

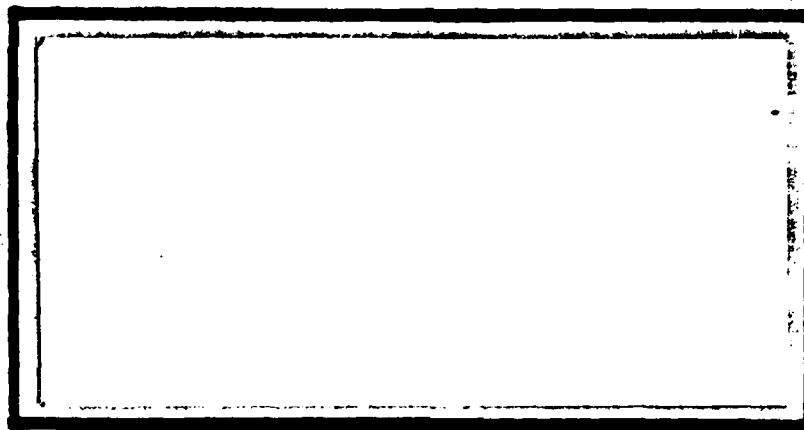
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A CASE STUDY OF THE IMPLEMENTATION OF
MANUFACTURING RESOURCE PLANNING
AT THE OGDEN AIR LOGISTICS CENTER

THESIS

Michael L. Finnern
Major, USAF

AFIT/GLM/LSM/88S-18

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THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

Michael L. Finnern

Major, USAF

September 1988

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Michael L. Finnern



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Abstract

The purpose of this case study was to examine the implementation of Manufacturing Resource Planning (MRP II) at the Industrial Products and Landing Gear (MAN) Division at the Ogden Air Logistics Center (ALC), Hill AFB, Utah. From a review of the literature, this study identifies several critical prerequisites for MRP II success. These lessons are considered key issues and fall into three general categories, referred to as "critical elements": People, Data, and Technical.

In collecting information for the case study, individuals assigned to the Depot Maintenance Management Information System (DMMIS) System Program Office at AFLC HQ and the MAN Division were interviewed. This case study documents the MRP II implementation at MAN and places special emphasis on treatment of key issues.

The issues associated with the People Element include management support, education, project team membership, and employee resistance to change. Although considerable attention has been given to pre-implementation education at MAN, there is concern that the same preparation may not be available to the other ALCs.

The Data Element contains the issues of bills of material, inventory records, labor standards, work centers,

and work control documents. A significant amount of effort has been devoted to developing an accurate data base. Although DMMIS is a maintenance program, it will rely heavily on inventory provided by depot supply. This relationship between maintenance and supply will be critical to the program's success.

The final element, Technical, is concerned with system design and software selection as well as the pilot project issue. The selection of a commercial vendor and off-the-shelf software was lengthy and detailed. Additionally, the contract specifies that MAN will be the pilot project for the DMMIS program.

This study provides several recommendations to improve the chances of success of the program.

A CASE STUDY OF THE IMPLEMENTATION OF
MANUFACTURING RESOURCE PLANNING
AT THE OGDEN AIR LOGISTICS CENTER

I. Introduction

Background

In 1972, Air Force Logistics Command (AFLC) initiated a system known as the Advanced Logistics System (ALS). This was to be a command-wide data processing system more powerful than anything to date. It was an attempt to modernize the command using one computer and one database. "The planning was excellent, the requirements were well thought out, but they were ahead of technology" (23). Without the requisite advances in technology, the system did not work and was eventually cancelled in late 1975. Although the program failed, the attention it focused on the need for computer system modernization continued in AFLC (23).

In the early 1980's, AFLC began a Logistics Management System modernization by logistics elements, of which maintenance was one element. As part of this program, in 1984, a risk assessment of all AFLC Air Logistic Centers (ALC) was conducted by an independent firm (Deloitte, Haskins and Sells). The findings pointed to an existing management information system that was designed to achieve the ALC's objectives. That system, already in use by many civilian

companies, was Manufacturing Resource Planning (MRP II) (33). As an integrated information system, MRP II has allowed industry to make great strides in inventory control and production management (10:83,86).

Problem Statement

Although MRP II has demonstrated tremendous capability and has been used extensively throughout civilian industry, the literature indicates that less than 10 percent of the users attain the system's full potential or Class A (see Appendix A) status (2:59). By identifying potential problem areas early in the planning phase, an implementation plan could be designed to prevent these problems from developing. By reviewing the benefits and problems of MRP, this thesis will determine what lessons can be learned from civilian industry concerning the implementation of a MRP system. With that in mind, it will review the application of these lessons to the MRP implementation at the Ogden ALC.

In reference to this problem, six investigative questions will be asked.

1. What is MRP and what does it do?
2. What are the benefits of MRP?
3. What are the pitfalls of MRP?
4. What type organization is best suited for MRP?
5. What issues should a successful MRP implementation address?

6. How are the MRP Critical Elements being addressed by the MRP implementation at the Industrial Products and Landing Gear Division at the Ogden ALC.

Justification

"In the last twenty years, American business has poured billions of dollars into material requirements planning (MRP) systems in the form of educational, software, and implementation/sustaining manpower costs" (28:48). As an example, Wight developed a scenario where a "typical manufacturing company" would spend \$745,000 (one time cost) to install a MRP system and \$145,000 per year thereafter to maintain it. However, that same company would save \$1,615,000 annually through reduced inventories, better customer service, increased productivity, and reduced purchasing costs (47:353-359).

The cost of installing MRP at the Industrial Products and Landing Gear Division (MAN) at Ogden ALC is approximately \$17 million. In addition, if it is successful, the system will be installed at the other two Ogden ALC product divisions of Aircraft (MAB) and Missile and Aircraft Systems (MAK) and the remaining ALC's during the program's 12 year contract (38). Fiscal responsibility and a time of shrinking military budgets require that each expenditure achieve its intended results. To that end, early identification of

system problems may lead to the successful allocation of resources.

Scope

Initially, this thesis will describe the broad topic of MRP as a system. A thorough understanding of what the system does is necessary before addressing the problem as outlined earlier. This will be accomplished by addressing investigative questions that are concerned with general, topical issues. These questions will be presented in the review of the literature found in Chapter II. Next, the thesis will narrow its perspective in a detailed review of the specific implementation of MRP at the Ogden ALC. The procedures for conducting this phase of the research will be presented in Chapter III, Methodology.

There are many aspects of MRP that would justify further study. This approach has been chosen because of the timeliness of the Ogden MRP implementation. As a result, findings or recommendations resulting from this study may be beneficial to a major, current and continuing Air Force program.

Limitations

Researching a management control system as complex as MRP required a limitation of the review to only those issues that applied to implementation. Although there may have been numerous other civilian corporations implementing MRP during

the course of this research, only Ogden's program was reviewed as a case study. The MRP system being installed at the Ogden ALC is being tailored to its operational mission. Therefore, specific findings may only apply to that ALC. However, general concept applications should be useful for all USAF MRP implementations.

Finally, information for the case study was obtained primarily through interviews with implementation team members and division management. The research was so designed because, at the time of the interviews, those individuals were the most knowledgeable of the program. Shop floor personnel were not interviewed. Consequently, results of this thesis do not necessarily represent their views.

Definitions

The use of technical terms or acronyms in either industry or the Department of Defense, cannot be avoided. As these acronyms are used, they will be described and the acronym will be identified in parenthesis. As a further aid to the reader, a complete definition of all terms is provided in a glossary at Appendix A. Toward providing a better understanding of the general topic, two acronyms and the concepts they represent are initially provided. In a review of the literature, the acronym MRP is used to represent two separate concepts. The first of these is Material Requirements Planning, referred to as MRP. The other concept is Manufacturing Resource Planning or MRP II. The two terms

are often used interchangeably, although MRP is actually only one module of MRP II. For this thesis, as in some of the literature, MRP will be used as a general term to describe both concepts (47:xix). If it is necessary to differentiate between the two, Material Requirements Planning or MRP II will be used. The technical definitions for Material Requirements Planning and Manufacturing Resource Planning are found at Appendix A. Finally, it should be noted that the system being installed at Ogden is MRP II.

To understand Ogden's MRP implementation, it is first necessary to understand the concept and purpose of MRP. Chapter II begins that process.

II. Review of the Literature

Overview

This chapter presents a review of the literature and provides the background information necessary to answer the problem stated in Chapter I. This will be accomplished by addressing five of six investigative questions. The methodology for answering the last question will be provided in Chapter III.

What is MRP and What Does It Do?

MRP is a computer-based material management system that was developed and first implemented in the late 1950's (2:59). It was developed as a means of controlling dependent demand items. These items, such as raw materials, subassemblies, or work-in-process materials are used in the production of finished goods (end items). Unlike the demand for independent items (finished products) which can be forecast, the demand for dependent items can be determined from production requirements (42:327). As an information system, MRP assists management in production requirements scheduling, inventory control, purchasing, and capacity planning while it interfaces with other functional areas to enhance the total manufacturing process.

The logic that runs MRP depends on the accuracy of several system inputs. The primary input is the master production schedule (MPS) which considers finished production

items from forecasts and customer orders. It uses this information to outline a production plan, specifying the quantity of components required and the time they will be needed. A second input, inventory status records, keeps track of what materials are available for the production process, what items are on-order, and what items are allocated to other jobs. The bill of materials (BOM), a third input, provides a list of materials for each assembly and subassembly required to produce an end item. This is used to determine the quantity of dependent demand items needed to construct that end item. Finally, the BOM describes the sequence of steps required to build the item by maintaining the materials in levels which show the way they are introduced into the manufacturing process. For example, raw materials are listed at the lowest level of the BOM and are introduced into production during the early stages of manufacture. Final assembly is listed at the highest level of the BOM structure (7:35-36; 32:49-51; 42:330-333).

Using the information from the MPS, BOM, and inventory status records, MRP works backwards from the finished product, "exploding" the end item into components and subassemblies through different levels of the bill of materials, (see Figure 1) (7:36). This explosion results in gross requirements for each component by multiplying the number of components per end item times the total number of end items required. These gross requirements are converted

to net requirements by adjusting for items on order or in inventory (10:83).

In Figure 1, component A exists on different levels of end item X and it is also used by end item Y. This situation frequently occurs when the manufacturer produces many similar products. Gross requirements are normally calculated one level at a time. However, that would cause multiple recalculations for component A as it appears on different levels, resulting in a waste of data-processing time. To resolve this problem, a technique called "low-level coding" is used. This procedure delays the requirement calculation of a component until the system processes the component's lowest level. Consequently, gross requirements for part A would not be figured until Level 2 (32:63).

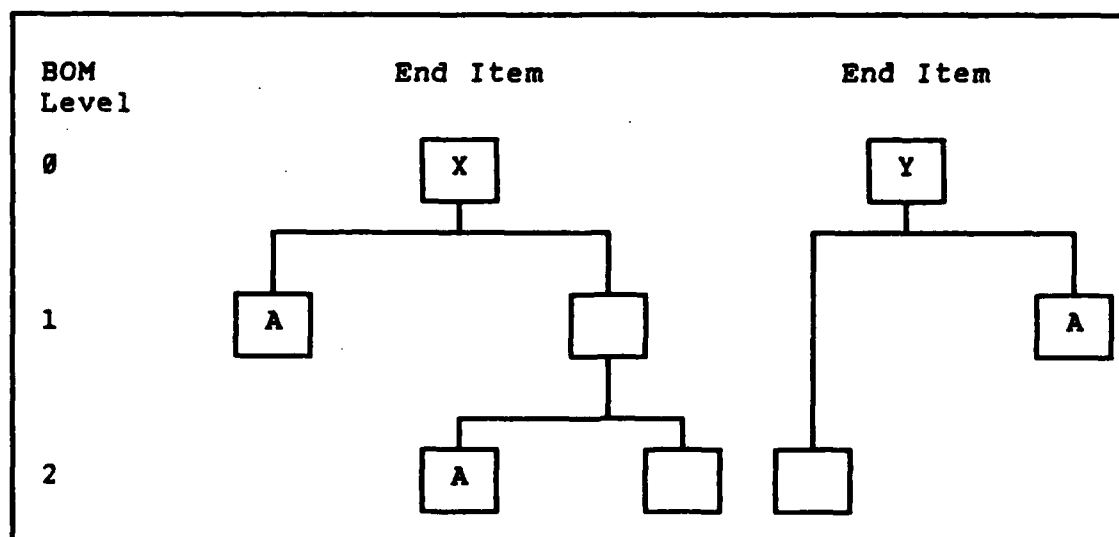


Figure 1. End Item "Explosion" of Components On Multiple Levels
(Adapted from 32:62)

The cornerstone of MRP is its application of the time dimension to the manufacturing process. The master production schedule considers the cumulative manufacturing lead times of all products in the schedule and establishes its planning horizon based on that time. The planning horizon is then segmented into production time periods which are usually stated in weeks and referred to as "time buckets." This addition of time to the production process is called time-phasing (42:331).

