.: PURCENQY
                          ----------------------

ORDER NO.:[PORDR1]      ORDER DATE : 20/03/87    DELVRY DATE : 30/03/87
SUPPLIER :[Fast-Wood Service   ]

                                                                    PURCHASE
   PART NO. DESCRIPTION          LDTIME  ONORD.QTY UNIT  ORD.QTY     PRICE
   -------  -----------          ------  --------- ----  -------   --------
 1)BACK0001 Back panel, 2W x 3L     1        60     pcs      60        5.00
 2)SIDE0001 Side panel, 1.5W x 3.   1        80     pcs      80       10.00
 3)HORZ0001 Horizontal panel, 2W    2       100     pcs     100        4.00

(A)mend      (D)elete      (H)ardcopy      (M)ore      (E)nd ? _
```

Figure A.27 Purchase Order Enquiry Menu

value for any of the above by hitting the <ENTER> key. The changes will be updated immediately to the inventory file and the MRP matrix.

(D) - enter the line number that you want to delete. The ordered quantity will be subtracted from the scheduled receipts quantity in the MRP matrix and the on-ordered quantity in the stock master file.

(H) - executing this command will produce a copy of the order on the printer. Before hitting the <ENTER> key, make sure that the printer is turned on. Otherwise the program will hang up and give you a "device time out" error.

(M) - due to the size of the screen, the program can only display fourteen lines of order item on the screen at one time. Typing in this command will clear the current lines and continue to display the rest of the order on the screen.

(E) - clears the screen and allows you to enter another purchase order number.

Enter an "*" in the purchase order number field to exit the program.

8. PURCHASE ORDER CANCELLATION

```
15-05-1987              PURCHASE ORDER CANCELLATION              PROG.: PURCCANC
                        --------------------------

ORDER NO.:[PORDR1]      ORDER DATE : 20/03/87    DELVRY DATE : 30/03/87
SUPPLIER :[Fast-Wood Service    ]

                                                                  PURCHASE
   PART NO. DESCRIPTION          LDTIME  ONORD.QTY UNIT  ORD.QTY    PRICE
   -------  -----------          ------  --------- ----  -------  -------
 1)BACK0001 Back panel, 2W x 3L     1        60     pcs      60      5.00
 2)SIDE0001 Side panel, 1.5W x 3.   1        80     pcs      80     10.00
 3)HORZ0001 Horizontal panel, 2W    2       100     pcs     100      4.00
                                                                  ---------
                                              TOTAL ORDER AMOUNT $ :  1500.00




Are you sure you want to cancel this order (Y/N) ? _
```

Figure A.28 Purchase Order Cancellation Menu

Instead of using the purchase order enquiry program to delete the on-ordered items one by one, this program allows you to cancel the entire order.

This is especially useful if you discover that the order number is incorrect after it has already been entered. You will have to use this program to cancel the entire order and reenter it using the correct order number.

Enter an "*" in the purchase order number field to exit the program.

9. PURCHASE ORDER RECEIPT

```
15-05-1987                  PURCHASE ORDER RECEIPT                  PROG.: PURCRECP

ORDER NO.: PORDR1        ORDER DATE : 20/03/87    DELVRY DATE : 30/03/87
SUPPLIER : Fast-Wood Service

                                                                    PURCHASE
   PART NO. DESCRIPTION          LDTIME  ONOR.QTY UNIT  ORD.QTY     PRICE   STATUS
   -------  -----------          ------  -------- ----  -------  -------  ------
 1)BACK0001 Back panel, 2W x 3L    1        60    pcs      60      5.00   *O/S*
 2)SIDE0001 Side panel, 1.5W x 3.  1        80    pcs      80     10.00   Receivd
 3)HORZ0001 Horizontal panel, 2W   2       100    pcs     100      4.00   *O/S*

