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AIRCRAFT SPARE PARTS PLANNING AND CONTROL

Miss Sirin Ruangdist

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for the Degree of Master of Engineering Program in Engineering Management
Regional Centre for Manufacturing Systems Engineering
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ในปัจจุบัน ธุรกิจการบินมีการแข่งขันสูงขึ้นมาก ผู้ให้บริการซ่อมบำรุงอากาศยานจึงหันมาให้ความสำคัญกับการวางแผนควบคุมวัสดุสำหรับใช้ในการซ่อมบำรุงอากาศยานโดยใช้คอมพิวเตอร์เข้ามาช่วยในการวางแผนจัดเตรียมวัสดุ หรือที่เรียกว่า Material Requirements Planning (MRP) ซึ่งได้มีการพัฒนาให้มีประสิทธิภาพเพิ่มขึ้นควบคู่ไปกับความก้าวหน้าทางเทคโนโลยีคอมพิวเตอร์

ในวิทยานิพนธ์นี้แสดงให้เห็นการศึกษาเพื่อพัฒนาระบบควบคุมชิ้นส่วนที่ใช้ในการซ่อมบำรุงอากาศยานในฝ่ายช่าง บริษัทการบินไทย จำกัด มหาชน โดยในระบบนี้จะให้ข้อมูลในการตัดสินใจ แก่ฝ่ายบริหารและผู้วางแผนการควบคุมวัสดุ อันได้แก่ รายงานแผนการสั่งซื้อวัสดุซึ่งทำให้เกิดค่าใช้จ่ายต่ำสุด และ แผนการใช้วัสดุในแต่ละเดือน ขั้นตอนในการพัฒนาระบบเริ่มตั้งแต่การศึกษาระบบที่ใช้ในปัจจุบัน, เก็บและวิเคราะห์ข้อมูล, ออกแบบระบบใหม่ และ ทดลองโปรแกรม

หลังจากทดลองใช้โปรแกรมที่พัฒนาขึ้นมาใหม่โดยอ้างอิงกับข้อมูลจริงที่ได้เก็บไว้ ปรากฏว่าผลที่ได้จากโปรแกรมนั้นสามารถลดค่าใช้จ่ายที่เกิดขึ้นจากการบริหารและควบคุมวัสดุได้ถึง 29.4 เปอร์เซ็นต์ อีกทั้งยังให้ผลการทำนายความต้องการวัสดุที่แม่นยำกว่าระบบเก่า ทำให้เกิดการขาดแคลนวัสดุคงคลังลดลง เพื่อให้ได้ผลการทำนายความต้องการวัสดุที่แม่นยำมากยิ่งขึ้น จำเป็นที่จะต้องใช้เวลาเก็บข้อมูลเพื่อให้ได้ข้อมูลมากขึ้น หลังจากให้ผู้ใช้โปรแกรมซึ่งได้แก่ ผู้วางแผนควบคุมวัสดุ และฝ่ายจัดซื้อ ทดลองใช้โปรแกรมแล้วปรากฏว่า โปรแกรมสามารถคำนวนได้ถูกต้อง, ใช้งานง่าย และให้ข้อมูลที่เพียงพอต่อผู้ใช้

ภาควิชาศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต ลายมือชื่อนิสิต.....

สาขาวิชาการจัดการทางวิศวกรรม ลายมือชื่ออาจารย์ที่ปรึกษา.....

ปีการศึกษา 2548 ลายมือชื่ออาจารย์ที่ปรึกษาร่วม.....

4671635921 : MAJOR ENGINEERING MANAGEMENT
KEY WORD: MATERIAL REQUIREMENTS PLANNING / AIRCRAFT MAINTENANCE / INVENTORY CONTROL SYSTEM

MISS SIRIN RUANGDIST : AIRCRAFT SPARE PARTS INVENTORY CONTROL. THESIS ADVISOR : ASSISTANT PROFESSOR DR. PAVEENA CHAOVALITWONGSE, THESIS COADVISOR : NIWAT YUTIBUN, 145 PP. ISBN 974-53-2436-1.

In today's competitive airline environment, maintenance and inventory controls problem have been the primary focus area of maintenance service organisation. This problem can be ameliorated by a MRP system. Fortunately, the increasing of the advent of the computer in nowadays gives an opportunity for development of material requirement planning.

This study concentrates on the improvement of a spare part inventory control system in Technical department, Thai Airways international Public Company Limited, incorporating a decision support system for inventory management. The decision support system involves determining an optimum ordering policy and making report of planned monthly demand and planned order releases for management level. The causes of an ineffectiveness of the current spare part inventory control system are ameliorated. The method of development included: current system analysis, data collection and analysis, system design and program testing and validation.

After testing the program, the proposed system is more cost-effective and more accurate than the current system. The inventory related costs reduced 29.4%. The time spent in spare parts planning and control process, and the shortage were reduced. However, to improve the proposed system to be more accurate, the necessary information such as past demand information should be more gathered. After a system validation by the end users within the Technical department, it was concluded that the program performs the calculation as expected, ease of use, and provides sufficient information for the users.

Department The Regional Centre for Manufacturing Systems Engineering Student's signature Sirin R.
Field of study Engineering Management Advisor's signature Paveena
Academic year 2005 Co-advisor's signature Niwat Y.

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Finally, the author would like to thank her grandmother and grandfather for their support and encouragement. And also, her mother who have always been there to offer inspiration.

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CHAPTER I
INTRODUCTION

Chapter 1 gives an introduction to the thesis. In section 1.1, an overview of what the problem is, what kind of tool would be used and what is inside the thesis are described. A brief overview of the company background and the aircraft maintenance concept are given in section 1.2 and 1.3, respectively. The problem occurring in the organisation is stated in section 1.4. The objective, scope of study, expected result and the expected benefits are given in section 1.5, 1.6, 1.7 and 1.8, respectively.

1.1 Introduction

Thai Airways Public Company Limited (THAI) was founded in 1960 as a joint venture between Thailand's domestic carrier, Thai Airways Company (TAC) and Scandinavian Airlines System (SAS). Technical department which is in charge of aircraft maintenance service provider was founded in 1985 at Donmuang. In today's competitive airline environment, maintenance and inventory controls problem have been the primary focus area of maintenance service organisation. The increasing of the advent of the computer in nowadays gives an opportunity for development of material requirement planning (Kumar and Meade, 2002). In this thesis, a computerised production planning system that uses bill-of-material and production forecast to determine future material needs and purchasing time will be applied to the Technical department to allow it to perform more proficiently.

The aim of this thesis is to develop the spare part planning and control system by applying MRP (Material Requirement Planning) concept to spare parts planning and control in passenger seat shop. The thesis comprises current material planning and control system studying and analysis, programming and program validation. The thesis describes the current spare part planning and control system, the design of the proposed system and the benefit of the proposed system.

1.2 Company Background

Thai Airways International was founded in 1960 as a joint venture between Thailand's domestic carrier, Thai Airways Company (TAC) and Scandinavian Airlines System (SAS) with the Scandinavian carrier initially providing a 30% share capital of two million Baht. In 1977, the Thai Government bought out SAS remaining 15 % holding and THAI became fully owned by the Thai people. In 1985, Technical department which is in charge of aircraft maintenance service provider was founded at Donmuang with the assistance from the SAS. Today, it becomes an important aircraft maintenance service provider in the South-East Asia region. The customers of Technical department are THAI-owned aircrafts and some airlines in Europe, Asia, etc.

In 1999, the new aircraft maintenance hub was founded in U-tapao, Chonburi province, to extend its capacity. In 2001, THAI board of directors announced the resolution for organisation restructuring because of the rapidly changing environment in airline business. THAI commits to provide high quality and reliable maintenance service as a top priority related to the Aviation Authorities such as FAA, EASA, etc. Today, THAI composes of two core businesses: airline business and business units. Figure 1.1 shows the organisation chart of THAI. The business units comprise five business units: Ground customer services, Ground support equipment services, Cargo and mail commercial, Catering and Technical business units.

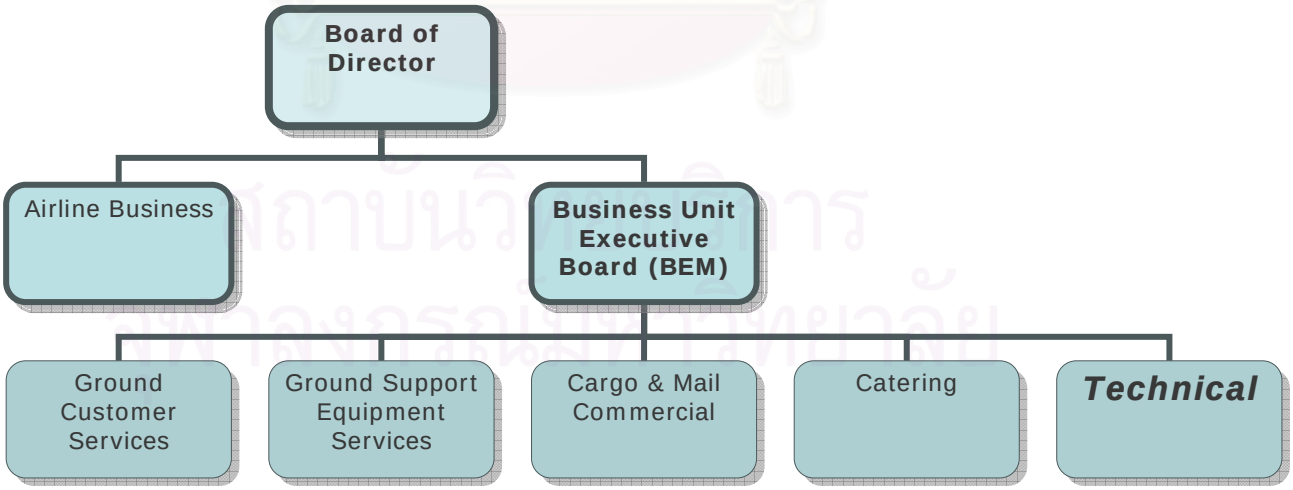


Figure 1.1 Organisation chart

The vision of Technical department is “to be the first choice world class aircraft maintenance, repair and overhaul facilities.”

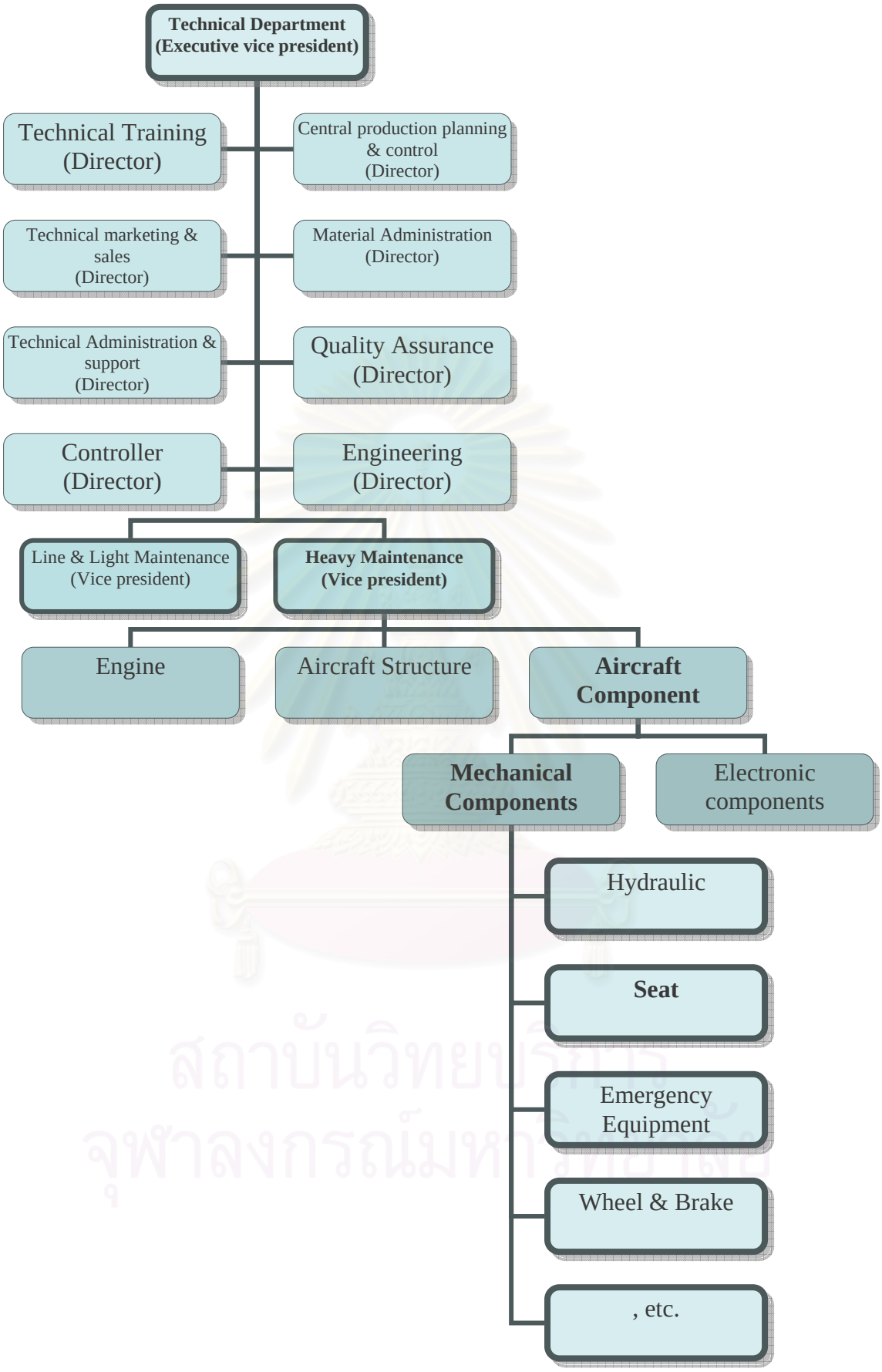


Figure 1.2 Technical department structure

The mission of Technical department is “to deliver products and services with uncompromising safety and the highest quality, together with sustainable environmental friendly standards. The products and services will meet all Aviation Authority Regulation and comply with relevant environmental laws, legislations and regulations”.

Figure 1.2 shows the organisation structure of Technical department. Technical department is separated into two departments: Line and light maintenance department and Heavy maintenance department. Line and light maintenance department is responsible for day-to-day problems to conform Federal Aviation Administration-FAA. Heavy maintenance department is responsible for aircraft maintenance and overhaul.

Heavy maintenance department is divided into three departments: Engine overhaul department, Aircraft structure overhaul department and Aircraft component overhaul department. Aircraft component overhaul department which is in charge of aircraft components repair and overhaul can be divided by types of component into two divisions: Mechanical component overhaul division and Electronic component overhaul division. Each division is composed of several shops. For example, Mechanical component overhaul division comprises hydraulic component shop, passenger seat shop, emergency equipment shop, wheel and brake shop, etc. Because of a huge amount of spare part in Technical department, only spare parts required in passenger seat shop are selected as a pilot project for spare part planning and control system study.

1.3 Aircraft Maintenance Concept

To be in compliance with the FAA constraints, the airline must adopt maintenance policies that every aircraft has to undergo. Figure 1.3 shows overall picture of aircraft maintenance requirement concept. Aircraft maintenance can be divided widely into 2 types: scheduled maintenance and unscheduled maintenance. Unscheduled maintenance will be performed when there is an unpredictable failure such as a structure crack, a leakage of fuel or hydraulic fluid, etc.

Scheduled maintenance is composed of line maintenance, light maintenance and heavy maintenance. Line maintenance is performed before take-off (Maintenance Pre-flight Check-MPC) and every end-of-day (Maintenance Service Check-MSC). Light maintenance is performed monthly. Heavy maintenance is performed every 4,000 fight-hour or 1.5-2

years for C-check, and every 24,000 fight-hour or 5-6 years for D-check depending on aircraft manufacturer.

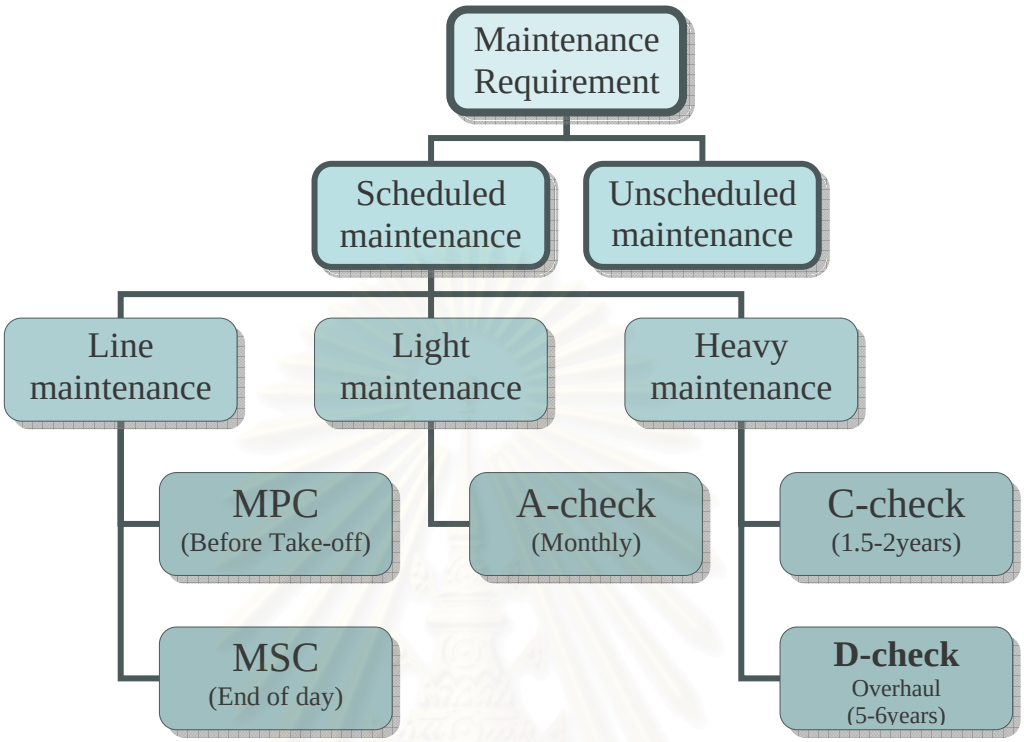


Figure 1.3 Aircraft maintenance requirement

1.4 Problem Statement

The major problem faced in maintenance service provider organisations is the management of spare parts, materials, tools, and equipment. Especially in airline operations business, inventory control problems have been primary focused (Cobb R., 1995). Lack of such things will create delays resulting in economic loss and negative company's reputation since it lengthens maintenance lead times or aircraft on ground (AOG). For example, when there is a shortage of seat cushion, the old one can be reused but the passengers will feel uncomfortable and dissatisfied. If that part is critical, aircraft has to be on ground and wait for spare parts. This unflavoured AOG results in loss of profit since the aircraft is not in serviceable condition. Therefore, spare parts for maintenance work should be stocked in appropriate level. A higher stock level, a higher carrying cost the company has to pay. A lower stock level, a higher loss of profit the company has to face.

The spare part and material planning and control system was set up by Scandinavian airlines systems (SAS) when the company was founded 40 years ago. Material planners performed their works manually by using information from such systems. Now the environment has changed. The number of THAI aircrafts has increased from 10 aircrafts to 81 aircrafts. In addition, the number of aircrafts will be up to 95 aircrafts by 2009. The number of spare parts also increases consequently. Therefore, the spare parts inventory planning and control system should be reviewed and developed to be suitable with current organisational environment.

1.5 Objective

The objective of this study is to design and develop the spare part planning and control system for non-repairable spare parts in seat shop.

1.6 Scope of Study

Spare parts in Technical Department are divided into 4 classes called Spare Part Class (SPC):

SPC 1	Expendable Parts	A part for which no authorized repair procedure exists or which the cost of repair would not be economical.
SPC 2	Repairable Parts	A part which is economically repairable and can be reused as a serviceable part. Normally, these items are assemblies but also include units without component parts which can be reworked.
SPC 3	Rotable Parts	A part that can be economically restored to a serviceable condition over period approximating the life of the fight equipment to which it is related.
SPC7	Recoverable Parts	A part which may be repaired one or more times before scrapping.

Spare part class does not include consumed material such as screw, nut, etc. When spare part SPC 2 or SPC 3 breaks, it would be sent to responsible shop. For example, if a coffee maker breaks, it would be declared as an unserviceable unit. A serviceable unit would be demanded from store and replace the broke one. The broke one would be sent to electronic

shop for repair. Then it would be serviceable unit and returned to store. Spare part SPC 1 can not be repaired while SPC 7 is authorised to have some minor repair in work front when the damage is not crucial. Therefore, spare parts SPC 1 and SPC 7 can be supplied by vendor only while spare parts SPC 2 and SPC 3 can be supplied by both vendor and repair shop. In this thesis, spare parts SPC2 and SPC3 would not be studied because the number of repairable parts returned to store in each year is unpredictable, and repair lead time is not reliable. Only spare parts SPC1 and SPC7 which have high turnover per year would be studied and gathered part information.

