THE IMPACT OF MRP ON A TRADITIONAL MANUFACTURING COMPANY

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ABSTRACT

Manufacturing systems are extremely complex and differ from most other business systems. They operate in a dynamic environment where real time changes in requirements, priorities and plans force revisions to information relationships. Moreover, those systems deal with decision-making processes combining rigorous procedures and management judgement and several functional disciplines having different and often conflicting objectives.

Modern manufacturing systems are linked to the goals and strategies of the business and are designed and implemented to support those goals and strategies. The main objective of a successful manufacturing system should be to manage the entire flow of materials (from suppliers to customers) as a single unit in order to reconcile functional objectives, optimize inventories and integrate functional systems.

Research has shown that the costs to design and implement a successful manufacturing system are about the same as those for an unsuccessful systems, but the ROIs differ significantly. MRP is normally where many companies decide to start the implementation of their manufacturing and control systems.

This thesis reviews the important relationships between the manufacturing systems and the company's overall strategy. It discusses the key issues involved in the design and implementation of manufacturing and control systems, focusing on the implementation of MRP. In the last section of the thesis a case study is presented about a company which is currently implementing a MRP II system. This section reviews all the changes this company has gone through during the past two years in preparation for the new system. It also applies the framework developed in sections I and II to the company's implementation process to identify problem areas.

Thesis Supervisor : Professor Charles H. Fine
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TABLE OF CONTENTS

CHAPTER I - MANUFACTURING PLANNING AND CONTROL SYSTEMS [1]

1. What is a System

A system is a set of procedures, policies and tools which are defined in support of objectives to be achieved. A planning and control system in a manufacturing company deals with all the activities from the acquisition of raw materials to the delivery of the final product to the customer. In this case the final objective is the delivery of the right product, at the right quality, to the right customer at the right time. A set of procedures, policies and tools are put in place to assure that this objective is achieved.

2. The Link Between Systems Design and Company's Overall Strategy

A firm's business mission is the foundation on which all business planning is based; it specifies where and how the firm will compete. Where a firm will compete is specified in terms of products and markets. How a firm will compete with other firms offering similar products to the same markets is specified by a chosen leadership strategy. The two alternate leadership strategies are lowest delivered cost and differentiated product.

In any firm, systems should be designed and implemented to support the firm's business mission. It is therefore necessary for the firm to have its strategy well defined before any effort is put into the design of systems that should support this strategy. Moreover, special consideration should be given to ensure that such systems be flexible enough to accommodate the business long-term needs and learning. To ensure that systems are designed for the needs of the business, it is important that management focus on long-term direction and business strategy during the systems' conceptualization stage.

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[1] This chapter was based on internal notes of Booz Allen & Hamilton.

3. Operations Strategy

Operations strategies will be essential to ensure a competitive advantage in the future world markets. The firm's operations strategy establishes the mission and specific manufacturing objectives for product segments to guide long-term productivity gains. It also provides a framework for decisions regarding investment in new plant and equipment, degree of vertical integration and facility expansion and consolidation. Moreover, an operations strategy guides the firm in its choice of manufacturing systems and controls, manufacturing and distribution organization and technology.

Once the firm's operations strategy is defined, a manufacturing technology scan should be undertaken to determine the investment necessary to support the established manufacturing mission. Moreover, a manufacturing systems strategy should also be developed to ensure the relative contribution to the firm's value-added streams as the new technology is implemented.

4. Manufacturing Systems

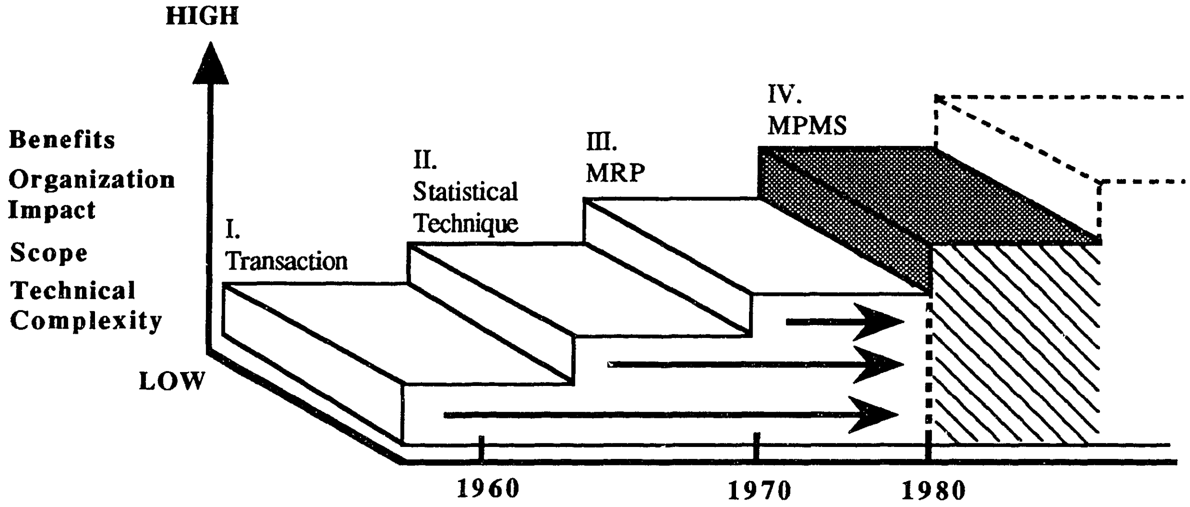
Manufacturing systems are extremely complex and differ from most other business systems. Those systems deal with decision-making processes combining rigorous procedures and management judgement and several functional disciplines having different and often conflicting objectives. Moreover, manufacturing systems operate in a dynamic environment where "real time" changes in requirements, priorities and plans force revisions to information relationships. Finally, such systems involve tightly integrated and interdependent information flows with critical accuracy requirements, large amounts of data, numerous transaction types and formidable processing requirements.

Successfully implemented manufacturing systems have played a significant role in increasing a firm's productivity, profitability and competitiveness. Modern manufacturing systems are linked to the goals and strategies of the business and are designed and implemented to support those goals and strategies.

5. Evolution of Manufacturing Systems

MANUFACTURING PLANNING AND CONTROL SYSTEMS

STAGES OF DEVELOPMENT



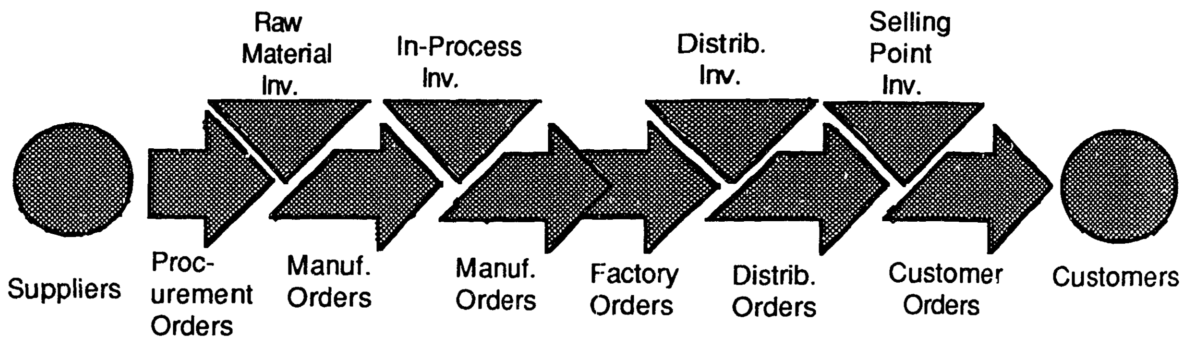
Stage I - Transaction : The transaction staged focused on automating records and reports and viewed the computer as a powerful calculator and typewriter.

Stage II - Statistical Technique : The statistical technique stage was devoted to the development of broader applications, frequently using statistical and other quantitative methods.

Stage III - MRP : The materials requirements planning (MRP) stage produced a major expansion in materials management systems and functions.

Stage IV - MPMS : In its broadest context, a manufacturing productivity management system bridge the gap between manufacturing strategies, day-to-day manufacturing management and financial accountability

6. Supply Chain Management



Manufacturing management is tied to the flow of materials and the set of process activities that transforms the products. This flow of materials, from suppliers to customers can be referred to as supply chain. A flow of materials occurs in any production or logistics process that produces raw materials or components, creates products for selling and moves them to customers. An entire spectrum of interrelated management problems arises in the overall flow, and systems must be created to deal with these problems on a routine basis. Furthermore, an accurate database is required to use the systems for routine decision making.

Traditionally the supply chain has been segmented organizationally and strategies and policies have been therefore largely within the organizational span of control. Consequently the supporting systems have tended to follow the organizational segmentation. The system emphasis has been on vertical integration by segment not on horizontal integration across the chain. The objective of a successful manufacturing planning and control system should be instead, to manage the total supply chain as a single unity in order to reconcile functional objectives, optimize inventories and integrate functional systems. I will from now on refer to such a system as a MPM system (Manufacturing Productivity Management).

A MPM system can be viewed a tool for better planning throughout the company. It is a closed loop system that ties marketing, engineering, production, materials, and distribution databases to financial and cost systems. Such a system will be a computer model of the business and a toll to determine the most profitable trade-offs in a changing environment. A MPM system allows the firm's operations to be accurately measured against plan and when successfully implemented is a flexible guide to day-to-day operations management.

MPMS should not be considered, however, as a surrogate for an organization that reflects the business strategy. The system will definitely not be a substitute for management judgement and decision making nor a compensation for poor market or materials forecasts. Finally, MPM system is also not to be viewed as a substitute for sound personnel policies and procedures.

There will be a significant difference in the benefits achieved and bottom -line impact between those who use manufacturing systems effectively and those who do not. Manufacturers that use a MPMS effectively can be the big winners in the 1990's - those that do not may not survive the competitive pressure.

7. The Supply Chain Architecture

The figure above is divided into three parts. The top third or 'Strategic' level is the set of activities and systems for overall direction setting. This phase establishes the firm's mission and competitive strategy. The middle third is the 'Tactical' level and includes forecasting, demand planning, supply planning and manufacturing resource planning.

Supply planning includes issues related to procurement, production and distribution planning. All activities of the business that place demands on manufacturing capacity are coordinated in demand planning. Forecasting is responsible for both short and long-term product requirements forecast.

Production planning is that activity which provides the production input to the company game plan and determines the manufacturing role in the agreed-upon strategic plan. The master production schedule is the disaggregated version of the production plan. That is, the master production schedule is a statement to manufacturing of which end items or product options are to be built in the future.

The master production schedule feeds directly into materials requirements planning (MRP). MRP determines (explodes) the period-by-period (time-phased) plans for all component parts and raw materials required to produce all the products in the master production schedule. This material plan can thereafter be utilized in the detailed capacity planning systems to compute labor or machine center capacity required to manufacture all the component parts.