(A)ll       (H)ardcopy       (M)ore       (P)art of       (E)nd ? _
```

Figure A.29 Purchase Order Receipt Menu

This program is used to transform the on-ordered quantity of the purchase order into the on-hand quantity in the stock master file. Partial shipment of the quantity is not allowed. The status line shows whether the stock item has been received or is still outstanding.

When a stock item is received, a flag ("-2") will be set in the purchase order record to indicate the receipt. The received quantity will be subtracted from the on-ordered quantity and added to the on-hand quantity in the stock master file.

(A)ll (H)ardcopy (M)ore (P)art of (End) ?

(A) - enter this command only if you want the entire order to be received. The program will first check to see if all the item status in the order is outstanding.

If it is not, an error message will be displayed informing you that an "(A)ll receive" command cannot be executed and you should use command "P" instead to receive individual outstanding ordered items.

(H) - executing this command will produce a copy of the purchase order on the printer. It will show the status (outstanding or received) of the item in addition to the order details.

(M) - due to the size of the screen, the program can only display fourteen lines of order item on the screen at one time. Typing in this command will clear the current lines and continue to display the rest of the order on the screen.

(P) - if the entire order cannot be received immediately using the command "All", you will have to use this command to receive "Part of" the order. Type in the line number of the item to be received. After each successful receipt, the status field of the item will be shown as "Receivd".

(E) - clears the screen details and allows you to enter another purchase order number.

Enter an "*" in the purchase order number field to exit the program.

IV. SYSTEM PROCESSING MODULE

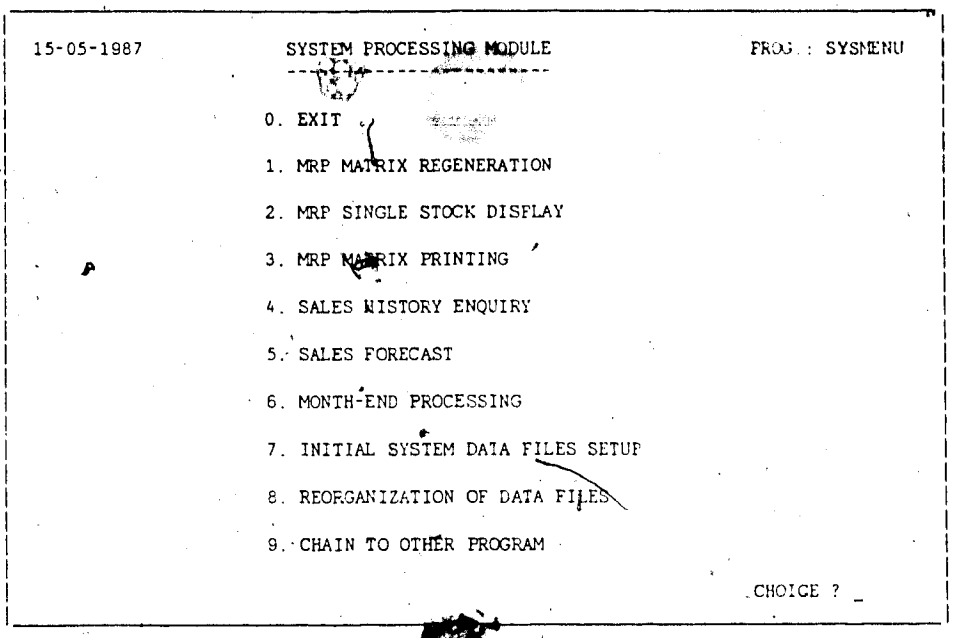


Figure A.30 System Processing Menu

1. MRP Matrix Regeneration - regenerates the entire MRP matrix with a new planning date.

2. MRP Single Stock Display - displays the MRP planning schedule for a particular stock on the screen.

3. MRP Matrix Printing - prints the MRP matrix for a range of stock numbers specified by the user.

4. Sales History Enquiry - displays the past twelve months' sales data for a stock item on the screen.

5. Sales Forecast - the program will generate a forecast for a particular stock using its past 12 months' sales data with either the moving average or the exponential smoothing method.

6. Month-End Processing - this program deletes the unwanted

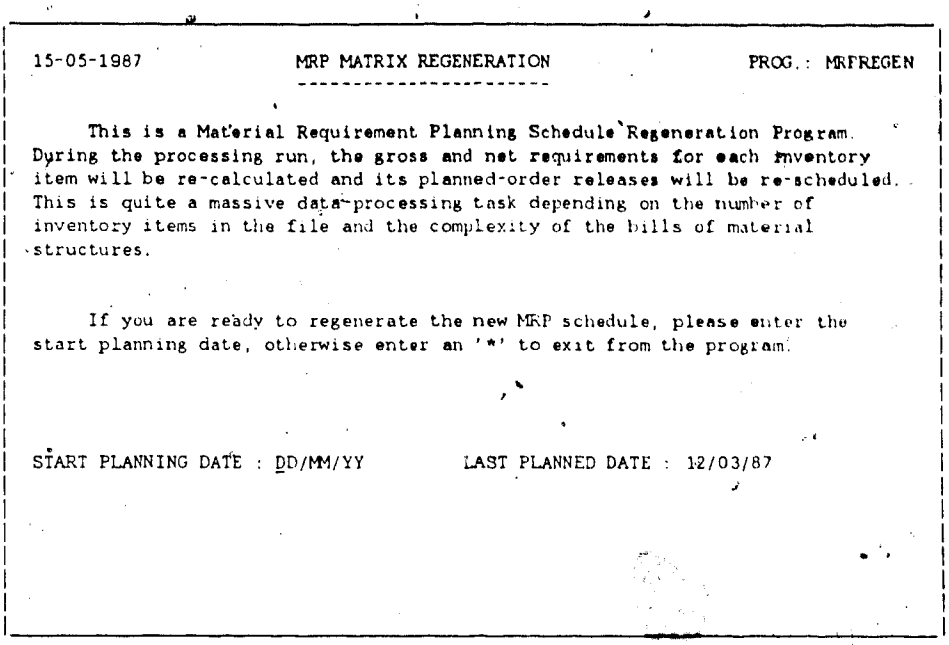
data records in the current month and resets the system date to the first day of the next month. It also rolls the sales history file record forward by one month to allocate space for next month's entry.

7. Initial System Data Files Setup - use this program only once to set up the initial data base for the system or for a new company.

8. Reorganization of Data Files - reorganizes your data using this program. It deletes unwanted records and rebuilds the data in a sequential format for faster access.

9. Chain to Other Programs - provides a means to chain to any other user written programs which will access and manipulate the data in the MRP application software.

1. MRP MATRIX REGENERATION



15-05-1987 MRP MATRIX REGENERATION PROG.: MRPREGEN

This is a Material Requirement Planning Schedule Regeneration Program. During the processing run, the gross and net requirements for each inventory item will be re-calculated and its planned-order releases will be re-scheduled. This is quite a massive data-processing task depending on the number of inventory items in the file and the complexity of the bills of material structures.

If you are ready to regenerate the new MRP schedule, please enter the start planning date, otherwise enter an '*' to exit from the program.

START PLANNING DATE : DD/MM/YY LAST PLANNED DATE : 12/03/87

Figure A.31 MRP Regeneration Program Menu

This program will regenerate the entire MRP matrix using information from the latest master production schedule and inventory status files. The user should do this at least once a week in order to roll the MRP planning horizon forward.

The start planning date must be entered as DD/MM/YY and usually is one week after the last planned date. Type in an "*" in the first column of this field to exit the program, otherwise, the program will prompt,

Are you ready for regeneration (Y/N) ?

Answer "Y" will instruct the program to start the regeneration process, "N" will exit to the system menu.

A MRP total regeneration could be a lengthy process. It depends on the amount of records in the master production schedule file and the complexity of the BOM

structures. However, a partial regeneration based on the "net change" to the order files can be done within a few minutes. It is recommended that one does the daily transaction updating with partial regeneration processing, and complete regenerate the total system on a weekly or fortnightly basis.

Note: see the related section on the regeneration algorithm used in the MRP model - chapter seven of the thesis.

2. MRP MATRIX DISPLAY