ABC Analysis is used for item aggregation because of its simple procedure. The analysis indicates that 15% of seat spare parts SPC1 and SPC7 account a large proportion of the turnover (75%) as shown in figure 1.4 and table1.1. Therefore, in this thesis the seat spare parts SPC1 and SPC7 in class A would be taken to account.

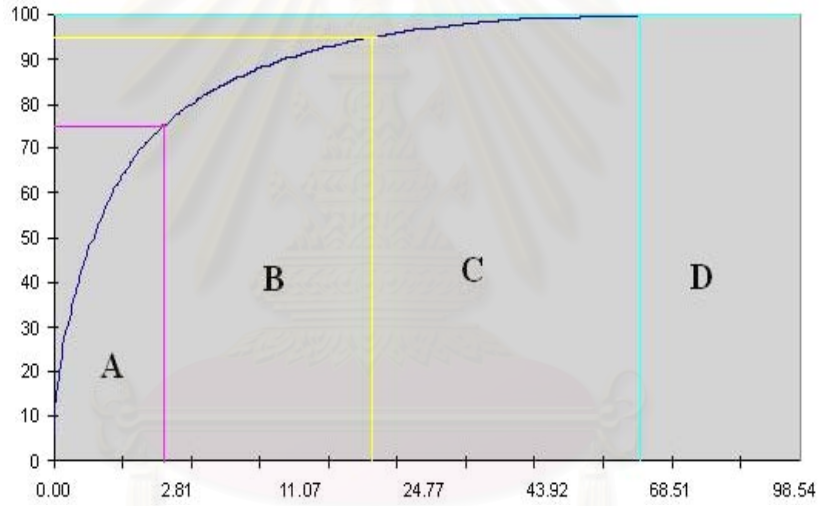


Figure 1.4 ABC Analysis

Table 1.1 ABC classification of seat spare parts SPC1 and SPC7

Code	Value		No. of items	Item (%)
	% of total	Baht/year		
A	≤75%	3,130,725	81	15
B	≤20%	834,860	155	28
C	≤5%	208,715	242	45
D	= 0	0	67	12
Total	100%	4,174,300	545	100

In conclusion, the scope of study includes;

- The proposed system will be developed by using some spare parts SPC 1 and SPC7 in class A as an example.
- The proposed system will be able to manage and control other spare parts SPC1 and SPC7 in different shops.
- Implementation of the proposed system including training of staff will not be included in this thesis.

1.7 Expected Result

The expected result is the proposed system for spare part planning and control which could be applied to other spare parts SPC1 and SPC7 in different shops.

1.8 Expected Benefits

The expected benefits of the proposed system are as follows;

- it will improve the spare part planning and control system to be more efficient.
- it will be ease of use.
- it will reduce paper works.
- it will reduce load carrying by material planners and purchasing personnel who are responsible for several thousand spare parts in many shops.
- it will provide useful information for material planners and management level in decision-making.

CHAPTER II
THEORETICAL BACKGROUND AND LITERATURE REVIEWS

The theoretical background used in this thesis including definition and objectives of MRP, independent and dependent demand, time-phased record, inventory-related costs, lot sizing techniques, cause-effect diagram, sample statistic and ABC analysis are described in section 2.1. In section 2.2, a brief review of the literatures relevant to the using of MRP in various industries and spare part inventory control is described.

2.1 Theoretical Background

2.1.1 Definition and Objectives of MRP

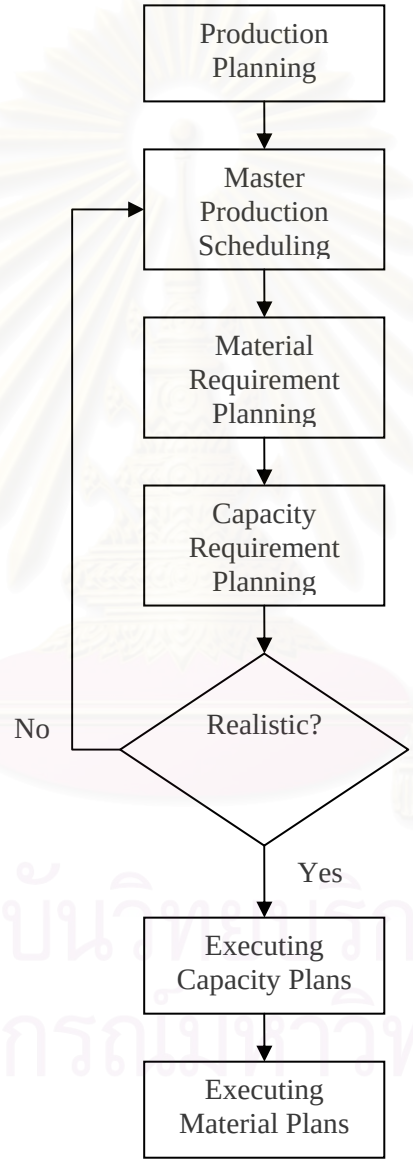
MRP, Material Requirements Planning, or sometimes referred to mrp and MRP-I is a computerised production planning system developed in the late 1960s and early 1970s which integrates company information to plan the activities in a manufacturer. MRP has been a set of planning techniques which enables management to operate in a manufacturing environment resulting in more efficient operations in term of material control. Wong C.M. and Kleiner B.H. (2001) gave an interested explanation of MRP that the heart of MRP concerns four questions. There are: 1) What are we going to make?; 2) What does it take to make it?; 3) What have we got?; 4) What do we have to get? MRP generates procurement and production planning from the master production schedule, bill of material and the inventory record. Therefore the success of installing the MRP system depends on realistic and accurate information including accurate forecast, accurate on-hand inventory information and accurate bill of material.

The objectives of MRP are;

1) to ensure that there will be sufficient materials needed for planned production.
2) to control inventory level to be minimise all the time

3) to help material planner planning when and how many to order

MRP-II, Manufacturing Resource Planning, is a new evolution of MRP. MRP-II integrates all functions including manufacturing, marketing, technical support and finance to make a one set of data for the company so MRP-II can be referred to “Closed Loop MRP” as shown in figure 2.1. The objective of MRP-II is to improve productivity through efficient resource utilisation.



Adapted from Fundamentals of Material Requirements Planning, Management Research News, Vol. 24 No.3/4

Figure 2.1 Closed Loop MRP

Kumar and Meade (2002) pointed the problem with MRP in current manufacturing environment. The first is the requirement for immediate delivery from the customers and second, an increased complexity in products. In current circumstance, customers have higher bargaining power when products being purchased are standard or undifferentiated. They can negotiate price, lead time, warranty and accessory packages. Since the number of competitor increases, the competitors become more equal in size and capability. The firms that have adopted new inventory management system such as MRP and could provide products at the lower price and shorter lead time would have a competitive advantage over the competitor. Although MRP can offer plans for ordering parts for each item, the lead time must be constant along the periods in the plans. MRP could not cope with the change of near incoming due date. The increasing of complexity of product is also a problem of MRP because some parts are not only used in few assemblies but may be used in many assemblies, and also subassemblies. Database used for MRP calculation then must be large and flexible for updating item information.

2.1.2 Independent Demand and Dependent Demand

Demand can be separated into 2 types: independent demand and dependent demand. Independent demand means demand of each item does not depend on each other, for example, demand of the finished products, demand for service parts, etc. Independent demand will fluctuate according to season or market environment change. Vice versa, dependent demand means demand of each item depend on demand of a higher level assembly, for example, demand of subassemblies, demand of component part, etc.

2.1.3 Time-Phased Record

MRP is developed for controlling parts which are dependent parts to be more effective than the ROP system. The role of MRP is to control required parts to support the master production schedule. The hearth of MRP is a presentation of the status and plan for each item which called time-phased record. Time-phased record displays the following information:

Gross demand: The expected future usage or demand for the item in each period

Planned order receipts: The existing orders due in at the beginning of each period

Beginning inventory level: The inventory on hand at the beginning of each period which does not include planned order receipts yet

Ending inventory level: The projected inventory status at the end of each period

Planned order releases: The planned replenishment orders for the item at the beginning of each period

Table 2.1 Time-phased record

		2004																
		Jul				Aug					Sep				Oct			
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
LT 8 wk	Gross demand																	
	Planned order receipts																	
SS 2 EA	Beginning inventory level																	
	Ending inventory level																	
	Planned order release.																	

where LT = Lead time = 8 weeks

SS = Safety stock = 2 items

In table 2.1, one period is one week. The number of periods presented in the record is called “planning horizon” which indicates the number of future periods in the plan. From table 2.1, the planning horizon is 17 weeks.

The material planners are directly involved with the MRP system. They are responsible for making decisions to plan and control material to be capable of meeting all maintenance schedules. Key actions taken by the MRP planners are (Vollmann, T.E. et al., 1992):

- Release orders
- Reschedule due dates of existing open orders when desirable
- Update planning factors for the spare parts under control
- Reconcile errors and eliminate these errors

2.1.4 Inventory-Related Costs

Cost related to inventory is not only cost associated with managing inventory which is most visible. There are three costs which most widely known in the context of inventory management: cost of preparing an order, cost for keeping inventory and cost incurred when there is a shortage.

Ordering cost

Ordering cost is the time and extra cost required to place an order for an item, receive it, handle the bill, and pay for it (Hohenstein C.L., 1982). This cost associates with issuing paperwork, order preparation, maintaining files, controlling quality, verifying accurate receipts, and other hidden costs.

Holding cost

Holding cost is the cost necessary to hold goods in stock for a year. This cost associates with investment on security, the cost of capital which is incurred on the inventory investment and the return on investment which could not be undertaken because funds must be committed to inventory. This cost could be taxes and insurance on inventory, costs of inventory obsolescence and costs for storing and operating inventory such as heat, light ad labour.

Shortage cost

This cost incurs when demand exceeds the available inventory on hand. It includes cost for keeping track of a back-order and income lost when the customer purchases the product from the competitors. Moreover, the shortage cost could not be measure when the customer goodwill is lost.

2.1.5 Lot Sizing Techniques

Lot sizing is a big issue for material planning management. No one method is suitable for all items. An appropriate approach depends on nature of demand of each item. There are many approaches to design the order quantity and time to order as follows;

- Lot For Lot (LFL)
- Economic Order Quantity (EOQ)
- Period Order Quantity (POQ)
- Part Period Balancing (PB)

Lot for Lot (LFL)

The easiest ordering policy is Lot-for-Lot which orders the exact amount needed for each period. This approach is not cost effective when fixed replenishment costs are high.

For example, in table 2.2, lead time for delivery part is 8 weeks. The beginning level after subtracting by safety stock of 2 items is 80 items. The net demand in week 36 is 20 items. Therefore planned order receipt in week 36 should be 20 and order must be placed in week 28. With this method, the order must be placed three times within 22 weeks period. Assume that ordering cost is 100 baht per order, and holding cost is 0.1 baht per item per week. The cost incurred when use LFL method are;

Ordering cost	=	3 x 100	=	300 baht
Holding cost	=	(80 x 9) x 0.1	=	72 baht
Total cost	=	300 + 72	=	372 baht

Table 2.2 LFL ordering policy

		2004																				
		Jul				Aug					Sep				Oct				Nov			
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
LT	Gross demand										100				50				60				
8	Planned order receipts										20				60				60				
SS	Beginning inventory level	80	80	80	80	80	80	80	80	80	80	0	0	0	0	0	0	0	0	0	0	0	0
2	Ending inventory level	80	80	80	80	80	80	80	80	80	0	0	0	0	0	0	0	0	0	0	0	0	0
	Planned order release.		20				60				60												

Economic Order Quantity (EOQ)

For the Economic Order Quantity ordering policy, the order quantity is equal to EOQ or may be times of EOQ. There are some assumptions when use this approach.

1. The demand rate is constant and deterministic.
2. The order quantity need not be an integral number of units, and there are no minimum or maximum restrictions on its size.
3. The item is independent from other items.
4. No shortages are allowed.
5. All parameters will be the same values for a long time.

$$EOQ = \sqrt{\frac{2DK}{I}}$$

$$= \sqrt{\frac{2 \times 10 \times 100}{0.1}} = 142 \text{ items}$$

; D = Demand per week

= (100+60+60)/22

= 10 items per week

K = Ordering cost = 100 baht per order

I = Holding cost per item per week

The economic order quantity is 142 items. From table 2.3, net demand of week 36 are 20 items. Order receipt in that week then should be 142 items. The ending level in week 36 then equals 142 + 80 – 100 = 122. In week 40, net demand is 60, but the beginning level is 122. Therefore, no order has to be placed. Similarly, in week 44, the beginning level is 62 therefore no order has to be placed.

The cost incurred when use EOQ method are;

Ordering cost = 1 x 100 = 100 baht

Holding cost = [(80 x 9) + (122 x 4) + (62 x 4) + (2 x 5)] x 0.1

= 146.6 baht

Total cost = 100 + 146.6 = 246.6 baht

Table 2.3 EOQ ordering policy

		2004																						
		Jul				Aug					Sep				Oct				Nov					
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
LT	Gross demand										100				50				50					
8	Planned order receipts										142													
SS	Beginning inventory level	80	80	80	80	80	80	80	80	80	80	122	122	122	122	62	62	62	62	2	2	2	2	
2	Ending inventory level	80	80	80	80	80	80	80	80	80	122	122	122	122	62	62	62	62	2	2	2	2	2	
	Planned order release.		142																					

Period Order Quantity (POQ)

The period order quantity or sometimes called POQ approach is to use a fixed order quantity based on using the average demand rate D in the EOQ equation. This approach is in contrast to the EOQ approach, which has irregular timing

but constant quantities. When there is significant variability in the demand, cost performance is better than EOQ (Silver E.A., 1998).

$$\text{Average time} = \frac{EOQ}{D}$$

$$= \frac{142}{10} = 14 \text{ weeks}$$

Therefore the average time that using all 142 items is 14 weeks.

Order quantity = Net demand x Average time

From table 2.4, net demand in week 36 is 20. The order quantity then is 20 x 14 = 280.

The cost incurred when use POQ method are;

Ordering cost = 1 x 100 = 100 baht

Holding cost = [(80 x 9) + (260 x 4) + (200 x 4) + (140 x 5)]x 0.1

= 326 baht

Total cost = 100 + 326 = 426 baht

Table 2.4 POQ ordering policy

		2004																						
		Jul				Aug					Sep				Oct				Nov					
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
LT	Gross demand										100				60				60					
8	Planned order receipts										280													
SS	Beginning inventory level	80	80	80	80	80	80	80	80	80	80	260	260	260	260	200	200	200	200	140	140	140	140	
2	Ending inventory level	80	80	80	80	80	80	80	80	80	260	260	260	260	200	200	200	200	140	140	140	140	140	
	Planned order release.		280																					

Part Period Balancing (PB)

This approach is to select the number of periods which the holding cost is mostly close to the ordering cost. The assumptions are made until the most balanced point is obtained. Part Period Balancing is sometimes called the Look-Ahead/Look-Back technique. Using PB approach requires computerised system to calculate the large amount of numbers and assumptions.

From table 2.5, net demand in week 36 is 20.

1st assumption: order quantity = net demand of week 36

= 20 items

Ordering cost = 1 x 100 = 100 baht

Holding cost (week 36 to week 39) = 0 baht

Ordering cost – Holding cost = 100 - 0 = 100 baht

2nd assumption: order quantity = net demand of week 36 + net demand of week 40

= 20 + 60 = 80 items

Ordering cost = 1 x 100 = 100 baht

Holding cost (week 36 to week 43) = (60 x 4) x 0.1 = 24 baht

Ordering cost – Holding cost = 100 - 24 = 76 baht

3rd assumption: order quantity = net demand of week 36 + net demand of week 40 + net demand of week 44

= 20 + 60 + 60 = 140 items

Ordering cost = 1 x 100 = 100 baht

Holding cost (week 36 to week 48) = [(120 x 4) + (60 x 4)] x 0.1

= 72 baht

Ordering cost – Holding cost = 100 - 72 = 28 baht

The third assumption makes ordering cost and holding cost most balanced. Therefore, the planned order release should be 140 items as shown in table 2.5. The cost incurred when use PB method are;

Ordering cost = 1 x 100 = 100 baht

Holding cost = [(80 x 9) + (120 x 4) + (60 x 4)] x 0.1 = 144 baht

Total cost = 100 + 144 = 244 baht

Table 2.5 PB ordering policy

		2004																				
		Jul				Aug					Sep				Oct				Nov			
		27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
LT	Gross demand										100				60				60				
8	Planned order receipts										140												
SS	Beginning inventory level	80	80	80	80	80	80	80	80	80	80	120	120	120	120	60	60	60	60	0	0	0	0
1	Ending inventory level	80	80	80	80	80	80	80	80	80	120	120	120	120	60	60	60	60	0	0	0	0	0
	Planned order release.		140																				

2.1.6 Cause-Effect Diagram

The cause-effect diagram or Ishikawa diagram or fishbone diagram is an effective tool for problem-solving process. It is used to trigger and promote ideas gotten from brainstorming. The perceived sources (cause) and problem (effect) are constructed as a diagram as shown in figure 2.2. The cause-effect diagram often comprises 6 causes that contribute to effect: materials, machine, method, personnel, measurement and environment. Each one of those causes is then investigated for sub-causes.

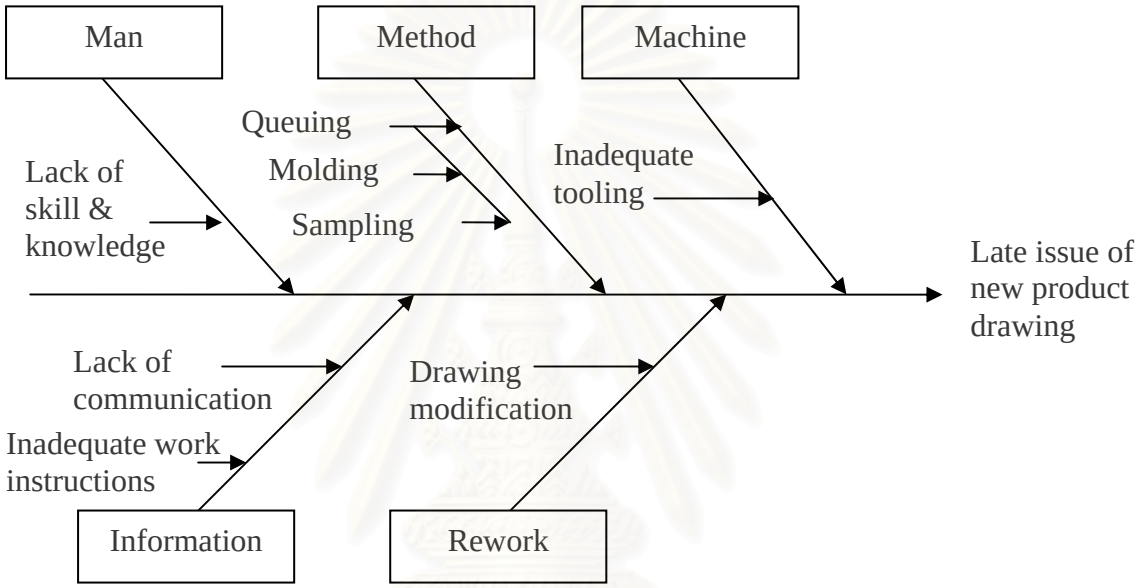


Figure 2.2 Cause-effect diagram

2.1.7 Sample Statistic

A well-know statistic for a sample is the mean ($\bar{x}$). The mean is the average of data values which is expressed in the following equation (Breyfogle, 1946);

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

where n = sample size

Range is a statistic that gives data variability. It equals the highest value subtracting by the lowest value. Range is a simple tool but is not suitable for a big sample size. A better tool

used for determining data variability is standard deviation (s). The equation of the standard deviation of a sample is

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

;where n = sample size

The n-1 term in the equation is called degrees of freedom. Note that if the number of population is know, the degrees of freedom is n, not n-1. A smaller standard of deviation means the higher confidence in the result of the experiment.

2.1.8 ABC Analysis

Vilfredo Federico Damaso Pareto, an Italian-Swiss engineer and economist, believed that 20 percent of a country's population does 80 percent of the work. The inventory manager adopts Pareto's argument to the inventory control management (Zenz G.J., 1994). The inventory is divided into three priority categories: A, B and C. The A items which may be 10 to 20 percent of the total items in the inventory may account for 65 to 80 percent of the inventory value. The B items which may be 10 to 15 percent of the total inventory may tie up 20 to 25 percent of the inventory value. The C items may be 65 percent of total items in inventory may account only 10 percent of the entire value in inventory. Figure 2.3 illustrates a classification of ABC analysis.

