1987

Functional specification definition for manufacturing resource planning software /

Manish Shah
Lehigh University

FUNCTIONAL SPECIFICATION DEFINITION

FOR

MANUFACTURING RESOURCE PLANNING SOFTWARE

by

Manish Shah

A thesis

Presented to the Graduate Committee

of Lehigh University

in Candidacy for the Degree of

Master of Science

in

Manufacturing Systems Engineering

Lehigh University

1987

This thesis is accepted and approved in partial fulfillment of the requirements for the degree of Master of Science

Sept 17, 1987

(date)

Professor in charge

MSE Program Director

Chairman of Department

ACKNOWLEDGEMENTS

Writing a thesis requires help from various sources, and I have been fortunate enough to receive it from many.

I owe my sincere thanks to Dr. Roger N. Nagle for supervising this work and lending advice from time to time in improving and perfecting this work. I wish to acknowledge a particular debt of gratitude for his valuable suggestions and leading me on a right path during the several phases of this thesis, and reviewing the material in depth.

My sincere thanks also go to Daniel Ellingson, General Dynamics (Electronics Division GDE), San Diego, CA for permitting to visit the facility at GDE and providing me an opprtunity to interview various experts and obtaining first hand experience of MRP -II implementation effort at GDE.

My sincere thanks also go to Jane Reese, Mack Trucks, Allentown, PA, for providing with valuable information on master scheduling bill of material structuring, and discussing problems related to software selection for MRP - II.

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

Manufacturing Resource Planning (MRP II) is a new way of running business involving manufacturing, logistics, and financial planning. This new approach requires a better understanding of the fundamentals of running and observing certain disciplines in record keeping.

Software for MRP II helps production planners in determining not only material requirements, but also capacity requirements, shop floor control, purchasing, financial planning and carrying out "What if" simulations.

The process of software selection is simplified by defining functional requirements of manufacturing enterprise. The thesis provides a methodology for defining functional specification. These specifications are developed keeping in mind various considerations. The entire task of defining is divided into various modules each related to a specific aspect of the business such inventory management, capacity management, purchasing, financial planning, and distribution management.

Software selection has become a difficult task, particularly in recent times with the proliferation of software.

This thesis provides methodology in defining functional requirements in light of various demands raised by above mentioned functions of a manufacturing enterprise.

Functional specification helps in prioritizing the needs for each activity, it provides as a reference system in evaluating different software packages and serves as a document which can be later enhanced for evaluating other systems.

The thesis attempts to provide functional specification for each of different manufacturing activities such as master scheduling, material requirements planning, bill of materials, shop floor control, capacity requirements planning, financial planning, manufacturing accounting, purchasing, distribution plannig, and performance measurement. Each of this specification provides information for the particular activity and the requirements imposed on the software by the activity. It also provides information as how to evaluate the software modules for each of this manufacturing activity.

1.0 INTRODUCTION

1.1 MANUFACTURING RESOURCE PLANNING (MRP II):

Production planning is essentially carried out for two reasons:

to determine rate of output for family of products, and to determine the level of employment.

Overall a production plan determines organizational needs for human resources, capacity requirements, and facilities requirements.

Material requirements planning develops a plan for raw material requirements (quantity and time) to attain the production rate set by the production plan.

Manufacturing resource planning (fig. 1.1) is a method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what if" questions. It is made up of a variety of functions, each linked together:

business planning,
production planning,
master production scheduling,
material requirements planning,
capacity requirements planning,

and the execution support system for material and capacity such as distribution planning and financial planning.

Output from these systems would be integrated with

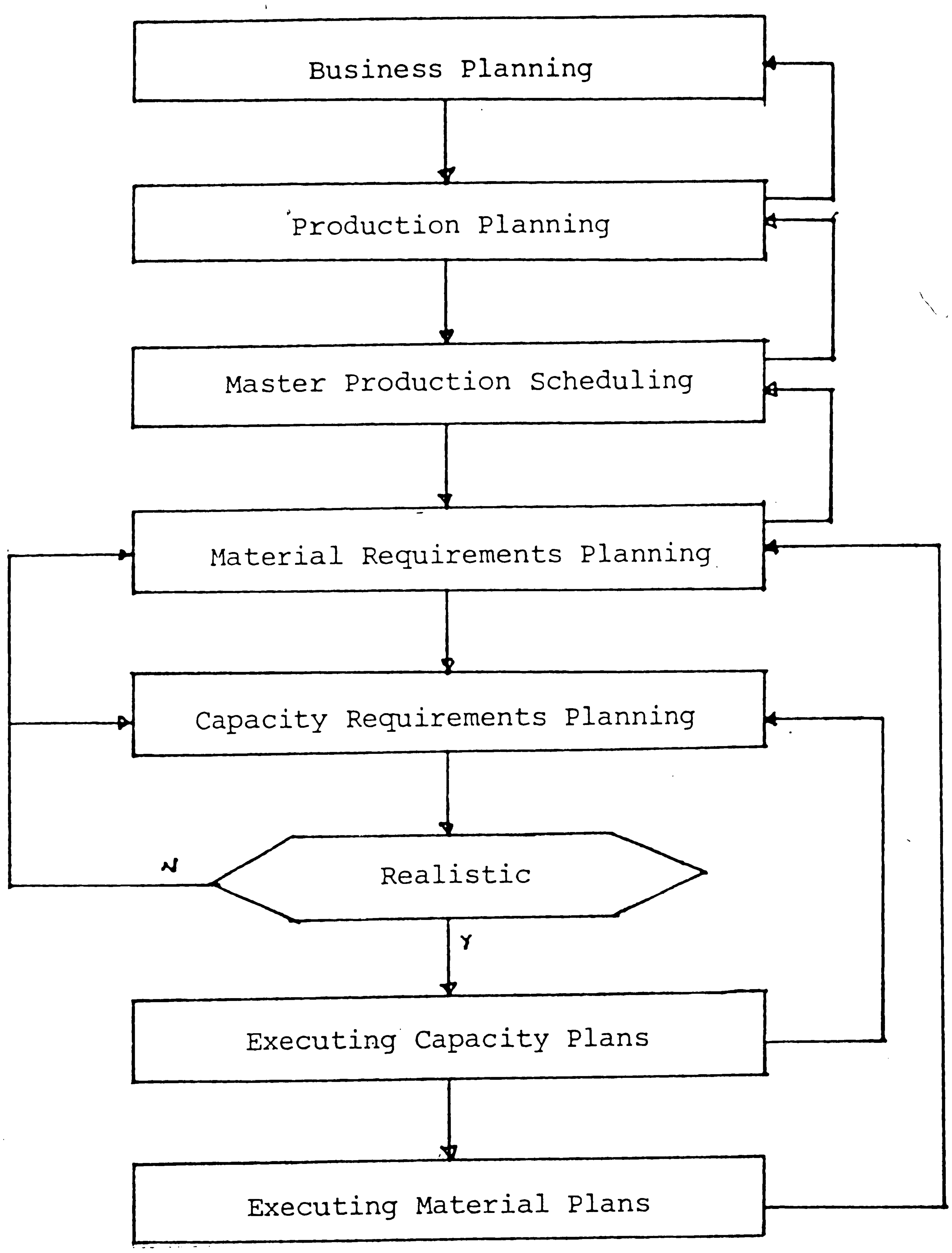


Figure 1.1
Flow Diagram
Manufacturing Resource Planning

financial reports such as the
business plan,
purchase commitment reports,
shipping budgets,
shipping budgets,
inventory projection in dollars, etc.

MRP II puts the fundamental scheduling logic of MRP to work in capacity requirements planning, shop floor control, and purchasing. Planners could use material requirements planning generated information to validate, executable production schedules and make sure they meshed with timetables of other factory operations.

MRP II is a company-wide game plan for planning, monitoring and controlling all the resources of a modern manufacturing company.

Major capabilities are illustrated in the following sections.

1.1.1 MATERIAL REQUIREMENTS PLANNING:

The logic of Material requirements planning asks the following questions:

What are we going to make?
What does it take to make it?
What do we have?
What do we have to get?

Material requirements planning uses the master production schedule (What are we going to make?) explodes it through the bill of material (What does it to take to make it?) and compares inventory records (What do we have?) to determine future requirements (What do we have to get?).

Material requirements planning contains capabilities far greater than merely giving better signals for reording. It keeps order due dates valid after the orders had been released to production or to vendors. It could detect when the due date of an order was out of phase with its need date. In ever changing manufacturing enviornment, material requirements planning keeps order due dates valid and in synchronization with these which is also known as priority planning, or scheduling.

Closed loop MRP contains tools to address both priority and capacity, and to support both planning and execution. The feed back provision enables the plans to be altered when necessary, there by keeping priorities valid as conditions changes.

Today, there is a wide variety of tools and techniques that are available such as CAD/CAM, Group Technology, Robotics and more. But none of them will probably ever yield their full potential unless they are coupled to an effective planning and scheduling system.

Here's why:

It does little good to be extremely efficient ... at producing the wrong items.

It does little good to make items at a very high level of quality ... if they are not the ones needed.

It does little good to work hard at reducing set up times and cutting lot sizes ... if bad schedules prevent knowing what's really needed and why.

Manufacturing inventory differs from distribution inventory in a fundamental way. In a manufacturing enviornment uncertainity exists only at the product level (final product or an assembly whichever is the end product) because of the uncertain customer demand but, at the component level such uncertainity hardly exists. The components to the end product needs only time phasing according to the end product forecast.

A MRP consists of a set of logically related procedures, decisions 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. An MRP system replans net requirements coverage as a result of changes in either the master production schedule, or inventory status, or product composition.

MRP system allocates existing on hand quantities to item gross requirements and reevaulates the validity of the timing of any open orders in determining net requirements.

To cover net requirements, the system establishes a schedule of planned orders for each item, including orders, to be released immediately plus orders scheduled for release at specified future dates. Planned order quantities are computed according to one of the several lot sizing rules specified by the system user as applicable to item in question. In its entirety, the information on item requirements and coverage that an MRP system generates is called the **material requirements plan.**

Traditional inventory system, order point is part based, where as material requirements planning is product based. Order point utilizes data on the historical demand-behavior of an inventory item, in isolation from all other items. MRP ignores history in looking towards the future as defined by the master production schedule, and works with data specifying the relationship of components that make up a product.

Traditional inventory analysis, even though takes into account various factors, doesn't take into account the nature (source) of demand. It is the concept of dependent versus independent demand that distinguishes the MRP from order point. Independent demand must be forecast, however dependent demand (horizontal/vertical) can be calculated precisely. Order point, assumes more or less uniform usage, in small increments of the replenishment lot size.

The underlying assumption of the gradual depletion of inventory at a steady rate will render the technique invalid when this basic premise is grossly unrealistic. In manufacturing enviornment inventory depletion tends to occurs in discrete 'lumps' due to lot sizing for subsequent stages of manufacture.

Inventory literature largely concerns itself with problems of quantity, while in the real world of manufacturing the question of timing, rather than quantity, is of paramount importance.

Prerequisites of MRP:

1. The first is the existence of a master production schedule (MPS) i.e., an authoritative statement of how many end items are to be produced and when. An MRP system presupposes that the MPS can, in its entirety, be stated in bills of material terms.

2. Each inventory item be unambiguously identified through a unique code (part no.).
3. Bill of material should be formed of such unique codes.
4. The availibity of inventory records for all items under the system's control containing inventory status data.
5. Precondition for the system's effective operation, is file data integrity pertaining to inventory status data and bill of material data.

MRP system assumes that every inventory item under its control goes into and out of stock, i.e. that these will be reportable receipts, following which the item will be in an "on hand" state and will eventually be disbursed to support an order for an item into which it is dispositioned.

MRP assumes that all components of assembly must be available at the time an order for that assembly is to be released to that factory.

Because of its focus on timing an MRP system can generate outputs that serve as valid inputs to other systems in the area of manufacturing logistics, such as purchasing system, shop scheduling system, dispatching systems, shop floor control systems, and capacity requirements planning.

When the inventory records containing the standard cost, the quantities on hand projected by period are simply costed out and summarized by item group to obtain a highly accurate forecast of the inventory investment level. The same is true for open purchase orders - provided they are recorded by valid due date, which can be converted into a purchase commitment report. The product structure file with its explosion and implosion serves as a basis of product costing. The entire data base, usually also including the routine file, permits the management to obtain profit and loss statement, by individual customer order, by customer, by market, by product, and by product family.

1.1.2 CAPACITY REQUIREMENTS PLANNING:

CRP picks up the planned orders as well as the released orders out of the MRP system. This stretches the load out further into the future to give shop people more time to react to needed changes in capacity. CRP is reallly an iterative technique, the master schedule drives MRP, and the output from the MRP is used for CRP. In the event the capacity is not going to be available to meet the master schedule, then something would have to be done.

CRP works from the forecast of the Capacity requirements based not only on the released orders, but also on the planned orders that would be shown in a material requirements plan, or in a time phase order point format. Capacity requirements planning makes a tentative plan to show the capacity that is needed. This can be compared with actual capacity available to determine whether or not the master schedule can be met.

When the capacity requirement exceeds available capacity, there are only two alternatives: either increase the capacity or revise the master production schedule. Here is where some tough decisions have to be made. Certainly computers will not be able to make the choice of which customers will suffer, whether to work overtime, whether to subcontract, or whether to run job through alternate operations.

The power of this type of system is not that it makes decisions for management, but that it puts the alternative into clear focus so that management can make decisions.

1.1.3 DISTRIBUTION REQUIREMENTS PLANNING:

Time phased order point is, simply, MRP logic used for independent demand items. The time phased order point will signal the planner to order material just like an order point in the non-time phased format will. But, the time phased formt will also signal when rescheduled orders are required. A company with branch warehouses would use the time phase order point at the branch warehouses. The planned orders from each of the branch warehouses would be entered as distribution requirements into the time phased order point for the finished goods at the main plant warehouse, in addition to any forecast customer demand to be supplied out of that warehouse. Time phased order point would link branch warehouse inventories to the main plant warehouse inventory. Planned orders at the branch warehouse level would become requirements on the finished goods inventory.

1.1.4 FINANCIAL PLANNING:

MRP provides a highly accurate base of information that can be used for financial planning. This information base provides an accurate raw material for financial planning, not the automatic calculation of financial statements.

The type of information needed for financial planning with MRP depends on the functions an organisation is planning to implement. The following is a list of financial planning functions within MRP and the information that is required for each:

Inventory valuation and projection will require standard cost by item. These costs are used to value the current inventory, and to project the inventory value at some date in future date.

Cash flow projections may be used to project purchased material costs, payroll expenses, and variable overhead expenses.

To project the purchased material cost, standard purchase material costs are taken into account and are extended by the purchasing schedule.

To project the payroll expenses, standard labor rates by labor grade, work center efficiency factors, and overtime rates are used. These rates are used with the capacity requirements planning information to project the payroll expenses.

To project variable overhead expenses, current or projected utilty rates and their required consumption figures are extended by the capacity requirements.

Carrying financial planning in this manner, lends more credibitility to the process as it is based on accurate manufacturing information, and the detail information at any level can now be summarized in a manner useful to the user.

Subsequent chapters describe methodology for defining functional specification for different modules of MRP II as mentioned before.

2.0 MRP II AND SOFTWARE

2.1 HOMEGROWN vs OFF-THE-SHELF SOFTWARE:

MRP II implementing team has to tackle this fundamental and foremost question as whether to develop a software package in-house or buy from the software vendor?

MRP software packages are big by anyone's standard. Just to take an estimate of the efforts involved, many of the commercially available packages require more than fifty years of efforts and this does not include writing technical and user's manuals, designing input forms, training programs, etc. If one takes a number like fifty manyears and divide it by the number of programmers and systems people, the magnitude of the problem becomes evident.

The track record of homegrown MRP software is poor, and very few people today even entertain the notion of developing their own MRP-II software. One of the reasons is size of the job, as mentioned above and the other reason is what is called as "design-the-tool" syndrom. It shouldn't be forgotten that task of MRP project team is to bring the MRP system quickly on board and reduce the payback period. Those who choose to develop homegrown system should bear in mind that "software development time" is a long time and it generally takes more time than MRP implemetation schedule permits. Just to develop Master Production Schedule (MPS) module takes anything between six months to one year not considering the time required to educate the user as how to use it.

Another fact that has been discovered is that people who tend to develop their own software also tend to design a custom system and then to proceed to rediscover the mistakes of others.

A major problem with homegrown software is that it tends to be designed around current business conditions. For example, a company may not have distribution centers or branch warehouses today. As a result, the system would be designed without the capability to support distribution centers.

Despite all the disadvantages mentioned above, there is a one advantage of "homegrown" software. This kind of software is developed by the very people familiar with the day - to - day requirements within the existing plant. They understand in precise manners the requirements and shortcomings of the existing systems. This leads to a development of sophisticated software. But when considering the trade-off between time, effort and the system sophistication it is always the off-the-shelf system that looks attractive.

This is not to say that available software packages are perfect. In fact, most of the MRP-II software packages are functionally incomplete. This is most common in the areas of financial planning using the operating numbers, simulations and so on. These functional deficiencies can be corrected by modifications. Many of today's software packages are complicated. In fact, most are more complicated than they need to be, and this complication creates bugs. Any source of change is likely to generate bugs. Bug free software is more of a hope than reality. Majority of bugs are irritations and inconveniences as opposed to really serious problems. However, it must be brought to notice that most of the software packages have proven record and are at large satisfactory as far as its performance is considered.

2.2 SOURCES OF SOFTWARE:

Basically, MRP-II software is supplied by hardware vendors or professional software vendors such as software houses, consulting houses, service bureaues, etc.

2.2.1 HARDWARE VENDORS:

Most of these vendors supply software for their own computers. The advantages of software from hardware vendors are:

1. Software will run on vendor's computer.
2. The same vendor is accountable for both the hardware and software.
3. Cost of software is lesser than those supplied by software houses, however, usually more modifications are required.

But it should not be forgotten that hardware manufacturers are in the business of selling hardware and not the software, and many a times, software is not as complete as other softwares. They also have very little incentive to reduce the hardware requirements for the software to run. The software is often tied to a particular type of computer or Data Base Management System (DBMS). Changing to another computer or DBMS may require significant modification.

2.2.2 SOFTWARE VENDORS:

1. For software vendors software is their primary product, so it is generally more complete than that from hardware vendors.
2. Vendor has an incentive to reduce the hardware requirements for the software since it expands the vendor's market.
3. Software is not only machine but data independent.

The only problem typical of software vendor is that they have smaller support staff and they have a very good chance of running out of support capacity if the package becomes quite popular.

A representative list of software vendors can be established using software vendors' guide provided by APICS (American Production and Inventory Control Society) and other organizations, from the experience and knowledge of company's team, and from surveys published in trade publications.

2.3 SOFTWARE JUSTIFICATION PROCESS:

There are several approaches to justifying the process of selection and analysis of MRP II software package. One of them is to justify up front and obtain funding for the total project prior to starting the evaluation. The other is to do the evaluation, select a vendor, and then justify the project. One major drawback to consider in using the second approach, is that the team may go through all the work to select a vendor only to find out that it cannot sell management on the need for new MRP II package. This problem however may be avoided by considering the expenses related to the process of selection and evaluation as a part of the divisional operating cost.