```
1987                    MRP MATRIX DISPLAY                    PROG.: MRPDISPL
                        ------------------

PART NUMBER : CABS0001   DESCRIPTION : Cabinet with shelves
              --------

  UNIT COST :    47.00   LEAD TIME :  1   UNIT : unt    LEVEL CODE :  0

ON-HAND QTY :     0    ROL :     0    SAFETY STK :     0   DRAWING NO. :

YTD PURCHASE:     0

RESERVED QTY:     2                   ON-ORDER QTY :     0

  PLANNING DATE : 12/03/87
        PERIOD (WEEK)    \11     12     13     14     15     16     17     18
                         --     --     --     --     --     --     --     --

   GROSS REQUIREMENTS :    0      0      0      0      0      0      4      0
   SCHEDULED RECEIPTS :    0      0      0      0      0      0      0      0
  PROJECTED AVAILABLE :    0      0      0      0      0      0     -4     -4
     NET REQUIREMENTS :    0      0      0      0      0      0      4      0
PLANNED ORDER RELEASES :    0      0      0      0      0      4      0      0

Hit <RETURN> after reading the details !
```

Figure A.32 MRP Matrix Display Menu

The material requirements planning schedule of any stock item can be displayed on the screen. It shows all the stock details plus its gross requirements, scheduled receipts, projected available, net requirements, and planned order releases quantity from the MRP matrix. The last MRP regeneration date is also shown. The week numbers are the actual number of weeks into the current year, e.g. week 11 means days between 12/03/87 and 18/03/87 inclusive.

Enter an "*" in the part number field to exit the program.

3. MRP MATRIX PRINTING

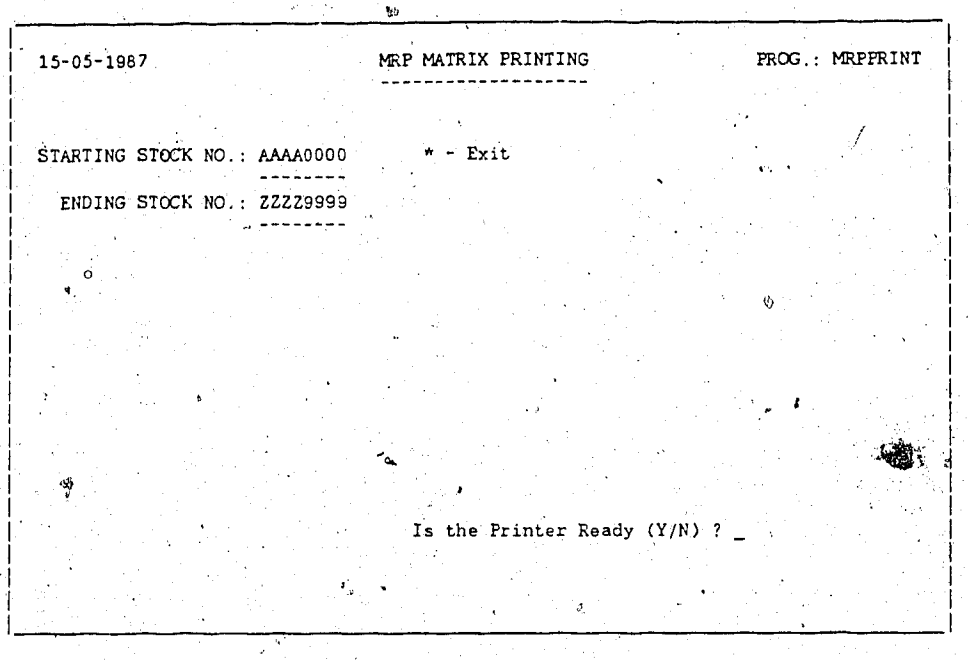


Figure A.33 MRP Matrix Printing Menu

This program allows the user to print the MRP matrix for a range of stock numbers. Some stock informations, such as part description, lead time, and safety stock will also be printed together with the matrix.

Enter an "*" in the starting stock number field to exit the program.

PART NO.: BACK0001	DESC.: Back Panel, 2W x 3L						LEAD TIME : 1	
SAFETY STK.: 0	@12/03/87		PERIOD (WEEK)					
STARTING BAL.: 20	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	6	0	0	0
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	20	20	20	20	14	14	14	14
NET REQUIREMENTS	0	0	0	0	0	0	0	0
PLANNED ORDER RELEASES	0	0	0	0	0	0	0	0

PART NO.: CABS0001	DESC.: Cabinet with shelves						LEAD TIME : 1	
SAFETY STK.: 0	@12/03/87		PERIOD (WEEK)					
STARTING BAL.: 0	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	0	0	4	0
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	0	0	0	0	0	0	-4	-4
NET REQUIREMENTS	0	0	0	0	0	0	4	0
PLANNED ORDER RELEASES	0	0	0	0	0	4	0	0

PART NO.: CABS0002	DESC.: Cabinet with drawers						LEAD TIME : 2	
SAFETY STK.: 0	@12/03/87		PERIOD (WEEK)					
STARTING BAL.: 0	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	0	0	0	0	3
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	0	0	0	0	0	0	0	-3
NET REQUIREMENTS	0	0	0	0	0	0	0	3
PLANNED ORDER RELEASES	0	0	0	0	0	3	0	0

PART NO.: DBOX0001	DESC.: Box for 7" depth drawer						LEAD TIME : 1	
SAFETY STK.: 0	@12/03/87		PERIOD (WEEK)					
STARTING BAL.: 10	11	12	13	14	15	16	17	18
GROSS REQUIREMENTS	0	0	0	9	0	0	0	0
SCHEDULED RECEIPTS	0	0	0	0	0	0	0	0
PROJECTED AVAILABLE	10	10	10	1	1	1	1	1
NET REQUIREMENTS	0	0	0	0	0	0	0	0
PLANNED ORDER RELEASES	0	0	0	0	0	0	0	0

Figure A.34 Sample MRP Matrix Printout

4. SALES HISTORY ENQUIRY