The essence of MRP is its ability to time-phase the system inputs which produce the system outputs of planned order release and released work orders. These outputs insure that in-process items are available at the right time to meet production needs. Since MPS initially does not consider capacity, this problem is handled by another system module, Capacity Requirements Planning (CRP). Planned order releases and released work order outputs are converted to capacity requirements by CRP. If there is insufficient lead time to purchase/produce materials or if capacity to handle the shop orders is unavailable, the CRP module notifies the MPS through the closed-loop feedback system. The MPS can then be updated and modified to make the production plan work (7:36; 10:83; 42:334,371).

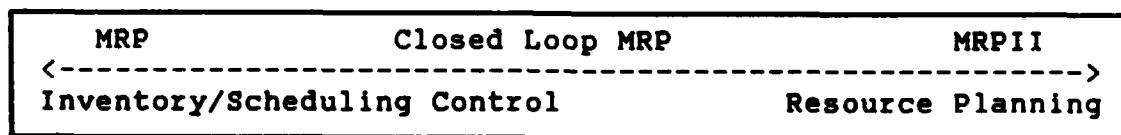


Figure 2. MRP Continuum

Now that the discussion of MRP's basic operation is complete, it is necessary to differentiate between Material Requirements Planning, commonly known as MRP, and Manufacturing Resource Planning or MRPII. The development of Manufacturing Resource Planning can be depicted as shown in Figure 2. As indicated, MRPII is more than an inventory/scheduling control system. It has evolved from MRP into an integrated information system that can be used to manage the entire production process. To accomplish this, it begins with top management's strategic goals and ends up with a detailed master schedule. The closed loop for system feedback is still maintained, but it also extends beyond the daily manufacturing process (see Figure 3). This is done by assimilating the objectives of the personnel, finance, marketing, engineering, and other functional departments to develop a production plan. This production plan is then used to produce a master schedule through the process explained earlier. The Material Requirements Planning (MRP) module contains the system logic but it is only one of many subparts of MRPII (10:83; 27:20).

With a better understanding of how MRP operates, it is now necessary to know why it is important. The next investigative question discusses how a company can benefit from MRP.

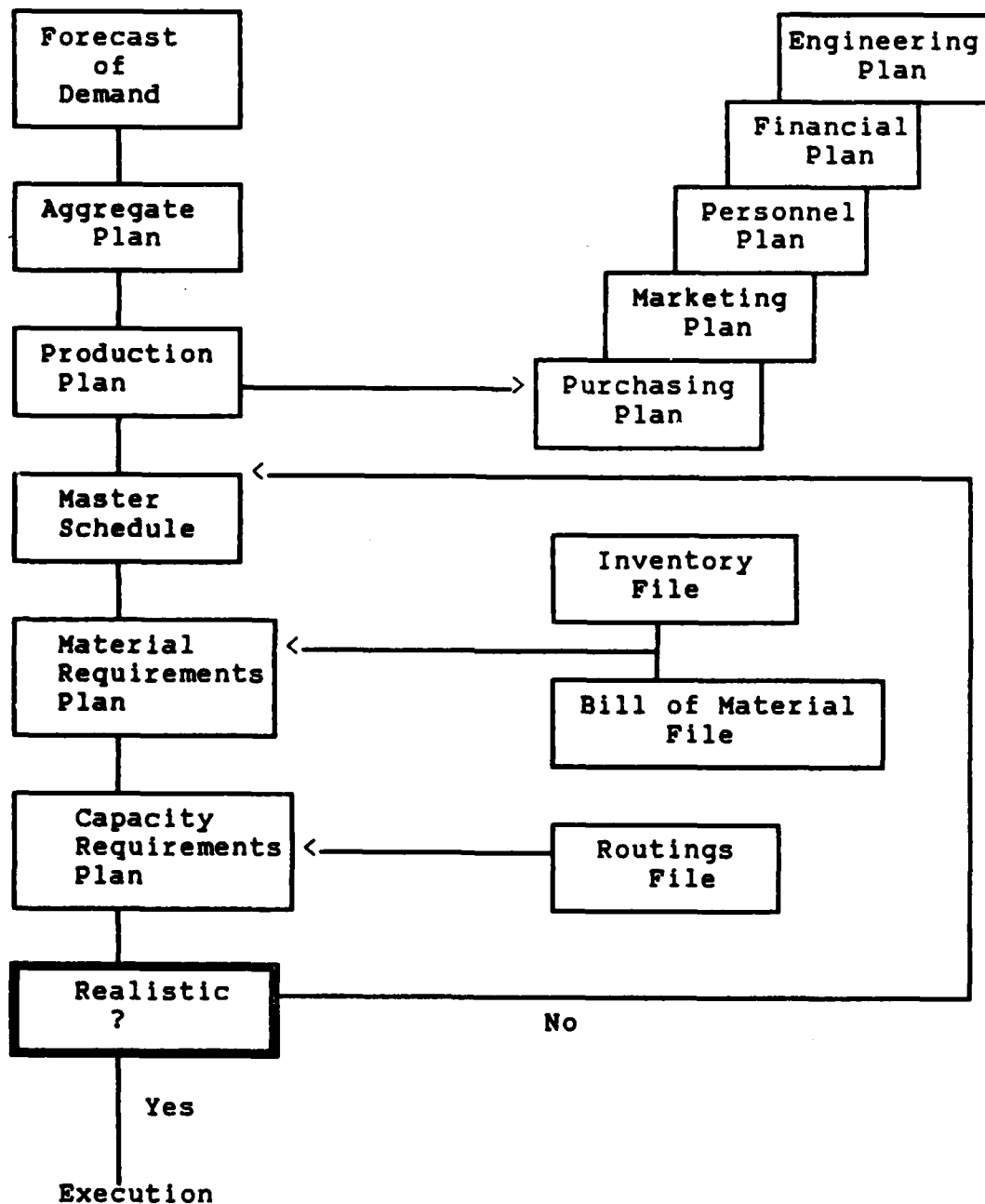


Figure 3. Manufacturing Resource Planning (MRP II)
(10:84)

What are the Benefits of MRP?

There are many benefits that can be derived from using a MRP system. The information available to management is generally more accurate and timely. This translates into better decisions resulting in cost savings and competitive advantage (36:143). As mentioned earlier, improved production scheduling is a benefit as is better inventory control. Although these concepts are difficult to quantify, there has been substantial benefit in other, more objective areas. In a study conducted of 433 MRP users, there was a 34 percent increase in inventory turnover, a 17 percent decrease in average delivery lead time, and a 24 percent increase in meeting delivery promises (2:64).

These benefits represent an increase in cost savings and customer service and could, themselves, warrant an in-depth analysis. For this thesis, however, it is enough to acknowledge their existence. The following discussion addresses the problems that prevent companies from fully realizing the benefits of a MRP system.

What are the Pitfalls of MRP?

Although there may be much to gain from MRP, the majority of the companies that have implemented the system have not realized the benefits as advertised. The literature agrees on several reasons for this disparity and the reason most often cited is a lack of management support (10:97). MRP is a very complicated system and frequently represents a

dramatic change of operation for most companies. If every level of management does not commit to it, employee confidence will not develop and the system will not succeed. If a manual system is allowed to continue as a "backup for the boss," MRP will never be trusted and will be rejected by the workforce.

Poor record keeping will also contribute to MRP failure. The system is dependent on accurate data in several areas-- current end-item forecasts, updated inventories, and comprehensive BOMs. While inventory records for manual control systems are often less than 70 percent accurate, MRP requires 95-99 percent data accuracy or the system will not function properly (30:460). Data errors could result in a build-up of inventory or, maybe even worse, a shutdown of production due to an unexpected lack of inventory. The numbers must be accurate from day one or the system will never be used by the people (47:135). This lack of discipline develops from a shortage of system knowledge and employee awareness which can be eliminated through education and training.

Education of employees is very important and yet often overlooked. Initially, training should expose the employees to the technical aspects of the system. However, education must also be an ongoing process because of job changes, promotions, and terminations. The fear of MRP's technology

and of the uncertainty of change can be reduced through employee education (10:96; 40:116-117).

Finally, fitting the system to the company must be emphasized. "A \$15 million company does not require the level of sophistication of a Fortune 300 company" (45:25). Management needs to select the right level of sophistication required for their company and then adapt the system to the company's environment. At the same time, as changes take place in MRP technology, enhancements should be considered to ensure the system's responsiveness to the changing environmental demands (28:51-52).

What Type Organization is Best Suited for MRP?

According to Wight, "MRP applies wherever there are network schedules concerning materials and production" (47:69). One of the most desirable aspects of MRP is its versatility. It works well with many different types of production: make-to-order, make-to-stock, repetitive, or job lot (5:79).

The Ogden ALC program will use MRP in a repair environment. Although repair is not usually considered a manufacturing process, it does involve a scheduling function, inventories, and the creation of utility of some finished good. Herein lies the responsibility of management--to tailor the system to the specific needs of the company. This process must be done during implementation.

What Issues Should a Successful MRP Implementation Address?

There are numerous checklists and guides available that plan the implementation process of MRP. Undoubtedly, every MRP consultant has probably developed his or her own tool for that purpose. This thesis is not concerned with identifying and analyzing these implementation plans. Instead, it will focus on several common concepts that have been identified as necessary for successful implementation and fall in the category of What, How, and When.

The items needed to make MRP work are referred to by Wight as "critical elements": Technical, Data, and People. Consequently, this thesis will use the same organization when addressing prerequisites for a successful MRP implementation. The technical element refers to the computer needs of hardware and software. Data refers to the master schedule, BOM, inventory records, routings, and work centers. Finally, people refers to the education of everyone affected by the system (47:365). This begins with the Chief Executive Officer (CEO) or Commander and concludes with the shop floor worker at the lowest level. It can also refer to the management of people as a resource. Figure 4 presents the critical elements and the issues identified in the literature as important for a successful MRP implementation. The following section will discuss each in more detail.

Issues. As stated earlier, one of the key reasons for MRP failure has been a lack of management support.

ELEMENTS	PEOPLE					DATA	TECHNICAL	
ISSUES	MGMT SPT	ED	FULL TIME MGR	PROJ TEAM USERS	RESIST CHANGE	DATA	SYSTEM DESIGN SELECT	PILOT
AUTHOR								
ANDERSON, SCHROEDER, TUPY, WHITE BARNES, SMITH	1A	1B			1A	1B		
BENSON	1B	1A	D	2C	D	2C	1A	2B
BENTLEY, ROTHSTEIN, WITT	2C	1A	D	D	2B	2C	D	D
BERGER	1B	1A	2C	2F	D	1A	1B	D
BISHOP	2C	2C	D	D	D	2C	D	D
BLOOD	D	1A	D	D	D	D	D	D
COX, CLARK	1C	D	D	D	1C	D	D	D
DOUCHKOFF	1A	1B	D	2B	2B	1A	2B	D
FIEDLER, ELWELL	2C	1A	D	D	D	D	D	D
FLOSI	2C	1A	1C	2C	2C	1A	2B	1B
FOX	1B	1B	1B	1B	D	2C	1B	1B
HARTLEY	1C	1A	D	2C	D	2B	D	1A
KRUPP	1C	1C	2B	2B	D	1C	D	D
KILMER, GOLDEN	2C	2C	D	D	D	2C	2B	D
MACHON, MYCZEK	1B	D	D	2C	D	D	D	2C
MCHUGH	1C	1A	1C	D	D	1B	1A	D
PFUNDER	1C	1C	D	D	D	D	D	D
SAFIZADEH, RAAFAT	1B	1C	D	D	D	1C	1B	D
STEVENS	1B	1B	D	D	1A	D	2B	D
ROBERTS	1B	1C	1C	1C	D	1C	1C	D
WALLACE	D	1A	D	D	D	D	D	D
WHITE	1B	1B	1B	1B	1B	D	D	1B
WIGHT	1C	1C	D	D	D	1C	1C	D
	1A	1A	1B	D	2C	1A	2B	1B

Figure 4. MRP Issues Matrix

KEY: Author's reference to issue by:

Importance of Issue

1. Critically Important
2. Important

Frequency of Reference

- A. Frequently
- B. Moderately
- C. Slightly
- D. Not Referred to

Consequently, top management involvement should be a primary issue for implementation. As workers become involved in the dual tasking of implementation and carrying out their regular jobs, positive support from management can help sustain the project (4:232).

As reported by Vollmann concerning a major MRP survey, the primary problem identified by surveyed firms while implementing MRP was "education of personnel" (43:38). According to Wight, "Education is the highest priority activity" (47:366). What then is the secret to this education process? The literature, although agreeing on the value of education, does not clearly outline one consistent plan. The most common approach was to break the education task into levels, usually with different educational styles for each level. There are many techniques to choose from, including: seminars, in-house live instruction, video tapes, workshops, company instructors, or guest lecturers. An executive overview session was suggested for top management with a more detailed case study or "hands-on" approach for the lowest level (20:202). The emphasis should be on developing a plan early and tailoring the style to match the target audience.

