THE DEVELOPMENT AND APPLICATION OF AN INTERACTIVE MATERIAL REQUIREMENTS PLANNING MODEL

THESIS SUBMITTED BY

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FOR THE DEGREE OF MASTER OF PHILOSOPHY

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SUMMARY

This thesis describes the development of the material requirements planning package called MARPLA, supplies information on the operation of the package and provides a set of practical exercises to be solved using the package in order to demonstrate the application of the material requirements planning technique in manufacturing inventories.

The package is programmed in BASIC language and is designed to be used on a Hewlett-Packard Access 2000 machine, occupying about 304 records of storage. MARPLA is a fully interactive package which does not require computing knowledge for its use.

MARPLA allows the user to generate time-phased net requirements and to develop a planned batch schedule for all component items of one or multiple end-products. In addition to this, the package performs the following functions:

(1) Explosion of the bill of material for the end-products.

(2) Calculation of gross requirements of each component per unit of end-product.

(3) Analysis of inventory costs if inventory cost data are supplied to the package.

(4) Re-generation of the overall requirements plan moving forward period-by-period in the planning horizon.

MARPLA has been designed mainly as a teaching aid for those students wishing to examine with some depth the planning and controlling functions of a material requirements planning system. In addition to the educational role of the package, the following applications can be considered:

(1) as a research tool to investigate decision making techniques concerning the use of safety stock, safety time and the selection of batching rules.

(2) as a practical instrument to be used by companies contemplating the installation of an MRP system that wish to carry out preliminary analyses of the applicability of material requirements planning to control their inventories.

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KEY WORDS: Requirements Planning - Safety stock - Batching

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CHAPTER 1

INTRODUCTION

In a manufacturing environment, inventory management is mainly concerned with generating information for ordering raw materials and components in order to satisfy the demand for finished products.

The material manager is faced with two fundamental questions :

1. How much to order ?
2. When to order ?

A change in the way of answering these questions occurred with the advent of digital computers. In the pre-computer era, the "how much" question was concerned with lot-sizing. All sorts of techniques based on economic order quantities (EOQ) used to solve the replenishment problem in industry, that is, to provide the materials and components required by production in the right quantities, at the right place and at the right time. However, the EOQ formula turned out to give an ineffective ordering quantity in the manufacturing environment, mainly because it assumes, first, that the demand is fairly uniform, and second, that the inventory usage per unit time is relatively small. Furthermore, the EOQ formula does not specify the timing of actual demands originated during the period it intends to cover, that is, from its arrival into stock until the next order is received.

When computers became available that were capable of processing vast amounts of data, new approaches for performing the replenishment task were developed in order to overcome the limitations imposed by the traditional inventory management techniques. Those new methods have become known as material requirements planning (MRP) systems. Since their first applications, in the 1960's, in the manufacturing industry, users have reduced their inventories and their delivery delays.

MRP systems place more emphasis on the "when" aspect of manufacturing inventory management than on the "how much" question. The timing of actions that are dependent, such as, providing semifinished components that go into assemblies, which then go into the end-product, is given more importance than the decisions on the quantities required. As a consequence, lot-sizing receives much less attention that getting the right material, to the right place, at the right time.

Manufacturing inventory management is directly related to production planning. A manufacturing inventory system has the function of translating the plan of production (the master production schedule) into component material requirements and the corresponding orders. Therefore, it decides upon purchasing and manufacturing activities and suggests the plant capacity required.

A material requirements planning system is defined by Dr. J.A. Orlicky (1) as a "set of logically related procedures, decision rules and records designed to translate a master production schedule into time-phased net requirements, and the planned coverage of such requirements, for each component inventory item needed to implement this schedule". Time-phased requirements planning not only determines when an order for a given component item should be placed, but also keeps rechecking to see when open orders are actually needed.

The range of application of time-phased requirements planning is very wide, since they can be used in managing manufacturing inventories, as well as, distribution inventories.

1.1. Types of business inventory

When choosing the most suitable system for planning and controlling business inventories, it is essential to distinguish between distribution and manufacturing inventories, since they differ considerably in their attributes, and therefore, in their requirements for a determined inventory control method.

A distribution inventory consists of end-products and service-parts, which are mainly produced to meet customer demand. The demand for each inventory item comes from different sources and is subject to uncertainty due to the fact that it must be forecast.

On the other hand, a manufacturing inventory consists of raw materials, component parts and subassemblies. The function of a manufacturing inventory is to meet its unique source of demand: the production plan, which is predictable.

While in distribution inventories, the demand must be forecast at the item level, which introduces uncertainty at this level, in manufacturing inventories, the demand for each inventory item is calculable, and therefore, uncertainty only exists at the end-product level.

The answers to the questions "how much" and "when" to order differ according to the type of inventory involved. In a distribution inventory, the economic order quantity formula answers the "how much" question, but there is no a certain answer to the "when" question. In a manufacturing inventory, both questions can be answered with certainty: order as much as it is required to satisfy the master production schedule in a planning period, and only when it is required.

A distribution inventory may be managed successfully by applying a convenient reorder point technique, but the effective planning and controlling of a manufacturing inventory definitely demands the use of material requirements planning. This is mainly due to the characteristics of the demand of the items involved in each kind of inventory, which will be discussed in the next section.

1.2. Independent and dependent demand

The selection of a determined inventory management technique depends, in the first place, on the nature of the demand of the items involved. An inventory item may be subject to dependent demand, to independent demand, or to both types of demand at the same time. The concept of independent and dependent demand was defined in 1965 by Dr. Joseph A. Orlicky (1).

An inventory item is subject to independent demand when such demand is not related to the demand for other items. This is the case of the items involved in a distribution inventory - finished products and service parts - and, as it was mentioned earlier, this kind of demand must be forecast.

On the other hand, the demand for a given inventory item is considered dependent when such demand is directly related to the demand for other items, or products. Raw materials, component parts, subassemblies - anything used to make something else - is subject to dependent demand. The relationship between dependent items is given by the successive manufacturing stages, whereby raw material is converted into semi-finished part, this is then converted into component-part, and so on, up to the assembly level, each of them representing a well defined inventory item. The demand for each of those items need not be forecast separately, it can be calculated from the demand for higher-level items. Then, in manufacturing inventories, forecasting is only applied at the end-product level.

In some cases, a given item is subject to both dependent and independent demand, as for example, a component item that is used in a determined manufacturing process as well as a service part. Such mixed demand is obtained by adding the dependent demand, which is calculable, to the independent demand, which must be forecast.

Once the nature of the demand for the inventory items involved has been determined, the next step is to select the inventory planning and controlling method that will give better results.

1.3. Methods for managing inventories

Two basic approaches for performing the replenishment task have been developed. They are:

(i) Statistical Inventory Control (SIC), also called Order Point techniques.

(ii) Material Requirements Planning.

Under the order point approach, the future demand pattern for each inventory item has to be determined by means of a forecast based on past usage. The uncertainty in the demand creates the need for a continuous physical availability of all inventory items . Thus, a replenishment order is placed whenever the supply of an inventory item drops to a predetermined quantity (known as reorder level). This quantity depends on the forecast demand over the replenishment lead time and the probability that the actual demand exceeds the forecast. A safety stock is sometimes incorporated into the reorder level quantity to compensate for the forecast error.

An order point system determines the size of the replenishment order for each inventory item separately, by means of the economic order quantity formula.

Conversely, a material requirements planning system calculates the requirements for each component inventory item according to the relationship of the components that make up the end-product. This calculation is based on the master production schedule that may itself be based on a forecast.

Under the MRP approach, the master production schedule for the end-product is translated into time-phased net requirements and the planned coverage of such requirements. The planned order release generates material requirements for component items at the lower levels and, as requirements or inventory availability change, these planned orders are rescheduled by the system, thus changing requirements at lower levels.

1.4. Comparison of SIC and MRP

Two main elements determines the basic differences between an SIC system and an MRP system. They are:

(i) the data required by the system, that is, quantity exclusively or quantity and time;

(ii) component demand, which may be forecast or calculated.

Having in mind these two elements, the differences between SIC and MRP can be summarized as follows:

(1) SIC only determines the order size. The economic order quantity formula is insensitive to the timing of actual demands arising during the period the EOQ is supposed to cover following its delivery into stock. MRP systems determine both, the quantity and the timing of the orders generated to cover the requirements.

(2) SIC gives all the inventory components the same treatment, assuming that each item is independent of all other items. SIC forecats the demand for each component item separately and, as a consequence, uncertainty exists at component level. MRP distinguishes between items subject to independent demand (i.e. end-products and service parts) and items for which the demand is dependent (i.e. raw materials, components, subassemblies). Forecasting takes place at the end-product level and uncertainty only exists at that level. The demand for component items is calculated according to the dependence between them in the product structure.

(3) SIC assumes uniform demand and gradual rate of inventory usage. The pattern of the demand is derived from the analysis of historical data. MRP looks into the future on a part-by-part basis, adapting itself to any pattern of demand.

(4) SIC models can reduce investments only by lowering service levels, whereas MRP systems reduce inventory investment

without decreasing the service levels.

(5) SIC systems are designed for managing inventories only, while MRP systems integrate the control of inventories and production processes, and provide information for other functions, such as, capacity planning, priority planning and performance control.

(6) SIC models require much less data handling and processing than MRP models.

1.5. Limitations of SIC models

Traditional statistical inventory control techniques have been highly successful when applied to finished products or any other item for which demand is independent. However, in a typical manufacturing inventory there are more dependent items in inventory than there are independent ones and, as it was mentioned earlier, SIC models treat all inventory items as if they were independent. Because component items are ordered independently to each other, their inventories do not match assembly requirements well.

Furthermore, under the SIC approach, individual forecast errors of the component items required to make up a determined product are added up, and consequently, the cumulative service level of the finished product is considerably lower than the service level of each component item. The common approach to raise the service level of the finished product is to raise the service level of the component items by increasing their order points. However, this approach results in higher average inventory levels for all components which, in turn, implies higher inventory expenses.

Many SIC models assume stable demand patterns and gradual inventory depletion. However, component items in a manufacturing inventory are subject to dis-continuous and non-uniform demand, and inventory depletion tends to be in discrete quantitites of variable size. This is shown in Figure 1.1 : when the stock-on-hand of the end-product equals or falls below the reorder level, an order is placed to produce a quantity of it, which will reduce the inventory of the component items in one sudden "jump". In the case that the inventory of the component items drops at its reorder point, a large depletion of the raw material inventory will take place as it is shown in Figure 1.1.

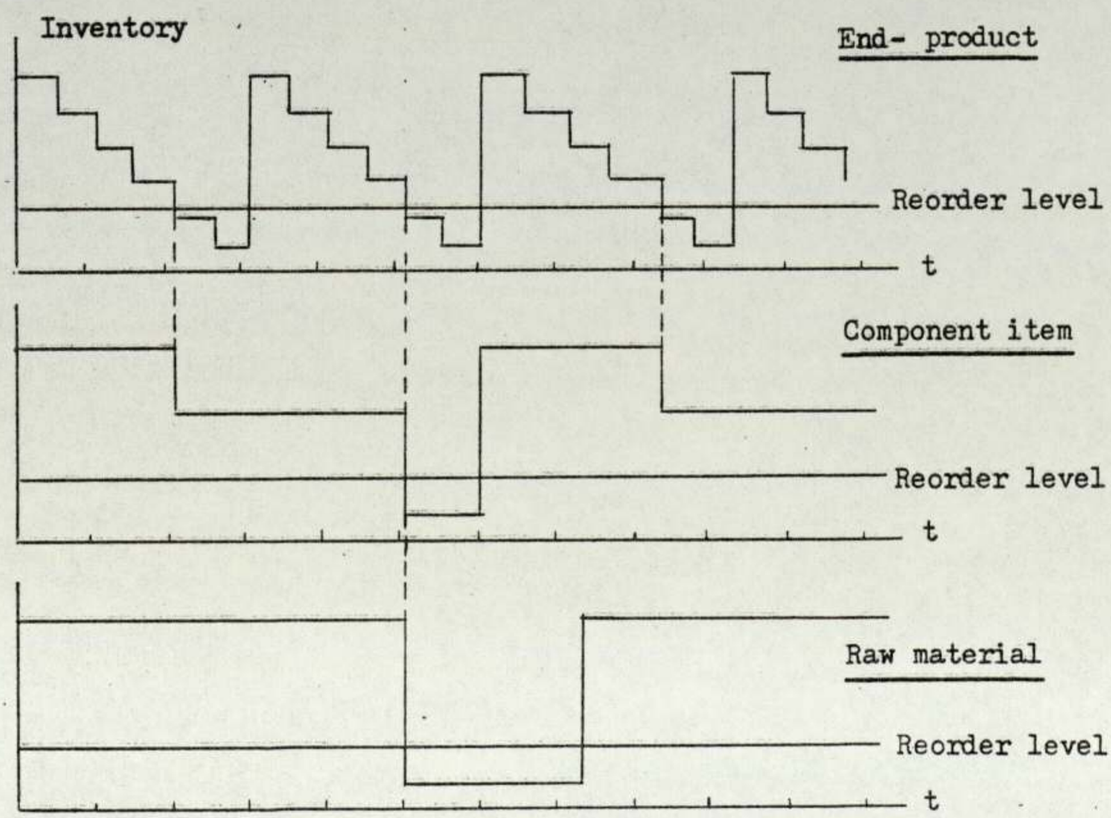


Figure 1.1. Reorder point and dependent demand

From the example in Figure 1.1, it is clear that for items with dependent demand, the use of order point techniques, which assume that it is convenient to have some stock-on-hand at all times, and to replenish inventory as soon as it drops at its reorder level, is undesirable if inventory level is to be kept low.

Having analysed the main limitations of SIC models in a manufacturing environment, it can be stated that while distribution inventories may be controlled by SIC techniques, manufacturing inventories should be controlled by MRP systems, since such systems have been designed to handle dependent demand, and most items in manufacturing inventories do have dependent demand.

Even though material requirements planning models were developed for controlling the inventories of dependent demand items, they can easily accomodate independent demand items, and therefore, can be extended to distribution inventories.

For many years, order point systems were used where MRP should have worked better, and so the results were unsatisfactory. Today, with tha availability of large computers, many industrial companies have installed an MRP system, and others are planning to do so.

CHAPTER 2

MATERIAL REQUIREMENTS PLANNING SYSTEMS

The overall manufacturing management function can be represented by a closed loop system constituted by four main components:

(1) Manufacturing management planning system. This system is in charge of processing customer orders and forecasting and planning the demand for finished products so that a general production plan can be developed. This plan is then translated into a specific master production schedule.

(2) Inventory management system. This system translates master production schedule for finished products into detailed requirements for all assemblies, components and materials that make up the products. The main outputs of the Inventory management system are the specifications in terms of quantity and timing of the manufacturing and purchasing orders for the items required to satisfy the master production schedules for the end-products.

(3) Operations management system. The function of this system is to ensure correct inventory order action and to report to the Manufacturing management system any change in the order schedules that may imply replanning at the

finished product level.

(4) Engineering data management system. This system supplies information on the bills of material, manufacturing routines and inventory parameters such as lead times and safety stocks, to all the other management systems. The accuracy of the data contained in the Engineering data management system is vital for the implementation of the whole management system.

A diagram of the overall manufacturing management system showing its major components and their relationships is given in Figure 2.1.

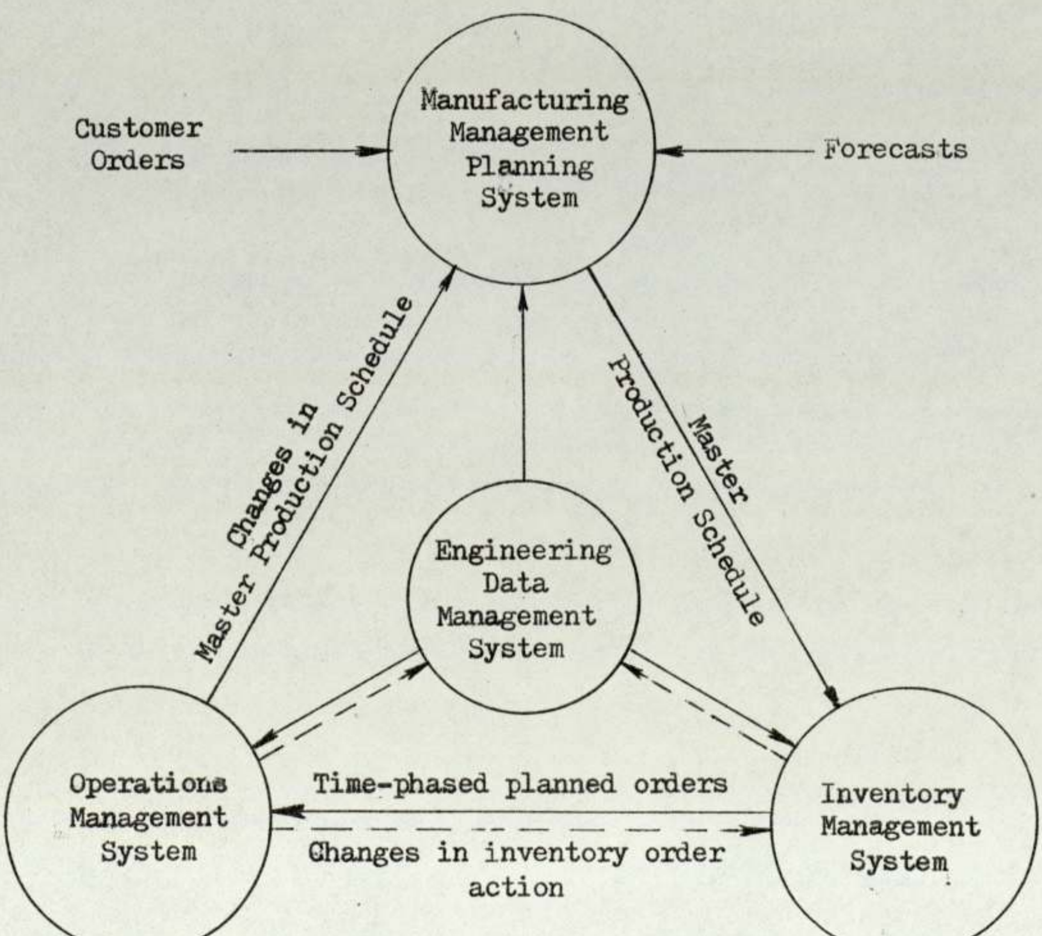


Figure 2.1. Manufacturing Management System

Material requirements planning systems play an important role within the manufacturing management system because they carry out the functions of both, the inventory and the operations management systems.

Material requirements planning systems can be defined as a set of procedures and decision rules designed to translate master production schedules for end-products into detail requirements for all inventory items that make up the end-products and, to generate and maintain correct inventory order action to cover those requirements. MRP systems can be used effectively to both plan and control production and material flow.

The logic of material requirements planning is based on the fact that the demand for materials, parts and components depends on the demand for end-products. Applying this principle of dependency of the demand, MRP systems calculate gross requirements for each inventory item and then allocate existing inventories (stock-on-hand and stock-on-order) against gross requirements in order to obtain net requirements. The net requirements are then translated into time-phased planned orders, and this information is used for future manufacturing and purchasing order action. Furthermore, MRP systems have the ability of replanning net requirements and re-evaluating the timing of planned order releases in order to cope with changes in the master production schedule, the inventory status or the product design.

Although the basic logic of MRP is simple, most systems are computerised for reasons of speed and efficiency. Rapid computation is needed to explode parts requirements from a master production schedule while simultaneously referencing inventory files to check stock status and lead times, and to keep the entire plan up to date in spite of late material arrivals and broken schedules.

If the computational power is available, the MRP logic linked with the appropriate data results in a manufacturing planning and control system whose objectives are inventory minimization and delivery schedule maintenance.

2.1. Requisites for material requirements planning systems

The basic logic of material requirements planning is applicable to the majority of the manufacturing systems, but its successful implementation is intimately related to the existence of certain requisites which should be carefully reviewed when considering the installation of an MRP system. These requisites are:

(1) The availability of a master production schedule which indicates how much and when end-products should be assembled so that customer orders or finished goods inventory requirements can be met.

(2) The availability of a bill of material which defines, in terms of part numbers, the structural relationships

between the parts and their components that make up an end-product.

(3) The availability of an inventory record file which contains descriptive information about each item such as current inventory levels, manufacturing and purchasing lead times, safety stocks, inventory costs, etc.

(4) The existence of a coding system which assigns a unique code-number (or part-number) to each inventory item so that each item can be clearly identified by its code-number for requirements planning purposes.

2.2. Assumptions of material requirements planning

The applicability of a standard material requirements planning system to production and inventory planning and controlling in a manufacturing business is conditioned by certain assumptions implicit in the correct performance of the system. However, in cases where some of the mentioned requisites or some assumptions do not exist, a non-standard version of the MRP system can be designed in order to adapt the system to the characteristics of the manufacturing environment. In general, material requirements planning is applicable in situations where the following assumptions are present:

(a) Accuracy in the data files.

The successful operation of an MRP system depends entirely on the grade of accuracy of the data contained in the bill of material and inventory record files. Even a very sophisticated MRP system will have little chance of success unless the data in the files are maintained accurate and up to date. If, for example, the opening stock figures are incorrect, then all the planning will be invalid, giving distorted priorities which will cause confusion on the shop floor and lack of credibility in the system. Top management must have a total commitment towards maintaining data accuracy and correct the causes of any error affecting the integrity of the data.

(b) "On-hand" condition of every inventory item.

MRP systems are based on the assumption that every inventory item is recorded as stock-on-hand before it is used in the production process as a result of an order placed for that item.

(c) Independency in the production processes.

A third assumption implicit in the logic of material requirements planning is that a manufacturing order for any inventory item can be totally completed independently of the existence of an order for any other item.

(d) Discrete usage of inventory items.

The standard MRP system assumes that the exact quantity of items corresponding to each planned order can be disbursed from the stockroom and used in the production process.

(e) Availability of all components on releasing assembly planned orders.

MRP systems assume that when an assembly planned order is released, all components required for the production of that assembly are available for their use.

(f) Availability of lead time data for each inventory item.

Finally, MRP systems assume that the lead time duration of each inventory item is known and can be supplied to the system as a fixed value. This information should be updated whenever the actual lead time differs from the value input into the system.

Having discussed the requisites and assumptions underlying the application of material requirements planning it can be stated that almost all manufacturing companies capable of developing a realistic master production schedule in terms of finished products can instal and implement an MRP system for the effective planning and controlling of the production and inventory.

It is the master production schedule that dictates how much and when the finished goods are needed, so that the MRP system takes this information and together with the data contained in the bill of material and inventory record files carries out the requirements generation process for all items in levels below the end-product. The master production schedule drives the MRP system and, consequently, the entire production and inventory management system.

2.3. Material requirements planning system inputs

Many versions of MRP systems have been developed which differ basically in the scope of the planning horizon they cover, in the size of the planning periods and, in the method and frequency of replanning. However, these different versions have common inputs and outputs, which are shown in Figure 2.2.

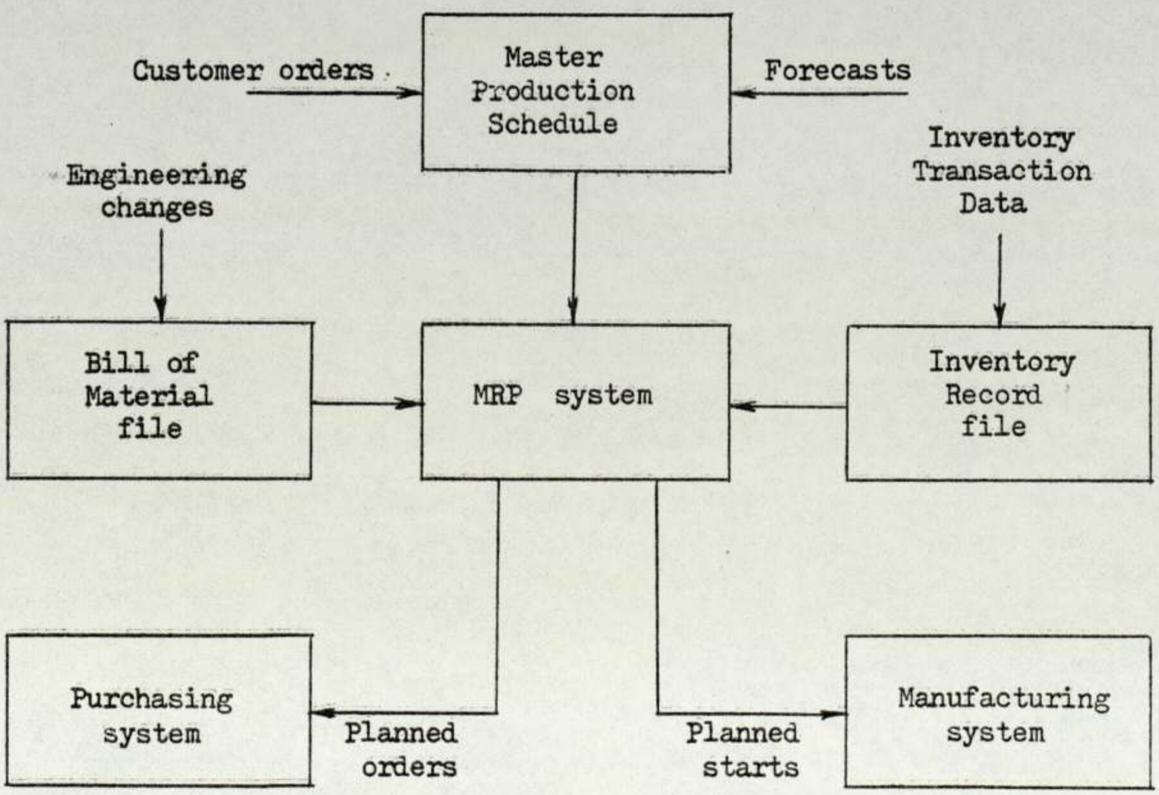


Figure 2.2. Inputs and outputs of MRP systems

The sources of MRP system inputs are:

2.3.1. The master production schedule.

The prime input to material requirements planning systems is the master production schedule, which is a time-phased statement of all production demands at the finished product level. The production plan precedes the master production schedule. The production plan, based on customer orders and forecast of the demand for the end-products, establishes production rates and resources required to meet the sales plan and the inventory plan. The master production schedule breaks down the production plan into more specific details (e.g. monthly production planning rates into weekly rates) based on product mix, models, material and capacity availability, all within planning time limits.

The master production schedule is used by the MRP system as a guide to generate requirements for those components needed to produce the end-products specified in the schedule. The master production schedule establishes the quantity of the end-product that should be produced and also, when it is needed. Figure 2.3 shows the master production schedule for an end-product, which indicates that 300 units are to be produced in week 2, 500 in week 3, 400 in week 5 and 600 units in week 7.

Week	1	2	3	4	5	6	7
Master Production Schedule		300	500		400		600

Figure 2.3. Master Production Schedule

The span of time the master production schedule covers is called the planning horizon, which should be at least as long as the longest composite lead time.The front of the master production schedule horizon is a fairly precise statement of what is going to be produced, since it is mainly based on actual customer orders. Far out in the future, the schedule is usually a forecast of anticipated production used as the basis of long-range capacity planning. As actual customer orders arrive, actual known demand replaces forecasts.

Realistic master production schedules that provide the best compromise between what marketing wants and what manufacturing can produce,are essential for the success of any MRP system. Overstated schedules only result in confused priorities due to large amounts of back-log orders that are continuously incorporated into the next period in the mistaken belief that they could be completed the next time. The master production schedule should be the best possible approximation of what actually will be produced, based on planned capacity, and it should have the approval and commitment by top management from all departemnts.

2.3.2. The bill of material file.

The bill of material file - also called product structure record - defines the structural relationships between the component items that make up an end-product. This file is used by the MRP system to generate gross requirements down through the product structure.

The bill of material file identifies each inventory item by its corresponding code- or part-number, which, therefore, must be unique for each item.

The bill of material reflects the method of production from raw materials to end-product. For each assembly, the bill of material lists its immediate "component" items and the quantity of each component required per unit of assembly. The assembly in question is referred to as "parent" item. The same information is listed for subassemblies and part items. Figure 2.4 shows the graphic representation of a bill of material file.

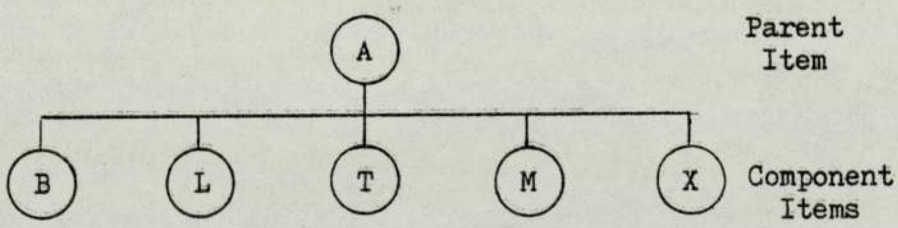


Figure 2.4. Bill of material representation

The bill of material defines product structure in terms of product levels, which represent the material conversion stages in the manufacturing process, from raw materials up to finished products. Each production stage is equivalent to a product level in the bill of material. By convention, levels are numbered from top to bottom, as shown in Figure 2.5.