```
15-05-1987                    SALES HISTORY ENQUIRY                    PROG.: SALENQRY

PART NUMBER : CABS0001   DESCRIPTION : Cabinet with shelves
              --------
  UNIT COST :    47.00     LEAD TIME :  1   UNIT : unt    LEVEL CODE :  0

ON-HAND QTY :     0    ROL :     0    SAFETY STK :    0   DRAWING NO.:

YTD PURCHASE:     0

RESERVED QTY:     2                   ON-ORDER QTY :    0

     S A L E S    D A T A    F O R    P A S T    1 2    M O N T H S

Mar '86 :  53  Apr '86 :  44  May '86 :  54  Jun '86 :  58  Jul '86 :  50

Aug '86 :  48  Sep '86 :  56  Oct '86 :  56  Nov '86 :  54  Dec '86 :  65

Jan '87 :  51  Feb '87 :  58  Mar '87 :   0

Do you want to plot the sales data (Y/N) ? _
```

Figure A.35 Stock Sales History Menu

This program allows you to display the past twelve months' sales quantity of the stock item on the screen.

The sales quantity of any stock item in the current month is initially set to zero during the last month-end processing run. When a customer order is delivered, the ordered quantity is added to the current month's sales quantity. At the end of the month, this represents the current month's sales for the particular stock.

Do you want to plot the sales data (Y/N) ?

Answer "Y" to the above question if your system is capable of displaying graphics on the screen. Otherwise, answer "N" to clear the screen and enter another part number.

5. SALES FORECAST

```
15-05-1987              SALES FORECAST              PROG. : FORECAST
                        --------------

    This program will generate a forecast for a particular stock using its past
12 months' sales data.  There are a total of 6 models to choose from - 3 for
moving average and 3 for exponential smoothing.

    Quantitative measurements of accuracy are provided in these models,  they
are the mean square error (MSE), the mean absolute deviation (MAD), and the mean
absolute percentage error (MAPE).

          0. EXIT

          1. MOVING AVERAGE - Simple moving average
                            - Weighted ''      ''
                            - Double   ''      ''

          2. EXPONENTIAL SMOOTHING - Simple expon. smoothing
                                   - Double   ''      ''
                                   - Triple   ''      ''

             ENTER YOUR CHOICE ? _
```

Figure A.36 Sales Forecasting Program Menu

This program uses a product's past sales data as input and generates a forecast for any number of future periods specified by the user. The output result is tabulated on the screen, and also can be plotted graphically if the hardware system is equipped with a color graphics adapter.

There are altogether six forecasting models to choose from; three for the moving average and three for the exponential smoothing. The user should experiment with various models to determine the one that is best suited for the particular application.

Note: see the section on the forecasting model for more details - chapter four of this thesis.

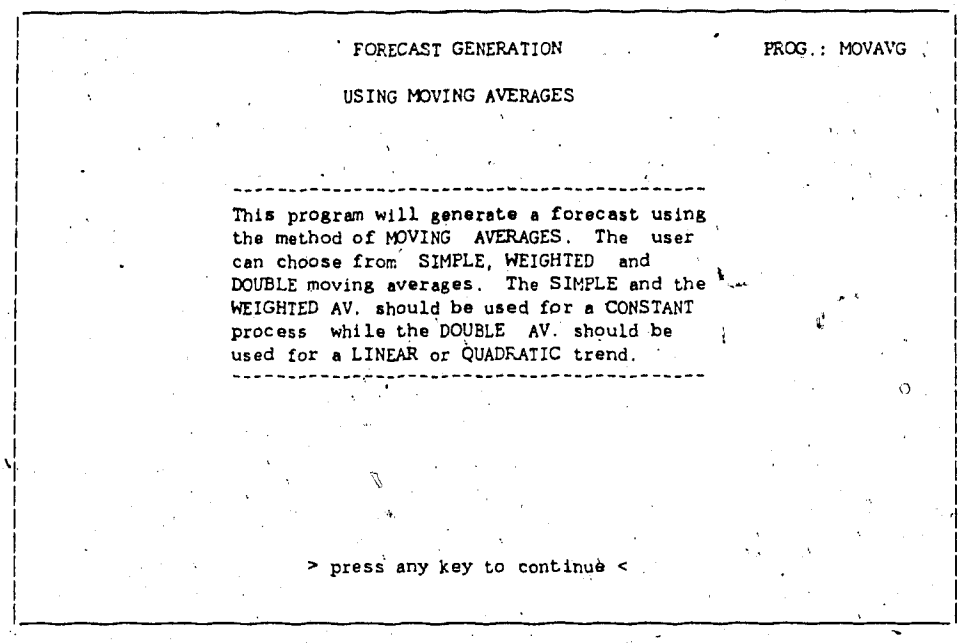


Figure A.37 Moving Average Forecast Menu

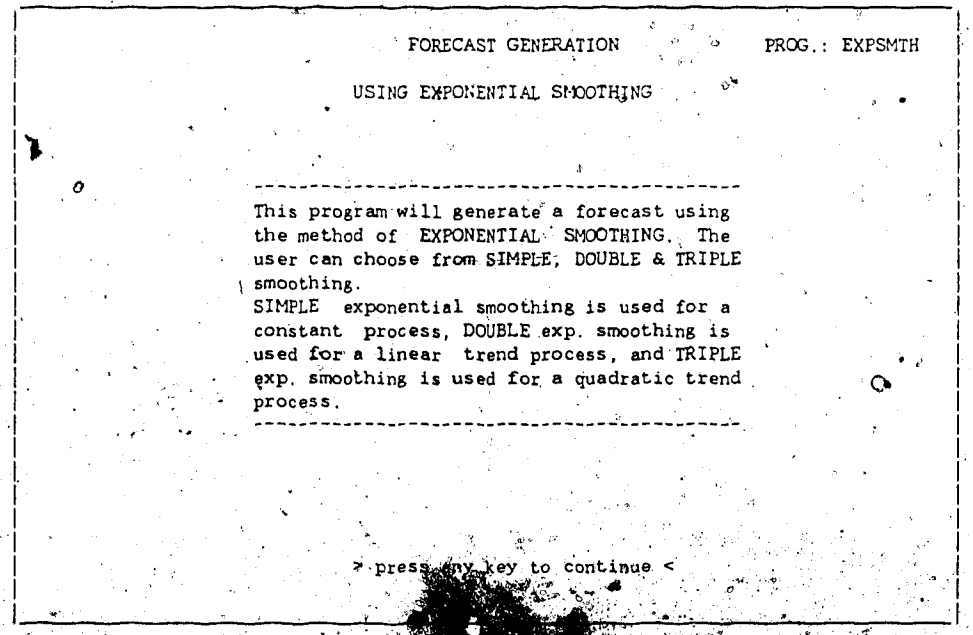


Figure A.38 Exponential Smoothing Forecast Menu

6. MONTH-END PROCESSING