Another distinction in the literature was the difference between education and training. Wight stated that education teaches "why" and training teaches "how" (47:392). It is this view of education that should start from the first day

of implementation. As a general approach, concepts and relationships of various material management principles are presented (39:85). As the target date for changeover to the new system approaches, training should take place. This will involve specific instruction on different job tasks. Another critical phase coincidental to the education plan is the establishment of an implementation management structure.

How MRP is implemented involves careful planning and organization by the people who will be using the system (24:185). This process involves setting goals and developing a plan to achieve those goals. The key actuator of this plan is the project manager--one who is selected to be responsible and held accountable for the implementation.

Success of the program depends on a strong and effective project manager and the literature agreed that he or she must be full-time (20:199; 24:187; 47:368). Assigning project manager duties to an employee as an "additional duty" is counterproductive and time consuming. Implementation is a full-time process and should receive full-time attention from the leader. The next most important attribute was that the manager be a user, a person aware of the companies needs and how the system will fit in with those needs. It is not necessary to identify the specific responsibilities of a project manager for this thesis; however, they can be found in Hartley (24:188).

Next, a project team must be selected made up of individuals who will use the system after its installation. Typical members might represent manufacturing, engineering, accounting, marketing, or any other major functional area of the company (24:188; 43:380). Team members can be part-time but should be available as required. Shaklee determined it necessary to use more than one full-time employee for its installation and varied the team size from one to seven during the project (20:202). The important point is that management must be willing to release critical people from their regular job to work on the project when necessary. This is usually very difficult because these same people are needed to run the company's daily operation (36:141). With education underway and a strong project team at work, management must be sensitive to the problem of employee resistance to change.

According to Wallace, "massive behavior change is required in companies implementing MRP II" (44:675). Anderson et al considered acceptance (of the new system) along with education and management support as the three main issues for implementing MRP (3:43). One way to oppose resistance or increase acceptance of the system is through user involvement (10:97). In the development of a Decision Support System, Davis states that "not only is user involvement priceless, it also helps generate interest on the part of the user and to reduce some of the inherent

reluctance humans exhibit when confronted with change" (13:188). Another factor influencing employee resistance of the new system is the length of the implementation project.

The literature presents two differing viewpoints on implementation duration. Well known consultants of MRP, such as Wight and Wallace, contend that an 18-24 month implementation schedule is desirable. A longer time frame may result in employee discouragement and a loss of intensity and enthusiasm (44:675; 47:466). In contrast, Branson Sonic Power Company implemented MRP in 1975 but did not consider it successful until 1981 (17:678). Other companies reported similar results. Flosi states that a major program such as MRP should have a "several year implementation period." He points out that in Shaklee's experience, thoroughness was preferred over speed (20:206). Electro-Motive Division of General Motors Corporation first considered MRP in the early 1970's. However, they did not formalize a project team until 1983 and, as of 1985, they expected full system operation in the late 1980's (29:636). As a final example, the Tektronix Plastics Products plant of Tektronix, Inc. began their implementation in September 1982 and received a Class A certification in June 1984. However, they had one false start prior to that attempt and the lessons learned from that failure aided in the final program success (21:304). As the literature indicates, an aggressive implementation plan does not work for every company.

The previous issues needed to be addressed to get the people ready for MRP. With a better understanding of the system, the next issue to be considered must be data accuracy (19:113).

Getting the data ready for MRP can be very time consuming and costly. The literature suggests that the data should be anywhere from 90-95 percent accurate for inventory records and 95-99 percent accurate for BOMs before MRP installation (24:190; 43:372; 47:484-485). Equally important to achieving that accuracy is maintaining it by using techniques such as secure storerooms and cycle counting. All agree that switching to the new system without accurate data will cause the system to fail. Concurrent with the data update, a company should begin the process of hardware and software selection (19:113).

In choosing the right software vendor, it is important to clearly identify the acceptance criteria and require vendors to substantiate any claims (20:200). Any non-generic MRP requirements must be fully explained. When a vendor is selected, the software should be evaluated and used to test the data.

The final step in the implementation process is the use of a pilot or test run. To accomplish this, a single product line or some segment of the company's output should be converted to the system first. This allows the three critical elements to be "checked out" before exposing the

entire company. This test should be used primarily to determine if the people have a thorough understanding of the system or if further education and training is required. Once this is demonstrated, MRP can be used for the remaining product lines (47:375).

Conclusion

The research question asks if any lessons can be learned from the literature by reviewing problems and benefits experienced by other companies that have installed MRP. This thesis must then determine how these lessons are being applied to the MRP implementation at the Ogden ALC.

As covered in this chapter, MRP is a very involved system that offers great advantages to a company, (if implemented correctly). To do this requires management support and attention given to the people, data, and technical elements of MRP. These critical elements are present in every system, regardless of what system customization is necessary. The next step is to determine how the Ogden ALC plan incorporates these critical elements. The methodology for this research will be presented in the next chapter.

III. Methodology

Overview

Chapter I presented the background and the research problem, while Chapter II answered five investigative questions through a literature review. This review began with a look at generic MRP, how it works, its benefits, and its problems and concluded by listing issues to consider for implementation. This chapter will further limit the scope of the research by establishing the methodology for reviewing one phase of MRP at one company, the implementation of MRP at the Ogden ALC. The objective of this methodology will be to answer the final investigative question, How are the MRP Critical Elements being addressed at the Industrial Products and Landing Gear Division at the Ogden ALC?

Methodology

The previous investigative questions established the knowledge base required to address the final question. Information to answer the last question was obtained from unstructured, personal interviews with key personnel associated with the Ogden implementation. The advantage of using the personal interview was the validity of information (12). Because the implementation was in process, much of the primary data had not been recorded and had to be obtained from the people directly involved. This type interview was

especially effective due to the exploratory nature of the thesis research.

A disadvantage of the personal interview was the cost of travel to conduct the interviews. With that in mind, an attempt was made to obtain the maximum information in the shortest period of time. This was accomplished by coordinating the visit with the deputy project manager and establishing interview appointments so as not to significantly interfere with their busy schedule.

Another disadvantage was the potential for interviewer bias (18:166). To reduce the risk of such bias, the respondent was allowed to discuss topical areas freely with minimal input from the interviewer. Each interview was initiated with, but not limited to, the investigative question. Additional input from the respondent was encouraged to gain further insight of the topic. An attempt was made to limit interviews to thirty minutes in length. However, this was not the case for two interviews.

One of the DMMIS project team members served as a liaison for the interviewer for the duration of the visit. In that capacity, he provided a personal tour of the facilities and remained with the interviewer for all subsequent interviews. As a result, he was available to answer questions and provide continuity throughout the course of the visit. Consequently, his interview spanned three days. The other exception was the deputy project manager.

His interview covered each issue in detail and followed the interview instrument of Appendix B. This was in contrast with the other respondents who discussed primarily the issues encountered in their specific work areas. As a result, the DPM's interview lasted approximately 2 1/2 hours. Interviews were conducted with the deputy project manager, the MAN Division Chief, two MAN branch chiefs, one DMMIS project team member, three division project team members, an engineering department supervisor, and a second level shop floor supervisor. All interviews were conducted at the respective user's facilities.

It is important to note that the intent of this study is not to predict the success or failure of the Ogden implementation. This cannot be done for two reasons. First, the implementation phase is a transition from the old system to the new system. MRP can only be tested by using the system and then determining if it performs as planned. This must be done after the implementation phase is complete. Secondly, the concepts involved are qualitative and do not fit a quantitative analysis. What can be identified by this thesis is how the lessons and key concepts from the literature are being adapted and applied to meet the goal of success. As specified in Chapter II, the users must establish goals for the project and the literature indicates that the ultimate goal should be to achieve Class A status (43:370).

Class is a concept of measurability consisting of four levels (A,B,C,and D) developed by Oliver Wight. It is used extensively by industry to categorize MRP companies by performance (43:366). The literature indicates that Class A companies use all the capabilities of the system whereas lower class levels only use them in varying degrees. It is important to note that attaining a level below Class A is not considered failing and, in most cases, constitutes an improvement over previous MRP capability (9:137). However, a company should begin the implementation phase with the intention of maximizing its investment by using the MRP system to its fullest potential--Class A.

The next chapter presents the case study of Ogden ALC's MRP II implementation. Using the information obtained from the previous investigative questions, Chapter IV will show how the project intends to adhere to and comply with the "critical element" issues outlined in Chapter II. The final chapter will summarize the findings of the case study and present any recommendations or conclusions concerning the Ogden MRP implementation.

IV. Analysis of Data

Overview

Having discussed the problem, background, and methodology of this thesis in the previous three chapters, this chapter describes the implementation of MRP at the Industrial Products and Landing Gear (MAN) Division of the Ogden ALC. The objective of this chapter is to answer the final investigative question, How is the MAN Division addressing the "critical elements" of MRP, as described in Chapter II?

Before discussing the issues associated with the implementation, it is necessary to understand what MAN does and how MRP will operate in that environment. To that end, a brief introduction of the MAN Division will be provided followed by a detailed review of the implementation issues.

Introduction

Manufacturing Resource Planning is the focal point of the AFLC program known as the Depot Maintenance Management Information System (DMMIS). The objectives of DMMIS are "to improve surge capability, better maintenance resource utilization, increase maintenance product, and be more responsive to AF requirements" (16).

The Industrial Products and Landing Gear Division at Ogden is the initial test bed for DMMIS. Its primary function is to repair landing gear for all aircraft in the US

Air Force inventory. Repair workloads are negotiated on a quarterly basis with ALC Material Management (MM) personnel. These negotiations result in the requirement to repair a specified number of landing gear for one fiscal quarter. The landing gear (LG) are already removed from the aircraft and are obtained from the ALC Depot Supply (DS). When the end item or LG arrives for repair, it is broken down into component parts which are then inspected to determine repairability. If the parts can be repaired, they are scheduled through the facility in a "push system" fashion (see Appendix A), repaired, and stored until needed for another end item. The repair process can include many subprocesses, including cleaning, chrome plating, baking, and grinding, depending on the specific part. If the parts cannot be repaired, they are returned to depot supply for disposal (46).

With DMMIS, a major change of philosophy will be required. Under the new system, component parts will be processed in two separate phases. The overall process will "push" the items into the initial storage area and then "pull" (see Appendix A) them through the repair facility (see Figure 5). More specifically, end items will be brought into the facility, disassembled, and the component parts will be cleaned and inspected just as they are under the present system. However, at that point they will be stored in an automated storage and retrieval system (AS/RS) before they

LANDING GEAR WHEELS AND BRAKES

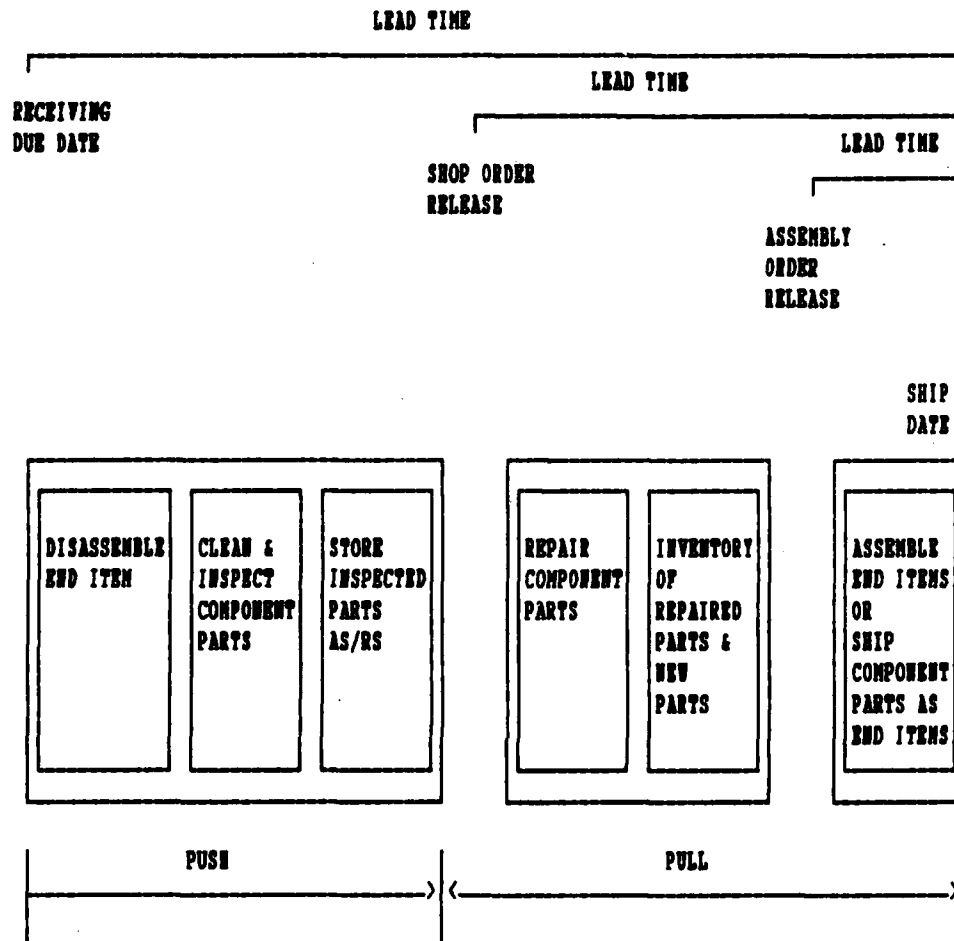


Figure 5. MAN Workflow Using MRP
(46)

are repaired and remain in storage until a demand is generated. When a demand occurs, the broken part will be drawn from inventory based on its repair lead time, repaired, and used for the demanded end item. This procedure will serve two purposes. First, it will greatly reduce the work-in-process (WIP) parts that currently stack up on the shop

floor, causing an idle time of 75 to 80 percent on much of the WIP inventory (38). Secondly, repair will not be performed until an end item is demanded, thereby providing a product to assign accumulated process time (see Appendix A).