Once decided, formation of project team should be the next step. This team may or may not later become the systems implementation team. A key user like the materials manager should be the project leader who is responsible for making the team approach work and represents users. A representative from purchasing or procurement may help in handling things like preparing the "Request For Proposal", reviewing terms and conditions, etc. After selection of vendor this representative may also handle the contract negotiations with some help from legal staff. To be able to evaluate the software packges technically, team may have one or two members from MIS organization. These members may be responsible for reviewing data base structure, run times, programming languages, data base management, and so on.

As early tasks, the team should define the time schedule for the evaluation and terminal date for completion of the effort. Team should also spell out how many vendors will be evaluated. It is recommended that number of vendors be limited to six or seven, this will save lot of time later on. It has also been found that once the evaluation procedure has begun it is common to add new vendors to the existing list, which should be resisted. Also, team must define clearly the evaluation criteria. This will help avoid the problem of evaluating too much.

2.4 DEFINING FUNCTIONAL SPECIFICATION:

The objective of a functional specification is to determine the inventory management and related problems, and determine how the inventory would be managed and where the major benefits may be realised so that a software can be selected. As far as possible, the specification should be real requirements and not a wish list of features some one would like to have.

If the division performing the analysis is a division of a major corporation, understanding other division's needs prior to starting the evaluation would save time and effort later. It is highly recommended to develop joint or common functional specification up front. This may slow down on the front end, but it will buy time in the long run.

The functional specification will become one of the team's primary evaluation tools with which the vendors will be rated against. It would also provide a documented trail of their responses. It represents the base line requirements of MRP system as defined by the users and MIS. The functional specification should be designed such that vendor can record their responses and ratings of their responses can be incorporated.

This effort can be accomplished by the project team meeting with users and obtaining their requirements. The best way to get started is to define information requirements by conducting interviews with users.

Following modules have been found to be necessary for MRP II software to function effectively:

1. **Master production schedule**

   It converts the production plan (rate of output) into weekly or daily schedule of production in terms of specific end-items.

2. **Material requirements planning**

   It converts the gross requiremetns into net requirements so that the priorities are set, input to capacity requirements planning is provided, and planned orders are generated.

3. **Bill of materials**

   It provides product structure to MRP logic in carrying out the netting process from parent level to its lowest component level.

4. **Shop floor control**

   It controls the execution of shop scheduling and dispatching system.

5. **Capacity requirements planning**

   It plans the capacity in terms of standard hours.

6. **Purchasing**

It helps in planning and controlling of purchased parts.

7. **Performance measurement**

It provides the indication of health of operation in areas such as inventory accuracy, bill of material accuracy, capacity planning, etc.

8. **Distribution Planning**

It is found to be useful to those businesses that have multi-plant manufacturing facilities and large number of interplant receivables.

This module provides an accurate picture of the scheduling and transportation loading to support the distribution schedule.

9. **Financial planning interface**

It helps in dollarizing projected inventory levels and in computing projected cash flow.

In addition to these modules following modules may be necessary depending upon the nature of the business.

10. **Accounting interface**

It traces the flow of information from the shop floor through the standard cost accounting system and feeds it back to the management in terms of reports and variances.

Considering the complexity of software selection task for MRP II, the selection process is explained in following chapters using an example of manufacturing organization. The particulars of the organization are provided in the subsequent paragraphs and specific features of software related to the various logistics activities are explained in details in various chapters as and when they are pertinent to the point of discussion. This is carried out with the help of an example of a hypothetical manufacturing operation, which is introduced in the following paragraph.

Citadel Inc. is engaged in the manufactring of wide variety of products such as lawn movers, vacuum cleaners, electric chain saws, blowers, circular saws, hammer drills, and related accessories. CITADEL has three manufacturing facilities located in Bridgeport, CT, Atlanta, GA, and Warren, MI. These manufacturing facilities supply their products to central distribution center in Chaple Hill, NC, which in turn supply the assembled end-items to seven distribution centers located across the nation at Philadelphia, Pa, Detroit, MI, Iowa City, IA, Dallas, TX, San Diego, CA, Bevearton, OR, and Boca Raton, FL. These seven distribution centers supply the products to almost 125 retail outlets.

The annual gross revenue is in the range of $150 to $180 million dollars. The demand for the product is very seasonal and more than 30 % of the sales is realised in the month of May and June.

Manufacturing facilities are located in such a way that Bridgeport facility manufactures assemblies for lawn movers, Atlanta facility manufactures assemblies for blowers and vacuum cleaners, and Warren facility manufactures assemblies for circular and elctric saws, and hammer drills. These products are supplied to assembly plant in Chaple Hill, NC. The central assembly plant has three assembly lines,

assembly line - 1,	assembles lawn movers,
assembly line - 2,	assembles vacuum cleaners, and blowers,
assembly line - 3,	assembles hammer drill, and saws.

Manufacturing of these different end-items takes advantage of interchangeable assemblies. The product structure of these end-items is shown in fig. 2.1.

Keeping in mind this manufacturing operation, functional specification for different modules of MRP II software is carried out at length in the following chapters.

Product	Model #	Subassemblies	Subassembly #
Lawn Mover	LM123	Power asse. (2 stroke)	LM 2150
		Power asse. (4 stroke)	LM 3150
		Carriage	LM 4150
		Exhaust	LM 5150
		Cutter	LM 6150
		Bag	LM 7150
Vacuum Cleaner	VC095	Motor Ass.	VC 1250
		Impeller	VC 2250
		Nozzle-Hose	VC 3250
		Carriage	VC 4250
Blower	BL037	Motor Ass.	VC 1250
		Impeller Ass.	BL 2350
		Hose-Nozzle Ass.	BL 4350
		Carriage Ass.	VC 4250
Hammer Drill	HD394	Casing Ass.	HD 1450
		Motor Ass.	HD 2450
		Drill Ass.	HD 3450
Circular Saw	CS444	Motor Ass.	HD 2450
		Blade Ass.	CS 2550
		Casing Ass.	CS 3550
Chain Saw	ES555	Motor Ass.	HD 2950
		Chain Ass.	ES 2650
		Casing Ass.	ES 3650

Figure 2.1
Product Structure

3.0 **MASTER PRODUCTION SCHEDULE**

Master production schedule (MPS) is typically a weekly or in some cases a daily schedule of production in terms of the specific items to be produced. Master production schedule for CITADEL would consist of lawn movers, vacuum cleaners, blowers, hammer drills, electric chainsaws and circular saws.

The objective of the master production is to seperate two basic issues:

1. The needs of the market place, and
2. Manufacturing capabilities.

The needs of the market place that have to be considered in master production schedule are:

1. Customer orders.
2. Forecats.
3. Branch warehouse demands or distribution center demands.
4. Interplant transfers.

The manufacturing capabilities that have to be considered in master scheduling are:

1. Inventory
2. Capital budget (production plan)
3. Vendor capacity
4. Availibility of resources such as material, tooling,

dollars, storage, etc.

Thus a master production schedule serves two principal functions namely:

Over the short horizon

To serve as the basis for planning of material requirements, the production of components, the planning of order priorities, and the planning of short-term capacity requirements.

Over the long horizon

To serve as the basis for estimating long-term demands on the company's resources such as productive capacity, warehousing capacity, engineering staff, and cash.

Master Production Schedule module should have the following necessary capabilities.

3.1 Master production scheduling.

  3.1.1 Rules for including items into MPS.

3.2 Two level master production scheduling.

3.3 Generating reports for master scheduler.

3.4 Exception messages.

3.5 Managing changes in master production schedule.

3.6 Forecasting.

The flow diagram showing the logical relationships among these capabilities is depicted in fig. 3.1.

3.1 MASTER PRODUCTION SCHEDULE:

MPS module should help master scheduler in preparing master production schedule from the production plan. Production plan is a rate of production for a type of product or a family of products stated in gross terms typically over a month. The production plan is usually set using the beginning inventory and a management decision on the desired ending inventory (Make-to-order stock) for the production period. This information, together with the expected demands coming from the sales forecast, customer orders, branch warehouse demands, and interplant orders is used to develop a production rate. The resulting production rate must then be checked against any vendor, capacity, or material limitations. The situation is similar in a make-to-order manufacturing, where the production plan is set using the beginning backlog of customer orders at the end of the production period.

MPS breaks down the production plan into a schedule for specific items, dates, and quantities. Scheduler sets the timing of the production lots and the quantities of these lots. The production plan is the budget that management sets for the MPS. Consequently, the MPS for the specific items within a family of products, when totalled, must equal the production plan for the family. If the MPS

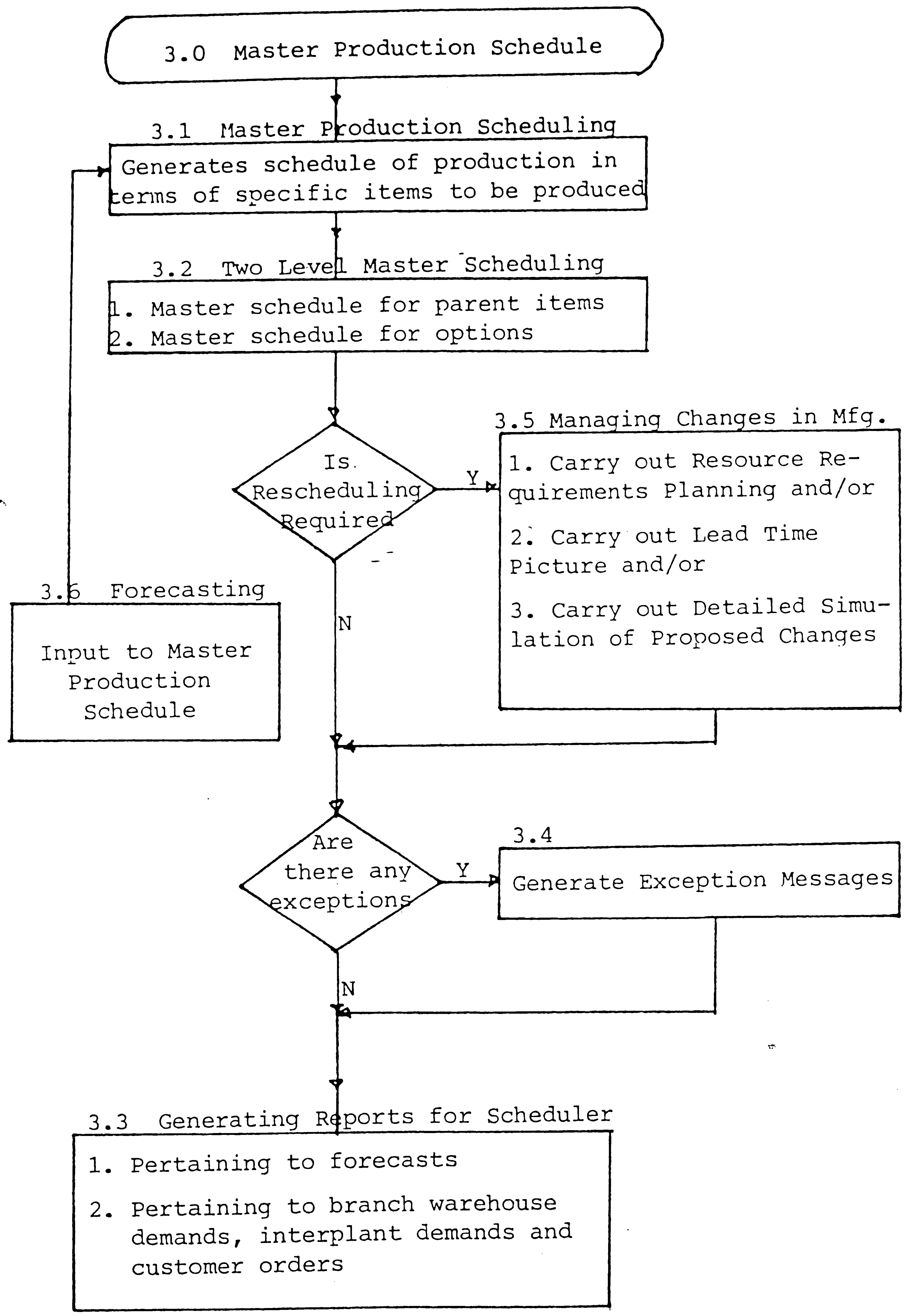


Figure 3.1
Master Production Scheduling

differs from the production plan, then it must be revised until it is equal to production plan.

For example, at CITADEL, management develops production plan which may be a rate of manufacture of lawn movers, blowers, vacuum cleaners, etc. Master scheduler takes this production plan and develops master production schedule consisting of daily or monthly schedule of production consisting of of end-items mentioned above and their quantity.

The factors that go into developing a MPS (shown in fig. 2.1 for make-to-stock)can be categorized into seven major groupings, and MPS module should be capable of handling each of them. These factors are:

sales forecast,
production forecast,
customer orders,
branch warehouse demands,
interplant orders,
management decisions;
and vendor, capacity, or material limitations.

Issues realted to some of these features are explained below.

A sales forecast is a statement of demand and not a statement of production. For any number of reasons, MPS may be set at levels above or below the sales forecast. Customer orders, regardless of the forecast, never appear exactly as the forecast predicts. This means that MPS may have to be changed to satisfy the customer orders. Deviations from the forecast fall into two categories:

deviations in the total quantity of the customer orders for a family of products,

and deviations in the mix of products within a family where the total forecast quantity is nearly correct.

If the forecast mix of products is incorrect, but the total quantity is nearly equal to the total forecast quantity, the software should help the master scheduler in shifting the production in the MPS from one item to another. If the total forecast quantity is in error, the master scheduler may decide to increase or decrease the quantites in MPS.

For a manufacturing organization having multiplant MRP, branch warehouse demands (or distribution center demands) and interplant orders are also factors that go into making up the MPS. These factors are planned orders from another MRP system or part of the same MRP system. Distribution requirements planning creates planned orders to supply the branch warehouses. These planned orders are branch warehouse demands that appear as one of the factors in the MPS at the central supply location. MRP in a multi-plant company creates planned orders for items needed at one plant and produced at another. These plant orders at the receiving plant produce the interplant orders which appear as one of the factors in the MPS at the supplying plant.

Management decisions of a variety go into making up the MPS. For example, to increase or decrease production as a way of providing a stable source of employment, to build stock in anticipation of shutdown, to put on a third shift, to schedule an item even though the customer order has not been received, or to decide among customers by changing the MPS when everyone cannot be supplied.

The MPS module should be able to highlight the problems, if any, related to vendors, capacity, or material limitations, and help the scheduler in seeking solutions, not by simply changing the MPS without informing the scheduler. A MPS that creates overload on the work center should be pointed out to scheduler and all attempts should be made to devise a solution. Extra shifts, subcontracting, off loading work to another work center, and any possible solutions should be investigated. If none of these provide a solution, MPS must remain or be reduced to a level that creates an attainable work load on the critical work center. The same approach should be used for vendor or material limitations.

It should not be forgotten that master scheduler is responsible for the accuracy of the MPS, he must therefore have direct control over it. The software can not be allowed to add, delete from, or change in any way the MPS developed by the master scheduler. The system should allow the scheduler to state a MPS consisting of master schedule orders and then have the master schedule used without any change.

A master schedule order, like a planned order in MRP module, is a statement of production which is not changed in any way by the computer. Master schedule orders are functionally equivalent to firm planned orders (explained in detail in ch. 4). In some systems, master schedule orders exist as distinct and separate types of orders in the system. In other systems, firm planned orders are used as master schedule orders. Either method is workable since master schedule orders and firm planned orders are functionally equivalent. Generally, the use of either a master schedule order or a firm planned order is based on technical consideration that make one or the other a better choice for a particular set of software.

The MPS module may plan master schedule orders and show these to the master scheduler as a way to reduce the work load on the master scheduler. However, these planned master schedule orders are not used except as information for the benefit of the master scheduler, in evaluating and authorizing the quantities that should be added to the MPS, and only when authorized, master schedule order should be passed on to MRP.

3.1.1 <u>RULES FOR INCLUDING ITEMS INTO THE MPS:</u>

Master production scheduling module works on the assumption that master schedule orders are not added, deleted, or changed by the computer without human evaluation and approval; once the MPS has been evaluated and approved, then it is exploded and posted as gross requirements to the component parts.

For example some of the items that can be included in MPS:

Make-to-order items with a long lead time. These are the items where lead time to customer is greater than or equal to the cumulative lead time to manufacture the item.

Make-to-order items with a short lead time. These are items where lead time to customer is less than the cumulative lead time to manufacture the item.

Make-to-order items where the final product configuration is assembled from a number of options, modules or subassemblies.

Make-to-stock items. These are end items which are shipped from stock.

Regardless of whether all these factors exist for each item in the MPS, the scheduling software should provide for them. A long lead time to make-to-order item may become a short lead time make-to-order due to economic conditions or marketing strategy. A make-to-stock may have large customer orders planned for future delivery. A branch warehouse distribution system may be started or multi-plant operation may have begun.

3.2 TWO LEVEL MASTER PRODUCTION SCHEDULING:

In some types of products there is an advantage in master production scheduling at two levels (shown in fig. 3.2 a, b). This is useful whenever the master scheduler must coordinate a number of MPSs. For example, for automobile manufacturer the two levels of scheduling would be a MPS for the automobiles, and also MPS for the different modules, e.g. at CITADEL in addition to MPS for end items, second level MPS may consist of power assembly and carraige assembly. The advantage in this method is that it allows the computer to assist the master scheduler in managing and coordinating a number of related master production schedules. This method for master scheduling a product at two levels can also be used for other types of make-to-order items where it is necessary to coordinate a number of related master production schedules. An example of this would be a family of master schedule items that require a special assembly line set-up. The goal of two level scheduling is to produce the most accurate picture of

Lawn Movers

	Weeks							
	1	2	3	4	5	6	7	8
Production Plan	100	100	100	100	100	100	100	100
Actual Demand	0	150	0	0	0	0	0	0
Master Production Schedule	0	150	0	0	0	50	0	0
Available to Promise	0	0	0	0	0	50	50	50

OH = 0
OQ = 50
LT = 1 wk.
SS = 0

Figure 3.2 (a)

Motor Assembly

	Weeks							
	1	2	3	4	5	6	7	8
Forecast	0	0	0	0	0	0	0	0
Production Forecast	0	0	0	0	0	0	0	0
Actual Demand	0	75	0	0	0	0	0	0
Master Production Schedule	0	75	0	0	0	25	0	0
Available to Promise		0	0	0	0	25	25	25

OH = 0
OQ = 25
LT = 1 wk.
SS = 0

Figure 3.2 (b)

demand on the product options. This demand, the production forecast, can be calculated in several different ways, regardless of whether a planning bill of material or a matrix of numbers is used. Some calculations of the production forecast are much more effective than the others.

One way to calculate a production forecast for a master schedule item is using planning bills of material (fig. 3.2 c). A planning bill of material is a bill of material where the parent item number is a type of product. The component item numbers in the bill of material are the modules or other master schedule items in the type of product. The quantities per assembly in the bill of material are the percentages that each module or other item in the type of the product contributes to the production of the product as a whole.