```
15-05-1987                  MONTH-END PROCESSING                  PROG.: MONTHEND
                            -------------------

     This Month-End Processing program should be executed only once a month after
all the stock transactions for the current month have been entered and reports
printed.

     The main functions of the month-end processing program are as follows :

i)   Rebuild the Customer Order (CUSTODR.DAT) and the Reserved Stock
        (RESVED.DAT) files.
ii)  Rebuild the Purchase Order (PURCODR.DAT) and the On-ordered Stock
        (ONORD.DAT) files.
iii) If current month is Dec.(last month of the year), the current year's data
        in the Master Production Schedule (MPSCHED.DAT) file will be deleted
        and replaced by next year's new requirements.
iv)  Sales data in the Sales History (SALHIST.DAT) file will be rolled forward
        a month to make room for storing next month's sales figures.

IMPORTANT : All current month's transactions should have been entered before
            running this program ! Check also that the current date is in the
            CORRECT month for this Month-End Processing !

Have all the transactions for the current month been entered (Y/N) ? _
```

Figure A.39 Month-end Processing Program Menu

The main functions of this program are to delete unwanted records in the order files (both customer & purchase orders), reset the system date and roll forward the months in the sales history file.

(i) rebuild customer order and reserved stock file :

When a customer order is delivered, the records associated with the ordered quantity and reserved quantity are not deleted from the MRP data base immediately. The program only sets a flag (symbol "|") as the last character in the CUSNAM$ field in the order file. Also, a minus number (-2) is assigned to the field NXTREC$ in the reserved stock file to indicate that this record has been delivered.

During the process of rebuilding the customer order and reserved stock files, those records that have either

one of the above flags set will not be copied onto their corresponding new files. At the end, after all the records have been checked and copied, the old files will be deleted from the MRP data base and the rebuilt files will be renamed as the originals.

The sizes of the customer order and reserved stock files may be smaller than or equal to the original files before the month-end processing run. This depends on whether any of the customer order records have been delivered or deleted during the month. This could well be utilized as a check for data integrity.

Note: see also related sections in the customer order enquiry and customer order delivery programs.

(ii) rebuild purchase order and on-ordered stock file :

This part of the program works exactly the same as in part (i) except that it is used for rebuilding the purchase order and on-ordered stock files.

Note: see also related sections in the purchase order enquiry and purchase order receipt programs.

(iii) master production schedule (MPS) file updating :

The gross requirements quantity of the stock item for each week is stored in the master production schedule (MPS) file. There are altogether 15 quarters (4 week interval each) in the MPS file for each stock. Thirteen quarters are needed for the current year (52 weeks) and the last two are for next year's gross requirements (week #1 to 8).

Since the year will be increased by one after the month-end processing if the current month is December, the records in the MPS files will therefore, have to be updated accordingly.

The program does this by copying next year's gross requirements (quarter 14 and 15) as the requirements for

the 1st and 2nd quarter of the current year. The rest of the gross requirements in the MPS record will be set to zero. After the program resets the date (to Jan. 1st of next year) at the end of the run, this will represent the updated MPS file. The gross requirements in the 1st and 2nd quarters of the year can be interpreted as the requirements generated from last year's customer orders.

The MPS file will only be updated if the current month is December (last month of the year). Therefore, it is extremely important that the system has the correct date before running this month-end processing program.

Note: see also related sections in the master production schedule model - chapter five of the thesis.

(iv) sales history data updating :

Each sales history file record stores a 13 months' sales history data. They represent the past twelve months' and the current month's sales quantity of a particular stock item.

The system date is reset every time after running the month-end processing program, so is the current month , which increases by one. Therefore, the past 12 months' sales history records associated with each month is no longer correct and has to be updated. This is accomplished by rolling the sales figure in the sales history record forward by a month in order to reflect the month change.

As the files associated with the order processing programs and the sales history file will be updated after every month-end processing run, the program will first ask you to confirm,

Have all the transactions for the current month been entered (Y/N) ?

Answer "N" if you have not and the program will let you exit to the system menu. If you answer "Y", you will

be prompted again with,

Are you Ready for Month-End Processing (Y/N) ?

Answer "Y" will instruct the program to start the processing. Otherwise, "N" will allow you to exit the program and return to the system menu.

7. INITIAL SYSTEM DATA FILES SETUP

```
15-05-1987              INITIAL SYSTEM DATA FILES SETUP          PROG.: INISETUP
                        -------------------------------

    This program should only be used to create the initial data files when the
system is first installed. There will be 11 new empty files created on the
diskette with extension .DAT after the initialization.