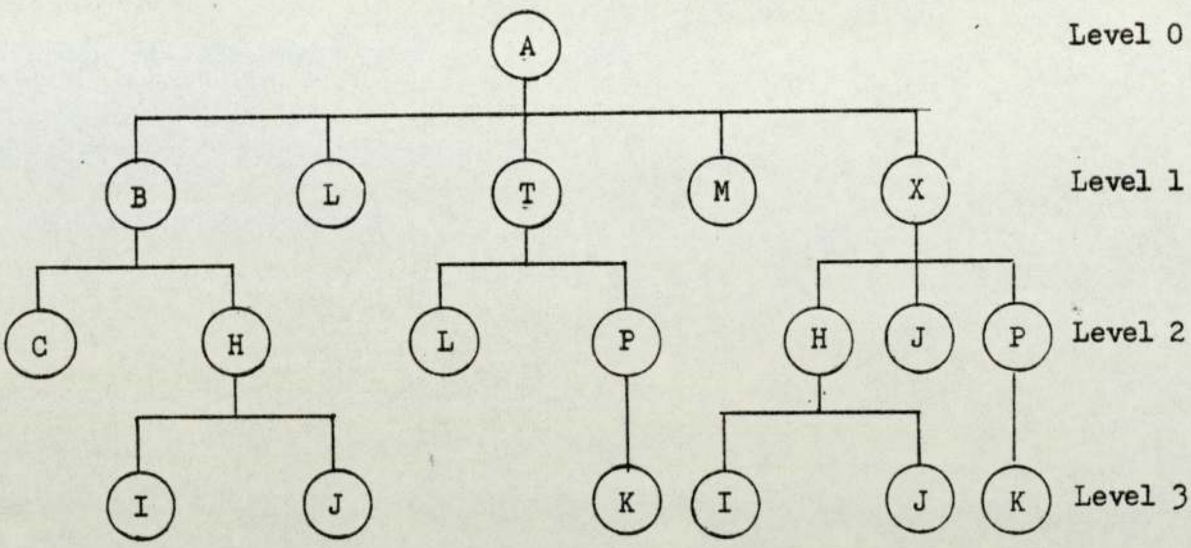


Figure 2.5. Levels of the bill of material

A high level of accuracy should be maintained in the bill of material file, since this file forms a major part of the foundations from which all the planning is carried out. Therefore, any change in the product design should be informed inmediately to this file.

2.3.3. The inventory record file.

The inventory record file or part master record file contains information on current inventory levels (stock-on-hand) of each inventory item. Any change in the status of the items as a result of an inventory transaction (e.g. disbursement, stock receipt) should be reported to the system, in order to maintain up to date the corresponding item inventory record.

The inventory record file contains descriptive information about each item, such as, lead times, lot-sizing methods, inventory costs and safety stocks. The information available in the inventory record file, together with the bill of material file, provides the framework for material requirements planning.

2.3.4. Independent demand for component items

Component items that are used in the current production process, and also as service parts, are subject to both dependent and independent demand. The dependent portion of the demand is generated internally by the MRP system in terms of gross requirements, whereas the independent portion is added to the calculated gross requirements for the component item in question. The independent demand for service-items is either forecast or determined from customer orders.

2.4. Material Requirements Planning Systems

The main function of an MRP system is to calculate gross requirements and their planned coverage for all component items that make up an end-product. Even though several versions of MRP systems have been developed, there is a basic logical procedure common to all those versions. Such procedure is, in general, as follows: an MRP system takes the master production schedule for a given end-product, looks up the bill of material file in order to determine what component items and/or raw materials are required to manufacture the end-product in question and then, examines the corresponding inventory record file to see if the material is on-hand. If the material is not on-hand, the system informs the inventory controller of the need of placing an order for an specified quantity of the material and also, tells the controller when the order will be needed. On the other hand, if the material is already on order, the system revaluates the due dates of the orders and communicates the inventory controller if the due dates need to be changed. In this way, an MRP model can easily predict shortages of material with enough time to prevent them.

MRP systems are reactive, they have an important built-in capacity to reschedule open orders when a change in the master production schedule or the inventory status takes place .

The processing logic of material requirements planning can be divided, for description purposes, in three basic stages:

(1) The netting process
(2) The offseting for lead time process
(3) The explosion of requirements process

2.4.1. The netting process

The logical procedure by which MRP models generate gross and net requirements is based on the relationships between parent items and their respective component items. Such information is contained in the bill of material file of the system. Requirements are computed from higher-level items to lower-level items, starting with the end-product.

Figure 2.6 shows the standard format of displaying time-phased gross requirements. The planning horizon is divided into planning periods, which represent days, weeks, months or any convenient unit of time. When the planning period is longer than a single day, it is necessary to specify the meaning of the timing of the data in relation to the period. That is, the inventory controller should establish whether the events assigned to the periods (e.g. release date of a planned start or completion date of an open order) will take place on the first day, the last day or the mid-point of the period, since the offseting for lead time process varies according to the chosen time convention.

Period	1	2	3	4	5	6	7
Gross Requirements	50		90		60	70	

Figure 2.6. Time-phased gross requirements

The logic of the netting process involves three different elements, all of them associated with timing information. They are:

(i) Gross requirements for component items, which represent the quantity required of a given component item to cover the order of its parent item. When a component item is common to various parent items, its gross requirements are computed by adding up, in each planning period, the requirements from all its parent items. At the end-product level, gross requirements are associated to the master production schadule.

(ii) Scheduled receipts (or open orders) for component items and for the end-product, which represent material already on order and scheduled to come in a predetermined date.

(iii) Stock-on-hand of each component item and of the end-product, which is the actual quantity of the item stored in the stockroom.

The stock-on-hand of each item varies whenever material is disbursed (i.e. material is used to satisfy gross requirements) or material is received into stock (i.e. a scheduled receipt for a given material is completed).

The stock-on-hand of each item, in each planning period, is calculated as follows:

$$\begin{pmatrix}\text{Stock-on-hand}\\ \text{in period i}\end{pmatrix} = \begin{pmatrix}\text{Stock-on-hand}\\ \text{in period i-1}\end{pmatrix} + \begin{pmatrix}\text{Scheduled receipts}\\ \text{in period i}\end{pmatrix} - \begin{pmatrix}\text{Gross require's}\\ \text{in period i}\end{pmatrix}$$

Figure 2.7 shows, in time-phased format, the computed values of the stock-on-hand in each planning period throughout the planning horizon.

Periods	1	2	3	4	5	6	7
Gross requirements	50		90		60	70	
Stock-on-hand 100	50	50	-40	60	0	-70	0
Scheduled receipts				60			

Figure 2.7. Computation of stock-on-hand values

For example, in period 3, the stock-on-hand is calculated as follows:

Stock-on-hand at the end of period 2:	50	
Scheduled receipts in period 3:	0	50
Gross requirements in period 3:		-90
Stock-on-hand at the end of period 3:		-40

A positive value of stock-on-hand indicates the quantity available to cover future gross requirements. A negative value indicates that there is not enough material to cover gross requirements in the period in question and therefore, there is a net requirement for the quantity indicated by the negative value of the stock-on-hand in that period. Thus, the netting process comprises - in each planning period - three possible cases:

(a) the computed value of the stock-on-hand is a positive value, which implies that the net requirement is equal to zero;

(b) the calculated value of the stock-on-hand is equal to the negative value of gross requirements in a given period. Then, net requirements equal gross requirements in the period in question;

(c) the computed value of the stock-on-hand in a given period is a negative value. Then, there are net requirements for a quantity equal to the absolute value of the stock-on-hand in such period, and the stock-on-hand is made equal to zero in the period under consideration.

The previous three cases are illustrated in Figure 2.8, where the net requirements of the example of Figure 2.7 have been calculated. Thus, in period 1, the stock-on-hand is equal to 50 units and there is not need for net requirements. In period 3, where the stock-on-hand has a negative value, net requirements equal this value and the stock-on-hand is made equal to zero. Finally, in period 6, the computed value of the stock-on-hand is equal to the gross requirements but with negative sign, and therefore, there is a net requirement for 70 units, equivalent to gross requirements.

Periods	1	2	3	4	5	6	7
Gross requirements	50		90		60	70	
Stock-on-hand 100	50	50	0	60	0	0	0
Scheduled receipts				60			
Net requirements			40			70	

Figure 2.8. Computation of net requirements

2.4.2. The offseting for lead time process

The existence of time-phased net requirements for a given item implies that there is a need to place new orders for that item in order to avoid future shortages. MRP systems cover net requirements by means of planned orders for purchased items and planned starts for manufactured items, which are scheduled to be released in the future. Three elements related to the planned orders (or planned starts) have to be determined by the MRP system. They are:

(1) Date for completing a planned order (due date). A planned order must be completed in the period of the planning horizon corresponding to the net requirements it intends to cover. It is important to specify whether the net requirements are needed at the beginning or at the mid-point of each period, since the selection of such convention will alter the timing of planned orders.

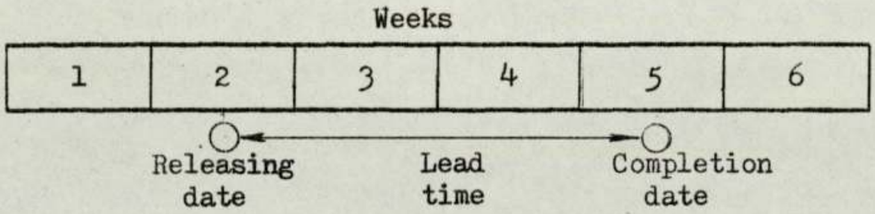
(2) Date for releasing a planned order. The timing of a planned order release for a given item is function of the lead time of the item. The lead time is the time required to complete a manufactured item or to receive into stock a purchased item, once an order has been placed for it. Therefore, the date for releasing a planned order is determined by substracting the value of the lead time

(expressed in the same time units of the planning periods) from the date of the planned order completion. This is illustrated in the following example:

Date for planned order completion (week): 5

Lead time (weeks): 3

Date for planned order release (week): 2



In the previous example, if the chosen timing convention for planned order release is such that the order is required at the beginning of week 5, which is the same as the end of week 4, the order will be released at the end of week 1. On the other hand, if the planned order completion date is at the mid-point of week 5, the order will be released in week 2. It is important to point out that the timing of the earliest planned order in the planning horizon is directly dependent on the timing of the earliest net requirements.

Generally, the value of the lead time for a given item varies from order ot order. Because the lead time is introduced into an MRP system as a fixed value, it is very likely that the expected lead time differs from the actual lead time. Therefore, if there is a significant difference between actual values of recent lead times and the expected (fixed) value, the MRP system should be kept up to date by introducing a new value for the lead time, which reflects the real situation.

(3) Planned order quantity. In pure MRP systems the planned orders are placed for the same quantity of the net requirements that the order it intends to cover. Figure 2.9 shows the time-phased planned orders corresponding to the example of Figure 2.8.

Periods	1	2	3	4	5	6	7
Gross requirements	50		90		60	70	
Stock-on-hand 100	50	50	0	60	0	0	
Scheduled receipts				60			
Net requirements			40			70	
Planned orders	40			70			

Lead time : 2 periods

Figure 2.9. Time-phased planned orders

The size of planned orders is usually determined by means of lot-sizing methods. In general, these methods determine convenient order quantities from an economic point of view, based on information about cost of holding stock, cost of placing an order and set-up cost per production batch. Depending on the lot-sizing rule selected by the inventory controller, a planned order may cover net requirements corresponding to one or more periods of the planning horizon, but it is a requisite that the planned order quantity at least equals that of the net requirements it intends to cover. In case that the quantity of a given order exceeds the quantity of the net requirements, the timing of the next planned order may be altered. The principles of operation of some lot-sizing rules usually available in MRP systems are described in Appendix I.

When a planned order moves into the current (earliest) planning period and is released, it is converted into a scheduled receipt. Figure 2.10 shows the effect of releasing the planned order in period 1 corresponding to the example of Figure 2.9.

Periods	2	3	4	5	6	7	8
Gross requirements		90		60	70		
Stock-on-hand 50	50	0	60	0	0		
Scheduled receipts		40	60				
Net requirements					70		
Planned orders			70				

Lead time : 2 periods

Figure 2.10. Status following a planned order release

2.4.3. The explosion of requirements process

Planned orders constitute a very powerful element of MRP systems because they generate material requirements at lower levels and, as requirements or inventory availability change, the planned orders are automatically rescheduled by the system, thus changing requirements at lower levels.

The process of generating gross requirements for component items is known as explosion of requirements and is carried out from the master production schedule level down to the component item levels. This process is governed by the linkage between parent items and their respective component items.

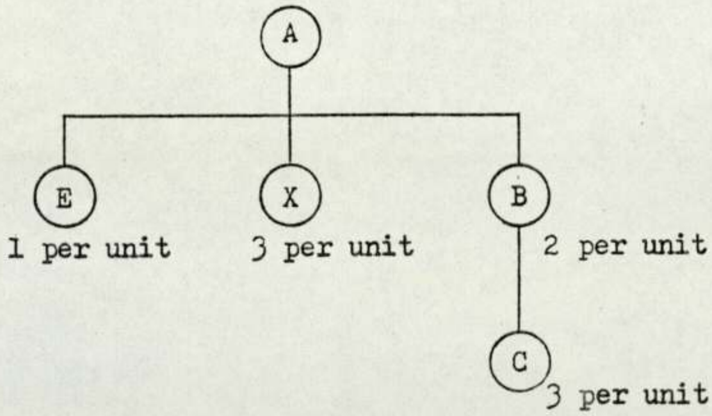
When determining gross requirements for component items, an MRP model has to consider two elements: the timing and the quantity of those gross requirements.

The timing of the gross requirements for a given component item coincides with the timing of the planned orders of its parent item. This is because the component item in question must be available at the time of releasing a planned order for the parent item.

The quantity of component gross requirements is function of the relationship between parent and component items, which is recorded in the bill of material file of the MRP system. Thus, for a given component item, its gross requirements in each planning period are equal to the quantity of the planned order of its parent item in such period, multiplied by the quantity of the component item required to produce one unit of its parent item.

Once the gross requirements for a given component item have been calculated, they are processed against inventory in order to determine net requirements, which are then offset for the lead time to obtain planned orders. These planned orders will then generate gross requirements for the items in the next lower level. The same procedure is carried out until the lowest level is reached. This repetitive process for the generation of requirements is the main reason why MRP models are particularly suitable for computer application. Figure 2.11 shows an example of the explosion of requirements process.

In some cases, a component item has multiple parents, its gross requirements being computed by adding - in each period - the gross requirements generated by each parent item. In addition to this, a component item may be subject to independent demand, which sholud be added to its gross requirements. This is illustrated in Figure 2.12.



ITEM A (Lead time: 1 period)

Periods	1	2	3	4	5	6	7
Gross requirements		10		30		25	
Stock-on-hand 5	5	10	10	0	10	0	
Scheduled receipts		15			10		
Net requirements				20		15	
Planned orders			20		15		

ITEM B (Lead time: 1 period)

Period	1	2	3	4	5	6	7
Gross requirements			40		30		
Stock-on-hand 20	20	30	0	0	0		
Scheduled receipts		10			10		
Net requirements			10		20		
Planned orders		10		20			

ITEM C (Lead time: 3 periods)

Periods	1	2	3	4	5	6	7
Gross requirements		30		60			
Stock-on-hand 50	50	20	20	0	10	10	10
Scheduled receipts					10		
Net requirements				40			
Planned orders	40						

Figure 2.11. Explosion of requirements

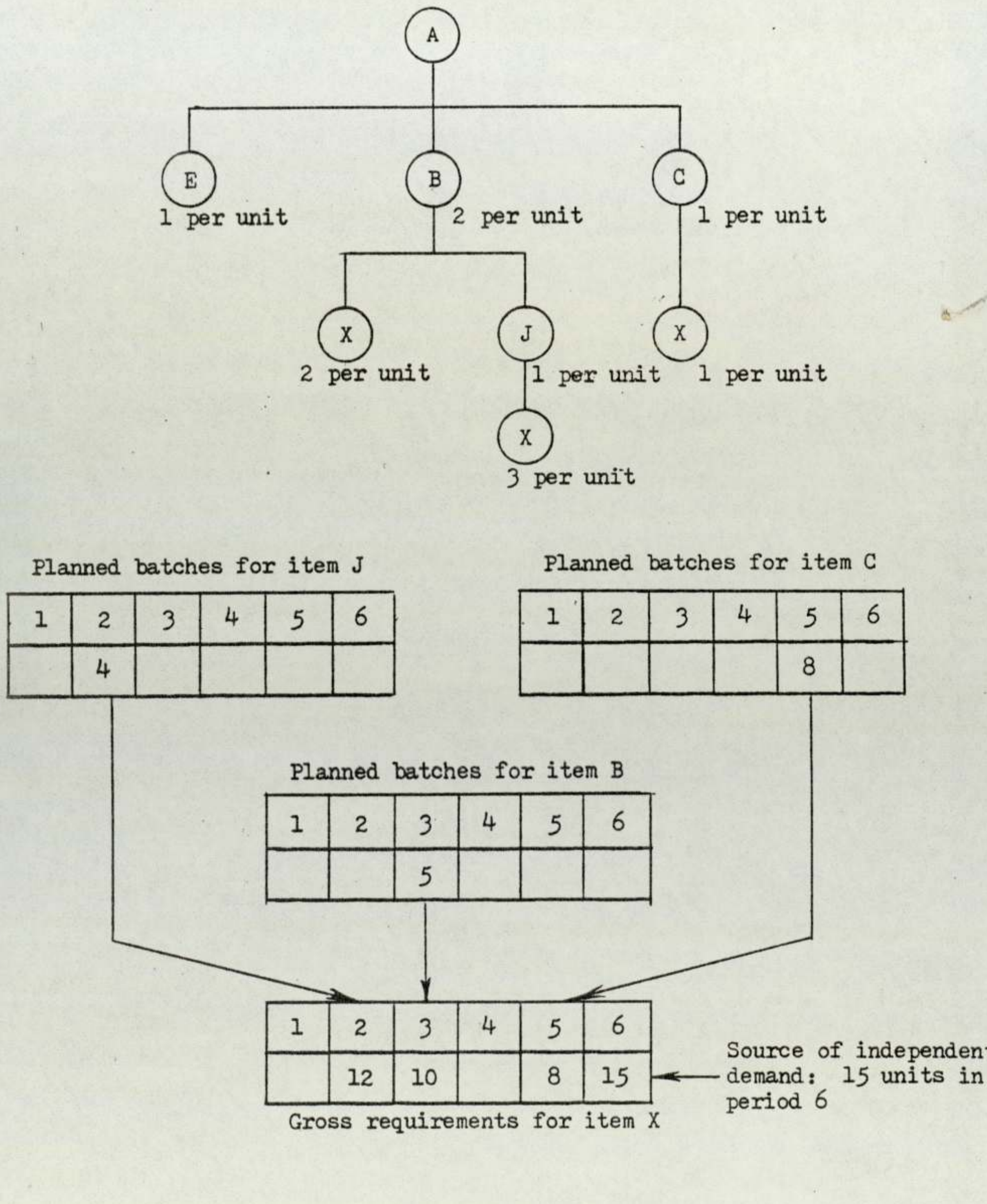


Figure 2.12. Gross requirements from different sources

2.5. Safety stock and safety time

Some companies using material requirements planning protect themselves against variations in the demand or unplanned losses in the manufacturing process by means of safety stocks. In this case, the quantity of safety stock should be either added to the gross requirements or substracted from the opening stock-on-hand, increasing requirements accordingly. Since the main objective of carrying safety stock is to compensate for forecast errors, it should be incorporated at the end-product level (master production schedule), where uncertainty in the demand may exist, or, for those component items subject to independent demand. The introduction of safety stock at the component level implies that a certain quantity might always be on hand, which is against the MRP principle of keeping inventories at a minimum level. Therefore, safety stock should not be planned for each inventory item separately under the MRP approach. In general, safety stock is calculated on the basis of historical demand for the item in question and of the desired service level.

When companies routinely schedule safety stock regardless available capacity, manufacturing frequently produces orders that include safety stock while delaying orders required to cover customer orders. To avoid this problem, procedures and systems for identifying and controlling safety stock requirements should be built into the MRP model.

While safety stock is usually introduced to compensate for demand variations, safety time is usually planned to protect against delays in the arrival of the orders. Thus, materials and parts that with some frequency arrive into stock in a longer time than their expected lead times, should require a safety time to be added to their lead times to ensure their availability in stock when they are needed in the production process. In this case, the logic of MRP should be altered in order to incorporate the concept of safety time into the offseting for lead time process and the calculation of the longest composite lead time.. That is, the net requirements are offset for a time equal to the lead time plus the safety time but when the mature planned orders are released, only the lead time is taken into account to determine the planning period in which the order needs to be completed. The longest composite lead time is increased by the sum of the safety times of the items on the branch of the bill of material holding the longest cumulative lead time.

The decision on introducing safety time for materials and parts should be based on the balance between the cost of holding inventories longer than required and the cost incurred by late arrivals of the orders.

Some companies adopt a combined policy to protect themselves against uncertainties, including both safety methods in the MRP system. For example, safety time may be planned at the raw material level and safety stock at the end-product level. When applying any of the two methods, the MRP system should include a control mechanism to monitor the usage of the stock-in-excess in terms of both, quantity and frequency of use, in order to feedback and correct any discrepancy between actual and expected performance.

2.6. Material requirements planning system outputs

Material requirements planning models constitute a powerful tool for managing inventory and production systems in a manufacturing environment. This is because such models generate output reports that can be used as data sources for other management systems, as for example, shop scheduling systems, capacity requirements planning systems, dispatching systems, shop floor control systems and purchasing systems.

The main outputs of an MRP model are planned order releases and scheduled receipts (open orders) reschedules. The former implies the placement of purchasing orders for bought-out items, or manufacturing orders (planned starts) for manufactured items, in order to meet the master production schedule for the end-product. The latter consists in changing scheduled receipts due dates as a consequence in a change in the master production schedule or the inventory status.

By rescheduling scheduled receipt due dates, the MRP system keeps the order priorities up to date. That is, when the due date of a scheduled receipt differs from the date when the order is actually needed, the system informs the inventory planner of the need to expedite (bring it earlier) or de-expedite (bring it later) the order so as to make the two dates coincide.

Priority planning and control is one of the most important functions in manufacturing organizations. Keeping valid priorities has significant effects, such as, it can reduce average lead times, lowering "in progress" inventories; it can result in rescheduled deliveries for purchased items thus reducing bought-out material inventories; it frees up time and capacity for other jobs if the component is manufactured internally.

Planned orders scheduled for release in the future constitute another important output of an MRP system, since the planned orders can be used as input for a capacity requirements planning system.

A well implemented MRP system can generate additional outputs, such as inventory forecasts, performance reports, open order cancellation notices and open order suspension notices among others. These outputs are generated according to the inventory controller's requirements.

2.7. Types of material requirements planning systems

There are two basic types of MRP systems, which differ in the frequency of replanning and in the element initiator of the replanning process. The two systems are;

(1) Regenerative systems

(2) Net change systems

2.7.1. Regenerative system

Regenerative systems constitute the traditional approach to material requirements planning. Under this approach, the entire planning process is carried out every time a new master production schedule is introduced into the system. That is, whenever an updated master production schedule is supplied to the system, the inventory status for all items is updated, the gross and net requirements for each component item are re-calculated and the corresponding planned order schedule is re-created. Although this batch method of requirements generation is simple from a computing point of view, it is very time consuming due to the enormous amount of data that have to be handled in each replanning process. A regenerative system can result in a high output of information which could take a number of weeks for the planners to work through, thus restricting the frequency of replanning. Weekly or longer cycles are characteristic of the regenerative systems.

2.7.2. Net change system

Net change systems are based on the principle of including in the replanning process only those component items whose data have changed from the previous requirements plan. Thus, the explosion of requirements is performed only partially, reducing the volume of data processed by the system and the time consumed in the replanning process. The master production schedule can be updated at any time by adding or substracting the net difference from the previous status.

In addition to the net changes in the production schedule, net change systems also cater for net changes in the inventory status as a result of unplanned transactions originated by the manufacturing problems daily faced by shop floor personnel. Each new requirements plan is obtained by adding the outputs of each new running of the system to the previous plan.

Net change MRP systems are designed for high frequency replanning, allowing the inventory controller to run the system in cycles shorter than a week.

The selection between a regenerative or a net change system depends on the requirements of each company, it being essential that the prospective user clearly understands what each approach means before deciding which alternative to implement. A company manufacturing a complex product with many levels of assembly is likely to perform more efficiently with a net change system than with a regenerative one due to the long computing time consumed and the large volume of outputs that the planner should have to work through at each regeneration of the whole requirements plan. On the other hand, a company involved in the manufacture of a relatively simple product with a rapidly changing master production schedule may obtain better results from a regenerative system than from a net change one, since each new requirements plan may differ significantly from the previous one.

It has been a common practice among companies to start with a regenerative system due to its simplicity and the ease in understanding its operation, and then move over to a net change system that will allow more frequent runnings to cope efficiently with the continuous changes of a dynamic business environment.

2.8. Firm planned order

The standard MRP system determines automatically the start date and the due date of a planned order according to the lead time and the lot-sizing rule specified. The MRP system also reschedules planned order due dates if a change in the master production schedule or the inventory status dictates so.

However, there are cases where the quantity and/or the timing of a planned order release need to be fixed manually by the planner, as for example, when a plant capacity problem can be solved by smoothing the work load by bringing forward the release date of one or more planned orders.

The planned orders manually fixed by the inventory planner are called firm planned orders and, the capability of the MRP system of accepting the firm planned order and also avoiding to place any other order into the same period as the firm one, is known as the firm planned order technique. The effective application of the planned order method requires a comprehensive understanding of the MRP system operation by the people involved in the production and inventory control task to avoid creating confusion in the order priorities and plant capacity problems.

2.9. Requirements pegging

Requirements pegging is the technique by means of which the material planner can trace item gross requirements to their sources. Pegging provides for each component item, a detail listing of its gross requirements in each period indicating all the parent items and external sources where the gross requirements come from. Pegging is therefore the reverse to requirements explosion and allows the planner to trace items gross requirements from raw materials up to the finished product through the structure of the bill of material. If the facility of tracing the sources of item gross requirements only includes the inmediately higher level, the technique is known as single-level pegging. But, if the sources of item gross requirements can be related to the master production schedule of the corresponding end-product then the technique is called full pegging. Figure 2.13 shows an example of single-level pegging.

A typical application of the use of pegging is where a problem of availability of a component cannot be solved to meet the scheduled completion date. Using requirements pegging, the problem order can be traced back to the order for the end-product which generated the component gross requirements. This order can then be adjusted in line with the current situation and revised requirements exploded through the bill of material.

Item L

Period	1	2	3	4	5
Gross requirements	100		150		80

Pegged requirements for item L

Period	Quantity	Parent item	External order
1	60	B	
1	40		No. 408
3	70	B	
3	80	C	
5	80	C	

Figure 2.13. Requirements pegging

2.10. Benefits of material requirements planning systems

In a manufacturing environment, material requirements planning systems constitute a superior tool for planning and controlling inventories. Companies operating well-implemented MRP systems have obtained enormous benefits from them, such as:

(i) Reduced component inventories, as a result of the elimination of safety stocks on dependent items and the timing of the receipts of components to coincide more closely with assembly requirements.

(ii) Reduced "in progress" inventories, as a result of considerable decrease of the time the assemblies remain on the shop floor waiting for the other parts and materials to arrive.

(iii) Better control of inventory investment which is kept at minimum levels as a result of reduced inventories, Thus, the money that was previously tied up in excess inventory can now be allocated to more important requirements such as capital investment.

(iv) Improved customer service, resulting from the close relationship between order quantities and requirements for component items.

(v) Lower manufacturing costs, as a consequence of a reduction in assembly work, since assemblies are put together in the way they were designed. In addition to this, the number of indirect employees decreases because less storekeepers and expediters are required for the inventory control task

(vi) Better occupation of management time because MRP systems provide valid information that prevents management using its time trying to solve daily planning problems. Management time can be devoted to planning and organizing for the future.

(vii) Improved long-range planning because MRP systems permit the material manager to plan in terms of future requirements on a component-by-component basis, which in turns gives the production manager the opportunity of planning future capacity requirements.

Companies currently using MRP systems have reported a reduction of 30% in component inventory levels, a reduction of 75% in the number of stock-outs, an increase of 5% in production efficiency and a reduction of 25% in the number of indirect employees (2).

To be successful with material requirements planning it not only requires a good system design, it also requires qualified people from all departments for the effective operation of the system and top management commitment to the production and inventory planning and control tasks.

CHAPTER 3

DESIGNING A MATERIAL REQUIREMENTS PLANNING SYSTEM

Material requirements planning is a technique particularly suitable for computer application because the same logical procedure for the generation of requirements is repeated for all component items down through the product structure. Furthermore, MRP systems require the use of the computer due to the large volume of data handled by them and the number of factors that must be coordinated to generate the overall requirements plan.

Three basic sections have been considered when designing the computerised MRP system:

(1) Data handling section
(2) Processing logic section
(3) Output section

3.1. Data handling section

The data handling section is designed to create and update the files for the storage of the data required by the package. Three files need to be created:

(1) Bill of material file

(2) Inventory record file

(3) Master production schedule and scheduled receipts file

After storing the data in each file, the user is offered the opportunity of printing out its contents in order to check and, if necessary, correct the information. A description of the contents of each file is given below.

3.1.1. Bill of material file

The bill of material file contains information on the number of end-products and the structure of the bill of material in terms of parent item - component item relationships. That is, for each parent item, its component items and their respective quantities required by unit of parent should be specified by the user.

Since the computer identifies each component item by means of a code-number, it is required to develop a coding system to identify unambiguosly each item involved in the end-product structure.

3.1.2. Inventory record file

The inventory record file contains the following item-inventory information:

- Stock-on-hand at the beginning of the current planning period
- Safety stock
- Lead time
- Safety time
- Batching rule
- Inventory cost data

The Inventory record file also contains information on the planning horizon such as the number of the current period and the total number of periods covered by the planning horizon. Additionally, the Inventory record file stores values, as calculated by the package, of the actual inventory costs incurred in the current planning period and cumulative inventory costs from previous periods (that is, if the requirements plan has been re-generated moving forward period-by-period in the planning horizon).

3.1.3. Master production schedule and scheduled receipts file

This file contains information on the quantity and timing of:

- Gross requirements schedule for the end-products
- Master production schedule for the end-products
- Independent demand for component items
- Scheduled receipts for each item

A simplified layout of the data handling section of the MRP package is shown in Figure 3.1.