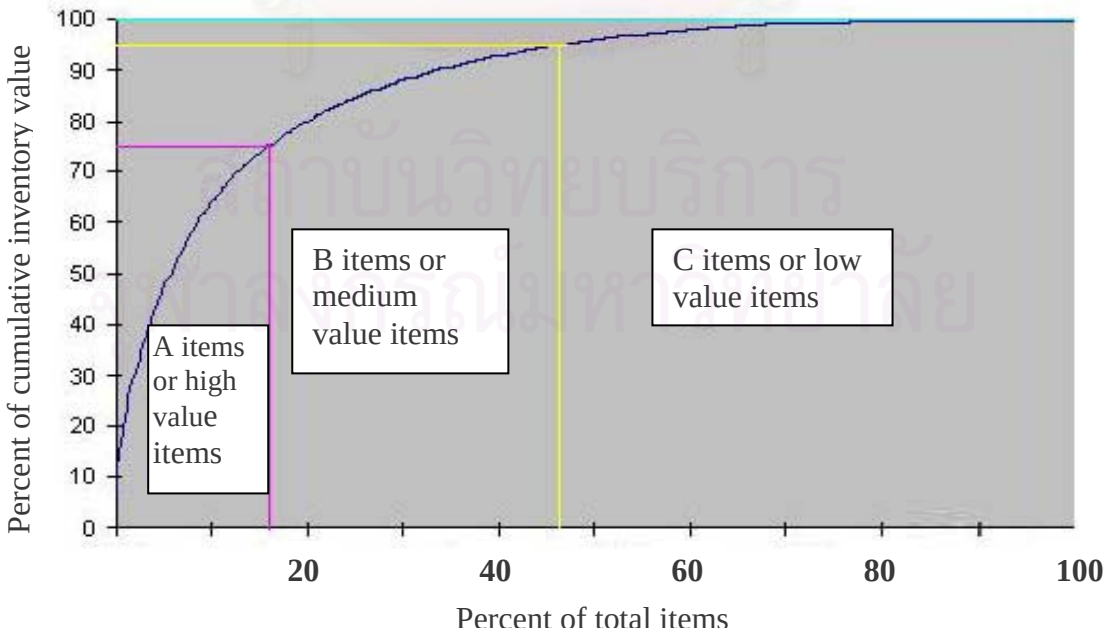


Figure 2.3 ABC method of inventory control

2.2 Literature Reviews

Nyman and Levitt (2001) studies the nature of maintenance activities & organising. He divides type of work performed by the maintenance department into 3 types: prompt emergency response, reliable routine service and timely backlog relief. To support operations effectively, maintenance resources of three types of work including workforce, tool and equipment, etc. must be balanced. Routine work is a preventive/predictive maintenance work which requires a predictable amount of time, and is performed according to a known schedule. Therefore, scheduling should be automatically updated when task falls due. In technical department, scheduling does not automatic response to backlog, but it would be updated every 3 months and then sent to all response shops. This late response results in inefficient performance such as insufficient workforce, lack of spare part, and lack of tool/equipment. The authors also suggest that the organisational structure for maintenance organisation should be divided into 3 groups by work type because the routine work should not be interrupted by the other two groups. Personally, I think that separating work into 3 groups is costly, complex and difficult to allocate maintenance resources. In technical department, the work is separated into 2 groups: preventive/predictive work (Heavy maintenance) and reactive work (Line& light maintenance). The mechanics of both groups would work separately.

I strongly agree with the author that “effective planning and scheduling of maintenance work depends upon reliable availability of parts and materials when needed”. The operation could not be effective if there is no cooperation and communication between Maintenance, Stores, Purchasing and Receiving. Maintenance must provide sufficient lead time for Purchasing to procure. Stores must maintain a reliable inventory to meet demand. In conclusion, to improve spare part inventory control, the new system must support and enhance communication between related functions.

Waddell and Sohal (1994) studied the advantages of forecasting to managerial decision making and studied various types of forecasting methods. They recommended that no forecasting method is perfect under all conditions. It must be monitored and controlled to make sure that errors are still acceptable.

Liu and Ridgway (1995) studied the development of a computer-aided inventory management system comprising four modules incorporating analytical techniques for ABC analysis, forecasting and the calculation of economic batch quantity and reorder level.

Their study describes the creation of modules for ABC analysis and demand forecasting which were integrated into the existing materials management system. In part 2 of their study, they reviewed inventory policies and lot-sizing techniques in a cutting tool manufacturer. Their study of sensitivity analysis is very useful for this thesis since it help to determine effect of input errors on total annual variable cost and EOQ. It determined how much the input can be error which the result will still be acceptable.

Negen et al. (1994) designed a computer-based information system for inventory management for spare parts in the service department. Their study is the most useful for this thesis since the objective of the study is quite the same, but they mostly focused on the design of the information system, and they used demand forecast models which are suitable for unstable and unpredictable demand. However, the context gotten from their study is the system and the information system design. The system design should provide:

- an easy update and retrieval of inventory information
- an efficient ordering system for replenishment
- more information for the management control of spare parts
- accountability and accuracy of information

For the information system design, it consists of 5 modules: information system (IS) kernel, demand input, parts-in transaction, parts-out transaction, release order, and reporting. The IS kernel contains the program and interacts with the database and the user. The parts-in and parts-out transactions handle all transactions related to the incoming parts and outgoing parts, respectively. The reporting module is also important since it produces report daily, weekly, or monthly for management level. The release order module will release order when the stock is to be replenished.

CHAPTER III

CURRENT SYSTEM ANALYSIS

In chapter 3, the organisation structure and the objective of Material administration department is described. The current spare part inventory control system including current procedures and current computer system using in Material administration department are discussed in section 3.1 and 3.2, respectively. The cause-effect diagram is used for segregating causes resulting to an ineffective spare part planning and control system in section 3.3.

From the Technical department organisation chart in figure 1.2, the Material administration department is responsible for planning and preparing materials to support maintenance activities in Technical department. The organisation structure of this department is shown in figure 3.1. Material administration department is composed of three departments responsible for different tasks. First, Material planning and control department is responsible for planning and controlling material to be sufficient for maintenance activities. Next, Technical material procurement department is responsible for placing both procurement order and repairing order. And last, Store and material service department is responsible for keeping material in store and delivering material to demander. Currently, the material planning and control is carried out manually by high work experience material planner.

The objective of the Material administration department is to provide the right material in the right amount at the right place at the right time at the right cost.

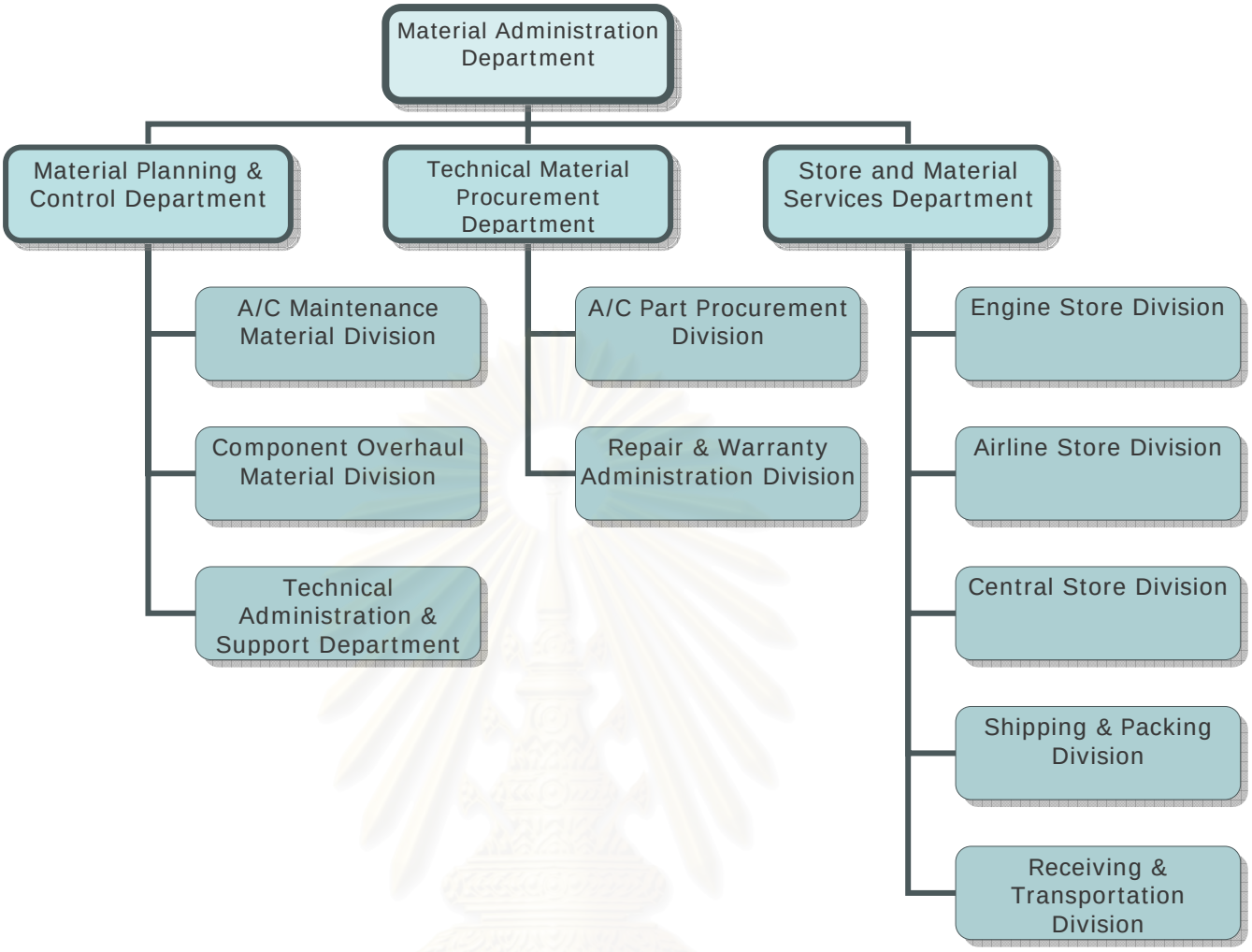


Figure 3.1 Material administration department structure

3.1 Current Procedures Analysis

Currently, most of works related to spare part planning and control are carried out manually. Computer system supports some processing and storing database for all stakeholders. Material planners' task is very important since it affects the profit of the organisation. If the planners make some mistake resulting to shortage, the work has to wait for spare parts, and aircraft on ground (AOG) is lengthen. AOG is unpleasant since it means the aircraft can not service for a while. And the company will lose some profit which can be made from that aircraft.

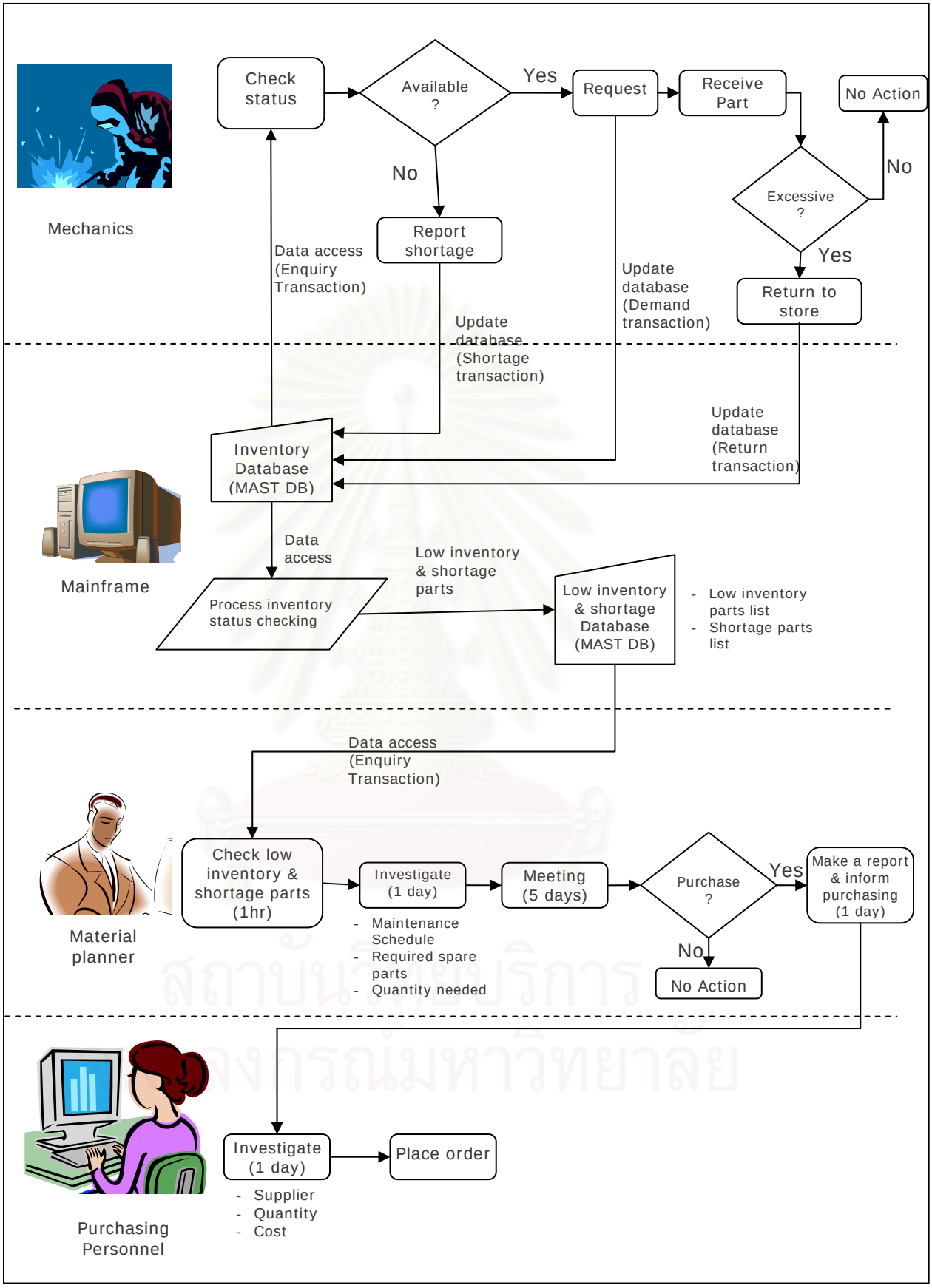


Figure 3.2 Current work flow of spare part planning and control

Figure 3.2 illustrates current work flow of spare part planning and control system. Mechanics check inventory status of required part. If that part is available, they then request that part. The inventory status of that part then is updated. If that part is unavailable, mechanics report the shortage and the inventory status of that part is updated as shortage status. At the end of everyday the shortage parts and parts which the quantity in store is lower than the reorder point (ROP) will be automatically detected and recorded in database. The material planners has to access to the database for checking low inventory level parts and shortage parts which might be from hundreds to thousands parts. Since parts in the list compose of spare parts in various shops, the planners have to select parts of an interesting shop which may take an hour. After that, they have to investigate those parts one by one by checking with aircraft maintenance schedule. The investigation includes when the parts will be used, and how many parts required by checking which aircraft and what task is it in the schedule. It takes about a day to investigate all parts in the list.

After investigating, material planners have to conduct a meeting with all stakeholders including shop planners, mechanics, engineers and managers to conclude the spare parts and materials required for an incoming task. The time wasted on finding a meeting date and conducting a meeting may be a week.

The parts which are not required in a near incoming task are just ignored. This method can result in shortage because of delay in placing order. The parts which have to be ordered would be informed to purchasing personnel to place order. The material planners have to prepare information such as required spare parts and quantity for purchasing personnel which may take a day.

After getting information from the material planners, the purchasing personnel group the parts by supplier and investigate how many to order. This procedure may take a day. If the material planners inform purchasing personnel late, the purchasing personnel must have high experience in doing their jobs so they can place the urgent orders quickly. In conclusion, the current procedure is a reactive approach which the material planners take action when the parts have low inventory status or shortage status.

3.2 Current Computer System Analysis

The MAST (Material Administration System for THAI), the computer system used for managing material, was developed with the assistance from the SAS. The MAST comprises several of transactions that cover all concerned functions as shown in figure 3.3.

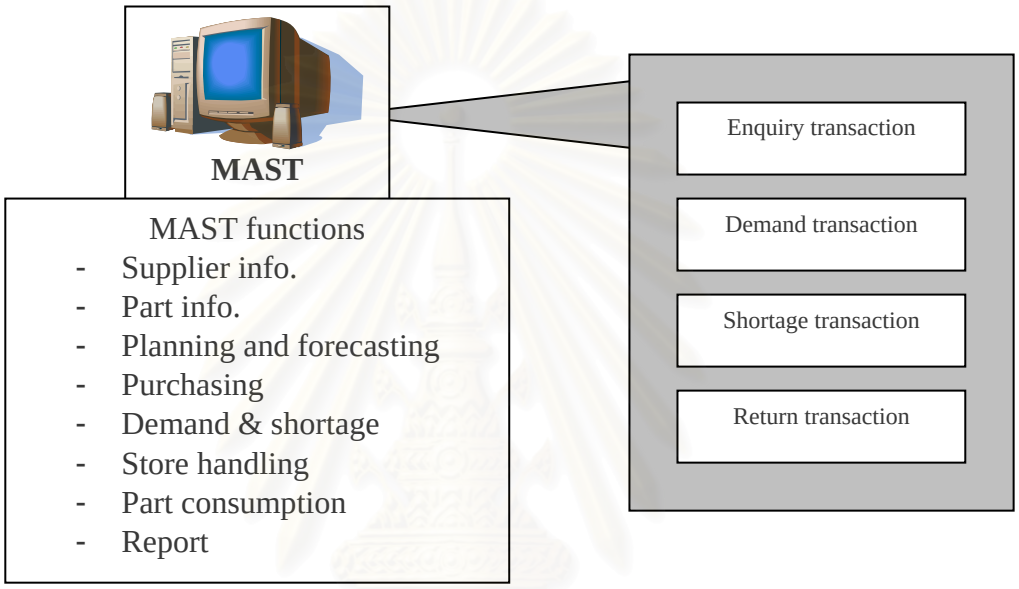


Figure 3.3 Material Administration System for THAI (MAST)

Enquiry transaction enables users access the mainframe database. The information provided by the enquiry transaction is part information, supplier information, planning and forecasting, demand information, store handling, and part consumption. The users involved in this transaction are mechanics, shop planners, material planners, engineers, purchasing personnel and managers. The mechanics, shop planners and engineers usually use this transaction to find available quantity of spare parts in store. Material planners and managers usually access to planning and forecasting, and part consumption information. Purchasing personnel usually access to supplier information, and part information.

From figure 3.2, when mechanics check spare part quantity in store by using enquiry transaction, if the spare part is available, the mechanics then request part from store

by using demand transaction. If the quantity in store is not enough, they then use shortage transaction to report shortage. If they request excessive parts, they have to return to store by using return transaction. The shortage reporting by mechanics will be automatically detected and recorded in database everyday. Which parts that are stored in low inventory database for 2 weeks and have not be placed order yet would be automatically printed out to material planners every Monday as a warning report.

Since the spare parts inventory control system was developed 20 years ago when the number of aircrafts in THAI fleet is no more than 20 aircrafts, The spare part inventory planning and control are performed simply. The average of demands in last three years is calculated to be forecasted demand in next year (see table 3.1). The forecasted demand is used for calculating EOQ and ROP. For example, demands of part 83-201C5134-1 in year 1, 2 and 3 were 719, 742 and 300 items. So the forecasted demand in year 4 is (719+742+300)/3 = 587 items. The safety stock, which is set to be equal to demand per month, is 587/12 = 49 items. This method is applied to every material and aircraft spare part but ROP is not suitable for spare parts which demand is unstable.

Table 3.1 Forecasted demand for year4

Part Number	Demand			Forecast Demand in year 4	Demand per month in year4 (Safety stock)
	Year1	Year2	Year3		
83-201C5134-1	719	742	300	587	48.9
83-201B6811-11	332	294	164	263.3	21.9
83-201D8114-403	171	94	38	101	8.4
83-201C5172-1	593	576	352	507	42.25

In fact, demand of most parts depends on the number of aircrafts scheduled in heavy maintenance schedule which is different in each year. For example, in some years many aircrafts type A360 were overhauled but in some year there was no A360 aircrafts overhauled. Table 3.2a and table 3.2b represent the actual demand of aircraft spare parts which affected by aircraft A360 and A330-300, respectively. In year 2004, a few A360 were scheduled to be checked so demand in that year dropped as shown

in table 3.2a. In contrast to A330-300 aircrafts which were scheduled to be checked in year 2004, demand in that year boosted as shown in table 3.2b.Therefore, using the current method, the forecasted demand could be greater or lower than the actual demand resulting to an incorrect ROP level. If the ROP calculated from the system is too low, it could result to a delay in placing order.