The eleven data files are: Stock MasterA        - MASTERA
                           Stock MasterB        - MASTERB
                           Stock Index          - INDEX
                           Prod. Structure      - BOM
                           Master Prod.Schedule - MPSCHED
                           Material Req.Planng  - MRP
                           Stock Sales History  - SALHIST
                           Customer Order       - CUSTODR
                           Reserved Stock       - RESVED
                           Purchase Order       - PURCODR
                           On-ordered Stock     - ONORD

WARNING : RUNNING THIS PROGRAM WILL DESTROY ALL EXISTING MRP DATA FILES.

                  Are you sure this is what you want to do (Y/N) ? _
```

Figure A.40 MRP System Setup Program Menu

This program should be used only to create the initial MRP data base after the system is installed. Be certain that an empty diskette is placed in the data drive, otherwise all existing MRP data will be lost and replaced with empty data files.

The following is a brief description of each file in the MRP data base. The user should refer to appendix B for a detailed specification of each file record.

(i) MASTERA.DAT - This is the first part of the stock master file that stores the stock number and pointers to the BOM structure file.

(ii) MASTERB.DAT - This is the second part of the stock master file. It stores the rest of the stock details such as the description, unit cost, drawing number, etc. One of the reasons for dividing the stock master file into two parts is

the reduced access time with a shorter record length file.

(iii) INDEX.DAT - This index file points to the records in the stock master file. The stock number is used as the key for accessing the individual records. When searching for a particular stock number, this file is first read to find the closest index and then the search continues in the master file. An index is built for every 10th record during the stock creation program. Therefore, the maximum number of records that have to be read in order to locate a particular stock number is ten and the time needed should not be any longer than half a minute.

(iv) BOM.DAT - This is the product structure file that stores the parent/son relationships assigned to each product/component. The entire content of the file is made up of pointers that link to the master file. If the BOM structure program crashes while inputting the relationships, it is extremely difficult to recover the original file. Therefore, it is important to keep a backup copy of the master file and this file before you input a new parent/son relationships.

(v) MPSCHED.DAT - This is the master production schedule file. It stores the gross requirements quantity generated by the customer order program.

(vi) MRP.DAT - This is the material requirements planning file that stores the regenerated MRP matrix for the eight week planning horizon. The contents of the file can be displayed on the screen using the MRP matrix display program. The file is updated after every regeneration or net change processing run.

(vii) SALHIST.DAT - This file stores the past twelve months' sales quantity for each stock item. The details of each month's sales can be displayed on the screen using the sales history enquiry

program. The content of the file is rolled forward by a month in the month-end processing program.

(viii) CUSTODR.DAT - This file stores the details of each ordered stock item in the customer orders.

(ix) RESVED.DAT - The reserved quantity in this file is linked to the allocated stock quantity in the corresponding customer order. New records will be added only if there are new stock allocations. Therefore, the contents of this file may or may not change after additions or deletions of items in the customer order file.

(x) PURCODR.DAT - This is the purchase order file. It stores the details of each on-ordered stock item in the purchase orders.

(xi) ONORD.DAT - The on-order quantity of each stock item in the purchase order is linked to the quantity in this file. A new record is added for each new purchase order entered. Unlike the RESVED.DAT file, the contents of this file changes everytime after additions or deletions in the purchase order file.

8. REORGANIZATION OF DATA FILES

```
15-05-1987          REORGANIZATION OF DATA FILES          PROG.: REORGDAT
                    ----------------------------

     When there is a large amount of deletions and random insertions of stock
numbers into the MASTER file, the time required to access a particular stock may
increase significantly depending on the sizes of the MRP data files.

     This program is used to reorganize and rebuild the MASTER & other related
files for more efficient file handling.

     Due to the limited storage capacity (approx.360K btyes) of one diskette,
after the reorganization, the rebuilt data files will be written onto the
diskette placed in drive A and the diskette in drive B: will still contain the
data before the reorganization. This is a safeguard, even if the program
is interrupted during the reorganization process, the original data files will
remain intact and usable.

     Depending on the size of the data files, this reorganization might be quite
a lengthy process. So the question is asked,