3.3 GENERATING REPORTS FOR MASTER SCHEDULER:

The software should provide the scheduler with a display of information that will assist him to develop and manage MPS. Several of the factors that go into making up the MPS can be presented in the form of numbers: forecast, branch warehouse demands, interplant demands and customer orders (fig. 3.3).

The other factors: management decisions, and vendor, capacity, or material limitations are a different, more

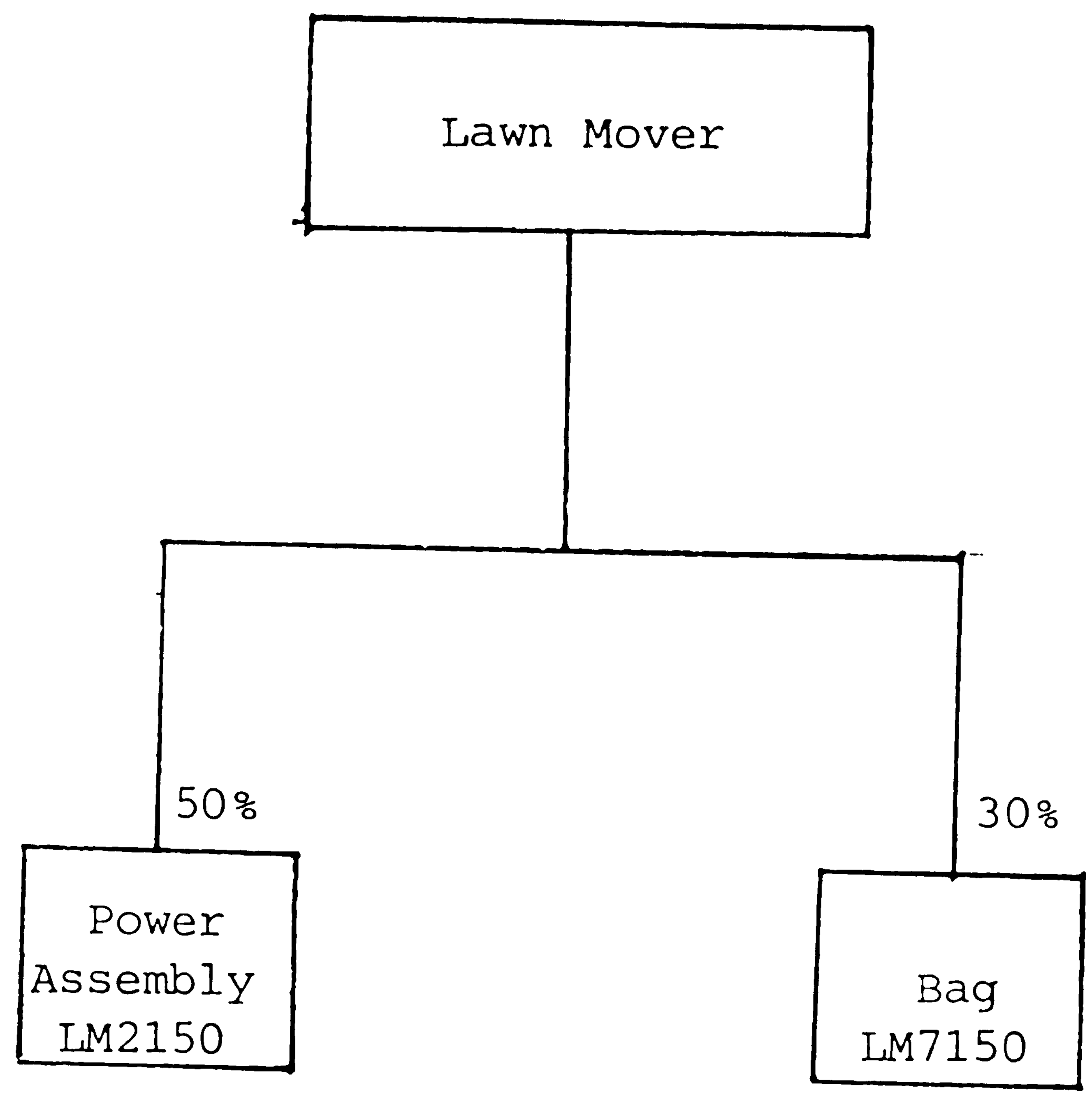


Figure 3.2 (c)

		1	2	3	4	5	6	7	8
		Weeks							
Customer Orders		10		40		70	80		100
Forecasts		30	30	30	40	40	40	40	40
Branch Warehouse Demands		10		10		10		10	
Projected Available Balance	100	50	20	40	40	20	0	70	50
Master Production Schedule			100		100	100	100	100	

OH = 100
LT = 1 wk.
OQ = 100

Figure 3.3
Master Production Schedule (Make-to-Stock)

subjective type of information and they are typically handeled in the form of memo.

The MPS report can be thought of as having three segments. These segments are listed below with the types of information that can appear on the report for each:

DEMAND	Sales forecast, Production forecast, Branch warehouse demands, interplant orders.
PRODUCTION	MPS, and Production planning.
CALCULATIONS	Projected available balance, available to promise.

The best arrangement would be to allow each of the lines to be printed as options. This makes the MPS report clearer and easier for the master scheduler to use.

The projected available balance calculation shows the projected stock build-up or depletion to the master scheduler. This calculation is similar to the projected on-hand balance calculation in MRP. The available to promise calculation shows where new customer orders can be promised for delivery based on the current MPS.

The MPS report should contain MPS totals. The purpose of these totals is to verify that the MPS is in fact a reflection of the production plan. The quantities in the MPS, when totaled, should equal the quantites in the production plan. For this reason, the logic which calculates totals for the MPS should also contain logic to provide sub-totals. The master scheduler is responsible for assigning an identifier to each of the master scheduled items within a sub-group. Sub-totals should be calculated and displayed in the MPS report wherever sub-groups have been assigned.

3.4 EXCEPTION MESSAGES:

The purpose of these exception messages is to allow the master scheduler to go directly to the items that require evaluation. The message relieves the master scheduler of the responsibility for scanning all of the master scheduling information for all the items in the MPS.

Different types of exception messages as a part of master scheduling system are as follows:

1. Rescheduling a master schedule order to an earlier date.
2. Rescheduling a master schedule date to a later date.
3. Not enough in the MPS to cover demands.
4. Master schedule order for release.

5. Over promised customer orders.

6. Past due master schedule orders.

The exception message to reschedule a master schedule order to a later or earlier date indicate that the master schedule is out of agreement with the latest forecast, customer orders, branch warehouse demands or interplant orders.

The exception message for overpromised customer orders is generated whenever more customer orders have been promised than the MPS can support. Generally, this indicates that an error has occured, either in customer order promising, or possibly a change to the MPS that was not made. The exception is created whenever the available to promise in the MPS report is less than zero.

The exception message for a past due master schedule order would be generated when a scheduled receipt for the master schedule item is past due. The exception message is produced by checking the due date of the order against the current date.

3.5 MANAGING CHANGES IN THE MPS:

Software should assist in effective management of the changes in MPS. Three methods are available to assess the effects of a change to the MPS. These are: Resource requirement planning, a lead time picture for a product, and detailed simulation of proposed changes to the MPS. Resource requirement planning is an approximate type of capacity planning using some representative routings for items in the MPS. These representative routings would indicate, for example, total machining hours required for an item, total assembly hours, and total hours required on a key piece of equipment. The representative routings are run against the MPS to give a rough cut capacity picture.

A lead time picture for a product is a way for the master scheduler to see the accumulated lead times for the items in a product. Using this picture, the master scheduler has quick guide which he can use to find the critical items which could affect a change to the MPS. Whether a change can be incorporated or not can only be determined when the master scheduler reviews the MRP reports for the critical items.

3.6 FORECASTING:

It is a supporting system to the MPS. Forecast is one of the inputs to MPS. The forecasting capability in a software package should recognize both the intrinsic and the extrinsic factors. Intrinsic forecasts are based on past. The most common ways to make this predictions is to use an average, a moving average, or a weighted moving average or seasonal forecast. The extrinsic forecast are based on outside information like marketing information, etc. Forecasting system should have a way to manually review the forecast after it has been generated and before the system is updated.

4.0 MATERIAL REQUIREMENTS PLANNING

MRP logic determines what is needed and when at all levels of the product. The logic further calculates what to order and its timing and keeps this plan of material requirements planning up to date as things change.

In other words, MRP logic, as shown in fig. 4.1, takes into account projected gross requirements either from the parent item or from the master production schedule in case of parent items, and subtracts on hand quantity (inventory) and scheduled receipts (released manufacturing or purchase order) to calculate projected available balance (net requirements) which when advanced using the lead time required to procure an item (for purchased item) or to manufacture an item (for manufactured item) calculates planned order release, e.g. at CITADEL, MRP would calculate net requirements for end items such as vacuum cleaners, lawn movers, etc. and explode these requirements through the product structure from assembly level to the component level.

The basic function of MRP is the conversion of gross requirements into net requirements, so that the latter may be covered by shop orders and purchase orders. It replans net requirements and its coverage over the entire product structure as a result of changes in either the master

	Weeks			
	1	2	3	4
Projected Gross Requirement (PGR)	300	200	400	150
Scheduled Receipts (SC)	350			
On Hand (Projected Available Balance) (PAB)	-100	0	0	0
Planned Order Requirement (POR)	100	400	150	

(PGR) - (SR) - (OH) = POR

Lead Time = 1 week

Figure 4.1
Material Requirements Planning Logic

production schedule, or inventory status, or product composition.

The three principal functions that the module can provide is to set the priorities, provide input to the capacity requirements planning module for the load calculation using the manufacturing orders generated by planned order release and develop appropriate ordering schedule using the purchase orders from the planned order release.

To be able to do so MRP module should be capable of:

4.1 MRP logic (net change / regeration capability).

4.2 Lot sizing.

4.3 Pegging the requirements.

4.4 Firm planned ordering.

4.5 Rescheduling.

4.6 Providing safety stock.

    4.6.1 Dependent demand items.

    4.6.2 Dependent demand items with supply problems.

    4.6.3 Independent demand item.

4.7 User controlled exceptions to regular processing logic.

4.8 Exception notices.

Flow diagram showing logical relationship among these capabilities is shown in fig. 4.2.

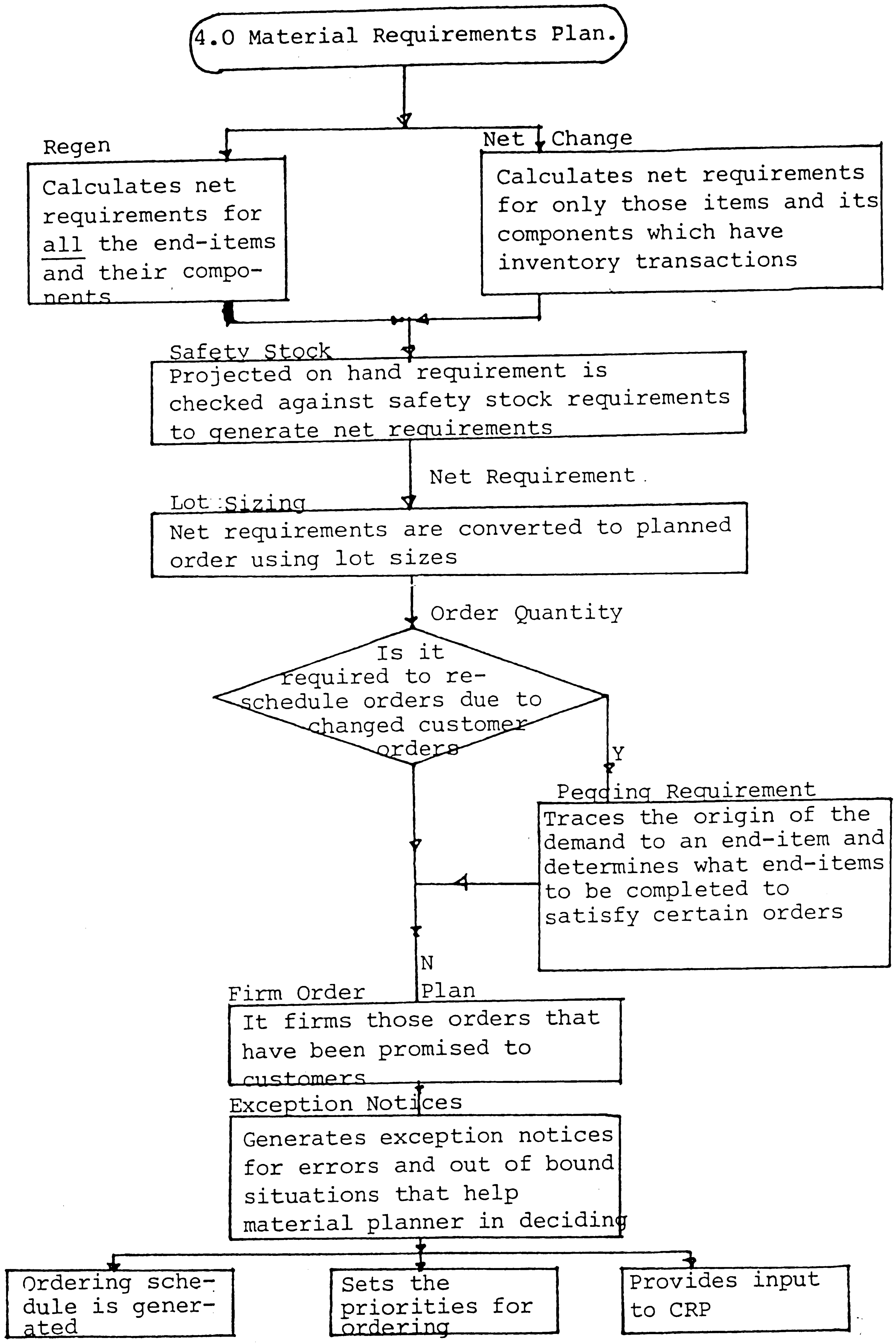


Figure 4.2
Material Requirements Planning Logic

4.1 MRP LOGIC (NETCHANGE/REGEN CAPABILITY) :

MRP system may be implemented as regenerative or as net change system. The main difference between the two lies in the frequency of replanning and what sets off the replanning process.

Under regenerative system net requirements for all the end items stated in the master production schedule, and for their component is recalculated. In order to calculate net requirements for all the parts and components, every active bill of material must be retrieved, the status of every inventory must be recompued, and the entire process generates voluminous output.

As evident, regeneration is always a big job, is the task of massive data handling which entails delay in obtaining the results of the requirement palnning run and dictates that the job be done periodically, e.g. at CITADEL, where items are made-to-stock and demand is seasonal, weekly regeneration should be sufficient.

It should be cautioned that, inventory transaction, under regenerative system, never triggers an explosion into a lower product level. This allows a gradual deterioration in the validity of the requirements data to take place following each requirements planning run.

The frequency of regeneration depends upon:

1. The enviornment in which MRP system must operate.
2. The use to which it is being put.

In a dynamic enviornment where customer orders fluctuate and orders are being changed frequently, requires continual change in material requirements quantity and their timing. In such an enviornment where strong need for timeliness is required regenerative system may not function satisfactorily.

Net chage MRP system responds to such dynamic requirement. Under net change system only those parent items are exploded when inventory transaction has occured pertaining to that item. This minimizes the scope of the requirements planning job at any one time and this permits frequent replanning. Because the explosion is partial, i.e. it covers only the items which have inventory transaction and extends to its components, it automatically limits the volume of the resulting output.

The net change concept views the master production schedule as one plan in continuous existence, rather than as successive versions or issues of the plan. The master production schedule can be updated at any time, by adding or subtracting the net difference, from its previous status. Periodic items of new schedule are treated with the same way, in effect as a special case of updating for change.

There are two types of net change system: batch and continuous.

Most net change systems today are batch net change. These systems accumulate a listing of the items which should be replanned in net change planning. This is usually done by making the item as one that should be planned during the next change planning run. Later, all items marked for replanning are processed in a batch processing run.

The other type of net change system operates by replanning items without delay. As a transaction occurs, which should cause net change planning, and any components that are affected, are replanned.

Typical practice in manufacturing companies is to use for daily purpose net change system and run regeneration once a month or once a six months depending upon the number of products on the system.

4.2 LOT SIZING:

One of the most researched areas in inventory control is the lot sizing algorithm. The factors that affect the relative effectiveness of the individual lot-sizing techniques are, the variability of demand, the length of the planning horizon period, and the ratio of the set-up and unit costs. Depending upon the practice followed at any organization lot sizing technique may differ. The software vendor should provide the technique used at a particular organization rather than an organization adopting one of those techniques provided with the software.

Of the many lot sizing techniques most widely used are:

Discrete lot sizing techniques

Fixed ordering policy (FO),
Economic Order quantity (EOQ),
Period order Quantity (POQ),
Part Period Balancing (PPB),
Least Total cost (LTC),
Least Unit Cost (LUC),
Least Cost with look ahead and look back logic (LC),
and Wagner Whitin algorithm (WW);

and lot for lot (L4L).

All the discrete lot sizing algorithms are based on the implicit assumption of certainity of demand. In reality the demand is variable in two respects, nonuniformity and discontinuity. The relative effectiveness of such an algorithm can be determined only in retrospect. The length of the planning horizon affects the comparative performance of the various algorithms. Shorter planning periods results in smaller requirements per period, enabling the lot sizing technique to get closer to the best balance between set up and carrying costs. The ratio of the set-up to unit cost directly affects the frequency of ordering and thus the lot size.

For the purpose of MRP, lot for lot approach should be used wherever feasible, and in case of significant set up costs LUC, LTC, PPB, or evn POQ should provide satisfactory results. When it comes to selecting a lot sizing technique to be incorporated in MRP system, the experience of the industry shows that neither detailed studies nor exhaustive debates are warranted - in practice, one discrete lot sizing algorithm is about as good as another.

Under **fixed ordering policy** all planned orders are created of equal quantities. It is used for quantities with sufficiently high ordering cost so that period by period ordering is ruled out.

Economic ordering quantity is based on an assumption of continuous, steady rate demand, and it will perform well only where the actual demand approximates this assumption. The more discontinuous and nonuniform the demand, the less effective the EOQ will prove to be.

Period order quantity is identical to EOQ, except that the ordering interval is computed. Period order quantity avoids residual quantity in an effort to reduce inventory carrying cost. For this reason period order quantity is more effective than economic order quantity as set-up costs per year is the same but carrying cost will tend to be lower under period order quantity. A potential difficulty with this approach, when several of zero quantity periods coincide, forcing the period order quantity technique to order fewer times per year than intended.

Part period balancing technique attempts to optimize the order quantity by balancing the ordering and carrying costs. These calculations take into considerations demands that vary from week to week.

Order quantity in lot for lot is equal to the net requirements.

The other techniques such as least total cost, least unit cost, least cost, and Wagner Whitin algorithm suffer from following problems.

The cost of rescheduling orders to satisfy a changing order quantity generally costs far more than savings that come from using the optimum order quantity. These costs come from the rescheduling and ordering that has to occur on the component parts to satisfy a parent order quantity that changes to take advantage of the optimum order quantity.

In additions to ordering cost and carrying costs, there are a number of other factors that have to be considered when determining an order quantity. These include size and space considerations of the warehouse, deterioration of the stored quantity, pallet sizes, etc.