Table 3.2 Demand for 3 years

Part Number	Year 2002	Year 2003	Year 2004
83-201C5134-1	719	742	300
83-201B6811-11	332	294	164
83-201D8114-403	171	94	38
83-201C5172-1	593	576	352

(a) part numbers which affected by A360

Part Number	Year 2002	Year 2003	Year 2004
505-00-315-00	469	652	1445
505-00-520-50	285	324	422
135-00-610-06	227	729	833
715-00-511-00	92	95	417

(b) part numbers which affected by A330-300

3.3 Cause-Effect Diagram for an Ineffectiveness of the Current System

Figure 3.4 shows fishbone diagram which segregate causes of an ineffective spare part inventory planning and control into 4 causes: man, method, equipment and environment. In the man related cause, to investigate the spare parts required, the material planners and purchasing personnel should have high experience to do their job. They have to know every part in detail. And they must concentrate on their work because their work involves numerical tasks. Lost concentration would make error and result in overstock and shortage.

In the method related cause, most of works are paperwork. Material planners use parts lists which printed on paper to investigate the quantity needed for each part. The investigation task then is time-consuming since the material planners have to deal with many spare parts lists and sheets of schedule. Besides time wasting on paperwork while investigating required quantity for each part, time spent on conducting meeting is also time-consuming.

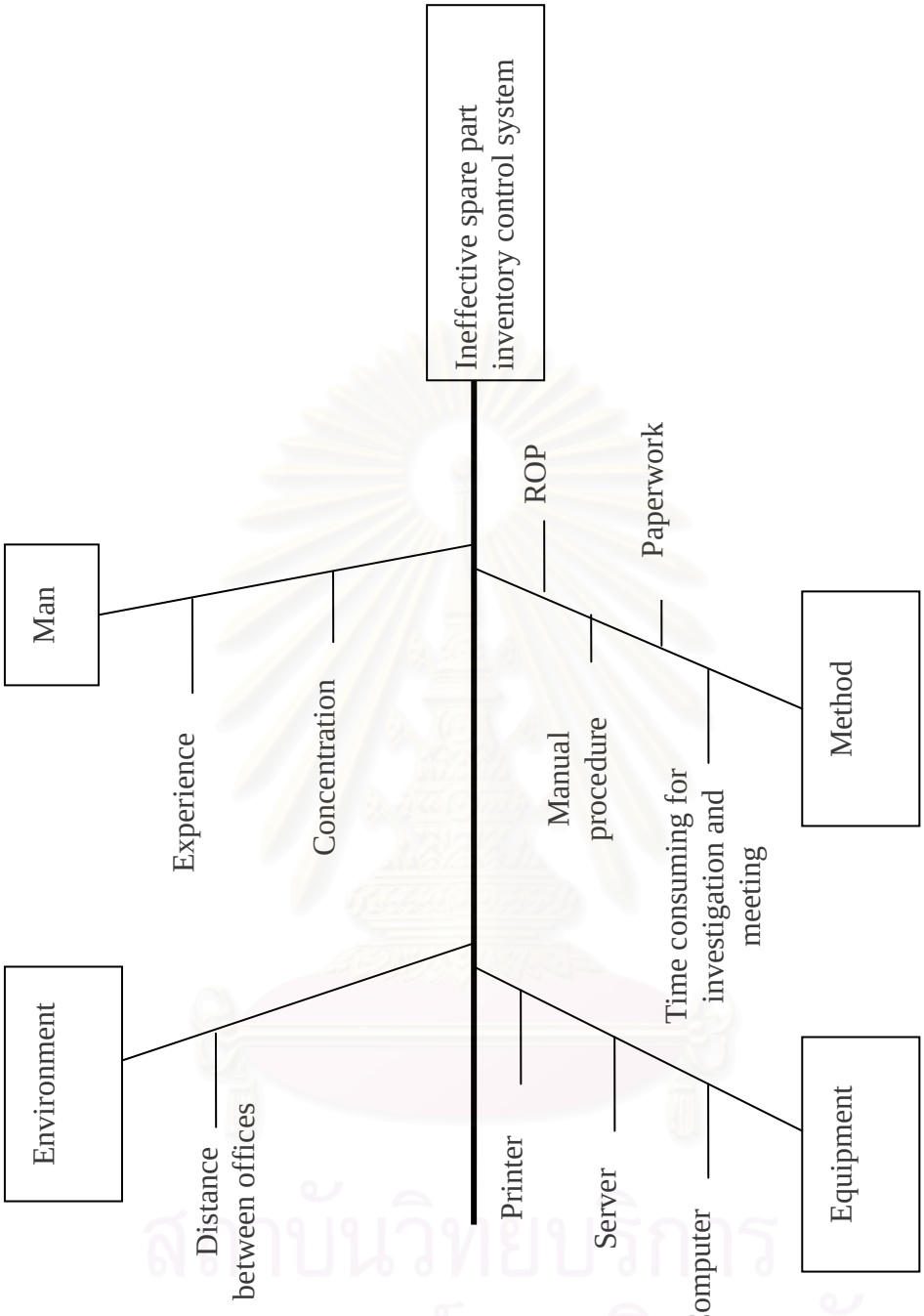


Figure 3.4 Fishbone diagram

The method of ROP is not suitable with the nature of spare part for aircraft maintenance task. The spare parts SPC1 and SPC7 are non-repairable parts which demand depends on schedule. The demand can be planned by the schedule. But the ROP method has some assumptions such as demand must be independent, and stable.

Therefore, using ROP method in the current system could result to an ineffective spare part control because of using an inappropriate approach.

In the equipment related causes, equipments used for material planning are printer, server and computer. Currently, the job of material planners is day-to-day job since the list of spare part needed is updated everyday. If the server breaks down which often happened, the planners and purchasing personnel will not be able to access to the database. Moreover, the list of parts which have no acting for 2 weeks would be printed out every Monday. If the printer breaks, the list would not be printed. The material planners have to use enquiry transaction to access to the database themselves.

In the environment related cause, since the offices of material planners, shop planners, mechanics, engineers, and management level are located separately, the communication between those stakeholders is difficult. Most of communication is performed by telephone.

In conclusion, the proposed system should ameliorate those causes which negatively affect the efficiency of the material planning and control system. The new system should be proactive instead of current reactive approach. Moreover, the new system should concentrate on the use of appropriate method, ease of use, reducing human error and reducing paperwork.

CHAPTER IV
DATA COLLECTION AND ANALYSIS

In chapter 4, general information necessary for this thesis was collected and analysed. Part information including part number, part name, price, lead time and supplier is gathered and shown in section 4.1. In section 4.2, the general expenses of year 2003/2004 is gathered to determine inventory related costs including ordering cost and holding cost. In section 4.3, the effective parts list for each aircraft is gathered. In section 4.4, the demands in year 2003 and 2004 were gathered and analysed to determine required spare parts quantities for line and light maintenance task, C-check task and D-check task. This information would be used as input for MRP computation in chapter 5.

4.1 Part Information

Part information including supplier, price, and lead-time is gathered by using enquiry transaction. Table 4.1 shows information of each part including part name, price in US dollar, price in THB, lead time and supplier. For example, part 522-00-520-50, a foodtray supplied by vendor code c1084/1, costs $160.5 or 6154.21 THB per item. Lead time from placing order to receiving order is 14 weeks.

Table 4.1 Part information

Part Number	Name	Price(US$)	Price(THB)	Lead time (week)	Supplier
522-00-520-50	FOODTRAY	160.5	6,154.21	14	c1084/1
517-00-315-00	ARMCAP	58.64	2,168.2	10	c1084/1
505-00-520-50	FOODTRAY	156.3	5,783.1	14	c1084/1
294-00-345-00	COVER	84.8	3,200.5	14	w0945/1
280-00-369-00	ESCUTCHE	43.1	1,620.23	15	c1084/1
184-00-520-00	FOODTRAY	281.89	10,429.93	13	c1084/1
142-00-530-00	BRCKT.LH	153.5	5,679.5	14	c1084/1
142-00-307-53AV	BUMPER	272.4	9,388.38	13	w0945/1

Refer to Appendix A1

4.2 Inventory Related Costs

To determine inventory related costs, the general expenses concerning to aircraft spare parts and materials control and purchasing was gathered as shown in table 4.2. Expenses of Store and material service department in year 2003/2004 which is responsible for inventory control, order receiving and order delivering were 134 million THB. Expenses of departments concerning material planning and procurement were 78 million THB. This expense includes investment on personnel and work area such as personnel cost, material and stationary cost, electricity cost, training cost, etc.

Table 4.2 Budget information for year 2003

General expenses of Store and material services department in year 2003/2004	134,000,000	THB
General expenses of Technical material procurement department and Material planning and control department in 2003/2004	78,000,000	THB
Aircraft spare part value in year 2003/2004	4,100,000,000	THB
Number of orders placed in 2003/2004	47,200	orders

Ordering cost (K) equals general expenses of Technical material procurement department and Material planning and control department in year 2003/2004 divided by number of orders placed in that year.

$$K = \frac{78,000,000}{47,200}$$

$$= 1652.5 \text{ THB per order}$$

Holding cost (I) equals general expenses of Store and material services department in year 2003/2004 divided by aircraft spare part value in that year, and plus the extra cost of money invested in inventory. The general expenses of Store and material service department includes personnel cost, security cost, electricity cost, building maintenance

cost, lift-truck maintenance cost, stock losses due to stock-handling damage, transportation cost, storage cost, etc. If the money were not invested in stock, it could be invested elsewhere and the organisation could earn a return on this capital. The extra cost of money invested in inventory therefore referred to the loan interest rate. However, the rate must be higher than the normal rate because of the element of risk to business capital (Hohenstein C.L., 1982). Therefore, the return of investment is reasonably assumed to be 10%.

$$I = \frac{134{,}000{,}000}{4{,}100{,}000{,}000} + 0.10$$

$$= 0.0327 + 0.10$$

$$= 0.1327 \text{ THB per unit per year}$$

The holding cost for each item can be determined by multiplying 0.1327 by its cost, as shown in table 4.3. For example, part 522-00-520-50 costs 6,154.21 THB per unit. Holding cost is equal to 6,154.21x 0.1327 = 816.66 THB per unit per year.

Table 4.3 Holding cost per item per year (THB)

Part Number	Price (THB)	Holding cost per unit per year (I) (THB)
522-00-520-50	6,154.21	816.66
517-00-315-00	2,168.20	287.72
505-00-520-50	5,783.10	767.42
294-00-345-00	3,200.50	424.71
280-00-369-00	1,620.23	215.00
184-00-520-00	10,429.93	1384.05
142-00-530-00	5,679.50	753.67
142-00-307-53AV	9,388.38	1245.84

Refer to Appendix A2

It was agreed by Material administration department manager that the holding cost and ordering cost gotten from above calculation is accepted. In section 5.5 “Sensitivity analysis”, the effect of holding cost and ordering cost errors would be determined. Keep in mind that the holding cost and ordering cost gotten from above calculation were calculated by using information in year 2003/2004. Therefore, when apply the proposed system, the

holding cost and ordering cost should be updated every year because spare part value tends to increase resulting from an increasing of aircrafts owned by THAI.

4.3 Effective Parts List

In this section, the words “aircraft type”, “aircraft register” and “aircraft group” are frequently used. Then the difference between those two words would be clearly described for easy to understand. The aircraft type is the model of the aircraft set by aircraft manufacturer. For example, aircraft types B737-400 and B747-300 are manufactured by Boeing, and aircraft types A300-600 and A300-600R are manufactured by Airbus. The aircraft register which has 3 alphabets is the specific name of each aircraft set by THAI. The first alphabet always is “T” indicating that the aircraft is owned by THAI. The second alphabet indicates which aircraft type, for example, “D” means aircraft type B737-400, “G” means aircraft type B747-300, etc. The third alphabet is assigned in order of date of aircraft arrival. For example, TDA is the first aircraft type B737-400 owned by THAI, and TDB is the second aircraft type B737-400 owned by THAI.

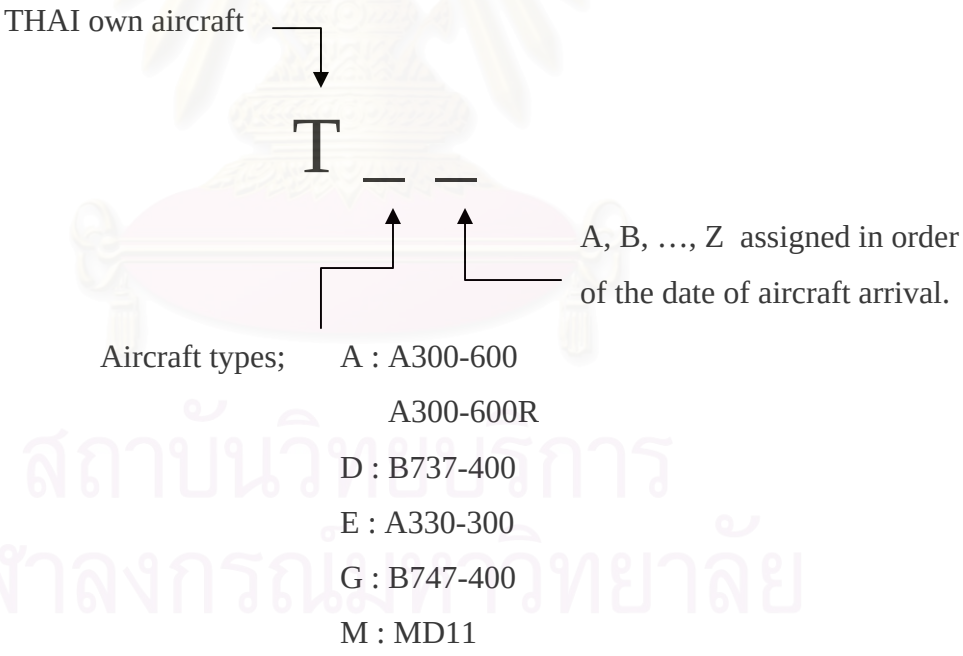


Figure 4.1 Aircraft register meaning

Aircraft group is the group of aircrafts which have the same seat configuration. Seat configurations indicate which seat brands installed on aircraft, number of seats and configuration. Table 4.4 shows aircraft types owned by THAI grouped into 14 groups. Aircraft registers in the same group have the same seat configurations. For example, there are three different seat configurations using in aircraft type B747-400: group 7440, group 7441 and group 7442. Aircraft register TGH, TGJ,…, TGN have the seat configuration group 7440. Aircraft register TGO, TGP and TGR have the seat configuration group 7441. And last, aircraft register TGT, TGW,…, TGZ and TGA-TGB have the seat configuration group 7442.

Table 4.4 Aircraft groups grouped by seat configuration

Aircraft type	Group	Aircraft register
B737-400	734	TDA, TDB,…, TDL
B747-300	743	TGD, TGE
B747-400	7440	TGH, TGJ, TGK,…, TGN
	7441	TGO, TGP, TGR
	7442	TGT, TGW,…, TGZ, TGA, TGB
A300-600	A361	TAA, TAB, TAC
	A362	TAD, TAE, TAF
A300-600R	A360R0	TAN, TAO,…, TAS
	A360R1	TAK, TAL, TAM
	A360R2	TAG, TAH
	A360R3	TAT, TAW,…, TAZ
A330-300	A330	TEJ, TEK,…,TEM
	A331	TEA, TEB,…, TEH
MD11	MD11	TMD, TME,…, TMG

Table 4.5 shows the effective parts list of each aircraft group. Keep in mind that only parts stated in the scope of study are shown in table below. The full effective parts list of seat shop is shown in Appendix A2. For example, aircraft group 743 has 4 effective parts: 517-00-315-00, 294-00-345-00, 280-00-369-00 and 132-00-611-00. Some parts are used in many groups, for example, part 517-00-315-00 is used in aircraft group 743 and 7440. This list would be used further in section 4.4 to determine required spare parts for each maintenance tasks.

Table 4.5 Effective parts list for each aircraft group

Aircraft group						
734	743	B7440	B7441	B7442	A36 1	A362
294-00-345-00	517-00-315-00	522-00-520-50	294-00-345-00	294-00-345-00	280-00-369-00	505-00-520-50
280-00-369-00	294-00-345-00	517-00-315-00	280-00-369-00	280-00-369-00	184-00-520-00	280-00-369-00
142-00-307-53AV	280-00-369-00	294-00-345-00	135-00-610-16	142-00-530-00		132-00-660-00
135-00-610-16	132-00-611-00	280-00-369-00	135-00-450-39AV	135-00-610-16		132-00-608-00
135-00-610-06		142-00-530-00	135-00-265-00AV	135-00-450-39AV		
135-00-265-00AV		132-00-660-00		135-00-265-00AV		
		132-00-611-00				

Aircraft group						
A360R0	A360R1	A360R2	A360R3	A330	A331	MD11
280-00-369-00	280-00-369-00	505-00-520-50	294-00-345-00	83-201D8114-403	83-201D8114-403	294-00-345-00
135-00-850-04AF		280-00-369-00	280-00-369-00	83-201D7953A401	83-201D7953A401	280-00-369-00
135-00-610-06		132-00-660-00	142-00-530-00	83-201C5283-401	83-201C5283-401	142-00-307-53AV
		132-00-608-00	142-00-307-53AV	83-201B6823-3	83-201C5134-1	135-00-612-02
		132-00-500-00	135-00-610-06	83-201B6811-13	83-201B6823-3	135-00-450-39AV
			135-00-450-39AV		83-201B6811-13	
			135-00-265-00AV			

Refer to Appendix A3

4.4 Required Spare Parts for Aircraft Maintenance

For easy to understand, demands would be separated simply by maintenance tasks into 3 groups; there are demand for line and light maintenance, demand for C-check and demand for D-check (or overhaul). Table 4.6 shows comparison of interval or frequency, job owners, time taken and demand characteristics between three groups.

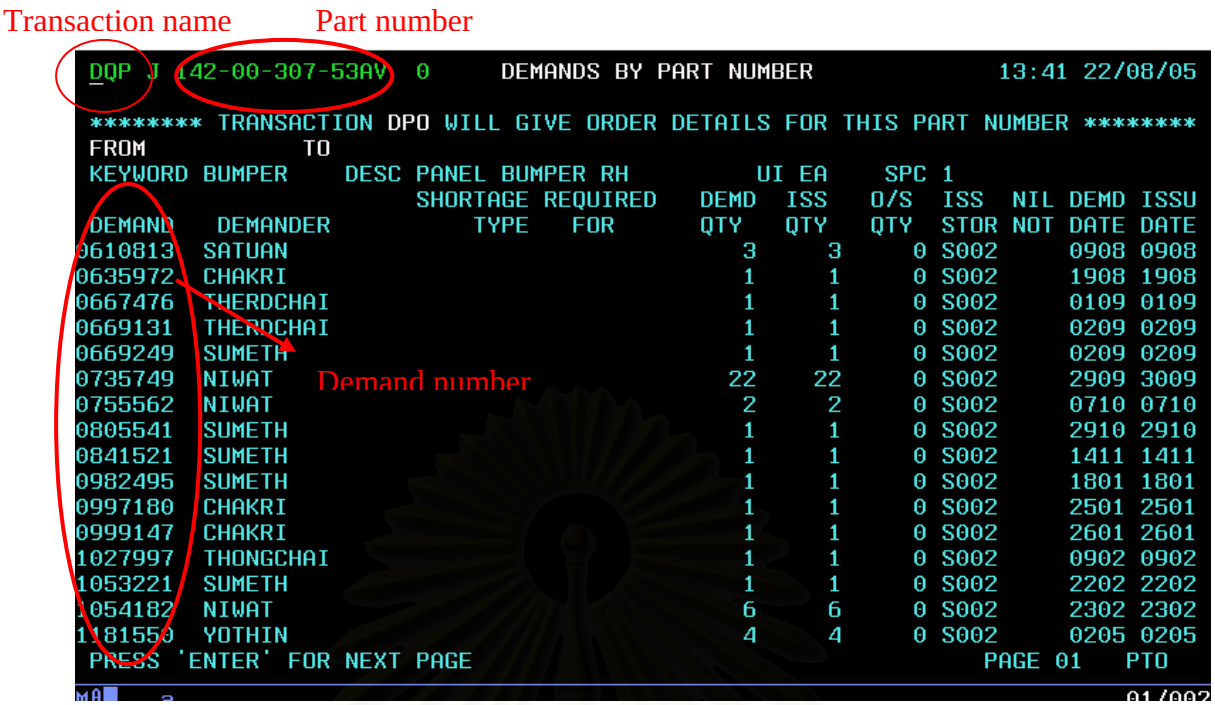
The line and light maintenance task, for instance, pre-flight checks MPC), every day checks (MSC), and A-checks (monthly check), is performed by line mechanics. Time taken is normally a few hours, except A-check. Demand is very small and stable. C-check is done every 1.5 to 2 years by shop mechanics and dock mechanics. Time taken is normally 1 to 2 weeks. Demand is small and uncertain. D-check or overhaul task is done by shop mechanics every 5 to 6 years. Time taken is normally 1 to 2 months. Demand is large and certain. The detail of each maintenance task would be described further in section 4.4.1, 4.4.2 and 4.4.3.