                ARE YOU READY FOR THE REORGANIZATION (Y/N) ? _
```

Figure A.41 Data Reorganization Program Menu

After a large amount of random deletions and insertions of new stock numbers into the stock master file, the records in the file will not be in any order and pointers are needed to locate them sequentially. The time required to access a particular stock record may increase significantly. Also the keys used in the index file may be removed and not reassigned during the deletion process.

If you find system performance has deteriorated (e.g. more time is needed to locate a particular stock number, typically in excess of half a minute), this program should be run to reorganize the data base to improve the performance.

This program rebuilds the stock master and other related files in a sequential format. An index is generated for every 10th record in the master file. This may be quite a lengthy process, depending on the size of the data files. Typically, it can take up to an hour for a 500 stock item data file.

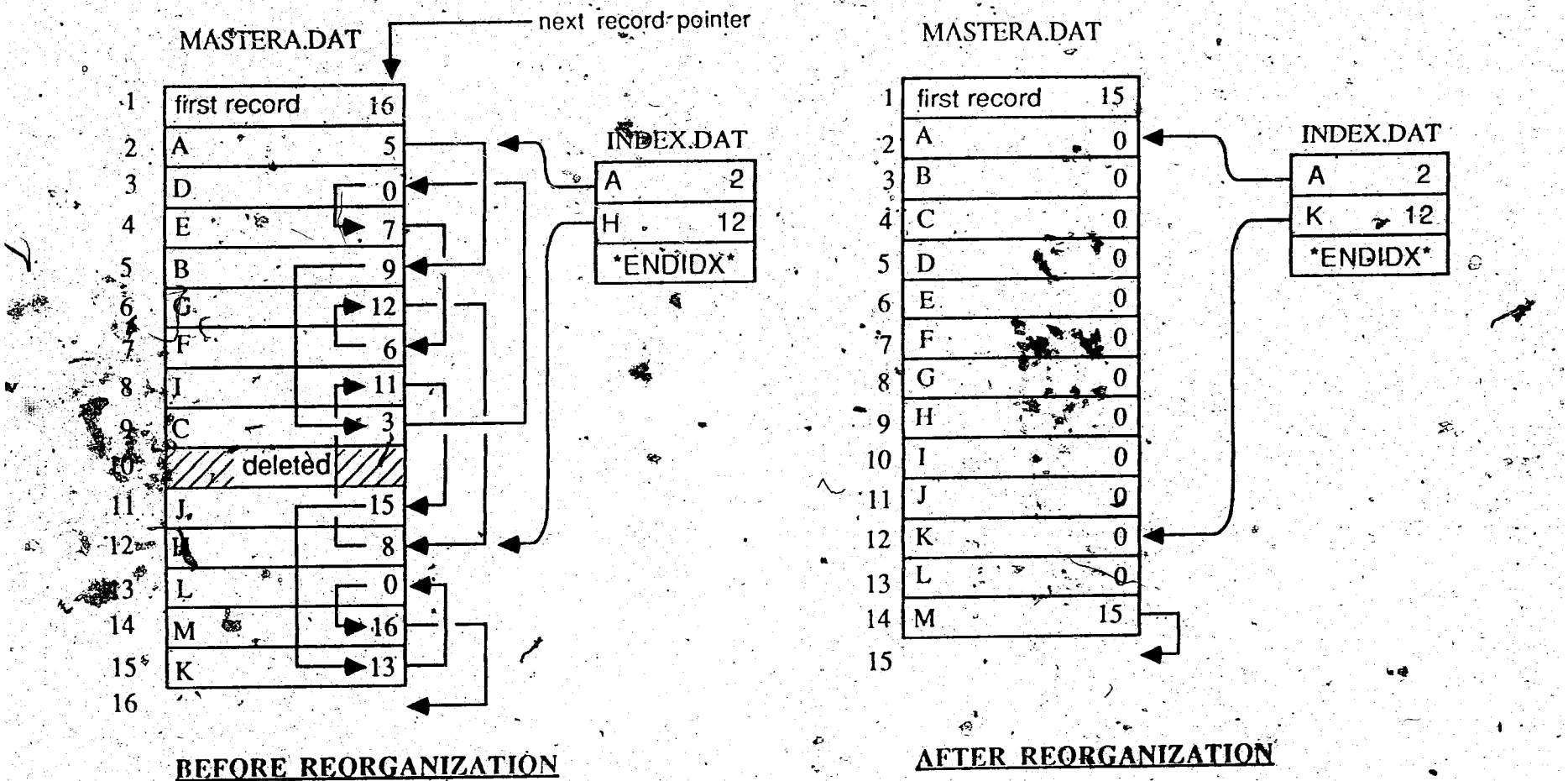


Figure A.42 Position of Stock Records Before and After Data Reorganization

9. CHAIN TO OTHER PROGRAMS

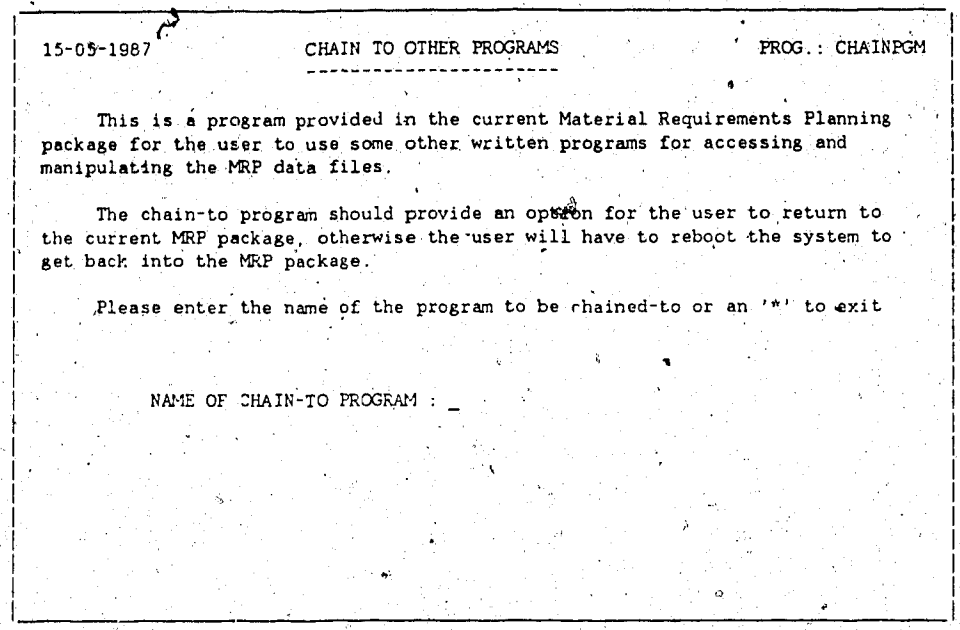


Figure A.43 Chain to Other Program Menu

This program provides a link from the MRP system data base to any other user-written routines. To run this program, remove the MRP system diskette from the default drive and replace it with the other user-program diskette. Type in the name of the program to be chained to and hit the <RETURN> key.

Note that it is up to the user-written programs to provide the necessary subroutines to access and manipulate the MRP data files. The program also should provide a means to return the system back to the MRP environment. Otherwise, you will have to bring up the MRP startup menu in order to return to the MRP software.

APPENDIX B

DATA RECORD FORMATS

MASTERA.DAT 173

MASTERB.DAT 173

INDEX.DAT 174

BOM.DAT 174

MRP.DAT 174

MPSCHED.DAT 175

SALHIST.DAT 175

CUSTODR.DAT 176

RESVED.DAT 176

PURCODR.DAT 177

ONORD.DAT 177

MASTERA.DAT : store part number and pointers to locate son & parent.

Position	No.of bytes	Field description	Variable
01-01	1	used/delete flag	FLAG$
02-09	8	part number	PARTNO$
10-11	2	pointer to locate 1st son	SONPTR$
12-13	2	ptr. to locate 1st parent	PARPTR$
14-15	2	level code	LVLCODE$
16-17	2	next record location	NXTREC$

Total =	17		

MASTERB.DAT : store details of each stock record.

Position	No.of bytes	Field description	Variable
01-30	30	part name	PARTNAME$
31-33	3	unit of measure	UOM$
34-37	4	unit cost	UCOST$
38-39	2	lead time	LTIME$
40-41	2	reorder level	ROL$
42-43	2	safety stock	SS$
44-45	2	qty on-hand	ONHDQTY$
46-47	2	qty reserved	RESVQTY$
48-49	2	qty on-order	ONORQTY$
50-51	2	Y-T-D rec'd	YTDRECD$
52-59	8	drawing no.	DWG$
60-61	2	not used	NOTU$

Total =	61		

INDEX.DAT : index file points to MASTERA.DAT.

Position	No.of bytes	Field description	Variable
01-08	8	part number index	PARTIX$
09-10	2	pointer to MASTERA.DAT	MASTPTR$.
Total =	10		

BOM.DAT : structure (son & parent) relationship.

Position	No.of bytes	Field description	Variable
01-02	2	pointer to locate son in MASTERA.DAT	PTRSON$