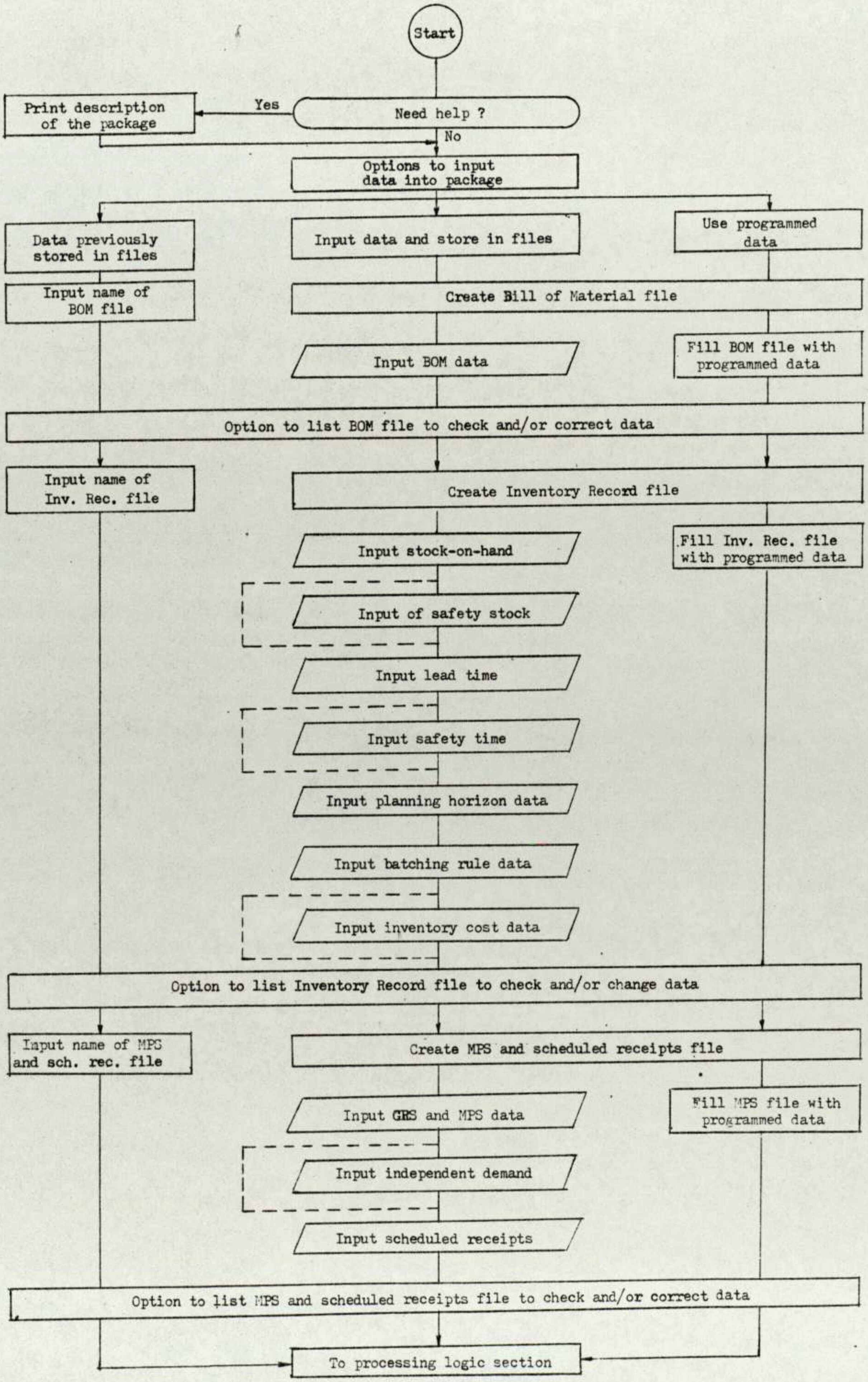


Figure 3.1. Simplified layout of the data handling section of the MRP package

3.2. Processing logic section

When designing the flow diagram of the overall material requirements planning system, four different logical processes have been considered. They are:

(1) Low-level coding
(2) Calculation of the longest composite lead time
(3) Requirements generation process
(4) Requirements re-generation process

3.2.1. Low-level coding process

As it was mentioned in chapter 2, the computation of requirements by an MRP system is carried out from the top level to the bottom level of the product structure. The most effective way of performing such computation is processing all the items on a given level once the items on the next higher level have been processed. This approach is called level-by-level processing.

In many cases, a given component item is common to various parent items, i.e. it has multiple sources of demand. This is the case of items C and E in the example of Figure 3.2. It is also frequent that a component item appears on different levels in the structure of the bill of material, as for example items C and F in Figure 3.2.

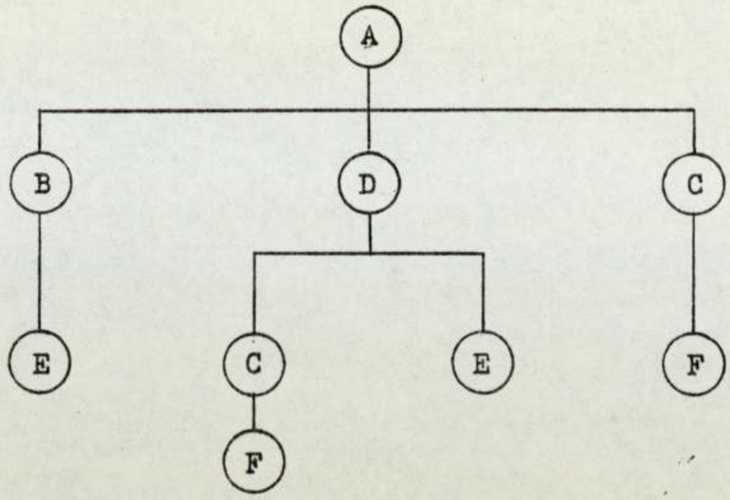


Figure 3.2. Common and multilevel component items

In order to determine net requirements for common components, MRP models usually apply a technique known as low-level coding. This technique consists in identifying the lowest level at which any common or multilevel component appears in the structure of the bill of material and re-arranging the bill of material in such way that each component appears only at one level. Once the structure of the bill of material has been re-arranged by the system, the level-by-level procedure can be applied. Thus, in the requirements generation process, the net requirements for all the parent items of a given common component item are determined before the gross requirements of the component item in question are computed. Figure 3.3 shows the concept of low-level coding.

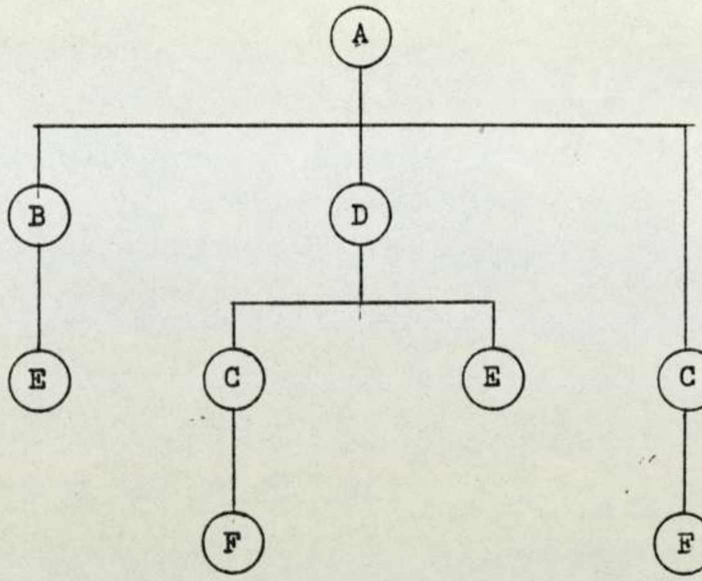


Figure 3.3. Low-level coding

When designing the flow diagram corresponding to the low-level coding process of the material requirements planning package, each component item is firstly allocated on that level of the bill of material inmediately below the level of its parent item. Thus, a common component item may appear on different levels of the bill of material. Then, the MRP package allocates each inventory item on the lowest level at which it appears, so that each item is allocated on only one level of the bill of material (low-level coding). A simplified flow diagram of the low-level coding section of the MRP package is shown in Figure 3.4.

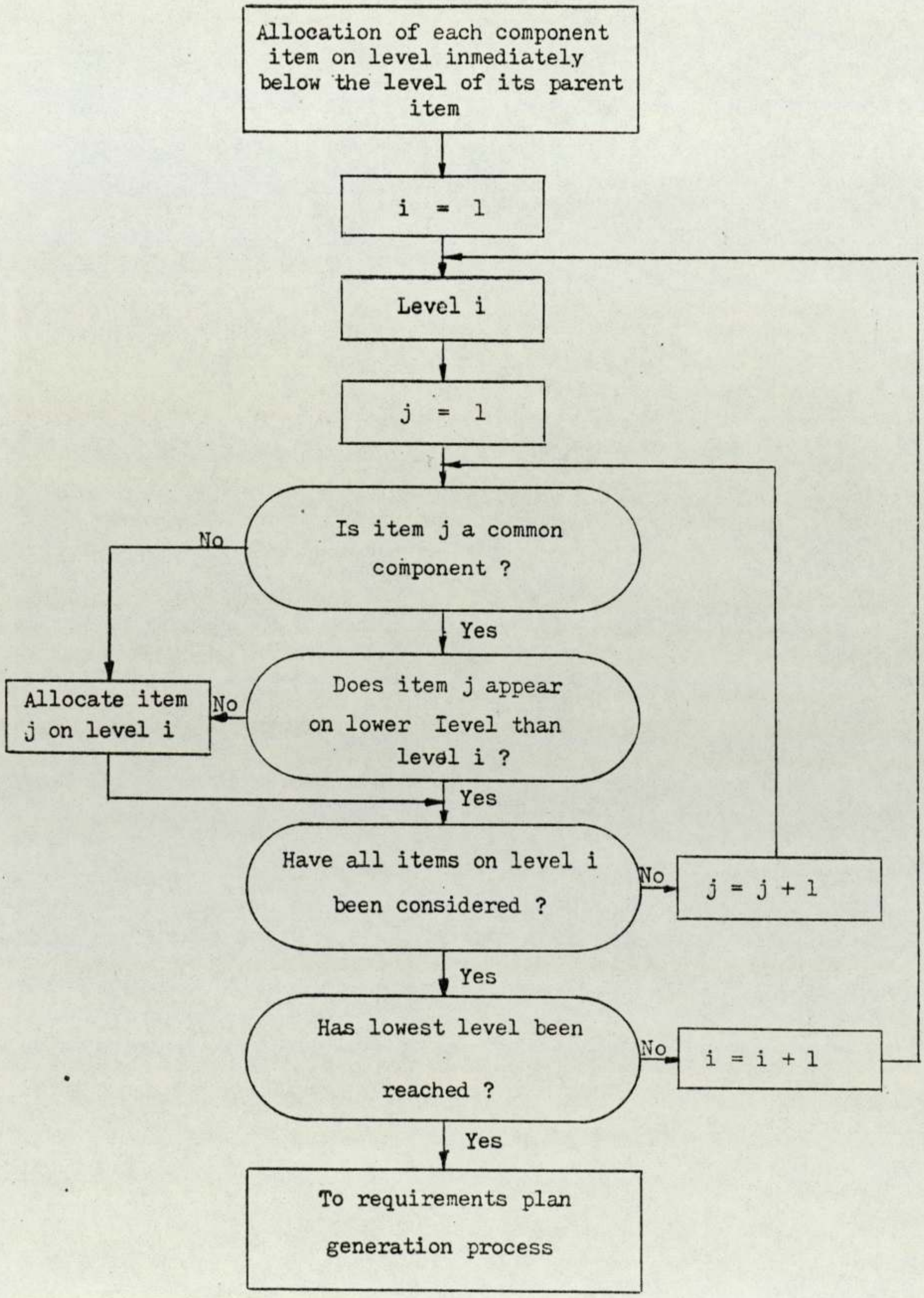


Figure 3.4. Simplified flow diagram of the low-level coding process

3.2.2. Calculation of the longest composite lead time

As it was mentioned earlier, the planning horizon must be long enough to cover the longest composite lead time down through the product structure. Therefore, the longest composite lead time has to be calculated by the MRP system before the information on the planning horizon length is input by the user, so that these two quantities are compared by the system in order to check if the above mentioned condition is fulfilled.

To calculated the longest composite lead time, the package computes the cumulative lead times down through each branch of the structure of the bill of material and by comparing those quantities, the package finds the longest composite lead time. In the even that safety time data are supplied to the system, the longest composite lead time is equal to the longest cumulative lead time plus the cumulative safety of the items on the bill of material branch holding the longest composite lead time.

Figure 3.5 shows a simplified flow diagram of the logical procedure followed by the MRP system to calculate the longest composite lead time.

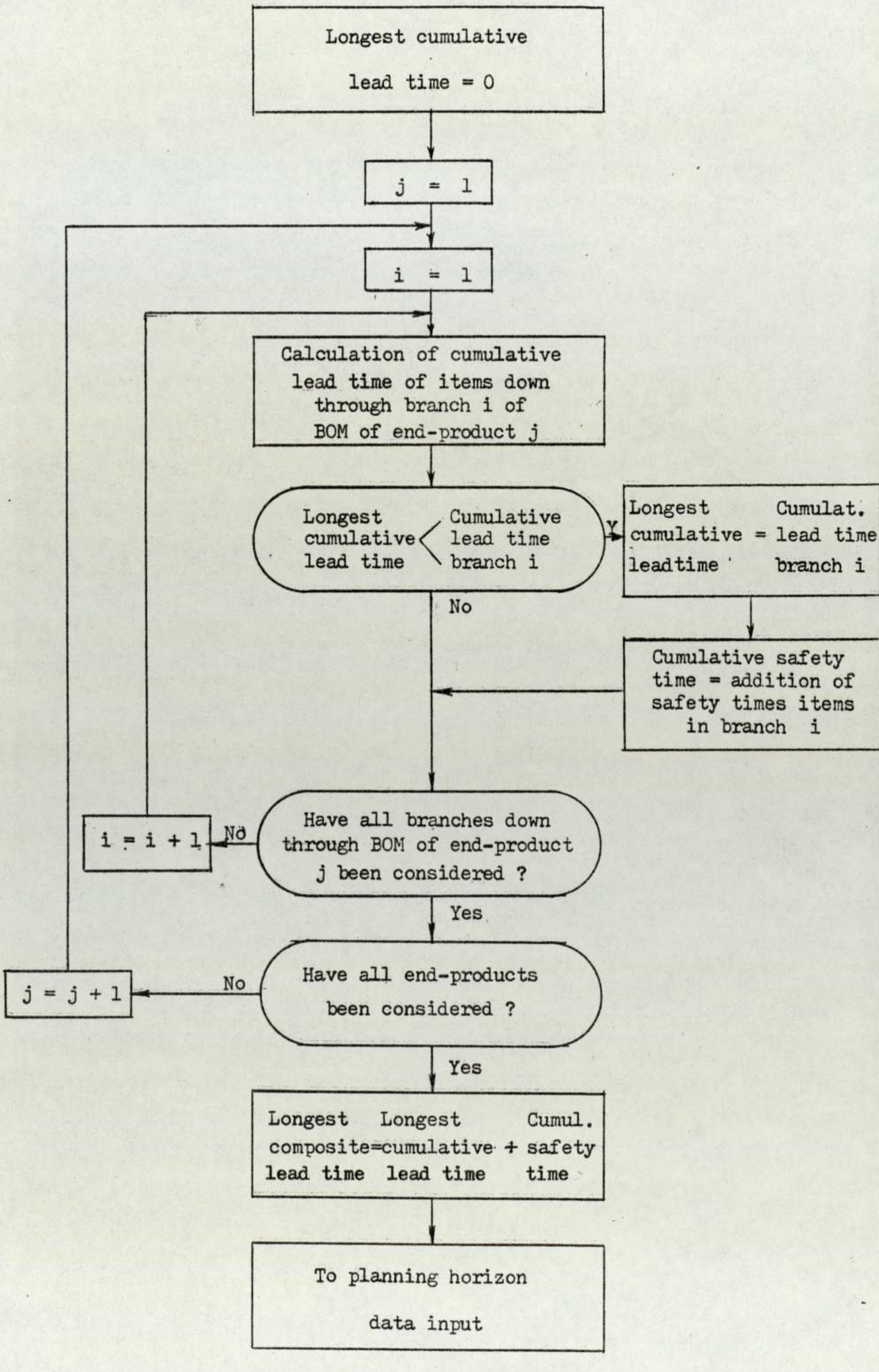


Figure 3.5. Simplified flow diagram of the calculation of the longest composite lead time

3.2.3. Requirements generation process

Once the material requirements planning system has been provided with all the required information and it has performed the low-level coding process, the explosion of requirements down through the product structure is carried out using the level-by-level approach. Thus, all the parent items of a given component item are allocated on the next higher level and this level is completely processed before the next-lower level is netted.

The MRP package batches the planned starts of each item applying the batching rule previously specified by the user for the item in question. Thus, the MRP system generates the overall planned batch schedule for all items involved in the bill of material for the finished products.

A simplified flow diagram of the requirements generation process is given in Figure 3.6.

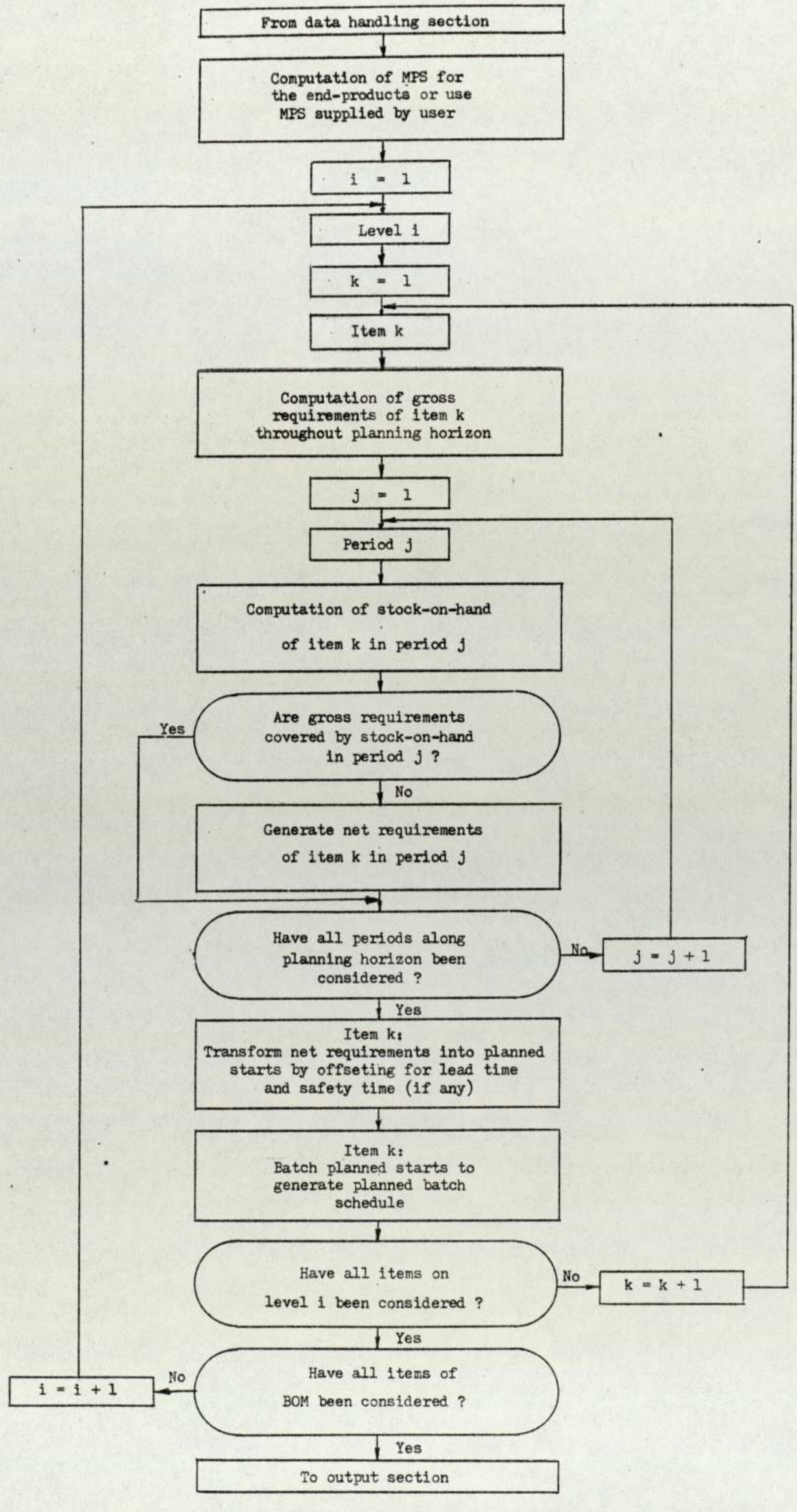


Figure 3.6. Simplified flow diagram of the requirements generation process

3.2.4. Requirements re-generation process

Once the requirements plan for all items has been printed out by the package, the user is offered the option of re-generating the requirements plan moving forward period-by-period in the planning horizon. For this purpose, the package searches out through the requirements plan of each item for mature planned batches in order to release them and transform them into scheduled receipts. In other words, any planned batch which appears in the current planning period is transformed into a scheduled receipt using the data of lead time of each item. The requirements re-generation process also involves the updating of stock-on-hand quantities of each item at the beginning of the new current period. A simplified flow diagram of this section of the MRP package is shown in Figure 3.7.

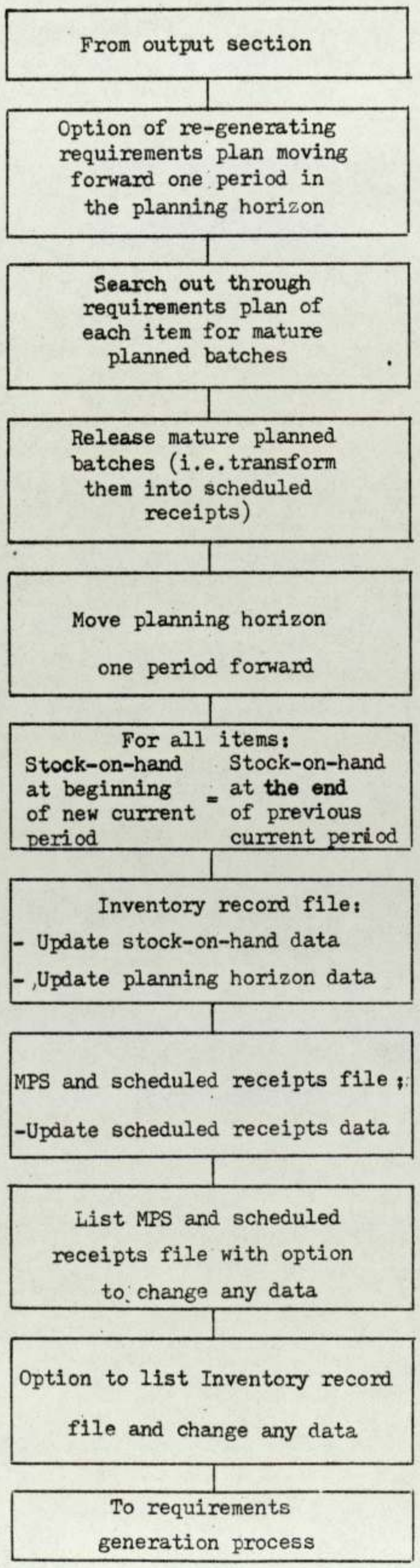


Figure 3.7. Simplified flow diagram of the requirements re-generation process

3.3. Output section

The output section of the MRP system is made up of the following reports:

- Requirements plan for each item involved in the bill of material of the end-products.

- Inventory cost analyses.

- Summary of the planned batches for each item throughout the planning horizon.

- Summary of the planned stock-on-hand of each item throughout the planning horizon, including the cumulative stock value and the average planned stock-on-hand.

- Summary of the orders that need to be expedited to meet a given master production schedule for the end-products.

- Gross requirements of each component item per unit of end-product.

The three main sections of the MRP package already mentioned, that is, the data handling section, the processing logic section and the output section, are interrelated in the way indicated in the general layout of the MRP package shown in Figure 3.8.

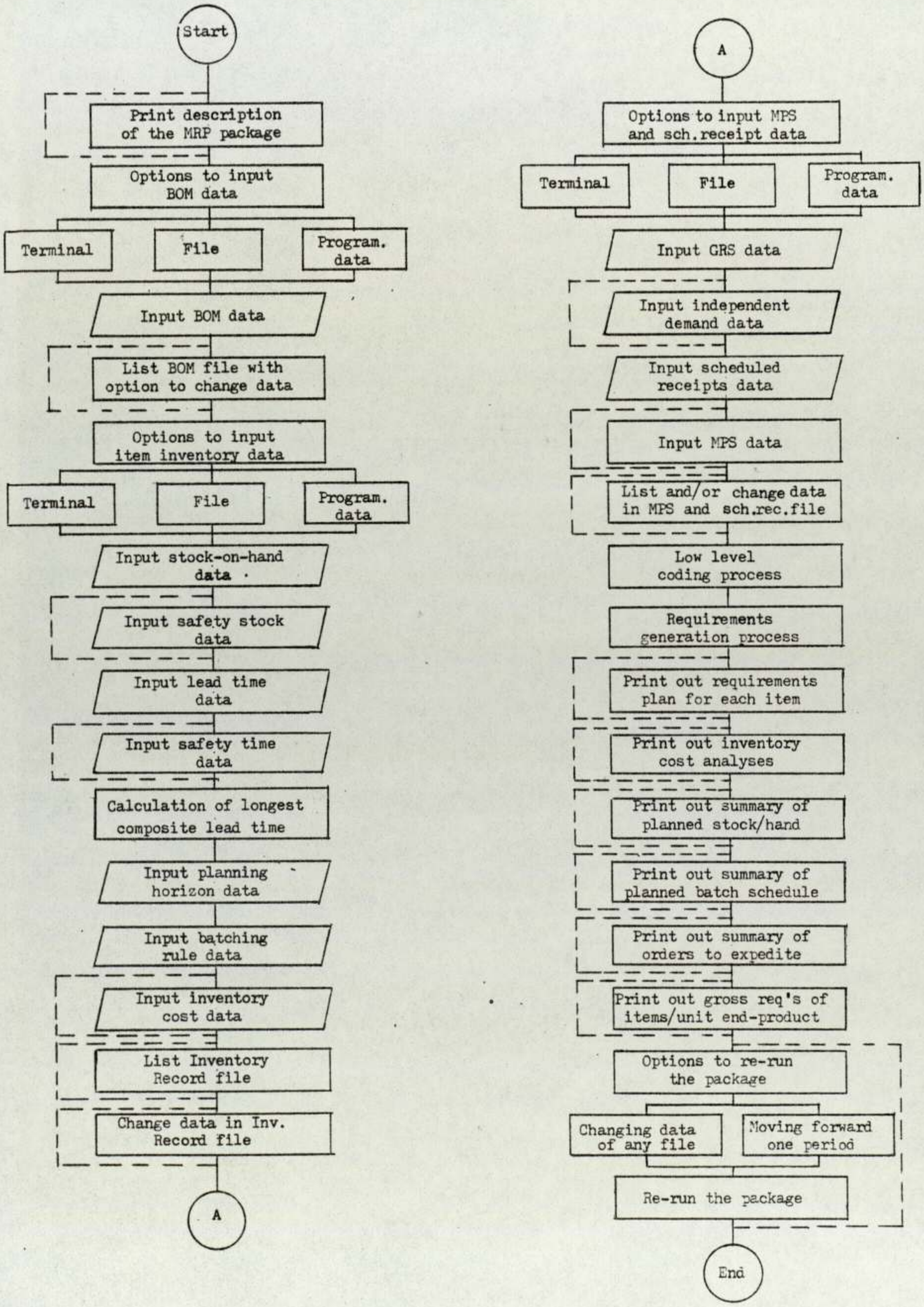


Figure 3.8. General layout of MARPLA

CHAPTER 4

OPERATING INSTRUCTIONS FOR THE MATERIAL REQUIREMENTS PLANNING SYSTEM

4.1. Package features

The computer system on material requirements planning developed by the author is called MARPLA. It is programmed in BASIC language and is designed to be used on a Hewlett - Packard Access 2000 machine. The package occupies about 304 records of storage.

MARPLA is an interactive package which allows the user to generate time-phased net requirements and to develop a planned batch schedule for all the component items of one or multiple end-products. The package has been designed mainly with teaching purposes and can be used by persons with no computing background.

MARPLA performs the following functions:

(i) Explosion of the bill of material for the end-products.

(ii) Calculation of gross requirements of each component item per unit of end-product.

(iii) Calculation of the longest composite lead time.

(iv) Generation of time-phased net requirements and their planned coverage for the component items of one or multiple end-products.

(v) Calculation of inventory cost information if inventory cost data for all components are input into the system.

(vi) Re-generation of the overall requirements plan moving forward period-by-period in the planning horizon.

The way in which the system has been designed is such that it can deal with common components and with multilevel components in the structure of the bill of material. The MRP package operates using the regenerative approach.

As the data are input into the package, the user can list the typed information so that it can be checked and corrected before the computer enters it into the corresponding file. Similarly, information already stored in files can be printed out in easy to read tables and can be changed before generating the requirements plan.

The user is offered eight options to select the batching rule of each item for the generation of the planned batch schedule.

Built into the package there is the facility of running the system using programmed data. Thus, the inexperienced user can generate the requirements plan and analyse the effects of changing the inventory parameters using data already stored in the system.

4.2. Preliminary instructions

4.2.1. Logging into the computer

The user logs into the computer by typing a code-number followed by a password, as for example:

HEL - L600,PASS

and after pressing the "Return" key, the computer types a message as the following one:

THE UNIVERSITY OF ASTON HP 2000 ACCESS SYSTEM
MONDAY 8 SEPTEMBER 1980 11:00 A.M. PORT 7
PLEASE GO AHEAD

At this point, the user has been accepted by the computer, and to obtain the control of MARPLA the user should type:

GET - MARPLA (Return key)
RUN (Return key)

Once the user has the control of MARPLA, the computer will execute the program and the user will have to type in the terminal the answers to the enquiries from the program.

4.2.2. Using the "HELP" aid

MARPLA gives the user the opportunity of responding to any enquiry from the system with the word HELP. When the user types in HELP after any question, the package prints out additional information explaining how to answer the corresponding question. In some cases, the way in which the system explains how to answer a given enquiry is by means of an example as it is shown in Figure 4.1 where a print out of the package illustrates the use of HELP aid.