There are problems in accountability if the computer is left with the job of calculating the order quantity. Experience indicates that the order quantity is something a person should be held accountable for maintaining.

The order quantity can also be modified by several factors. Typical modifiers are:

MINIMUM: When a minimum is specified, any planned order that are less than the minimum are rounded up to the minimum.

MULTIPLE: A multiple is used to round the order quantity upto the next multiple of the number specified.

MAXIMUM: If specified, it indicates the largest planned order that should be created for this item. In some systems, an exception message is given for planned orders that exceed the maximum. In other systems the planned order is broken up into smaller orders.

The inventory planner has limited means at his disposal when trying to rebalance the status of a given inventory item. He can not change the quantity on hand, nor can he change the gross quantity by direct intervention. He can only change the orders, i.e. the timing of an open order and both the quantity and timing of planned order. Thus to be able to change the gross for a given item he must change the planned order schedule of its parent item(s). To be able to do so inventory planner depends on two special capabilities, pegged requirements and firm planned order.

4.3 CAPABILITY OF PEGGING THE REQUIREMENTS:

The calculation of a given gross requirements bucket represents a total, the breakdown and source of which are obscured. Because of the recurrence of the requirements within the planning horizon of the master production schedule and the commom usage of a component item by several parent items, pegging is highly useful in tracing the orgin of the demand as shown in fig. 4.3.

For example such a capability would help CITADEL in determining the origin of the demand, whether from a distribution center, or from an assembly line or an individual customer order. Single-level pegging, is the capability to trace the source of item demand to the immediately higher level only. With this a succession of peg is required to trace item demand to an end-item lot called for by the master production schedule.

Under full peg approach, each individual requirement for a component item is identified with a specific product lot, or customer order, listed in the master production schedule. This can be extended to orders and even on hand quantities of the component item, so that it may always be known which group of parts "belong" to which product lot. Full pegging is useful when the product is custom-engineered and made to order, when the different standard products have few or no common components, or when the master production schedule consists of special contracts. Common component usage and repetitive production tends to make full pegging impractical.

4.4 FIRM PLANNED ORDER CAPABILITY:

It is the capability of the system to freeze the quantity and/or timing of a planned order release.

The system plans and replans the planned order release schedule in each time-phased item record according to the lead time and lot-sizing rule specified. The schedule is revised as net requirements change, automatically. The firm planned order command immobilizes the order in the schedule, forcing the MRP system to "work around" it in adjusting coverage of net requirements. The firm planned order forbids the system to put another planned order into the "frozen" bucket. For example, if CITADEL has total order for item VC 3250 for 30 quantities and the master scheduler decides to meet the deadline for only one order for item VC 3250 of quantity 10 and would not like this order to be rescheduled in the case of subsequent rescheduling, he can flag this order as a firm order signaling the system to reschedule the schedule leaving this order untouched. This would ensure the availability of the item VC 3250.

4.5 RESCHEDULING CAPABILITY:

MRP module should be able to respond to a changed gross requirements schedule. A changed gross requirments schedule necessitates a recomputation of the projected on-hand schedule, and the new schedule contains the clues to the action required. In order to avoid inventory excess and/or shortages open order misalignment should be avoided. The two tests for open order misalignment are

1. Are there any open orders scheduled for periods following the period in which a net requirements appear?
2. Is there an open order scheduled for a period in which the gross requirement equals or is less than the on hand quantity at the end of the preceeding period?

If the relative priorities in the shop and open purchase orders are to be kept valid, the planner must be able to reschedule due dates not only for orders needed earlier than originally planned, but also for those needed later. The general tendency of the planner is to concentrate on orders that need to be completed early to prevent shortages, and to delay action or ignore the others.

Even when the rescheduling of the plannned order is carried out by the system the planner may decide not to advance the order due date when there is safety stock or when the new date would be impossible to meet. In the latter case, the proper course of action is to peg upwards in an efforts to solve the problem, possibly all the way to master production schedule, which may have to be changed.

4.6 SAFETY STOCK:

MRP module should respond to the safety stock requirements. Safety stock may be implemented either as safety stock quantity or as safety lead time. Safety time is little easier to maintain, and it works best in the case of infrequent demands. However most commercially available software system include only a safety stock quantity.

There are number of legitimate uses of safety stock in an MRP system.

4.6.1 DEPENDENT DEMAND ITEMS:

It makes more sense to provide safety stock through the master production schedule rather than keep the safety stock on each of the different items that make up a product. By going up above a dependent demand items to the master production schedule, one will be able to plan matched sets of parts.

4.6.2 DEPENDENT DEMAND ITEM WITH SUPPLY PROBLEM:

First course of action is try to get more of the items into stock rather than allowing the safety stock to be used. Safety stock should be used only when this cannot be done.

4.6.3 INDEPENDENT DEMAND ITEM:

Inventory planner has to decide which items require safety stock. For example he may decide to keep safety stock on those spare parts for certain types products, which are only certain number of years old. In another situation he may want to keep safety stock for fairly popular options, for others it may be prohibitive to carry safety stock. The safety stock really depends on the situation. Factors that affect how much safety stock to keep on independent demand items are things like: size of the forecast error, cost of the item, service policy for the item, lead time, lot size, etc.

4.7 USER CONTROLLED EXCEPTIONS TO REGULAR PROCESSING LOGIC:

In certain situations, human judgement is required to evaluate and solve a problem, and the planner must be able to override the system's regular logic. Some of those commands are,

Hold Command - to prevent planned order (matured) from being issued, may be because of contemplated substitution in raw materials.

Scrap Tag Command - that tells system not to call for release of a new order if its quantity is smaller than the scrap allowance of an existing order.

4.8 EXCEPTION NOTICES:

Exception messages are helpful to planner in detecting errors, out of bound situations and in general detecting anomalies in planned schedules. Exception message should be in readable language form and should help planner in taking corrective action. Some of the basic messages that are found helpful are

1. Reschedule an order to an earlier date.
2. Reschedule an order out to a later date, or cancel an order.
3. Past due schedule receipt.
4. Planned order due for release.

In many systems, there are a number of other exception messages in addition to the basic messages listed above. These include things like:

1. Beginning balance is less than zero.
2. No order policy, lot size, or lead time.
3. Qualities that exceed field sizes.

The beginning balance less than zero could mean the on-hand balance is negative, or that more of the item has been allocated than is available on hand. Either of these situations is of interest to the planner.

If an order policy or lot size is missing, the system will generally default to lot for lot ordering. If the lead time is missing, the system will generally default to zero lead time. These defaults may be what the planner had in mind, but in all such cases, someone should review the situation.

Someone should decide what the order policy and lead time should be, enter this information. This way the planner knows what has been specified.

Field oversize occurs when the quantity in a field is bigger than the size of the field. The choices are to change the unit of measure or to change the system.

5.0 **BILL OF MATERIAL**

Bill of Material (BOM) are MRP's network. For each product, BOM links all the items together. They are used to take planned production for an item or an assembly and determine what components are needed and when. In order to generate right orders and at the right time MRP module refers to BOM. Thus without the accurate BOM, it would be difficult for MRP to schedule the components and plan shop and purchase orders.

Getting accurate BOM has three parts. One is to make sure the right part numbers and quantities per assembly appear on the BOM. The second part is to make sure the BOM are complete, and the third part is that the BOM must be structured properly. Refer fig. 5.1.

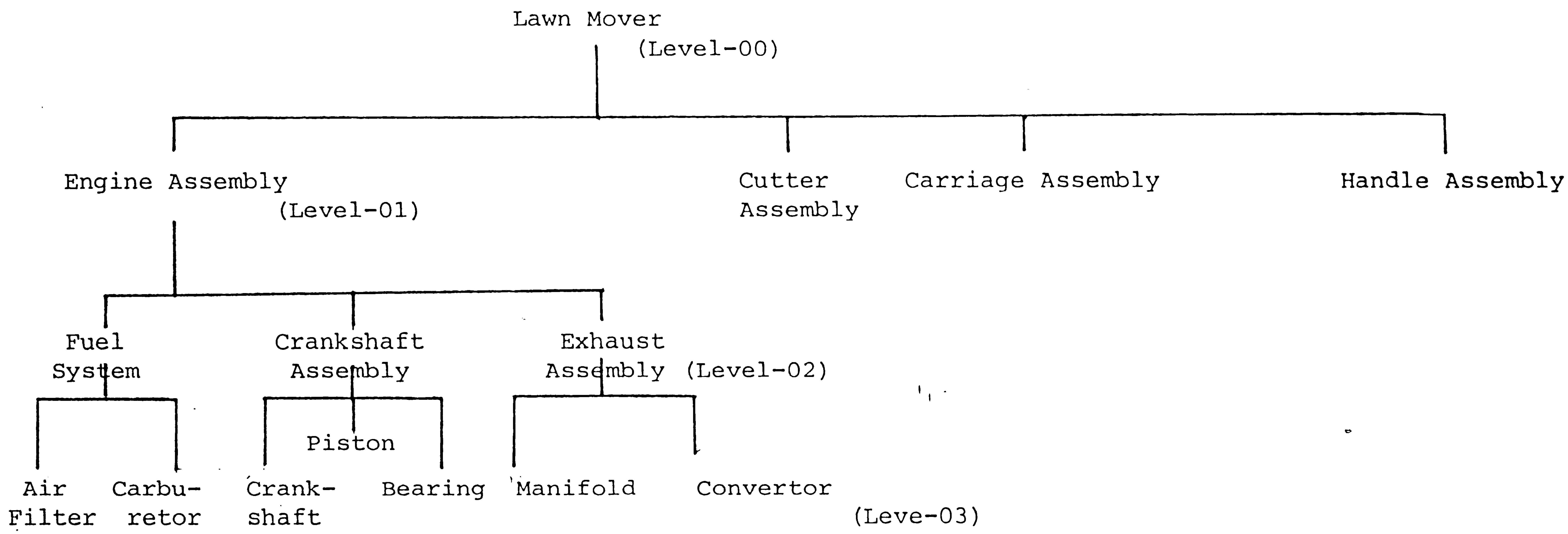
Structuring the BOM can be thought of having three parts:

Identifying stocking levels

These are the points where the items go into a stockroom, either to wait for other parts, or in a semi-finished state.

Identifying phantom levels

These are self consumed assemblies. Items do not physically go back into stockroom, but instead are immediately consumed by another assembly.


Lawn Mover
(Level-00)
Engine Assembly
(Level-01)
Cutter Assembly
Carriage Assembly
Handle Assembly
Fuel System
Crankshaft Assembly
Exhaust Assembly
(Level-02)
Piston
Air Filter
Carbu-retor
Crank-shaft
Bearing
Manifold
Convertor
(Leve-03)

Identifying modules

These are options and possibly common parts in a product with options.

There are two common methods for auditing the accuracy of the BOM.

Factory Test:

Components are issued from the stockroom based on the BOM. Then any unplanned issue or receipts are tracked to see if they are the result of a BOM error.

Office test:

Qualified people audit the BOM to pick out errors. These are typically people from the stockroom, assembly, the shop, and engineering who are familiar with the way the product is built.

Before the BOM module can be effectively implemented, measure a representative sample of the BOM, verify the BOM for correct part numbers and quantities per assembly, structure in the BOM, review the procedure for handling engineering changes and achieve 98% accuracy.

Bill of material module should have following capabilities.

5.1 The ability to maintain and store parent-component relationship.

5.2 Low level coding.

5.3 Updating gross requirements when BOM are changed.

5.4 Ability to assist in implementing engineering changes.

5.5 Reporting capabilities.

The flow diagram showing logical relationship among these capabilities is shown in fig. 5.2.

5.1 THE ABILITY TO MAINTAIN AND STORE PARENT-COMPONENT RELATIONSHIP:

A bill of material system should provide the capabilities to add, change, and delete single level BOM which is a list of components that make up an item. The system should allow large number of components in any single level BOM. The information for a parent-component relationship must include a quantity per assembly. Generally, quantity per assembly has no unit of measure itself, but uses the unit of measure of the parent and component items. Alongwith this information, some system include a scrap quantity for a component which represents any losses for that component during the process of part issue and assembly. As single level BOM define the parent-component relationship, where-used relationship lists all the parent items that a component goes into. Some BOM keep the where-used

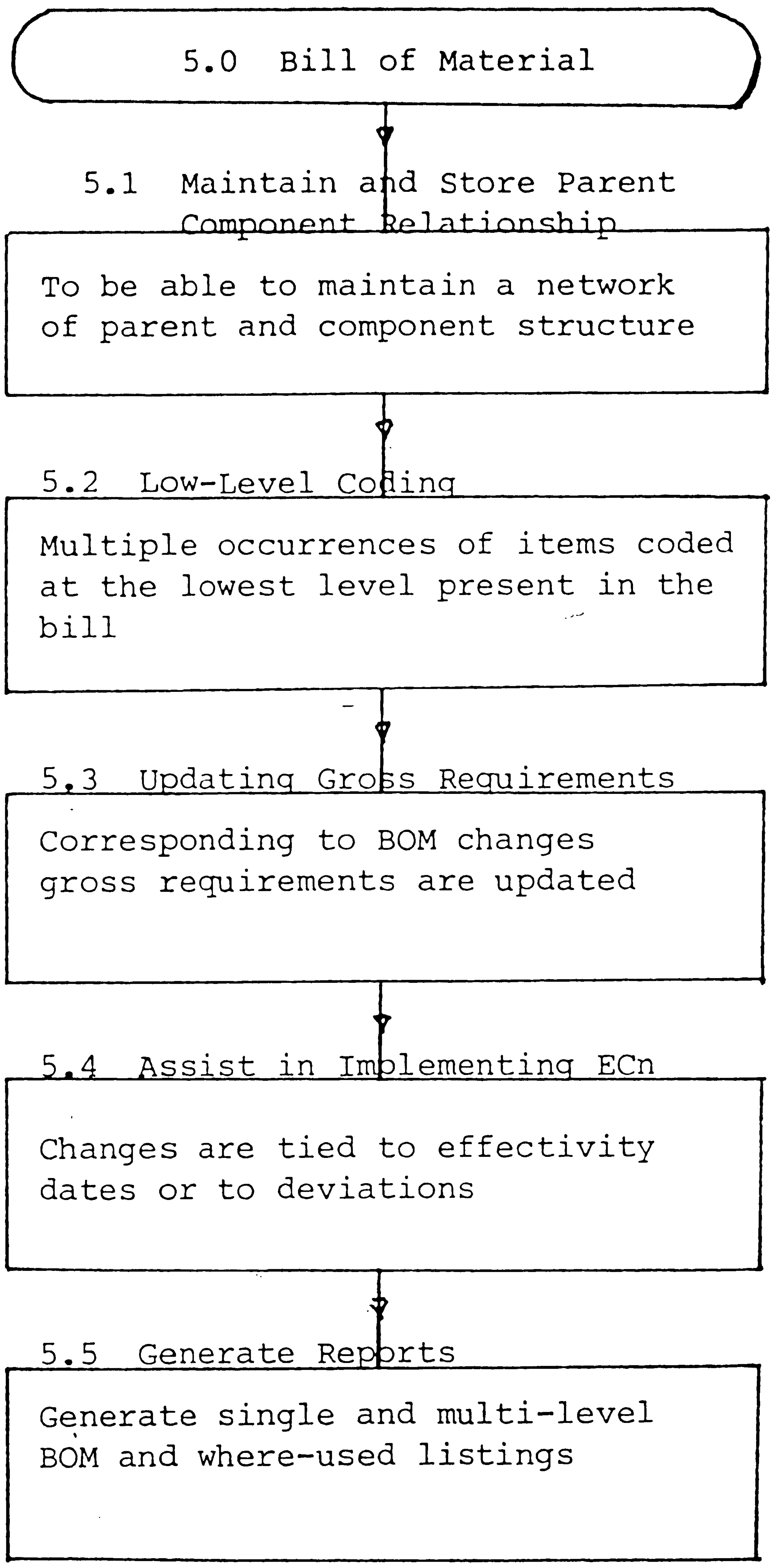


Figure 5.2
Bill of Material Logic

information up-to-date all the times where as some carry the updating procedure periodically.

Some BOM systems contain specialized transaction for reducing the clerical time required to maintain the BOM. Multiple-delete transaction deletes not one parent-component relationship, but all the relationship for that parent item. This transaction removes a complete BOM. The transaction is used most often when an item is being obsoleted.

A multiple-replace transaction searches the where-used list and replaces one component with another in all uses. This transaction is used where one component is replacing another in every BOM where the original item is used.

The same-as-except transaction copies a BOM and attaches it to another parent item. This is normally followed by some transaction to change a few of the items in the copied BOM. An extensive use of this transaction means that many BOM are being constructed with similar characteristics. This generally means that the BOM should be restructured into modular BOM.

5.2 <u>LOW LEVEL CODING:</u>

When a component appears on a product structure at more than one level, then the component itself has multiple-level associated with it.

This creates the problem of reprocessing and renetting at every recurrence of gross requirements stemming from parent items that appear on multiple levels. This would mean multiple retreivals of the component items records from storage during requirements explosion, and a reduction in data processing efficiency.

This problem is solved by employing low level coding technique. The lowest level at which an inventory item appears is identified through an analysis of BOM file, and the low level code is added to the BOM.

In the level by level requirements computation process, the processing of the item is then delayed until the lowest level on which it appears is reached. At that point, all the possible gross requirements resulting from parent items at any of the higher levels have been established and the need for multiple retrieval and processing has been forestalled. This concept of low level coding is illustrated in fig. 5.1.

Like the where-used relationship, the low level codes can be maintained as changes to the product structure occur or they can be recreated periodically. If they are created, this should be done before a regeneration or a net change run. If this is not done items may be planned incorrectly because their location in the total product structure may be incorrect.

5.3 UPDATING GROSS REQUIREMENTS WHEN BOMs ARE CHANGED:

One way to maintain the gross requirements is to update them at the time the BOM are changed. The method is frequently used because the BOM are an easy way to find and update the gross requirements. Once the BOM has changed, finding and updating the gross requirements is more difficult.

A second way to provide this function is to include logic which completely destroys all gross requirements and planned orders when a change is made to the BOM. At the time the BOM is changed, the parent item is marked indicating that a BOM change has been made for the item. Then the planned orders for the parent items are destroyed and all gross requirements are erased as well. During net change planning, new planned orders are created for the parent item and exploded using the new version of the BOM. This has the same effect as finding and correcting the gross requirement when the BOM is changed.

The third method for providing the function is to flag items with BOM changes, and then, during net change planning, match the current BOM against the old gross requirements. As difference between the BOM and gross requirements are found, this logic adds, changes and deletes gross requirements. The only disadvantage to the method is that developing the matching logic is generally more complicated than developing the logic needed for the other two approaches.

