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Short Communication

The material requirements planning system for aircraft maintenance and inventory control: a note

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Abstract

Airline operators and maintenance organizations were queried regarding their maintenance and inventory procedures. Of 175 respondents, 152 were using the reorder point system, and the remainder the material requirements planning (MRP) system. The survey was intended to examine the experience of companies using MRP. It indicates that the aircraft parts industry takes this system seriously. However, it is more difficult to implement in the aircraft maintenance environment than in a commercial environment, where the need for spare parts is unpredictable. But if the obstacles are understood and a sound plan is realised by good management, MRP can be successfully implemented, with substantial benefits.

Keywords: Parts management; Material requirements planning system; Reorder point systems

1. Introduction

Traditionally, manufacturing companies have controlled their parts through the reorder point (ROP) technique. Gradually, they recognized that some of these components had dependent demand, and material requirements planning (MRP) evolved to control the dependent items more effectively. However, component parts assembled to meet repair plan requirements for parent parts have a dependent demand, making inventory management more complex. Thus, MRP must be adapted specifically to managing dependent-demand inventory and scheduling replenishment orders.

Continuously monitored and periodic systems are merely order-launching techniques. Aviation companies often use past averages, rather than forecasting parts requirements, to determine how much to order and when. This is often satisfactory for independent demand inventories, but not for aviation parts inventories. This note uses a survey to discuss the MRP's background, its features, and compares MRP and traditional ROP systems. It investigates the extent to which MRP can be applied to aviation operation and maintenance.

1.1. MRP background

MRP determines the quantity and timing of the acquisition of dependent demand items needed to satisfy master schedule requirements. One of its main objectives is to keep the due date equal to the need date, eliminating material shortages and excess stocks. MRP breaks a component into parts and subassemblies, and plans for those parts to come into stock when needed. MRP relates each component or subassembly to every other part and to the component as a whole.

With computer technology advances, maintenance and repairs have become integrated within the system. MRP is sold for manufacturing applications, but it could potentially be useful in aircraft parts inventory. Manufacturing and aircraft maintenance are subject to demand shifts as the result of product or component changes. When the demand for an item can be calculated through its dependence on another item, as with aircraft component overhaul, MRP effectively anticipates future orders based on fluctuations in demand, whereas the ROP inefficiently uses historical averages and triggers one order at a time.

1.2. The aviation industry survey

A survey of 283 aviation companies was conducted and 62% replied. It revealed that many companies were

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seeking alternative concepts such as MRP. Eight airline operators and 15 maintenance service organizations acknowledged the implementation of MRP. The responding companies varied in geographical location, size and method of operation. The preponderance of companies were from Europe (72) and North America (43).

1.3. The use of MRP

Fifteen of the companies using MRP were making use of recognized software packages supplied by a vendor; eight had developed an in-house system designed by a consultant. Nineteen used the same inventory records (e.g., gross requirements, scheduled receipts, projected on-hand inventory, net requirements, planned order receipts and planned order release). Four had introduced additional inventory records.[1] Eight of the companies accepted a computer statement, and 15 accepted a computer statement only after reviewing it. None used manual calculations alone.

Global competition means delivery becomes increasingly important. Lead-times for purchased items are determined following negotiation between the purchasers, within the company and with its suppliers. Thirteen of the companies using MRP companies arrived at their lead-time by agreement and five used past data, based on their knowledge of the market and up-dated it if change occurred. The others used both methods.

Anderson et al. (1982) suggest that most (70.4%) MRP users work in time buckets[2] of one week. But here only five companies used the MRP monthly time bucket. Six applied weekly time buckets because of the volume of items involved, or they used weekly time buckets for 'short jobs' and monthly for 'longer jobs.' Twelve companies worked in days because of the batch quantity of their workload demand. The most popular planning horizon was a year or less; only five used a three-year horizon, and another five used a 1–6 month period. Two companies used a two-year horizon.[3]

To enable MRP to carry out its explosion, the formulas for lot sizing must be part of its computer program. Most companies used more than one method for this.

- Economic order quantity (12 companies).
- Lot for lot technique, the simplest of the variable ordering techniques (11 companies).
- Since fixed order quantity does not exactly match requirements—generating high inventory and creating inventory remnants (four companies).
- Fixed period requirements orders a supply for a given number of periods each time (four companies applied this using regular orders especially for consumable parts).
- Fixed order period, which sets a fixed time between orders and orders the amount required to meet the demand in that period (three companies).
- Part-period algorithm (two companies).
- Least unit cost (three companies).
- Part-period balancing (one company).

Maintenance organizations saw these methods as not applicable to them; they pursued minimum inventory and small lot size.