Table 4.6 Types of maintenance tasks

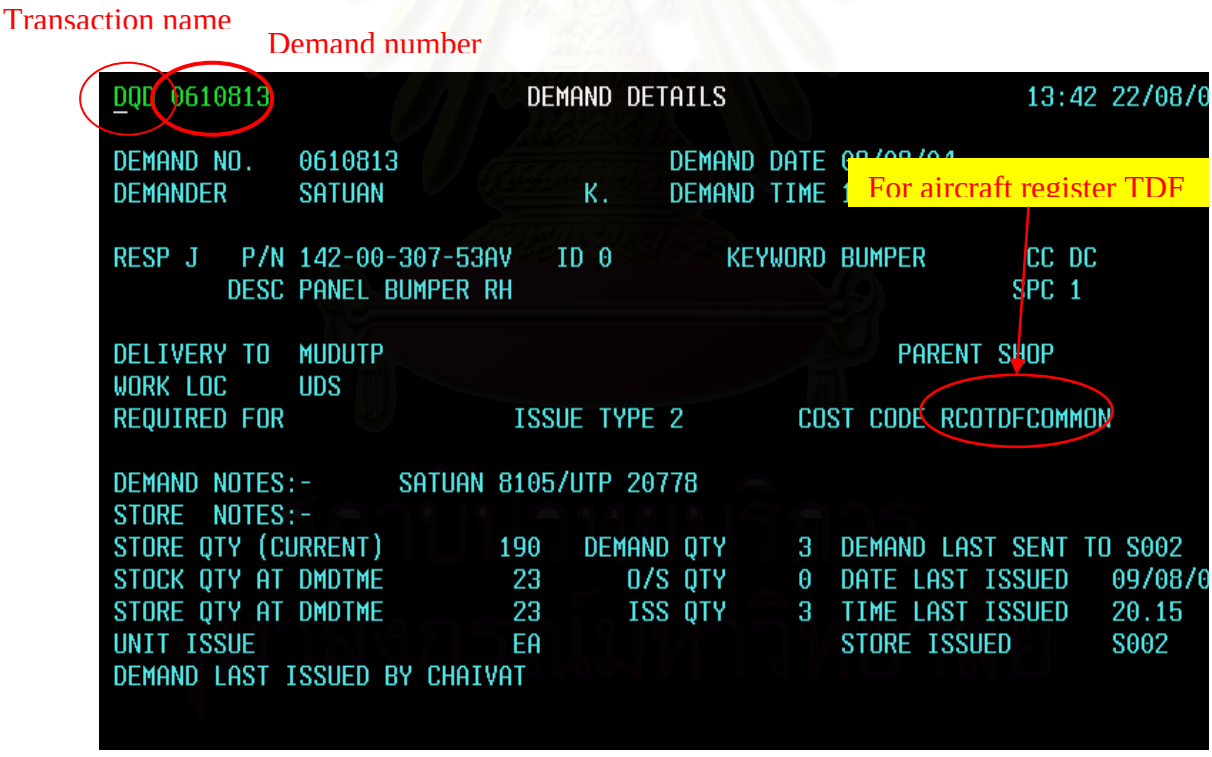
Types of maintenance tasks		Interval/frequency	Performed by	Time taken	Demand characteristics
Line and Light Maintenance	MPC	Before take-off	Line mechanics	Few hours	Very small and stable
	MSC	End-of-day	Line mechanics	Few hours	Very small and stable
	A-check	Every month	Line mechanics	1-2 days	Very small and stable
Heavy Maintenance	C-check	≈1.5-2years	Shop mechanics and dock mechanics	1-2 weeks	Small and uncertain quantity
Heavy Maintenance	D-check (Overhaul)	≈5-6 years	Shop mechanics	1-2 months	Large and certain quantity

The past demands of last two years were gathered by using enquiry transaction. To separate demands by type of maintenance tasks, two enquiry transactions were needed as shown in figure 4.2. The first transaction in figure 4.2a was used to determine the frequency of demanding, demand number, the demander, the quantity per demand, etc. But with this transaction, the user could not know the purpose of demanding. The second transaction (see figure 4.2b) then was used to get into detail of each demand number to find a purpose of that demand. This procedure was the most time-consuming because each part may have hundreds demands per year.

For example, the past demands of part 142-00-307-53AV are shown in list as shown in figure 4.2a. From figure 4.2b, demand number 0610813, which requested by Mr. Satuan, was requested for aircraft register TDF.



(a)



(b)

Figure 4.2 Enquiry transactions (a) transaction for number of demand (b) transaction for detail of each demand

Because of the limitation of the current system, only the detail of demands in last 2 years can be accessed. Therefore, demands in year 2003 and 2004 were gathered and separated into 2 groups: line demand (demand for line and light maintenance) and heavy demand (demand for C-check and D-check), as shown in table 4.7. The last column presents line demand as a percentage of total demand. Some parts had no line demand and, in some parts, line demands were insignificant because of the limited time and limited work space on aircraft. Since line and light maintenance is normally performed on aircraft, most parts are difficult to remove and replace on aircraft. Line demand is then insignificant in contrast to heavy demand.

Table 4.7 Demands separated by maintenance task

P/N	Demand year 2003 (unit)	Demand year 2004 (unit)	Line demand (unit)	Heavy demand (unit)	Line demand (% of total demand)
522-00-520-50	298	698	0	996	0.00%
517-00-315-00	460	676	2	1134	0.18%
505-00-520-50	324	422	4	742	0.54%
294-00-345-00	179	131	6	304	1.94%
280-00-369-00	384	298	60	622	8.80%
184-00-520-00	430	305	68	667	9.25%
142-00-530-00	102	109	0	211	0.00%

Refer to Appendix A4

4.4.1. Line and Light Maintenance

Line and light maintenance task is performed by line mechanics. This task includes MPC which is pre-flight check, MSC which is performed every end-of-day and A-check which is performed every month. Each task is normally done within a few hours except A-check which may take 1-2 days. Demand for line and light maintenance would be called “line demand”. Not every part has line demand. Some part never has line demand since it can not be removed and replaced on aircraft as done in line maintenance. Only parts which have line demand were gathered and analysed line demand as shown in table 4.8. The average requested quantity was determined by dividing the sum of demand quantity by the number of demand. The standard deviation was then calculated to determine a consistency of demand behaviour and shown in table 4.8.

Avg. requested quantity ($\bar{q}$) = $\frac{\sum_{i=1}^{n} q_i}{n}$

where q = requested quantity (units)

n = number of demand

Standard deviation ($б_a$) = $\sqrt{\frac{\sum_{i=1}^{n} (q_i - \bar{q})^2}{n-1}}$

As can be seen in table 4.8, the standard deviation was lower than 1 therefore line demand was very consistent. The actual requested quantity insignificantly differed from the average quantity. For example, part 280-00-369-00, the average requested quantity was 3 (2.5) units and standard deviation is 0.72. The actual request quantity could be 2 units or 3 units a time.

Table 4.8 Line demand (year 2003-2004)

P/N	Demand (units)	Avg. requested quantity (units)	Standard deviation ($б_a$)	Average line demand per year (units)
517-00-315-00	2	1	0	1
505-00-520-50	4	1	0	2
294-00-345-00	6	1	0	3
280-00-369-00	60	1.7	0.72	30
184-00-520-00	68	2.2	0.7	34

Refer to Appendix A4

Besides the consistency of requested quantities, the frequency of demand was stable in each year as shown in figure 4.3. For example, part 294-00-345-00 and 505-00-520-50 are normally requested 1 unit in every 2- 3 months. Part 522-00-520-50 is averagely requested 3 units in every month.

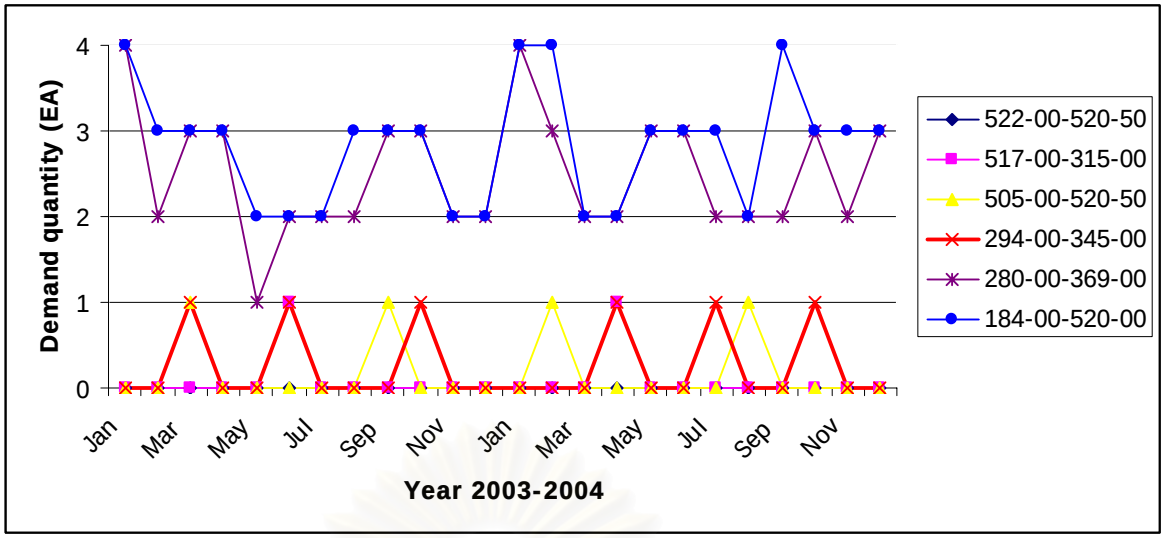


Figure 4.3 Line Demand from January2003 to December2004

The characteristics of line demand are small and stable therefore the average of line demand in last 2 years is assumed to be the forecasted line demand in next year. The last column “Average line demand per year (units)” in table 4.8 shows the average of line demand in year 2003 and 2004 which would be a forecasted demand for year 2005. For example, part 280-00-369-00, the average line demand in year 2003 and 2004 was 60/2 = 30 units. So line demand in year 2005 was forecasted to be 30 units.

However, average line demand per year depends on the number of seats installed on aircraft. As mentioned in chapter 1, the number of aircrafts will increase from 81 aircrafts to 95 aircrafts within 4 years. The number of seats and spare parts then tend to increase consequently. Therefore, the average line demand per year per seat of each spare part is determined by dividing average line demand per year by the number of seats installed on aircraft.

Table 4.9 shows the part number, seat models which that part is installed on, the number of seats of that seat model, average line demand per year, and average line demand per year per seat. For example, part 294-00-345-00 is one part of seat model 3211-x which has 1744 seats installed on aircraft. Average line demand per year of part 294-00-345-00 is 3 units, therefore, average line demand per year per one seat is 3/1744 = 0.002 units per year per seat. In the near future when the new aircraft is arrived, the number of seats increases. Average line demand per year

should be calibrated by multiplying the number of seats by the line demand year per seat.

Table 4.9 Average line demand per year per seat

Part Number	Seat model	Number of seats (units)	Line demand per year (units)	Line demand per year per seat (units)
522-00-520-50	3152-1	1914	0	0
517-00-315-00	3152-1,3152-3	2562	1	0.0004
505-00-520-50	3153-x	1450	2	0.001
294-00-345-00	3211-x	1744	3	0.002
280-00-369-00	315x-x	15856	30	0.002
184-00-520-00	3154-x	1870	34	0.018
142-00-530-00	3152-x	5597	0	0
142-00-307-53AV	3211-x	1744	0	0

Refer to Appendix A5

In conclusion, since line demand is stable and the inventory status is known all the times, the Order Period-Order Quantity (OPOQ) is then suitable for controlling spare parts for line demand.

Table 4.10 shows safety stock (SS) and economic order quantity (EOQ) for line demand of seat spare parts in class A. For example, part 280-00-369-00 was requested 30 units a year for line and light maintenance. Holding cost per year per unit is 214.98 THB per year per unit.

Table 4.10 Safety stock and economic order quantity for line demand

P/N	Line demand per year	Holding cost /year	EOQ	Standard deviation ($б_a$)	Lead time (week)	$б_1$	Safety stock (SS)	T
522-00-520-50	0	816.56	0	0	14	0.00	0	0
517-00-315-00	1	287.68	4	0	10	0.00	0	208
505-00-520-50	2	767.32	3	0	14	0.00	0	78
294-00-345-00	3	424.65	5	0	14	0.00	0	87
280-00-369-00	30	214.98	22	0.72	15	1.44	4	39
184-00-520-00	34	1383.87	9	0.7	13	1.40	4	14
142-00-530-00	0	753.57	0	0	14	0.00	0	0
142-00-307-53AV	0	1245.68	0	0	13	0.00	0	0

Refer to Appendix A6

$$EOQ = \sqrt[2]{\frac{2DK}{I}}$$

Where D = line demand per year

K = ordering cost = 1653 THB per order

I = holding cost per year per unit

Therefore, $EOQ = \sqrt[2]{\frac{2 \times 30 \times 1653}{214.98}}$

$= 22$ units

From table 4.8, standard deviation ($б_a$) of part 280-00-369-00 is 0.72. Lead time (L) is 15 weeks or 4 months. The forecast interval is a month. The adjustment factor must be applied since the forecast interval is different from the lead time interval.

$$б_1 = \frac{б_a \times \sqrt[2]{\text{lead time interval}}}{\text{forecast interval}}$$

$$= \frac{0.72 \times \sqrt[2]{4}}{1}$$

$= 1.44$

From the consultation with the management of Material administration department, the acceptable service level for high value spare part in class A is 99%. From table 4.11, the safety factor (k) for service level of 99% is 2.33.

Safety stock (SS) $= k \times б_1$

$= 2.33 \times 1.44$

$= 4$ units

Table 4.11 The normal distribution table

Safety factor (k)	Service level (%)	Probability of shortage (%)
2.07	98	2
2.25	98.8	1.2
2.33	99	1
2.50	99.4	0.6
2.75	99.7	0.3
3.00	99.9	0.1

Figure 4.4 shows order period-order quantity for part 280-00-369-00. The period T, the cycle period, is equal to order quantity divided by demand rate per week. Part 280-00-369-00 has line demand per year of 30 units.

$$\text{Line demand per week} = 30/52$$

$$= 0.58 \text{ units/month}$$

$$T = \frac{\text{EOQ}}{\text{Line demand rate}}$$

$$= 22/0.58$$

$$= 39 \text{ weeks}$$

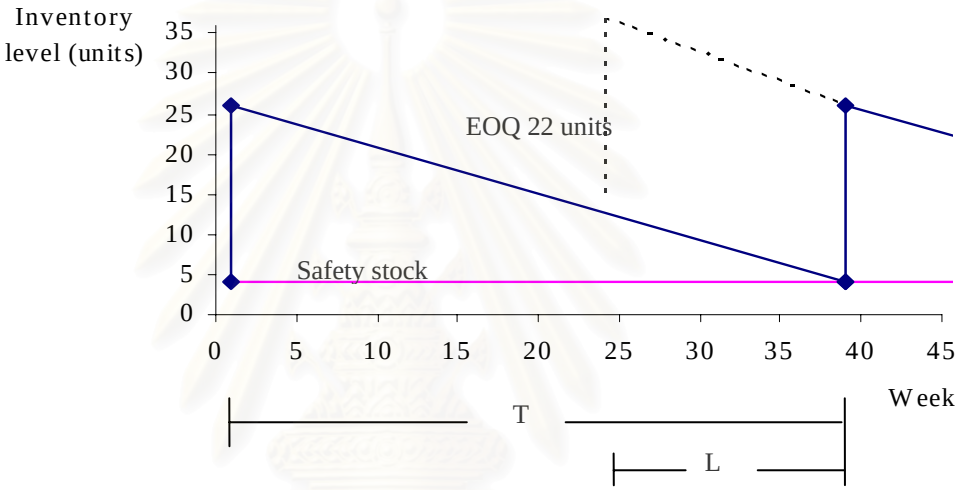


Figure 4.4 Fixed order period with fixed order quantity

In conclusion, part 280-00-369-00 should be ordered every 39weeks with an economic quantity of 22 units. And there should be a safety stock of 4 units to avoid shortage. This approach would be applied to the proposed system to determine ordering policy for line demand.

4.4.2. Heavy Maintenance - C-Check Task

C-check task is performed every 1.5-2 years by shop mechanics and normally takes 3-4 weeks. The effective parts list in table 4.5 in section 4.3 was used to determine what spare parts are required for each aircraft. And the enquiry transactions were used to determine historical requested quantity for C-check. For C-check task, just some seats which were getting old or broken would be removed and sent to repair

therefore the number of removed seats was decided by visual inspection. Demand for C-check is then quite uncertain.

From table 4.12, the requested quantity of each item for C-check occurred in year 2003 and 2004 were gathered. For example, between year 2003 and 2004, part 184-00-520-00 was requested 3 times for aircraft group A361; there were 79 units, 75 units and 80 units. The quantity per demand is slightly different therefore the maximum demand quantity is set to be spare quantity required for C-check. Table 4.13 shows the acceptable spare quantity required for C-check. For example, part 184-00-520-00 was required 80 units for aircraft group A361 to perform C-check.

Table 4.12 Demands for C-check in year 2003-2004

	734	743	B744 0	A361	A362	A360R2	A360R3	MD11
522-00-520-50			20, 18, 19,20					
517-00-315-00		25, 24	25, 24, 25,25					
505-00-520-50					10, 9,9	10,9		
294-00-345-00								
280-00-369-00								
184-00-520-00				79, 75,80				
142-00-530-00								
142-00-307-53AV	4,5,5,6,6						6, 8	21,19,22

Table 4.13 Required spare parts quantities for C-check

	734	743	B7440	B7441	B7442	A361	A362	A360R0	A360R1	A360R2	A360R3	A330	A331	MD11
522-00-520-50			20											
517-00-315-00		25	25											
505-00-520-50							10			10				
294-00-345-00														
280-00-369-00														
184-00-520-00						80								
142-00-530-00														
142-00-307-53AV	6										8			22

Refer to Appendix A7

4.4.3. Heavy Maintenance - D-Check Task

Overhaul task spends a long time to complete task, normally 2-3 months. Demand is large and certain because every seat is removed from aircraft to be overhauled in responsible shop. Therefore, the quantities of spare parts required for D-check are certain and known when the number of seats on that aircraft is known. Spare parts quantities required for D-check is gathered and shown in table 4.14.

Table 4.14 Required spare parts quantities for D-check

	734	743	B7440	B7441	B7442	A361	A362	A360R0	A360R1	A360R2	A360R3	A330	A331	MD11
522-00-520-50			316											
517-00-315-00		406	406											
505-00-520-50							114			201				
294-00-345-00	6	31	31	31	26						14			22
280-00-369-00	12	62	62	62	50	28	28	46	46	46	28			44
184-00-520-00						233								
142-00-530-00			32		25						14			
142-00-307-53AV	6										8			22

Refer to Appendix A8

In conclusion, the required spare parts quantities for C-check and D-check in table 4.13 and 4.14 would be used as an input for MRP computation to determine planned demand and ordering policy for heavy demand. And the EOQ and safety stock gotten from OPOQ approach in table 4.10 would be used to determine ordering policy for line demand. The example of program computation would be clearly described in chapter 5.

CHAPTER V
THE PROPOSED SYSTEM ANALYSIS

In this chapter, the proposed system design, testing and result would be described. Section 5.1 shows the proposed system design comprising conceptual design, database structure design and user interface design. The program is tested and validated in section 5.2 and 5.3, respectively. In section 5.4, the effectiveness of the proposed program is determined in term of cost-effective and program accuracy. In section 5.5, the effect of errors in holding cost and ordering cost is studied to determine the sensitivity of the program.

5.1 The Proposed System Design

System design is separated into 3 issues: conceptual design, database structure design and user interface design. Conceptual design concerns what the new work flow will be look like, how does it ameliorate the problems and who will involve in the new system. Database structure design concerns what kinds of data will be required, how to group the data to be uncomplicated. Grouping the information properly will make the program accessing to the database easily and running quickly. User interface design concerns how to design program to be user friendly. The program was developed in Visual Basic 6 because it is ease of use and friendly with Window Operating System (Window OS). Microsoft Excel is used for MRP computation and storing database.

5.1.1 Conceptual Design

The conceptual design focuses on the design of the system resources which are the programs and procedures.

5.1.1.1 Design of the Procedure

The proposed system was designed to ameliorate the problems of the current system which were illustrated in section 3.3 “cause-effect diagram”. The proposed program would enable material planners to make a decision in advance which is proactive approach instead of current reactive approach. The procedures would be improved to reduce time-consuming and reduce manual work.

- Enable planners to make decision in advance

  Since in the current system the planners would take an action when the spare parts are shown in the low inventory level and shortage list, this could make a delay in procurement. Therefore, the proposed system should enable material planners to plan in advance by providing decision support information such as time-phased record, planned monthly demand, etc.

- Reduce process and time

  Currently, there is no knowledge base information system. The required spare parts lists for each aircraft group are recorded in document and have no link to other groups. The material planners have an insufficient information to make a decision themselves. The meeting between stakeholders which is time-consuming procedure then is necessary to conclude the required spare parts and quantities. In the proposed system, all necessary information were gathered and recorded in an electronic database. The material planners can computerise the system to get decision support information. The meeting is no required, but may be conducted as needed.