5.4 ABILITY TO ASSIST IN IMPLEMENTING ENGINEERING CHNGES:

For constantly changing BOM, the changes in BOM were tied to a date. This is the part of the most systems and is called effectivity dates. The dates are stored as part of the descriptive information for a parent-component relationship. The dates are used to determine when a component is active as a part of the BOM. Generally, effectivity dates are set up as a start date and an end date, and the component is active as part of the BOM between the two dates. The planned explosion logic in MRP checks the planned order start date against effectivity dates in the BOM. If the component is active on the start date of the planned order, gross requirements are generated and posted, if not the component is by-passed and no gross requirements are generated. Effectivity dates provide a date driven BOM change system. In common situation, where BOM change is determined more by an event than a date. But as the events are always changing and so the effectivity dates must be changed as well. This makes it difficult for the planner to work with the system. Another problem with the effectivity dates, that they do not allow for temporary material substitutions. No provision is made for an item that may be used for one order, then not used for some time, and then used again. What is needed in this situation is a way to allow a nearly unlimited number of subtitutions on a BOM.

Easier way to handle engineering changes and material substitution is to allow deviations to normal BOM, and have this deviations tied to an order, which means they are for this order and do not apply for all orders. Because deviations are tied to an order and not determined by date, if the order is rescheduled, the BOM deviation moves as well. This eliminates the need for the planner to continually update effectivity dates as scrap, inventory adjustments, and changes to master schedule changes the date. This also eliminates the incorrect gross requirements which occur when planned order cross the effectivity dates.

In a company where sorting or disassembly operations or chemical processes are a significant part of the business, the BOM module requires some additional capabilities to show by-products or scheduled receipts from dis-assembly, and sorting. In addition, capacity requirements planning should show the proper requirements for labor and equipment, taking into account both normal production and the dis-assembly or sorting.

5.5 REPORTING CAPABILITIES:

1. Single level BOM.
2. Single level where-used listings.
3. Multi-level BOM.
4. Multi-level where-used listings.

Single level BOM and single levle where-used listing reports are self-explanatory and are shown in fig. 5.3.

Multi-level reporting takes the BOM which is stored in the computer as single level BOM and combines it. A multi-level BOM starts with the single level BOM for an item. Each component in this BOM is checked to see if it has a BOM. If so, component is exploded. If the component on this second level bill has a BOM, BOM is exploded in the same fashion. The explosion of material continues until the lowest levels are reached. The multi-level where-used listing goes through the same process in the other direction.

* Lawn mover (1)
  * Engine assembly (1)
    * Fuel assembly (1)
    * Air filter (1)
    * Carburettor (1)
  * Crank shaft assembly (1)
    * Crankshaft (1)
    * Piston (2)
    * Bearing (3)
  * Exhaust assembly (1)
    * Manifold (1)
    * Convertor (1)
  * Cutter assembly (1)
  * Carraige assembly (1)
  * Handle assembly (1)

PARENT COMPONENT BOM

  * Carburettor
  * Air filter
  * Fuel system
  * Engine assembly
* Lawn mover

WHERE USED BOM

Fig. 5.3

Parent/Componet and where used BOM

6.0 **SHOP FLOOR CONTROL**

MRP module helps in planning priorities and shop floor control module helps in controlling the execution of these priorities. MRP can plan priorities, and if these priorities are not communicated to the shop floor and acted upon, MRP is reduced to an order launcher.

Shop floor control (SFC) allows to

1. Identify specific work centers that are or will be overloaded.
2. Execute the plan on the shop floor as well as they should.
3. Monitor the execution of the capacity plan.

For a satisfactiory performance of the SFC system, the accuracy of routings should be raised to at least 98% in terms of operations, operation sequence, work center, and reasonable standards. Following additional things also have to be achieved.

1. The shop knows what the correct priorities are on the jobs, and that these are up-to-date. This means that information on what is needed and when is being communicated effectively to the shop using the dispatch list.
2. The foremen's responsibility has been agreed upon and

the foremen are responsible for meeting the due dates on orders.

SFC include shop scheduling and dispatching system. SFC provides the way to communicate the priorities between the planner and the shop floor. Using the SFC, the shop schedule can be shown by department or by workcenter and operation, instead of showing only the manufacturing orders and the due dates for each. The ability to see where the orders are and where they should be is of tremendous importance to the shop floor people. They are being held accountable for meeting the scheduled due dates, and the more closely they can monitor progress against the schedule, the better they will be at meeting the date.

The objective of the dispatch list is to help the foreman by communicating the right priorities. The responsibilities of the foreman is to meet the agreed upon dates for dispatch. He is also responsible for agreement or disagreement for rescheduling, providing feedback to MRP module, and for the approval or the rejection of short release.

The dispatch list only communicates priorities. It doesn't tell the foreman how to run the jobs, it doesn't try to combine setups, it doesn't try to make the best use of skilled operators. It simply communicates the priorities.

In some cases, however, having a very detailed shop schedule and operation-by-operation dispatching would not be very helpful. For example in packaging or process lines, where orders flow from work station to work station without queue delays or move time between operations, or for products where only one operation is performed. In such a case, instead, having shop scheduling by operation, the scheduling of shop by departments would make more sense. This simplified scheduling system would show, by department, the jobs that need to be completed in a given week or day.

The SFC module should have following capabilities:

6.1 Maintain an open shop order file for each manufacturing scheduled receipt.

6.2 Provide back scheduling logic to determine operation schedule dates.

6.3 Provide a daily dispatch showing a shop schedule.

6.4 Status reporting of all orders.

The flow diagram showing logical relationship among these capabilities is shown in fig. 6.1.

6.1 MAINTAIN AN OPEN SHOP ORDER FILE FOR EACH MANUFACTURING SCHEDULED RECEIPT:

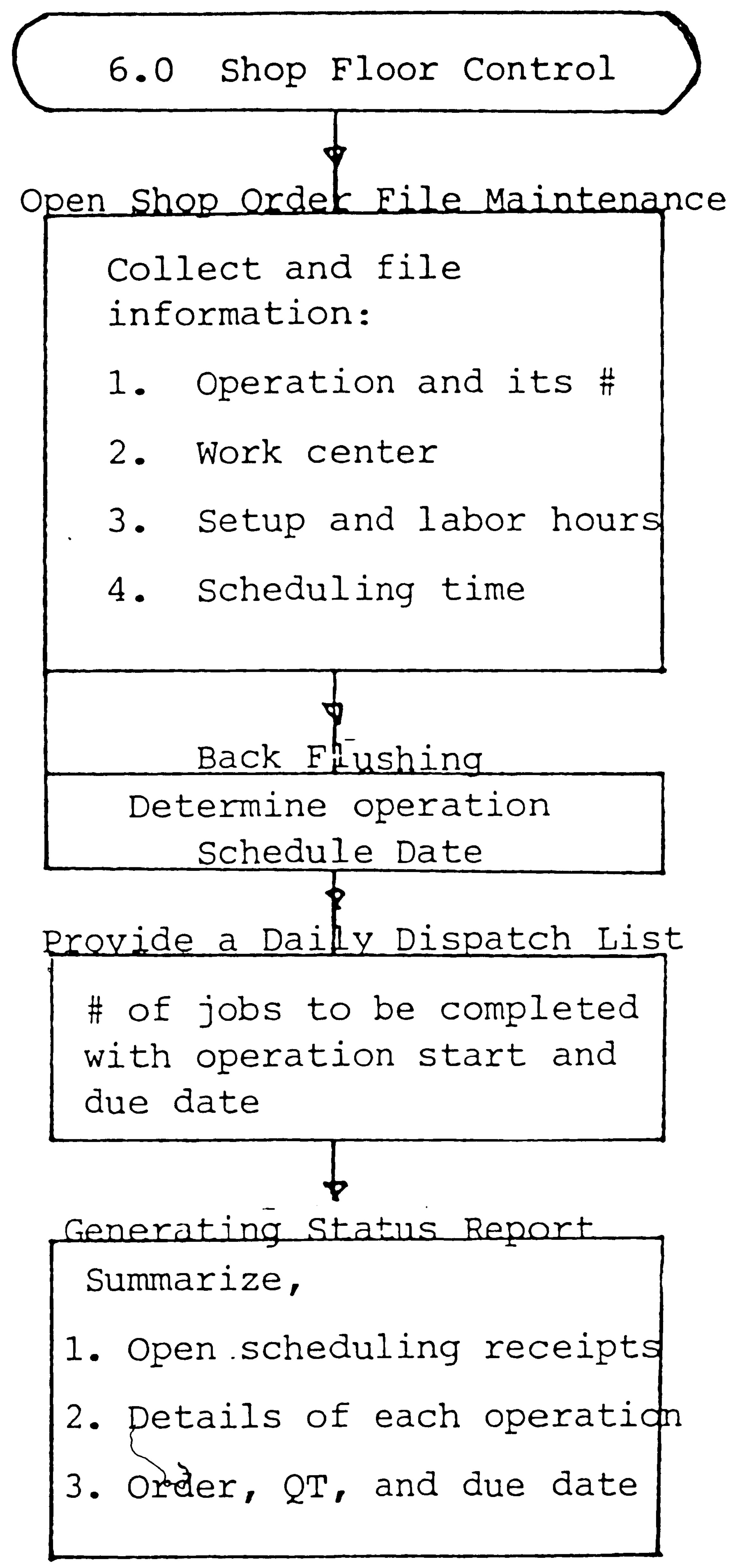


Figure 5.1
Shop Floor Control Logic

When a scheduled receipt is created for a manufactured item, a copy of routing for that item containing information such as operation number, description of the operation, work center, set up and labor hours, and scheduling time is attached to the scheduled receipt. This entire information is stored in an open shop order file. The logic to maintain this open shop order file should include the logic explained above to copy the routings and attach it to the scheduled receipt. It should also include logic to handle phantom, transient, or self consumed assemblies that are components, for example when scheduled receipts of items such as vacuum cleaners, lawn movers, etc. are created at CITADEL, SFC module should attach shop floor routings containing information such as operation sequence, labor requirements and order due date are provided immediately to the foreman. Foreman can make use of this information and develop manufacturing sequence, tooling and job requirements.

The maintenance logic should include transaction to add, delete, and change the operations attached to an order.

6.2 <u>PROVIDE BACK SCHEDULING LOGIC TO DETERMINE OPERATION SCHEDULE DATES:</u>

Shop schedule consist of operation schedule dates for each operation. These dates will be used in determining the shop performance. Operation schedule dates should include an opeartion start date and an operation due date, back scheduled from the order due date using simple scheduling rules.

Some examples of simple and typical scheduling rules are the following:

1. Schedule forty hours a week.
2. Allow two days for move and queu between departments.
3. Allow two weeks for outside vendor operations.

These rules should not be complicated as they create trouble in understanding how the schedule was calculated.

The SFC system should also make some provision for special circumstances where the planner or shop people want to override the normal scheduling rules. An example of this would be an item where two or more of the operations are normally overlapped, or where a product is being manufactured on an assembly line. Instead of waiting for the first operation to be completed, the second and possibly the third operations are started as soon as enough material is available. This can be done by allowing deviations to the normal scheduling rules to be stored in the routing. A deviation would be stored as a scheduling time for each operation. In the case of overlapping operations above, a negative scheduling time, like minus two days for example, could be used on the overlapping operations. This would schedule the second, and third operation two days before they would normally have been scheduled to start.

The back scheduling logic in the system should also include the ability to update the operation schedule dates when the order is rescheduled. The logic generally operates by calculating the difference between the old due date and the new date. This difference is then applied to the operation start and operation due dates.

6.3 PROVIDE A DAILY DISPATCH SHOWING A SHOP SCHEDULE:
The daily dispatch list shows the jobs that are in each work center ready to be worked on. It also looks ahead a few days and shows the jobs that will be coming to the work center. It contains a list of jobs to be done showing the operation start and due dates as well as the order due date. The operation start dates are used to determine what job to work on next. The operation due dates and order due dates are vital pieces of information. These are the dates the shop people are responsible for meeting. Where daily dispatch lists are shown by departments, dispatch list shows department start date and department due date for each order as well as the order due date. The order due date is included in the dispatch list to help the shop

people determine when to feedback the information to the planners. The due date of an order is the date the order is needed back in the stock room. If an order is to be late by more than a day or so, the planner need to begin to make alternate plans.

The operation transactions should exist in the SFC system. These are the move transaction and the operation complete transaction. Move transactions signal the arrival, and the operation complete transaction signal the end of an order through each operation. The move transaction says that the material has been moved to the work center for an operation, and it is now available to be started. The operation complete transaction says that the work is done at this operation, and it should be taken off the schedule of work to be completed.

6.4 STATUS REPORTING OF ALL ORDERS:

The status reporting is a listing of all the open manufacturing scheduling receipts. The report should show the summary information for each order as well as the details of each operation. The summary information may contain items such as order quantity, due date, and order date. The detailed information for each operation should include:

Operation number,

operation description,
set up and run hours,
operation start date,
operation due date,
opeartion status, and etc.

This report may be used by planners and shop people to evaluate shop orders. They are useful in determining whether or not an order can be rescheduled to an earlier date, and in trying to find a way to complete an order that is behind schedule by the due date of the order.

The module should also have flagging capability for a quantity difference upon arrival at the next operation and completion, and also for comparing actual lead time to planned lead time. It should be able to handle split shop orders for material review board, handle for engineering changes, manufacturing changes, part shortages, etc. Module should also be capable of providing visibility of engineering revisions on routings.

7.0 CAPACITY REQUIREMENTS PLANNING

MRP is used to plan the items that are consumed. These are things like components or consumable toolings like grinding wheels, welding rods, etc.

Capacity Requirements Planning (CRP) is used to plan workcenters, machinery, labor, any type of equipment like testing equipment, modular components in a packaging or assembly line, tooling, fixtures, gauges, etc. CRP is a tool to plan all these things.

CRP is a tool to show the capacity picture for a work center in the same way that the MRP reports show the picture for an item. CRP is a tool that shows the capacity requirements and does not attempt to solve the capacity problems. That is the planner's job. The planner is provided with information showing any capacity problems, howver, the computer does not automatically attempt to solve these problems.

Problem with some of the capacity planning systems that attempt to solve capacity problems is that the solution to these types of problems do not lend themselves well to the computer. The solutions are basically human, and the judgement and evaluation of a planner is the best way to handle them. In fact, many of the ways to solve the capacity problems will probably never be programmed into a computer. Subcontracting, running a job on different pieces of equipment, changing order quantities, overtime, extra shifts reducing the lead time for parent item, running jobs early, and many others are common ways to solve capacity problems. For the most part, these are human decisions.

Capacity problems all have one thing in common:

Someone needs to know about the problem before it appears on the shop floor.

The function of the CRP system is to identify these problems and present them to the planner. The responsibility of the planner is to find solutions to these problems.

The functional requirements for the capacity requirements planning module are the following:

7.1 Generate CRP from both planned and released orders.

7.2 Allow the orders to follow or deviate from the normal routing.

7.3 Reporting capabilities.

The flow diagram showing logical relationship among those capabilities is shown in fig. 7.1.

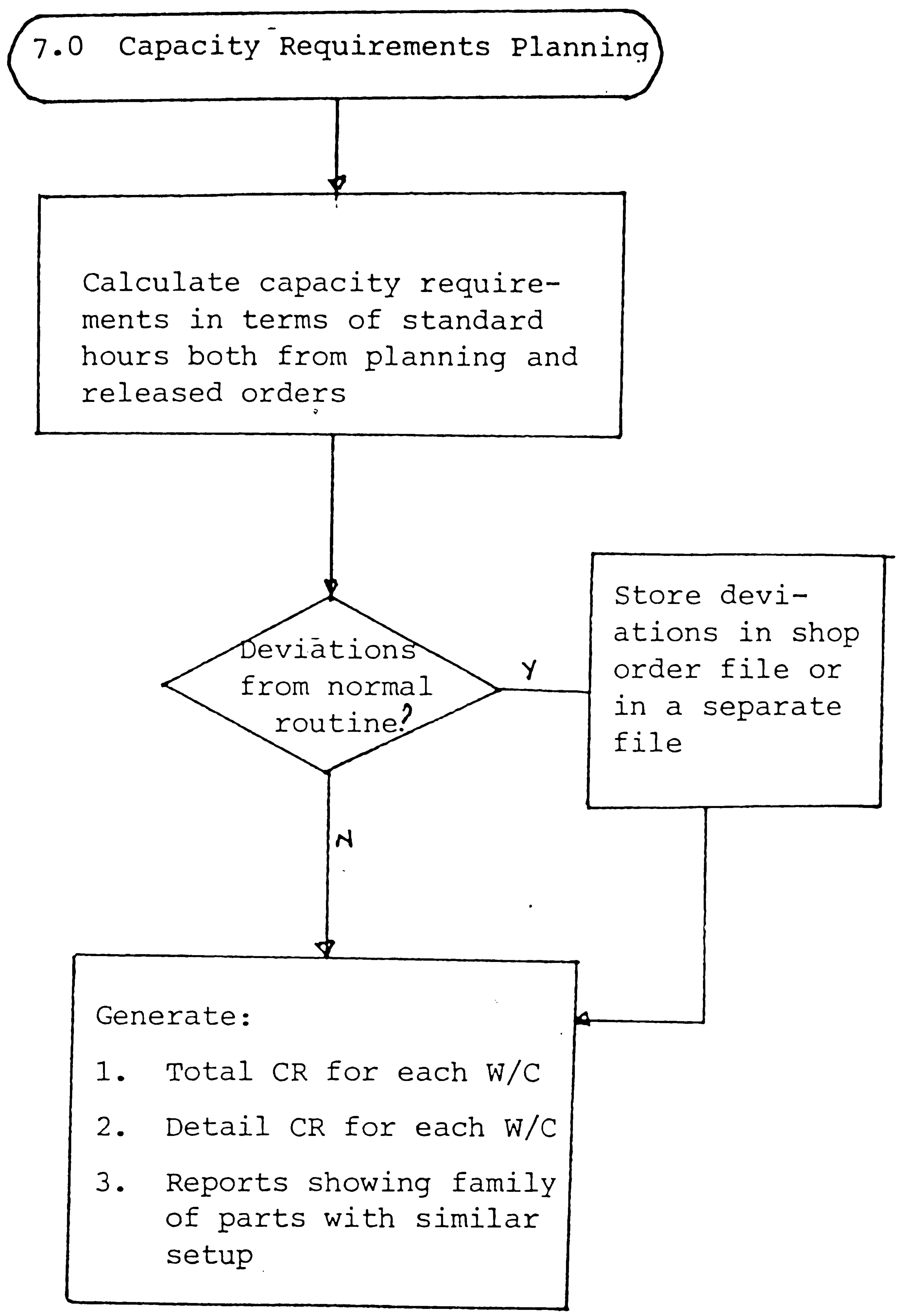


Figure 7.1
Capacity Requirements Planning Logic

7.1 GENERATE CAPACITY REQUIREMENT FROM BOTH PLANNED AND RELEASED ORDERS:

The CRP module should calculate capacity requirements using both the planned and released orders. The capacity requirement for released orders are extracted from the shop floor control system. The open shop floor order file contains all the manufacturing operation by date. The operations which are not complete are the capacity requirement for the orders.

Capcity requirements are normally calculated in standard hours. No efficiency calculations or percentage is typically used. The reason for this is that the output of the workcenter will be stated in standard hours of output. These hours of output are the number of standard hours that a work center is producing, which can differ quite a bit from the number of hours work center is manned. Using the actual standard hours of output for a work center takes into account all the factors that can affect the out put of a workcenter. It includes time the machine is down for repairs, lost production due to a broken tool, bad standards, time that the machine is available and an operator is not, etc.