Another change will involve the role of shop employees. The current plan is to reallocate personnel and not reduce their numbers. This will be done by cross training workers to work at more than one work center (38). The goal is not necessarily to maximize machines, rather, it is to minimize repair time (end item flow time) (22).

The conversion process began in the summer of 1986 with an operational analysis. This involved a review of the present system and an analysis of what needed to be accomplished to incorporate MRP at the ALC. Phase II, the pre-implementation phase, followed in April 1988 and continues at the present time. The purpose of this phase is to prepare the facility for the conversion, assist management with their transition, and adapt the MRP program to the ALC. In addition, activity lists have been developed to improve inventory control, engineering data, and the BOMs (38; 46). The contractor arrived in April 1988 to survey the user and validate the software requirements. Finally, the target date for full system operation at MAN has been established as April 1990 (46).

The heart of the new system will be an IBM mainframe computer that will interface with the existing Tandem

computer. The present plan is to use the Tandem as a front-end computer to collect daily activity data from shop floor transactions and then update inventory lists, part routings, and schedules. The back-end computer, the IBM, will query the Tandem for the new data, update the entire system and forward the update back to the Tandem. As a result, if the IBM computer should ever go off-line, the Tandem will continue to operate the system with relatively current data (38; 46).

How is the MAN Division Addressing the Critical Elements of MRP?

Each critical element of MRP contains one or more specific issues that must be considered. The following sections discuss the elements by focussing on each issue separately. For organizational purposes, each issue will be reviewed in its entirety before proceeding to the next issue unless the issues are interrelated, in which case they will be discussed together. The issues will be examined in order of relative importance as outlined by the literature review in Chapter II.

People. This element includes such issues as management support, education, project team membership, and employee resistance to change.

Management support. As reported by the literature, management support is critical to the successful implementation of an MRP system. The MAN Division Chief

stated that in any organization contemplating installing MRP, the chief must be "convinced he wants it" or the effort will "slow down to a grind" (25).

There are several examples of management support for the system. The ALC Commander conducts regular briefings on the status of the DMMIS implementation. He has also initiated a new program to evaluate the potential of a center reorganization to better accommodate MRP. This project, known as Project Purple, would restructure each specific workload area (ie. landing gear, armament, sheet metal, etc.) within a product division into a vertically integrated company composed of Material Management, Depot Supply, Procurement, and Maintenance. Each company would be responsible for all functional areas required to support their operation (22). This willingness to undertake such a major organizational change demonstrates the commander's strong commitment to DMMIS.

The MAN Division Chief briefs the people in his division quarterly by talking to small groups of approximately 40 people on various topics such as safety and production. In addition, he always includes a discussion of MRP and the division's current implementation status. He routinely visits the shop floor and questions the workers on specific MRP processes that have been initiated in daily operations. Following one such encounter, a shop floor scheduler sought the assistance of one of the project team MRP experts because

"the boss was asking" about it. As a result of that interest, the scheduler became aware of the process and discovered that it was helpful in her daily scheduling job (25).

Another visible example of support is management's willingness to assign key personnel to MRP duties. The MAN Division alone has 53 people working fulltime on the project with prospects of adding 11 more in the near future. As the implementation date nears, the numbers are expected to continue to climb (22). Members from the Missile and Aircraft Systems (MAK) Division project team acknowledge management's support. Although they are a full year behind MAN in the implementation schedule, management has been very supportive in providing people to assist in gathering data (35). Finally, a MAN production second-level supervisor was equally impressed with the total support from management. He believes that "whatever has to be changed, they're willing to do it . . . whether it be policy, regulation, or whatever to make it work" (31). Still, for management support to be effective, it must be communicated.

Communicating the support can be just as critical as the support itself. The DMMIS Project Management Office (PMO), HQ AFLC, publishes a DMMIS newsletter that is distributed to all ALCs. It contains articles on DMMIS issues from throughout the command. Additionally, each project office is queried quarterly about current status and what direction

they are headed in the implementation process. These newsletters are made available to all personnel throughout the command. At the ALC level, management uses the base newspaper, quality circles, and staff meetings to spread the word about DMMIS (46). A by-product of management support is the encouragement and promotion of project ownership by the employees.

The MAN Division conducted a contest to develop its own logo for the implementation. The logo represented something all division employees could identify with as their own. The effort was so successful that the other two product divisions have developed their own logos and other ALCs have expressed an interest in doing the same. Additionally, MRP II posters were designed, printed, and displayed throughout the ALC to increase employee awareness of the project. Finally, the DMMIS project team members developed their own business cards and name tags to display their pride and commitment to the program (46).

According to the DMMIS Deputy Project Manager, management support for this effort "overall, is very good." The main concern is that there may be a lack of understanding about what is required to make the system work. As typical of most military organizations, this project has multiple levels of management. Consequently, the higher the management structure, the less system detail there is

available to the decision makers (22). Education is a critical factor for increasing this understanding.

Education. Throughout every interview, education (and/or training) was repeatedly addressed. The project team believed that detailed education for mid-level management was critical (46). This placed the knowledge base in a position to influence and motivate those on the shop floor. The MAN Division Chief believed that before any real preparation could begin, his branch chiefs needed education on MRP (25). According to the DPM, "education from the center's (Ogden ALC) point of view has a very high priority, it's how to get through the maze to make it happen" (22).

In examining this issue further, the education efforts of MAN that have taken place prior to the Ogden contract option will be discussed first. Then, a review of the education to be provided by the vendor will be presented.

MAN began its education program with a 16-hour overview class taught at a local college, Weber State, to MAN management personnel in Sep/Oct 1984. This was followed by another overview offering from the winter of 1985 through June 1986. Next, a 20-hour, hands-on course called Systems Aided Manufacturing Management (SAMM), was taught at Weber State until April 1987. At that time it was contracted to be taught on base and continues to be taught at the time of this writing. This course was developed for an MRP novice and designed to walk the user through a basic MRP program

demonstrating the logic behind the system. The Deputy Project Manager (DPM) indicated that this course has been mostly a public relations effort in that it presents just enough information to arouse student interest (22). A member of the MAK implementation team admitted that he had been a skeptic of MRP until he took the course. He indicated that the course "gives you a real good foundation to start to build on. I testify to that" (34).

In the fall of 1987, the local American Production and Inventory Control Society (APICS) chapter was contacted in search of a more detailed course of instruction for tutoring newly assigned project team members (22). As a result, a 63-hour course was developed to cover the main components of MRP and basically follows the organization of the APICS certification program. Its modules include Shop Floor Control, Capacity Management, Material Requirements Planning, Master Scheduling, Inventory Management, and the interfaces with Procurement/Costing. This course is designed to be taught no more than three hours a day, two times a week over a ten week period. Additionally, students are given homework and tested to insure a measurable level of understanding is achieved. The instructor is certified in Production and Inventory Management (CPIM) through APICS, is currently employed in civilian industry as a materials analyst, and has MRP implementation experience. The organization of this course represents some key concepts that the project team

believes are critical for a successful education program (22).

The first concept concerns instructor qualification. The DMMIS contract requires that all instructors must carry the APICS CPIM classification. The DPM believes that this is not sufficient. He believes that "the biggest problem we're going to find (in education) is what's the perception of a qualified instructor." He contends that certification is no substitute for experience and that the two must be combined for an effective education program. Since MRP is a dynamic process, the instructor must be actively involved in industry to be able to relate the most current system theories.

Length of instruction is another concept critical to the education effort for mid-level management. Three hour blocks of instruction are viewed as the most desirable because they don't overburden or "burn-out" the student. It also gives the student the opportunity to reflect on the material from one session to the next. The final concept ascribed to by the implementation team concerns the use of educational tests. Because the material is so detailed and because MRP represents a totally new approach to business, students from the DMMIS environment should be tested to evaluate student understanding (22).

Another educational effort proposed by the implementation team involves the cooperation of Weber State College and the local APICS chapter. Through the

encouragement of the DPM, these two organizations are combining their resources to provide an MRP course at the college for academic credit. The college intends to hire APICS personnel to teach a course based on materials used by a community college program in Oregon. Students employed by the government will be able to apply for tuition assistance to pay for 50 percent of the cost of the class if the course work relates to their job (22).

As of the writing of this paper, approximately 650 personnel have attended the 20-hour hands-on course, 37 have attended operations analysis training, 73 have attended the 63-hour MRP class, 261 have attended an MRP overview course, and an unknown number have attended the Weber State MRP course of instruction. Additionally, several people have attended seminars and classes in California, Chicago, and Ohio (46).

The DMMIS contract requires the vendor, Grumman Data Systems (GDS), to provide education during the 12-year term of the contract. In fact, education alone represents approximately 2 percent of the \$84 million contract cost. It should be noted that at the writing of this thesis, the percentage of contract dollars dedicated to training was unknown. Following the validation of the contract, they will begin their education program in October 1988. Their program will consist of a curriculum of 11 different courses as well as some type of overview offering. Initially, GDS planned on

educating only a percentage of the population by assigning people to selected course offerings. As a result, the most instruction a person could get would be 44 total hours covering every block of the curriculum. This was unacceptable. The Air Force preferred to send a smaller number of people through the entire program to become totally familiar with the system. These people could then pass on their expertise to others in the organization. As a result of this negotiation, a cadre of 300 personnel will receive the entire curriculum of 11 courses--144 hours of instruction. Two thousand people will attend a two day overview course and GDS will provide a predetermined number of executive level seminars. Ogden ALC has approximately 7000 personnel assigned to maintenance. The plan is to have everyone eventually receive at least some type of overview education (22).

Another responsibility of GDS, as directed by the contract, is training. As specified in Chapter II, training is separate from education. Since the new system will make use of a centralized data base, everyone will receive some form of training on how to interface with that data base. The amount of training required will be a function of the individual's job (22).

One issue of education and training should be considered for the purpose of long range planning. When the education and training commitments of the contract are met, should the

ALC continue these programs in-house? This is especially important in view of the high turnover of personnel. The DPM believes that in some critical positions, such as schedulers and planners, the turnover may be approximately once every two years. This emphasizes the need for a strong continuing education program. Fortunately, all education and training material developed and used by GDS for DMMIS will remain the property of AFLC. This will provide a source of course material should the ALC choose to conduct their own program. The DPM believes that keeping the training program in-house and using knowledgeable employees to train others could be a viable approach to future training. A possible drawback to in-house education may be as specified earlier: lack of qualification or experience and currency (22).

The DMMIS contract requires the vendor to provide education to ALC personnel once the Air Force initiates the ALC's option of the contract. The current interpretation of the contract is that GDS is the only vendor that can provide education for DMMIS. As a result, the ALCs cannot contract for education on their own. Therefore, no education will take place at the other ALCs until their contract option is accepted. Consequently, the 20-hour hands-on class and the 63-hour MRP class will no longer be available for the Ogden personnel unless the classes are contracted for by some organization other than Maintenance (46). This presents an interesting paradox. To insure the success of their

implementation, one would expect that the other ALCs would take steps in preparation for their option. These steps should include developing their BOMs, work control documents, inventory files, routings, and other MRP topics. However, until they receive some type of education, they will not understand the system well enough to do any quality preparation. In contrast, MAN has been educating and preparing for this program for three years prior to the start of their option and they believe they still have a long road to travel. There are some initiatives that may alleviate this problem.

Of the proposed cadre of 300 people that will receive the full GDS curriculum, approximately 50 positions will probably be made available to other ALCs. This would allow them to import a core of expertise at their location prior to their contract option. These education positions would then be reimbursed to Ogden ALC when the other ALCs begin their education phase (46). Also, other ALC representatives will be given the opportunity to visit Ogden ALC to observe the implementation in progress. Lessons learned and guidance for systems development will be made available. Additionally, MAN is identifying operations that may be similar to any of the other 17 product divisions within the command (25). If this action proves successful, it could prevent the duplication of efforts and increase the effectiveness of the implementation process. Finally, the continuing education

program at the Air Force Institute of Technology (AFIT) may be able to provide some form of education to "fill the void" for the other ALCs. From this discussion, it is clear that education is a key aspect of the DMMIS implementation.