- Reduce manual work

  As mentioned previously in chapter 3, 75% of current spare parts planning and control system is performed manually. The computer just provides a list of low inventory and shortage parts. The material planners

have to investigate and calculate required spare parts and quantities themselves. Therefore, in the proposed system, the required spare parts and quantities would be computerised in stead of manual work. The material planners just insert a heavy maintenance schedule and update part information.

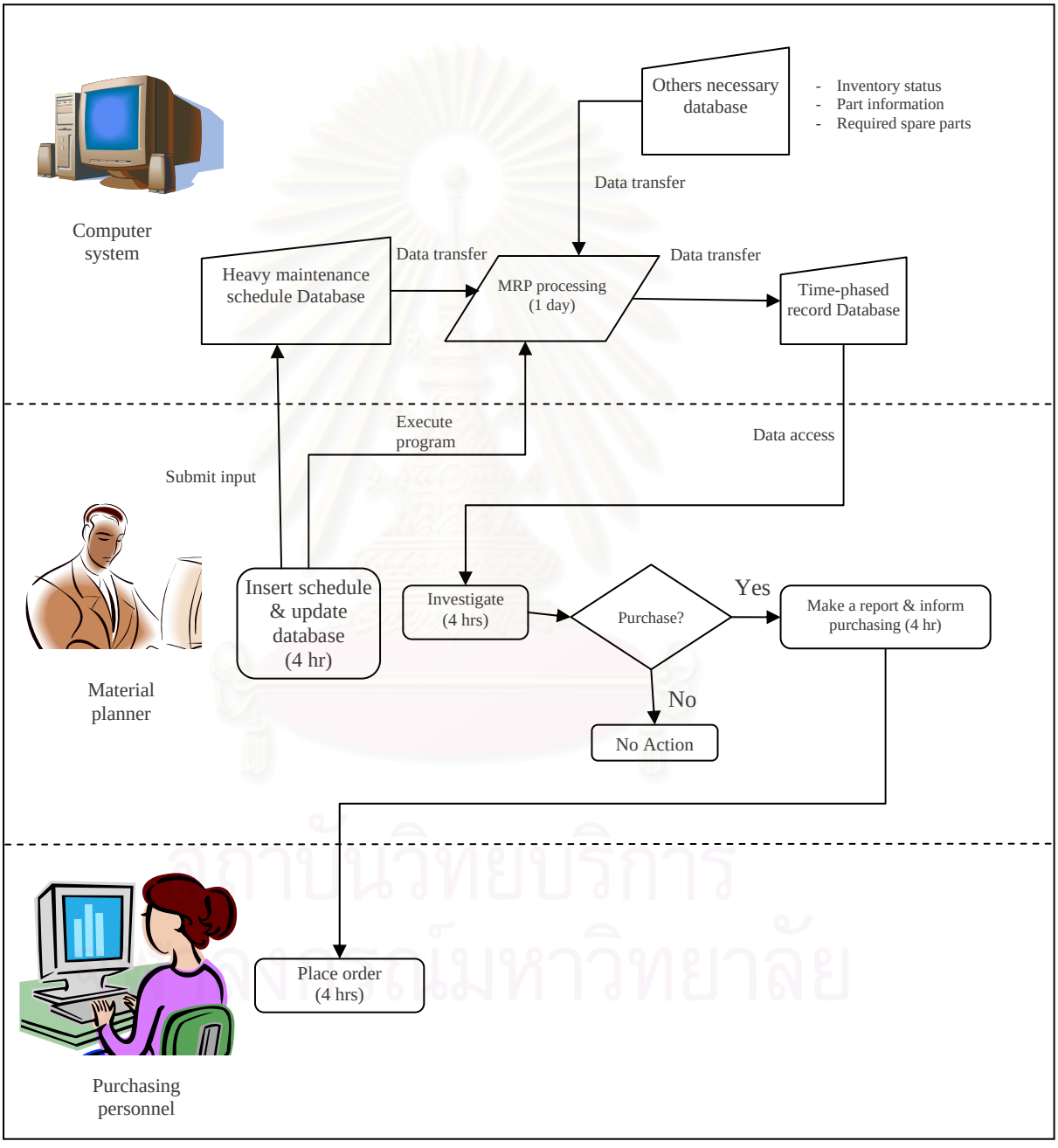


Figure 5.1 Flowchart of spare part planning and control when using the proposed system

Figure 5.1 shows the work flow when applying the proposed system. The changes of work flow begin from computer system through purchasing personnel. The material planners insert the heavy maintenance schedule into the Heavy maintenance schedule database and update part information. Then they execute the program. The necessary information including inventory status, part information and planned monthly demand are accessed from the database for MRP computation. The output is then gotten and recorded in the Time-phased record database. The output is in the form of time-phased record which provides material planners a suggested ordering policy. There are two situations when they execute the MRP computation: when the schedule is updated every 3 months and when the actual inventory is out of plan.

Then the material planners investigate parts by using time-phased record report and planned order releases report gotten from the program. No meeting with all stakeholders is required to determine the required spare part quantity because the material planners already have a decision-making supporting information.They may take some consideration such as which part is out-to-date and is no longer used.

After consideration, the material planners have to do a report of planned order releases which gotten from the proposed system and inform purchasing personnel to place order. The purchasing personnel then work easier and faster since the planned order releases report is already grouped by supplier and shows necessary part information such as price, lead time, etc.

Table 5.1 Comparison between current procedure and the proposed procedure

Stakeholders	Stages	Current system	Proposed system
Computer system	- Inventory status checking	0.5 hr	-
	- MRP computation	-	4 hrs
Material planners	- Check low inventory and shortage parts list	1 hr	-
	- Insert and update schedule and part information	-	4 hrs
	- Investigate required parts	1 day	4hrs
	- Meeting with all stakeholders	5 days	-
	- Make report	1 day	4 hrs
Purchasing	- Investigate and place orders	1 day	4 hrs
Total		8 days, 1.5 hrs	2 day, 4 hrs

Table 5.1 illustrates the comparison between the current procedure and the proposed procedure. The first stage of spare part inventory control system is performed by the computer system. As described previously in chapter 3, the computer processes an inventory status checking at the end of every day. The program spends a half day to check inventory status of spare parts in every shop in Technical department. An approximate time spent on checking inventory status of spare parts in each shop is a half hour. In the proposed system, this procedure is replaced by the MRP computation stage. The MRP program spends about 4 hrs to compute the optimum ordering policy for line demand and heavy demand for spare parts in one shop. Although the proposed system spent longer time in computer system than the current system, the output gotten from the proposed system is more useful and gives a lot of information to support decision-making.

In the first stage of material planners, since the list of low inventory and shortage parts composes of the spare parts in various shops, the planners have to look through the list and select only the parts in an interesting shop which may take an hour. In the proposed system, the stage of checking low

inventory and shortage parts list is unnecessary since the MRP program computes the ordering policy for each shop separately. The stage of insert and update schedule and part information which may takes 4 hours is added in the proposed system.

In the current system, the required spare parts investigation stage takes a day since the planners have to manually check item one-by-one with the heavy maintenance schedule. In the proposed system this stage will take about 4 hours since the program provides time-phased record with a suggested ordering policy for each part.

In the proposed system, the required spare parts for C-check and D-check tasks, and the past line demand are gathered and recorded in database, and used in the MRP program. Therefore, the meeting between all stakeholders to discuss the required spare parts for an incoming task is unnecessary in the proposed system. The report making stage which currently takes about a day will be reduced to 4 hours since the program provides a conclusion of planned order releases and necessary information of each part.

In the stage of purchasing personnel, since the report provided by the material planners gives necessary information for placing order, the time spent on investigating and placing order stage then reduces from a day to 4 hours in the proposed system.

In conclusion, applying the proposed system will result in a reduction of procedures from 6 stages to 4 stages, and time spent on spare parts control system from about 8 days to 2 and a half working days.

5.1.1.2 Design of the Program

From section 4.4, the demands of spare part are separated into two groups: line demand and heavy demand. The order period - order quantity (OPOQ) would be used to determine ordering policy for line demand, and the part period balancing approach is used to determine ordering policy for heavy demand. To sum up, there are two ordering policy gotten from the program: ordering policy for line demand and ordering policy for heavy demand. The

program would conclude the suggested ordering policy including how many units to order and when to order in an interesting planning period.

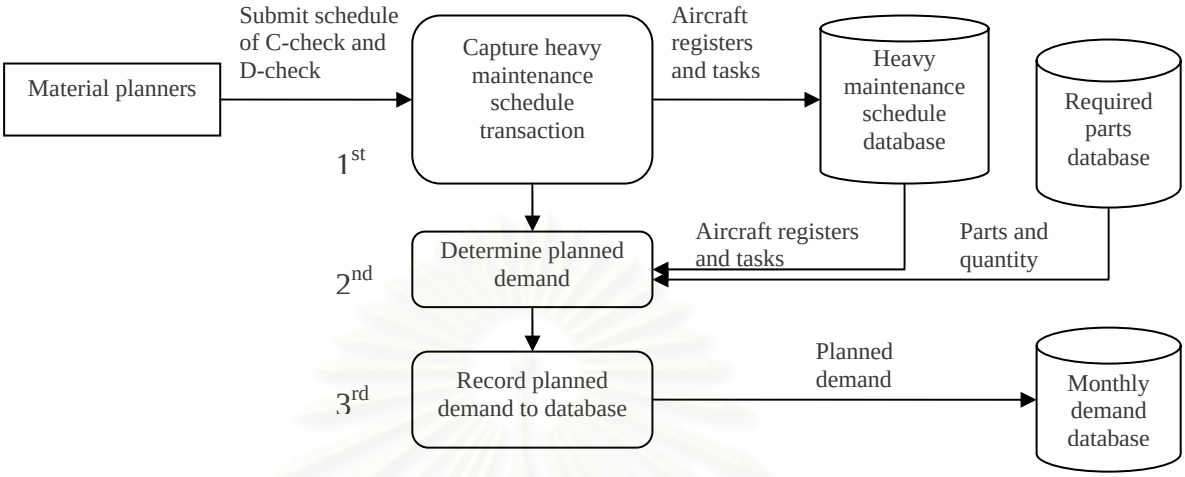


Figure 5.2 Aircraft maintenance schedule transaction

Figure 5.2 to figure 5.7 illustrate the logical systems of the proposed system. The arrow represents data flow direction. Figure 5.2 shows the logical system of the aircraft maintenance schedule transaction. The end users, which are the material planners, enter aircraft registers and maintenance tasks into the transaction. At first stage, the program captures the aircraft maintenance schedule transaction and the input inserted. The data will be converted to computer-readable form and recorded in the heavy maintenance schedule database. After that, in the second stage, the required parts for heavy maintenance tasks in the required parts database will be accessed to determine the planned monthly demand. The methodology of determining planned monthly demand would be described in section 5.2.1.

In the last stage, the output which is the planned monthly demand for heavy maintenance task is recorded in the monthly demand database. Therefore, in aircraft maintenance schedule transaction will produce two outputs: aircraft maintenance schedule and planned monthly demand.

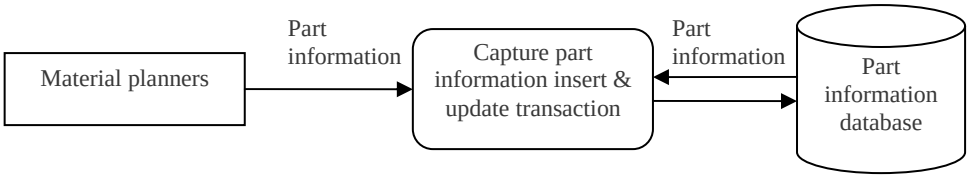


Figure 5.3 Part information insert and update transaction

From figure 5.3, the end users can get the part information via part information insert and update transaction. The data will be gotten from the part information database. This transaction also enables the end users to edit the part information such as price, lead time, etc.

After the end users enter heavy maintenance schedule and update the part information, they now can get the time-phased record via time-phased record transaction. Figure 5.4 illustrates the logical system of MRP computation. The end users or the material planners submit the inputs including starting month and year, and computation mode. There are two modes: normal mode and re-execute mode. When the normal mode is selected, the current week is set to be the first week in the time-phased record computation. The normal mode must be selected when there is the first time of program computation since there is no record yet in time-phased record database. The re-execute mode is selected when the end users want a plan of the future period.

In the first stage, the program captures the time-phased-record transaction and the input submitted by the end users. Then the starting week (t) is determined. If the end users select normal mode, the starting month is fixed to be the current week. Since in this thesis, the program was tested by using the historical inventory level data of the beginning of June 2004 as a current time. And because of the first computation, the normal mode must be selected. Therefore, the starting week-t is set to be week 23 of year 2004.

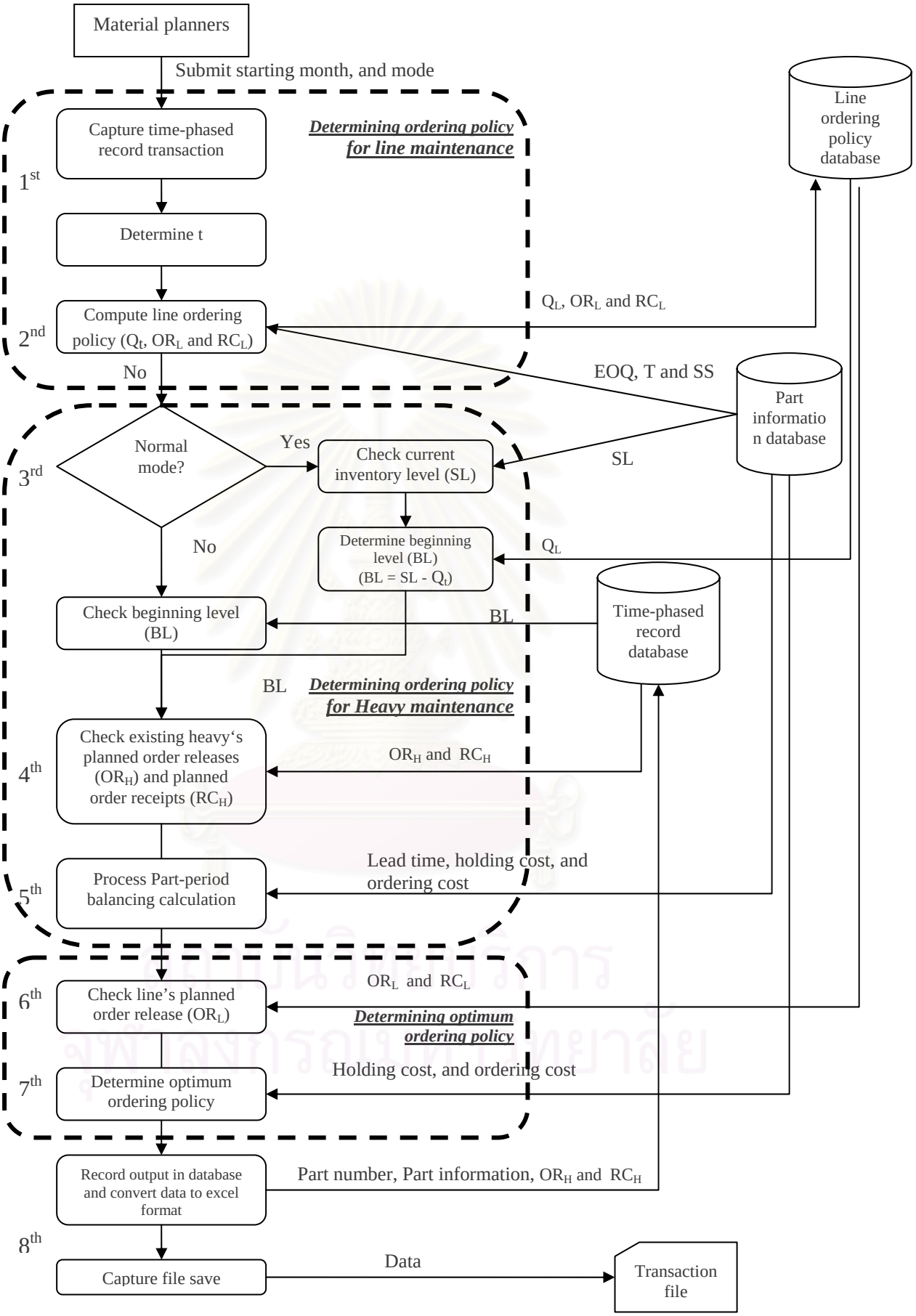


Figure 5.4 Time-phased record transaction

In the second stage, the inventory level for line demand at week t (Q_t) is gotten from the line ordering policy database. If there is no data of Q at week t since it is the first program running, the Q_t is set to be EOQ + SS. For example, part 280-00-369-00, from table 4.10 in section 4.4.1, EOQ is 22 units, safety stock (SS) is 4 units, lead time (L) is 15 weeks, and cycle period (T) is 39 weeks.

Therefore, $Q_{23, 2004} = EOQ + SS$

$= 22 + 4$

$= 26$ units

Since cycle period T is 39 weeks and the lead time (L) is the 15 weeks, the first order must be released at

$OR_L^1 = T - L$

$= 39 - 15$

$= 24$

$= 24^{th}$ week

Therefore, the first order for line demand OR_L^1 must be released at the 24^{th} week or in week 46. The order quantity is equal to EOQ which is 22 units. But, in fact, the order of 22 units is unusual to order. Therefore, the order quantity must be 30 units. Since the cycle period is 39 weeks, the next order must be released at

$OR_L^2 = T + OR_L^1$

$= 39 + 47$

$= 86^{th}$ week

Since the 86^{th} week is out of the 52 planning horizon, therefore, there is only one planned order release for line demand between June 2004 and May 2005. And the order of 30 units is expected to receipt (RC_L) at

$RC_L^1 = OR_L^1 + L$

$= 24^{th} + 15$

$= 39^{th}$ week

Therefore, the planned order receipt is expected to receipt in 39th week or week 10 of year 2005. To sum up, there are three outputs gotten from this stage recorded in line ordering policy database: $Q_{23,\ 2004}$ = 26 units, $OR_L{}^1{}_{46,\ 2004}$ = 30 units, and $RC_L{}^1{}_{9,\ 2005}$ = 30 units.

From the third stage to the seventh stage, the ordering policy for heavy demand is determined. In the third stage, the beginning level of the first week in time-phased record is determined. If the re-execute mode is selected, the beginning level of the starting week –t (BL_t) is gotten from the time-phased record database. But in this example, the normal mode is selected, therefore, the BL_t is equal to the current inventory level subtracting by the reserved quantity for line demand (Q_t). The current inventory level can be gotten from the part information database.

$$BL_t = SL_t - Q_t$$

Where SL_t = stock level at week t

From appendix A12, the inventory level of the beginning of June 2004 is 206 units.

Therefore,
$$BL_{23,\ 2004} = SL_{23,\ 2004} - Q_{23,\ 2004}$$
$$= 206 - 26$$
$$= 180 \text{ units}$$

In stage 4, on hand planned order releases (OR_H) and planned order receipts (RC_H) for heavy maintenance task are checked in the time-phased record database. In this example, there is an assumption of no on hand OR_H and RC_H between June 2004 and May 2005.

In stage 5, after getting the beginning level of the first week, the on hand planned order release and the on hand planned order receipt, the program is now starting to calculate the time-phased record as shown in figure 5.5. The planned monthly demand is gotten from the heavy monthly demand database in appendix A10.

Figure 5.5 Time-phased record of 280-00-369-00

		2004																
		Jun				Jul				Aug					Sep			
		23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39
LD	DM	42				12				12					0			
15wks	RC																	
SS	BL	180	138	138	138	138	126	126	126	126	114	114	114	114	114	114	114	114
4unit(s)	EL	138	138	138	138	126	126	126	126	114	114	114	114	114	114	114	114	114
	OR																	

		Oct					Nov				Dec				Jan			
		40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4
LD	DM	28					50				0				12			
15wks	RC																	
SS	BL	114	86	86	86	86	86	36	36	36	36	36	36	36	36	24	24	24
4unit(s)	EL	86	86	86	86	86	36	36	36	36	36	36	36	36	24	24	24	24
	OR							*30*									140	

		2005																
		Feb				Mar					Apr				May			
		5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
LD	DM	12				0					0				152				
15wks	RC					*30*									140				
SS	BL	24	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0
4unit(s)	EL	12	12	12	12	12	12	12	12	12	12	12	12	12	0	0	0	0	0
	OR																		

; where LT = Lead time = 15 weeks

SS = Safety stock = 4 units

DM = Planned demand

RC = Planned order receipt

BL = Beginning level

EL = Ending level

OR = Planned order release

In week 18, there is a demand of 152 units but there are only 12 units in stock. Therefore, the order of 140 units must be placed in week 3 to receipt it in week 18.

In stage 6, planned order releases (OR_L) and planned order receipts (RC_L) for line and light maintenance task in the line ordering policy database are brought to the time-phased record as shown in italic font style in figure 5.5. From stage 2, we have got OR_L of 30 units in week 46 year 2004 and RC_L of

30 units in week 9 year 2005. The RC_L from line ordering policy would not be added in the beginning level, but only shown in the time-phased record.