In terms of safety stocks, four companies did not use them; 19 were applying safety stock to their MRP system. Thirteen were applying safety stock procedures, depending on material significance and cost. Only one applied safety stock methods at all levels; six used them at low-level, and seven restricted safety stock controls to end item (component) level.[4] In theory, safety stock control can be calculated from experience simply by guessing or averaging. However, nine companies surveyed used statistical methods; eight calculated from their own experience, and four took an average by reviewing past usage. No company simply guessed. Three were maintenance organizations ordering parts based on contracts received and did not use safety stock.

The bill of materials (BOM) processor (software package) links the BOM file with the inventory status file so that the requirements explosion accounts for current inventory levels of all components. Nineteen companies applied BOM software packages. The others did not use the BOM software package, as it was not seen as applicable to their business. Six companies used a single-level BOM; nine used multi-level BOM; five used both methods, and the others not use any.

Twenty-one companies used a regenerative MRP system. The most common basis for re-planning with a regenerative system was weekly (13); next common was daily (4). These data can be compared with earlier studies. According to Hamid et al. (1991), 75% of respondents to their survey updated their system by a

[1] Service level 94–96% (an average 95% of demand should be satisfied); consumption forecast based on extrapolation of last two years' consumption; trend analysis (statistical analysis of demand); time gates (asset check alternatives, parts groups (to enable pre-modification stock to be used up; and for on-condition materials, a replacement index used as an expected percentage of removals (additional planning factor).

[2] The body of the record divides the future into time periods called *time buckets*. Time buckets normally represent weeks, but they can be expressed in days or months.

[3] Anderson et al. (1982) found the average planning horizon in MRP systems was 40 weeks. Blackburn et al. (1986) concluded that as the horizon increases, nervousness decreases and cost performance improves.

[4] This compares with Wemmerlov's (1979) survey of 13 MRP installations where three companies used safety stock at all levels; five used them only on low-level items, and five applied them strictly to the end item or finished goods level.

regenerating method. Anderson et al. (1982) found that 56.7% of MRP users updated their master schedule (MS) weekly, while 16.4% updated daily. LaForge and Sturr (1986) found that 45% updated their MS weekly, while 24% did so daily. Anderson et al.'s (1982) study found 30.3% used the net change approach. In a study by LaForge and Sturr (1986), 38% used net change whilst here 14 used net change MRP based on weekly re-planning.

The extension of master scheduling to deal with all master planning and the addition of certain financial features to the closed-loop system was labelled MRP II. Responses saw 11 using MRP, eight using MRP II, and the remainder using both.

In terms of automation, not all replies referred to the same set of criteria. Thus the answers were divided into two groups. The first indicates that nine companies had 90%–100% of their system operating automatically, while five had approximately 50%–80% of their system automated. The second group indicates that three companies' orders were generated automatically as material reached the reorder level but manually when orders were reviewed and released. Three companies operated fully automatically for low-cost parts (consumables) and manually for high-cost parts (rotables), and the other two companies had fully automatic systems for all orders as material reached the reorder level, but these orders were reviewed manually and released automatically via an electronic data interchange (EDI)[5] system. Such a system benefited the company by its direct impact on the financial performance for a number of years, but many airlines' purchasing managers regard EDI as outmoded. The internet offers new opportunities for managing their supply chains (McDonald, 2000).

Thirteen companies used the 'ABC' (Pareto) analysis; six used the standard airline system designating consumables, repairables and rotables. Six enterprises used minimum equipment list (MEL), which considers whether the component is an Aircraft on Ground (AOG) item or not. None applied lead-time blocks (or the availability of ordering the item from the supplier). Seven companies used 'value' or 'average unit price'. Three companies used still other classifications, such as sub-category A–Z, depending on target service level for each item (by service level); warranty liabilities, with new parts issued with warranties; and insurance for slow and fast moving stock. Three companies who carried out only contract work believed this question was not applicable.

Sixteen companies worked to an agreed time only, while five others worked to an agreed time but also monitored progress as the due date approached. None worked to an agreed time plus exchange, and only two worked with an agreed time penalty clause. None relied solely on a contract with no advance time-limit agreement.

What happened when the airline changed the fleet size or brought a new type of aircraft into service and what action would be taken when historical data was not recorded? The survey shows a variety of course of action taken:

- Fourteen companies used their experience or the manufacturer's initial provisioning data to calculate which parts and how many would be required. In most cases they integrated the manufacturer's information with their own experience.
- Eighteen companies asked the manufacturer for initial provisioning data, mostly when new aircraft were introduced.
- Seven used/consulted other operators using the same aircraft and engine type.
- Two companies believed this question did not apply to their business, either because they carried out other operators' aircraft maintenance or they believed the manufacturer's data was not reliable.