Sometimes it is necessary to calculate capacity requirements for more than one resource needed in an operation. For example, in some companies, a single operator may run several different NC machines simultaneously. In this situation, it's essential to be able to see both the capacity requirements for labor (do we have enough operators?) and the capacity requirements for NC machines (do we have enough equipment?).

Many software packages are limited to planning one work center or resource per operation. For companies where there are only a few operations that affect more than one resource, this would probably not be a problem. If a company has a significant number of operations that affect two or more resources, then this capability should be provided in the system. Otherwise, the capacity planner will not have all the tools needed to plan and get the required labor and equipment.

7.2 REPORTING CAPABILITIES:

Three reports display the capacity planning information. The capacity requirement should be totalled and displayed for each workcenter and also listed individually to backup the totals. For grouping orders with common set-ups a third report should display all the orders in a manufacturing family.

A capacity planning summary report displays the totals of the capacity requirements by workcenter and time period.

The totals are calculated by workcenter and time date. The planner can find capacity problems using this report by comparing the normal capacity in standard hours to the capacity requirements.

In some companies, a good argument can be made that displaying capacity requirements in weekly time buckets is a illusion of accuracy that doesn't exist. For example, in a machine shop where an order goes through cutoff, milling, drilling, and other operations, may sit in a queue in front of each machine before being processed. In this case, capacity requirements are calculated by estimating the date the order will arrive at a workcenter. Normal scheduling rules are used to develop these dates, and deviations from the dates will occur causing some of the jobs to arrive sooner then anticipated and others later than expected.

For the planner to be able to solve capacity problems, he will need a list of the detailed capacity requirements which make up each weekly total. For example, planner working to reduce an overload on a workcenter needs a list of the items causing the capacity requirements for that workcenter in the weeks that are overloaded. Once he knows which orders are causing the capacity requirement, he can begin to solve the problems.

The detailed listing shows where the capacity requirements are coming from. This dispaly of capacity requirement should include:

workcenter,
date,
item numbers causing the capacity requirements,
and hours.

The hours are needed to allow the planner to work efficiently with the report. By listing the hours, the planner can concentrate on those few orders causing the bulk of the load. Some systems also distinguish the different types of orders causing the requirements (scheduled requirement, purchase order, etc.) or list the operation number and opeartion description.

In some companies, a significant portion of the capacity requirement in a workcenter may be setup time. When many of the items crossing a workcenter have common or similar setups, it is possible to eliminate some of the setup time by scheduling similar items together. In this situation, a listing of the items with common setups and which have planned orders during the next few months, would be helpful for a capacity planner. Once a planner knows which orders have similar setups, he can adjust the schedule, and run items in a manufacturing family one after another. One simple way would be to have the capacity planners assign a family code (Group Technology code) for any items that are candidates for grouping. These codes would be used to run items together in MRP II. By such an interface, it would be possible to identify the items that are really needed, see which ones could be grouped for efficient processing, and the material and capacity are available to run them when planned.

7.3 ALLOW THE ORDERS TO FOLLOW OR DEVIATE FROM NORMAL ROUTINGS:

Deviations from normal routings are situations where an operation is added, deleted or changed for an order. The order could be a scheduled receipt, firm planned order, or a planned order. Allowing deviations to be attached to a planned order only makes sense in a net change system, in a regenerative system all planned orders and gross requirements are destroyed at the beginning of the planning run. These deviations are attached to the order. If the order is rescheduled changed operations move with the order.

Deviations to the normal routings are normally provided by allowing the routings to be copied for firm planned orders and added to the open shop order file. The routings for these orders does not have to be stored in the open shop order file. It would also be possible to have a separate file to store operations for these firm planned orders. The capacity planner can maintain by adding, deleting or changing operations. The operations are then used in capacity requirements planning. Capacity requirement for firm planned order or planned order with these deviations from the normal routing are taken from the file of operations. The orders are not extended by the routing to generate capacity requirements.

8.0 **PURCHASING**

The difference between planning and control of purchased versus manufactured items is the creation of a scheduled receipt. To open a manufacturing order, production planner enters it into the computer and delivers shop paper to the stock room or appropriate supervisor, and so the manufacturing order is placed. Placing the purchase order, on the other hand, requires a greater number of tasks. The purchase order placement can involve requests for quotations, bidding, contract negotiations, price negotiations, plant visits, sampling, and other complicated professional activities.

When the buyer schedules directly from the time-phased inventory record, they can factor critical information about the supply marketplace into the scheduling decisions. Only the buyers are up-to-date on the latest lead times, price breaks, pending strikes, combined-order opportunities, and other economic complexities of the marketplace that affect the buying decisions. Buyers must have the authority to change planned due dates and quantities so they can take full advantage of current market and vendor circumstances. Further they must know the long-term item priorities, beyond the next order release, if they are to develop beneficial long-term vendor relationships. Buyers need the latitude for decision making and the long-term visibility provided by authority for scheduling their own items and accessing the time-phased inventory record.

Keeping these requirements of the purchasing people in mind purchasing module should be capable of following:

8.1 Provide a vendor scheduling tool.

8.2 Provide a tool for vendor negotiations.

8.3 Maintain purchase order controls.

8.3.1 Schedule dates that include inspection.

8.3.2 Outside processing operations.

8.4 Measuring vendor performance.

The flow diagram fig. 8.1 explains purchasing logic.

8.1 PROVIDE A VENDOR SCHEDULING TOOL:

Like shop scheduling, vendor scheduling is a part of the execution system for MRP II. The shop schedule or dispatch list is a part of the shop floor control system and communicates the schedule dates and manufacturing orders to the shop. The vendor schedule is a part of the purchasing system and communicates the due dates for purchased items to vendors.

The vendor scheduling report should show the scheduled receipts that have been authorized for the vendor, and it looks ahead, beyond the vendor's quoted lead time, to display any planned purchased orders in the future.

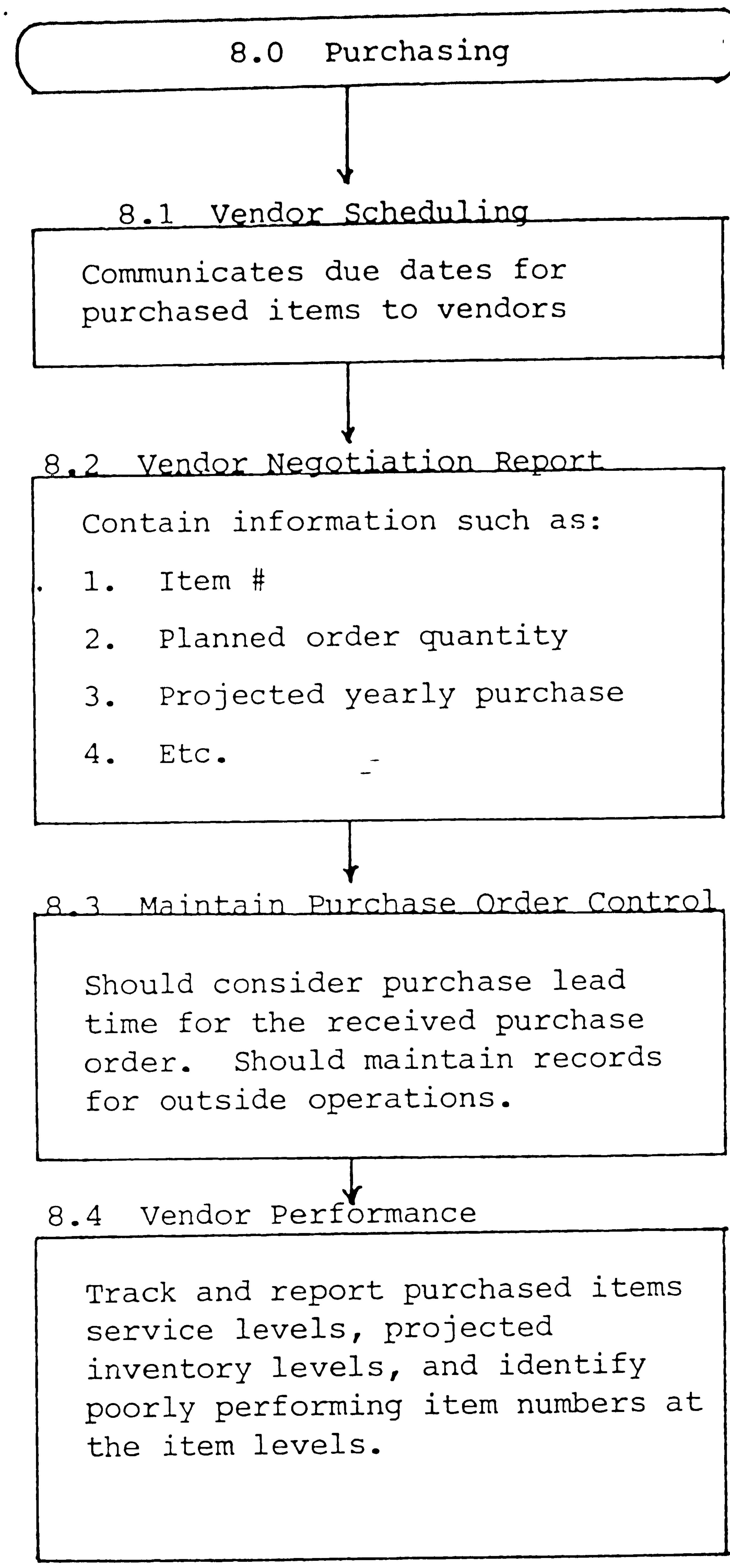


Figure 8.1
Purchasing Logic

Regardless of whether or not vendor scheduling is done, a vendor has to do some type of planning beyond the backlog of customer orders.

Without vendor scheduling, this planning out beyond the backlog of customer orders would have to be based on forecasts of requirements that may or may not be close to the real purchasing schedules. With vendor scheduling it is possible to show the vendors planned purchased orders before they would be normally placed. This allows the vendor to plan both the capacity and material out beyond the backlog of customer orders, which in turn make the vendor more effective in executing the schedule once an order is finally authorized.

For certain products which are ordered from several different vendors, a company may want to show that no one vendor will get all the business. This can be done in several ways:

one would be to use a percentage to split each of the planned orders among several vendors.
Second approach would be to show each vendor the total quantity the customer will be buying from all suppliers and also show each vendor the percentage that the vendor will supply.
Third approach would be to show every other or every third

planned order to a vendor.

One of the responsibilities in working with vendors is to properly follow-up with the vendor to assume on-time delivery. Depending on the relationship with the vendor, how well the vendor works with the vendor schedule, etc. This responsibility may require extensive follow-up or no follow-up at all. If follow-up is needed, it would be done using a follow-up date in the purchasing system. This date is typically stored for each line item on a purchase order. When this date is due, a message appears to remind a buyer or vendor scheduler that follow-up is required. The buyer or vendor scheduler can then reset the follow-up date if another follow-up is required, or leave the date blank if no other follow-up is needed. The follow-up date would typically appear on the vendor schedule, although it could also appear on a separate listing or exception report.

Firm planned ordering tool with vendor's identification, as well as the item's due date and quantity can help planning long-term item strategies. It gives the buyer a tool to override the planned order logic of the computer and change quantity and date as well as adding the vendor identification. Buyer can use this tool that extends to the end of the planning horizon. Firm planned order can also provide meaningful cash commitments information by the item number or vendor. In addition to improving parts-planning capabilities, the firm planned purchase order can be used to create subsidiary time-phased vendors records. The time-phased vendor record would use firm planned purchase orders and scheduled purchase receipts information for each part supplied by a vendor to show the complete plan for that vendor. Planner could use this information to analyze the vendor load, determine cash commitments, and transmit long-term plans to the vendor. It can be used by the scheduler to plan long-term relationships.

8.2 PROVIDE A VENDOR NEGOTIATIONS TOOL:

Before MRP II, the right information on what would be purchased and when, was not easily available, and could not be updated easily. Purchasing module in MRP II makes such information available. Planned purchases are in the system because are the planned orders. In addition, these planned orders are updated each time MRP is run. This information can be extracted from the system and displayed for negotiations, value analysis, etc. Normally, this display would take the form of vendor negotiation report showing the planned purchases over the next quarter, next six months, next year, and so forth. A buyer can use this report to concentrate on the big dollar purchase, on large variance item, etc.

Vendor negotiations report may consist of:

Item number
planned order quantity
yearly planned order total
planned order release date
cost variance
projected yearly purchase dollars
projected yearly variance

In fact bargain can be struck by showing your load on vendor's plant, the load that is based on your actual and projected requirements. The actual requirements numbers can be calculated from the existing open purchase orders. Projected requirements numbers can be calculated from the firm planned purchase order. The entire vendor load can then be calculated by accumulating a vendor's projected requirements from each time-phased inventory record and displaying the sum of those requirements in the time-phased vendor record.

8.3 MAINTAIN PURCHASE ORDER CONTROL:

8.3.1 SCHEDULE DATES THAT INCLUDE INSPECTION:

The delivery date on a purchase order and the date items are due to arrive in the stockroom are two different dates, and the system should recognize this. The time required to receive and inspect a purchase order accounts for the difference in those two dates. Generally vendors work in terms of the delivery date for an order, and MRP is concerned with the date the items will be available in the stockroom.

The way to recognize these two dates is to provide two dates for each purchase order and line item:

a purchase order delivery date
and a date the items are expected to be available in the stockroom.

The purchase order delivery date is the date that is used in all dealings with the vendor. The stockroom date is the date that is used in the MRP netting and exception logic.

A receiving/inspection lead time is the difference between the two dates. A buyer or vendor scheduler could specify both dates (the delivery date and the stockroom date) for each order. Or the buyer or vendor scheduler could specify one of the dates, and have the system calculate the other date using the receiving/inspection lead time.

To provide a type of a dispatch list for those items in the inspection area is also helpful. A dispatch list can be provided by sorting and listing the items in the inspection area by stockroom date. Another approacah would be to allow a routing on purchased items, and then use the shop floor control to provide a dispatch list for items in inspection.

8.3.2 <u>OUTSIDE PROCESSING OPERATIONS:</u>

Many times manufacturing orders are routed to vendors for some type of outside processing. For example an item may be routed through the machine shop, outside for plating, and then back to the machine shop for additional machining. In this situation, the shop floor control system includes a shop order and routing that covers all the inside and outside operations. The purchasing system should provide a way to store and maintain an additional purchase order to record the purchase of the outside operation.

One difference between purchase orders for outside operation and normal purchase order is that, purchase orders for outside operations are tied directly to manufacturing orders in the shop floor control system. As a manufaturing order is rescheduled, the operation due dates rescheduled for all operation, including outside vendor operations. These operation schedule dates are compared to the due date of the corresponding purchase orders for outside operations, and exception messages are generated for any orders where the dates are different.

8.4 <u>VENDOR</u> <u>PERFORMANCE</u> <u>MEASUREMENT:</u>

The performance goals for incoming parts need to be related to the desired effects: no shortages and low inventory levels. Accordingly, MRP system must track and report purchased item service levels and projected inventory levels. The purchased item service level is best reported as a rolling service level figure, such as a six month service level. The service level could be defined as the percentage of items in stock when it is needed for a kit release. The performance report can help the buyer in evaluating the vendor's performance.

Many departments do measure vendor performance, but this measure often misses the mark. Vendor ratings are not item specific. They are useful for general policy determination, e.g., don't buy from vendor A, but they are not useful for fine-tuning procurement strategies for each purchased item. However, if a buyer knows that a item has had too many stockouts he can easily find the responsible vendor, without the need for overall vendor evaluations, simply by looking at the purchase history records. Buyer need to identify poorly performing item numbers at the item level and then take the specific action required to improve the service level or inventory turns of that item.

Despite one's best efforts, a long-term vendor relationship will be strengthened or undermined by the buyer's and the vendor's short-run performance. Purchased item need dates will change often in the short run as the inevitable problems occur on the shop floor.

The planner must inform the vendor of the new priorities or he cannot build the correct items. The vendor dispatch list is the means for communicating this information. It displays the vendor's orders ranked by due-date priority. The report extends over several weeks. The key vendors may need a new dispatch list every week. They need to know the deexpedites as well as the expedites. The vendor dispatch list should be the buyer's primary tool for expediting and deexpediting purchase orders.

9.0 PERFORMANCE MEASUREMENT

Companies already have spent a great deal of time and money devising systems which report financial statistics under normal accounting procedures. They often do not receive the same kind of detailed information about the actual performance of the production & inventory control operation. Even when the accounting numbers ordinarily should give some indication about the health of operations, they lump together results and help obscure rather than illuminate the root cause of operational problems and successes.

Usually there are five ways indicators can help promote more efficient operations. these include:

	Indicator	Measure
TIMING The time it takes to process an order serves as an indicator of both efficiency and lead time needed to meet reliable promises.	Order entry	Order procrssing time
ACHIEVEMENT The number of parts forecast in the corporate plan and actually ordered by customers helps zero in on the effectiveness of forecasting procedures.	Forecast	Actual to forecast parts
COMPLETENESS Looking at a document as a whole is a good way to see if it is adequate for the MRP explosion calculation.	Engineering documents	Bill of material (%)
ACCURACY Comparing perpetual inventory records to actual on-hand balances ascertains the effectiveness of recording decisions.	Record accuracy	Book-to-cycle count comparision
PLANNING Monitoring production control's ability to schedule production and ship as promised gives a feel for its basic planning capabilities.	Production control	Original delivery promises met (%)

There are number of reasons for instituting a formal performance measurement program, both before and after MRP-II is operating:

1. To establish objective measurements, rather than informal, subjective measurements.
2. To develop a standard that can be compared to other companies.
3. To identify problems, to assist in prioritizing problems so they can be solved, and to provide scorecard for monitoring performance.

The utilization of this measurement technique can have these advantages:

1. Each functional manager receives a monthly one-page report which highlights the more important quantitative aspects of his responsibilities.
2. Each executive receives the more important indicators for these functions supervised.
3. The president is given report of important statistical measures which highlight the critical company operations.
4. The graphic presentation format of the report facilitates the observation of favorable/unfavorable trends to permit corrective action.

5. Considerable excess reporting is eliminated.

The performance may be measured by software in the folowing areas:

9.1 Master production schedule
9.2 Material requirements planning
9.3 Capacity requirements planning
9.4 Bills of material
9.5 Inventory Control
9.6 Routings
9.7 Purchasing
9.8 Shop floor control
9.9 Delivery performance

The flow diagram for performance measurement is explained in fig. 9.1.

9.1 MEASURING MASTER PRODUCTION SCHEDULE PERFORMANCE:

The objective of the master production schedule is to determine the product mix to be produced within the production rates of the production plan. The MPS is the bridge between sales and manufacturing. It is what, how much and when at the product, model, feature, or option level for scheduling the manufacturing resources to meet the sales plan.

The key measurement is the master schedule performance. The master production schedule is the schedule of the detail product mix to be produced to meet the sales plan. The master production performance is the actual MPS produced as a percent of the planned MPS by model, feature and option.