The bottom third or 'Operational' level depicts the execution systems. Shop floor control systems establish priorities for all shop orders at each work center so that orders can be properly scheduled. Purchasing systems provide detailed information for vendor scheduling. This information relates to existing purchase orders as well as to planned purchase orders.

8. Benefits of a MPM System

A successfully implemented MPM system has a positive impact on the firm's bottom line by substantially raising its productivity and helping it gain important competitive advantages. While many companies have tried to realize these benefits, relatively few have succeeded. Research has shown that the costs to design and implement a successful manufacturing system are about the same as that for an unsuccessful system, but the ROIs differ dramatically. Japanese companies are most often successful while American companies are frequently disappointed with the results achieved.

Japanese travel worldwide extensively to investigate similar leading-edge systems before attempting to implement manufacturing systems. The process used in Japan to achieve consensus with respect to system design and its fit with the organization strategy is time consuming but the process foster understanding and commitment to the system and generally will ensure trouble free and fast implementation.

Moreover, Japanese firms generally achieve superior performance with manufacturing system by focusing on all the key areas of the company. Personnel transfers between the several business functions are used to teach employees the business operations and company philosophy therefore simplifying functional systems integration and allowing day-to-day scheduling of the workforce. In the United States however, companies often look at manufacturing systems as having an impact only on this specific area and overlook its impact on the rest of the company.

Japanese industry and universities are now working to combine Kanban and MRP techniques for wider applicability.

The benefits included in the MPMS stage include improved management decisions which are based on more sound information, simulation and 'what-if' capabilities. Systems such as MRP II allows management to study the trade-offs between demand, capacity, cost and profit. An adequate use of those systems brings a further improvement in customer service, inventory control and production distribution. Assets are therefore better utilized and purchasing decisions are significantly improved.

Manufacturing companies can normally be put into the following categories according to their use of systems:

Unsuccessful - All shapes and sizes of systems (manual through integrated data). Senior management lacks understanding of systems and the commitment to utilize them as business tools. Organizations are not tuned to manage materials or balance objectives. Responsibility for objectives are not assigned and/or not tracked. Mistrust of systems and lack of data accuracy exists at all levels. Inventory performance ranges from poor to out of control.

Uninitiated - Largely have manual systems and use "rule of thumb" techniques. The responsibility for materials is fragmented and usually at low levels in the organization. Those companies generally achieve few improvements in inventory performance.

Aware but Wary - Those companies have some integrated computer systems and have developed some analytical tools. They have also combined some materials management functions at middle management level. Inventory performance is improving and performance would be worse if present systems were not installed.

Comers - Those companies have extensive and generally integrated computer systems. They have developed several analytical tools. Materials management functions are unified at the senior executive level. Responsibilities are clearly assigned for performance objectives. Most companies in this category experience significant inventory improvements and rank among industry leaders in the management of materials, production and distribution.

Successful - Those companies have extensive on-line integrated databases systems. Systems have simulation, query and "what if" capabilities. Senior management uses system to balance customer, production and profit priorities in changing business conditions. Companies in this category have modified materials, production and distribution organization and systems to support business strategies. Most of them are achieving major inventory improvements and excellent return on investments and have formal systems updating programs to reflect changing business goals and conditions.

9. Critical Steps in Systems Design

The following section describes the steps involved in the design process from inception to conception.

Success Factors : The first step in the system design process involves the identification of the key success factors necessary for the company to achieve the goals and objectives of the 1990's: improved manufacturing productivity and flexibility, product competitiveness, improved customer service, production and distribution resource deployment, supporting infrastructure, lower costs.

Operations Strategy : An important step is the development of an operations strategy that relates the manufacturing function to the goals and objectives of the company as a whole. The development of a business strategy should take into consideration the environment the company operates in, including its competition and product and market characteristics. Furthermore, an appropriate manufacturing response should be established to the goals and objectives of the agreed upon operations strategy.

Technological Requirements : The following step should be to determine the technologies required to support the manufacturing mission. This should include, for example, the firm's productivity goals, competitive success requirements, capacity shortfall and the product volume requirements.

Current Systems : A fifth step should be to diagnose the current manufacturing systems. Those systems should be evaluated by measuring the current system performance against the established objectives for the company's operations. Adequacy of the current systems to those objectives should also be addressed. Potential for growth and heightened effectiveness should be studied to identify the gaps between the current systems capabilities and the manufacturing mission requirements. The necessary investment to fill out those gaps should be evaluated.

System Conceptualization : The next step would be to conceptualize the type and sophistication of the system needed to successfully integrate manufacturing systems and the new technology. The system's overall architecture and functional scope along with its required performance levels and feedback mechanism should be defined during this stage.

Migration Path : The following step should be to chart the migration path of the current systems to the ideal manufacturing productivity management systems. Implementation priorities should be established, measurable "pay as you go" benefits should be defined and their likely impact on the organization should be assessed.

System Implementation : Only then a development team should be organized including end users, supporting specialists and a project manager who should be dedicated full time to the project.

10. The Implementation Stage

The organization and its people should be prepared for the installation of the new technology and the manufacturing planning and control system. The transformation of the organization must begin with its leaders, who must first internalize the desired transformation, and then lead, by example, the way to a new way of life. Without a strong visible commitment by top management, demonstrated by their actions, as well as their words, the implementation of the new system will most certainly fail. During the implementation stage it is very important that new procedures and policies be established. Furthermore, conflicting functional objectives should be resolved and objectives should be assigned and tracked.

Moreover, it is important that basic reporting and record accuracy disciplines be instituted to support the systems being implemented. Databases and files have to be built or cleaned up prior to implementation. A successful implementation will also involve realistic and agreed-upon schedules and milestones. Finally, an ongoing update programme should be established to reflect changing business needs.

Management issues during the implementation process involve direction and support. Senior management of the firm should provide direction and be involved throughout the project. Functional management should design the conceptual system along with EDP, define its goals and the objectives and accept full accountability. Finally, first-line management should implement the system and provide feedback on operating problems.

Personnel issues involve education, training and motivation. Programs should be established to explain to employees the planned changes and the new procedures to ensure the active intelligent cooperation of the people affected by the system. It is also very important that incentives be revised to reward key managers for adopting the new system and for achieving integrated heightened objectives.

Profile of systems development and implementation costs:

Systems Design, Programming, Debugging	56%
Special Hardware/Software	30%
Education, Training, Installation	14%

11. Functional Conflicts

To be successful in the future competitive environment companies will have to balance conflicting functional objectives through organizational, policy and procedural changes. The several functions of an organization have different objectives which will or will not translate in a positive impact in the desired overall business strategy. Manufacturing, for example, is interested in long runs and a stable schedule which although having a positive impact on the manufacturing costs (which is an overall objective) will also have a negative impact on customer service and inventory investment. Marketing on the other side is interested in flexibility and product availability. Those objectives will normally be translated into a high inventory investment, good customer service (which is an overall objective) and a high manufacturing cost. Finance might be interested in low investment by keeping inventories low.

It is the management function to design policies and procedures to balance the above conflicting objectives and achieve the overall business strategy.

12. Future Developments

The importance of manufacturing systems evolution and expansion will increase during 1990's and will be aided by a number of elements including advancements in technology, industry specialized products, distributed information processing and integrated application software.

The continued technology gains and a turbulent economic and competitive climate will spur the incentives to install a new generation of manufacturing systems to support the new technologies. A high commitment to the implementation of such systems will differentiate the successful of the unsuccessful. Companies which are successful in this process experience substantial improvements in their productivity, product quality, product design, materials management, asset utilization, cost control and profitability. Unsuccessful ones are likely not be able to compete in this future environment.

A further integration between engineering and manufacturing with the use of computer-aided manufacturing will provide companies with an integration between the design and manufacturing databases with all the befits associated with it. Databases will include both geometric and alpha data. Data management and data protection will be greatly facilitated by new technologies. Benefits of this will include improved engineering change control, automated design through machining process, efficient production control and greater project control.

This integration of manufacturing systems with new technology for design and manufacturing processes is complex and is likely to face many obstacles. Organization conflicts and labor uneasiness will often occur because of the dramatic changes involved. A large and prolonged capital outlay will require a firm management commitment in the process. Finally, a lack of technical and programming skills will certainly affect most organizations.

In summary, the application of new technologies to the manufacturing process and manufacturing systems will make the job more complex but will bring greater returns for companies which are able to successfully adapt themselves to the new environment.

13. MRP in a MPMS

MRP is normally where many companies decide to start the implementation of their MPM system. MRP plays a central role in a MPM system, since it provides the link between the 'Strategic' part of this system and its 'Operational' level. MRP translates the company's production plan in the detailed steps necessary to accomplish this plan. It provides the necessary information back to the 'Tactical' level for the development of capacity plans and procurement requirements plan. I will in the next section describe in detail a manufacturing requirements planning system and the steps involved in the implementation of such a system.

CHAPTER II - MANUFACTURING REQUIREMENTS PLANNING

1 INTRODUCTION

MRP II has been defined in many different ways by many different people. Some of them seem more appropriate than others and tend to show what this system really implies for the now many companies that have adopted it. Thomas Wallace called it "a management system based on network scheduling" or "organized common sense". [2] MRP II can be viewed as a management philosophy - a new way of running a manufacturing company.

MRP II was first invented in the 1960's as Material Requirements Planning. At that time, researchers were looking for a better way for ordering material and parts and schedule the product flow through the shop. Its basic logic is based on the answers to the following four questions: [3]

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

MRP's main parts are the master production schedule (What are we going to make?), the bill of materials (What does it take to make it?) and inventory records (What do we have?). It uses this information to calculate the company's future requirements (What do we have to get?).

As Thomas Wallace puts it, MRP was a breakthrough, since for the first time ever in manufacturing, there was a formal mechanism for keeping priorities valid in a changing manufacturing environment. [4] Moreover, besides addressing the important issue of priorities, MRP also helps solve the other half

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[2] Thomas Wallace, MRP II: Making it Happen. The Implementers' Guide to Success with Manufacturing Resource Planning, Oliver Wight Limited Publications, 1985, p. 3.

[3] Wallace, p. 5.

[4] Wallace, p. 5.

of the manufacturing equation, dealing with the capacity issues. The development of systems to execute shop floor control and vendor scheduling resulted in the closed loop MRP. The main characteristics of a closed loop MRP are: [5]

- It is a series of functions, not merely Material Requirements Planning

- It contains tools to address both priority and capacity, and to support both planning and execution

- It has provisions for feedback from the execution functions back into the planning functions

The latest development in the evolution of MRP is called Manufacturing Resource Planning or MRP II. Two elements were added to the basic MRP, finance (the ability to 'translate' the operating plan into financial terms) and simulation (the ability to ask 'what if' questions).

MRP II is a vehicle to get valid plans and schedules, not only of materials and parts and production. It also means valid schedules of shipment to customers, of manpower and machine requirements, of required engineering resources, of cash flow and profit.