Project Team. Although this issue is a function of organization that can be applied to all three elements, it will be discussed under the people element. This is because it is concerned primarily with the individuals of the team, their qualifications and their interaction with the rest of the workforce. In discussing this issue, this thesis will follow the example of the literature and divide the issue into two parts: project team manager and project team membership.

As stated in Chapter II, the project team manager should be assigned to the project in a full-time capacity. The DMMIS project team at the Ogden ALC actually has two full-time managers, a Program Manager (PM) and a Deputy Program Manager (DPM). Typical of most military organizations, the PM is a military officer and the DPM is a civilian employee. This arrangement serves two purposes. First, it allows the military officer the opportunity to incorporate his or her experience in military affairs into the project. Second, the civilian employee provides the stability and corporate knowledge necessary to keep such a large, complicated project focussed on its goals and objectives. During the course of this project, there have been two different PMs. This is not

unusual in a military environment where military members are frequently reassigned to new duties at regular intervals. In contrast, the civilian employee is the original DPM. As such, he has been instrumental in developing the objectives of the project and the plan to achieve those objectives. He was characterized as the original champion of this project by many of those people interviewed for this thesis. This quality complements the second desirable characteristic of a project leader; that he or she be a user of the system.

The DPM served in several civil service positions before assuming his present duties. These included Chief, Production Planning Section for MAN and Chief of Logistics Improvement Section for the Resource Management Division. Additionally, he has experience as a private Management Consultant and Senior Management Science Analyst. Finally, he is certified in Production and Inventory Management, CPIM (15:2).

The second part of this issue is the project team membership. Designated as MA-1, the primary members of the DMMIS Project Team represent functional areas of the division: Production, Engineering, Scheduling, and Planning. These individuals are assigned to the team full-time. Additionally, the team has representatives from depot supply, maintenance systems, finance, and computer systems. These individuals represent organizations that will interface with DMMIS. Finally, it should be noted that the DPM purposefully

did not include any personnel with staff backgrounds on the project team. His objective was to use representatives from the shop floor to take advantage of their expertise in division operations (22).

In addition to the primary project team, each of the three product divisions has their own team of full-time employees representing the major functional areas. MAK Division has two representatives from Production and one each from Engineering, Scheduling, and Maintenance Systems. Aircraft (MAB) Division has the same membership as MAK, but with only one production and two engineer representatives. Additionally, MAN has a Quality representative instead of Maintenance Systems. These teams are responsible only for their respective divisions and receive support and guidance from MA-1 (46).

Each project team maintains offices in their respective divisions, collocated with their workforce counterparts. They are available to answer questions about the implementation and they maintain a set of MRP reference publications which is made available to all employees. A primary function of the team is to publicize and increase employee awareness of the project (46).

As part of the organizational structure, multiple steering committees (SC) have been established at different levels in the command, starting at AFLC HQ. Ogden ALC has its own SC chaired by the ALC Vice Commander. This SC

includes members representing all the ALC directorates and serves as a forum for discussing inter-directorate issues (22).

The final issue of the people element that is affected positively by management support, benefits directly from education, and can be identified by an effective project team is employee resistance to change.

Resistance to Change. When the interviewees were asked about their perception of employee resistance to change, the responses ranged from "there's a lot" to "not really" much resistance. Probably the most enlightening response was "that varies with the person you talk to" (35). Of all the issues associated with the critical elements, this one is probably the least quantifiable and the most obscure. To understand the impact of this issue on the implementation, impressions of those people interviewed will be discussed separately beginning with the MAN Division Chief.

He stated, "the key is recognizing that there is always resistance to change." Management support gives the company direction and education provides the knowledge required for the employee to understand the reason for the change. Another, possibly more important factor when dealing with doubting employees is management sensitivity to the demands being placed on the worker. When they are tasked to incorporate a new process or procedure into their daily routine, supervisors must realize that mistakes will occur.

The worker should not necessarily be held accountable for the same production standard if the new procedure has a significant impact on the production process. During the transition, if supervisors believe that their people are putting forth the required effort, they must be willing to stand up and protect them from any repercussions for productivity loss (25).

The engineering branch chief believed that resistance was not significant because, essentially, MRP makes sense. The key is helping everyone understand the benefits of the system and then support will subsequently follow. The principles of MRP are sound, but the first line supervisor must be convinced that the system has something that will help him do his job. Other systems have been tried but they have all failed, primarily because they "really didn't do anything for the guy on the floor" (6).

Another branch chief, for the scheduling and inventory branch, also referred to previous failed programs. He indicated that some people have gone through several failed attempts to improve the system. As a result, they now believe that MRP is something to live with for a year and then it too will disappear. However, he does feel that workers are beginning to see the benefits of the system. He contends that a concept crucial to breaking down the resistance is the realization that roles will have to change on the shop floor. In the past, the production department

controlled material while it progressed through the work centers and the scheduling department controlled it before and after work. Under the new system, he believes scheduling will control the entire process (41).

One of the Engineering Supervisors in charge of constructing the bill of materials and other data documents, has a little different perspective on the issue. He works closely with shop floor personnel and believes there is definitely resistance to this new program regarding his area of expertise. Part of his job is to identify the requirements of each work center and detail the operations to be performed at each work center. Unlike the old system, the new system breaks each operation into suboperations. As a result, workers are concerned about how the same job can be defined so differently under the new system. They want to know if they are losing time or gaining time. Consequently, he believes that some of the people are "terrified" of the new system. At the same time, some of the shop floor mechanics that are using the new documents are happy with them and claim "this is exactly what we needed" (37).

The DPM believes the solution for resistance to change is education. By assuming that all people are rational, the education should give them the knowledge necessary to make the transition. Consequently, he has focused more attention on that issue than any other, as discussed earlier. In working with the change issue, he believes these negative

employees can be divided into two subgroups: those who refuse to make the change and those who are incapable of making the change. Reassigning individuals to different jobs is one solution, but it provides very little flexibility for the manager. Whatever the best solution may be, management must be prepared to deal with both groups. Another important aspect affecting the employee's ability to accept the change concerns the length of time allowed for the transition process (22).

The workers are oriented to "getting the product out the door." They operate an informal system that is very effective in achieving that goal. If the implementation period is too short, they may not be able to transition to using the new formal system and, seeing their production goals in jeopardy, they may return to the informal system. The DPM believes there is an increase of risk because of the short time required for the workers to make that transition. The contract allows two years for the implementation at MAN, but he believes 3-5 years is a more realistic estimate. From the literature, professional consultants such as Wallace and Wight recommend 18 months as a good target for implementation (44:675; 47:376). However, the DPM suggests that the majority of Class A implementations today are successful after 2-3 trials and 6-8 years of preparation (22). Another method for resolving employee concerns about

the changing environment is to visit other companies that have successfully installed the system.

According to the DPM, visiting companies with operational MRP systems can be very effective. In fact, the previous MAN Division Chief, a staunch MRP supporter, became a champion for the program after visiting a private company and witnessing repair and manufacture functions being performed in the same facility. Several problems have been encountered with this method, however. First, the majority of the companies operating an MRP system are smaller than MAN and most people don't believe the associated problems could be the same. Second, MRP is used primarily in manufacturing environments in contrast to the repair world of AFLC. Finally, most people think they should visit an aerospace company to be able to relate the information to their situation. This is especially misleading because the Aerospace Industry lags behind the rest of private industry concerning MRP (22).

Another aspect of employee resistance to change deals with the expectations of project success. As mentioned previously, several unsuccessful management control programs precede this effort. These include the Advanced Logistics System (ALS) and Maintenance Job Tracking (MJT). Although it is important to know that they did exist, it is not the intent of this thesis to discuss them further. However, because of those programs, there are indications that this

project may be perceived as maintenance's last opportunity to prove itself (22). This in turn could put unnecessary pressure on the workforce to make the transition to the new system prematurely. Future events will determine if this perception is valid.

Finally, in the opinion of production people from both MAN and MAK, the production effectiveness report currently in use will be a major obstacle for resolving employee resistance to change. This is a measure of worker productivity which considers the number of manhours expended on each item worked and then accumulates all the time to determine the output per man, per day, in labor hours. Currently, production is tasked with maintaining 94 percent effectiveness which translates to 5.4 labor hours per man, per day. For anything more or less than 94 percent, production is considered ineffective. Instead of using labor hours, those respondents who addressed this problem believed that actual material output, i.e. repaired parts, should be the unit of measurement (31; 34). Others believed the performance measure should be based on the work center's ability to complete work as scheduled (22). Otherwise, the employees will expend great energy using the informal system to control production to maintain the required effectiveness level.

This concludes the discussion of the first critical element, people, and its associated issues. After a company

has addressed the issues of this element, it is ready to move to the next phase, the data element.

Data. This element represents the information required to operate an MRP system. Its accuracy is critical, for without it, the system will not function properly. The issues associated with this element include bills of material (BOM), inventory records, labor standards, work centers, and work control documents (WCD). Although the accuracy of all data is important, the issue that is frequently addressed first is the BOM. This is because it lays the foundation for the remaining data issues.

Bills of Material. The fundamental problem encountered in developing BOMs was establishing an understanding of an MRP BOM. Materials Management personnel maintained what they believed to be true Engineering BOMs, but they were not complete. They showed indenture levels but they did not show any parent/child relationships as required by MRP. As a result, parts were listed at different levels of the end item but it was not possible to tie any of the levels together. Maintenance personnel also believed they had a partial list of BOMs, but they turned out to be nothing more than parts lists. Therefore, the process of developing BOMs for the new system became more involved than originally anticipated (22).

To assist in this process, mechanics from the shop floor were assigned to work directly for the Planning Department.

This was considered very beneficial by the engineers because the mechanics had a true feel for the operation. They were able to describe exactly how and what parts were actually being used to construct a particular item. In some cases, mechanics were using parts that were not in the Technical Orders (TO) because the parts were not available or because the mechanics preferred to use other parts. After the BOM was completed, the mechanic took it to the shop floor to audit it by having another mechanic build the item from the BOM. The process established a good communication flow between the shop floor and engineering and resulted in quality BOMs. A by-product of this effort was a "cleaning-up" of the TOs. Approximately 250 changes to the TOs resulted from this effort including some major rewrites. One TO had to be completely rewritten based on the information discovered and procedures established from this process (37).

The BOM development began in May 1987 and was almost complete at the time of this writing. At one time, there were as many as 18 production people and 22 engineering people working on the BOMs. They produced approximately the following number of BOMs for the respective product families: 592 BOMs for landing gear, 170 for wheels and brakes, 486 for cable/electric/hydraulics, and 6165 for sheet metal (6).

The measurement of accuracy for the BOMs is just as difficult as the development process. According to the DPM, a new measure of accuracy must be developed. The first part

of BOM accuracy is determined if the part number is on the bill. That factor is the same as a manufacturing BOM. However, a repair BOM contains a second component. Since, in a repair environment, a new part may not be used all the time, a usage rate must be calculated. Then the question becomes, is the usage rate accurate? This usage rate will most likely be a changing number and must be figured as a percentage. The standard measure used for manufacturing BOMs of 99 percent accuracy is difficult to apply to the repair environment (22).

Another factor affecting the accuracy of the BOMs is engineering changes to the BOMs and TO changes. MAN has a TO monitor that notifies the planning supervisor when a change arrives. At that point, the BOMs are audited and changed if required. The problem is the system is not very responsive. Materials Management personnel are responsible for making changes and then forwarding those changes to the divisions. It can take as long as six months for the division to receive a change. The only way to expedite this process is for maintenance to assume responsibility for the BOMs, which does not appear to be a viable alternative at this time (22).

Inventory Records. The next issue requiring attention was the inventory files. With the majority of the BOMs complete, the division conducted a wall-to-wall inventory of their work-in-process (WIP) inventory. The Scheduling and Inventory Branch Chief indicated that it was

probably the first such inventory completed in five years. It made all existing inventory visible including that which had been hidden under benches and in tool boxes as "private" safety stock (41). In completing the inventory, the new BOMs were broken down into part numbers. They were then compared to end item quantities documented on work orders and quantities that had been routed in from other shops. These figures were compared to the actual inventory and it was discovered that there was a significant number of parts in WIP that didn't need to be worked (46). A production supervisor involved in the inventory knew there would be excess inventory, but not how much. As a partial explanation, he stated that whenever an item was condemned, its sub-assembly parts would normally stay in WIP and would be unaccounted for by the system. These items (e.g. nuts, bolts, washers) are low in cost but still require manhours to identify and store. In addition, the cost of those operations, including rework, may be more than buying the items new. As a result, it may be possible to throw away some of those items, replace them with new items when needed, and still reduce inventory and cost. After the excess items were identified, they were removed from WIP and stored in a separate facility. They will be cycled back into WIP as required by the shop floor (31). Once the wall-to-wall inventory was complete, a means was needed to maintain the accuracy of the WIP.