<u>Figure 4.1.</u> <u>Print out of an example of the "HELP" aid</u>

```
WHAT IS THE HIGHEST CODE-NUMBER IN THE BILL(S) OF MATERIALS
OF THE END-PRODUCT(S).?HELP

-- EXPLANATION --

END-PRODUCT(S) AND COMPONENTS SHOULD BE NUMBERED WITH
'SUCCESSIVE' NUMBERS FROM '2' (INCLUSIVE) TO A MAX.
OF  20   .
IN THE FOLLOWING EXAMPLE, THE HIGHEST CODE-NUMBER IS 11 :
        E.G.

                                                        LEVEL

        (3)                         (5)                  0
         !                           !
     ---------                 ---------------
     !       !                 !       !      !
    (2)     (6) 2PER      1PER(7)     (8)   (10)1PER     1
    1PER     !                 !      4PER    !
           -----               !              !
           !   !               !              !
          (4) (8)         3PER(9)            (2) 3PER    2
         3PER 1PER             !
                               !
                          2PER(11)                       3


-- END OF EXPLANATION --

WHAT IS THE HIGHEST CODE-NUMBER IN THE BILL(S) OF MATERIALS
OF THE END-PRODUCT(S).?10
```

4.2.3. Description of the package

After getting the material requirements planning package MARPLA and typing the word RUN, the first question the user is required to answer is:

DO YOU NEED HELP ?

If the answer is NO, the system passes directly to the data input section. If the answer is YES, the system gives the user a complete explanation of how to use the package, including a detail list of the information required from the user and a description of the outputs of the system. In this way, the user can prepare all the data required by the package before running it.

Figure 4.2 shows a print out of the description of the package given by the system.

Figure 4.2. Print out of the description of the package

```
GET-MARPLA
RUN
MARPLA

MATERIAL REQUIREMENTS PLANNING SYSTEM
-------- ------------ -------- ------

DO YOU NEED HELP ?
YOUR REPLY ('YES' OR 'NO') ?YES


THIS IS AN INTERACTIVE PROGRAM FOR THE SIMULATION OF A
MATERIAL REQUIREMENTS PLANNING POLICY.

USERS ARE REQUIRED TO SUPPLY TO THE COMPUTER THE FOLLOWING
INFORMATION:
   (1) STRUCTURE OF THE BILL OF MATERIAL INFORMATION;
   (2) LEAD-TIME OF EACH ITEM INFORMATION;
   (3) STOCK-ON-HAND OF EACH ITEM AT THE BEGINNING OF THE
       PLANNING HORIZON INFORMATION;
   (4) PLANNING HORIZON SPAN INFORMATION;
   (5) MASTER PRODUCTION SCHEDULE FOR THE END-PRODUCT(S) INFORMATION;
   (6) INDEPENDENT DEMAND FOR 'COMPONENT' ITEMS INFORMATION;
   (7) SCHEDULED RECEIPTS FOR EACH ITEM INFORMATION;
   (8) SAFETY STOCK INFORMATION;
   (9) SAFETY TIME INFORMATION;
  (10) BATCHING RULE INFORMATION;
  (11) INVENTORY COST INFORMATION.
  (12) GROSS REQUIREMENTS SCHEDULE FOR THE END-PRODUCT(S)
       INFORMATION,

THE ABOVE DATA ARE STORED IN THREE FILES CREATED AS THE PROGRAM
IS RUN. AFTER STORING THE DATA IN THE RESPECTIVE FILES, USERS CAN
LIST THE FILES TO CHECK THE DATA AND CHANGE THEM IF NECESSARY.


** STRUCTURE OF THE BILL OF MATERIAL **

*CODING SYSTEM- THE FOLLOWING CONDITION IS REQUIRED TO RUN
                THE PROGRAM:
   (1) THE CODE-NUMBERS OF THE END-PRODUCT(S) AND OF THE
       'COMPONENT' ITEMS ARE 'SUCCESSIVE' NUMBERS FROM '2'
       (INCLUSIVE) TO A MAXIMUM OF  20   .

*LEVELS-

   (1) BY CONVENTION, LEVELS ARE NUMBERED FROM TOP TO BOTTOM,
       BEGINNING WITH LEVEL '0' FOR THE END-PRODUCT(S).A MAXIMUM
       OF  10    LEVELS IS ALLOWED TO BE ENTERED.

   (2) A'COMPONENT' ITEM MAY HAVE MULTIPLE 'PARENTS', AND/OR
       IT MAY EXIST ON DIFFERENT LEVELS IN THE STRUCTURE OF
       THE BILL OF MATERIAL.
```

Figure 4.2. (Cont....)

E.G.

```
                                                         LEVEL

           (3)                          (5)                0
            !                            !
        ---------                 ---------------
        !       !                 !      !      !
       (2)     (6) 2PER      1PER(7)    (8)    (10)1PER    1
       1PER     !                 !     4PER    !
              -----               !             !
               !  !               !             !
             (4) (8)         3PER(9)           (2) 3PER    2
            3PER 1PER             !
                                  !
                             2PER(11)                      3
```

** LEAD-TIME DURATIONS OF EACH ITEM **

USERS ARE REQ'D TO INPUT A FIXED LEAD-TIME FOR EACH ITEM,
AND TO SPECIFY UNIT OF MEASUREMENT FOR TIME OF LEAD-TIME.

** STOCK-ON-HAND OF EACH ITEM ** - -

USERS ARE REQ'D TO INPUT STOCK-ON-HAND QTY. OF EACH ITEM,
AT THE BEGINNING OF THE 'CURRENT' UNIT TIME OF THE PLANNING HORIZON.

** PLANNING HORIZON SPAN **

THE PLANNING HORIZON SHOULD AT LEAST EQUAL THE LONGEST COMPOSITE
LEAD-TIME OF THE END-PRODUCT(S).
THE PLAN'G HORIZON SPAN IS THE SAME ONE FOR ALL THE END-PRODUCTS.
A MAXIMUM OF 25 TIME UNITS IS ALLOWED TO BE ENTERED.
THE UNIT FOR MEASURING TIME OF THE PLANNING HORIZON IS THE
SAME UNIT SPECIFIED FOR LEAD-TIME DURATIONS.
USERS ARE REQ'D TO INPUT THE NUMBER OF THE 'CURRENT' TIME UNIT
OF THE PLAN'G HORIZON, AND THE TOTAL NUMBER OF TIME UNITS COVERED
BY IT.

** GROSS REQUIREMENTS SCHEDULE FOR THE END-PRODUCT **

OPTIONS FOR THE INPUT OF GROSS REQUIREMENTS
SCHEDULE FOR THE END-PRODUCTS:

(1) INPUT OF A NUMBER OF QUANTITIES PER UNIT TIME.

(2) INPUT OF A CONSTANT QUANTITY PER UNIT TIME THROUGHOUT THE
PLANNING HORIZON.

Figure 4.2. (Cont....)

** MASTER PRODUCTION SCHEDULE FOR THE END-PRODUCT **

THE MASTER PRODUCTION SCHEDULE MAY BE GENERATED BY THE PACKAGE OR IT MAY BE INPUT BY THE USER.

OPTIONS FOR THE INPUT OF MASTER PRODUCTION SCHEDULE (PLAN OF PRODUCTION) FOR THE END-PRODUCT(S).

(1) INPUT OF A NUMBER OF QUANTITIES TO PRODUCE PER UNIT TIME OF THE PLANNING HORIZON.

(2) INPUT OF A CONSTANT QTY. TO PRODUCE PER UNIT TIME.

** INDEPENDENT DEMAND FOR 'COMPONENT' ITEMS **

USERS HAVE THE OPTION OF INTRODUCING DATA OF INDEPENDENT DEMAND QTY. PER UNIT TIME FOR 'COMPONENT' ITEMS.
USERS ARE REQ'D TO INPUT, FOR EACH ITEM, THE FOLLOWING DATA:

(1) TOTAL NUMBER OF TIME UNITS OF THE PLANN'G HORIZON WITH INDEPENDENT DEMAND;

(2) THE NUMBER OF EACH OF THOSE TIME UNITS AND ITS CORRESPONDENT INDEPENDENT DEMAND QTY.PER TIME UNIT.

** SCHEDULED RECEIPTS OF EACH ITEM PER UNIT TIME **

USERS ARE REQ'D TO INPUT, FOR EACH ITEM, THE FOLLOWING DATA:

(1) THE TOTAL NUMBER OF TIME UNITS OF THE PLANN'G HORIZON WITH SCHEDULED RECEIPTS;

(2) THE NUMBER OF EACH OF THOSE TIME UNITS AND ITS CORRESPONDENT SCHEDULED RECEIPT QTY. PER UNIT TIME.

** SAFETY STOCK INFORMATION **

USERS HAVE THE OPTION OF INTRODUCING DATA OF SAFETY STOCK OF END-PRODUCT(S) AND/OR OF 'COMPONENT' ITEMS.

** SAFETY TIME INFORMATION **

USERS HAVE THE OPTION OF INTRODUCING DATA OF SAFETY TIME OF END-PRODUCT(S) AND/OR OF 'COMPONENT' ITEMS.

Figure 4.2. (Cont....)

** BATCHING RULE INFORMATION **

USERS MAY USE A PARTICULAR BATCHING RULE FOR EACH ITEM OR THE SAME BATCHING RULE FOR ALL ITEMS OF THE B.O.M. THE FOLLOWING OPTIONS OF BATCHING RULES ARE INCLUDED IN THE PACKAGE :

(1) LOT-FOR-LOT
(2) FIXED ORDER QUANTITY
(3) FIXED PERIOD REQUIREMENTS
(4) ECONOMIC ORDER QUANTITY (EOQ)
(5) ECONOMIC TIME CYCLE (ETC)
(6) LEAST-UNIT COST (LUC)
(7) LEAST-TOTAL COST (LTC) (PART PERIOD ALGORITHM) (ORLICKY'S VERSION)
(8) LEAST TOTAL COST (LTC) (PART PERIOD ALGORITHM) (NEW'S VERSION)

USERS ARE OFFERED THE OPTION OF PRINTING OUT A DESCRIPTION OF ANY OF THE ABOVE RULES.

** INVENTORY COST INFORMATION **

FOR ITEMS BATCHED USING THE LOT-LOT, THE FIXED ORDER QTY. OR THE FIXED PERIOD REQ'S RULE, INVENTORY COST ANALYSES MAY BE OBTAINED IF THE FOLLOWING COST INFORMATION IS AVAILABLE FOR THE ITEM :

(1) COST OF PLACING A REPLENISHMENT ORDER (OR SET-UP COST/BATCH).
(2) PURCHASE (OR WORKS PRIME) COST/UNIT.
(3) HOLDING INTEREST RATE PER ANNUM EXPRESSED AS A % OF THE PURCHASE (OR WORKS PRIME) COST/UNIT.

FOR ITEMS BATCHED USING THE EOQ, THE ETC, THE LUC, OR THE LTC RULE, THE ABOVE-MENTIONED COST INFORMATION IS REQ'D FOR THE BATCHING PROCESS ITSELF AND FOR OBTAINING INVENTORY COST ANALYSES.

THE MAIN OUTPUTS OF THE PROGRAM ARE THE PLANNED BATCHES FOR EACH ITEM, BATCHED ACCORDING TO THE SPECIFIED BATCHING RULE; THIS IS, WHAT TO PRODUCE OR ORDER FROM A SUPPLIER, HOW MANY AND WHEN, IN ORDER TO MEET A GIVEN MASTER PRODUCTION SCHEDULE FOR THE END-PRODUCT(S).
THE PROGRAM ALSO PRINTS OUT INVENTORY COST ANALYSES WHICH INCLUDE :

(1) FORECAST INVENTORY COST FOR EACH ITEM THROUGHOUT THE PLAN'G HORIZON.

(2) PLANNED INVENTORY COST OF EACH ITEM AT THE END OF THE 'CURRENT' PLAN'G PERIOD.

(3) CUMULATIVE TOTAL ACTUAL INVENTORY COSTS.

(4) ACTUAL STOCK VALUE AT THE BEGINNING OF THE PLAN'G HORIZON.

Figure 4.2. (Cont...)

IN ADDITION TO THIS, USERS HAVE THE OPTION OF RUNNING THE PROGRAM TO PRODUCE THE FOLLOWING OUTPUTS:

(A) EXPLOSION OF THE BILL OF MATERIAL FOR THE END-PRODUCT(S).

(B) GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF END-PRODUCT(S).

(C) SUMMARY OF THE PLANNED BATCHES OF EACH ITEM THROUGHOUT THROUGHOUT THE PLAN'G HORIZON.

(D) SUMMARY OF THE PLANNED STOCK ON HAND OF EACH ITEM AND TOTAL PLANNED STOCK VALUE THROUGHOUT THE PLAN'G HORIZON.

USERS HAVE THE OPTION OF RE-RUNNING THE PROGRAM CHANGING SOME DATA OR MOVING AHEAD PERIOD-BY-PERIOD IN THE PLANNING HORIZON.

USERS HAVE THE OPTION OF RUNNING THE PACKAGE USING PROGRAMMED DATA WHICH ARE INCLUDED IN THE PACKAGE. THIS MEANS THAT THE USER CAN GENERATE ALL THE SYSTEM OUTPUTS AND ANALYSE THE EFFECTS OF CHANGING PARAMETERS WITHOUT HAVING TO INPUT ANY DATA.

IN THE PLANNING HORIZON.

NOW, LET'S BEGIN.

PLEASE TYPE IN YOUR ANSWER ACCORDING TO THE INSTRUCTIONS.
IF YOU NEED AN EXPLANATION ABOUT ANY ENQUIRY FROM THE PROGRAM, TYPE 'HELP' AFTER THE CORRESPONDING QUES. MARK.
BE SURE TO PRESS THE 'RETURN KEY' AFTER EACH ANSWER.

4.3. Instructions to input data into the MRP package

As it was mentioned in chapter 3, the data required by the material requirements planning package are stored in three different files:

- Bill of material file
- Inventory record file
- Master production schedule and scheduled receipts file

Every time the MRP system is used with a new set of data, it is necessary to create the above mentioned three files while running tha package. On the other hand, if the MRP system is used with data previously stored in files, the user only has to input into the computer the name of each file and the system will retrieve the stored information from the files to generate the requirements plan, In both cases, the user has the opportunity of listing the contents of each file to check the information and, if necessary, to change any data.

A user running the package with bill of material data previously stored in a file is offered the option of inputing new data into the inventory record file and/or the master production schedule and scheduled receipts file. In this way, the user can generate requirements plans under different conditions for the same product structure.

When the system is run using the programmed data option, the user has still to create the mentioned three files, so that the package transfers the programmed data into the respective user's file. The user may list the contents of each file and change any data before generating the requirements plan.

The way of introducing the data into the MRP system is now explained in detail with the aid of computer print out as produced by MARPLA.

4.3.1. Input of the structure of the bill of material information

The data of the structure of the bill of material required by the package are the following:

(i) Number of end-products

(ii) The end-product code-numbers

(iii) The highest code-number in the bill(s) of material of the end-product(s)

(iv) The highest level number of the bill(s) of material

(v) For each item, it is required to input its total number of component items and their respective quantities per unit of parent item

When preparing the bill of material of the end-products, the user should consider the following conditions required by the package:

(a) Coding system

The code-numbers of the items included in the bill(s) of material of the end-product(s) should be successive numbers from "2" (inclusive) to a maximum of 20.

(b) Levels

The levels of the bill(s) of material should be numbered from top to bottom, beginning with level "0" for the end-product(s). The package has been designed to allow a maximum of 10 levels to be fed into the computer.

The illustrative example shown in Figure 4.3 will be used to demonstrate how to input the data into the computer. The inventory data of each item of the product structure shown in Figure 4.3 are given in the table of Figure 4.4. The introduction of the bill of material data into the system is shown in the print out of Figure 4.5.

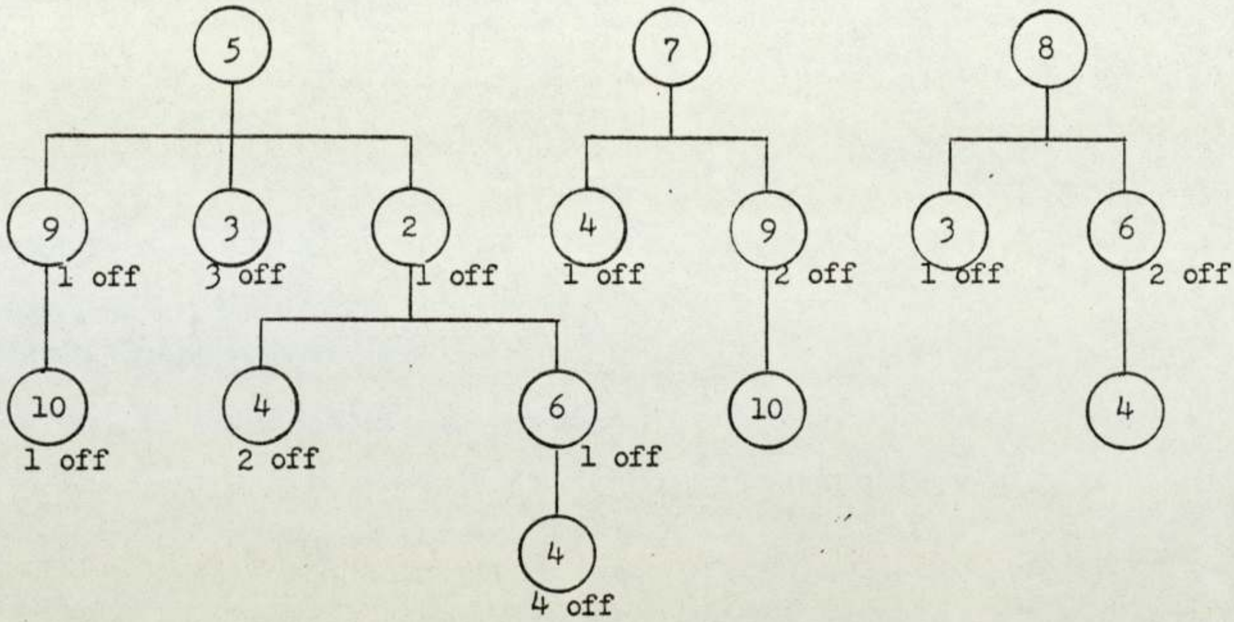


Figure 4.3. Illustrative example of bill of material

ITEM CODE NO.	STOCK ON HAND	SAFETY STOCK	LEAD TIME (week)	SAFETY TIME (week)	BATCHING RULE	SET-UP COST	ANNUAL INVENTORY HOLDING RATE (%)	PURCHASE COST / UNIT
2	120	0	2	1	LUC	100	30	20
3	300	300	5	1	LTC	50	10	20
4	500	0	2	0	EOQ	130	25	25
5	100	80	3	0	LOTLOT	100	20	30
6	300	0	1	0	LUC	30	25	10
7	200	80	2	0	LOTLOT	80	30	58
8	350	80	3	0	LOTLOT	60	25	12
9	300	0	1	0	ETC	140	20	35
10	300	0	4	0	LOTLOT	40	20	5

Figure 4.4. Inventory data of the items involved in the bill of material of Figure 4.3.

Figure 4.5. Input of bill of material data

```
GET-MARPLA
RUN
MARPLA

MATERIAL REQUIREMENTS PLANNING SYSTEM
-------- ------------ -------- ------

DO YOU NEED HELP ?
YOUR REPLY ('YES' OR 'NO') ?NO

PLEASE TYPE IN YOUR ANSWER ACCORDING TO THE INSTRUCTIONS.
IF YOU NEED AN EXPLANATION ABOUT ANY ENQUIRY FROM THE
PROGRAM, TYPE 'HELP' AFTER THE CORRESPONDING QUES. MARK.
BE SURE TO PRESS THE 'RETURN KEY' AFTER EACH ANSWER.


INPUT OF THE STRUCTURE OF THE BILL OF MATERIAL INFORMATION
----- -- --- --------- -- --- ---- -- -------- -----------


YOU HAVE THE FOLLOWING OPTIONS TO INPUT YOUR DATA:

   (1) TO INPUT YOUR DATA FROM THE TERMINAL AND TO STORE THEM
       IN A BILL OF MATERIAL FILE.

   (2) TO USE YOUR DATA IN A BILL OF MATERIAL FILE
       PREVIOUSLY STORED BY MEANS OF THIS PROGRAM.

   (3) TO USE PROGRAMMED DATA.

YOUR OPTION ('1','2' OR '3') ?1

WHAT NAME DO YOU WANT TO GIVE TO YOUR BILL OF MATERIAL
FILE ( ANY NAME WITH MAXIMUM 6 CHARACTERS )

YOUR ANSWER ?BOMSTR


HOW MANY END-PRODUCTS DO YOU HAVE ?3


PLEASE, TYPE IN THE CODE-NUMBER(S) OF THE END-PRODUCT(S)
AFTER EACH QUES.MARK.

?5
?7
?8


WHAT IS THE HIGHEST CODE-NUMBER IN THE BILL(S) OF MATERIALS
OF THE END-PRODUCT(S).?10
```

Figure 4.5. (Cont....)

```
WHAT IS THE HIGHEST LEVEL NO. OF THE BILL(S) OF MATERIALS ?3


FOR EACH ITEM, TYPE IN THE FOLLOWING INFORMATION :

   (1) THE TOTAL NUMBER OF COMPONENTS. (IF NONE, TYPE '0')

   (2) EACH 'COMPONENT' CODE-NUMBER AND ITS QTY. REQ'D
       PER UNIT OF 'PARENT'.


*ITEM CODE-NUMBER  2
 NUMBER OF 'COMPONENTS' ?2


     'COMPONENT' CODE-NUMBER ?4
      QUANTITY REQUIRED ?2

     'COMPONENT' CODE-NUMBER ?6
      QUANTITY REQUIRED ?1

*ITEM CODE-NUMBER  3
 NUMBER OF 'COMPONENTS' ?0


*ITEM CODE-NUMBER  4
 NUMBER OF 'COMPONENTS' ?0


*ITEM CODE-NUMBER  5
 NUMBER OF 'COMPONENTS' ?3


     'COMPONENT' CODE-NUMBER ?3
      QUANTITY REQUIRED ?3

     'COMPONENT' CODE-NUMBER ?9
      QUANTITY REQUIRED ?1

     'COMPONENT' CODE-NUMBER ?2
      QUANTITY REQUIRED ?1

*ITEM CODE-NUMBER  6
 NUMBER OF 'COMPONENTS' ?1


     'COMPONENT' CODE-NUMBER ?4
      QUANTITY REQUIRED ?4

*ITEM CODE-NUMBER  7
 NUMBER OF 'COMPONENTS' ?2


     'COMPONENT' CODE-NUMBER ?4
      QUANTITY REQUIRED ?1

     'COMPONENT' CODE-NUMBER ?9
      QUANTITY REQUIRED ?2
```

Figure 4.5. (Cont....)

```
*ITEM CODE-NUMBER  8
 NUMBER OF 'COMPONENTS' ?2


     'COMPONENT' CODE-NUMBER ?3
      QUANTITY REQUIRED ?1

     'COMPONENT' CODE-NUMBER ?6
      QUANTITY REQUIRED ?2

*ITEM CODE-NUMBER  9
 NUMBER OF 'COMPONENTS' ?1


     'COMPONENT' CODE-NUMBER ?10
      QUANTITY REQUIRED ?1

*ITEM CODE-NUMBER  10
 NUMBER OF 'COMPONENTS' ?0
```

After introducing the product structure data, the user has the option of printing out the explosion of the bill of material, that is, a matrix that shows the component item of each parent item and their respective quantities required per unit of parent item. The explosion of the bill of material gives the user the opportunity of checking the data corresponding to the product structure and of changing them if they have not been correctly input. Figure 4.6 shows the computer print out of the explosion of the bill of material of the illustrative example of Figure 4.3.

Figure 4.6. Print out of the explosion of the bill of material

```
DO YOU WANT AN EXPLOSION OF THE B.O.M. FOR THE END-PRODUCT ?
(IT ALLOWS YOU TO CHECK YOUR DATA AND TO CHANGE THEM IF
THEY ARE NOT CORRECT).

YOUR REPLY (ANSWER 'YES' OR 'NO') ?YES

**** EXPLOSION OF THE B.O.M. FOR THE END-PRODUCT ****

             COMPONENT ITEMS
              2  3  4  5  6  7  8  9  10

   PARENT  2  0  0  2  0  1  0  0  0  0
   ITEMS
           3  0  0  0  0  0  0  0  0  0

           4  0  0  0  0  0  0  0  0  0

           5  1  3  0  0  0  0  0  1  0

           6  0  0  4  0  0  0  0  0  0

           7  0  0  1  0  0  0  0  2  0

           8  0  1  0  0  2  0  0  0  0

           9  0  0  0  0  0  0  0  0  1

          10  0  0  0  0  0  0  0  0  0

ARE YOUR DATA CORRECT. (ANSWER 'YES' OR 'NO') ?YES
```

4.3.2. Input of stock-on-hand information

The user is required to input into the system the stock-on-hand of each inventory item available at the beginning of the current (earliest) planning period.

The print out of Figure 4.7 illustrates the way of introducing the stock-on-hand data of the items of the example of Figure 4.3 (see table of Figure 4.4).

Figure 4.7. Input of stock-on-hand data

```
INPUT OF INVENTORY DATA INFORMATION
----- -- --------- ---- -----------

WHAT NAME DO YOU WANT TO GIVE TO YOUR INVENTORY RECORD
FILE ( ANY NAME WITH MAXIMUM 6 CHARACTERS )

YOUR ANSWER ?INVRE


INPUT OF STOCK-ON-HAND OF EACH ITEM AT THE BEGINNING
----- -- ----- -- ---- -- ---- ---- -- --- ---------

          OF THE 'CURRENT' PLANNING PERIOD
          -- ---  -------  -------- ------


PLEASE, TYPE IN THE STOCK-ON-HAND OF EACH ITEM, AT THE
BEGINNING OF THE 'CURRENT' PLANNING PERIOD, AFTER EACH QUES.MARK.


    ITEM       STOCK ON
 CODE NUMBER     HAND

     2          ?120
     3          ?300
     4          ?500
     5          ?100
     6          ?300
     7          ?200
     8          ?350
     9          ?300
     10         ?300
```

4.3.3. Input of safety stock information

Users are offered the option of introducing data of safety stock for each item. Safety stock is entered as a constant quantity for each inventory item.

Figure 4.8 shows the print out of the input of safety stock data for the items of the example of Figure 4.3 (see table in Figure 4.4.).

Figure 4.8. Input of safety stock data

```
INPUT OF SAFETY STOCK INFORMATION
----- -- ------ ----- -----------


DO YOU WANT TO INPUT DATA OF SAFETY STOCK ?
YOUR REPLY (ANSWER 'YES' OR 'NO') ?YES

PLEASE, TYPE IN THE SAFETY STOCK OF EACH ITEM AFTER EACH QUES.MARK.
(IF NONE, TYPE '0')


    ITEM         SAFETY
 CODE-NUMBER     STOCK

      2            ?0
      3            ?300
      4            ?0
      5            ?80
      6            ?0
      7            ?80
      8            ?80
      9            ?0
      10           ?0
```

4.3.4. Input of lead time information

The user should feed into the package the lead time of each inventory item included in the bill of material. Lead times are introduced as constant quantities. The unit of measuring time of lead time durations should be specified by the user.

Figure 4.9 shows the print out of the input of lead time data of the items of the example of Figure 4.3 (see table in Figure 4.4).

Figure 4.9. Input of lead time data

```
INPUT OF LEAD-TIME OF EACH ITEM INFORMATION
----- -- ---- ---- -- ---- ---- -----------


LIMIT TO A MAXIMUM OF 6 CHARACTERS, SPECIFY UNIT OF MEASUREMENT
OF TIME OF LEAD-TIME DURATIONS. (E.G. 'WEEK', 'MONTH', 'PERIOD', ETC.)

YOUR REPLY ?WEEK

TYPE IN THE LEAD-TIME DURATIONS OF EACH ITEM, AFTER EACH
QUESTION MARK.

    ITEM       LEAD-TIME
 CODE-NUMBER    (WEEK)
     2           ?2
     3           ?5
     4           ?2
     5           ?3
     6           ?1
     7           ?2
     8           ?3
     9           ?1
     10          ?4
```

4.3.5. Input of safety time information

Users may input data of safety time for each inventory item that makes up the bill of material for the end product. Safety times are introduced as constant quantities and their unit of measure of time should be the same unit specified for lead time durations.

The computer print out of Figure 4.10 illustrates the introduction of safety time data into the MRP system (see table in Figure 4.4).

Figure 4.10. Input of safety time data

```
INPUT OF SAFETY TIME INFORMATION
----- -- ------ ---- -----------


DO YOU WANT TO INPUT DATA OF SAFETY TIME ?
YOUR REPLY (ANSWER 'YES' OR 'NO') ?YES

PLEASE, NOTE THAT THE UNIT OF MEASURE OF TIME OF THE
SAFETY TIME IS THE SAME UNIT SPECIFIED FOR LEAD-TIME DURATIONS.
IN YOUR CASE, IT IS WEEK.

TYPE IN THE SAFETY TIME OF EACH ITEM AFTER EACH QUES.MARK.
(IF NONE, TYPE '0')


     ITEM         SAFETY-TIME
  CODE-NUMBER       (WEEK)
      2              ?1
      3              ?1
      4              ?0
      5              ?0
      6              ?0
      7              ?0
      8              ?0
      9              ?0
      10             ?0
```

4.3.6. Input of planning horizon information

The information requested by the package in relation to the planning horizon is the number of the current (earliest) planning period and the total number of periods covered by the planning horizon. The package has been designed to allow a maximum of 25 planning periods to be fed into the computer.

The unit of measure of time of the planning periods should be the same unit for lead time durations, previously specified by the user.

Since the planning horizon should be long enough to cover the longest composite lead time, the system calculates such lead time before the user input the planning horizon span data. Then, the system checks whether the total number of planning periods covers the longest composite lead time. If it is not so, the planning horizon length should be increased at least to equal the mentioned lead time.