2. IMPLEMENTATION

According to Oliver Wight, companies that have been already implemented MRP can be classified as following : [6]

Class A : Uses the system to manage the business with outstanding results

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[5] Wallace, p. 7.

[6] Oliver W. Wight, MRP II: Unlocking America's Productivity Potential, Oliver Wight Limited Publications, 1981, pp. 453-454.

Class B : Uses the system to schedule and load, primarily in manufacturing and materials with very good results

Class C : Uses the system to order primarily in the production & inventory control department with fair to good results

Class D : The systems "works" in data processing, but nowhere else and is considered another computer failure.

Research has shown that the resources allocated to the MRP implementation process by companies classified as A,B,C or D are approximately the same. What then differentiate the results obtained? The answer to this question is the way such a complex system was implemented throughout the organization. Although details of how to successfully implement MRP (or how to become a class A company) may vary depending on the kind of company, the kind of product, etc, the main steps and issues involved in such implementation are the same for all the organizations.

Several important characteristics of the environment that a successful MRP systems operates in have to be thoroughly understood by the top management of a company before it attempts to implement such a system. Indeed many of those attempts have ended in disappointment or utter frustration. Common underlying reasons why MRP systems fail are inadequate training and lack of top management commitment to a company-wide effort. The lack of understanding of issues as the ones described bellow have also been frequently cited as the reason for the disappointing results obtained by companies in class D. [7]

- **MRP should be considered as a people system.** MRP is commonly misperceived as another computer system. Companies (especially management) should view MRP instead as a people system made possible by the computer. As Ollie Wight puts it "If you consider MRP II as a computer system to order parts, what you'll

[7] Wallace, pp. 14-15.

probably wind up with is a computer system to order parts. On the other hand, if you look upon MRP II as a set of tools with which to run the business far more effectively, and if you implement it correctly, that's exactly what you get". Since it is people who actually take the decisions and run the business, MRP II should be viewed as a people system.

- **MRP is a business system.** MRP involves every department within the company and not only manufacturing, or materials or distribution. Moreover, the system provides a link which is so often missing among those departments and when successfully implemented will help integrate the several functional areas of a company.

- **MRP is a new way of life.** The system requires a new set of values. Most companies implementing MRP II must undergo massive behavior change to be successful. It requires people to do their jobs differently.

Implementing MRP II successfully involves two major elements, an aggressive implementation schedule, supported by a massive mobilization of the company's resources and full top management commitment and set of steps already undertaken by many companies in class A to ensure a successful implementation.

2.1 Implementation Time

It is very difficult to implement MRP in less than a year, because of the number of changes involved in such an implementation. On the other hand, it should not take the company more than two years. By taking too long the company will not be able to maintain the enthusiasm of the people running the business for the project. It will also be hard to keep the implementation of MRP as a top priority in the company for three or four years. Moreover, during a longer time to implement the system the company is likely to face problems as a promotion of the manager in charge for that implementation or changes in the market environment the company operates (a market decline can cause the company to take resources out of the project, for example).

2.2 Implementation Steps [8]

First Cut Education - Top managers of the company must learn about MRP and what is involved in its implementation. They must learn the differences between being a Class A company and being a Class D company.

Cost Justification and Commitment - Benefits, both tangible and intangible, should be listed down on paper to arouse commitment in a way of measurement the success of the system in the future. It is important to have top managers understand the reason to commit to MRP as a company.

User-Controlled Project Team - Each element of MRP II must be implemented by the same people who will be held accountable for operating it in the future. The project team should be made primarily of users.

Full-Time Project Leader - A person who is fully knowledgeable of the company's operations should be assigned to the project full-time.

Executive Steering Committee - The entire implementation process should be led by the Steering Committee, which should be composed by the top management of the company.

Professional Guidance - The implementation team should be in constant contact with an external consultant. It is important that this person have been involved previously in a MRP implementation process in a company that could be classified as a Class A company.

Education of Critical Mass - At least 80% of all the people in the company need to receive education on MRP II prior to implementation.

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[8] Wallace, pp. 20-22.

Pilot Approach to MRP - The company should prove that master production scheduling and material requirements planning are working satisfactorily on a pilot group of products, before cutting over all products and parts.

Close the Loop - After the pilot is successfully tested, the implementation team should tie in the executions systems - shop floor control, vendor scheduling, etc. into the planning systems

Finance and Simulation - The final step on the implementation process should be the integration of the operational systems with the financial systems and the use the "what-if" capability.

Dedication to Continuing Improvement - It is not enough for a company to learn how to use MRP as a way of running its business. Companies should continue to work hard at making it better and better. Continuous improvements in the system should be a first priority.

2.3 Implementation Strategy

The implementation of MRP should be divided into three main phases, and within each phases a variety of individual tasks should be accomplished simultaneously.

Phase I is what is normally called the Basic MRP and includes Production Planning, Master Production Scheduling, Master Requirements Planning along with the support functions of Forecasting, Customer Order Entry, Inventory Accuracy, Bill of Material Accuracy and Structure plus Anticipated Delay reporting from the shop floor and purchasing. Basic MRP should be considered not as a stand-alone system but as a foundation for the subsequent phases.

Since top management is accountable for operating production planning, they must be the ones to implement it. In addition to its responsibility for leadership, resource allocation and breaking bottlenecks, the Steering Committee should also be responsible for implementing production planning .

Phase II is called closing the loop and involves Shop Floor Control, Capacity Requirements Planning and Input/Output Control for the factory, supported by routing accuracy and Vendor Scheduling for the "outside factories", i.e., the vendors.

Phase III involves tying in the financial system into the MRP II operational data base and activating the "what-if" capability of MRP II.

2.4 Key Issues in Implementing MRP

People - The key element in making MRP work properly is the people. If the people part of the implementation process is managed properly, then the people will understand the objectives and know how to get there. The question of how can the system help me do my job has to be answered to each employee. A time of user experimentation can be of immeasurable value to achieve this objective. If the system is well understood by the employees of the company they will take care of getting the data accurate and keeping it accurate.

Data Accuracy - The accuracy of the inventory records, bill of materials and routings is essential for success of a MRP system. This issue requires much of the company's overall attention and managerial emphasis.

Hardware and Software - Hardware and software issues are important, since MRP II can not be done manually, but it is of lesser significance overall than the other elements. The software is a tool for improving the processing efficiency of certain pieces of the formal system (which is assumed to exist prior to the installment). Installing the software without a clear understanding of the architecture of the formal system can only cause frustration and resistance.

3 EDUCATION

3.1 Objectives of the Training Process

Education for MRP II is seen as having two critically important objectives: [9]

- **Fact Transfer** - This takes place when people learn the "what's, why's and how's". It is essential, but by itself, it is not nearly enough.

- **Behavior Change** - This occurs when people who have lived in the world of the informal system become convinced of the need to do their jobs differently. It is when they truly understand why and how they should use a formal system as a team to run the business more professionally, and how the system will benefit them.

It therefore not difficult to imagine why it is so important to have top management on board and leading the task of educating people in MRP II. The new system induces several changes in the organization and many new procedures have to be established to assure a trouble-free implementation. New communications lines between the company's functional areas have to be created, detailed auditing procedures for information must be developed and new inventory control methods and engineering change notice procedures are required.

Many of the problems facing MRP implementation are behavioral due to a natural resistance to change on the part of the individuals. Doing education properly is synonymous of managing the process of behavior change. When this is accomplished the people involved will come to believe in a new set of tools, a new set of values and in a new way of managing a manufacturing company. Moreover, people acquire ownership of this new way of doing things. Executing the process of behavior change is a management issue, not a technical one. The result of the process, which is essential for any successful MRP implementation, are teams of people who believe in this new way to run

[9] Wallace, pp. 81-83.

the business, and who are prepared to change the way they do their jobs to make it happen.

3.2 Managing the Change Process [10]

Applying the Lewin-Schein concept of change, the process of managing the behavior change necessary for a successful MRP implementation involves three main stages: unfreezing, changing, refreezing.

Unfreezing - This stage relies on the theory that to learn something new, a person must first 'unlearn' old ideas or behaviors. The first step in this stage is to make individuals realize the need for the change. This can be accomplished by emphasizing the deficiencies of the old system as declining customer service, inventory imbalances, increasing product cost, unpredictable shipping performance, etc.

Top management of the company must go through this process before anyone else in the company and after that give clear indication what the new goals and objectives of the company are. Management leadership and support are especially important in the case of those individuals who are not directly affected by the inefficiencies of the old system and who might otherwise not see the need for change.

It is in this stage that the goals and objectives are established, a cost benefit analysis is done and the decision to implement the new system is made. A task force is organized and new procedures start to be established.

Changing - Once individuals recognize the need for change, the actual changing process starts. During this stage most of the emphasis is put on the technical side of MRP. The new software is installed, new and accurate Bill of Materials are designed, an accurate count of inventories is obtained, etc. There is a greater effort at user education on the principles of MRP. Attention should be especially paid to maintaining enthusiasm and momentum for the process.

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[10] Edna M. White, "Implementing an MRP System Using the Lewin-Schein Theory of Change, "Production and Inventory Management," First Quarter, 1980, pp. 1-11.

Top management in this stage must learn how to use the master production schedule to make decisions about future events. The change process that individuals go through while implementing MRP is further complicated by the fact that not only new procedures have to be learnt but jobs have to be redefined. With an MRP system, the amount of routine in lower management jobs is increased and autonomy is decreased. Individuals have to learn how to accept this new environment as a requirement for the company well being.

Refreezing - This stage is achieved when the system is operational and in use. Employees stop learning the changes and the system reaches a new stable state. If the change process was successfully managed, individuals will refreeze with new behaviors which integrate MRP with the organization. Only companies that reach this stage can be truly considered as Class A companies.

3.3 Key Elements in Managing the Behavior Change [11]

To successfully manage the behavior change necessary to create the organizational environment that suits MRP and utilizes its inherent strengths, certain six elements have necessarily to be present throughout the implementation process.

Management Leadership - The first element and perhaps the most important one in this process is active management leadership and participation in the education process. Change must cascade down the organization chart; it does not flow uphill. Moreover, if top management does not understand fully the concept of MRP, it might take decisions that will surely compromise the success of such a system.

Line Accountability - In order to make possible ownership and behavior change, the process of change must be managed and led by a key group of people who must be held accountable for the success of the change process (the success of MRP II at the operational level), they must know as a group how

[11] Wallace, pp. 83-91.

the business is being run today and they must have the authority to make changes in how the business is being run. Ideally, those people should be the department heads, the operating managers of the business.

Immersion - The key people involved in the process of implementation need an intensive, in-depth educational experience.