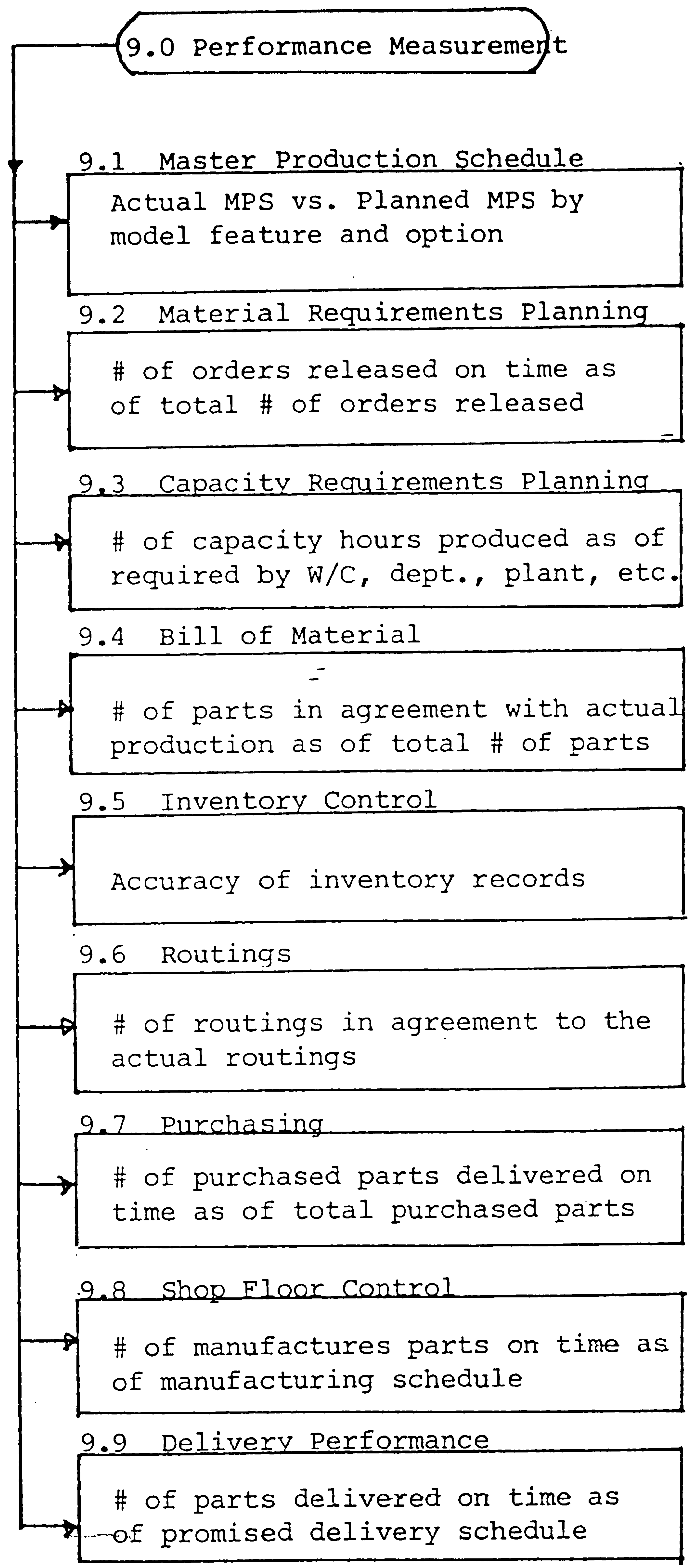


Figure 9.1
Performance Measurement

9.2 <u>MEASURING MATERIAL REQUIREMENTS PLANNING PERFORMANCE:</u>

The objective of the MRP is to determine the time phased requirements for parts required to produce the product and to maintain the part priorities for production. It is the what, how much and when of production at the parts level.

The key measurement is release reliability. Release reliability indicates whether the orders are being released to production or purchasing with sufficient lead time so that the parts can be completed or delivered by the due date for production. Release reliability is the number of orders released on time as a percent of the total number of orders.

9.3 <u>MEASURING MATERIAL REQUIREMENTS PLAN PERFORMANCE:</u>

The objective of the capacity requirements planning is to plan the capacity and the labor required to produce the product. It is the what, how much and when of the capacity and labor required to produce the plan.

The key measurement is capacity requirements planning performance. The capacity plan should be developed by work center, department, and the plant to determine the capacity required to meet the plan. The capacity plan performance is the number of capacity hours produced as percent of the capacity hours required by work center, department and plant.

9.4 MEASURING BILLS OF MATERIAL PERFORMANCE:

The objective of the bills of material is to specify the parts and materials; the quantity of the parts and materials; and the assembly of the process relationship required to produce the product.

The key measurement is bill of material accuracy. Bill of material accuracy indicates whether the bill of material represents the product as it is being produced. Bill of material accuracy is the number of parts on the bill of material that are in agreement with actual production as a percent of the total number of parts.

9.5 MEASURING INVENTORY CONTROL PERFORMANCE:

The objective of the inventory control is to maintain accurate and timely inventory status information. It is the what and how much that is on hand in inventory and that is available to produce the product.

The key measurement is inventory accuracy. Inventory accuracy indicates the accuracy of the on hand inventory record as compared to the physical inventory. Inventory accuracy is the number of parts where the physical count equals inventory record as a percent of the total number of parts counted.

9.6 <u>MEASURING ROUTING PERFORMANCE:</u>

The objective of the routings is to specify the operations to be performed to produce the product. The routing should specify operations or sequences, the machine or work center, the tooling or fixtures, and the setup and run hours for each operation. It is the what,and how much of the operations and standard hours required to produce the product.

The key measurement is routing accuracy. Routing accuracy indicates whether the routing represents the operations as they are being performed in the shop. Routing accuracy is the number of operations that are in agreement with the actual operations.

9.7 <u>MEASURING PURCHASING PERFORMANCE:</u>

The objective of the purchasing is to deliver the purchased materials on the due date to meet the plan. It is the detailed, what, how much, and when for purchased material to execute the plan.

The key measurement is schedule performance. Schedule performance indicates whether the vendors are delivering purchased part on schedule. Schedule performance is the number of purchased parts delivered as a percent of the purchased parts scheduled.

9.8 <u>MEASURING SHOP FLOOR CONTROL PERFORMANCE:</u>

The objective of shop floor control is to deliver the manufactured parts on the due date to meet the production plan. It is a detailed execution of what, how much, and when of labor material on the shop floor.

The key measurement is schedule performance. Schedule performance indicates whether manufacturing parts are being completed on time in the shop. It is the number of manufacturing parts completed as a percent of the manufacturing parts scheduled.

9.9 <u>MEASURING DELIVERY PERFORMANCE:</u>

The objective of the delivery performance is to build the product on time, ship the product on time, and deliver the product to the customer when it was promised.

The key measurement is of schedule performance. Delivery schedule performance indicates whether the product was delivered to the customer when it was promised. If the customer delivery was promised from the sales plan, product will be available for delivery to the customer when it was promised. Delivery schedule performance is units delivered as a percent of units promised.

10.0 ACCOUNTING INTERFACE

The purpose of accounting interface is to trace the flow of information from the shop floor through the standard cost accounting system and show the feedback available to management in the form of reports and variances.

The job of accounting interface is to take the information generated from the shop floor and distribute these costs to the products manufactured. It calculates actual performance and any variances from standard cost. The standard costs are arrived at by using industrial engineering time studies or historical performance based on records. The standard cost should be a reasonable expectation of performance.

The accounting interface accumulates the material, labor and overhead cost associated with each shop order as it is processes through the plant. As these costs are accumulated, they can be compared with the standard cost and variances can be calculated. These variances can be used by management to take corrective action.

The accounting interface may consist of the following capabilities:

10.1 To track various cost components.

10.2 To track various variances.

10.3 To be able to provide input to budget.

10.4 To be able to generate reports.

The flow diagram showing logical relationship among these capabilities is shown in fig. 10.1.

10.1 <u>CAPABILITY TO TRACK VARIOUS COST SOMPONENTS:</u>

The standard cost can be divided into three parts.

fixed costs,
variable costs,
and overhead cost.

Fixed costs are the costs that can not be changed in a short period of time and are associated with general or operation of the business. This would include taxes and insurance on the building, security systems, and a minimum amount of power. Other items that may be included in fixed costs would be a minimum staff. Fixed costs generally would be thought of as costs that could not be avoided in the short run.

Variable costs are costs that vary with the production cost of the product. These would include raw material, direct labor, and the variable portion of the indirect labor.

Overhead costs are costs that can not be directly tied to an item within a product and must be spread over the entire product mix. For an example, foreman's salary would be

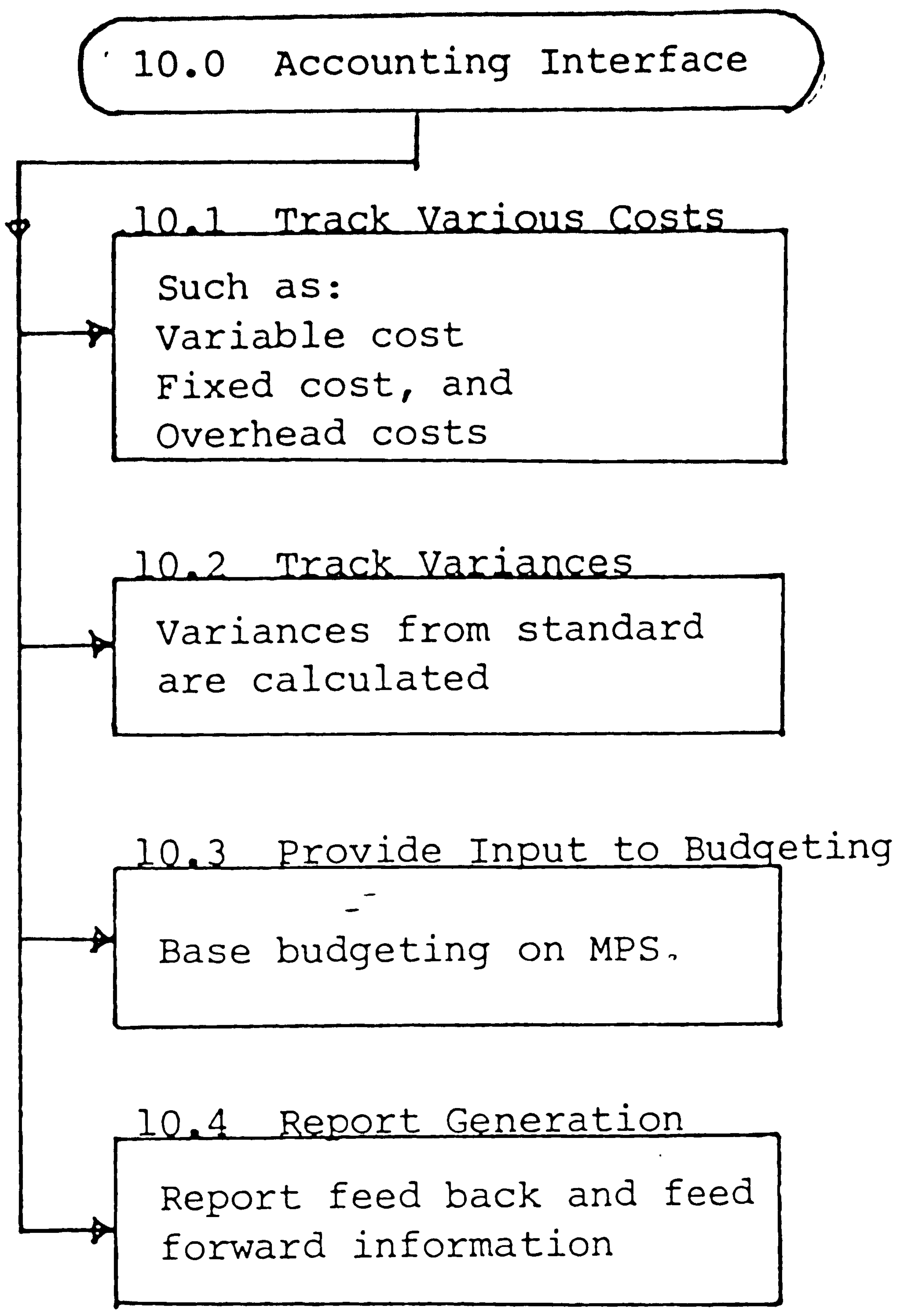


Figure 10.1
Accounting Interface Logic

difficult to split up based on the attention he gave to each item or each product going through his department. His salary would be considered as part of overhead cost and spread on a propotional basis over all the products going through his department.

10.2 CAPABILITY TO TRACK VARIANCES:

Variances from standard are normally expensed to the profit and loss statement on a monthly basis. An unfavorable variance would indicate that the department earned less than the standard cost allowed for a particular number of pieces and a favorable variance would indicate that the department earned more than the standard cost allowed for a particular operation. The time that the operator expended doing a particular lot of parts times his personal labor rate would indicate the actual amount of money spent on that lot. This would be compared to the allowed or standard housed in the cost accounting data base and the difference would a variance.

Some typical variances are,

raw material variance,
direct labor variance,
vendor delivery variance,
and idle capacity variance.

10.3 CAPABILITY TO PROVIDE INPUT TO BUDGETING:

The budgeting system is based on the expected production level in the plant in the coming months or years. The master production schedule is an excellent tool to use for budgeting purposes. This is especially true if the master production schedule contains 52 weeks of information. It is possible to design the master production schedule to include weekly schedules for a period of time up to six months and then show monthly master production schedule from sixth month to a year. The budget would be based on the normal production expected during the time period. This production would be calculated in direct labor hours or some other equitable base, such as machine hours.

10.4 GENERATE REPORT FOR THE MANAGEMENT:

The purpose of the accounting interface is to provide feed back and sometimes feed forward to management to show their historical performance. It will help the management assess what is going to happen beforen it happens so that corrective action can be made before the fact and not after the fact.

One of the important reports used by the management is the report containing information showing how they did against the direct labor standard, fixed standard, and controllable standard.

Additional reports would be those showing raw material usage and variance and controllable usage and variance. These figures can be analyzed on a cost basis to determine why variances were favorable or unfavorable. Favorable variances should be analyzed with same concern as unfavorable variances because they can tell us that either the standard is wrong and the standard cost should be adjusted or some type of superior performance or method was used that could be applied to other areas.

The reports are more useful when they feed forward information to management alerting the potential problems or areas of concern. By integrating the MRP module and the accounting interface, the master schedule can be priced out and this information can be fed forward to operating departments, who can examine the direct labor hours that will be available to a department during the coming time period.

This type of feed forward information allows the department manager to better manage his resources of labor and material and avoid variances due to fluctuating production schedules.

A costed out master schedule and a costed out work in process inventory can provide valuable tools to materials management personnel to plan and achieve inventory goals and raw materials expenditures. Using the costed out master schedule in relation to sales forecast provides the necessary data to calculate pro forma statements of finished goods inventory for the ensuing time period.

11.0 FINANCIAL PLANNING INTERFACE

The financial information from MRP II consists of projection of inventory levels, cash disbursements for labor, cash receipts, and etc. These projections can be combined with other financial information to delvelop a complete financial plan. The type of information that MRP II provides is not financial planning, nor it is an attempt to develop profit and loss statements or balance sheets. Instead, the interface from MRP II provides a simple way to extract certain kinds of financial data, organize it, and present it to people who can use it in their financial planning. People develop financial plan, MRP II provides the information to do it well.

MRP II provides detailed and accurate information on:

1. Projected inventory value.
2. Cash disbursements for material, direct labor, and overhead.
3. Cash receipts.

The functional requirements for the financial planning interface in an MRP II system are the following:

11.1 Provide a tool for calculating current inventory value and for projecting inventory value.

11.2 Provide a tool for planning cash flow.

11.3 Provide a tool for allocating fixed overhead expense.

The flow diagram showing logical relationship among these capabilities is shown in fig. 11.1.

With MRP II, information for financial planning is calculated directly from the numbers in the operating system. The financial planning interface to MRP II takes the company game plan expressed in manfacturing terms like units, pounds, and hours, and converts into dollars and other units meaningful to top management, and financial people. In MRP II, the financial projections are developed by taking the details on each individual item, order, manufacturing event, etc. and extending them by the cost information for the item, order, etc. The details of the company game plan are costed out and summarized to show the overall financial effects of the plan.

The software in the financial planning interface can prepare accurate projections of the material, direct labor, and variable overhead costs based on the company game plan. As the company game plan changes, the financial plan for MRP II changes also. And since financial plans were developed directly from the manufacturing numbers, it is possible to look into the system and track a financial number back to the individual manufacturing events that

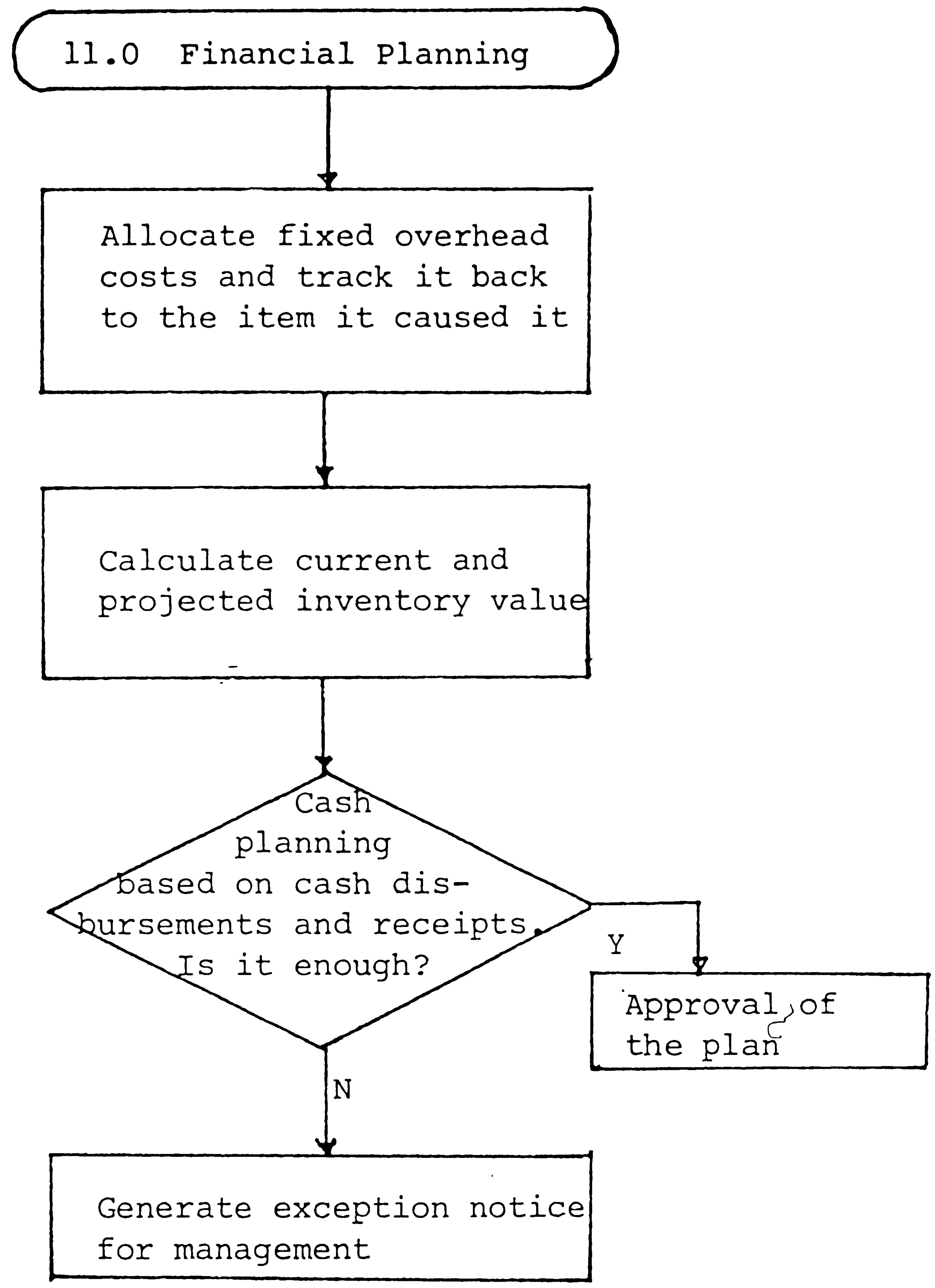


Figure 11.1
Financial Planning Interface

caused it. The software should be able to combine financial data from MRP II with other financial information like principal and interest payment, depreciation, taxes, research and development expenses, general administrative expense, etc.