The user should also input the number of planning periods that there are in a year.

Figure 4.11 illustrates the planning horizon span corresponding to the example of Figure 4.3. The way of introducing these data into the system is shown in the print out of Figure 4.12.

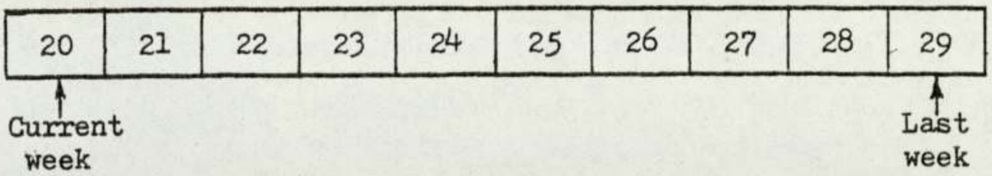


Figure 4.11. Planning horizon span

Figure 4.12. Input of planning horizon data

```
INPUT OF THE PLANNING HORIZON INFORMATION
----- -- --- -------- ------- -----------


PLEASE, NOTE THAT THE UNIT OF MEASURE OF TIME OF THE
PLAN'G HORIZON IS THE SAME UNIT SPECIFIED FOR
LEAD-TIME DURATIONS. IN YOUR CASE, IT IS WEEK.

THE PLAN'G HORIZON SHOULD AT LEAST EQUAL THE LONGEST COMPOSITE
LEAD-TIME OF THE END-PRODUCT(S), WHICH IS EQUAL TO  9     WEEKS.

THE PLAN'G HORIZON SPAN IS THE SAME FOR ALL THE END-PRODUCTS.


WHAT IS THE NUMBER OF THE 'CURRENT' WEEK ?20

HOW MANY WEEKS DOES THE PLANNING HORIZON COVER ?10


THEN,THE PLANNING HORIZON'S 'CURRENT' WEEK IS WEEK  20
     THE PLANNING HORIZON'S 'LAST' WEEK IS WEEK  29


HOW MANY WEEKS ARE THERE IN A YEAR ?52
```

4.3.7. Input of batching rule information

Users are given the option of choosing a particular batching rule for each inventory item, or, the same batching rule for all items of the bill of material. The following eight options are included in the package to select the batching rules of the items:

(1) Lot-for-lot
(2) Fixed-order quantity
(3) Fixed-period requirements
(4) Economic order quantity (EOQ)
(5) Economic time cycle (ETC)
(6) Least unit cost (LUC)
(7) Least total cost (LTC) (Part period algorithm) (Orlicky's version) (1)
(8) Least total cost (LTC) (Part period algorithm) (New's version) (3)

Built into the package there is the facility of printing a description followed by an example of any of the above batching rules as an aid for the user to understand the basic principles of each rule.

The computer print out of Figure 4.13 illustrates the introduction of the batching rule data for the items of the example of Figure 4.3 (see table in Figure 4.4).

The batching procedure followed by each rule is explained in Appendix I.

Figure 4.13. Input of batching rule information

```
SELECTION OF BATCHING RULES
--------- -- -------- -----

* OPTIONS FOR BATCHING POLICY:

   (1) USE OF THE SAME BATCHING RULE FOR ALL ITEMS OF THE
       BILL(S) OF MATERIALS OF THE END-PRODUCT(S).

   (2) USE OF DIFFERENT BATCHING RULES FOR THE ITEMS OF THE
       BILL(S) OF MATERIALS OF THE END-PRODUCT(S).

YOUR OPTION ('1' OR '2') ?2


* OPTIONS OF BATCHING RULES:

YOU HAVE THE FOLLOWING OPTIONS TO CHOOSE THE BATCHING RULE(S)
OF THE ITEMS:

   (1) LOT-FOR-LOT
   (2) FIXED ORDER QUANTITY
   (3) FIXED PERIOD REQUIREMENTS
   (4) ECONOMIC ORDER QUANTITY (EOQ)
   (5) ECONOMIC TIME CYCLE (ETC)
   (6) LEAST-UNIT COST (LUC)
   (7) LEAST-TOTAL COST (LTC) (PART-PERIOD ALGORITHM)
       (ORLICKY'S VERSION)
   (8) LEAST-TOTAL COST (LTC) (PART-PERIOD ALGORITHM)
       (NEW'S VERSION)

DO YOU WANT A DESCRIPTION OF ANY OF THE ABOVE BATCHING RULES ?

YOUR REPLY ('YES' OR 'NO') ?NO


TYPE IN YOUR OPTION OF EACH BATCHING RULE FOR EACH ITEM
AFTER EACH QUES.MARK.

       ITEM          OPTION OF
   CODE-NUMBER    BATCHING RULE
        2               ?6
        3               ?8
        4               ?4
        5               ?1
        6               ?6
        7               ?1
        8               ?1
        9               ?5
        10              ?1
```

4.3.8. Input of inventory cost information

For items batched according to the EOQ, the ETC, the LUC or the LTC batching rules, inventory cost data are required to carry out the batching process itself and also, to print out inventory cost analyses. When the lot-for-lot, the fixed-order quantity or the fixed-period requirements batching rules are used, inventory cost data are not necessary for the batching process itself, but they may be input in order to print out inventory cost analyses.

The item inventory information required by the package is the following:

(i) Cost of placing a replenishment order or set-up cost per batch.

For bought-out items, this cost represents the total administrative cost of placing an order; while for internally manufactured components, this cost represents the set-up cost per batch. It is assumed that this cost is not a function of the size of the replenishment order or the batch.

(ii) Purchase (or works prime) cost per unit.

For bought-out components, this cost represents the total price paid by the company for the item; while for internally manufactured components, this cost represents the total works prime cost, that is, the cost of labour plus material plus works overheads.

(iii) Holding interest rate per annum.

The cost of storing inventory items is taken as a percentage of the purchase (or works prime) cost per unit. Usually, the annual holding inventory cost is between 20% and 30% of the purchase (or works prime) cost per unit.

Once the inventory cost data for all items have been input into the computer, they are printed out in a table so that the user can check the typed information before it is stored in the inventory record file.

The print out of Figure 4.14 shows the introduction of inventory cost data of the items of the example of Figure 4.3 (see table in Figure 4.4.) , and the option of listing the contents of the Inventory record file in order to check and/or correct the data.

Figure 4.14. Input of inventory cost data

```
INPUT OF COST INFORMATION
----- -- ---- -----------


FOR ITEMS BATCHED USING THE LOT-FOR-LOT OR THE FIXED ORDER
QTY. OR THE FIXED PERIOD REQ'S RULE, INVENTORY COST ANALYSES
CAN BE OBTAINED IF THE FOLLOWING COST INFORMATION IS AVAILABLE
FOR THE ITEM:

   (1) COST OF PLACING A REPLENISHMENT ORDER OR SET-UP COST/BATCH.

   (2) PURCHASE (OR WORKS PRIME) COST/UNIT.

   (3) HOLDING INTEREST RATE OR STORAGE COST PER ANNUM, EXPRESSED
       AS A PERCENTAGE OF THE PURCHASE (OR WORKS PRIME) COST
       (USUALLY 20-30% PER ANNUM).

FOR ITEMS BATCHED USING THE EOQ, THE ETC, THE LUC OR THE LTC
RULE, THE ABOVE-MENTIONED COST INFORMATION IS REQ'D FOR THE
BATCHING PROCESS ITSELF AND FOR OBTAINING INVENTORY COST ANALYSES.


PLEASE TYPE IN THE FOLLOWING COST DATA AFTER EACH QUES.MARK.
(TYPE 'HELP' FOR AN EXPLANATION OF THE TERMS).



** ITEM CODE-NO.  2

   SET-UP COST = ?100
   PURCHASE COST/UNIT = ?20
   ANNUAL HOLD'G INTEREST RATE (%) = ?30

** ITEM CODE-NO.  3

   SET-UP COST = ?50
   PURCHASE COST/UNIT = ?20
   ANNUAL HOLD'G INTEREST RATE (%) = ?10

** ITEM CODE-NO.  4

   SET-UP COST = ?130
   PURCHASE COST/UNIT = ?25
   ANNUAL HOLD'G INTEREST RATE (%) = ?25

** ITEM CODE-NO.  5

DO YOU WISH TO INPUT COST DATA ?
YOUR ANSWER ('YES' OR 'NO') ?YES

   SET-UP COST = ?100
   PURCHASE COST/UNIT = ?30
   ANNUAL HOLD'G INTEREST RATE (%) = ?20
```

Figure 4.14. (Cont...)

```
** ITEM CODE-NO.  6

   SET-UP COST = ?30
   PURCHASE COST/UNIT = ?10
   ANNUAL HOLD'G INTEREST RATE (%) = ?25

** ITEM CODE-NO.  7

DO YOU WISH TO INPUT COST DATA ?
YOUR ANSWER ('YES' OR 'NO') ?YES

   SET-UP COST = ?80
   PURCHASE COST/UNIT = ?58
   ANNUAL HOLD'G INTEREST RATE (%) = ?30

** ITEM CODE-NO.  8

DO YOU WISH TO INPUT COST DATA ?
YOUR ANSWER ('YES' OR 'NO') ?YES

   SET-UP COST = ?60
   PURCHASE COST/UNIT = ?12
   ANNUAL HOLD'G INTEREST RATE (%) = ?25

** ITEM CODE-NO.  9

   SET-UP COST = ?140
   PURCHASE COST/UNIT = ?35
   ANNUAL HOLD'G INTEREST RATE (%) = ?20

** ITEM CODE-NO.  10

DO YOU WISH TO INPUT COST DATA ?
YOUR ANSWER ('YES' OR 'NO') ?YES

   SET-UP COST = ?40
   PURCHASE COST/UNIT = ?5
   ANNUAL HOLD'G INTEREST RATE (%) = ?20
```

** INVENTORY COST DATA **

ITEM CODE-NO.	SET-UP COST/BATCH	PURCHASE COST/UNIT	ANNUAL HOLDING INTEREST RATE / UNIT	ANNUAL INVENTORY HOLDING COST / UNIT
2	100.000	20.000	0.3000	6.000
3	50.000	20.000	0.1000	2.000
4	130.000	25.000	0.2500	6.250
5	100.000	30.000	0.2000	6.000
6	30.000	10.000	0.2500	2.500
7	80.000	58.000	0.3000	17.400
8	60.000	12.000	0.2500	3.000
9	140.000	35.000	0.2000	7.000
10	40.000	5.000	0.2000	1.000

ARE YOUR INVENTORY COST DATA CORRECT ('YES' OR 'NO') ?YES

Figure 4.14. (Cont....)

```
DO YOU WANT TO LIST YOUR FILE INVRE ?
(BY LISTING YOUR FILE YOU CAN CHECK YOUR INVENTORY DATA AND
CHANGE THEM IF YOU WISH).

YOUR REPLY ('YES' OR 'NO') ?YES
```

** DATA IN THE INVENTORY RECORD FILE CALLED INVRE **

ITEM CODE NO.	STOCK ON HAND	SAFETY STOCK	LEAD TIME	SAFETY TIME	BATCHING RULE	SET-UP COST/ BATCH	INVENTORY HOLDING COST/UNIT & PERIOD
2	120	0	2	1	LUC	100.00	0.11538
3	300	300	5	1	LTC(NEW)	50.00	0.03846
4	500	0	2	0	EOQ	130.00	0.12019
5	100	80	3	0	LOTLOT	100.00	0.11538
6	300	0	1	0	LUC	30.00	0.04808
7	200	80	2	0	LOTLOT	80.00	0.33462
8	350	80	3	0	LOTLOT	60.00	0.05769
9	300	0	1	0	ETC	140.00	0.13462
10	300	0	4	0	LOTLOT	40.00	0.01923

```
* PLANNING HORIZON DATA :

NO. OF FIRST PLAN'G PERIOD =  20
NO. OF LAST PLAN'G PERIOD =   29
NO. OF WEEKS IN A YEAR =    52


DO YOU WANT TO CHANGE SOME DATA IN THE FILE INVRE ?

YOUR REPLY ('YES' OR 'NO') ?NO
```

4.3.9. Input of gross requirements schedule for the end-product information

The gross requirements schedule for the end-products is " the schedule of withdrawals from a stores point " and " includes demands which can be met from existing stocks " (3). The gross requirements schedule is based on forecasts of the demand and customer orders.

The MRP package includes two options for the introduction of the gross requirements schedule for the end-products. They are:

(1) Input a number of successive quantities per unit time of the planning horizon.

(2) Input a constant quantity per unit time throughout the planning horizon.

The design of the MRP package is such that the values involved in the gross requirements schedule should be kept between 0 and 9999.

Figure 4.15 shows the gross requirements schedules for the end-products of the example in Figure 4.3 according to the option 1. The introduction of these data into the computer is demonstrated in the print out of Figure 4.16.

Weeks

End-product	20	21	22	23	24	25	26	27	28	29
5	0	120	100	80	0	50	0	0	130	100
7	0	120	0	250	100	70	0	200	0	150
8	0	0	180	150	0	0	200	200	0	100

Figure 4.15. Example of gross requirements schedules for the end-products

Figure 4.16. Input of gross requirements data

```
INPUT OF M.P.S. AND SCHEDULED RECEIPTS INFORMATION
----- -- ------ --- --------- -------- -----------


WHAT NAME DO YOU WANT TO GIVE TO YOUR M.P.S. & SCHEDULED RECEIPTS
FILE ( ANY NAME WITH MAXIMUM 6 CHARACTERS )

YOUR ANSWER ?MPSCHE


INPUT OF THE GROSS REQUIREMENTS SCHEDULE FOR THE END-PRODUCT(S)
----- -- --- ----- ------------ -------- --- --- --- ----------

 ** INPUT OF G.R.S. FOR THE END-PRODUCT  5

 YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE GROSS REQUIREMENTS
 SCHEDULE FOR THE END-PRODUCT:

    (1) INPUT A NUMBER OF SUCCESSIVE QUANTITIES PER
        UNIT TIME OF THE PLANNING HORIZON.

    (2) INPUT OF A CONSTANT QUANTITY PER UNIT TIME.

 YOUR OPTION (ANSWER '1' OR '2') ?1

 TYPE IN THE G.R.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

        WEEK        QUANTITY

         20            ?0
         21            ?120
         22            ?100
         23            ?80
         24            ?0
         25            ?50
         26            ?0
         27            ?0
         28            ?130
         29            ?100
```

Figure 4.16. (Cont....)

```
** INPUT OF G.R.S. FOR THE END-PRODUCT  7

YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE GROSS REQUIREMENTS
SCHEDULE FOR THE END-PRODUCT:

   (1) INPUT A NUMBER OF SUCCESSIVE QUANTITIES PER
       UNIT TIME OF THE PLANNING HORIZON.

   (2) INPUT OF A CONSTANT QUANTITY PER UNIT TIME.

YOUR OPTION (ANSWER '1' OR '2') ?1

TYPE IN THE G.R.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

      WEEK        QUANTITY

       20            ?0
       21            ?120
       22            ?0
       23            ?250
       24            ?100
       25            ?70
       26            ?0
       27            ?200
       28            ?0
       29            ?150


** INPUT OF G.R.S. FOR THE END-PRODUCT  8

YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE GROSS REQUIREMENTS
SCHEDULE FOR THE END-PRODUCT:

   (1) INPUT A NUMBER OF SUCCESSIVE QUANTITIES PER
       UNIT TIME OF THE PLANNING HORIZON.

   (2) INPUT OF A CONSTANT QUANTITY PER UNIT TIME.

YOUR OPTION (ANSWER '1' OR '2') ?1

TYPE IN THE G.R.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

      WEEK        QUANTITY

       20            ?0
       21            ?0
       22            ?180
       23            ?150
       24            ?0
       25            ?0
       26            ?200
       27            ?200
       28            ?0
       29            ?100
```

4.3.10. Input of independent demand for component items information

The MRP system gives the user the opportunity of introducing data of independent (forecast) demand for component items. The following information, for each component item, should be fed into the computer:

(1) The total number of planning periods with independent demand throughout the planning horizon.

(2) The number of each of those planning periods and their corresponding independent demand quantity per unit time.

In the illustrative example of Figure 4.3, the component items 2 and 10 are subject to independent demand, which is shown in Figure 4.17. The computer print out of Figure 4.18 indicates the way of feeding this information into the system.

	Weeks									
Item	20	21	22	23	24	25	26	27	28	29
2									150	
10								350		

Figure 4.17. Example of item independent demand

Figure 4.18. Input of independent demand data

```
INPUT OF INDEPENDENT DEMAND QTY. PER UNIT TIME FOR 'COMPONENT' ITEMS
----- -- ----------- ------ ---  --- ---- ---- ---  --------- -----


DO YOU WANT TO INPUT DATA OF FORECASTS OF INDEPENDENT .
DEMAND FOR 'COMPONENT' ITEMS ?

YOUR REPLY (ANSWER 'YES' OR 'NO') ?YES
FOR EACH ITEM, TYPE IN THE FOLLOWING INFORMATION:
   (1) THE TOTAL NUMBER OF WEEKS OF THE PLANNING
       HORIZON WITH INDEPENDENT DEMAND. (IF NONE, TYPE '0')

   (2) THE NUMBER OF EACH OF THOSE WEEKS AND ITS
       CORRESPONDING FORECAST DEMAND, QTY. PER UNIT TIME.

*ITEM CODE-NUMBER  2
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?1
     NUMBER OF THE WEEK ?28
     INDEPENDENT DEMAND,QTY.PER WEEK ?150



*ITEM CODE-NUMBER  3
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?0


*ITEM CODE-NUMBER  4
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?0


*ITEM CODE-NUMBER  6
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?0


*ITEM CODE-NUMBER  9
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?0


*ITEM CODE-NUMBER  10
 TOTAL NUMBER OF WEEKS WITH INDEPENDENT DEMAND ?1
     NUMBER OF THE WEEK ?27
     INDEPENDENT DEMAND,QTY.PER WEEK ?350
```

4.3.11. Input of scheduled receipt information

Users should provide the MRP system with the following information in relation to the scheduled receipts for each inventory item:

(1) The total number of planning periods with scheduled receipts throughout the planning horizon.

(2) The number of each of those planning periods and their respective scheduled receipt quantity per unit time.

Figure 4.19 shows the scheduled receipts for each inventory item involved in the bill of material of Figure 4.3. The introduction of this information into the computer is demonstrated in the print out of Figure 4.20.

	Weeks									
Item no.	20	21	22	23	24	25	26	27	28	29
2										
3					390					
4	3070									
5		200	150							
6	210									
7			170							
8			200							
9	140									
10										

Figure 4.19. Example of item scheduled receipt data

Figure 4.20. Input of scheduled receipt data

```
INPUT OF SCHEDULED RECEIPTS OF EACH ITEM PER UNIT TIME
----- -- --------- -------- -- ---- ---- --- ---- ----

FOR EACH ITEM,PLEASE TYPE IN THE FOLLOWING INFORMATION:

   (1) THE TOTAL NUMBER OF WEEKS OF THE PLANNING HORIZON
       WITH SCHEDULED RECEIPTS. (IF NONE, TYPE'0')

   (2) THE NUMBER OF EACH OF THOSE WEEKS AND ITS
       CORRESPONDING SCHEDULED RECEIPTS.

*ITEM CODE NUMBER  2
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?0

*ITEM CODE NUMBER  3
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?24
     SCHEDULED RECEIPTS, QTY. PER WEEK?390

*ITEM CODE NUMBER  4
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?20
     SCHEDULED RECEIPTS, QTY. PER WEEK?3070

*ITEM CODE NUMBER  5
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?2
     NUMBER OF THE WEEK?21
     SCHEDULED RECEIPTS, QTY. PER WEEK?200
     NUMBER OF THE WEEK?22
     SCHEDULED RECEIPTS, QTY. PER WEEK?150

*ITEM CODE NUMBER  6
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?20
     SCHEDULED RECEIPTS, QTY. PER WEEK?210

*ITEM CODE NUMBER  7
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?22
     SCHEDULED RECEIPTS, QTY. PER WEEK?170

*ITEM CODE NUMBER  8
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?22
     SCHEDULED RECEIPTS, QTY. PER WEEK?200
```

Figure 4.20. (Cont....)

```
*ITEM CODE NUMBER  9
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?1
     NUMBER OF THE WEEK?20
     SCHEDULED RECEIPTS, QTY. PER WEEK?140


*ITEM CODE NUMBER  10
 TOTAL NUMBER OF WEEKS WITH SCHEDULED RECEIPTS ?0
```

4.3.12. Input of master production schedule for the end-products information

The master production schedule is a time-phased statement of what is actually expected to be produced at the finished product level and is based on the gross requirements schedule.

Two alternatives for developing the master production schedule are offered to the user by the MRP package. They are:

(1) The master production schedule(s) for the end-product(s) is generated by the package to satisfy, if possible, the gross requirements schedule. That is, the master production schedule is developed following the same netting and offseting for lead time procedures as for the generation of the planned batch schedule for the component items.In this case, if safety stock and/or safety time data have been specified for the end-products, they are taken into consideration in the netting and offseting for lead time processes,respectively.

(2) The master production schedule(s) for the end-product(s) is input by the user into the package. In this case, the user should develop the master production schedule taking into consideration any information concerning with the end-products, such as, safety stock, safety time and batching rule. The package calculates the planned stock-

on-hand in each period by adding any scheduled receipt and any planned production batch due for that period and substracting the gross requirements (if any) in the period in question.

The MRP package includes two options for the introduction of the master production schedule by the user. They are:

(i) Input a number of successive quantities to produce per unit time of the planning horizon.

(ii) Input a constant quantity to produce per unit time throughout the planning horizon.

As for the gross requirements schedule, the values involved in the master production schedule should be kept between 0 and 9999.

Figure 4.21 shows the master production schedule for the end-products of the example in Figure 4.3. The introduction of these data into the computer is shown in the print out of Figure 4.22.

	Weeks									
End-product	20	21	22	23	24	25	26	27	28	29
5	0	0	0	0	70	70	70	70	70	70
7	0	0	100	100	100	100	100	100	100	100
8	0	0	0	90	90	90	90	90	90	90

Figure 4.21. Example of master production schedules for the end-products

Figure 4.22. Input of master production schedule data

```
INPUT OF THE MASTER PRODUCTION SCHEDULE (MPS) FOR THE END-PRODUCT(S)
----- -- --- ------ ---------- -------- ----- --- --- --- ----------


YOU HAVE THE FOLLOWING OPTIONS IN RELATION TO THE M.P.S.

   (1) THE MPS FOR THE END-PRODUCT(S) IS GENERATED BY THE PACKAGE
       TO SATISFY, IF POSSIBLE, THE GROSS REQUIREMENTS SCHEDULE.
       THAT IS, THE GRS IS NETTED AGAINST STOCK-ON-HAND AND SCHEDULED
       RECEIPTS TO OBTAIN NET REQ'S WHICH ARE THEN OFFSET FOR LEAD TIME
       TO GENERATE PLANNED STARTS. FINALLY, A PREVIOUSLY SPECIFIED
       BATCHING RULE IS APPLIED TO THE PLANNED STARTS TO GENERATE MPS
       FOR THE END-PRODUCT IN QUESTION. IF SAFETY STOCK AND/OR SAFETY
       TIME HAVE BEEN SPECIFIED FOR THE END-PRODUCT, THEY ARE TAKEN INTO
       ACCOUNT IN THE NETTING AND OFFSETING FOR LEAD TIME PROCESSES
       RESPECTIVELY.

   (2) THE MPS FOR THE END-PRODUCT(S) IS INPUT BY THE USER.
       IN THIS CASE, SAFETY STOCK (IF ANY), SAFETY TIME (IF ANY) AND
       BATCHING RULE FOR THE END-PRODUCT IN QUESTION SHOULD BE TAKEN
       INTO ACCOUNT WHEN DEVELOPING THE MPS. THE PACKAGE CALCULATES THE
       PLANNED STOCK-ON-HAND IN EACH PERIOD BY ADDING ANY SCHEDULED
       RECEIPT AND ANY PLANNED PRODUCTION BATCH DUE TO THAT PERIOD
       AND SUBSTRACTING THE GROSS REQ'S IN THE PERIOD IN QUESTION.


PLEASE TYPE YOU OPTION ('1' OR '2') ?2

** INPUT OF M.P.S.FOR END-PRODUCT NUMBER  5

YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE MASTER PRODUCTION
SCHEDULE FOR THE END-PRODUCT:

   (1) INPUT OF A NUMBER OF SUCCESSIVE QUANTITIES TO PRODUCE PER
       UNIT TIME OF THE PLANNING HORIZON.

   (2) INPUT OF A CONSTANT QUANTITY TO PRODUCE PER UNIT TIME.

YOUR OPTION (ANSWER '1' OR '2') ?1

TYPE IN THE M.P.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

      WEEK        QUANTITY

       20           ?0
       21           ?0
       22           ?0
       23           ?0
       24           ?70
       25           ?70
       26           ?70
       27           ?70
       28           ?70
       29           ?70
```

Figure 4.22. (Cont....)

```
** INPUT OF M.P.S.FOR END-PRODUCT NUMBER  7

YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE MASTER PRODUCTION
SCHEDULE FOR THE END-PRODUCT:

   (1) INPUT OF A NUMBER OF SUCCESSIVE QUANTITIES TO PRODUCE PER
       UNIT TIME OF THE PLANNING HORIZON.

   (2) INPUT OF A CONSTANT QUANTITY TO PRODUCE PER UNIT TIME.

YOUR OPTION (ANSWER '1' OR '2') ?1

TYPE IN THE M.P.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

      WEEK        QUANTITY

       20            ?0
       21            ?0
       22            ?100
       23            ?100
       24            ?100
       25            ?100
       26            ?100
       27            ?100
       28            ?100
       29            ?100


** INPUT OF M.P.S.FOR END-PRODUCT NUMBER  8

YOU HAVE THE FOLLOWING OPTIONS TO ENTER THE MASTER PRODUCTION
SCHEDULE FOR THE END-PRODUCT:

   (1) INPUT OF A NUMBER OF SUCCESSIVE QUANTITIES TO PRODUCE PER
       UNIT TIME OF THE PLANNING HORIZON.

   (2) INPUT OF A CONSTANT QUANTITY TO PRODUCE PER UNIT TIME.

YOUR OPTION (ANSWER '1' OR '2') ?1

TYPE IN THE M.P.S. QUANTITY PER UNIT TIME AFTER EACH QUESTION MARK

      WEEK        QUANTITY

       20            ?0
       21            ?0
       22            ?0
       23            ?90
       24            ?90
       25            ?90
       26            ?90
       27            ?90
       28            ?90
       29            ?90
```

Figure 4.22. (Cont....)

DO YOU WANT TO LIST YOUR M.P.S. AND SCHEDULED RECEIPTS FILE MPSCHE?
(BY LISTING YOUR FILE YOU CAN CHECK YOUR DATA AND CHANGE THEM
IF YOU WISH).

YOUR REPLY ('YES' OR 'NO') ?YES

** DATA IN THE M.P.S. AND SCHEDULED RECEIPTS FILE CALLED MPSCHE **

G.R.S. FOR THE END-PRODUCT(S)

UNIT TIME	20	21	22	23	24	25	26	27	28	29
END-PRODUCT CODE-NO.										
5	0	120	100	80	0	50	0	0	130	100
7	0	120	0	250	100	70	0	200	0	150
8	0	0	180	150	0	0	200	200	0	100

INDEPENDENT DEMAND OF COMPONENT ITEMS

UNIT TIME	20	21	22	23	24	25	26	27	28	29
ITEM CODE-NUMBER										
2	0	0	0	0	0	0	0	0	150	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	350	0	0

SCHEDULED-RECEIPTS OF EACH ITEM

UNIT TIME	20	21	22	23	24	25	26	27	28	29
ITEM CODE-NUMBER										
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	390	0	0	0	0	0
4	3070	0	0	0	0	0	0	0	0	0
5	0	200	150	0	0	0	0	0	0	0
6	210	0	0	0	0	0	0	0	0	0
7	0	0	170	0	0	0	0	0	0	0
8	0	0	200	0	0	0	0	0	0	0
9	140	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0

Figure 4.22. (Cont....)

M.P.S. FOR THE END-PRODUCT(S)

UNIT TIME	20	21	22	23	24	25	26	27	28	29
END-PRODUCT CODE-NO.										
5	0	0	0	0	70	70	70	70	70	70
7	0	0	100	100	100	100	100	100	100	100
8	0	0	0	90	90	90	90	90	90	90

DO YOU WANT TO CHANGE SOME DATA IN THE FILE MPSCHE ?

YOUR REPLY ('YES' OR 'NO') ?NO

REQUIREMENTS GENERATION PROCESS IN PROGRESS

4.4. File updating

Once the requirements plans for all items of a given bill of material and the other output reports have been printed out by the system, two options to re-run the package are offered:

(1) Changing the file contents.

(2) Re-generating the requirements plan moving one period ahead in the planning horizon.

If the first option is chosen, the user may change any data of the inventory record file, or the master production schedule and scheduled receipts file, or both, or the bill of material file, before the requirements generation process is carried out. In all cases, the user may list the contents of the file to check the information.

Figure 4.23 shows the file updating options as printed out by the MRP package MARPLA.