Coverage - Education has to be widespread because of the need for behavior change so widely throughout the company. The critical mass means 80% - minimum of all the people in the company. Total coverage means mandatory. Education for MRP II can be optional under only one condition - if success with MRP II is considered as optional. Education is a process with the objectives of behavior change, teamwork, ownership. The process cannot succeed with spotty, sporadic, random participation.

Continuing Reinforcement - A program is needed that occurs over an extended period of time. In this process of facilitating behavior change, two-way communications are essential. The essence of MRP II education is dialogue and it must be involving and reassuring.

4. DATA AND POLICIES

inaccuracy of the data base supporting material ordering has been often cited as one of the reasons for MRP failures. It is essential to build a solid foundation of highly accurate numbers before the master production scheduling and material requirements planning "go on the air". [12] Moreover, during the initial implementation phase, policies setting the ground rules and giving directions as to day-to-day activities have to be established.

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12 Wallace, pp. 111.

4.1 Data Management [13]

Data accuracy is essential for a MRP system to work since the figures in the computer must be right before they can be trusted and used throughout the company. Data for MRP II can be divided into two generai categories: forgiving and unforgiving. Forgiving data can be less precise. Unforgiving data has little margin for error and if not highly accurate can harm MRP II in a fatal way.

Examples of unforgiving data include inventory balances, schedule receipts, allocations, bills of materials, and routings (excluding standards). Forgiving data include lead times, order quantities, safety stocks, standards, demonstrated capacities and forecasts.

Inventory Balances - The inventory balances in the computer must be 95% accurate, at a minimum. This data is considered unforgiving important because it represents the starting point for materials requirements. Large amounts of incorrect recommendations coming out of MRP will result in a loss of confidence by the users, a return to using the hot list and a unsuccessful implementation of MRP II.

The cost of the control used to obtain such an accuracy should not exceed the cost of the inaccuracies. Moreover, the range of tolerances employed should reflect their impact on the company's ability to produce and ship on time. The way to achieve this level of accuracy involves some very basic management principles. Provide peopie with the right tools to do the job, teach the people how to use the tools and then hold them accountable for results.

1. A "zero defects" attitude - This is the "people" part of getting and maintaining inventory accuracy. Employees responsible for the stockroom should understand the importance of inventory accuracy and its impact on the success of MRP II (and therefore on the success of the company itself).

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13 Wallace, pp. 109-131.

2. Limited access - This is the "hardware part" of getting accuracy. In most cases, limited access means having the area physically secured. The primary reason to secure the stockroom is to keep accountability in. In order to hold the stockroom foreman accountable for inventory accuracy, the company must give him the necessary tools.

3. A good transaction system - This is the "software" part of the process. The system for recording inventory transactions and updating stock balances should be simple, and should represent reality.

4. Cycle counting - This is the mechanism through which a company gains and maintains inventory record accuracy. It has four main objectives:

   - To discover the causes of error: as soon as the causes are identified, they should be promptly corrected.

   - To measure results: Cycle counting should frequently generate accuracy percentages, so the people know whether the records are sufficiently accurate.

   - To correct inaccurate record: when a cycle count does not match the computer record, the item should be recounted.

   - To eliminate the annual physical inventory: this becomes practical after the 95% accuracy level has been reached on an item-to-item basis.

The 95% accuracy level is just the minimum number for running MRP II. The company should not be satisfied with less than 98% accuracy.

Schedules Receipts and Allocations - Schedule receipts can be either open shop orders or open purchase orders. They must be at least 95% accurate on both quantity and order due date. Typically, the company must review all schedule receipts to verify quantity and timing. Then, establish good order close-out procedures to keep "residual garbage" from building up in the schedule receipt files.

Allocations accuracy should also be at least 95% accurate. Allocations should not be a major problem to fix.

Bills of Materials - The accuracy target for bills of material is even higher than on inventory balances: 98% minimum, in terms of item number, unit of measure and quantity per parent item. An error in either of these elements will generate requirements incorrectly. To calculate the bill accuracy the company can use the tight method (where one incorrect relationship would imply in zero accuracy for that product BOM), the loose method (where only the incorrect relationship is considered inaccurate) and middle-of-the-road method (where the whole level which includes the wrong relationship is considered inaccurate). The last method is the one used more frequently to calculate BOM accuracy..

To achieve the 98% BOM accuracy the company has to take measures to both acquire this accuracy initially and then to monitor accuracy on an ongoing basis.

1. Floor audit: The company can put a number of engineers into the assembly and subassembly areas to compare what is actually being built to the bill of materials and correct errors as they are discovered.

2. Office/factory review: The company can form a team of engineers, foremen, material planners and cost people to review the bills jointly around a conference table.

3. Product Teardown: A finished product can be taken apart and its parts and pieces can be compared with the computer listing.

4. Unplanned issues/receipts: The reason behind those issues should be verified to assure that they have not been caused by an inaccurate BOM.

In addition to being accurate the Bill of Materials should be complete, properly structured and integrated. Bills should include everything involved in making the product. Moreover, the company should make an effort to have the various bill of materials integrated into a single, unified bill which serves the needs of all of the different departments.

Routings - The accuracy concerning the operations to be performed, their sequence, and the work centers at which they will be done have to be at least 98%. Standards, though, are forgiving and if they are good enough to calculate product costs, payroll and efficiencies they will be accurate enough for MRP II. Methods for auditing and correcting routings include floor audit and office/factory review as in the case of BOM accuracy.

4.2 Policies [14]

A number of key policy statements are required for the successful operation of Manufacturing Resource Planning. The basic ones are the ones which address production planning, master production scheduling, material planning and engineering change.

The **production planning policy** should address issues such as who is accountable, who attends the production planning meetings, who develops the data, frequency of the meetings, meeting content, guidelines for making changes to the production plan, product families, etc.

The **master production scheduling policy** needs to define the role of the master scheduler and other individuals involved, time fences, who is authorized to change the schedule, ground rules for promising customer orders, the fact that the MPS must match the production plan, allowable safety stock, feedback requirements from planners, feedback required to sales and marketing, performance measurements, etc.

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[14] Wallace, pp. 131-133.

The **material planning policy** should focus on guidelines for allowable order quantities, use of safe stock and safe time, where to use scrap and shrinkage factors, ground rules for lead time compression, feedback required from purchasing and plant, feedback to master scheduler, performance measurements, etc.

The **engineering change policy** should define the various categories of engineering change. Further, for each category, it needs to spell out who is responsible for initiating the change, who establishes effective dates, who implements and who monitors. Also included should be guidelines on new product introduction, communication between engineering and planning, performance measurements, etc.

Both the project team and executive steering committee need to be involved in the establishment of those policies. The project team should identify the required policies, create spin-off task forces to develop them, revise/approve the draft policies and forward the approved drafts to the executive steering committee. The steering committee should revise and approve the draft policy and the general manager should sign it to go into effect on a given date.

5. KEY PROBLEMS FACING MRP

5.1 Lead Times

Many people think of lead times as a constant. In fact, it is not a value to be measured as much a parameter to be managed. Lead times can be divided into four categories: setup, processing, moving and queue. [15] None of those should be considered fixed in a manufacturing environment.

Examples are increasingly quoted in which setups that initially took hours have been reduced to minutes, especially in Japanese factories. Typically, this

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15 Thomas E. Vollmann, William L. Berry and D. Clay Whybark, Manufacturing Planning and Control Systems, 2nd Edition, Dow Jones-Irwin, 1988, p. 164.

requires availability of the new die or other set-up feature at the machine, easy removal methods, space for the old set-up to be moved aside, space for tools and sufficient clearance for operator and maintenance personnel to work together on the changeover.

Moving and queue can also be significantly compressed with an effective shop-floor layout and practice. The drive for an effective layout should be the product flow. A U-shaped flow pattern, for example, results in adjacent input and output areas and allow workers to operate more than one machine more easily. [16]

The key to MRP is that you have to tell it the lead time to manufacture a part, a component or assembled product. MRP mandates building to the schedule delivery of the final product and it must know how long it takes for a part to be 'processed' through the manufacturing system.

MRP must assume a fixed production environment with fixed lead times. It is very susceptible to getting lead times wrong because the production times vary depending on the degree of congestion or loading within the shop. The problem with MRP is that its releases produce the very conditions that determine lead times, but these lead times have already been taken as known and fixed in making the releases. [17]

Moreover, because of the high costs of reprocessing the information very often, a single lead time number must suffice in MRP for all conditions faced on the floor. Consequently the number must be set high enough to accommodate all variations up to the worst case. If an order is ever late, people have the incentive to increase the planned lead time in the system so that the delay does not occur again. Therefore, orders will tend to be released too soon and will often be completed early, thereby increasing inventories in the system.

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[16] Ian D. Hill, "Modern Manufacturing Techniques Require Flexible Approach to Facilities Planning," Readings in Production and Operations Management - A Productivity Perspective, Allyn and Bacon, 1990, pp. 86-87.

[17] Uday Karmarkar, "Getting Control of Just-in-Time," Harvard Business Review, September-October, 1989, pp. 122-131.

Finally, one of the most problematic aspects of MRP is the removal of any responsibility for lead time reduction from the shop floor. There will not be any incentive to reduce lead times if there are no rewards for completing work faster than MRP's fixed standards say.

5.2 Other Problems with MRP [18]

Another big problem with MRP is its unnecessary complex and centralized nature. MRP II systems plan and coordinate materials flow and produce order releases to the shop floor. But in many situations the shop floor can be more flexible than MRP II. For example, an assembly group might want to change its build schedule because parts are not available for some current schedule. Yet the change is not done because the appropriate paperwork is not available and will not be available until the next run of MRP. It often makes no sense to run MRP daily since it takes time to collect and distribute all the necessary data. Moreover, a good size MRP system can tie up the central computer for hours. Yet some shops would be better off working in just such short cycles.

Some MRP enhancements have addressed these problems. MRP vendors have created "shop floor control" modules which track progress on the shop floor. The resource management tools in MRP II analyze capacity and resource loading. The best known of these systems is "rough-cut capacity planning". This method analyzes the load that MRP order releases create on the shop floor. If this load exceeds the capacity of the work center, the implication is that the work in the shop will not get done in the time allowed. The human planner must then find some way to cure the problem diagnosed. Sophisticated techniques for evaluating the lead-time consequences of MRP releases are also available now.

While helpful, these method increase MRP costs and can be subject to the same criticisms as the system they are meant to restore: they remove responsibility and incentives from the job floor and they only as good as the information put on them.

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[18] Karmarkar, pp. 122-131.

6. ALTERNATIVES TO MRP [19]

6.1 Push Versus Pull Systems

The basic difference between a pull system like Kanban and a push system like MRP is that a pull system initiates production in response to a present demand while a push system initiates production in anticipation of future demand.