The financial projections made possible by MRP II are typically used by a number of people within a company. Financial planner use it to plan cash flow, project profits, develop prices, evaluate make/buy decisions, etc. Top management may use it to evaluate different business strategies, obtain lines of credit, justify new equipment and facilities, etc.

11.1 <u>Provide a tool for calculating current inventory value and for projecting inventory value.</u>

The financial planning interface should provide a way to develop both the present value and projected value of inventory in future. The present inventory includes inventory in the stockroom, in inspection, in transit, in field service, on the shop floor, etc. The projected value inventory include both stockroom and finished goods inventory, as well as the work in process inventory projected for the future.

The present value of inventory would be calculated by adding the value of the inventory on hand to the value of work-in-process. The value of the inventory on hand would be found by taking the balance in the stockroom plus any additional inventory for each item and extending it by the unit cost. This cost would be totalled for all items in stock to develop the value of the on-hand inventory. The value of the work-in-process would be developed by taking the material costs for each order and adding in any labor that has been reported on the order. In addition, an overhead cost based on the work centers and departments through which the order has been processed would be added. All orders would be summed to give the total value of work on the shop floor.

The projected inventory value would be calculated from the projected on-hand balances and from the orders in the MRP II system. The projected on hand balances in MRP would be extended by the unit costs to give the inventory value of raw material and completed components in the stock room. The projected value of work-in-process would be developed by taking all scheduled receipts, firm planned orders, and planned orders and extending them by the proper material, labor and overhead costs.

Two reports would typically display the present or projected inventory value. The present or projected inventory value should be totalled, and, in the case of the projected inventory value, displayed in time phased format.

11.2 PROVIDE A TOOL FOR PLANNING CASH FLOW:

The financial planning software should provide a method for projecting cash flow. Cash flow projections cover both cash disbursements and cash receipts. Cash disbursements can be calculated for material, direct labor, and variable overhead expenses. These cash disbursements can be combined with other financial numbers to develop a complete cash flow projection for the company.

Expenses for purchased material can be calculated by extending the purchasing schedule by the unit material costs. The purchasing schedule is the sum of the scheduled receipts, firm planned orders, and planned orders receipts for purchased items. To develop a projection for purchased material, this purchasing schedule would be adjusted by the payables cycle.

Capacity requirements planning can be used to project the direct labor payroll expense, including overtime, and to calculate variable overhead expenses such as cost of electricity, cost of natural gas etc.

The inflow of cash, i.e. cash receipts, can be projected using the master scheduling system. Projected shipments would be extended by the selling price to give projected billings. The dates of these billings would be adjusted by the receivables cycle to get a cash receipt projection.

11.3 PROVIDE A TOOL FOR ALLOCATING FIXED OVERHEAD EXPENSE:

Financial interface module should help in allocating overhead cost and tracing it back to the items that caused it. For example, the cost of a highly specialized machining center and the engineers that can and should be traced back to the items produced on the machines. The cost of a paced assembly line should be divided among the assemblies built on the line. And the cost of a special powder paint area should be allocated to the items painted in the area.

The financial interface module should provide a way to allocate fixed overhead more accurately. This can be done by prorating the fixed overhead expense based on the capacity requirements plan for a machining center, work center, department, etc. By extracting the capacity requirement from the capacity requirements planning system and summarizing them by item, it is possible to determine the overhead being absorbed by each item. The capacity requirements plan includes the item, operation numbers, and hours required, in the machining center, work center, department, etc. It also includes the total labor or machine hours required by machine center, work center, department, etc. By totalling the hours for each item and operation, and then dividing by the total labor or machine hours, it is possible to see the percentage of the fixed overhead absorbed for each item going through the area.

12.0 **DISTRIBUTION REQUIREMENTS PLANNING**

Distribution resource planning (DRP) is used for scheduling all of the resources necessary to obtain, to handle, to move, and to store material throughout the entire distribution network and to intermesh the distribution networks stock requirements with the schedules of manufacturing and/or vendor sources.

The objectives of DRP are:

1. To establish or to improve the integration between a firm's distribution function and its manufacturing source of supply.

2. To enable a firm to effectively manage its entire function including not only inventory, but also transportation, warehousing, and people.

DRP allows visibility into entire distribution network. It allows the central facility to see the actual demands for products that will be needed at distribution centers.

DRP also provides an accurate picture of the transportation loading and scheduling needed to support the distribution schedule. Using the projection of transportation requirements by volume, weight and number of pallets, and the tools of MRP, a transportation planner can do a more effective job of truck and freight car loading.

The functional requirements for DRP are the following:

1. Provide a method for developing distribution or interplant requirements and for posting them to the master production schedule at the supply facility.

2. Maintain the distribution information on scheduled receipts that are in transit to branch warehouses or branch plants.

3. Generate and display the transportation plan.

Flow diagram explaining distribution requirement planning is explained in fig. 12.1.

12.1 DISTRIBUTION REQUIREMENTS PLANNING COMPUTATION:

Distribution resource planning starts by running MRP for all the items at all the distribution centers or receiving plants. For the distribution centers, MRP is run using the forecast and any customer orders that are promised for future delivery as gross requirements. For the receiving plants, the master production schedule would be the source of requirements for component items. In either case, the normal MRP logic nets these requirements against the on hand balance, safety stock, and any scheduled receipts (in-transit orders on the way to this branch warehouse or

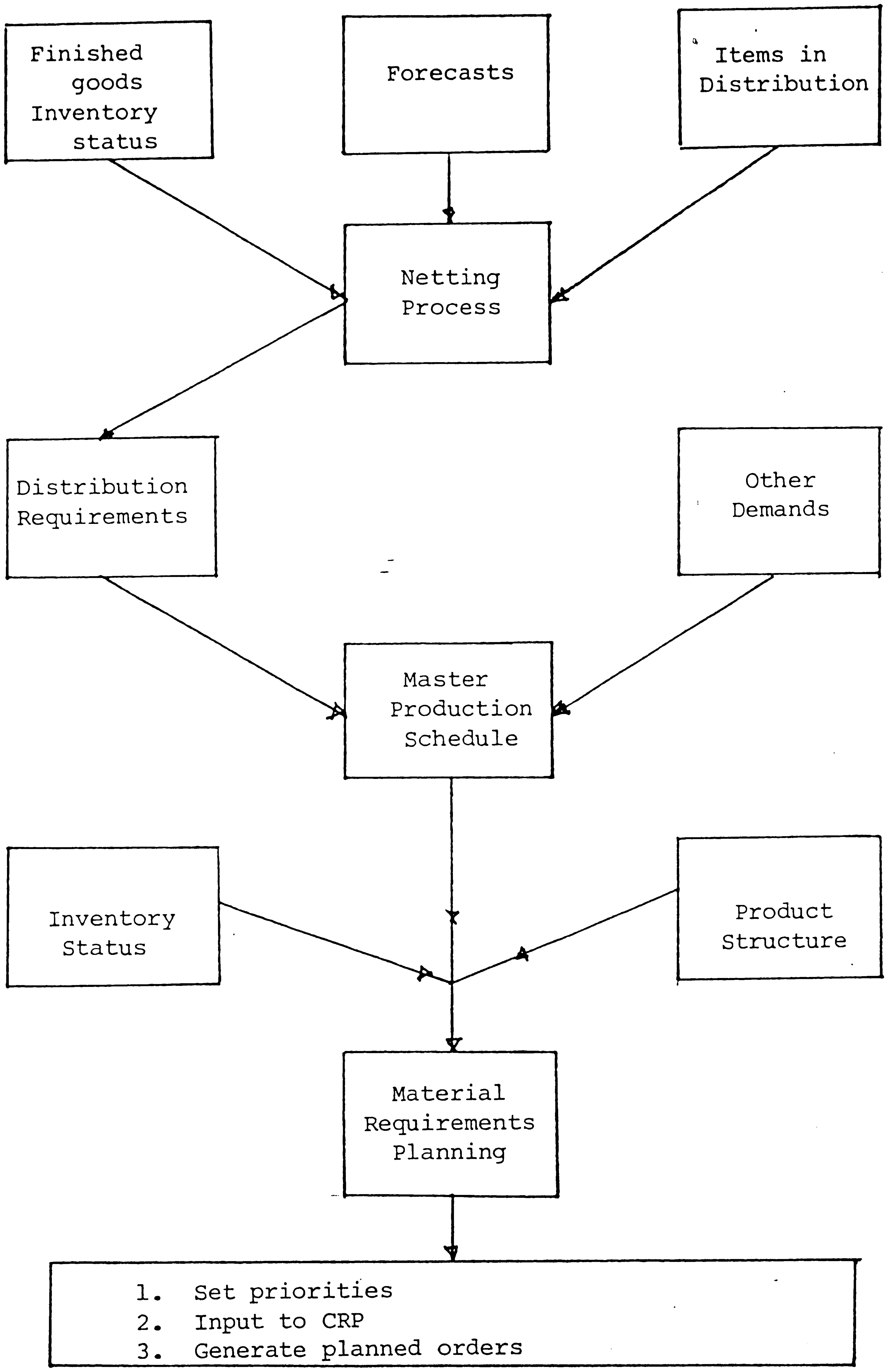


Figure 12.1
Distribution Requirements Planning

receiving plant). Planned orders are created to cover the remaining gross requirements. These planned orders will be supplied by the central facility, and so they are exploded and appear in the master schedule report for the central facility as a one kind of demand.

12.2 MAINTAIN DISTRIBUTION SCHEDULE RECEIPT THAT ARE IN TRANSIT:

In a distribution or multi-plant enviornment, it is necessary to show the material that is in transit to the MRP system. This material is scheduled receipt for the receiving location. The system that maintains these scheduled receipts functions much like the system that maintains manufacturing scheduled receipts. When a movement is created to ship material from the central facility to a distribution center or receiving plant, the items in the central facility are allocated to the shipment and a scheduled receipt is created at the receiving location. When the items are shipped from the central facility, the on-hand balance and the allocation are reduced. When the items are received at the branch warehouse or receiving plant, the scheduled receipt is reduced and the on-hand balance is increased. This same process can also be used when items are shipped from one warehouse to another.

While the system for items that are in transit is similar to the manufacturing scheduled receipts system, there are also some differences. The most fundamental difference is that items which are in transit require that shipment information be stored for the movement. In addition to the movement number, item number, quantity, and date, this information includes things like the shipper, means of shipment, freight cost, value of the shipment, insurance, and an indication of what is in transit and what has not been shipped. For this reason, many times a separate system is used to maintain the information on items that are in transit. Other items, the scheduled receipts system for manufacturing item is modified to allow this type of information to be stored.

12.3 GENERATE AND DISPLAY TRANSPORTATION PLAN:

Accurate transportation scheduling and loading, is a necessacity if a distribution network is to be managed effectively.

Transportation planning is a way to plan the weight, volume, and number of pallets to be shipped based on the distribution resource plan. Transportation planning simulates these transportation requirements for the purpose of taking advantage of freight rates. By simulating the transportation requirements, a company can see which periods have less than full truckloads or railcars. By adjusting the shipping schedule to ship full truckloads, at the greatest possible weight, a transportation planner can take advantage of the best rates, and as a result minimize freight costs. And the products that must be shipped early can be determined well in advance, rather than left to chance.

The logic of transportation planning is similar to that capacity requirements planning. In capacity requirements planning, the planned orders are extracted from MRP and extended by the standard hours for each operation in the routing. The capacity requirements are then summarized and displayed for each work center and time period.

In transportation planning, the planned orders for the distribution centers or receiving plants are extracted from DRP and extended by the product weight, package volume, and the quantity of the product that will fit on a pallet or a container. These transportation requirements are scheduled for the start date of each planned order. After the transportation requirements have been generated, they are summarized and displayed by time period.

A transportation planning report displays the weight, and number of pallets required to ship to each distribution center in each week. Using this report, a distribution planner can see into the DRP system, anticipate problem in loading, and solve them while there is still time enough to ship the right products.

13.0 CONCLUSION

With the proliferation of software vendors and the exacting needs of the business, understanding of the business needs and in particular the manufacturing needs should be evaluated prior to the evaluation of manufacturing resource planning software.

Defining functional specification helps the organization in evaluating the present nature of the operation and future needs of the manufacturing. Selected software should at least help in conducting the existing operation of business but should also be able to incorporate the future needs.

Specifically, in each area MRP II should be able to conduct following activities.

Master production scheduling, software should be able to carry out two-level master scheduling and easily incorporate changes in master production schedule. The master production schedule should be able to highlight the problems, if any, related to vendors, capacity, or material limitations, and help the scheduler in seeking solutions, not by simply changing the master schedule without informing the scheduler. Exception message should allow the master scheduler to go directly to the items that require evaluation.

Material requirements planning, module should perform accurately MRP logic and replan net requirements and its coverage over the entire product structure as a result of changes in either the MPS, or inventory status, or product structure.

The three principal functions that the module can provide is to set the priorities, provide input to the capacity requirements planning module for the load calculations using the manufacturing orders generated by planned orders release and develop appropriate ordering schedules using the purchase orders from the planned order release.

Pegging ability in this module is highly useful in tracing the origin of the demand. Firm planned order capability should allow the module to freeze the quantity and/or timing of a planned order release.

Bill of Material, module should provide the capability to maintain and store parent-component relationship. It should be able to generate low-level coding for components having multiple-levels associated with it. It should be able to update gross requirements when bill of materials are changed and assist in implementing engineering changes using the concept of effectivity.

Shop Floor Control, module should be able to identify specific work centers that are or will be overloaded, execute the plan on the shop floor as well as they should, monitor the execution of the capacity plan.

Capacity Requirements Planning, should show the capacity picture for a work center and identify problems related to the capacity and present them to the planner.

Purchasing, module should be able to function as a vendor scheduling tool, should be effective in controlling purchase order, and should track the performance of the vendor-item specific.

Performance measurement, module should identify and assist in prioritizing problems so they can be solved, provide a standard so the company-wide performance can be compared, and provide a score-card for monitoring performance.

Accounting interface, module should track various cost components (fixed, variable, and overhead), should track various variances (raw material, direct labor, vendor delivery, etc.), should be able to provide input to the budgeting process, and generate reports for the management.

Financial Planning interface, module should provide a way to certain kinds of financial data such as inventory investment, WIP investment, human resource investment, etc., organize the data and present it to the people who can use it in their financial planning. It should provide detailed and accurate information on cash disbursment for material, direct labor, and overhead, and cash receipts.

Distribution Requirements planning, module should provide a method for developing distribution or interplant requirements, should maintain the distribution information on scheduled receipts that are in transit, and generate and display the transportation plan.

In addition to this modules some additional modules may be required and the needs for them should be evaluated based on the nature of the operation.

LIST OF REFERENCES

[1] Benson, R. J., Can purchasing supply tomorrow's factory?, APICS conference proceedings, 1981, pp. 305-359.

[2] Hanson, S.R., The standard cost accounting interface, APICS conference proceedings, 1983, pp. 442-446.

[3] Buker, D.W., Performance measurement, APICS conference proceedings, 1981, pp. 157-160.

[4] Edson, N.W., Measuring MRP system effectiveness, APICS conference proceedings, 1981, pp. 315-318.

[5] Shachter, H.I., How to select manufacturing software package, APICS conference proceedings, 1982, pp. 497-499.

[6] Cook, M.E., How to evaluate software packages, APICS conference proceedings, 1981, pp. 126-130.

[7] Paul, H.J., Micro MRP-II for small manufacturing companies,APICS conference proceedings, 1983, pp. 131-134.

[8] Pennente, E.A., Manufacturing, MRP and microcomputers, APICS conference proceedings, 1983, pp. 146-150.

[9] Rowan, R.T., Wellendorf, J.A., Implementing manufacturing control software package in a process

industry, APICS conference proceedings, 1980, pp. 81-84.

[10] Everdell, R., Planning bills of material: tools for master scheduling, APICS conference proceedings, 1983, pp. 265-268.

[11] Ford, Q., Distribution requirements planning and MRP, APICS conference proceedings, 1981, pp. 275-278.

[12] Perry, W., Distribution resource planning: key to successful MRP II, APICS conference proceedigns, 1983, pp. 44-46.

[13] Brace, J.F., Taylor, G.L., The demise of traditional cost accounting, APICS, conference proceedings, 1980, pp. 306-307.

[14] Wallace, T., Mrp II: Making it happen, Oliver Wight Ltd. Publications, Inc., 1985.

[15] Orlicky, J., Material Requirements planning, Mc Graw Hill Book Co., 1975.

[16] Sepehri, M., Newest manufacturing software packages offer modules which meet specialized needs, Industrial Engineering, Oct. 1985, pp. 28-43.

[17] Editor, MRP II, and JIT combat waste in manufaturing, Modern materials handling, June 1985, pp. 70-73.

[18] Goddard, W., A corporate game plan for productivity, Production Engineering, May 1984, pp. 70-75.

[19] Proud, J., Controlling the master schedule, Production and Inventory management Review and APICS News, Second Quarter, 1981, pp. 78-90.

[20] Thompson, K., MRP II in the repetitive manufacturing enviornment, Production and Inventory management Review and APICS news, Fourth Quarter, 1983, pp.1-13.

[21] Hass, R.J., Evaluation and selection of manufacturing software- User's experience, Production and Inventory management and APICS news, third quarter, 1981, pp. 70-77.

[22] Clark, S., Cox, J., Jesse, R., and Zmund, R., How to evaluate your material requirements planning system, Production and Inventory management Review and APICS news, 1982, pp. 15-19.

[23] Heard, E., MRP software- cart or horse?, Production and inventory management Review and APICS news, 1981, 1(6), pp. 24-34.

[24] Wight, O.W., Production and inventory management in the computer age, Cahners Publication Co., Inc., 1974.

[25] Davenport, F., <u>Financial management through MRP</u>, Production and Inventory management Review and APICS news, second quarter, 1983, pp. 63-70.