Figure 4.23. Print out of the file updating options

```
DO YOU WANT ANOTHER SIMULATION ?
YOUR REPLY (ANSWER 'YES' OR 'NO') ?YES

OPTIONS FOR ANOTHER SIMULATION:

   (1) CHANGING ALL OR SOME OF YOUR DATA.
   (2) RE-GENERATING THE REQ'S PLAN MOVING ONE WEEK AHEAD IN
       THE PLANNING HORIZON.

YOUR OPTION ('1' OR '2') ?1

OPTIONS FOR ANOTHER SIMULATION CHANGING YOUR DATA :

   (1) WITH COMPLETE NEW DATA.
   (2) CHANGING DATA OF THE INVENTORY RECORD FILE.
   (3) CHANGING DATA OF THE M.P.S. & SCHEDULED RECEIPTS FILE.
   (4) CHANGING DATA OF THE INV.REC. FILE AND THE M.P.S. &
       SCHEDULED RECEIPTS FILE.
   (5) CHANGING DATA OF THE B.O.M FILE.

YOUR OPTION ('1','2',....,'5') ?3



** DATA IN THE M.P.S. AND SCHEDULED RECEIPTS FILE CALLED MPSCHE **



PLEASE SPECIFY WHICH DATA YOU WISH TO CHANGE :

   (1) GROSS REQUIREMENTS SCHEDULE FOR THE END-PRODUCT(S);
   (2) INDEPENDENT DEMAND OF COMPONENT ITEMS;
   (3) SCHEDULED RECEIPTS OF EACH ITEM;
   (4) MPS FOR THE END-PRODUCT(S).

YOUR OPTION ('1','2','3' OR '4') ?3

PLEASE TYPE IN THE ITEM CODE-NUMBER WHOSE SCHEDULED RECEIPTS WILL
BE CHANGED ?3
```

4.5. Requirements re-generation

The user may re-run the MRP package to re-generate the requirements plan and the other output reports moving forward period-by-period in the planning horizon. In this case, the mature planned batches are automatically released by the system and transformed into scheduled receipts, and the stock-on-hand of each item at the beginning of the new current period is updated by the system. The user has the opportunity of changing any data of the master production schedule and scheduled receipts file before the re-planning process is carried out.

4.6. Ending the program

There are two different ways of ending the program:

(1) By answering negatively to the question if another simulation is wished after the overall requirements plan have been printed out.

(2) By pressing the "Break" key in the computer terminal at any stage of the program.

CHAPTER 5

OUTPUTS OF THE MATERIAL REQUIREMENTS PLANNING SYSTEM

The main outputs of the material requirements planning system MARPLA are the planned batches, batched according to the specified batching rule, for each inventory item involved in a given bill of material; that is, what to produce or order from a supplier, how many and when, in order to meet a determined master production schedule for the end-product.

For each inventory item, the package prints out a table containing the following information in each planning period:

1. Gross requirements at the mid-point of each planning period

2. Physical stock-on-hand at the end of each planning period

3. Planned stock-on-hand at the end of each planning period

4. Scheduled receipts at the mid-point of each planning period

5. Net requirements at the mid-point of each planning period

6. Planned starts at the mid-point of each planning period

7. Planned batches at the mid-point of each planning period

The physical stock-on-hand throughout the planning horizon is calculated on the basis that no orders will be placed to cover the net requirements; while the planned stock-on-hand is computed assuming that the planned orders determined by the MRP system will be completed as projected, the scheduled receipts will be received as predicted and stock will be disbursed as planned.

In the requirements generation process for each inventory item, the planned starts are determined by offseting for the lead time and the safety time (if any) the net requirements; while the planned batches are determined by applying the specified batching rule to the planned starts.

The package prints out the tables containing the mentioned information for each inventory item in the order determined by the position of the items in the bill of material once the low-level coding process has been carried out. In this way, the table corresponding to a given component item will be printed out after the table(s) for its parent item(s) has been printed out.

Each table has a heading which includes data such as lead time, stock-on-hand, safety stock, safety time and batching rule for the item in question.

The package offers the option of printing out the requirements plan either for all the items involved in the bill of material or for particular items specified by the user.

For printing out purposes, the design of the package is such that the values of the quantities involved in the requirements plan tables should be in the range 0 - 9999. However, if there were a case where the figures involved in the requirements plans were greater than 9999, it would be simple to modify the package to allow figures with more than four digits to be display in the tables.

The timing convention adopted by the package for the offsetting for lead time process is the mid-point convention. In the event that for a given item its net requirements cannot be offset for the lead time and safety time (if specified), the following successive steps are carried out by the MRP package:

(1) Firstly, the package tries to cover the net requirements in the period in question using the safety stock (if any). If the safety stock can be used in order to cover the net requirements, a message will be printed immediately below the table corresponding to the item, specifying the planning period(s) in which the safety stock has been entirely or partially used to cover the net requirements.

If the safety stock (if any) cannot cover the net requirements in the period(s) in question, the second step is carried out by the package.

(2) Secondly, the package tries to offset the net requirements only for the lead time. That is, the safety time (if specified) is not used in the offsetting process. In this case, a message will

be printed immediately below the table corresponding to the item in question, specifying the planning period(s) in which the net requirements have been offset only for the lead time.

If the net requirements in the period(s) in question cannot be offset even for the lead time, the third step is carried out.

(3) Thirdly, if the net requirements in a given planning period cannot be offset for the lead time and the safety time (if specified); and cannot be covered by the safety stock (if any); and cannot be offset for the lead time alone, then the net requirements are not offset at all, and a message will be printed out immediately below the table corresponding to the item in question, specifying the planning period(s) in which the net requirements cannot be offset for the lead time and the time within which they need to be expedited.

Once the requirements generation process has been completed and the requirements plans have printed out, the package gives the user the option of printing out various MRP reports, including inventory cost analyses for those items for which inventory cost data have been supplied to the computer. By offering the displaying of the different output reports as options, the package allows the user to print out only those reports that have interest for analysis and decision-making purposes. A description of the reports is given below.

First, the package prints out forecast inventory cost analyses for each item, which include total inventory cost, total set-up cost and total inventory holding cost throughout the planning horizon. The forecast total inventory holding cost is calculated by multiplying the inventory holding cost per unit and per period by the planned stock-on-hand at the end of each planning period. (The planned stock-on-hand at the end of each planning period is calculated assuming that the planned batches included in the requirements plan of each item will be released when they become mature and will be completed on the date established by the system, that the scheduled receipts will arrive into stock as planned and the stock will be disbursed as projected). If there is stock-on-hand at the end of the last planning period, it is considered that this stock will be carried for one period in order to calculate its corresponding inventory holding cost. The forecast total set-up cost is calculated by multiplying the total number of planned batches in the planning horizon by the set-up cost of the item. The sum of these two forecast costs gives the forecast total inventory cost for each item.

Second, the package prints out planned inventory cost analyses for each item at the end of the current planning period, assuming that stock will be disbursed and orders will be received as predicted by the system. This report includes inventory holding cost corresponding to the stock-on-hand at the end of the current planning period, set-up cost if a planned batch is to be released in that period and total inventory cost.

Third, if the requirements plan is re-generated moving forward period-by-period in the planning horizon, the package prints out the cumulative total actual inventory costs over the periods previous to the current planning period.

Fourth, the package prints out a report on actual stock value at the beginning of the planning horizon. This is a summary of the current stock status of each item, also including information on unit cost and stock value.

Fifth, the package prints out a table containing information about planned stock-on-hand for each item throughout the planning horizon, resulting from the projected planned batches, the projected scheduled receipts and the projected stock disbursements. This report also gives information on the average planned stock-on-hand per period for each item and the total cumulative stock value throughout the planning horizon.

Sixth, the user has the option of printing out a summary of the planned batches of each item throughout the planning horizon.

Seventh, a summary of the orders that need to be expedited (if any) may be printed out. This report contains information on the quantity of the orders that should be completed within a shorter time than that of the lead time, the planning period when each order is required and the lead time of the item in question.

Finally, the user is offered the option of printing out gross requirements of each item per unit of end-product.

Figure 5.1 shows the print out of a running of the material requirements planning package MARPLA, where the illustrative example of Figure 4.3 has been used to generate the overall requirements plan.

Figure 5.1. Print out of a running of the MRP package

```
REQUIREMENTS GENERATION PROCESS IN PROGRESS


DO YOU WANT TO PRINT OUT REQUIREMENTS PLANS ?Y

OPTIONS TO PRINT OUT THE REQUIREMENTS PLANS:

(1) FOR ALL ITEMS
(2) FOR PARTICULAR ITEM(S) SPECIFIED BY THE USER

YOUR OPTION ('1' OR '2') ?1



**** MATERIAL REQUIREMENTS PLANNING SYSTEM RUN ****

* COMMENT: IN THE REQUIREMENTS PLAN FOR EACH ITEM SHOWN  BELOW,
           THE QUANTITIES CORRESPONDING TO GROSS REQ'S, SCHEDULED
           RECEIPTS, NET REQ'S, PLANNED STARTS AND PLANNED BATCHES
           CORRESPOND TO THE MID-POINT OF THE RESPECTIVE PLAN'G PERIOD,
           WHILE STOCK-ON-HAND QUANTITIES CORRESPOND TO THE END
           OF THE RESPECTIVE PLAN'G PERIOD.


ITEM CODE-NUMBER=  5
 S/H  LT  SAFETY STOCK  SAFETY TIME  UNIT TIME  BATCHING RULE
 100   3       80             0       WEEK       LOT FOR LOT
-------------------------------------------------------------
UNIT TIME     20   21   22   23   24   25   26   27   28   29
-------------------------------------------------------------
GROSS REQ.     0  120  100   80    0   50    0    0  130  100
PHYSIC. S/H  100  180  230  150  150  100  100  100    0    0
PLANNED S/H  100  180  230  150  150  100  100  170  110   80
SCH/RECEIPT    0  200  150    0    0    0    0    0    0    0
M.P.S.         0    0    0    0   70   70   70   70   70   70
-------------------------------------------------------------


ITEM CODE-NUMBER=  7
 S/H  LT  SAFETY STOCK  SAFETY TIME  UNIT TIME  BATCHING RULE
 200   2       80             0       WEEK.      LOT FOR LOT
-------------------------------------------------------------
UNIT TIME     20   21   22   23   24   25   26   27   28   29
-------------------------------------------------------------
GROSS REQ.     0  120    0  250  100   70    0  200    0  150
PHYSIC. S/H  200   80  250    0    0    0    0    0    0    0
PLANNED S/H  200   80  250    0    0   30  130   30  130   80
SCH/RECEIPT    0    0  170    0    0    0    0    0    0    0
M.P.S.         0    0  100  100  100  100  100  100  100  100
-------------------------------------------------------------
```

Figure 5.1. (Cont....)

ITEM CODE-NUMBER= 8

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
350	3	80	0	WEEK	LOT FOR LOT

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	180	150	0	0	200	200	0	100
PHYSIC. S/H	350	350	370	220	220	220	20	0	0	0
PLANNED S/H	350	350	370	220	220	220	110	0	90	80
SCH/RECEIPT	0	0	200	0	0	0	0	0	0	0
M.P.S.	0	0	0	90	90	90	90	90	90	90

ITEM CODE-NUMBER= 2

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
120	2	0	1	WEEK	LUC

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	0	0	70	70	70	70	220	70
PHYSIC. S/H	120	120	120	120	50	0	0	0	0	0
PLANNED S/H	120	120	120	120	500	430	360	290	70	0
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	0	0	0	0	20	70	70	220	70
PL'D. START	0	0	20	70	70	220	70	0	0	0
PL'D. BATCH	0	0	450	0	0	0	0	0	0	0

ITEM CODE-NUMBER= 3

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
300	5	300	1	WEEK	LTC(NEW)

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	0	90	300	300	300	300	300	300
PHYSIC. S/H	300	300	300	210	300	0	0	0	0	0
PLANNED S/H	300	300	300	210	300	1200	900	600	600	300
SCH/RECEIPT	0	0	0	0	390	0	0	0	0	0
NET REQUIR.	0	0	0	0	0	300	300	300	300	300
PL'D. START	600	300	300	300	0	0	0	0	0	0
PL'D. BATCH	1200	0	0	300	0	0	0	0	0	0

* COMMENT: AT WEEK 23 ; 90 UNITS OF SAFETY STOCK WERE USED TO COVER GROSS REQ'S OF ITEM 3 .

* COMMENT: NET REQ'S OF ITEM 3 AT WEEK 25 WERE OFFSET ONLY FOR LEAD-TIME.

Figure 5.1. (Cont....)

ITEM CODE-NUMBER= 9

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
300	1	0	0	WEEK	ETC

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	200	200	270	270	270	270	270	270
PHYSIC. S/H	440	440	240	40	0	0	0	0	0	0
PLANNED S/H	440	440	240	40	540	270	0	540	270	0
SCH/RECEIPT	140	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	0	0	0	230	270	270	270	270	270
PL'D. START	0	0	0	230	270	270	270	270	270	0
PL'D. BATCH	0	0	0	770	0	0	810	0	0	0

ITEM CODE-NUMBER= 6

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
300	1	0	0	WEEK	LUC

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	450	180	180	180	180	180	180	180
PHYSIC. S/H	510	510	60	0	0	0	0	0	0	0
PLANNED S/H	510	510	60	360	180	0	360	180	0	0
SCH/RECEIPT	210	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	0	0	120	180	180	180	180	180	180
PL'D. START	0	0	120	180	180	180	180	180	180	0
PL'D. BATCH	0	0	480	0	0	540	0	0	180	0

ITEM CODE-NUMBER= 10

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
300	4	0	0	WEEK	LOT FOR LOT

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	0	770	0	0	810	350	0	0
PHYSIC. S/H	300	300	300	0	0	0	0	0	0	0
PLANNED S/H	300	300	300	-470	0	0	0	0	0	0
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	0	0	470	0	0	810	350	0	0
PL'D. START	0	0	810	350	0	0	0	0	0	0
PL'D. BATCH	0	0	810	350	0	0	0	0	0	0

* COMMENT: NET REQUIREMENTS OF ITEM 10 AT WEEK NUMBER 23
CANNOT BE OFFSET FOR LEAD-TIME, SO THEY NEED TO BE
EXPEDITED WITHIN 3 WEEK(S)

Figure 5.1. (Cont....)

ITEM CODE-NUMBER= 4

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
500	2	0	0	WEEK	EOQ

UNIT TIME	20	21	22	23	24	25	26	27	28	29
GROSS REQ.	0	0	2920	100	100	2260	100	100	820	100
PHYSIC. S/H	3570	3570	650	550	450	0	0	0	0	0
PLANNED S/H	3570	3570	650	550	450	0	790	690	760	660
SCH/RECEIPT	3070	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	0	0	0	0	1810	100	100	820	100
PL'D. START	0	0	0	1810	100	100	820	100	0	0
PL'D. BATCH	0	0	0	1810	890	0	890	0	0	0

** END OF RUN **

DO YOU WANT TO PRINT OUT FORECAST INVENTORY COST ANALYSES ?Y

*** FORECAST INVENTORY COST ANALYSES ***
THROUGHOUT THE PLANNING HORIZON

ITEM CODE NO.	BATCHING RULE	INVENTORY HOLDING COST/UNIT & PERIOD	SET-UP COST/ BATCH	NO. SET UP	TOTAL SET-UP COST	TOTAL INVENTORY HOLDING COST	TOTAL INVENTORY COST	UNITS LEFT
2	LUC	0.11538	100.0	1	100.00	245.77	345.77	0
3	LTC(NEW)	0.03846	50.0	2	100.00	181.15	281.15	300
4	EOQ	0.12019	130.0	3	390.00	1325.72	1715.72	660
5	LOTLOT	0.11538	100.0	6	600.00	148.85	748.85	80
6	LUC	0.04808	30.0	3	90.00	103.85	193.85	0
7	LOTLOT	0.33462	80.0	8	640.00	284.42	924.42	80
8	LOTLOT	0.05769	60.0	7	420.00	111.35	531.35	80
9	ETC	0.13462	140.0	2	280.00	374.23	654.23	0
10	LOTLOT	0.01923	40.0	2	80.00	17.31	97.31	0
			TOTAL COSTS =		2700.00	2792.64	5492.64	

<u>Figure 5.1.</u> (Cont....)

DO YOU WANT TO PRINT OUT PLANNED INVENTORY COST ANALYSES
AT THE END OF THE 'CURRENT' WEEK ?Y

*** PLANNED INVENTORY COST ANALYSES ***
AT THE END OF THE 'CURRENT' WEEK

ITEM CODE NO.	NO. SET UP	SET-UP COST	STOCK ON HAND	INVENTORY HOLDING COST/UNIT & PERIOD	TOTAL INVENTORY HOLDING COST	TOTAL INVENTORY COST	UNIT COST	STOCK VALUE
2	0	0.0	120	0.11538	13.85	230.77	20.000	2.40E+03
3	1	50.0	300	0.03846	11.54	338.46	20.000	6.00E+03
4	0	0.0	3570	0.12019	429.09	8925.00	25.000	8.92E+04
5	0	0.0	100	0.11538	11.54	192.31	30.000	3.00E+03
6	0	0.0	510	0.04808	24.52	294.23	10.000	5.10E+03
7	0	0.0	200	0.33462	66.92	307.69	58.000	1.16E+04
8	0	0.0	350	0.05769	20.19	403.85	12.000	4.20E+03
9	0	0.0	440	0.13462	59.23	1184.62	35.000	1.54E+04
10	0	0.0	300	0.01923	5.77	230.77	5.000	1.50E+03
TOTAL COST=		50.0			642.64	692.64		1.38E+05

DO YOU WANT TO PRINT OUT THE STOCK VALUE OF EACH ITEM AT THE
BEGINNING OF THE PLAN'G HORIZON ?Y

*** ACTUAL STOCK VALUE AT THE BEGINNING ***
OF THE 'CURRENT' WEEK

ITEM CODE NO.	STOCK ON HAND	UNIT COST	STOCK VALUE
2	120	20.000	2.40E+03
3	300	20.000	6.00E+03
4	500	25.000	1.25E+04
5	100	30.000	3.00E+03
6	300	10.000	3.00E+03
7	200	58.000	1.16E+04
8	350	12.000	4.20E+03
9	300	35.000	1.05E+04
10	300	5.000	1.50E+03

TOTAL VALUE= 5.47E+04

Figure 5.1. (Cont....)

DO YOU WANT TO PRINT OUT PLANNED STOCK-ON-HAND AVAILABILITY
THROUGHOUT THE PLANNGING HORIZON ?Y

*** PLANNED STOCK-ON-HAND ***

UNIT TIME	20	21	22	23	24	25	26	27	28	29	AVER STO. PER UNIT TIME	CUMUL STOCK VALUE
ITEM CODE-NUMBER												
2	120	120	120	120	500	430	360	290	70	0	213	4.26E+04
3	300	300	300	210	300	1200	900	600	600	300	501	1.00E+05
4	3570	3570	650	550	450	0	790	690	760	660	1169	2.92E+05
5	100	180	230	150	150	100	100	170	110	80	137	4.11E+04
6	510	510	60	360	180	0	360	180	0	0	216	2.16E+04
7	200	80	250	0	0	30	130	30	130	80	93	5.39E+04
8	350	350	370	220	220	220	110	0	90	80	201	2.41E+04
9	440	440	240	40	540	270	0	540	270	0	278	9.73E+04
10	300	300	300	0	0	0	0	0	0	0	90	4.50E+03

CUMULATIVE TOTAL VALUE= 6.78E+05

DO YOU WANT TO PRINT OUT THE SUMMARY OF THE PLANNED BATCHES OF
ALL ITEMS THROUGHOUT THE PLAN'G HORIZON ('YES' OR 'NO') ?Y

*** SUMMARY OF PLANNED BATCHES ***

UNIT TIME	20	21	22	23	24	25	26	27	28	29
ITEM CODE-NUMBER										
2	0	0	450	0	0	0	0	0	0	0
3	1200	0	0	300	0	0	0	0	0	0
4	0	0	0	1810	890	0	890	0	0	0
5	0	0	0	0	70	70	70	70	70	70
6	0	0	480	0	0	540	0	0	180	0
7	0	0	100	100	100	100	100	100	100	100
8	0	0	0	90	90	90	90	90	90	90
9	0	0	0	770	0	0	810	0	0	0
10	0	0	810	350	0	0	0	0	0	0

Figure 5.1. (Cont....)

DO YOU WANT TO PRINT OUT A SUMMARY OF THE ORDERS THAT NEED TO BE EXPEDITED ?YES

*** SUMMARY OF THE ORDERS THAT NEED TO BE EXPEDITED ***

ITEM CODE-NUMBER	LEAD TIME	WEEK WHEN THE ORDER IS REQUIRED 20	21	22	23	24	25	26	27	28	29
10	4				470						

DO YOU WANT TO PRINT OUT GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF END-PRODUCT ?

YOUR REPLY (ANSWER 'YES' OR 'NO) ?YES

**** GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF ****
END-PRODUCT CODE-NO. 5

ITEM CODE-NUMBER	GROSS REQUIREMENTS PER UNIT OF END-PRODUCT
2	1
3	3
9	1
4	6
6	1
10	1

**** GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF ****
END-PRODUCT CODE-NO. 7

ITEM CODE-NUMBER	GROSS REQUIREMENTS PER UNIT OF END-PRODUCT
4	1
9	2
10	2

**** GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF ****
END-PRODUCT CODE-NO. 8

ITEM CODE-NUMBER	GROSS REQUIREMENTS PER UNIT OF END-PRODUCT
3	1
6	2
4	8

DO YOU WANT ANOTHER SIMULATION ?
YOUR REPLY (ANSWER 'YES' OR 'NO') ?NO

DONE

CHAPTER 6

APPLICATION OF THE MRP PACKAGE AS A TEACHING AID

The MRP package MARPLA has been designed mainly as a practical tool to help in understanding the planning function of a material requirements planning system. By analysing the requirements plans and other output reports generated by the package, the user can investigate the effects of changing the different inventory parameters involved in the MRP system and make recommendations regarding the most appropriate policy to adopt.

MARPLA is a fully interactive package which does not require computing knowledge for its use. A number of alternatives to input data, print out reports and change variables are offered in order to provide the user with a flexible system to make the decisions for the implementation of the MRP model.

The MRP package can be run either with programmed data or with data supplied by the user. The objective of including the option of using the package with programmed data is that an inexperienced user running the package for the first time, can generate requirements plans, display MRP output reports, draw plans, make decisions and evaluate the outcome of these decisions on subsequent MRP outputs, without having to input any data into the computer. For this purpose, a case study has been designed so that the user can gain a comprehensive understanding of the benefits and difficulties of operating and implementing a material requirements planning system in the real business environment.

Once the user is familiar with the use of the package, he can run it with his own data, storing them in files for later retrieval and manipulation.

A summary of the features of the MRP package that make it specially useful as a teaching aid is given below:

(1) The MRP package is self-explanatory thanks to the "HELP" facility by means of which the user can request an explanation of the way of responding to any enquiry from the system at the time of answering it. When appropriate, the explanation is illustrated with an example.

(2) The data required to run the system are stored in files so that they are always readily available for their retrieval and use, eliminating the need of inputing all data every time the package is used.

(3) Options to list the contents of the files are offered throughout the package so that the user can check the data and, if desired, change them before each regeneration of the requirements plan is carried out.

(4) At the stage of inputing the batching rules information, the user has the opportunity of printing out a description, accompanied by an illustrative example, of any of the batching rules included in the package.

(5) The effects of changing the inventory parameters can be evaluated by analysing the different MRP output reports printed by the package. The display of each output report is given as an option so as to allow the user to print out only those reports that may reflect the impact of the parameter changes.

(6) A complete description of the MRP package can be printed out, including a list of the data required, an explanation of the way of inputing those data and a description of the outputs. Thus, an inexperienced user may print out this description in order to prepare the data and make a working plan before he actually runs the package.

(7) The coding system required to identify each item is simple to develop.

The application of the MRP package as a teaching aid pursues the following aims:

(i) The user evaluates the applicability of material requirements planning as a powerful planning tool in a manufacturing environment.

(ii) The user understands the logic of MRP by means of practical demonstrations.

(iii) The user appreciates the capacity implicit in the logic of material requirements planning to establish and maintain the correct priority of the orders.

(iv) The user analyses the effects of changing inventory parameters, such as safety stock, lead time or batching rule, over the overall requirements plan and the inventory costs.

(v) The practice of changing inventory parameters and analysing their effects reflects the dynamic characteristic of the real business environment.

(vi) The user gains an understanding of the use of data files and appreciates the importance of maintaining updated and accurate information for the generation of realistic requirements plans.

(vii) Material requirements planning is viewed as a method that integrates the master production schedule, the bill of material file and the inventory record file for the generation of the requirements plans.

(viii) The development of a feasible master production schedule at the end-product level is viewed as the starting point of the generation of realistic plans down through the product structure.

(ix) The user learns to understand and analyse the information available from the MRP system outputs in order to make valid decisions.

(x) The user appreciates the advantages of installing computerised MRP systems which carry out all the time consuming operations, leaving time available to the planner for the analysis of the system outputs and the implementation of the plans.

To help a first time user to obtain the maximum benefit from the MRP system, a set of exercises based on the case study included in the package have been designed in order to provide a view of the kind of daily problems faced by the planner and the way a material requirements planning system copes with them. The exercises are described in the next section.

EXERCISES FOR THE STUDY OF MATERIAL REQUIREMENTS PLANNING USING AN INTERACTIVE COMPUTER PACKAGE

The exercises proposed below are based on the programmed data included within the MRP package called MARPLA, the idea being that the user not only generates the requirements plans and display the output reports, but that he makes decisions and analyses the performance of the MRP system under varying conditions.

The exercises are progressive, that is, each new exercise is based on the results of the previous one, which are stored in the user's file for his own use.

Exercise 1

Objective : to familiarize the user with the MRP package.

(a) GET and RUN the MRP package called MARPLA. Print out the complete description of it by answering "YES" to the first enquiry that is made (i.e. DO YOU NEED HELP ?). Analyse the information required by the package, how to input it into the computer and the outputs from the MRP system.

(b) Select the option of using "programmed data" at the stage of inputing the bill of material information (option 3) and print out the explanation of the use of those data by answering "NO" to the question "ARE YOU FAMILIAR WITH RUNNING THE PACKAGE USING PROGRAMMED DATA ?" . The print out on pages 135 and 136 shows the description of the programmed data while the diagram given in Figure 6.1 represents the end-products selected for the programmed data option.

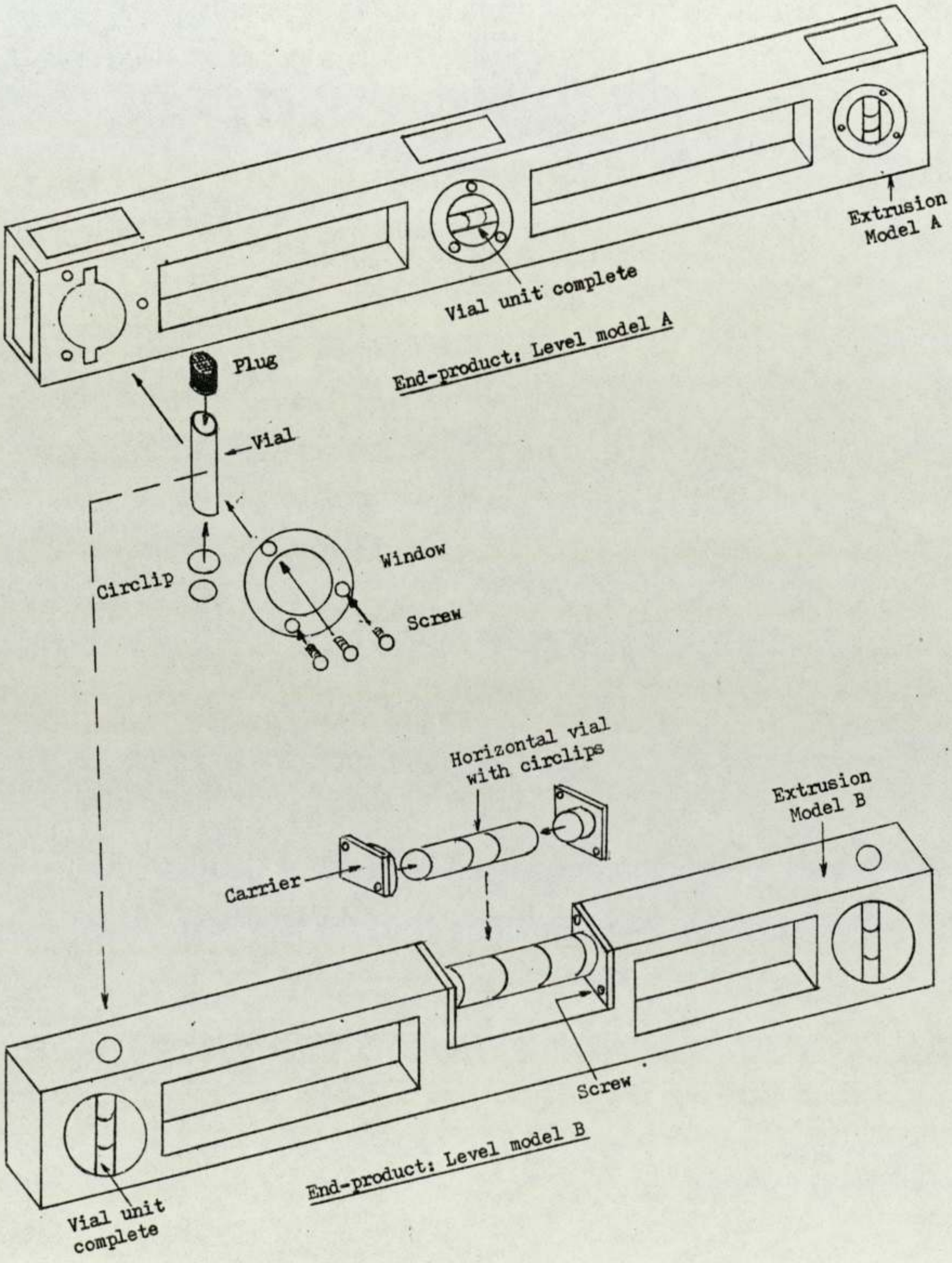


Figure 6.1. Drawing of the end-products showing their component items

```
GET-MARPLA
RUN
MARPLA

MATERIAL REQUIREMENTS PLANNING SYSTEM
-------- ------------ -------- ------

DO YOU NEED HELP ?
YOUR REPLY ('YES' OR 'NO') ?NO

PLEASE TYPE IN YOUR ANSWER ACCORDING TO THE INSTRUCTIONS.
IF YOU NEED AN EXPLANATION ABOUT ANY ENQUIRY FROM THE
PROGRAM, TYPE 'HELP' AFTER THE CORRESPONDING QUES. MARK.
BE SURE TO PRESS THE 'RETURN KEY' AFTER EACH ANSWER.


INPUT OF THE STRUCTURE OF THE BILL OF MATERIAL INFORMATION
----- -- --- --------- -- --- ---- -- -------- -----------


YOU HAVE THE FOLLOWING OPTIONS TO INPUT YOUR DATA:

   (1) TO INPUT YOUR DATA FROM THE TERMINAL AND TO STORE THEM
       IN A BILL OF MATERIAL FILE.

   (2) TO USE YOUR DATA IN A BILL OF MATERIAL FILE
       PREVIOUSLY STORED BY MEANS OF THIS PROGRAM.

   (3) TO USE PROGRAMMED DATA.

YOUR OPTION ('1','2' OR '3') ?3


ARE YOU FAMILIAR WITH RUNNING THE PACKAGE USING PROGRAMMED
DATA ('YES' OR 'NO') ?NO

 A CASE STUDY IS INCLUDED WITHIN THE PACKAGE SO THAT THE USER CAN
RUN IT WITHOUT HAVING TO INPUT ANY DATA. AS THE PACKAGE IS RUN, THE
USER IS ASKED TO CREATE THREE FILES TO LOAD AND STORE THE PROGRAMMED
DATA FOR THE USER'S PERSONAL MANIPULATION. THAT IS, ALL THE CHANGES
THE USER INTRODUCES INTO THOSE DATA WILL BE RECORDED INTO THE USER'S
FILES. TO RE-LOAD THE ORIGINAL DATA, THREE NEW FILES NEED TO BE CREATED.

AFTER CREATING (I.E. NAMING) EACH FILE, THE USER HAS THE OPTION
OF LISTING ITS CONTENTS TO ANALYSE THE DATA AND, IF DESIRED, CHANGE
THEM.

THERE ARE TWO END-PRODUCTS WITH SOME COMMON COMPONENTS.THE END-PRODUCTS
ARE TWO DIFFERENT MODELS OF SPIRIT LEVELS. THE BOM OF EACH END-
PRODUCT IS SHOWN BELOW IN TERMS OF ITEM CODE-NUMBERS AND A
DESCRIPTION OF EACH ITEM IS ALSO GIVEN.
```

** BILL OF MATERIAL FOR THE END-PRODUCTS **

```
                                                              LEVEL

               (2)END-PRODUCT                 (11)END-PRODUCT  0
                !                                !
                !                                !
    -------------------------        ---------------------
    !       !      !        !        !      !       !       !
    !       !      !        !        !      !       !       !
   (3)     (8)    (9)    (10)       (3)    (8)    (12)    (15)  1
    !3OFF  9OFF   3OFF   1OFF        !2OFF 4OFF    !1OFF  1OFF
    !                                !             !
 -------                         -------        -------
 !     !                          !     !        !     !
 !     !                          !     !        !     !
(4)   (5)                        (4)   (5)     (13)   (14)      2
1OFF   !1OFF                     1OFF   !1OFF  1OFF  2OFF
       !                                !
    -------                          -------
    !     !                          !     !
    !     !                          !     !
   (6)   (7)                        (6)   (7)                   3
   1OFF  2OFF                       1OFF  2OFF
```

** DESCRIPTION OF THE ITEMS OF THE BOM **

ITEM CODE-NUMBER	DESCRIPTION
2	END-PRODUCT: LEVEL MODEL 'A'
3	VIAL UNIT COMPLETE
4	PLUG
5	VIAL WITH CIRCLIPS
6	VIAL
7	CIRCLIP
8	SCREW
9	WINDOW
10	EXTRUSION FOR LEVEL MODEL 'A'
11	END-PRODUCT: LEVEL MODEL 'B'
12	HORIZONTAL VIAL UNIT COMPLETE
13	HORIZONTAL VIAL WITH CIRCLIPS
14	CARRIER
15	EXTRUSION FOR LEVEL MODEL 'B'

THE STRUCTURE OF THE BOM INFORMATION IS STORED IN THE BOM FILE. ITEM INVENTORY INFORMATION IS STORED IN THE INVENTORY RECORD FILE. TIME DEPENDENT INFORMATION(I.E. M.P.S., INDEPENDENT DEMAND AND SCHEDULED RECEIPTS) IS STORED IN THE MPS AND SCHEDULED RECEIPTS FILE.