SYSTEM / ASPECT	MRP SYSTEM	KANBAN SYSTEM
Initial Development	Top down information system - Production control - System inventory count	Botton round total production system - Physical goods control - Design - Production engineering - Quality control
In-house Development and Implementation	Formal education	Small group improvement activity
Application	No restriction	Repetitive production rate
Planning Philosophy	Master production schedule / time-phased requirements	Level monthly production linked to daily item throughput
Control Philosophy	I/O control despatching list	Adjust capacity by labor/overtime First come first served
Inventory	Plan lead time inventory	Accept minimum

6.2 JIT-Kanban

System Characteristics and Benefits

JIT should be viewed as a statement of objectives or an approach to minimize waste in manufacturing. It has been used by companies as a way for providing

19 Karmarkar, pp. 122-131.

smoother production flows and making continual improvements in processes and products. To achieve this on-going improvement in a JIT environment each operator in any conversion process should be given whatever he or she needs just when it is needed. To operate in a JIT environment, a company has to receive synchronized deliveries from suppliers and its materials have to flow consecutively through predicable paths at a pace determined by the last operator in the chain.

The result of a JIT environment is greatly reduced inventories, eliminating the confusions associated with high inventory level. It will also save the company the investment that goes along with high stockup of materials. Moreover, due to its emphasis on incremental reductions in lead times it will improve the company's responsiveness and operational flexibility.

The production system in a JIT environment will discipline itself according to the next customer's need leading to continuous improvement in lead times and customer service. Moreover, the production supervisor owns the inventory that are produced, they are not pushed into other hands. The impact that long lead times have on WIP as well as finished inventory becomes transparent to the cell. Furthermore, the kanban method of posting circulating work orders makes the current and future work load of the manufacturing cell obvious to everybody involved in the production process. The result of this is that planning setups in advance therefore or opportunistically consolidating batches to save setup can become routine. In contrary to a MRP environment, responsibility for improvements is transferred to the shop floor.

Finally, the fixed pool of cards in a kanban cell reduces the extent to which demand fluctuations are passed by the cell to other upstream cells. The cards provide an upper bound that filters out extreme variations. At the same time, the system disciplines the downstream customer by punishing wide fluctuations or demand surges. A sudden surge will not be satisfied until the limited number of cards circulate many times. This encourages uniform demand and level schedules on the downstream side.

Problems with JIT

The kanban method works best where there is a uniform flow - a level-loaded, synchronous, or balanced system. Since future events are not recognized by pull techniques which always aim to fill up depleted inventory at the next stage of production, a kanban system does not plan well. When such a system is implemented in an environment full of variations, it is even less likely to than MRP to bring the expected benefits. Extra cards or containers have to be introduced to cover variability and avoid back orders. Since the system is reactive, changes in demand level are transmitted slowly from stage to stage. Even if it is perfectly obvious that demand is rising, there is no standard way to prepare for the situation.

JIT in MPM Systems [20]

The primary place where JIT makes its contribution in a MPM system is at the 'operational' level. JIT implies in a greatly streamlined execution on the shop floor and in purchasing. Such a system can eliminate large portions of standard shop-floor control systems, sharply reduce the costs of detailed shop scheduling, bring significant reductions in WIP and lead times and provide a better vendor scheduling.

Just-in-Time Systems have three cornerstones: product design, manufacturing process design, and the whole person concept. Critical issues in product design include quality, design for manufacturing and reduced number of levels in the Bill of Materials. A natural linkage exists between the BOM level reduction and the design of the manufacturing process cells. For the use of fewer levels to be practical, a manufacturing process has to be put in place so that a number of product conversions are included in one routing.

Another important element to be taken into consideration when designing a manufacturing process is to make sure that the process is flexible enough to accommodate a fairly mixed set of products, and some variation in demand for the products, as well. The objective should be for the manufacturing process to be able to make any product, right behind any other, with minimal disruption.

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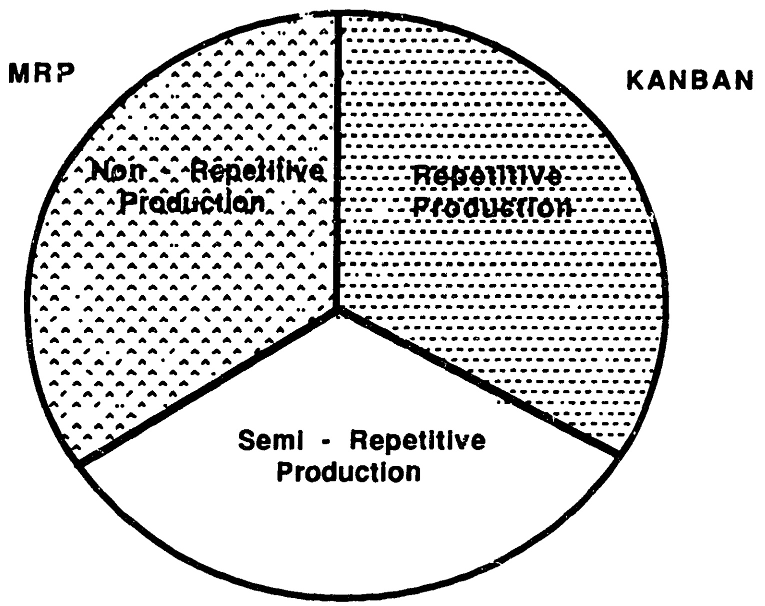
[20] Vollman, pp. 249-251.

The whole person concept recognizes that the workers' range of capabilities and level of knowledge are assets to the firm. Education and cross training are therefore investments in this asset base.

In summary, the impact of a JIT process in the 'operational' level of a MPM system is a change in focus to inventory and throughput time reduction, which means that inventory is not built to level out capacity requirements. Moreover, with no defects, zero inventories, no disturbance and fast throughput, detailed scheduling is easier and problems are likely to be corrected on a local basis.

6.3 Hybrid Systems



MRP and KANBAN COMBINED

Since both push and pull systems have pros and cons it should be helpful to evaluate a hybrid system. The best solution is often a hybrid that uses the strengths of both approaches. Pull methods tend to be cheaper because they do not require computerization - hardware or software. They leave control and responsibility at a local level and offer attractive incentives for lead-time management. MRP systems are good at materials planning and coordination and provide a natural hub for interfunctional communication and data management. When it comes to work release, they are good at computing quantities even if they are weak on timing. A successful hybrid system can use each approach to its best advantage.

For a continuous-flow system, ongoing materials planning is not essential and JIT supply techniques work well. Order releases do not change from week to week, so a rate based approach can be used. In a repetitive manufacturing environment with fairly stable but varying schedules, materials planning can be a combination of JIT and MRP. Order releases may require MRP calculations if changes are frequent or if it necessary to coordinate with long lead times or complex materials supply and acquisition. JIT works well on the job floor.

In a more dynamic and variable manufacturing environment like job shop manufacturing MRP becomes invaluable for planning and release. JIT cannot cope with increasing demand and lead-time variability. Shop floor control requires higher levels of tracking and scheduling sophistication. Finally, in very complex environments, even job release requires sophisticated push methods.

In many situations push and pull systems can coexist and are complementary. Most important it is perfectly possible to take elements of a system and add on to the other. If pull systems have natural lead times reduction incentives and push systems do not, for example, there is nothing which prevents managers from instituting a program of incentives in the context of a push system. Given the importance of lead time reduction, in fact, it is crucial for managers to measure lead-time performance and provide feedback on response and turnaround times to each work center and shop. Through MRP Systems do little to encourage good lead-time performance directly, managers can introduce measurement and incentive schemes based on MRP's data collection capabilities.

There is nothing to stop managers from compensating for the deficiencies of pull systems either. Pull systems, for instance, have no means of lot tracking - pegging lots to specific customers. But customers may want to keep track of their orders, and there may be special regulatory or quality control reasons for maintaining a lot's identity. So why not add lot tracking and data collection systems to a kanban line, leaving the release function as a pull system? (One simple and effective approach is to accumulate the information physically, with the lot itself as it moves through various process stages, and then record it electronically at inventory points in the process).

Theoretically, there is no limit on the variety of control methods that can be developed. Most are hybrids. Attempts to implement pure push systems are usually accompanied by the growth of some informal, reactive pull procedures. The most common is the "hot list", by which assembly tells manufacturing which parts it wants most on a given day.

In a way, such informal procedures are only piggy-backing on the official MRP system, using short term release information that MRP has not yet processed. The trouble with any informal procedure, however, is that it is very unsystematic, it may be based on assembly's guess of what it can get from parts and does not take into account the actual position of open orders in parts. Moreover, it undermines the credibility of the official systems. Since there can be no coordination between the two, disbelief in the official system becomes self-fulfilling. Instead:

JIT-MRP

There are now several modifications of existing MRP II systems, which add pull elements and remove some of the problems connected with the system's lack of responsiveness. These systems are appropriate for continuous -flow or level-repetitive processes, where production is at a level rate and lead times are constant. In these situations, the order release and inventory management functions are of little value. The facility can be designed to operate in a JIT manner so that any material that enters the facility flows along predictable paths and leaves at predictable intervals. Work is released by a pull mechanism, so there is no WIP buildup on the floor.

Such a JIT-MRP line produces to meet a daily or weekly build rate rather than build to specific individual work orders. This means that inventory positions is not necessary for release calculations. Inventory levels can be adequately calculated after the fact on a so called "back-flush"or "post deduct" basis by subtracting to allow for production that has already taken place. In short, MRP serves mainly for materials coordination, materials planning, and purchasing and not for releasing orders. The shop floor is operated as a JIT system.

Tandem Push-Pull

In a repetitive environment where lead times are fairly stable, either an MRP or a pull approach can achieve order release. MRP would be best for purchase planning of items with long lead times. Actual build routines closely correspond with the MRP II schedules, yet the timing of subassembly and assembly releases can be eliminated to allow the shop floor to change rapidly in response to short-term demand pull. Subassembly and assembly are flexible, short-cycle processes that can easily be run on a pull basis.

In this common situation, push and pull systems can simply be juxtaposed - MRP II to ensure parts availability based on the end-item schedules and kanban for actual subassembly and assembly releases. MRP can be run only as frequently as necessary for parts purchasing and planning. Since the floor schedules can change quickly, the MRP database will always be plying catch-up with actual parts withdrawals. This approach has been particularly successful in subassembly and assembly environments in which manufacturing cycle times are much shorter than parts purchasing and fabrication lead times.

Requirement-Driven Kanban

In situations where final assembly schedules are unstable with respect to volume and mix, but certain portions of the production processes face fairly steady demand, individuals cells within the manufacturing chain can be run with Kanban control while MRP II runs much of the rest of the process.

One approach for such a case is to use MRP II to plan the number of cards in the cell on the basis of the gross requirements for all the parts produced in the cell. The MRP system does not have to monitor the inventory level at the cell or match demand with available inventories since the system does not make order releases. The gross requirements are an aggregate forecast of the demand from the cell. Of course, as the gross requirements increase, additional card are introduced into the cell in advance of the demand increase. They are withdrawn as the requirement level drops. MRP thus plays the role of planning advisor to the cell, setting the budget level in terms of the number of cards but not specifying the "expenditure" or release of the cards.