All the information gained from the inventory is stored on a micro-computer in a WIP program developed by MAN. The item is entered into the program when the material leaves Evaluation and Inspection (E&I) and enters repair. When the item completes repair or goes back to E&I, it is taken out of the program. Estimated completion dates are also assigned to the item as it enters repair to determine how long it spends in WIP. Eventually this program will be replaced by the more complete and accurate MRP software. However, at the present it is useful for two reasons. First, it gives management control of the WIP inventory. Second, it enables the workers to become familiar with MRP-type data requirements and output products (46).

In addition to the WIP inventory, the division has other inventories that must be controlled, such as maintenance inventory center (MIC) and match-up inventories. MIC inventories are new parts that have been received from supply and are normally stocked for 30 days average usage. They contain thousands of line items of inventory worth over \$1,000,000 in each of 12 MICs (41). Match-up inventories are repaired items that are received from WIP. The division is in the process of securing the three match-up areas by installing fences and gates and restricting access to authorized employees only. Previously, no such measures were taken. MICs are also secure areas with restricted access, but they have been that way for 10-15 years. The division

believes these efforts are necessary to maintain the inventory accuracy at the level required by MRP (46).

Another method for controlling inventory accuracy is cycle counting (see Appendix A). Presently, this technique is being used by individual MICs using a random sampling program on a micro-computer. In conjunction with cycle counting, the MICs are developing an ABC classification (see Appendix A) of their inventory items. This classification will be used to select items for counting based on a predetermined frequency of count and tolerance level. For example, A items will be counted more frequently and have a lower tolerance level of error compared to B items. It should be noted that an independent ABC Classification will have to be completed for each division. This is because, depending on the product line, an A-type item in one division may only be a B-type item in another division (46). It should also be noted that cycle counting is not a random sampling technique. Over a specified period of time, it will produce an inventory of every item in stock. Therefore, it is comparable to a wall-to-wall inventory and so recognized by the accounting profession (22).

Inventory accuracy goals of 95 percent have been established. Initially, before measurement efforts began, MIC inventories were approximately 50-60 percent accurate (22). Within three months prior to this thesis, a complete inventory was made of all 12 MICs assigned to MAN. The

results showed an improvement to 80-87 percent depending on the individual MIC. In fact, one MIC was 100 percent and two others were 98-99 percent (41). Currently, there are no plans to delay implementation should inventory accuracy not reach 95 percent. Instead, they will use the implementation date as the target date and assign manpower as required to reach the accuracy goal by the target date (22; 46).

One other factor normally associated with inventory records is inventory lead time (see Appendix A). This lead time becomes a critical part of the MRP calculation as discussed in Chapter II. Ordinarily, lead times are part of the item master and refer to the time it takes for the company to place an order and receive the parts from the original manufacturer. Normal operation of an ALC would have an item manager computing a requirement for the part, procurement obtaining the part, and supply stocking the part. For DMMIS, supply will be the sole source vendor with a routine fill time of 12 hours; therefore, the lead time for all parts will be a function of how fast supply can deliver the part. In contrast, "for a totally integrated, vertical company with all the functions of item manager, procurement, supply, and repair, lead times would be true lead times as if you were going all the way back to the original manufacturer" (22).

Regardless of how the lead times are determined, it is imperative that the original equipment manufacturer deliver

the materials as required. The MAN Division Chief believes the procurement of parts may be the most critical problem associated with the DMMIS implementation. A private company can demand that the vendor deliver materials at the time specified in the contract as firm lead times and in the quantity agreed to by both parties. If this performance is not met, the vendor can be penalized. However, this type of performance is not normally a part of military procurement contracts. If problems surface in this area, they will become visible very fast and possibly result in major changes to procurement laws (25).

Another area critical to this element is scheduling. Maintaining valid production schedules is a strong point in MRP and one of the key indicators of invalid scheduling is expediting. According to Vollmann as reported by Cox et al., "the inefficiency of the production scheduling system can be measured by the amount of expediting required to maintain control" (10:95). Currently, expediting is the normal operating mode at MAN and MAK. Production foremen spend approximately half of their time expediting parts, materials, and assets (34). In MAN, when replacement parts are not available, a gear assembly is brought in prematurely, disassembled, and the needed part is taken, expedited, and used to complete the repair on the original item. Much time is wasted in this process (31).

Other Data Issues. Many of the other issues in the data element are interrelated, such as work centers, labor standards, and work control documents. Therefore, progress or delays in one issue often impact others. The work control document (WCD) for a particular item identifies all the steps required in the repair process and the work centers responsible for the repair. As described by the planning supervisor, previously a WCD might have listed an operation as "machine part". The new WCD might break that operation down into 10 suboperations. As a result, more work control centers needed to be identified. Also, the additional repair operations and work control centers changed the routing document for the part. Finally, labor standards had to be revised to account for the breakdown of the WCD repair operation. As a result of the finite operations identified in the new WCDs, the number of labor standards increased as much as 42 percent (37). This was not an increase in work time for each item. Rather, it was a more detailed breakout of labor hours associated with the new suboperations. According to the Engineering Branch Chief, this effort was extremely time-consuming. In his experience with the Air Force, labor standards were always written to the Resource Cost Center (RCC) level but never to a particular piece of equipment as required by MRP (6).

Finally, a by-product of the data element is quality. A common response during the interview process was that quality

would become more "visible". The quality specialist from the MAN project team believes that this perception is true because of the availability of data from MRP. The information contained in WCDs and routing documents can assist the quality specialist in tracking a specific part and determining if all processes are performed as required. Currently, this same type of data search is conducted manually and is very cumbersome and time-consuming. To accomplish this in DMMIS, a quality module is being developed that will interact with MRP to extract information that will be fed into a software system for data analysis known as Statistical Analysis System (SAS). This information can then be used for trend analysis and product audits (26).

This concludes the discussion of the data element. Having addressed the issues of the first two elements, a company should be in a position to begin work on the third and final element, the technical element.

Technical. This element has two issues, MRP system selection and the pilot program. System selection is often the most visible aspect of an MRP system because the majority of the implementation cost can be attributed to the hardware and software. Also, because the pilot program represents the final stage of system implementation, it is appropriate that this issue be the last issue of the "critical elements" to be reviewed.

System Design and Software Selection. AFLC took a new approach to the Request for Proposal (RFP) for DMMIS. Their objective was to contract for Commercial-Off-the-Shelf (COTS) software as opposed to their normal procedure of contracting to develop software from scratch. This was done because of the abundance of state-of-the-art software on the market. Also, considering the dynamic and evolving nature of MRP, this would insure that the most current system capabilities would be made available to AFLC in the form of software updates. To accommodate the unique military repair environment, the contract allows for 25 percent software customization (8).

From the beginning, there was very little specific guidance for source selection. To make up for this shortfall, a large amount of time and effort was expended by contracting and program management personnel in developing the functional specifications for the requirements document. As a result, a very detailed RFP was developed which contained additional performance specifications for further guidance. A critical part of this document was an attachment which detailed the system's functional requirements, the L-1 questionnaire. This questionnaire was designed to evaluate proposed application software and was not to be used by the contractor for system design (14).

Another aspect of the RFP that was critical to this program was the Functional Capability Demonstration (FCD).

This was a requirement for all competing vendors to demonstrate their proposed systems, at their expense, to a program validation team. The FCD was to be conducted at the vendor's facility and, using specified data, it had to demonstrate their system's ability to manipulate "what-if" scenarios, provide training to validation team members, operate in a degraded mode, and allow validation team members hands-on access to the system (14).

A program such as this normally attracts an average of three vendors competing for the contract (11). However, in this case, six vendors responded with each one providing enough documentation to fill a schoolroom. This response was unexpected and required contracting personnel two weeks just to log in the material before the review process could begin. During the review a Modification Requirement (MR) took place. This was a major change to the RFP to reduce the system's cost as a result of unexpected budget cuts. Although the MR resulted in significant changes to the RFP, competing vendors did not have to change their entire proposals. Instead, they were only required to respond to the specific areas impacted by the MR (8).

Results of the FCD were especially helpful during source selection. Although all six vendors indicated that they were capable of meeting the functional specifications of the RFP, the FCD proved otherwise. Only three vendors had systems that performed satisfactorily during actual

demonstrations. This may be attributed to the fact that, although there is an abundance of MRP software available, there are very few programs designed to handle repair work on the scale of AFLC (23).

The DMMIS contract was issued on 29 Jan 1988, to Grumman Data Systems. Although the contract has a proposed life of 12 years, it must first be successfully installed at the Ogden ALC Industrial Products and Landing Gear Division. This initial implementation is a test bed for the system and is comparable to a major weapon system "fly-off". If successful, DMMIS will be installed at the other Ogden product divisions, the remaining ALCs, AGMC, and AFLC HQ. However, even if the system passes the test bed requirements, it can still be terminated early at pre-established review points called Critical Design Reviews (CDR)(8).

The basic contract involves the purchase of 19 options, of which the first 8 are for development, architecture, and installation and the remaining options are for maintenance (see Appendix C for contract timeline). Contract costs include \$17 million for the test bed installation and a total cost of \$84 million for the entire AFLC implementation. However, the contract allows for additional purchases of line items such as software, hardware, additional maintenance, and continuing education (8).

The contract began as a three-type hybrid: Firm-Fixed-Price (FFP), Fixed-Price Incentive (Firm Target)(FPIF), and

Fixed Price Incentive (Successive Targets)(FPIS). Following the MR and its associated reduction of costs, the contract was changed to a two-type contract: FFP and FPIF. The FFP applies to off-the-shelf hardware and software. The FPIF and its associated 80/20 share formula pertains to system development and implementation. In addition, the 80/20 share applies to both sides of the target cost (8; 14).

Pilot. Originally, the Aerospace Guidance and Metrology Center (AGMC) at Newark AS OH, was to be a test bed for this program concurrent with MAN. However, because of the expense and the scope of work involved in bringing two pilots on-line at the same time, AGMC's program was cancelled as a test bed and moved further down the implementation schedule. Also, it was felt that AGMC would not be a good pilot because their workload does not adequately represent the other ALCs (23). As a result, MAN will be AFLC's pilot program for DMMIS. According to the DPM, it is doubtful that GDS will conduct a separate pilot initiative within MAN, although their implementation strategy has not been fully released as of this writing. To better understand the options available to GDS, a review of two basic implementation strategies is necessary.

The first strategy results in MRP preparations being accomplished along functional lines in the company. For example, all BOMs and inventory files are updated for the entire company specifically for the MRP module. Then all the

work centers and routings are completed for the capacity planning module. The second strategy involves taking one segment or product line and completing all activities for that portion. That segment is then "turned on" to test the system. Since most sections of MAN are interrelated, it would be difficult to separate one specific area as a pilot. Therefore, the DPM believes GDS will implement MAN using the first strategy (22).

Conclusion

This chapter has addressed the implementation of MRP at the Industrial Products and Landing Gear Division at Ogden ALC. In doing so, the people, data, and technical critical elements were discussed. The people element included all the issues pertaining to the management of a company's most valuable resource. These issues included management support, education, employee resistance to change, and project team organization. These issues must be considered before any further implementation preparation begins. The second element, data, concentrated on the accuracy of the information available to the MRP system. The issues for this element were bills of material, inventory records, work centers, work control documents, and labor standards. In addition, the development of quality as a separate MRP module was reviewed. Finally, the technical element was considered. This element represents the application of technology to the issues of the first two elements. The issues of this element

were MRP system selection and the implementation pilot program.

The purpose of this chapter was to identify how the MAN Division is addressing each of these issues in their MRP implementation process. The final chapter, Chapter V, will present any recommendations resulting from this case study.

V. Conclusions and Recommendations

Overview

This thesis first discussed MRP from a very broad, generic viewpoint. It then narrowed the scope of discussion to a specific MRP implementation. This chapter will step back from the detailed dialogue of Chapter IV and tie all the concepts together. In doing so, first a summary of the thesis will be presented. Secondly, conclusions and recommendations concerning the critical elements will be provided. Next, a personal observation by the author will be offered followed by recommendations for future research.

Summary

By reviewing the benefits and problems associated with MRP, the literature indicates that there are lessons to be learned from civilian industry concerning MRP's implementation. The purpose of this thesis was to determine how these lessons are being applied to the Air Force implementation of MRP at Ogden Air Logistics Center. In developing this research effort, six investigative questions were proposed. The first five questions were designed to establish a foundation for the research.

1. What is MRP and what does it do?
2. What are the benefits of MRP?
3. What are the pitfalls of MRP?
4. What type organization is best suited for MRP?

5. What issues should a successful MRP implementation address?

The sixth question focussed directly on the research problem.

6. How are the MRP Critical Elements being addressed by the MRP implementation at the Industrial Products and Landing Gear Division at the Ogden ALC?

The first five research questions were addressed in the literature review of Chapter II. The critical elements of MRP implementation at Ogden MAN Division were presented in the case study found in Chapter IV. However, before further discussion takes place, some remarks concerning the unconventional nature of this MRP application are in order.