ONCE THE USER HAS RUN THE PACKAGE USING THE PROGRAMMED DATA OPTION AND UNDERSTANDS HOW TO OPERATE THE SYSTEM, THE USER IS RECOMMENDED TO SUPPLY HIS/HER OWN DATA TO CARRY OUT FURTHER ANALYSIS OF THE MATERIAL REQUIREMENTS PLANNING TECHNIQUE.

NOW, LET'S BEGIN

(c) Now start creating your own files to load the programmed data. The first file to be created and loaded is the bill of material file. Display the contents of this file and analyse the information contained in the explosion of the bill of material by comparing it with the product structure printed out by the package in the explanation of the use the programmed data. Do not change any data in any of the three files at this initial stage.

The accompanying print out shows the data contained in the bill of material file.

WHAT NAME DO YOU WANT TO GIVE TO YOUR BILL OF MATERIAL
FILE (ANY NAME WITH MAXIMUM 6 CHARACTERS)

YOUR ANSWER ?FILE1

DO YOU WANT YOUR FILE FILE1 LISTED ?
(BY LISTING YOUR FILE YOU CAN CHECK YOUR DATA AND CHANGE THEM
IF YOU WISH).

YOUR REPLY ('YES' OR 'NO) ?YES

** DATA IN THE B.O.M. FILE CALLED FILE1 **

NO. OF END-PRODUCTS = 2

CODE-NO. OF END-PRODUCT(S) = 2 , 11 ,

EXPLOSION OF THE B.O.M.

		COMPONENT-ITEMS													
		2	3	4	5	6	7	8	9	10	11	12	13	14	15
PARENT ITEMS	2	0	3	0	0	0	0	9	3	1	0	0	0	0	0
	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	1	2	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	11	0	2	0	0	0	0	4	0	0	0	1	0	0	1
	12	0	0	0	0	0	0	0	0	0	0	0	1	2	0
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DO YOU WANT TO CHANGE SOME DATA OF THE EXPLOSION OF THE BOM ?

YOUR REPLY ('YES' OR 'NO') ?NO

(d) Create the inventory record file and print out the item inventory data and the planning horizon information stored in this file. Note that no safety stocks and safety times have been specified at this stage and that all items are batched according to the lot-for-lot rule. The computer print out given on page 140 shows the contents of the inventory record file.

WHAT NAME DO YOU WANT TO GIVE TO YOUR INVENTORY RECORD
FILE (ANY NAME WITH MAXIMUM 6 CHARACTERS)

YOUR ANSWER ?FILE2

DO YOU WANT YOUR FILE FILE2 LISTED ?
(BY LISTING YOUR FILE YOU CAN CHECK YOUR DATA AND CHANGE THEM
IF YOU WISH).

YOUR REPLY ('YES' OR 'NO') ?YES

** DATA IN THE INVENTORY RECORD FILE CALLED FILE2 **

ITEM CODE NO.	STOCK ON HAND	SAFETY STOCK	LEAD TIME	SAFETY TIME	BATCHING RULE	SET-UP COST/ BATCH	INVENTORY HOLDING COST/UNIT & PERIOD
2	400	0	1	0	LOTLOT	6.00	0.00942
3	1000	0	1	0	LOTLOT	2.00	0.00083
4	900	0	2	0	LOTLOT	0.50	0.00005
5	1000	0	1	0	LOTLOT	2.00	0.00074
6	700	0	3	0	LOTLOT	0.50	0.00060
7	1500	0	2	0	LOTLOT	0.50	0.00005
8	6000	0	1	0	LOTLOT	0.50	0.00014
9	1500	0	2	0	LOTLOT	0.50	0.00009
10	550	0	4	0	LOTLOT	2.00	0.00369
11	120	0	1	0	LOTLOT	6.00	0.00923
12	100	0	1	0	LOTLOT	2.00	0.00138
13	200	0	2	0	LOTLOT	2.00	0.00083
14	180	0	2	0	LOTLOT	0.50	0.00009
15	130	0	2	0	LOTLOT	2.00	0.00277

* PLANNING HORIZON DATA :

NO. OF FIRST PLAN'G PERIOD = 10
NO. OF LAST PLAN'G PERIOD = 19
NO. OF WEEKS IN A YEAR = 52

DO YOU WANT TO CHANGE SOME DATA IN THE FILE FILE2 ?

YOUR REPLY ('YES' OR 'NO') ?NO

(e) Create and list the contents of the MPS and scheduled receipts file which contains time-dependent information. Note that at this initial stage no data of master production schedule for the end-products have been specified because it will be left to the package to develop the MPS based on the gross requirements schedules for the end-products. Equally note that no item is subject to independent demand and that, for certain components, some orders were already started and should be received into stock on predetermined dates (these orders are called scheduled receipts). The information stored in the MPS and scheduled receipts file is shown in the print out given below.

```
WHAT NAME DO YOU WANT TO GIVE TO YOUR M.P.S. & SCHEDULED RECEIPTS
FILE ( ANY NAME WITH MAXIMUM 6 CHARACTERS )

YOUR ANSWER ?FIL3


DO YOU WANT YOUR FILE FIL3 LISTED ?
(BY LISTING YOUR FILE YOU CAN CHECK YOUR DATA AND CHANGE THEM
IF YOU WISH).

YOUR REPLY ('YES' OR 'NO) ?YES


** DATA IN THE M.P.S. AND SCHEDULED RECEIPTS FILE CALLED FIL3 **


G.R.S. FOR THE END-PRODUCT(S)


--------------------------------------------------------------
UNIT TIME      10   11   12   13   14   15   16   17   18   19
--------------------------------------------------------------
END-PRODUCT
 CODE-NO.
     2        300  250  200  350  300  100  400  250  250  200
    11         90   80   70  100  100   70  150   80   90   80
--------------------------------------------------------------
```

INDEPENDENT DEMAND OF COMPONENT ITEMS

UNIT TIME	10	11	12	13	14	15	16	17	18	19
ITEM CODE-NUMBER										
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0

SCHEDULED-RECEIPTS OF EACH ITEM

UNIT TIME	10	11	12	13	14	15	16	17	18	19
ITEM CODE-NUMBER										
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	1100	0	0	0	0	0	0	0	0
5	1000	0	0	0	0	0	0	0	0	0
6	0	100	900	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	200	400	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	50	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	100	0	0	0	0	0	0	0	0
15	0	50	70	0	0	0	0	0	0	0

DO YOU WANT TO CHANGE SOME DATA IN THE FILE FIL3 ?

YOUR REPLY ('YES' OR 'NO') ?NO

(f) Display the requirements plans for the items and analyse the information given in them. To understand the logic of MRP, choose a particular item and study the contents of each row of its table of requirements, making use of the information printed above the table (what is the relation between planned starts and planned batches?; would the stock-on-hand be driven to zero after a few weeks if a batching rule different to the lot-for-lot were applied?). Display the requirements tables for the end-products (item code-numbers 2 and 11) and analyse the master production schedules generated by the package (are the MPS for the end-products realistic in terms of production planning?; can the MPS be met in terms of component availability ?; does the MPS satisfy the gross requirements schedule for each end-product ?). The print out on page 144 shows the requirements tables for the two end-products containing the master production schedules generated by the package.

REQUIREMENTS GENERATION PROCESS IN PROGRESS

DO YOU WANT TO PRINT OUT REQUIREMENTS PLANS ?YES

OPTIONS TO PRINT OUT THE REQUIREMENTS PLANS:

(1) FOR ALL ITEMS
(2) FOR PARTICULAR ITEM(S) SPECIFIED BY THE USER

YOUR OPTION ('1' OR '2') ?1

**** MATERIAL REQUIREMENTS PLANNING SYSTEM RUN ****

* COMMENT: IN THE REQUIREMENTS PLAN FOR EACH ITEM SHOWN BELOW, THE QUANTITIES CORRESPONDING TO GROSS REQ'S, SCHEDULED RECEIPTS, NET REQ'S, PLANNED STARTS AND PLANNED BATCHES CORRESPOND TO THE MID-POINT OF THE RESPECTIVE PLAN'G PERIOD, WHILE STOCK-ON-HAND QUANTITIES CORRESPOND TO THE END OF THE RESPECTIVE PLAN'G PERIOD.

ITEM CODE-NUMBER= 2

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
400	1	0	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	300	250	200	350	300	100	400	250	250	200
PHYSIC. S/H	100	0	0	0	0	0	0	0	0	0
PLANNED S/H	100	0	0	0	0	0	0	0	0	0
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	150	200	350	300	100	400	250	250	200
PL'D. START	150	200	350	300	100	400	250	250	200	0
M.P.S.	150	200	350	300	100	400	250	250	200	0

ITEM CODE-NUMBER= 11

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
120	1	0	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	90	80	70	100	100	70	150	80	90	80
PHYSIC. S/H	30	0	0	0	0	0	0	0	0	0
PLANNED S/H	30	0	0	0	0	0	0	0	0	0
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
NET REQUIR.	0	50	70	100	100	70	150	80	90	80
PL'D. START	50	70	100	100	70	150	80	90	80	0
M.P.S.	50	70	100	100	70	150	80	90	80	0

(g) Display the various reports concerning inventory costs:

(1) Forecast inventory cost analyses throughout the planning horizon: provides information on the total set-up cost (or ordering cost), total holding inventory cost and total inventory cost (i.e. the sum of the two first costs) of each item throughout the planning horizon if the requirements plan is executed as projected. This report is particularly useful to plan capital investment in inventory and also to analyse the costs under different approaches concerning safety stocks, safety times and batching rules. The accompanying print out shows the forecast inventory cost report.

DO YOU WANT TO PRINT OUT FORECAST INVENTORY COST ANALYSES ?YES

*** FORECAST INVENTORY COST ANALYSES ***
THROUGHOUT THE PLANNING HORIZON

ITEM CODE NO.	BATCHING RULE	INVENTORY HOLDING COST/UNIT & PERIOD	SET-UP COST/ BATCH	NO. SET UP	TOTAL SET-UP COST	TOTAL INVENTORY HOLDING COST	TOTAL INVENTORY COST	UNITS LEFT
2	LOTLOT	0.00942	6.0	9	54.00	0.94	54.94	0
3	LOTLOT	0.00083	2.0	8	16.00	0.37	16.37	0
4	LOTLOT	0.00005	0.5	6	3.00	0.05	3.05	0
5	LOTLOT	0.00074	2.0	6	12.00	1.60	13.60	0
6	LOTLOT	0.00060	0.5	4	2.00	0.89	2.89	0
7	LOTLOT	0.00005	0.5	5	2.50	0.08	2.58	0
8	LOTLOT	0.00014	0.5	7	3.50	0.94	4.44	0
9	LOTLOT	0.00009	0.5	7	3.50	0.14	3.64	0
10	LOTLOT	0.00369	2.0	4	8.00	3.14	11.14	0
11	LOTLOT	0.00923	6.0	9	54.00	0.28	54.28	0
12	LOTLOT	0.00138	2.0	7	14.00	0.18	14.18	0
13	LOTLOT	0.00083	2.0	5	10.00	0.30	10.30	0
14	LOTLOT	0.00009	0.5	6	3.00	0.03	3.03	0
15	LOTLOT	0.00277	2.0	6	12.00	0.47	12.47	0
			TOTAL COSTS =		197.50	9.41	206.91	

(2) Planned inventory cost analyses at the end of the current week: supplies information on the stock status and inventory costs of each item at the end of the current week if the requirements plan for that week is carried out as projected. While the previous report gives the planner long-range information, this report provides short-term information.

(3) Actual stock value at the beginning of the current week: this is a summary of the current stock status of each item including the actual capital tied up in stock.

(4) Planned stock-on-hand: this is a summary of the projected stock-on-hand of each item in each period throughout the planning horizon, resulting from the projected scheduled receipts and planned orders. Using the planned stock figures, the average planned stock per period and the cumulative stock value are calculated for each item. This report is useful to forecast the capital that will be tied up in stock during the next planning periods.

The computer print out given on the next page shows the planned stock-on-hand report corresponding to the requirements plan generated with the original programmed data.

DO YOU WANT TO PRINT OUT PLANNED STOCK-ON-HAND AVAILABILITY
THROUGHOUT THE PLANNGING HORIZON ?YES

*** PLANNED STOCK-ON-HAND ***

UNIT TIME	10	11	12	13	14	15	16	17	18	19	AVER STO. PER UNIT TIME	CUMUL STOCK VALUE
ITEM CODE-NUMBER												
2	100	0	0	0	0	0	0	0	0	0	10	2.04E+02
3	450	0	0	0	0	0	0	0	0	0	45	8.10E+01
4	610	460	0	0	0	0	0	0	0	0	107	1.07E+01
5	1710	460	0	0	0	0	0	0	0	0	217	3.47E+02
6	700	160	620	0	0	0	0	0	0	0	148	1.92E+02
7	1500	220	0	0	0	0	0	0	0	0	172	1.72E+01
8	4450	2370	0	0	0	0	0	0	0	0	682	2.05E+02
9	1050	450	0	0	0	0	0	0	0	0	150	3.00E+01
10	400	200	50	150	50	0	0	0	0	0	85	6.80E+02
11	30	0	0	0	0	0	0	0	0	0	3	6.00E+01
12	100	30	0	0	0	0	0	0	0	0	13	3.90E+01
13	200	130	30	0	0	0	0	0	0	0	36	6.48E+01
14	180	140	0	0	0	0	0	0	0	0	32	6.40E+00
15	80	60	30	0	0	0	0	0	0	0	17	1.02E+02

CUMULATIVE TOTAL VALUE= 2.04E+03

(h) Display the summary of the planned batches which concentrates in a single table the planned batch rows of the requirements tables of each item. This report is used by the purchasing and production departments for planning purposes. Note that towards the end of the planning horizon, planned batches for component items cannot be determined because of the offseting for lead time process down through the product structure. This report is shown in the print out of the next page.

DO YOU WANT TO PRINT OUT THE SUMMARY OF THE PLANNED BATCHES OF ALL ITEMS THROUGHOUT THE PLAN'G HORIZON ('YES' OR 'NO') ?YES

*** SUMMARY OF PLANNED BATCHES ***

UNIT TIME ITEM CODE-NUMBER	10	11	12	13	14	15	16	17	18	19
2	150	200	350	300	100	400	250	250	200	0
3	290	1250	1100	440	1500	910	930	760	0	0
4	640	440	1500	910	930	760	0	0	0	0
5	0	640	440	1500	910	930	760	0	0	0
6	880	910	930	760	0	0	0	0	0	0
7	660	3000	1820	1860	1520	0	0	0	0	0
8	0	1180	3100	1180	4200	2570	2610	2120	0	0
9	600	900	300	1200	750	750	600	0	0	0
10	0	350	250	250	200	0	0	0	0	0
11	50	70	100	100	70	150	80	90	80	0
12	0	70	100	70	150	80	90	80	0	0
13	0	40	150	80	90	80	0	0	0	0
14	60	140	300	160	180	160	0	0	0	0
15	0	70	70	150	80	90	80	0	0	0

(i) Display the summary of the orders that need to be expedited. This report gives information for each item on the quantity of the orders that need to be expedited (if any), when they are required and the lead time of the item in question. Orders that need to be expedited result from net requirements arising during the lead time, which cannot be offset for the lead time and indicate possible material shortages if no action is taken to expedite the orders. This report is useful to the planner to make decisions concerning priority planning.

In this exercise, a message is printed by the package indicating that there is no need to expedite any order.

(j) Finally, display the gross requirements of each item per unit of end-product which indicate the total quantity of each component required to manufacture one unit of finished product. From this report, common components can be easily identified.

At this stage, the user should understand the basic logic of MRP and should be capable of analysing the information contained in the different MRP output reports. The user may continue directly with the next exercise by answering "YES" to the question "DO YOU WANT ANOTHER SIMULATION ?", or he may end the program by responding negatively to the mentioned enquiry. In this second case, the user may continue doing the exercises later by choosing the option 2 when he is asked the way of inputing the data into the computer, since all the data have been already stored in his own files.

Exercise 2

Objective: development of a master production schedule

The maximum plant capacity is 400 units of finished product per week and it is desirable that the same quantity of each end-product be produced each week. Based on these conditions, is the current master production schedule for the end-products realistic ?, why ?.

Develop a master production schedule for each end-product that fulfils the above conditions and meets the gross requirements schedule. To input the new MPS into the package, select the option of re-running it changing data of the MPS and scheduled receipts file (option 3). Analyse the requirements plans and the other output reports under the revised master production schedules (is there any component shortage ?; do the inventory costs increase in relation to the previous MPS ?, why ?)

One approach to develop a feasible master production schedule would be to plan the weekly production of each finished product using the average requirements per week from the previous output and the initial stock-on-hand figures. This is shown in Figure 6.2.

Under the revised master production schedules, the weekly production is 340 units of end-product, which is within the specified capacity limits, leaving some unused capacity for unexpected increases in the demand.

Weeks	10	11	12	13	14	15	16	17	18	19
End-product 2	300	250.	200	350	300	100	400	250	250	200
End-product 11	90	80	70	100	100	70	150	80	90	80

Gross requirements schedules

Weeks	10	11	12	13	14	15	16	17	18	19
End-product 2	250	250	250	250	250	250	250	250	250	250
End-product 11	90	90	90	90	90	90	90	90	90	90

Revised master production schedules

Figure 6.2. Development of a master production schedule

The impact of the revised master production schedules on the overall requirements plan is illustrated by means of the following accompanying reports printed out by the MRP package:

(1) Requirements plan tables for the end-products showing that the revised MPS satisfies the gross requirements schedule for each end-product (i.e. the planned stock-on-hand is not negative in any week of the planning horizon).

(2) Forecast inventory cost analyses which indicate that the total forecast inventory cost are higher under the revised MPS than under the original one, mainly due to an increase in the set-up cost and ordering cost.

(3) Planned stock-on-hand of each item throughout the planning horizon which shows an increase in the cumulative stock value in relation to the previous plan.

(4) Summary of the planned batches throughout the planning horizon which shows an increase in the number of batches and orders when compared with the original plan.

(5) The message on the need to expedite orders indicates that no component shortages are expected under the revised master production schedules.

The prints out of the mentioned reports are given on pages 153 to 155.

**** MATERIAL REQUIREMENTS PLANNING SYSTEM RUN ****

* COMMENT: IN THE REQUIREMENTS PLAN FOR EACH ITEM SHOWN BELOW, THE QUANTITIES CORRESPONDING TO GROSS REQ'S, SCHEDULED RECEIPTS, NET REQ'S, PLANNED STARTS AND PLANNED BATCHES CORRESPOND TO THE MID-POINT OF THE RESPECTIVE PLAN'G PERIOD, WHILE STOCK-ON-HAND QUANTITIES CORRESPOND TO THE END OF THE RESPECTIVE PLAN'G PERIOD.

ITEM CODE-NUMBER= 2

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
400	1	0	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	300	250	200	350	300	100	400	250	250	200
PHYSIC. S/H	100	0	0	0	0	0	0	0	0	0
PLANNED S/H	100	100	150	50	0	150	0	0	0	50
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
M.P.S.	250	250	250	250	250	250	250	250	250	250

ITEM CODE-NUMBER= 11

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
120	1	0	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	90	80	70	100	100	70	150	80	90	80
PHYSIC. S/H	30	0	0	0	0	0	0	0	0	0
PLANNED S/H	30	40	60	50	40	60	0	10	10	20
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
M.P.S.	90	90	90	90	90	90	90	90	90	90

*** FORECAST INVENTORY COST ANALYSES ***
THROUGHOUT THE PLANNING HORIZON

ITEM CODE NO.	BATCHING RULE	INVENTORY HOLDING COST/UNIT & PERIOD	SET-UP COST/ BATCH	NO. SET. UP	TOTAL SET-UP COST	TOTAL INVENTORY HOLDING COST	TOTAL INVENTORY COST	UNITS LEFT
2	LOTLOT	0.00942	6.0	10	60.00	5.18	65.18	50
3	LOTLOT	0.00083	2.0	9	18.00	0.06	18.06	0
4	LOTLOT	0.00005	0.5	7	3.50	0.01	3.51	0
5	LOTLOT	0.00074	2.0	7	14.00	1.00	15.00	0
6	LOTLOT	0.00060	0.5	5	2.50	0.50	3.00	0
7	LOTLOT	0.00005	0.5	6	3.00	0.07	3.07	0
8	LOTLOT	0.00014	0.5	8	4.00	0.58	4.58	0
9	LOTLOT	0.00009	0.5	8	4.00	0.07	4.07	0
10	LOTLOT	0.00369	2.0	6	12.00	1.85	13.85	0
11	LOTLOT	0.00923	6.0	10	60.00	2.77	62.77	20
12	LOTLOT	0.00138	2.0	9	18.00	0.08	18.08	0
13	LOTLOT	0.00083	2.0	7	14.00	0.21	14.21	0
14	LOTLOT	0.00009	0.5	7	3.50	0.01	3.51	0
15	LOTLOT	0.00277	2.0	8	16.00	0.11	16.11	0
			TOTAL COSTS =		232.50	12.49	244.99	

DO YOU WANT TO PRINT OUT PLANNED STOCK-ON-HAND AVAILABILITY
THROUGHOUT THE PLANNGING HORIZON ?YES

*** PLANNED STOCK-ON-HAND ***

UNIT TIME / ITEM CODE-NUMBER	10	11	12	13	14	15	16	17	18	19	AVER STO. PER UNIT TIME	CUMUL STOCK VALUE
2	100	100	150	50	0	150	0	0	0	50	60	1.22E+03
3	70	0	0	0	0	0	0	0	0	0	7	1.26E+01
4	40	210	0	0	0	0	0	0	0	0	25	2.50E+00
5	1140	210	0	0	0	0	0	0	0	0	135	2.16E+02
6	700	80	50	0	0	0	0	0	0	0	83	1.08E+02
7	1500	60	0	0	0	0	0	0	0	0	156	1.56E+01
8	3390	780	0	0	0	0	0	0	0	0	417	1.25E+02
9	750	0	0	0	0	0	0	0	0	0	75	1.50E+01
10	300	50	0	150	0	0	0	0	0	0	50	4.00E+02
11	30	40	60	50	40	60	0	10	10	20	32	6.40E+02
12	60	0	0	0	0	0	0	0	0	0	6	1.80E+01
13	170	80	0	0	0	0	0	0	0	0	25	4.50E+01
14	120	40	0	0	0	0	0	0	0	0	16	3.20E+00
15	40	0	0	0	0	0	0	0	0	0	4	2.40E+01

CUMULATIVE TOTAL VALUE= 2.85E+03

DO YOU WANT TO PRINT OUT THE SUMMARY OF THE PLANNED BATCHES OF ALL ITEMS THROUGHOUT THE PLAN'G HORIZON ('YES' OR 'NO') ?YES

*** SUMMARY OF PLANNED BATCHES ***

UNIT TIME	10	11	12	13	14	15	16	17	18	19
ITEM CODE-NUMBER										
2	250	250	250	250	250	250	250	250	250	250
3	860	930	930	930	930	930	930	930	930	0
4	720	930	930	930	930	930	930	0	0	0
5	0	720	930	930	930	930	930	930	0	0
6	880	930	930	930	930	0	0	0	0	0
7	1800	1860	1860	1860	1860	1860	0	0	0	0
8	0	1830	2610	2610	2610	2610	2610	2610	2610	0
9	750	750	750	750	750	750	750	750	0	0
10	100	250	250	250	250	250	0	0	0	0
11	90	90	90	90	90	90	90	90	90	90
12	30	90	90	90	90	90	90	90	90	0
13	10	90	90	90	90	90	90	0	0	0
14	140	180	180	180	180	180	180	0	0	0
15	20	90	90	90	90	90	90	90	0	0

DO YOU WANT TO PRINT OUT A SUMMARY OF THE ORDERS THAT NEED TO BE EXPEDITED ?YES

THERE IS NO NEED TO EXPEDITE ANY ORDER FOR ANY COMPONENT ITEM TO MEET THE M.P.S. FOR THE END-PRODUCT(S).

Exercise 3

Objective: to analyse the effects of introducing safety stock.

The Sales Department recommends the introduction of a safety stock at the end-product level to provide for unexpected increases in customer orders, and suggests to build-up a safety stock of 100 units for end-product code-number 2 and 50 units for end-product code-number 11.

One way of introducing safety stock is by increasing the master production schedule. However, the introduction of safety stocks should be done with some caution because it may distort the order priorities for the component items at the lower levels. That is, if safety stock at the finished item level is planned regardless of available capacity, manufacturing may start producing orders that include the safety stock while delaying orders required to fill actual customer orders. It is also important to monitor the usage of the safety stock since it may well be the case that it is not being used and is only adding extra inventory carrying costs.

To introduce the safety stock information into the package, select the option of re-running it changing data in both, the inventory record file and the MPS and scheduled receipts file. Change the safety stock data for the end-products in the inventory record file. Then, in the MPS and scheduled receipts file, increase the

MPS so as to build up a safety stock of 100 units for the end-product code-number 2 and 50 units for the end-product code-number 11. If the maximum plant capacity is 400 units of end-product per week, how can the safety stock be built up keeping production within the limits ?

One approach to build up the mentioned safety stock levels for the end-products that fulfils the conditions of limited plant capacity and no distortion in the order priorities is to spread the safety stock quantity among various weeks as shown in Figure 6.3.

Weeks	10	11	12	13	14	15	16	17	18	19
End-product 2	250	250	250	250	250	260	310	280	250	250
End-product 11	90	90	90	90	90	140	90	90	90	90

Figure 6.3. Master production schedules including safety stock

The requirements plan tables corresponding to the end-products are shown in the computer print outs on the next page, where the MPS have been increased to build up the specified safety stocks.

**** MATERIAL REQUIREMENTS PLANNING SYSTEM RUN ****

* COMMENT: IN THE REQUIREMENTS PLAN FOR EACH ITEM SHOWN BELOW, THE QUANTITIES CORRESPONDING TO GROSS REQ'S, SCHEDULED RECEIPTS, NET REQ'S, PLANNED STARTS AND PLANNED BATCHES CORRESPOND TO THE MID-POINT OF THE RESPECTIVE PLAN'G PERIOD, WHILE STOCK-ON-HAND QUANTITIES CORRESPOND TO THE END OF THE RESPECTIVE PLAN'G PERIOD.