2. Benefits of successful installation of MRP

Twenty-two companies were pleased with the results of MRP usage, and one had not had time to assess the merit of its recently installed system. Nineteen saw improved service, and four were still discovering its use. The most common benefits were reduced inventory costs, improved scheduling effectiveness and reduced component shortages (Fig. 1).[6] The survey also indicated other benefits not targeted in the questionnaire: better turn-around time, reduced shelf stock, increased inventory turns, increased inventory turnover rate, minimised outlay and optimised cash flow.

If an MRP system failed, it was for; lack of top management commitment to the project (1 company), lack of education/training in MRP for those who will have to use the system (3), unrealistic master schedule (3) or inaccurate data, particularly BOM data and inventory data (3). This seems to confirm Blood's (1993) belief that most companies who are frustrated with MRP have trouble with its execution, not with the system itself.

Only six companies surveyed had problems. Most indicated that the reason for not realising the full potential of the MRP system was mainly lack of training, unrealistic MS and inaccurate data, particularly BOM and inventory data. One company cited lack

[5] EDI is the computer-to-computer exchange of business documents such as purchase orders.

[6] See also Clode (1993) and Krueger (1990) for comparative analyses.

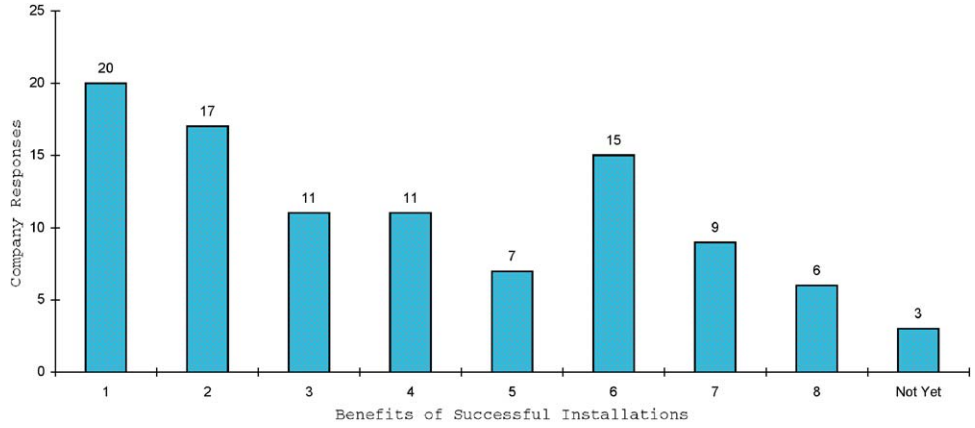

Fig. 1. Benefits of MRP: Legend 1—reduction in inventory costs; 2—improvement in scheduling effectiveness; 3—ability to respond more quickly to market demands; 4—increase in on-time customer deliveries; 5—reduction in over-time costs; 6—reduction of component shortages; 7—reduction of the use indirect labor; 8—reduction of the use of direct labor.

of top-management commitment to the project. Some did have problems initially but ultimately overcame them.

3. Discussion and conclusions

Airlines often believe that their industry's uniqueness comes from a combination of four market characteristics: global need for parts, demand unpredictability, traceability of parts for safety reasons, and high cost of not having a part (AOG). There is some evidence that MRP offers the scope for accurately controlling inventory for reducing stock for schedule airline maintenance. However, presently, few companies use the MRP system, but from the survey it is seen that of the 152 companies who still use the ROP system, about half are dissatisfied and considering implementing the MRP system.

There appears a need to classify problems that arise from MRP use into those associated with management and those arising from technical sources. Of the reasons management cites for MRP system failure most could be resolved with comprehensive MRP education and training prior to and during implementation. The technical sources of difficulty of implementing MRP cited ranged from unpredictable consumption of parts, through unscheduled parts requirements (on-condition maintenance), to difficulty forecasting with unpredictable parts. There are ways around some of these—e.g., Ghobbar and Friend (2003) discuss the forecasting of intermittent demand in relation to these primary maintenance processes.

In conclusion, the MRP survey determined that planning horizon length varied among companies depending on the type of work at hand, in accordance with their planning forecast. We intend to look at the effect of this factor on the MRP lot-size in conjunction with the demand variation. After each repair a multi-level BOM must be updated, with the amending of the end item plans, EIP, and the building of new BOMs using all available data from the manufacturer or other operators. Multi-level BOM was effective for rotables repair but not for airframe work. Replacement parts and other repair material could be entered into the BOM structure as order dependent demanded. This step provided improved inventory and cost control of repairs along with the collection of maintenance information for review and analysis.

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