Many component manufacturing shops supplying subassembly and assembly operations, where the mix may change substantially but the total volume does not vary much, can use this approach.

CHAPTER III - MRP II IMPLEMENTATION PROCESS - A CASE STUDY

1. INTRODUCTION

The company I chose to study (which I will call Electronic) is a supplier of electronic systems to the United States Government. It consists of three sectors (or divisions) : A, B, and C plus 5 smaller divisions. Electronic is in the process of implementing a MRP II system both in Sector A and Sector B. I will in this chapter focus on the changes that have been taking place in Sector A as part of the MRP implementation process, although I will refer to Sector B in a number of examples.

Section 2 of this chapter describes the competitive environment Electronic operates in, including a short description of the Government regulations that have an important impact on this industry. Section 3 describes the organization of Electronic prior to MRP. Section 4 goes through the changes that have been happening in the company during the past two years according to a redefined operations strategy to raise the competitiveness of its products both in terms of cost and time to the market. Finally, Section 5 uses the framework developed in Chapters I and II to evaluate the implementation process so far.

Most of the information I used to write this chapter of the thesis was gathered through interviews with people in the several functional areas of Sector A. Interviews were conducted in a unstructured manner and whenever possible conflicting issues or points of views were checked with a third person or through a second interview with the persons in question.

Although the literature had prepared me for the impact of MRP on an organization, I was very impressed by the resources and mobilization effort that is going on in Electronic to implement such a system. The people in Sector A are very aware of the impact MRP is going to have in the company as a whole and especially in the way jobs are done. Reactions to the system go from fear to enthusiasm.

2. COMPETITIVE ENVIRONMENT

Electronic supplies electronic equipment to the Army, Navy and Air Force of the United States. It has therefore to comply to strict regulations with respect to the systems supplied. In a time where defense spending was at very high levels, competition was more focused on the quality of the systems delivered. Improved world relations and the implied reductions in defense spending will likely yield fewer contracts and a consequent increase in competition in this industry. Companies will therefore have to emphasize not only quality but also cost performance and delivery time.

It is important that the operations of the company be flexible enough to accommodate the frequent changes in products required by government specifications. The government usually requires the total commitment of an organization before a contract is signed. To show this commitment a company might go as far as building a brand new facility only for one specific contract. Since the bidding process is very costly to the contractor the government allows the companies to charge a certain percentage in the current contract to cover the costs of the next contract. In Electronic, the costs of the proposal preparation might reach $10 Million.

2.1 Government Regulations

Government regulations regarding contract bids, profit margins, and prepayments affect its contractors by changing the business incentive system in the following manner :

Contract Bids

Most of the contracts in the past were done on a cost-plus basis. Contractors generally would bid for cost plus 7-8% profit margin. No real incentive existed for improvements that lead to reduction in the manufacturing cost of a product. Moreover, there was a tendency for using costing methods that would show the highest possible cost for a product being produced. The Government has changed its system and now most of the contracts are fixed price contracts. 70% of Electronic current contracts are fixed price contracts.

Profit Margins

When a bid is submitted for a particular contract it has to include not only the price but also a detailed description of all the expenses the contractor expects to incur during the life of the contract. The Government allows profit margins to vary between 7-8%. If measures undertaken by the contractors allow the products to be produced at a lower cost the Government will require the company to return part of the extra profit (in the case when the Government believes that management knew beforehand what the actual cost would be). The Government might allow the contractor to keep the extra profit but will expect the contractor to submit a lower bit in the next contract.

Since profit margins are fixed, there is little incentive for measures that would improve cost performance of the contractors, especially in times where defense spending is at a high level.

Prepayments

The Government will make prepayments to its contractors in the amount of the cost of material acquired during the previous month plus a negotiated profit margin which varies between 0% and the margin specified in the contract. Contractors would therefore have an incentive to buy all the material which was expected to be used in the contract upfront and realize its profit as soon as possible. Inventory turns in the industry average 1-1.5.

The Government has been more aware of the impact those regulations have on the cost of its contracts and the performance of its contractors. Recently, the Government issued a document outlining what was called the "key elements of material management and accounting system". Among other things it requires Government contractors to maintain a 98% bill of material accuracy and a 95% master production schedule accuracy. It also requires the contractors to assure that the cost of purchased and fabricated material charged or allocated to a contract are based on valid time-phased requirements. This was done to discourage contractors to buy the material upfront and keep it in inventory.

The inventory accuracy, according to the new regulations, should also be kept at a minimum level of 95%. The result of those measures was the increase in riskiness born by the contractor who in turn required a higher profit margin. New profit levels are being negotiated and should stay around 10-12%.

3. ELECTRONIC CURRENT OPERATIONS ORGANIZATION

3.1 Business Units

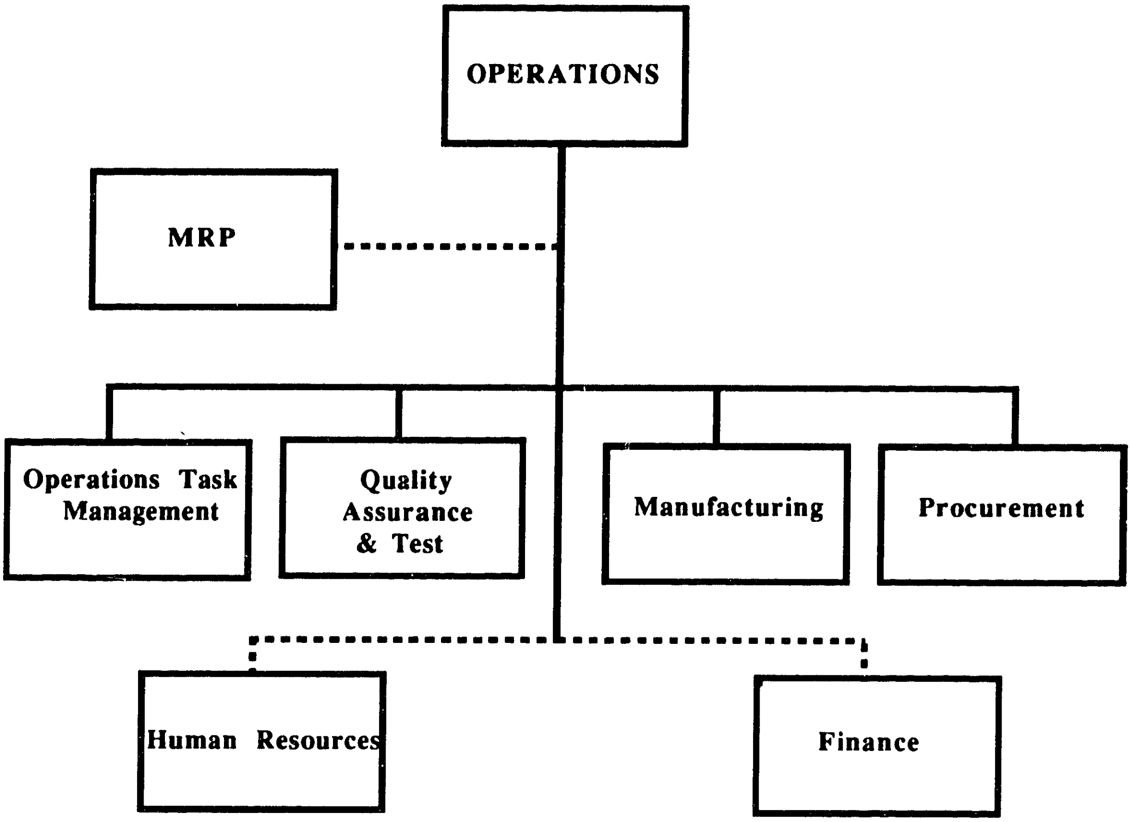
Sector A

This business unit manufactures PC boards, harnesses and hardware, populates PC boards and performs electronic assembly and test for about 100 programs (contracts). The major business problems in this sector relate to time-phased procurement, the commingling of contract inventories to improve asset utilization and productivity, integrated scheduling through all levels of the bill of material and capacity planning across all contracts.

Sector B

This business unit primarily performs electronic assembly and test for one major customer program. The major business problems in Sector B relate to the control of purchased assemblies from 28 subcontractors which comprises 78% of the manufacturing costs. This control includes time-phased buying, productivity issues and the tracking of Company-owned inventory around the world.

3.2 Electronic Organization Structure



The organization chart of Sector A appears in Exhibit X. The Operations Director recognizes the impact MRP will have in the company and is therefore evaluating different options of how to reorganize the functions at Sector A.

Currently, Manufacturing is responsible for product planning and control, product and industrial engineering, prototype development, capital equipment, CIM and all assembly and fabrication activities. Quality Assurance coordinates the vendors' quality control activities. It is also responsible for product testing, quality audit and evaluation, general maintenance and calibration. Procurement coordinates all procurement activities.

The Director of Operations assigns production responsibility to a Deputy Program Manager for Operations (DPM/O) who ensures that the program meets schedule, cost and contractual objectives. The DPM/O is one of the two Deputy

Program Managers in each Program Management Office (the other is assigned by the Director of Engineering). The DPM/O has dual responsibility as the representative of the Director and the Program Manager.

The responsibilities of the DPM/O include preparing Operations' input to bid proposals, including narrative and cost estimates, negotiating approval for and issuing Task Authorizations, directing all Operations activities on contract and being the program liaison between Operations, the Program Office and other parts of the organization.

Currently the master scheduling is under the responsibility of the deputy program manager. His responsibilities include providing centralized operations management for program performance and proposal activities. Each task manager is assigned one or more programs (contracts). Their job was described to me as one of having many responsibilities but no authority. They are responsible for coordinating all activities associated with a specific contract and assuring that the product is delivered on time to the customer.

3.3 MIDAS

MIDAS (Material Information Data System), the system current in place in Electronic, was developed in-house for a period of ten years. MIDAS was defined for me by the Operations Director of Electronic as "automated islands of information". The first module implemented was Receiving, followed by Inventory, Bill of Materials, Purchasing and Shop Floor Control. The only two modules that "talk" to each other are Receiving and Purchasing. Information is transferred manually between the modules otherwise and is therefore subject to errors.

No special attention was paid to changes in job functions while the system was being implemented. It just automated the way things were being done in the past without any previous evaluation of the task in question.

Different people throughout the organization have different opinions about the system. Some modules were described as being too complicated and hard to be updated. On the other hand, managers are not used to use the reports generated by the system and are reluctant to believe in the information contained in them. This turns into a vicious cycle, since employees do not see the necessity to update a system with information that will not be used.

The MRP project manager described MIDAS as being good at what it is capable of doing. Its major drawback is that it is not an integrated system. It has no scheduling capabilities nor 'what-if' functions. The link between the MIDAS modules would be provided by a MRP system.