In stage 7, now we got planned order releases for both line and light maintenance, and heavy maintenance. The program will capture the first order release in the planning period. From figure 5.5, the first order release is placed in week 46 with the quantity of 30 units. The program determines the next planned order release which is placed in week 3 year 2005 with the quantity of 140 units. The program makes an assumption of placing orders separately.

Assumption 1 : Placing 2 orders separately

The orders of week 46 and week 3 are placed separately in those weeks.

Ordering cost = 2 x 1,653

= 3,306 THB

Since the spare parts are ordered the exact amount needed, there is no spare part left in stock.

Holding cost = 0 THB

Therefore, total costs incurred by using assumption 1 is

Total cost = 3,306 + 0

= 3,306 THB

Assumption 2 : Placing the second planned order with the first planned order

The planned orders are placed together at week 46.

Ordering cost = 1 x 1,653

= 1,653 THB

Since the planned order release for heavy maintenance is placed 9 weeks earlier, the order is then expected to be receipted in week 9 instead of week 18. The 140 units of part 280-00-369-00 then are held in stock for 9 weeks.

From appendix A2, the holding cost per unit per year is 215 THB. The holding cost per unit per week is 215/52 = 4.13 THB.

Holding cost = (140 x 4.13) x 9

= 5,209.62 THB

Therefore, the total incurred by using assumption 2 is

Total cost = 1,653 + 5,209.62

= 6,862.62 THB

The assumption of placing 2 orders separately is more cost-effective than the assumption of placing 2 orders together. Therefore, the program shows those 2 planned order releases separately as shown in figure 5.5. If the assumption of placing orders together is more cost-effective, the program will sum the quantities of those orders and place in the earliest week. Since this stage is done after part-period balancing computation, the result of integrating orders will not affect the number in BL and EL rows in the time-phased record. When those integrated orders are receipt, the quantities of RC_L will not be included in the beginning level of that week.

In stage 8, after getting complete time-phased record, the outputs including planned order release and planner order receipt would be saved in time-phased record database and converted to excel format. The material planners can save file in their directory.

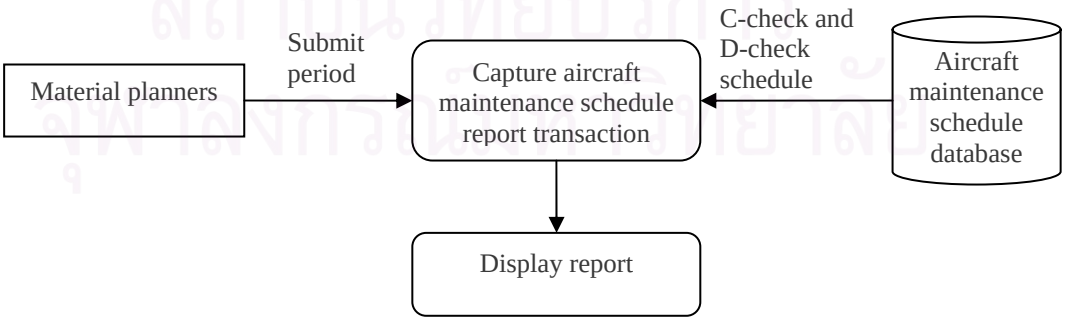


Figure 5.6 Aircraft maintenance schedule report transaction

From figure 5.6, the end users can get C-check and D-check schedule report via aircraft maintenance schedule report transaction. They just submit the interesting period. The data will be sorted from the aircraft maintenance schedule database and displayed on the user interface.

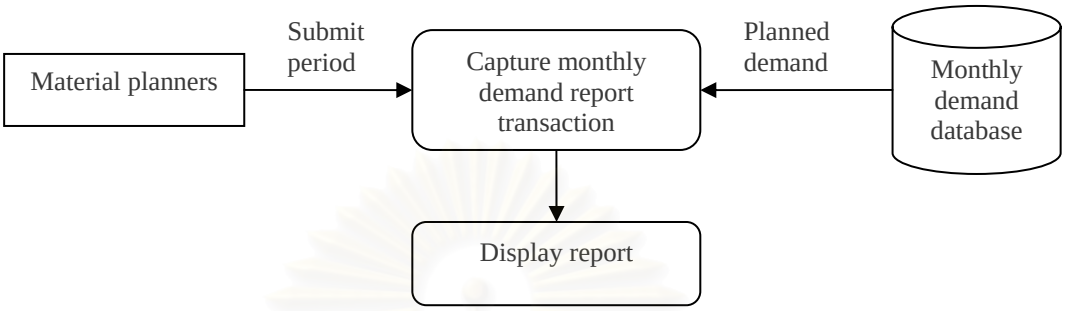


Figure 5.7 Monthly demand report transaction

From figure 5.7, the end users can submit the interesting period to get planned demand report from the monthly demand database.

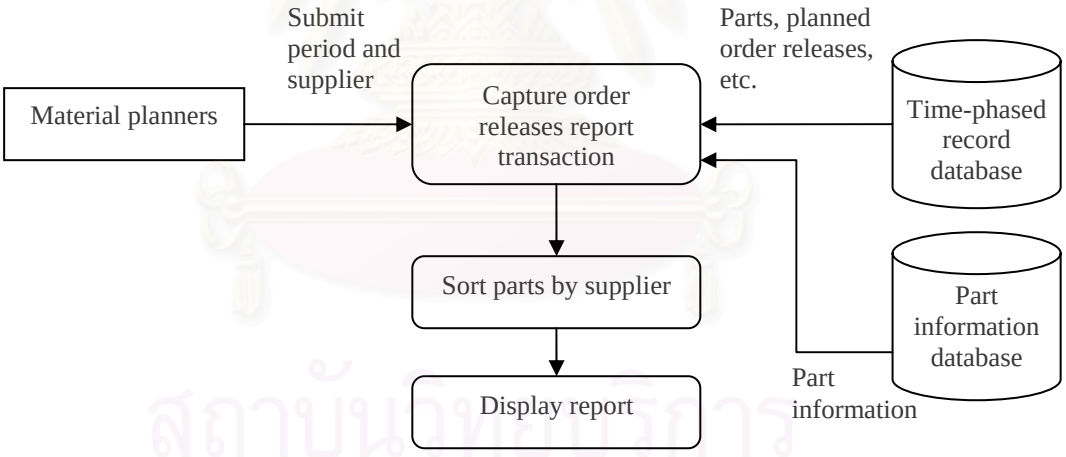


Figure 5.8 Order releases report transaction

From figure 5.8, the end users can get the planned order releases report sorted by supplier via the order releases report transaction. The part information (e.g. price, lead time, supplier, etc.) of each part is gotten from part information database. The data is then sorted by supplier and displayed on the user interface.

5.1.2 Database Structure Design

The database structure design focuses on the design of the structure of databases and files to be used by the proposed system. The existing database of THAI could not be used because the propose system was developed on Window OS. It then requires some modification and need to be stored in Microsoft excel.

Table 5.2 shows database structure which comprises 6 databases used in MRP computation. Database 1 stores general information of each spare part such as supplier, price, lead time, etc. Database 2 stores required spare parts for C-check and D-check tasks. Database 3 stores schedule for heavy maintenance. Database 1, 2 and 3 can be updated to be flexible for change. Database 4 stores monthly demand which results from program calculation when insert aircraft maintenance schedule into database 3. Database 5 comprises ordering policy for line demand (e.g. OR_L, RC_L, Q_t, etc). Database 6 comprises planned order releases, planned order receipts, etc. which results from MRP computation.

Table 5.2 Database structure

Name of database					
1. Part information	2. Required spare parts	3. Aircraft maintenance schedule	4. Monthly demand	5. Line ordering policy	6. Time-phased record
-Part number -Description -Supplier -Price per unit -Line demand per year -Holding cost per year -Lead time (LD) -Safety stock (SS) -Inventory level (SL) -Economic order quantity (EOQ)	- Spare part required for C-check - Spare part required for D-check	- Month - Year - Aircraft type - Check type (C-check and D-check)	- Part number - Month - Year - Demand for heavy maintenance	- Part number - Week - Quantity reserved for line (Q_t) - Planned order release (OR_L) - Planned order receipt (RC_L)	- Part number - Week - Demand - Beginning level - Ending level - Planned order released (OR_H) - Planned order received (RC_H)

Table 5.3 Output design

Output	Purpose	Contains	Database
1. Time-phased record	▪ For material planner to make a decision	Week, part number, description, planned demand, quantity taken out, quantity come in, quantity on hand and planned order release	Time-phased record database
2. Monthly demand report	▪ For material planner to observe the accuracy of the system ▪ For manager and supplier	Week, part number, description, location in store, demand, quantity taken out, quantity come in and quantity on hand	Monthly demand database
3. Aircraft maintenance schedule report	▪ For material planner to check the schedule	Month, year, check type and fleet	Aircraft maintenance schedule database
4. Planned order releases	▪ For purchasing personnel to purchase	Part number, supplier, week, month, year and order quantity	Time-phased record database

There are 4 outputs provided by the proposed program: time-phased record, monthly demand, aircraft maintenance schedule, and planned order releases reports. Table 5.3 shows the purpose of outputs, contains and the database related to the outputs. The time-phased record provides material planners planned demand, planned order receipts, planned order releases, , etc. of each part to support their decision-making. The monthly demand report provides material planners, manager and supplier a planned demand for each part in each month. The supplier then can prepare production schedule to fulfill the planned order. So THAI can be convinced that the parts ordered will be received in time.

The aircraft maintenance schedule report provides material planners the C-check and D-check schedule in each month to check the correct of the

schedule before running the MRP computation. The planned order releases report provides the purchasing personnel the planned order release of each part sorted by supplier. So they can work easier.

5.1.3 User Interface Design

The user interface design focuses on designing the interactions between end users and computer systems (James A.O., 1991). It concentrates on the conversion of data between human-readable and machine-readable forms. Therefore, user interface design produces displayed screens, forms, documents and reports.

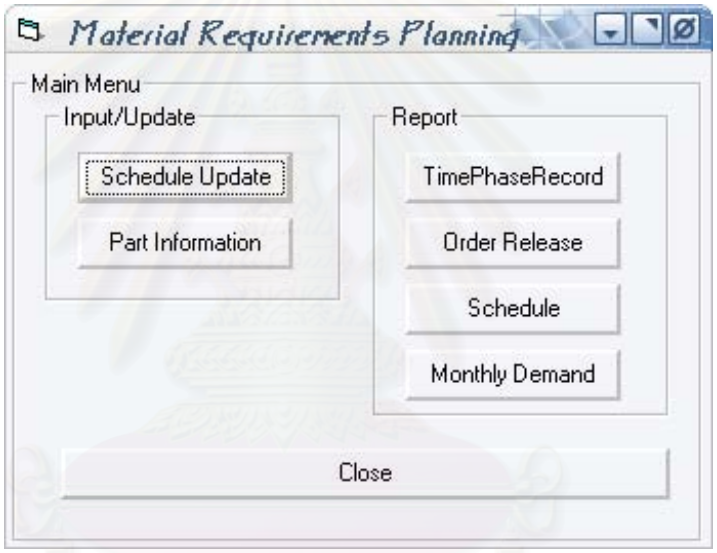


Figure 5.9 Main menu window

On the menu window, there are 2 input buttons for inserting and updating input; there are schedule update, and part information, as shown in figure 5.9. And there are 4 output buttons for getting report; there are time-phased record, order release report, schedule report and monthly demand report.

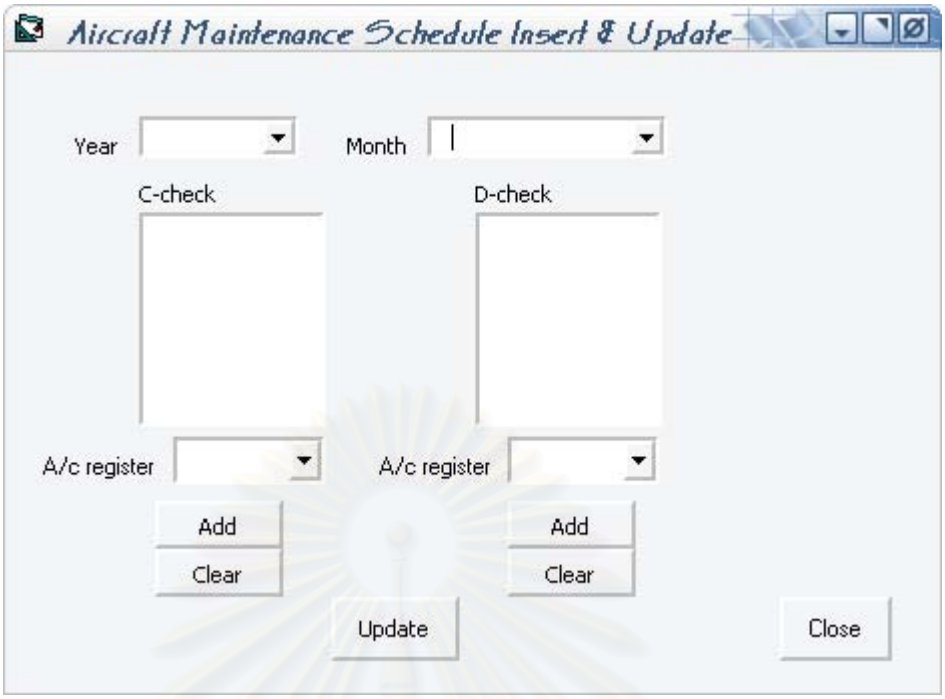


Figure 5.10 Aircraft maintenance schedule input window

Before executing the MRP computation, the end users have to insert input that is aircraft maintenance schedule in the aircraft maintenance schedule insert & update window as shown in figure 5.10. The aircraft lists for C-check schedule and D-check schedule are separated for ease of use.

Part information update window (see figure 5.11) enables end users to easily check and edit part information such as price, holding cost per year and lead time which may change every year.

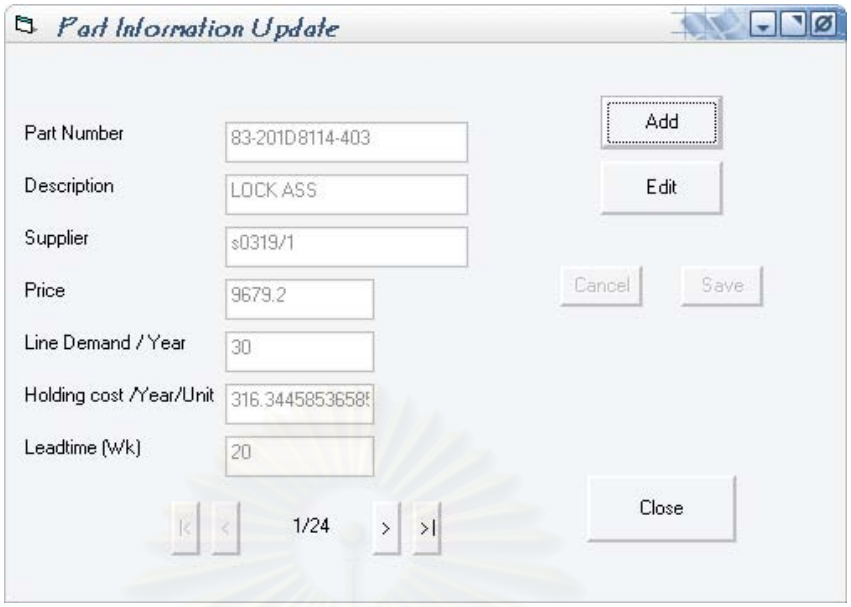


Figure 5.11 Part information update window

To get a time-phased record report, the end users have to select starting year, starting month, and mode (see figure 5.12). Normal mode means the program will compute by starting the current month and using the current stock level as the beginning level. Re-execute mode means the users can select any starting month and year which has been computed previously. This mode is useful when the users want to update the schedule or others information. The program will run for a while, and the output will be displayed in excel format as shown in figure 5.13. The time-phased record report is the key output for material planners for making a decision when to order and how many to order.

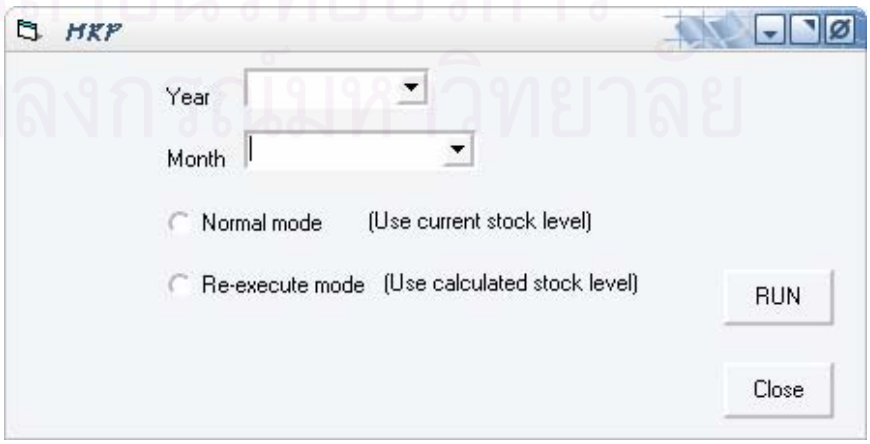
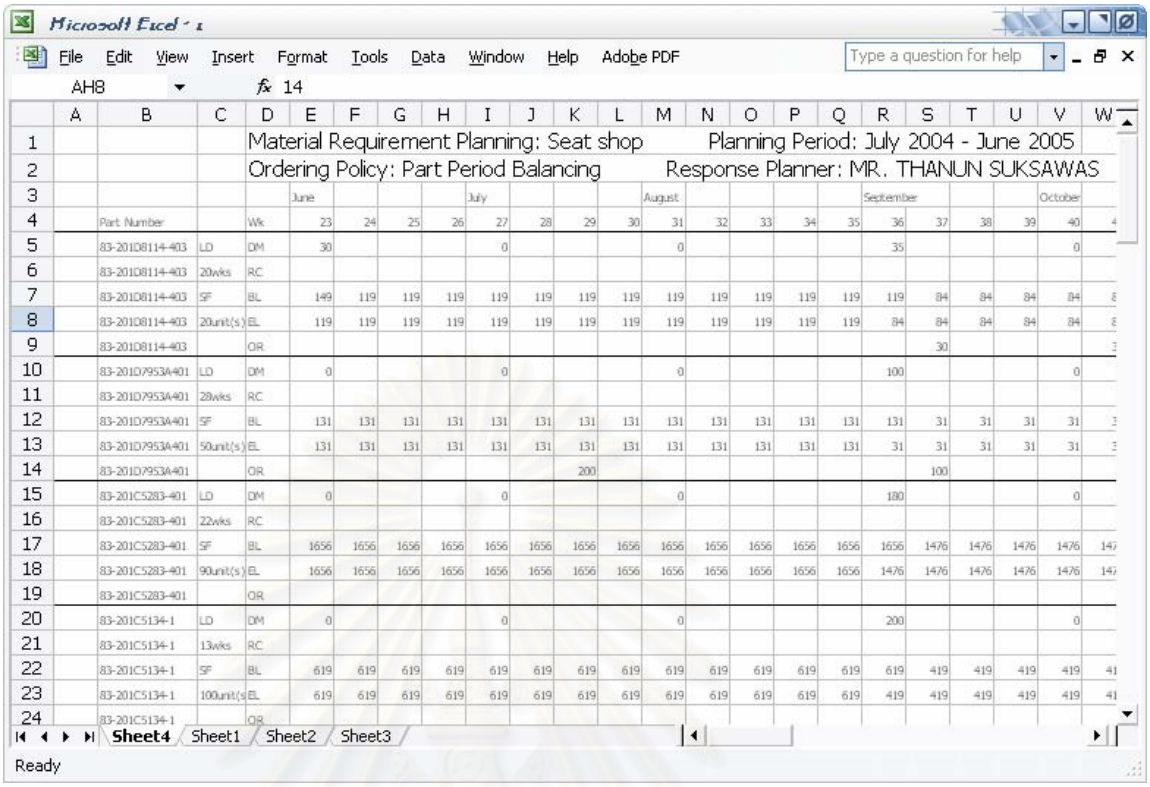


Figure 5.12 MRP window



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AH8 — fx 14

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1				Material Requirement Planning: Seat shop														Planning Period: July 2004 - June 2005					
2				Ordering Policy: Part Period Balancing														Response Planner: MR. THANUN SUKSAWAS					
3					June				July				August					September				October	
4		Part Number		Wk	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
5		83-201D8114-403	LD	DM	30				0				0					35				0	
6		83-201D8114-403	20wks	RC																			
7		83-201D8114-403	SF	BL	149	119	119	119	119	119	119	119	119	119	119	119	119	119	84	84	84	84	
8		83-201D8114-403	20unit(s)	EL	119	119	119	119	119	119	119	119	119	119	119	119	119	84	84	84	84	84	
9		83-201D8114-403		OR															30				
10		83-201D7953A401	LD	DM	0				0				0					100				0	
11		83-201D7953A401	28wks	RC																			
12		83-201D7953A401	SF	BL	131	131	131	131	131	131	131	131	131	131	131	131	131	131	31	31	31	31	
13		83-201D7953A401	50unit(s)	EL	131	131	131	131	131	131	131	131	131	131	131	131	131	31	31	31	31	31	
14		83-201D7953A401		OR							200								100				
15		83-201C5283-401	LD	DM	0				0				0					180				0	
16		83-201C5283-401	22wks	RC																			
17		83-201C5283-401	SF	BL	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1476	1476	1476	1476	
18		83-201C5283-401	90unit(s)	EL	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1476	1476	1476	1476	1476	
19		83-201C5283-401		OR																			
20		83-201C5134-1	LD	DM	0				0				0					200				0	
21		83-201C5134-1	13wks	RC																			
22		83-201C5134-1	SF	BL	619	619	619	619	619	619	619	619	619	619	619	619	619	619	419	419	419	419	
23		83-201C5134-1	100unit(s)	EL	619	619	619	619	619	619	619	619	619	619	619	619	619	419	419	419	419	419	
24		83-201C5134-1		OR																			

Sheet4 Sheet1 Sheet2 Sheet3

Ready

Figure 5.13 Time-phased record report display

Time-phased record gotten from MRP computation is a 52 weeks planning horizon or a one year plan. The information provided in the time-phased record report includes part number, week number (wk), lead time (LD), safety stock (SS), planned demand (DM), planned order receipts (RC), beginning level (BL), ending level (EL), and planned order releases (OR). The users can edit the report to make it more official form.