It was noted in Chapter II that MRP is particularly well adapted to manufacturing and works favorably with many different types of production. Through the years, MRP has also been successfully applied to the repair environment. However, these surroundings can frequently produce just as many problems as MRP can solve. In both the MAK and MAB Divisions, repair work required on the majority of end items is never the same. For example, extensive testing on an electrical circuit board may be necessary to isolate a relatively minor repair. Even at that, the test may only be valid for that failure and may need to be reaccomplished to determine if additional failures are present (34). For aircraft, it may not be possible to ascertain exactly what

parts will be required to repair the end item. Individual parts are considered for replacement on a percentage basis (i.e. part A will be replaced on aircraft B 10% of the time) (35). As a result, BOMs are structured for operations and not components.

Another aspect of this program that is especially challenging is the sheer size of the environment. AFLC has approximately 39,000 employees and expends 44 million maintenance manhours a year for repair work. This repair effort is accomplished in 536 buildings at five ALCs, AGMC, and other sites not receiving DMMIS (14). Add to this the fact that the corporate offices (AFLC HQ) are not located with any of the repair centers and one can begin to see the magnitude of this undertaking. It is with these unique characteristics in mind that the following conclusions and recommendations are made.

People Element--Conclusions

This element focussed on four issues: management support, education, project team membership, and employee resistance to change. All of these issues have been addressed by those responsible for the DMMIS implementation at MAN. First, there is evidence of strong management support from all levels of command for both the project and the people tasked with managing the program. This support has come in many forms, including a willingness to provide the quality and quantity of personnel necessary to complete

the job. Additionally, efforts have been made at all levels to publicize the program and to keep it paramount in the minds of all employees.

Second, the project team is made up of users of the system and is headed by two full-time managers. There appears to be a very cooperative relationship between the primary project team, the individual division project teams, the work force in general, and other ALCs. In fact, during this thesis research visit, the project team engineer was on temporary duty to another ALC assisting with their BOM preparation. Continued interaction of this type will be critical to the success of DMMIS.

Third, an extensive education program has provided a strong foundation for MAN's implementation effort. The project team has been very effective in coordinating educational offerings through a local college and in developing an on-base curriculum. However, the availability of pre-implementation education for the remaining ALCs is in jeopardy. Without the access to education prior to an ALC's contract option, the success of that option could be seriously threatened. As indicated by Wallace, "first-cut education" is necessary before any formal implementation begins to inform key personnel of the new system (44:676). Top management, department heads, and project team members must be knowledgeable about the system to work effectively with the contractor at the start of the contract option.

Also, the wearisome job of data preparation should begin as soon as possible. This is especially valid since those people interviewed believed that this area would be beneficial to the division regardless of the success of the project. Data conversion cannot begin without sufficient system education.

Finally, the consensus of the people interviewed indicated that employee resistance to change does exist, although the degree of resistance could not be determined. Generally, the lower the interviewed person was in the management structure, the more he perceived resistance to be a problem. If not suppressed, the ultimate result of this resistance could be a return to the informal system at the expense of the formal system. However, everyone interviewed indicated that resistance has been reduced as a result of exposure to MRP concepts.

People Element--Recommendations

Provisions must be made for pre-implementation education for each ALC to be administered prior to the ALC's DMMIS contract option. This education should be in addition to that provided by the DMMIS contract and could be provided through a civilian college, a local APICS chapter or the Air Force Institute of Technology. The 63-hour course developed by the Ogden ALC project team in conjunction with their local APICS chapter is a good example of such an offering.

An aggressive education plan will reduce employee resistance to change. As demonstrated by MAN, the more the workers learn and interact with MRP, the more comfortable and excited they become about its potential. Continued visible support by management will also be effective in curtailing resistance. Finally, AFLC should carefully reevaluate the timetable for the implementation to ensure that each ALC is provided the time necessary to transition to the new system. The MAN implementation may not provide a good "standard" to measure this time requirement. This is because MAN was provided a "running start" in preparation for this project in comparison with the other ALCs, who must begin "flat-footed." More specifically, MAN began their preparation in early 1985 with their first educational courses and expect full system implementation by April 1990, approximately 60 months preparation time (46). As a result of this education, MAN personnel were knowledgeable enough to complete a large proportion of the data transition and facility preparation prior to the start of their contract option in April 1988. In contrast, the contract options for the remaining ALCs vary from 19 to 30 months (see Appendix C.) This time frame must include all education, data updates, and facility changes. It is reasonable to expect that MAN would take more time to implement than the other ALCs because, by virtue of their test bed status, they must "learn the hard way," a very time-consuming process. Lessons learned from their experience

should greatly reduce the implementation time required by the other centers. Nevertheless, each ALC has a different mode of operation because of their diverse product lines and will require an undeterminable amount of "new" learning to adapt to MRP. Sufficient time must be available for this transition.

Data Element--Conclusions

This element dealt with the issues of bills of material, inventory records, labor standards, work centers, and work control documents. A significant amount of effort has been devoted to developing an accurate data base. A common criticism of people associated with this issue was that the amount of work necessary to get the data in shape was greatly underestimated. This, in itself, will be a valuable lesson for the other ALCs. An equally critical issue is inventory control. Procedures are currently being established to maintain required accuracy through secure storage areas and cycle counting. These efforts will be necessary to maintain accuracy and to emphasize to the shop floor worker the importance of inventory control to the whole system. However, two potential problems exist in this element.

The first problem concerns the relationship between the materials vendor, depot supply, and the user. Maintenance, the user, has little control over the order and purchase of its materials because depot supply, a support agency, is responsible for those functions. Consequently, material lead

times are not well-defined. This is especially troubling given that lead times are critical to MRP's logic and directly affect the entire system. These lead times must be known and they must be dependable. The result is a situation where maintenance has a vested interest in program success while depot supply fills the role of a materials broker with no emotional ties to the project. Herein lies great potential for organizational conflict.

The second problem involves processing technical order and engineering changes. The current system does not appear to respond to the urgency of such changes. Those people responsible for maintaining the BOMs are not assigned to maintenance and do not directly see the impact of changes on the product line.

Data Element--Recommendations

Ogden's company concept, Project Purple, which combines all functional areas in one vertically integrated company, would place the supply function in the user arena. This would give maintenance more direct control over their material and could provide additional incentive for the vendor to perform. Currently, the civilian vendor is only responsible to a "middle man"--depot supply. The new organization would provide a direct interface between the vendor and end user. Additionally, this organizational structure could decrease the processing time of technical order and engineering changes by assigning people responsible

for the BOM, materials management, directly to the using company. There is some concern that the implementation of Project Purple would dilute the management attention currently being devoted to the DMMIS project at MAN. However, if Project Purple is implemented early enough, its organization could be developed before the MRP hardware and software arrive. This organizational change could greatly increase the effectiveness of MRP at Ogden as well as the other ALCs.

Technical Element--Conclusions

Although the purpose of this thesis was to review the implementation of MRP at one division of the Ogden ALC, it is important to consider the issue of system design and software selection with respect to the entire DMMIS program.

A lengthy and in-depth process culminated in the selection of Grumman Data Systems as the DMMIS system contractor. As a result, there appears to be a great deal of confidence in the company's ability to deliver a quality product.

Finally, the experience gained from the MAN pilot will be valuable during the remainder of the DMMIS implementation. Originally, MAN and AGMC were scheduled to be implemented as two separate, yet concurrent pilots. Because it is more practical to implement one pilot and focus all attention on that effort, the decision to use MAN as a single pilot and implement AGMC at a later date appears sound. However,

because MAN is as large as many private industrial companies, it should have a pilot program of its own. This is especially critical since the entire DMMIS project relies on the success of the pilot project in the MAN Division.

Technical Element--Recommendations

As the MAN pilot effort proceeds, it is critical that feedback be provided to the other ALCs. This information can be useful in developing a knowledge base throughout the command. This will be even more important as the implementation timetable progresses to the point where more than one ALC undergoes implementation at the same time. As part of this information crossfeed, lessons learned should be well documented and communicated.

Additionally, the contractor's implementation plan for MAN should be reviewed to ensure that a pilot effort is specified. As stated in Chapter IV, a pilot strategy by functional areas would be the most appropriate for MAN's interrelated product line. This same approach could then be used at each ALC.

Observation

There is a by-product of this program that may prove to be just as valuable as DMMIS itself. The pre-implementation preparation at MAN has identified areas with potential for improvement in an already successful organization. Some of these include inventory control, inventory records, technical

order accuracy, bills of material development, and work order priority. If the DMMIS implementation should not reach its full potential, it appears that the effort will not have been wasted. A new mode of operation, a goal of continuous and incremental improvement, has been established and should continue to benefit MAN.

Finally, a personal, subjective characterization of this project by the author is presented. DMMIS is much more than off-the-shelf MRP II software. It is more than MRP II. It is a new philosophy of business and as such, it has many objectives as stated in Chapter IV. Not only is it to provide interactive communication between AFLC HQ and all the ALCs, it is also intended to improve inventory management (by reducing the sheer size of the command's parts inventory), workload scheduling, and the efficiency and effectiveness of the repair work environment. MRP is a major project in itself and it is only one part of DMMIS. Hopefully, DMMIS has not grown in size and expectations to a point where it cannot function. Finally, from contacts made through the course of this research, there appears to be a general feeling of "guarded optimism" about the project. This is understandable considering the scope of the project. Previous program failures (ALS) were attempted during the infancy of current technology. Hopefully, the lessons learned from these unsuccessful attempts will improve chances of success

for this project. Only time will determine if this optimism will prevail.

Recommendations for Future Research

At this stage of the DMMIS implementation, there is not enough information to predict success or failure. Further research would be appropriate following the completion of the MAN installation, as the implementation begins at the other ALCs. This research could be accomplished in two forms. First, it could be a historical documentation of the implementation efforts at Ogden for the purpose of detailing lessons learned. This information, in a single document, could be very useful in implementing the system at other ALCs. Second, a survey of the users at MAN could be conducted to determine the benefits and costs of the system and implementation problems that were encountered. These findings could then be compared to the survey conducted by Anderson et al. MRP could prove to be a valuable system for other organizations in DOD and should be closely researched and documented for future application.

Appendix A: Glossary of Terms

Except as noted, all definitions obtained from the APICS Dictionary (1).

ABC CLASSIFICATION: Classification of the items in decreasing order of annual dollar volume or other criteria. This array is then normally split into three classes, called A, B, and C. Class A contains the items with the highest annual dollar volume and receives the most attention. The next grouping, Class B, receives less attention, and Class C, which contains the low-dollar volume items, is controlled routinely. The ABC principle is applicable to inventories, purchasing, sales, etc.

BILL OF MATERIAL: A listing of all the subassemblies, intermediates, parts, and raw materials that go into a parent assembly showing the quantity of each required to make an assembly. There are a variety of display formats of bill of material, including single level bill of material, indented bill of material, modular (planning) bill of material, transient bill of material, matrix bill of material, costed bill of material, etc.

CAPACITY: 1. In a general sense, refers to an aggregated volume of workload. It is a separate concept from priority.
2. The highest reasonable output rate which can be achieved with the current product specifications, product mix, work force, plant, and equipment.

CAPACITY REQUIREMENTS PLANNING (CRP): The function of establishing, measuring, and adjusting limits or levels of capacity. The term capacity requirements planning in this context is the process of determining how much labor and machine resources are required to accomplish the tasks of production. Open shop orders, and planned orders in the MRP system, are input to CRP which "translates" these orders into hours of work by work center by time period.

CLASS: A measure of MRP success.

Class A: Closed-loop system used for both priority planning and capacity planning. The master production schedule is leveled and used by top management to run the business. Most deliveries are on time, inventory is under control, and little or no expediting is done.

Class B: Closed-loop system with capability for both priority planning and capacity planning. However, the master production schedule is somewhat inflated. Top management does not give full support. Some inventory

reductions have been obtained, but capacity is sometimes exceeded and some expediting is needed.

Class C: Order launching system with priority planning only. Capacity planning is done informally with a probably inflated Master Production Schedule. Expediting is used to control the flow of work. A modest reduction in inventory has been achieved.

Class D: The MRP system exists mainly in data processing. Many records are inaccurate. The informal system is largely used to run the company. Little benefit is obtained from the MRP system (2:58).

CLOSED LOOP MRP: A system built around material requirements planning and also including the additional planning functions of sales and operations (production planning, master production scheduling, and capacity requirements planning). Further, once this planning phase is complete and the plans have been accepted as realistic and attainable, the execution functions come into play. These include the manufacturing control functions of input-output measurement, detailed scheduling and dispatching, as well as anticipated delay reports from both the plant and vendors, vendor scheduling, etc. The term "closed loop" implies that not only is each of these elements included in the overall system but also that there is feedback from the execution functions so that the planning can be kept valid at all times.

COMPONENT: A term used to identify a raw material, ingredient, part, or subassembly that goes into a higher level assembly, compound, or other item. May also include packaging materials for finished items.