A PC based MRP was purchased last year to fill the need for capacity planning and scheduling but is not linked to the MIDAS system and information has to be transferred manually.

3.4 Inventory Management

Inventory accuracy in Electronic is very low (87%). Several reasons account for that. Although MIDAS has a module of inventory control, many of the data entering functions are done manually and are therefore subject to errors. A bar code system is being implemented to avoid such errors. It is Electronic's objective to reduce manual data entry to a minimum.

Another problem with the current system is that once the kit (number of parts necessary for a production run) is 'staged' or complete, all the material included in the kit disappears from the system (it is considered work-in-process and its value is not accounted for). Since transfers of materials between contracts occur often, planners responsible for specific contracts order their kits to be 'staged' as early as six months in advance to avoid material shortage. During those six months the kit stays invisible to the system.

The Government requires its contractors to make an allowance when buying material to avoid future shortages. Once the contract is finished and all the systems have already been delivered, Electronic cannot dispose or make use of any remaining parts which belonged to that specific contract. The Government has to give instructions with respect to the usage of that material and that normally takes a long time. This contributes for the higher inventory level at the warehouse.

Finally, the Government requires that items which were purchased for a specific contract be traceable throughout the production process. Since MIDAS does not have the capability of commingling parts for different contracts (even though they are the same part), parts for different contracts have to be kept in separate locations in the warehouse. In the case of Electronic this repetitive storage can be as high as 100 times (if all contracts use the same part, it could be stored in 100 different locations). One has to remember that the same part might have as many as three different codes depending on the government agency which signed the contract.

3.5 Procurement

Electronic currently has 6,000 suppliers. In terms of US$, 65% of its final product is subcontracted. An incoming inspection was done until December in 100% of parts received. According to the Manufacturing Manager, Procurement is more worried with the purchase cost per unit than with the quality of the vendor and the impact it has on manufacturing. Changes of suppliers are frequent and sometimes unexpected (by other departments).

MIDAS does not have the capability of calculating the requirements for more than one contract at once. Therefore, economies of scale are not achieved when ordering parts for two different contracts (the same part can be ordered in several small batches).

3.6 Scheduling

There is not a formal system for scheduling production in the work centers. Manufacturing receives from task managers (which are responsible from one or more contracts) a rough schedule for that contract (it basically tells manufacturing when the customer wants the product delivered).

Scheduling is then done by considering the standard hours available in each work center. This task is not automated and is done with the help of PC worksheets. Recently a PC-based MRP was acquired, but the system is not linked to MIDAS and information has to be manually entered.

3.7 Shop Floor Control

MIDAS has a module which controls the material flow in the work centers. I received conflicting information about the usage and performance of this system. For one person the system was very good but its functions were not used. The reason for that, according to him, was the fact that management did not use the reports generated by the system and employees in the work centers felt that updating the system was unnecessary since the information would not be used anyway.

When managers were questioned about the usage of the reports they said that they did not use the system because the reports generated were too complicated and contained unnecessary information. Still, some of the people in the work centers insisted that the system is updated as soon as each task is completed.

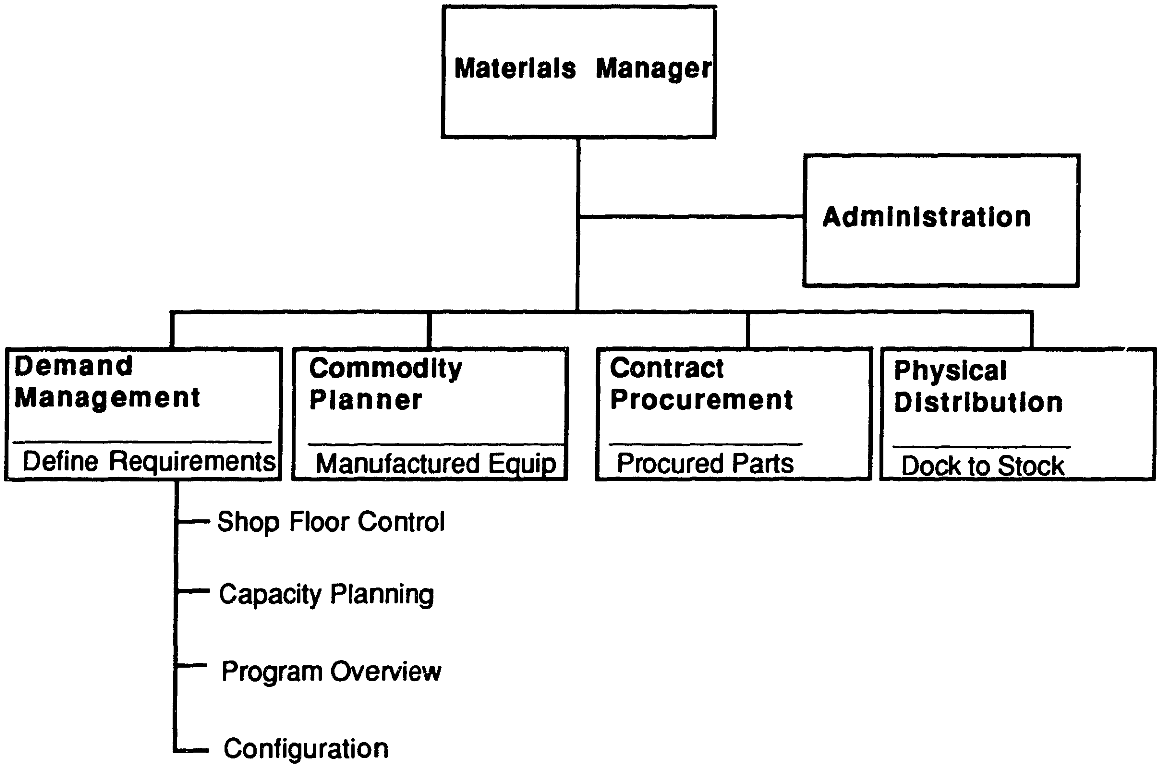
3.8 Engineering

Engineering in Electronic reports to the Vice President for Engineering who is at higher level position than the Operations Director of Electronic who reports tof for a Sector Vice-President. The Operations Director feels that such an structure does not provide him with leverage to assure the manufacturability of the products designed by engineering.

Both engineering and manufacturing have separate bills of materials. Changes done by engineering in the design of the products are not included automatically in the manufacturing bill of materials. Those changes, according to manufacturing, are frequent and have a negative impact in production. Some of those changes are caused by the fact that the Government requires that a product be designed and produced in a very short period of time (180 days for example) in order for the contract be granted. But manufacturing believes that many of those changes could be avoided if the product was designed right in the first place. As one manager said "The design world never makes mistakes, they make design changes. They don't call them errors; defects only appear in the manufacturing floor".

4. CHANGES TOWARDS A MORE EFFICIENT ENVIRONMENT

4.1 New Organization Structure



Under the MRP environment the organization structure of Electronic will change. A new position is going to be created - Materials Manager. The function of the Materials Manager will be to get the right material, at the right place, at the right quantity at the right time. Reporting to him there will be Demand Management, Commodity Planner, Contract Procurement and Physical Distribution.

This organization structure will provide the benefit of having the responsibility and accountability for the master schedule, inventory control and shop floor control under one group.

4.2 Inventory Management

The objective of Electronic in the case of inventory is to bring inventory accuracy from 87% to 98% before the introduction of MRP. With the introduction of the new system, inventory turns are expected to increase from the current level of 0.8 to 3 or 4.

As part of the process of change that Electronic is going through, a new warehouse was built 2 miles of the Sector A plant. All the inventory was transferred to this new warehouse and the space previously occupied by the stockroom was transformed in productive space. The separate building provided Electronic with a better control of its inventory.

A task force was formed with the objective of improving the accuracy of inventory records and reducing the inventory dollars. An effort is being made to either utilize or dispose of existing material from obsolete/inactive material accounts before additional material is ordered. The team will also, where it makes contractual sense, hold and combine material acquisitions. Furthermore, the team is examining the feasibility of physically grouping requisitions for the same material from multiple accounts.

The next step will be the implementation of cycle counting to bring accuracy to a higher level.

4.3 Procurement

In December, the first significant change in materials management occurred with the agreements between Electronic and eight high quality vendors. These agreements will now allow superior quality vendors to ship directly their finished goods to Electronic's stock base without the need for incoming inspection.

A detailed diagram of the Purchase Requisition process, and Purchase Order process have been created. This exercise exposed many efficiencies within the process. Steps will be eliminated from the process before it is automated in order to reduce the total cycle time.

4.4 Shop Floor Control - Work Centers

Electronic has seven work centers: Cards/Multi Layer Boards, Fabrication, Cable Harness, Wire Wrap, Subassembly/Final Assembly, Shelter and Volume. Most of these workcenters went through great changes during the past two years.

With the objective of process simplification and effective allocation of people and machines with a consequent increase in productivity and reduction in production cost a series of steps were undertaken in each work center.

In the past two years, operations has emphasized its cost reduction efforts by addressing the process required to manufacture products. This included the formation of Continuous Flow Manufacturing Teams. Team activities simplified the product flow and increased assembly throughput. Results included reduced work-in-process inventory on the production inventory and less paper work.

The changes implemented in the work centers were significant and would not have been achieved without the cooperation of all employees, according to the Operations Director. When he assumed this position two years ago, he felt he had to change the company's manufacturing strategy from one which was only reactive to Government regulations to one which would allow the company to successfully compete in the future market place.

He saw that a successful combination for Electronic would be to implement a pull system in the work centers while using MRP as an umbrella to integrate all the manufacturing functions. He understood, however, that an MRP system should not be installed until operations were simplified and lead times significantly reduced.

Most of those changes would have a significant impact in the way people were viewing their jobs and they would be successful or not depending on management effectiveness in managing people through this change process.

The Operations Director feels that the best way to achieve that is through participation. The employees in the work centers were informed about the objectives of the changes. They were also informed that their input would be extremely important in the process. Teams were formed in each work center and employees were able to voice their opinions with respect to how the process could be simplified. Employees got ownership of the process improvement.

The layout of each work center was changed to conform to the product flow. Almost no space was allowed for work-in-process inventory, which were transferred between work centers using racks with wheels, to decrease the time wasted in storing the products in the stock room before they are transferred to the other work center.

The role of the supervisor changed from one of a person who tells the subordinates what to do and how to do it to one of a leader who involves the subordinates in the search for solutions.

According to the Operations Director, one of the requirements for the Shop Floor Control module of MRP to work is that it should be kept simple. He said that an important thing in the work center is to be able to walk in and immediately notice if there is a problem and where the problem is.

4.5 Bill of Materials

To address the problem of improving the accuracy of the Bill of Materials a task force was formed with the objective of establishing policies and procedures to not only have an accurate bill of materials but also to keep this accuracy at a high level after MRP is implemented.