03-04	2	pointer to locate next son in BOM.DAT	NXTSON$
05-06	2	pointer to locate parent in MASTERA.DAT	PTRPAR$
07-08	2	pointer to locate next parent in BOM.DAT	NXTPAR$
09-12	4	qty req'd per assembly	QTY$
Total =	12		

MRP.DAT : MRP matrix for eight weeks planning horizon. Each period PER$ consist of 5 fields - GROSRQ$, SCHREC$, PRJAVL$, NETREQ$, PLNREL$.

Position	No.of bytes	Field description	Variable
01-10	10	1st period	PER1$
11-20	10	2nd period	PER2$
21-30	10	3rd period	PER3$
31-40	10	4th period	PER4$
41-50	10	5th period	PER5$
51-60	10	6th period	PER6$
61-70	10	7th period	PER7$
71-80	10	8th period	PER8$
Total =	80		

MPSCHED.DAT : Store the gross req'mt of the stock item in the master production schedule.
Each Quarter Q$ store req'mt for four consecutive weeks.

Position	No.of bytes	Field description	Variable
01-08	8	1st quarter, week 1- 4	Q1$
09-16	8	2nd " " , " 5- 8	Q2$
17-24	8	3nd " " , " 9-12	Q3$
25-32	8	4th " " , " 13-16	Q4$
33-40	8	5th " " , " 17-20	Q5$
41-48	8	6th " " , " 21-24	Q6$
49-56	8	7th " " , " 25-28	Q7$
57-64	8	8th " " , " 29-32	Q8$
65-72	8	9th " " , " 33-36.	Q9$
73-80	8	10th " " , " 37-40	Q10$
81-88	8	11th " " , " 41-44	Q11$
89-96	8	12th " " , " 45-48	Q12$
97-104	8	13th " " , " 49-52	Q13$
105-112	8	1st qtr, nxt.yr,wk 1- 4	Q14$
113-120	8	2nd qtr, nxt.yr,wk 5- 8	Q15$

Total =	120		

SALHIST.DAT : Store the monthly sales history figures.

Position	No.of bytes	Field description	Variable
01-02	2	current month of last year	M1$
03-04	2	curr month +1 of last year	M2$
05-06	2	" " +2 " " "	M3$
07-08	2	" " +3 " " "	M4$
09-10	2	" " +4 " " "	M5$
11-12	2	" " +5 " " "	M6$
13-14	2	" " +6 " " "	M7$
15-16	2	" " +7 " " "	M8$
17-18	2	" " +8 " " "	M9$
19-20	2	" " +9 " " "	M10$
21-22	2	" " +10 " " "	M11$
23-24	2	last month of current year	M12$
25-26	2	curr month +1 of this year	M13$

Total =	26		

CUSTODR.DAT : store the item details of customer orders.

Position	No.of bytes	Field description	Variable
01-02	2	next item location	NXTITM$
03-08	6	order number	ORDRNO$
09-16	8	order date DD/MM/YY	ORDATE$
17-24	8	due date DD/MM/YY	DUDATE$
25-44	20	customer name	CUSNAM$
45-46	2	ordered qty	ORDQTY$
47-48	2	allocated qty	ALCQTY$
49-56	8	stock number	PRTNUM$
57-60	4	unit price	UPRICE$
Total =	60		

RESVED.DAT : store reserved stock item details.

Position	No.of bytes	Field description	Variable
01-02	2	next reserved stock	NXTRES$
03-10	8	reserved stock no.	RESPART$
11-12	2	reserved qty	RESQTY$
13-18	6	order number	RESORDR$
19-26	8	due date DD/MM/YY	RESDATE$
27-46	20	customer name	RESNAME$
Total =	46		

PURCODR.DAT : store the item details of purchase orders.

Position	No.of bytes	Field description	Variable
01-02	2	next item location	NXTPUR$
03-08	6	order number	PURNO$
09-16	8	order date DD/MM/YY	PURDATE$
17-24	8	delvry date DD/MM/YY	DVDATE$
25-44	20	supplier name	SUPNAM$
45-46	2	ordered qty	PURQTY$
47-54	8	stock number	PRTPUR$
55-58	4	purchase price	PPRICE$
Total =	58		

ONORD.DAT : store on-ordered stock item details.

Position	No.of bytes	Field description	Variable
01-02	2	next on-ordered stock	NXTONO$
03-10	8	on-ordered stock no.	ONOPART$
11-12	2	on-ordered qty	ONOQTY$
13-18	6	order number	ONOORDR$
19-26	8	delvry date DD/MM/YY	ONODATE$
27-46	20	supplier name	ONONAME$
Total =	46		