CUMULATIVE LEAD TIME: The longest planned length of time involved to accomplish the activity in question. For any item planned through MRP, it is found by reviewing the lead time for each bill of material path below the item. Whichever path adds up to the greatest number defines cumulative lead time.

CUSTOMER SERVICE: Delivery of product to the customer at the time which the customer or corporate policy specifies.

CYCLE COUNTING: An inventory accuracy audit technique where inventory is counted on a cyclic schedule rather than once a year. For example, a cycle inventory count is usually taken on a regular, defined basis (often more frequently for high-value fast-moving items and less frequently for low-value or slow-moving items. Most effective cycle counting systems require the counting of a certain number of items every work day with each item counted at a prescribed frequency. The

key purpose of cycle counting is to identify items in error, thus triggering research, identification, and elimination of the cause of errors..

DEPENDENT DEMAND: Demand is considered dependent when it is directly related to or derived from the schedule for other items or end products. Such demands are therefore calculated, and need not and should not be forecast. A given inventory item may have both dependent and independent demand at any given time.

END ITEM: A product sold as a completed item or repair part; any item subject to a customer order or sales forecast.

EXPEDITING: The "rushing" or "chasing" of production or purchase orders which are needed in less than normal lead time.

FEEDBACK: The flow of information back into the control system so that actual performance can be compared with planned performance.

GROSS REQUIREMENT: The total of independent and dependent demand for a component prior to the netting of on-hand inventory and scheduled receipts.

HARDWARE: In data processing, refers to the computer and its peripherals.

INDEPENDENT DEMAND: Demand for an item is considered independent when such demand is unrelated to the demand for other items. Demand for finished goods, parts required for destructive testing and service parts requirements are some examples of independent demand.

INVENTORY: Items which are in a stocking location or work in process and which serve to decouple successive operations in the process of manufacturing a product and distributing it to the customer. Inventories may consist of finished goods ready for sale; they may be parts or intermediate items; they may be work in process; or they may be raw materials.

JOB LOT: A specific quantity of a specific part or product that is produced at one time.

LEAD TIME: A span of time required to perform an activity. In a logistics context, the time between recognition of the need for an order and the receipt of goods. Individual components of lead time can include: order preparation time, queue time, move or transportation time, receiving and inspection time.

LOW LEVEL CODE: Identifies the lowest level in any bill of material at which a particular component may appear. Net requirements for a given component are not calculated until all the gross requirements have been calculated down to that level. Low level codes are normally calculated and maintained automatically by the computer software.

MAKE-TO-ORDER PRODUCT: A product which is finished after receipt of a customer order. Frequently long lead time components are planned prior to the order arriving in order to reduce the delivery time to the customer. Where options or other subassemblies are stocked prior to customer orders arriving, the term "assemble-to-order" is frequently used.

MAKE-TO-STOCK PRODUCT: A product which is shipped from finished goods, "off the shelf," and therefore is finished prior to a customer order arriving.

MANUFACTURING RESOURCE PLANNING (MRP II): A method for the effective planning of all resources of a manufacturing company. Ideally, it addresses operational planning in units, financial planning in dollars, and has a simulation capability to answer "what if" questions. It is made up of a variety of functions, each linked together: business planning, sales and operations (production planning), master production scheduling, material requirements planning, capacity requirements planning, and the execution support systems for capacity and material. Output from these systems would be integrated with financial reports such as the business plan, purchase commitment report, shipping budget, inventory projections in dollars, etc. Manufacturing resource planning is a direct outgrowth and extension of closed-loop MRP.

MASTER PRODUCTION SCHEDULE (MPS): The anticipated build schedule for those items assigned to the master scheduler. The master scheduler maintains this schedule and, in turn, it becomes a set of planning numbers which "drives" material requirements planning. It represents what the company plans to produce expressed in specific configurations, quantities, and dates. The master production schedule is not a sales forecast which represents a statement of demand. The master production schedule must take into account the forecast, the production plan, and other important considerations such as backlog, availability of material, availability of capacity, management policy and goals, etc.

MATERIAL REQUIREMENTS PLANNING (MRP): A set of techniques which uses bills of material, inventory data, and the master production schedule to calculate requirements for materials. It makes recommendations to release replenishment orders for material. Further, since it is time-phased, it makes

recommendations to reschedule open orders when due dates and need dates are not in phase. Originally seen as merely a better way to order inventory, today it is thought of as primarily a scheduling technique, i.e., a method for establishing and maintaining valid due dates (priorities) on orders.

NEED DATE: The date when an item is required for its intended use. In an MRP system, this date is calculated by a bill of material explosion of a schedule and the netting of available inventory against that requirement.

NET CHANGE MRP: An approach via which a material requirements plan is continually retained in the computer. Whenever there is a change in requirements, open order or inventory status, or bill of material, a partial explosion is made only for those parts affected by the change.

PLANNING HORIZON: The span of time from the current to some future point for which plans are generated.

PROCESS TIME: The time during which the material is being changed, whether it is a manufacturing operation or a hand assembly.

PULL (SYSTEM): 1. In production, it refers to the production of items only as demanded for use, or to replace those taken for use. 2. In a material control context, it refers to the withdrawal of inventory as demanded by the using operations. Material is not issued until a signal comes from the user. 3. In distribution, it refers to a system for replenishing field warehouse inventories wherein replenishment decisions are made at the field warehouse itself, not at the central warehouse or plant.

PUSH (SYSTEM): 1. In production, it refers to the production of items at times required by a given schedule planned in advance. 2. In material control, it refers to the issuing of material according to a given schedule and/or issued to a job order at its start time. 3. In distribution, it refers to a system for replenishing field warehouse inventories wherein replenishment decision making is centralized, usually at the manufacturing site or central supply facility.

REGENERATION MRP: An MRP processing approach where the master production schedule is totally re-exploded down through all bills of material, to maintain valid priorities. New requirements and planned orders are completely "regenerated" at that time.

REQUIREMENTS EXPLOSION: The process of calculating the demand for the components of a parent item by multiplying the

parent item requirements by the component usage quantity specified in the bill of material.

ROUTING: A set of information detailing the method of manufacture of a particular item. It includes the operations to be performed, their sequence, the various work centers to be involved, and the standards for setup and run. In some companies, the routing also includes information on tooling, operator skill levels, inspection operations, testing requirements, etc.

SAFETY STOCK: 1. In general, a quantity of stock planned to be in inventory to protect against fluctuations in demand and/or supply. 2. In the context of master production scheduling, safety stock can refer to additional inventory and/or capacity planned as protection against forecast errors and/or short term changes in the backlog. Sometimes referred to as "overplanning" or a "market hedge."

TIME BUCKET: A number of days of data summarized into a columnar display. A weekly time bucket would contain all of the relevant data for an entire week. Weekly time buckets are considered to be the largest possible (at least in the near and medium term) to permit effective MRP.

TIME PHASING: The technique of expressing future demand, supply, and inventories by time period. Time phasing is one of the key elements of material requirements planning.

WORK CENTER: A specific production facility, consisting of one or more people and/or machines, which can be considered as one unit for purposes of capacity requirements planning and detailed scheduling.

WORK IN PROCESS (WIP): Product in various stages of completion throughout the plant including raw material that has been released for initial processing, up to completely processed material awaiting final inspection and acceptance as finished product. Many accounting systems also include the value of semi-finished stock and components in this category.

Appendix B: Interview Instrument

Management Support

1. To what degree does top management support this project?
2. Is there a steering committee and to whom do they report?
3. Is top management support visible at every level of the organization?
4. Does top management expect miracles from the implementation project?
5. What evidence is there of management support? (commitment of resources, acknowledgement that something must be given up for training, etc.)
6. Is there a project champion and is the champion high enough in the organization to be effective?
7. Has the center commander briefed all personnel on the potential for improvement in effectiveness?

Education

1. What is the education plan that will be used to prepare personnel for the MRP II portion of DMMIS? (top level management, intermediate supervisors and shop floor personnel)
2. What priority does education have in the overall implementation plan?
3. How many personnel need education? Training?
4. How much education has been done to date? Training?
5. What percentage of personnel will be educated by the implementation date? Trained?
6. What problems do you expect to encounter in educating personnel? Training? (instructor availability, loss of work time, classroom space)
7. Who will conduct education classes for each level? Training? (on-site, off-site)
8. What percentage of the implementation cost will be devoted to education?
9. How much personnel turnover does your division experience?
10. Are you encouraging personnel to become involved in the local APICS chapter and becoming APICS certified?
11. Have you considered and is it possible to use AF funds to reimburse individuals for successfully completing the APICS certification exams?
12. Will in-house trainers be used?
13. Have you considered using AFIT's continuing education faculty for education or training?
14. Do all personnel understand the concepts behind MRP II?

Project Implementation Team

1. Is a full-time manager assigned to the project?
2. Does he believe success is possible?
3. Is the project manager an "insider?"
4. Are all functional areas represented on the project team?
5. Will they be accountable for success?
6. Do they believe that the project will be successful?

Change Management

1. No doubt this project has the potential for being one of the most disruptive in AFLC history. What steps are being taken to prepare personnel for the changes?
2. Do you anticipate any loss in capability during the transition to DMMIS?
3. Has slack been built into the schedule to account for it?
4. What will happen to those who resist the change? Will they be retained? Has the impact been considered?
5. Has AFLC considered sending personnel to civilian companies to study MRP II successes?
6. Are expectations for success very high?
7. What is the impact of success/failure on ALC operations?

Data Accuracy

1. What techniques will be used to develop BOM for products whose component repair requirements are not deterministic? Repair-unique environment.
2. Has BOM accuracy been measured to date?
3. How is BOM accuracy measured?
4. What BOM accuracy goals have been established?
5. Are there plans to delay implementation until the desired level of BOM accuracy is achieved?
6. Are procedures being established to modify BOMs as engineering/TCTO changes are issued?
7. What techniques will be used to maintain inventory accuracy? (cycle counting, secure store rooms, etc.)
8. Has a cycle counting program been established?
9. Has inventory accuracy been measured to date?
10. How accurate are inventory records by location?
11. How is inventory accuracy measured?
12. What inventory accuracy goals have been established?
13. Are there plans to delay implementation until the desired level of inventory accuracy is achieved?

14. Are procedures being established to simplify the transaction processing for inventory actions? (bar coding, paper work elimination through use of on-line terminals.)
15. Are lead times for new parts deterministic? If not, how will stochastic lead times be accounted for in MRP calculations?
16. Is a concentrated effort being made to reduce lead times?
17. Will safety stock be used to account for variability?
18. Will the inventory status be maintained in a single computer?

Pilot Program

1. Will a pilot program be used?
2. What area will be used as a pilot for MRP II?
3. Why was this area selected?
4. Describe the implementation plan?
5. What are the plans for implementation at the other ALCs?

Appendix C: DMMIS Master Schedule

	1986		1987		1988		1989		1990		1991		1992		1993		1994	
	JU	OC	JA	AP	JU	OC	JA	AP	JU	OC	JA	AP	JU	OC	JA	AP	JU	OC
BASLINE	IOC POC POE																	
OO-ALC/NAH	APR 88 APR 90																	
OO-ALC	APR 89 OCT 90																	
AGMC	JAN 90 DEC 91																	
OC-ALC	JUL 90 JAN 92																	
SA-ALC	JAN 91 JUL 92																	
VR-ALC	JUL 91 JAN 93																	
SN-ALC	JAN 92 JUL 93 POC SEP 93																	

Note: Data as of 2 Mar, 1988. Obtained from DMMIS System Program Office.

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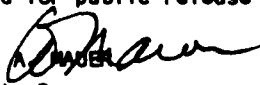
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→ The purpose of this case study was to examine the implementation of Manufacturing Resource Planning (MRP II) at the Industrial Products and Landing Gear (MAN) Division at the Ogden Air Logistics Center (ALC), Hill AFB, Utah. From a review of the literature, this study identified several critical prerequisites for MRP II success. These lessons were considered key issues and fell into three categories, referred to as "critical elements": People, Data, and Technical.

In collecting information for this case study, individuals assigned to the Depot Maintenance Management Information System (DMMIS) System Program Office at AFLC HQ and the MAN Division were interviewed. This case study documents the MRP II implementation at the MAN Division and places special emphasis on treatment of key issues.

→ The issues associated with the People Element included management support, education, project team membership, and employee resistance to change. Although considerable attention has been given to the pre-implementation education at MAN, there is concern that the same preparation may not be available to the other ALCs.

→ The Data Element contained the issues of bill of materials, inventory records, routings, labor standards, work centers, and work control documents. A significant amount of effort was devoted to developing an accurate data base. Although DMMIS is a maintenance program, it will rely heavily on inventory provided by depot supply. → This relationship between maintenance and supply will be critical to the program's success.

The final element, Technical, dealt with system design and software selection as well as the pilot project issue. The selection of a commercial vendor and off-the-shelf software was lengthy and detailed. Additionally, the contract specifies that MAN will be the pilot project for the DMMIS program. → These are the

This study provides several recommendations to improve the chances of success of the program.