ITEM CODE-NUMBER= 2

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
400	1	100	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	300	250	200	350	300	100	400	250	250	200
PHYSIC. S/H	100	0	0	0	0	0	0	0	0	0
PLANNED S/H	100	100	150	50	0	150	10	70	100	150
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
M.P.S.	250	250	250	250	250	260	310	280	250	250

ITEM CODE-NUMBER= 11

S/H	LT	SAFETY STOCK	SAFETY TIME	UNIT TIME	BATCHING RULE
120	1	50	0	WEEK	LOT FOR LOT

UNIT TIME	10	11	12	13	14	15	16	17	18	19
GROSS REQ.	90	80	70	100	100	70	150	80	90	80
PHYSIC. S/H	30	0	0	0	0	0	0	0	0	0
PLANNED S/H	30	40	60	50	40	60	50	60	60	70
SCH/RECEIPT	0	0	0	0	0	0	0	0	0	0
M.P.S.	90	90	90	90	90	140	90	90	90	90

Exercise 4

Objective: to analyse the effects of increases in the demand.

On the first day of week 11, the following customer orders for additional units of end-products have been received:

end-product code-number 2:

50 units for week 18

300 units for week 20

end-product code-number 11:

30 units for week 17

30 units for week 18

100 units for week 20

Input the above information into the MRP package by selecting the option of re-generating the requirements plans moving forward period-by-period in the planning horizon, and introduce the new customer orders into the gross requirements schedules. List the MPS and scheduled receipts file and analyse the updated scheduled receipt information to understand the process of releasing mature planned orders (or batches).

After re-generating the requirements plans, establish the effects of the increase in the demand: can the new gross requirements schedule be met ?; is the safety stock used to cover unexpected customer orders ?; is there any component shortage ?.

The accompanying print out shows the requirements plan tables for the end-products where it can be seen that the new gross requirements schedule can be met by the MPS thanks to the introduction of the safety stocks.

```
**** MATERIAL REQUIREMENTS PLANNING SYSTEM RUN ****

* COMMENT: IN THE REQUIREMENTS PLAN FOR EACH ITEM SHOWN  BELOW,
           THE QUANTITIES CORRESPONDING TO GROSS REQ'S, SCHEDULED
           RECEIPTS, NET REQ'S, PLANNED STARTS AND PLANNED BATCHES
           CORRESPOND TO THE MID-POINT OF THE RESPECTIVE PLAN'G PERIOD,
           WHILE STOCK-ON-HAND QUANTITIES CORRESPOND TO THE END
           OF THE RESPECTIVE PLAN'G PERIOD.


ITEM CODE-NUMBER=  2
 S/H  LT  SAFETY STOCK  SAFETY TIME  UNIT TIME  BATCHING RULE
 100   1      100             0        WEEK       LOT FOR LOT
-------------------------------------------------------------
UNIT TIME      11   12   13   14   15   16   17   18   19   20
-------------------------------------------------------------
GROSS REQ.    250  200  350  300  100  400  250  300  200  300
PHYSIC. S/H   100    0    0    0    0    0    0    0    0    0
PLANNED S/H   100  150   50    0  150   10   70   50  100   50
SCH/RECEIPT   250    0    0    0    0    0    0    0    0    0
M.P.S.        250  250  250  250  260  310  280  250  250    0
-------------------------------------------------------------


ITEM CODE-NUMBER=  11
 S/H  LT  SAFETY STOCK  SAFETY TIME  UNIT TIME  BATCHING RULE
  30   1       50             0        WEEK       LOT FOR LOT
-------------------------------------------------------------
UNIT TIME      11   12   13   14   15   16   17   18   19   20
-------------------------------------------------------------
GROSS REQ.     80   70  100  100   70  150  110  120   80  100
PHYSIC. S/H    40    0    0    0    0    0    0    0    0    0
PLANNED S/H    40   60   50   40   60   50   30    0   10    0
SCH/RECEIPT    90    0    0    0    0    0    0    0    0    0
M.P.S.         90   90   90   90  140   90   90   90   90    0
-------------------------------------------------------------
```

Exercise 5

Objective: application of batching rules.

The Production and Purchasing Departments consider that it might be possible to cut inventory and production costs by applying some kind of batching procedure to the planned starts (or planned orders) instead of covering them on a period-by-period basis. Using the batching rule options offered by the package, try to implement an economical batching policy. For this purpose, re-run the package choosing the option of changing data in the inventory record file and change the batching rule information according to the selected policy.

The computer print out concerning the forecast inventory cost analyses given on page 162 shows the various inventory costs under the batching policy indicated in the same report. The summary of the planned stock-on-hand, the planned batches and the orders that need to be expedited under the new batching policy are shown in the prints out on pages 162 and 163.

DO YOU WANT TO PRINT OUT FORECAST INVENTORY COST ANALYSES ?YES

*** FORECAST INVENTORY COST ANALYSES ***
THROUGHOUT THE PLANNING HORIZON

ITEM CODE NO.	BATCHING RULE	INVENTORY HOLDING COST/UNIT & PERIOD	SET-UP COST/ BATCH	NO. SET UP	TOTAL SET-UP COST	TOTAL INVENTORY HOLDING COST	TOTAL INVENTORY COST	UNITS LEFT
2	LOTLOT	0.00942	6.0	9	54.00	6.40	60.40	50
3	LTC(NEW)	0.00083	2.0	4	8.00	3.27	11.27	0
4	EOQ	0.00005	0.5	2	1.00	1.08	2.08	4288
5	LTC(NEW)	0.00074	2.0	3	6.00	0.00	6.00	0
6	EOQ	0.00060	0.5	2	1.00	1.29	2.29	0
7	EOQ	0.00005	0.5	2	1.00	1.24	2.24	5170
8	EOQ	0.00014	0.5	5	2.50	2.49	4.99	675
9	EOQ	0.00009	0.5	2	1.00	0.93	1.93	312
10	EOQ	0.00369	2.0	3	6.00	7.46	13.46	273
11	LOTLOT	0.00923	6.0	9	54.00	3.14	57.14	0
12	LTC(NEW)	0.00138	2.0	2	4.00	1.83	5.83	0
13	EOQ	0.00083	2.0	1	2.00	1.03	3.03	299
14	EOQ	0.00009	0.5	1	0.50	0.29	0.79	641
15	EOQ	0.00277	2.0	2	4.00	3.75	7.75	70
			TOTAL COSTS =		145.00	34.20	179.20	

*** PLANNED STOCK-ON-HAND ***

UNIT TIME / ITEM CODE-NUMBER	11	12	13	14	15	16	17	18	19	20	AVER STO. PER UNIT TIME	CUMUL STOCK VALUE
2	100	150	50	0	150	10	70	50	100	50	73	1.49E+03
3	0	930	0	1060	0	1020	0	930	0	0	394	7.09E+02
4	0	720	3504	3504	1374	1374	4288	4288	4288	4288	2763	2.76E+02
5	0	0	0	0	0	0	0	0	0	0	0	0.00E+00
6	800	0	1010	167	167	0	0	0	0	0	214	2.79E+02
7	1500	0	0	2315	2315	5170	5170	5170	5170	5170	3198	3.20E+02
8	780	2545	4310	1700	3175	25	1520	3285	675	675	1869	5.61E+02
9	0	0	2181	1431	651	2652	1812	1062	312	312	1041	2.08E+02
10	50	0	150	0	281	512	232	523	273	273	229	1.84E+03
11	40	60	50	40	60	50	30	0	10	0	34	6.80E+02
12	0	410	320	230	90	0	180	90	0	0	132	3.96E+02
13	0	10	10	10	10	299	299	299	299	299	153	2.76E+02
14	0	140	140	140	140	641	641	641	641	641	376	7.53E+01
15	0	0	285	195	55	340	250	160	70	70	142	8.55E+02

CUMULATIVE TOTAL VALUE= 7.96E+03

~~DO YOU WANT TO PRINT OUT THE SUMMARY OF THE PLANNED BATCHES OF~~
ALL ITEMS THROUGHOUT THE PLAN'G HORIZON ('YES' OR 'NO') ?YES

*** SUMMARY OF PLANNED BATCHES ***

UNIT TIME ITEM CODE-NUMBER	11	12	13	14	15	16	17	18	19	20
2	250	250	250	250	260	310	280	250	250	0
3	1860	0	1990	0	2130	0	1860	0	0	0
4	4774	0	0	0	4774	0	0	0	0	0
5	0	1990	0	2130	0	1860	0	0	0	0
6	1287	0	1693	0	0	0	0	0	0	0
7	0	6575	0	6575	0	0	0	0	0	0
8	4375	4375	0	4375	0	4375	4375	0	0	0
9	2931	0	0	2931	0	0	0	0	0	0
10	541	541	0	541	0	0	0	0	0	0
11	90	90	90	90	140	90	90	90	90	0
12	500	0	0	0	0	270	0	0	0	0
13	0	0	0	559	0	0	0	0	0	0
14	0	0	0	1041	0	0	0	0	0	0
15	375	0	0	375	0	0	0	0	0	0

DO YOU WANT TO PRINT OUT A SUMMARY OF THE ORDERS THAT NEED TO
BE EXPEDITED ?YES

*** SUMMARY OF THE ORDERS THAT NEED TO BE EXPEDITED ***

ITEM	LEAD	WEEK WHEN THE ORDER IS REQUIRED									
CODE-NUMBER	TIME	11	12	13	14	15	16	17	18	19	20
4	2	720									
5	1	720									
6	3		290								
7	2		680								
13	2	330									
14	2	780									

DO YOU WANT TO PRINT OUT GROSS REQUIREMENTS OF EACH ITEM PER UNIT OF
END-PRODUCT ?

YOUR REPLY (ANSWER 'YES' OR 'NO') ?NO

DO YOU WANT ANOTHER SIMULATION ?
YOUR REPLY (ANSWER 'YES' OR 'NO') ?NO

DONE

The applicability of the MRP package MARPLA as a teaching aid has been tested by means of demonstrations addressed to post-experience course groups and actual runnings of the package carried out by post-graduate students.

For demonstration purposes, the facility of running the package with data readily available within it has proved to be of a great usefulness . This facility allows the demonstrator to concentrate on the analysis of the outputs from the MRP system without having to input any data, but still being able to show the kind of data required by an MRP model, by listing the contents of each file. Furthermore, changes can be introduced into the data so that their effects on the requirements plan and inventory costs can be analysed.

Students using the package as a tool for the study of material requirements planning have found the "HELP" facility very useful and have made valuable comments on the operation of the package which have been considered by the author for the improvement of the design of the package.

CHAPTER 7

CONCLUSIONS

This thesis describes the development of the material requirements planning package called MARPLA, supplies information on the operation of the package and provides a set of practical exercises to be solved using the package in order to demonstrate the applicability of the material requirements planning technique in managing manufacturing inventories.

MARPLA has been designed mainly as a teaching aid for those students wishing to examine with some depth the planning and controlling functions of a material requirements planning system. The package has been designed to be used on a Hewlett-Packard Access 2000 machine, occupying about 304 blocks of storage.

The MRP package MARPLA is fully interactive allowing the user to establish a continuous communication with the computer throughout the entire simulation process. Furthermore, this interaction between the user and the MRP system is by means of a simple language and no computing knowledge is required from the user.

Another feature of MARPLA that makes it particularly useful as a teaching tool is the availability of the "HELP" facility, by means of which the user can request an explanation of the way of responding to any enquiry from the package when the user is in doubt.

The above mentioned features of MARPLA have been designed with the double objective of providing a practical means for the study of the material requirements planning technique and encouraging students to use the computer as an effective learning tool.

MARPLA allows the user to generate time-phased net requirements and to develop a planned batch schedule for all component items of one or multiple end-products. In addition to this, the package generates the following reports:

(1) Inventory cost analyses, if inventory cost information is provided by the user.

(2) Planned stock-on-hand availability for each item throughout the planning horizon including the corresponding cumulative stock value and the average planned stock-on-hand per unit time.

(3) Summary of the planned batches for each item throughout the planning horizon.

(4) Summary of the orders that need to be expedited to satisfy the master production schedule for the end-products.

(5) Gross requirements of each component item per unit of end-product.

MARPLA also allows the user to perform a dynamic simulation of the requirements generation process by offering the option of re-generating the requirements plans moving forward period-by-period in the planning horizon.

When designing the MRP package MARPLA, it has been the aim of the author to provide the user with a flexible system in relation to the introduction of the data into the computer and the display of the different output reports. Thus, the following facilities have been included in the design of the package:

(i) The use of data files to store all the information required by the package so that the user does not have to input the data every time the package is run. This facility is particularly useful if the amount of data required by a material requirements planning system is considered.

(ii) Options to list and change the data stored in any file are offered before carrying out each new requirements generation process, so that the user understands the importance of keeping the information contained in the files accurate and up to date in order to generate valid outputs from the system.

(iii) The display of each output report is offered as an option so as to give the user the opportunity of printing out only those reports of interest in each new running of the package.

To encourage the inexperienced user to run the package, a set of data have been included within it so that the user can generate all the MRP output reports and even analyse the effects of changing the inventory parameters without having to supply any data to the computer. To support this facility, a set of exercises based on the programmed data have been designed in order that the user simulates the kind of situations usually found in manufacturing industries, makes decisions on the selection of the inventory parameters and studies the way a material requirements planning system behaves under different conditions.

In addition to the educational role of MARPLA, the following applications of the package can be considered:

(1) as a research tool to investigate decision-making techniques concerning the use of safety stocks, safety times or the selection of lot-sizing methods.

(2) as a practical instrument to be used by companies contemplating the installation of an MRP system and wishing to carry out preliminary analyses of

the applicability of material requirements planning to manage their inventory systems.

Finally, it should be mentioned that although the aim of the author in developing a comprehensive material requirements planning package mainly for teaching purposes has been successfully accomplished, more facilities can always be added to the package to enlarge even more its area of application. It is hoped that MARPLA constitutes a truly useful contribution to the teaching material available to introduce students in business courses and production engineering into the design and operation of material requirements planning systems.

APPENDIX I

BATCHING RULES

The material requirements planning package MARPLA gives the user the opportunity of choosing a **particular** batching rule for each item of the bill of material, or, the same batching rule for all items. Eight options are offered by the package to select the batching rules. The description of the batching procedure of each rule, as it is carried out by the package, is given below.

(1) Lot for lot

This rule provides period-by-period coverage of the demand, that is, in each planning period, the order (or batch) quantity is equal to the demand. In this way, holding inventory costs are minimized. Figure I.1 illustrates this method of batching.

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	100	80	0	120	110	130	0	150	100	90	0	880

Figure I.1. Lot for lot

(2) Fixed order quantity

Under this technique, the user specifies a fixed order quantity (or batch), which may be determined intuitively or empirically. In the event that, in a given planning period, the order (or batch) quantity is not enough to cover the demand, the order quantity is increased to cover the demand in question. For example, if, in the schedule shown in Figure I.1 the demand in period 11 is now 400, the fixed order quantity being equal to 300, then the order in period 11 is increased to 380 in order to cover the demand in question. This is illustrated in the example of Figure I.2.

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	400	1280
Batches	300				300			300			380	1280

Figure I.2. Fixed order quantity

(3) Fixed period requirements

Under this approach, the user specifies how many periods of the planning horizon each order (or batch) should cover. Thus, while the batching interval is fixed, the batch size varies.

The ordering interval is increased only when the demand is zero after a period that has already been included in the previous order (or batch). Figure I.3 shows an example of this rule, where the ordering interval is 2 periods.

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	180			230		130		250		90		880

Figure I.3. Fixed period requirements

(4) Economic order quantity (EOQ)

Under this model, a fixed order (or batch) quantity is calculated according to the classical EOQ formula:

$$EOQ = \sqrt{\frac{2\ A\ Co}{C}} \qquad (1)$$

where: A : Annual demand

Co: Ordering or set-up cost / batch

C : Annual inventory holding cost per unit

When the EOQ technique is used in an MRP system, the annual demand is based on an assumed future demand rather than on historical demand.

The EOQ approach implies placing an order equal to the EOQ every time the stock falls to or below a re-order level, which may include a safety stock.

As for the fixed order quantity, when the order quantity (EOQ) is not enough to cover the demand in a given period, the order quantity is increased to cover the demand in question. Figure I.4 demonstrates the use of this rule, where:

Ordering cost: Co = 250 / order

Annual inventory holding cost: C = 6 / unit

Number of periods in a year: 12

Annual demand: A = 880 x 12 / 10 = 1056

$$\text{Economic order quantity: } EOQ = \sqrt{\frac{2 \times 1056 \times 250}{6}} = 297$$

Note : the demand in period 11 has not been taken into consideration for the calculation of the annual demand.

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	297			297				297				891

Figure I.4. Economic order quantity

(5) Economic time cycle (ETC)

Under this technique, a fixed ordering (or batching) interval - known as the ETC - is calculated by dividing the Economic order quantity (EOQ) by the average demand per period, and rounding the result to the nearest integer number. Thus:

$$E\ T\ C = \frac{E\ O\ Q}{Av} \qquad (2)$$

where: EOQ : Economic order quantity
Av : Average demand per period

The ETC represents the number of periods that the corresponding EOQ would cover. Under the ETC model, the ordering interval is fixed while the order quantity varies. Both, the EOQ and ETC rules incur approximately the same total set-up cost, but inventory holding costs tend to be lower under the ETC model.

The example shown in Figure I.5 illustrates the use of the ETC.

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	180			360				340				880

EOQ = 297 (from example in FigureI.4)
Average demand per period : Av = 880 / 10 = 88
Economic time cycle : ETC = 297 / 88 = 3.37 = 3

Figure I.5. Economic time cycle

(6) Least-unit cost (LUC)

The idea of the least-unit cost model is to spread the set-up cost of a batch over as many units as possible, batching successive demands until that demand which would produce an extra inventory holding cost higher than the saving achieved by the spreading of the set-up cost. The unit cost is calculated by dividing the sum of the set-up cost and the cumulative inventory holding cost by the total number of items in the batch.

Figure I.6 shows the computation of the leat-unit cost and the use of the rule.

Period	Demand	Batch size	Total set-up cost	Total holding cost	Total inventory cost	Inventory cost-per unit
1	100	100	250	0	250	2.50
2	80	180	250	40	290	1.61
4	120	300	250	220	470	1.57 ••
5	110	410	250	440	690	1.68
5	110	110	250	0	250	2.27
6	130	240	250	65	315	1.31 ••
8	150	390	250	290	540	1.38
8	150	150	250	0	250	1.66
9	100	250	250	50	300	1.20
10	90	340	250	140	390	1.15 ••

Computation of the least-unit cost

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	300				240			340				880

Figure I.6. Least-unit cost

(7) Least total cost (Part-period algoritm) (Orlicky's version) (1)

The least-total cost policy is to equate the set-up cost and the inventory holding cost in order to minimize the total inventory cost. To achieve its objective, the LTC model batches successive demands until the set-up cost per unit more nearly equals the inventory holding cost per unit.

The LTC algorithm makes use of the economic part-period concept (EPP) for the computation of the batch quantities. The EPP is defined as that quantity of an item which would imply an inventory holding cost equal to the set-up cost, if carried in inventory for one period. The EPP is calculated as follows:

$$EPP = \frac{Co}{C / N} \qquad (3)$$

where: Co : Ordering or set-up cost per batch
C : Annual inventory holding cost per unit
N : Number of periods in a year

The LTC technique batches successive demands until the cumulative part-period cost most nearly equals the EPP value.

The computation of the EPP value and the use of the LTC model are illustrated in Figure I.7, where:

Ordering cost : Co = 250 / order
Annual inventory holding cost : C = 6 / unit
Number of periods in a year : N = 12
Economic part-period value : EPP = 250 / (6 / 12) = 500

Period	Demand	Batch size	Cumulative part-period (CPP)	|EPP-CPP|
1	100	100	0	500
2	80	180	80	420
4	120	300	440	60 ••
5	110	410	880	380
5	110	110	0	500
6	130	240	130	370
8	150	390	580	80 ••
9	100	490	980	480
9	100	100	0	400
10	90	190	90	310 ••

Computation of least-total cost

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	300				390				190			880

Figure I.7. Least-total cost (Orlicky's version) (1)

(8) Least-total cost (part-period algorithm) (New's version) (3)

The version of the LTC model described by C. New batches successive demands just to the point where the inclusion of the next period would cause the cumulative part-period cost to exceed the EPP value. In other words, the batching process stops just before the period in which the inventory holding cost exceeds the set-up cost.

Figure I.8 demonstrates this version of the LTC model, where:

Ordering cost : Co = 250 / order

Annual inventory holding cost : C = 6 / unit

Number of periods in a year : N = 12

Economic part-period value : EPP = 250 / (6 / 12) = 500

Period	Demand	Batch size	Cumulative part-period
1	100	100	0 ≤ 500
2	80	180	80 ≤ 500
4	120	300	440 ≤ 500 ••
5	110	410	880 > 500
5	110	110	0 ≤ 500
6	130	240	130 ≤ 500 ••
8	150	390	580 > 500
8	150	150	0 ≤ 500
9	100	250	100 ≤ 500
10	90	340	280 ≤ 500 ••

Computation of the least-total cost

Period	1	2	3	4	5	6	7	8	9	10	11	Total
Demand	100	80	0	120	110	130	0	150	100	90	0	880
Batches	300				240			340				880

Figure I.8. Least-total cost (New's version) (3)

APPENDIX II

STRUCTURE OF MARPLA

The whole material requirements planning package developed by the writer is made up by a set of chain programmes interrelated by means of common variables. That is, each program uses variables already input or calculated in other programmes in order to perform its own calculations. Figure II.1 illustrates the structure of the overall MRP package. The program referred to as MARPLA is the central program, since it is in charge of passing the control of the system to the other programmes. The function of each constituent program of the package is described below.

Program	Storage length (records)	Function
1. Main program MARPLA	4	Controls the execution of the package and performs the explosion of requirements.
2. Program BATDES	17	Explains and illustrates the batching procedure of each rule included in BATSEL.
3. Program BATSEL	10	Includes various options to select the batching rule of each item and stores this information in the Inventory record file.
4. Program BOM	15	Input bill of material data from terminal and stores them in the BOM file.
5. Program BOMFL	8	Prints contents of BOM file and offers option of changing data in this file.

Program	Storage length (records)	Function
6. Program CASE	11	Explains use of programmed data and copies data into corresponding user's files.
7. Program CHANGE	5	Offers options to re-run the package.
8. Program COST	6	Conducts and prints out inventory cost analyses throughout the planning horizon.
9. Program COST1	7	Conducts and prints out inventory cost analyses in the current planning period.
10. Program DCOST	6	Input item inventory cost data from terminal and stores them in the Inventory record file
11. Program DESCR1	7	Prints out description of the package.
12. Program DESCR2	14	Prints out description of the package commenced by DESCR1.
13. Program DESCR3	4	Prints out definition of each inventory cost at the user's request.
14. Program DYNAMI	5	Updates the Inventory record file and the MPS and scheduled receipts file for re-generation of the requirements plan moving forward one period.
15. Program EOQ	2	Generates planned batch schedule according to the economic order quantity rule.
16. Program ETC	3	Generates planned batch schedule according to economic time cycle rule.
17. Program FOQTY	3	Generates planned batch schedule according to fixed order quantity rule.

Program	Storage length (records)	Function
18. Program FPREQS	2	Generates planned batch schedule according to fixed period requirements rule.
19. Program GROSS	4	Computes and prints out gross requirements of each component item per unit of end-product.
20. Program GRS	6	Input gross requirements schedule data from terminal and stores them in the MPS and scheduled receipts file.
21. Program INDATA	6	Prints options to input data into the package and creates the three files required.
22. Program INDDEM	7	Input independent demand data from terminal and stores them in MPS and scheduled receipts file.
23. Program INVFL	11	Prints out contents of Inventory record file and offers option of changing any data in this file.
24. Program LEADTI	3	Input lead time data from terminal and stores them in the Inventory record file.
25. Program LOGIC	5	Performs low-level coding process of the bill of material.
26. Program LOTLOT	1	Generates planned batch schedule according to lot-for-lot rule.
27. Program LTC	2	Generates planned batch schedule according to least-total cost rule (Orlicky's version).

Program	Storage length (records)	Function
28. Program LTCN	2	Generates planned batch schedule according to least-total cost rule (New's version).
29. Program LUC	2	Generates planned batch schedule according to least-unit cost rule.
30. Program MAREP1	4	Computes stock-on-hand values, net requirements and planned starts for each item throughout the planning horizon.
31. Program MPS	10	Input master production schedule data from terminal and stores them in MPS and scheduled receipts file. Offers two options in relation to the MPS data.
32. Program MPSFL	13	Prints out contents of MPS and scheduled receipts file and offers option of changing any data in this file.
33. Program NOTES	5	Prints out messages on use of safety stock and safety time,and need of expediting net requirements.
34. Program OUTDAT	6	Retrieves data from the three files required by the package.
35. Program PBATCH	4	Prints out summary of planned batches of all items throughout the planning horizon.
36. Program PLANNG	8	Computes longest cumulative lead time and input data of planning horizon from terminal and stores them in the Inventory record file.

Program	Storage length (records)	Function
37. Program PSTOC1	5	Prints out projected stock-on-hand and cumulative stock value throughout the planning horizon.
38. Program PSTOCK	4	Computes projectedstock-on-hand and cumulative stock value throughout the planning horizon.
39. Program RESULT	7	Prints out heading of tables of requirements plan for each item.
40. Program RQPLAN	5	Prints out table of requirements plan for each item.
41. Program SAFETY	3	Input safety stock data from terminal and stores them in the Inventory record file.
42. Program SAFTIM	3	Input safety time data from terminal and stores them in the Inventory record file.
43. Program SCHREC	6	Input scheduled receipts data from terminal and stores them in the MPS and scheduled receipts file.
44. Program STOCK	3	Input stock-on-hand data from terminal and stores them in the Inventory record file.
45. Program SVALUE	4	Computes and prints out stock value at the beginning of the current period.
46. Program XPEDIT	6	Prints out summary of the orders that need to be expedited throughout the planning horizon.

Program	Storage length (records)	Function
47. File BOMCA	10	Stores programmed data concerning the bill of material data.
48. File INVCA	10	Stores programmed data concerning the inventory record data.
49. File MPSCA	10	Stores programmed data concerning time-dependent information (i.e. MPS, GRS, scheduled receipts and independent demand).

Total length = 304 records

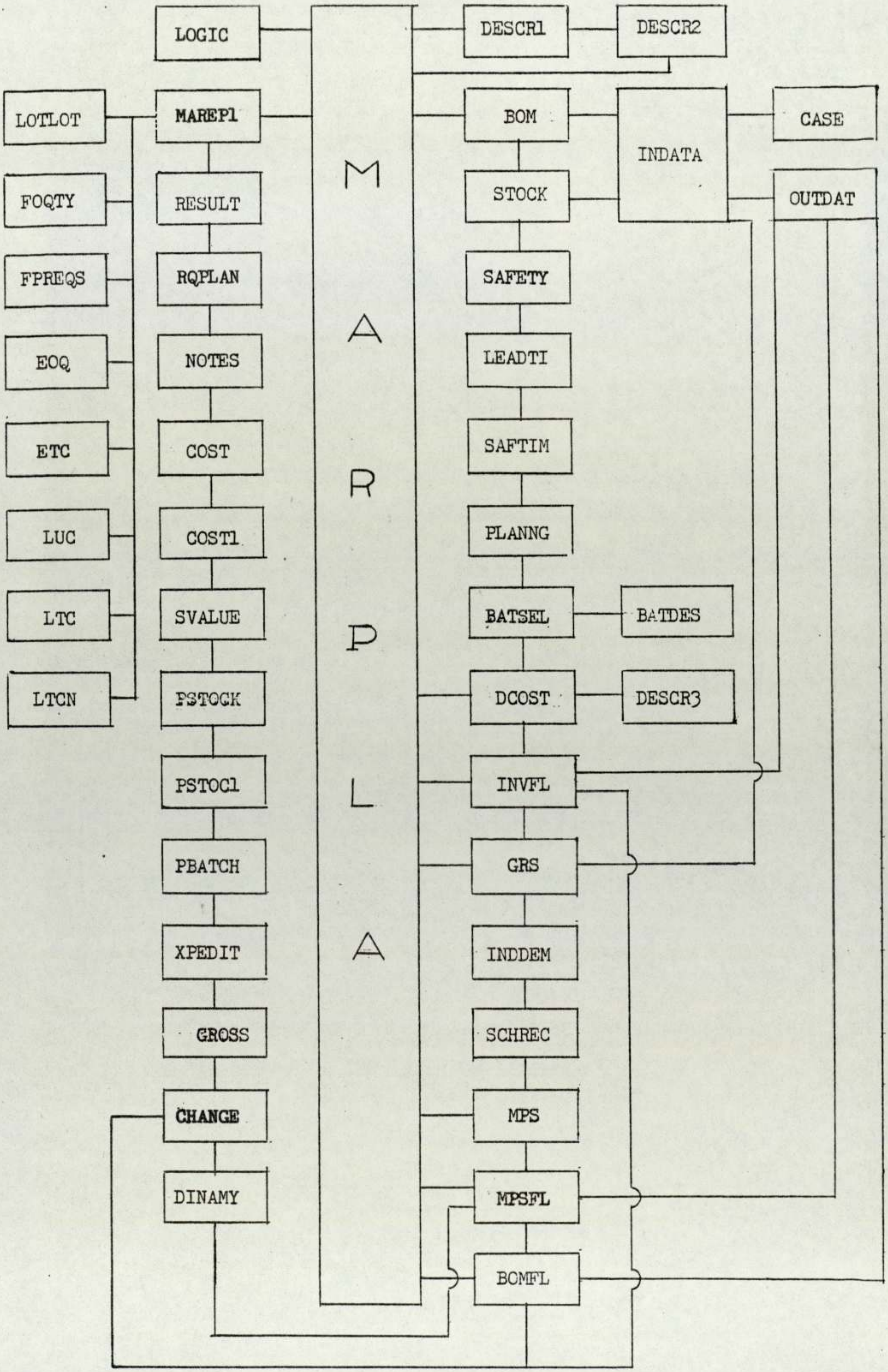


Figure II.1. Structure of MARPLA

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