This task force will also address the issue of the interface between the engendering bill of materials and the manufacturing bill of materials.

4.6 Engineering

An effort is being undertaken to reduce the lead times of the transfer of information between Engineering and Manufacturing. A team has been working on a project which will provide a way of linking Manufacturing and Engineering by having the engineers design their models in a CAD system which has 3D capabilities. The program would translate the model into instructions which can be understood by a computer controlled machine in the work center. As a means of getting both Engineers and Management enthusiastic about the project, the team produced one part only four hours after the part had been designed.

5. MRP II PHASED IMPLEMENTATION APPROACH

This section will apply the framework presented in Chapter I to the systems design process in Electronic and will combine this with the framework presented in Chapter II to the MRP implementation process.

5.1 Success Factors

Key success factors were identified as being product competitiveness both in terms of cost and quality, and improved customer service. Those success factors are critically important at a time when budget reductions in defense spending are increasing competition for fewer contracts.

5.2 Operations Strategy

Once the success factors were identified, an operations strategy was developed to achieve those objectives (quality, customer service, cost competitiveness). It was recognized that the ability of Electronic to compete in the future marketplace will depend greatly on its overall manufacturing capability.

5.3 Technological Requirements

After the new operations strategy was defined, Electronic manufacturing capability had to be improved to be able to support that strategy. A system that would provide the company with inventory reductions, increased productivity and overall improved efficiency was considered essential to achieve those objectives.

5.4 Current Systems

The system currently in place (MIDAS) was evaluated to determine if the software could be modified and integrated. The results of this analysis showed that MIDAS would not provide a satisfactory solution since it was designed on an old and outdated hierarchical database system that is currently unsupported by the market place. Once the conclusion was reached that the technology of MIDAS is in a stagnant stage, future investments in functionality enhancements were suspended and the decision to purchase a commercially available system was made.

5.5 System Conceptualization

Project Scope

The scope of the project (MRP II implementation) was defined in the funding document as to include the entire manufacturing process. The system will handle the Engineering Bills of Materials and Change Notices, structure the entire procurement process and be responsible for the delivery of a complete manufactured product to the customer. The system will also integrate manufacturing with finance, providing the required financial data to the ledgers, accounts payable and project cost systems.

Software Selection Process

Once the decision was taken to purchase new software, a dedicated team of user representatives was formed including Operations, Engineering, Information Management and Finance from Sectors A and B. This team created a document with 99 functional requirements (49 being mandatory and 50 being desirable) and 27 technical requirements (7 being mandatory and 20 being desirable) to be fulfilled by the software vendors.

All vendors visited each Electronic manufacturing location and responded to a questionnaire regarding their Government contractors client installed base. Each vendor was asked to write a proposal in which it should detail information in how its software fulfilled the above requirements.

This analysis resulted in two vendors eligible for final review. Site visits were then performed in facilities which have the vendor's software installed.

The final review included criteria as conformance with D.O.D. requirements (Government regulations), vendors planned future releases, cost and tangible benefits provided by each vendors software functions.

The new system will replace the current system entirely and provide new functionality to Electronic. The new functionality includes the following:

Master Scheduling - This application will help master schedulers to develop a realistic and comprehensive production schedule. It maintains product forecasts and desired inventory levels. Using this data combined with current and future customer orders, the system generates a master schedule. Once management adjustments are made based on resource availability, the master production schedule is released to the Contract Materials Planning module for production processing.

Contract Materials Planning - This application will assist material and contract planners in a defense contract environment. It fully supports the objectives of traditional material requirements planning, but also complies with the unique requirements of the defense environments.

To achieve those objectives, this application maintains contract-specific data. It supports cross-contract, or intra-contract lot sizing and full level assembly pegging in the product structure. It allocates costs accurately to a specific contract, and provides all the information needed for auditable progress payment accounting.

Capacity Planning - This module helps production management determine the most efficient production schedule based on projected plant load. It will also allow management to analyze the manufacturing facilities' capability to meet future production needs.

5.6 Migration Path

The software acquired by Electronic is modular in its design, which will allow logical phased implementation. The implementation process will be divided into the five following phases:

Phase 1 - Contract Materials Planning, Manufacturing BOM, Inventory
Phase 2 - Purchasing, Receiving
Phase 3 - Engineering BOM, Master Production Schedule
Phase 4 - Shop Floor Control
Phase 5 - Financials

The database currently in use by the MIDAS system will be cleaned-up and translated for the use by the new system. Bridges (new programs and modifications that are built for the single purpose of having one system temporarily 'talk' to another system during a phased implementation) will be built between MIDAS modules and the new software modules while they are in place.

5.7 First Cut Education

Managers in the operations sector of Electronic in both Sectors A and B already went through a training program with the objective of both understanding the features provided by the new system and raising their awareness of the impact such a system will have in Electronic.

5.8 Cost Justification

Before a decision was made with respect to the implementation of the new system, a funding document was prepared to the top management of the company in which both tangible and intangible benefits were listed.

The anticipated benefits from MRP II implementation are both tangible and intangible. Specifically, the utilization of an integrated scheduling tool will maximize resources usage throughout the manufacturing process resulting in reduced labor costs, increased machine utilization, and enhanced procurement efficiency. The tangible benefit of aggressive management of materials to required utilization rates will reduce facility storage requirements and lower the investment cost for carrying stocked material. A further benefit will be realized when utilization of such a system increases the on-time delivery to customers.

The listed intangible benefits of the system included providing a single source of accurate data to enhance management decision making for change notice cut-in, make/buy decisions, and factory and labor capacity planning. The day to day work assignments and responsibilities of operations personnel, production planners, production foreman and operations task managers will be tied to the integrated system regarding decisions on delivery requirements, production capacity, design releases, and materials availability. This integration will improve employee accountability and will yield increased performance on programs through employee involvement.

According to the funding document, the successful implementation of MRP II is expected to move Electronic in the direction that will keep the company competitive in an arena where world-class manufacturing companies are active and lead to on-time delivery of the highest quality products at a cost competitive price

Quantified Benefits

Reduced Inventory Costs	49.5% of annual savings
Operating Savings	
Direct Labor Costs	45.4%
Procurement Leverage	45.0%
Facilities	7.6%
Inventory Carrying Costs	2.0%
-	-----------
Total annual savings	100.0%

Quantified Costs	
Program Office	13.7%
Sector A Implementation Team	21.6%
Sector B Implementation Team	14.7%
Information Management	40.2%
Software Purchase	9.8%

	100.0%

5.9 User-Controlled Project Team

A full-time project team was created with representatives of the several areas being affected by the new system. In each of the Sectors the project team is formed by representatives from Production Control, Industrial Engineering, Distribution and MIDAS. There are also currently two representatives from Procurement and one from Engineering. The composition of the project team will change during the implementation process to reflect the several areas being affected by the system.

5.10 Full-Time Project Leader

A full-time project leader as assigned to the project, reporting to the operations manager of Sector A. His previous function was of controller of the Sector A.

5.11 Executive Steering Committee

The Executive Steering Committee is formed by the Sector controller (who is the chairman of the committee, Sector A Operations Director, Sector B Operations Director, Sector B Program Director, Engineering Systems Director and the Contracts director). According to the Project Leader, the committee meets monthly for two hours, unless any extraordinary circumstances appear. The Project Leader has a weekly meeting with each one of the committee members.

5.12 Professional Guidance

The professional guidance is given by a group of consultants which are part of the implementation team of the software supplier. This group of consultants was already involved in a number of MRP implementations in several defense contractors.

5.13 Education of Critical Mass

There are two levels of training:

Generic MRP Education - It will instruct both management and users what is the best way to use the tools that are available with an MRP System.

Software Training - Training specific to the software will be conducted to all operating managers and users. The objective of this program is to enhance concepts learned in Generic MRP education while thoroughly examining the functional aspects of the new MRP II system.

Training programs are being performed in both Sectors, but the strategy of those programs has been different. In Sector A the approach is to train first the departments heads and let them train their own subordinates. In Sector B the approach has been to train as many people as possible as soon as possible. According to some people the approach used in Sector B is better since it keeps the excitement alive. People in Sector A are complaining that they are not kept informed of the development of the implementation process.

5.14 Pilot Approach to MRP

A conference room pilot was installed and a small database is being created to test the several features of the software and have the future users become acquainted with the new system.

The Conference Room Pilot will be used to develop business models of "as is" and "to be" and validate the software selection. This stage of the implementation process should result in the confirmation of the new policies and procedures that are ratified by all programs and plant personnel. This includes management reporting that will be used to run the plant in the future.

The final steps of the implementation process will include closing the loop, linking finance and what-if capabilities.

5.15 Expected Benefits

The MRP II system will interface with Engineering, Finance and Computer Aided Manufacturing and will manage production material, production scheduling, bills of material, shop floor control and capacity planning. The new system, when fully utilized across Electronic is expected to provide flexibility to economically combine resources to satisfy requirements of a large production opportunity at Electronic, with the ability to perform at the Sector and Division levels to satisfy specific customer needs.

Used effectively, the system will improve the cost competitiveness of Electronic, critically important at a time when budget reductions in defense spending are increasing competition for fewer Department of Defense contracts.

By lowering inventory levels, the new system will increase return on investment and will Government regulations material management and accounting system.

6. CONCLUSION

I have devoted the majority of this chapter going through the changes that have been happening in Electronic during the past two years. During this period a new manufacturing strategy was defined as a way to compete in the future market place. MRP II was chosen as the tool to make this new manufacturing strategy happen. Management understood, however, that such a system could not be implemented before major changes were done in the organization.

The business units were evaluated in order to determine the major problems faced by each one of them. After the problems were identified, the search of solutions begun if the participation of all the employees involved in order for them to acquire ownership of the new environment.

I do not expect Electronic to face major problems in the implementation of MRP II. However, management has still to pay attention to a number of issues which can compromise the success of such an implementation.

The interaction between Manufacturing and Engineering should be carefully reviewed. Specifically the reason for the number of the designs change be so high. If this problem is not solved MRP will not bring the expected benefits since the accuracy of the lead times and bill of materials will be compromised.

Some managers believe that the MRP system should be only used in those contracts where product changes are kept a minimum due to the high costs of running MRP very often. Although this might help the company in the preparation of the proposals will certainly not bring the systems expected benefits and might lead to mistrust and frustration. The company should instead try to reduce the number of engineering changes in its product as mentioned above.

Management should also review its current job evaluation system. The new environment will require that different measures be used to evaluate job performance (for example, employees should be held accountable for keeping the information in the system as accurate as possible).

Management leadership will be very important in the new environment. Decision making should be based as much as possible on reports generated by the system to show to employees that keeping information accurate in the system is very important.

Finally, it seems that MRP is being considered as a manufacturing system. It should be made understood to top management that if the system is to work to its full capability, the system should be considered as a business system.

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