Figure 5.14 shows the order release report window which provides user a report of suggested time to place order and suggested order quantity in a 12 months period starting from the selected time. The users can sort the interesting information by supplier.

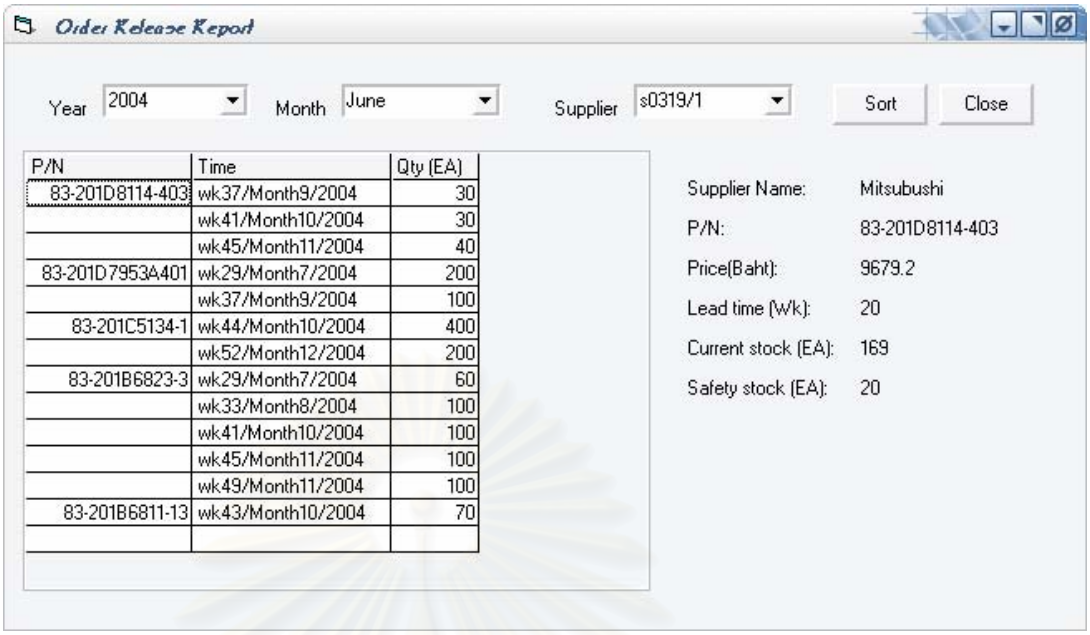


Figure 5.14 Order release report

Besides time-phased record, the users can make a report of aircraft maintenance schedule and a report of monthly demand in the interesting period as can be seen in figure 5.15 and 5.16, respectively. This information will be useful for management level for decision-making. Especially, monthly demand report, it provides suppliers the planned consumption of their product for production planning.

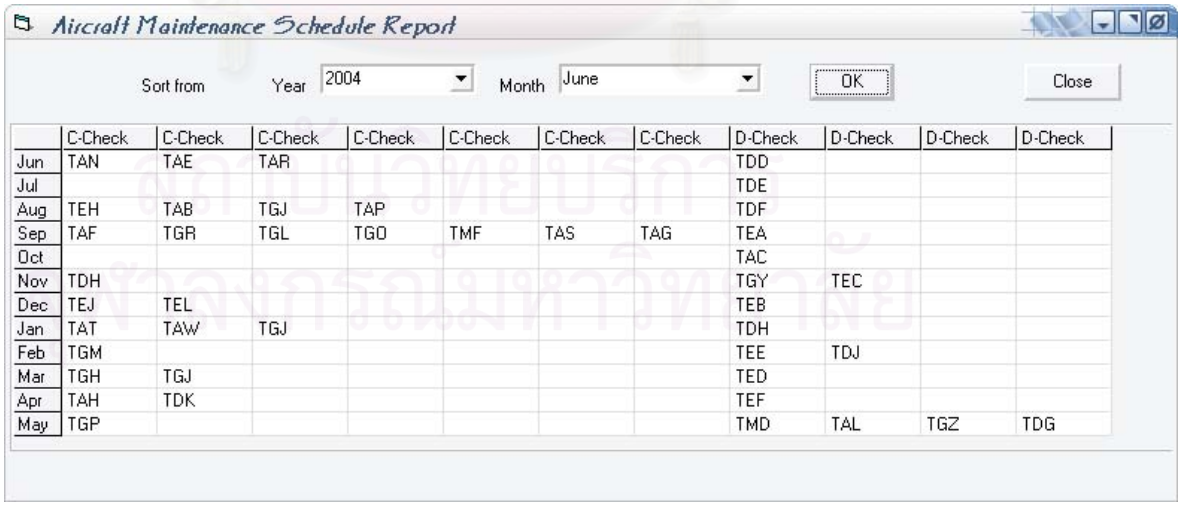
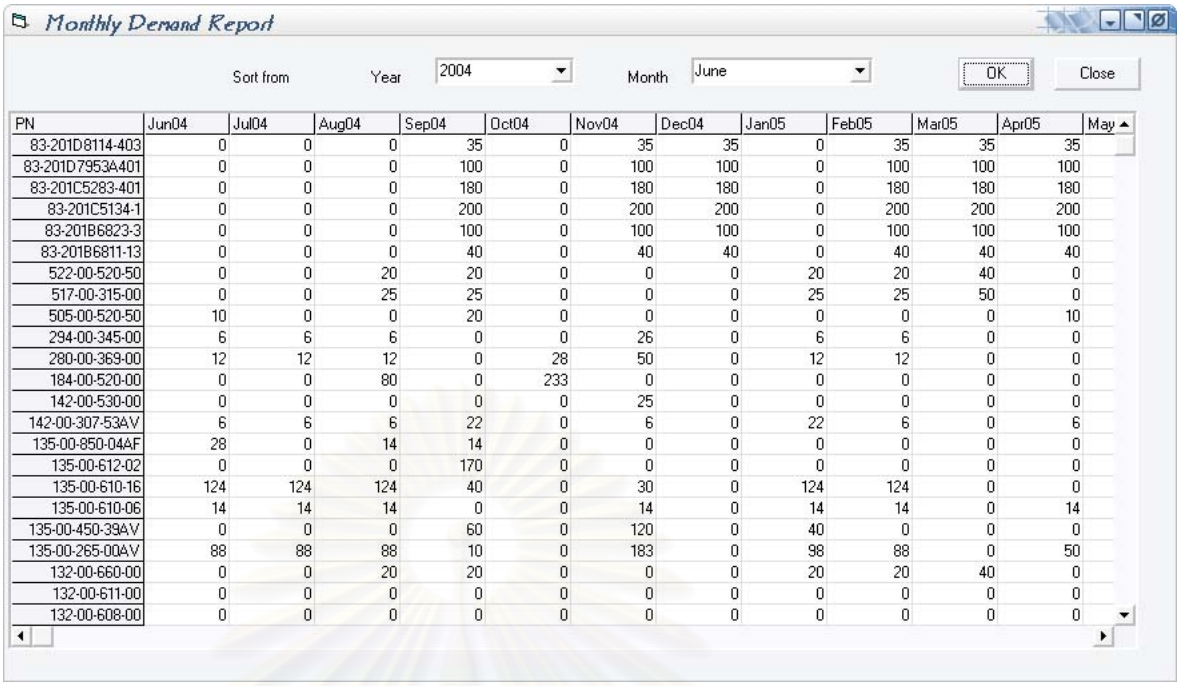


Figure 5.15 Aircraft maintenance schedule report



PN	Jun04	Jul04	Aug04	Sep04	Oct04	Nov04	Dec04	Jan05	Feb05	Mar05	Apr05	May
83-201D8114-403	0	0	0	35	0	35	35	0	35	35	35	
83-201D7953A401	0	0	0	100	0	100	100	0	100	100	100	
83-201C5283-401	0	0	0	180	0	180	180	0	180	180	180	
83-201C5134-1	0	0	0	200	0	200	200	0	200	200	200	
83-201B6823-3	0	0	0	100	0	100	100	0	100	100	100	
83-201B6811-13	0	0	0	40	0	40	40	0	40	40	40	
522-00-520-50	0	0	20	20	0	0	0	20	20	40	0	
517-00-315-00	0	0	25	25	0	0	0	25	25	50	0	
505-00-520-50	10	0	0	20	0	0	0	0	0	0	10	
294-00-345-00	6	6	6	0	0	26	0	6	6	0	0	
280-00-369-00	12	12	12	0	28	50	0	12	12	0	0	
184-00-520-00	0	0	80	0	233	0	0	0	0	0	0	
142-00-530-00	0	0	0	0	0	25	0	0	0	0	0	
142-00-307-53AV	6	6	6	22	0	6	0	22	6	0	6	
135-00-850-04AF	28	0	14	14	0	0	0	0	0	0	0	
135-00-612-02	0	0	0	170	0	0	0	0	0	0	0	
135-00-610-16	124	124	124	40	0	30	0	124	124	0	0	
135-00-610-06	14	14	14	0	0	14	0	14	14	0	14	
135-00-450-39AV	0	0	0	60	0	120	0	40	0	0	0	
135-00-265-00AV	88	88	88	10	0	183	0	98	88	0	50	
132-00-660-00	0	0	20	20	0	0	0	20	20	40	0	
132-00-611-00	0	0	0	0	0	0	0	0	0	0	0	
132-00-608-00	0	0	0	0	0	0	0	0	0	0	0	

Figure 5.16 Monthly demand report

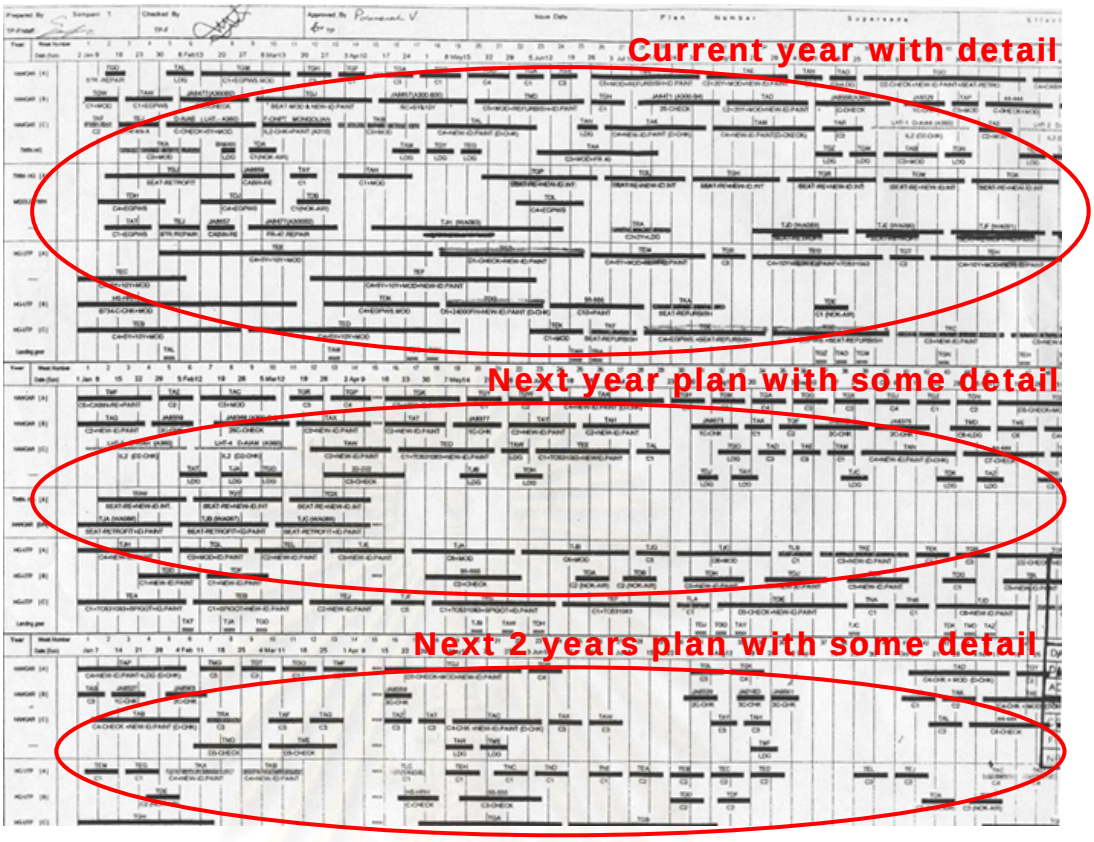
5.2 Program Testing

To test MRP computation, three basic inputs are required: inventory status, bill of materials, and master production schedule (MPS). The inventory status of each part can be gotten from the part information database. The required parts lists for heavy maintenance gotten from section 4.4 are used as bill of materials. The last input, MPS, is gotten from aircraft maintenance schedule database. In section 5.2.1, the methodology of determining planned demand of the program would be described. Then the program was test, and the output was shown in section 5.2.2.

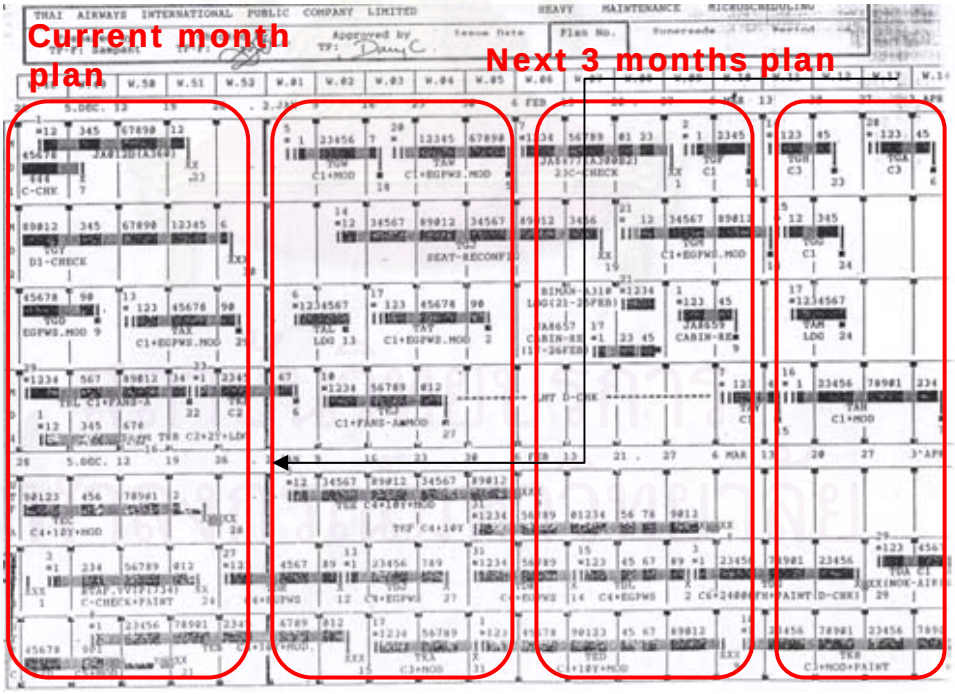
5.2.1 Determining the Planned Demand

As described previously, demand of aircraft spare parts comes from three parts: line and light maintenance, C-check, and D-check. Line demand has been forecasted in section 4.4. To determine demand for C-check and D-check, heavy maintenance schedule is needed as a master production schedule. The example of schedule is shown in figure 5.17. There are 2 types of schedule: macro scheduling which is a 3 years plan and micro

scheduling which is a 4 months plan. The micro schedule is usually updated every 3 months and distributed to involved functions in Technical department. In the updated schedule, most tasks are as same as the old one but the due in date might be different. The due in date of some tasks usually starts later than a previous schedule. In the macro scheduling, some tasks in the updated schedule could start many months later than an old schedule.



(a)



(b)

Figure 5.17 The examples of heavy maintenance schedule

(a) Heavy maintenance macro scheduling three years plan

(b) Heavy maintenance micro scheduling four months plan

In schedule there are a lot of abbreviations such as mod., C1, C2, etc. The C-check task might use C1, C2 and C3 abbreviations. The D-check task might use D1, D2, C4 or C6 abbreviations. Each aircraft has a different maintenance requirement set by aircraft manufacturer. Table 5.4 shows aircraft maintenance interval set by aircraft manufacturer. To separate schedule into two groups: D-check task and C-check task, the maintenance requirement for each aircraft must be known.

For example, aircraft type A330-300 which the aircraft register begins with "TE" has A-check and C-check. But for C4, which means the fourth C-check, the task description is quite equal to D-check. Therefore, C4 task for aircraft register "TE_" is assumed to be D-check. For aircraft type B737-400, the task which is equal to D-check is not C4 but C6. For MD11, both D1 and D2 are equal to D-check.

Table 5.4 Aircraft maintenance interval set by aircraft manufacturer

Aircraft type	Fleet	Task	Flight hour /month /year
A330-300	TE	A	500h
		C	15months
		C4	5years
A300-600/R	TA	A	400h
		C	15months
		C4	5years
B747-400	TG	A	600h
		C	18months
		D	6year
B747-300	TG	A	450h
		C	5,300h
		D	26,000h
B737-400	TD	A	250h
		C	4,000h
		C6	24,000h
MD11	TM	A	700h
		C	6,000h
		D1	30,000h or 72 months
		D2	22,400h or 60 months

In table 5.5, the heavy maintenance micro schedule between June 2004 and May 2005 was rewritten and selected only the C-check and D-check tasks. The schedule was separated into two tasks: C-check and D-check. The number of aircrafts in D-check task schedule in each month is normally no more than 4 aircrafts because of the limitation of the number of hangars. Similarly, the number of aircrafts in C-check schedule in each month is not more than 7 aircrafts.

Table 5.5 Schedule from Jun'04-May'05

Task	2004							2005				
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
D-check (Overhaul task)	TDD	TDE	TDF	TEA	TAC	TGY TEC	TEB	TDH	TEE TDJ	TED	TEF	TMD TAL TGZ TDG
C-check	TAN TAE TAR	-	TEH TAB TGJ TAP	TAF TGL TMF TAG TGR TGO TAS	-	TDH	TEJ TEL	TAT TGJ	TGM	TGH TGJ	TAH TDK	TGP

Refer to Appendix A9

The material planners are responsible for entering C-check and D-check schedule of an interesting period into aircraft maintenance schedule transaction. The data in aircraft maintenance schedule database and required spare parts database would be used to determine planned demand in that period. The program is then ready for MRP computation. The methodology of determining planned demand in June 2004 would be clearly described as an example.

From table 5.5, there were 4 aircrafts scheduled in June 2004. The concerned aircraft groups were given in table 5.6. Aircraft register TDD which is B734 group was overhauled. Aircraft register TAE which is A362 group, and

aircraft register TAN and TAR which are A360R group were performed C-check.

Table 5.6 Concerned aircraft groups

Aircraft type	Group	Aircraft register
B737-400	734	TDA, TDB, TDC, TDD, …, TDL
A300-600	A361	TAA, TAB, TAC
	A362	TAD, TAE, TAF
A300-600R	A360R0	TAN, TAO,…, TAR, TAS

Referred to table 4.4

The required spare parts for the interesting aircraft groups from table 4.13 and table 4.14 was brought to table 5.7. Performing D-check for TDD requires 3 parts: 294-00-345-00, 280-00-369-00 and 142-00-307-53AV. Performing C-check for TAE requires part number 505-00-520-50. There is no spare part required for TAN and TAR. The planned demands then were gotten by adding required spare parts for TDD and TAE as shown in the last column of table 5.6. Using this method, the program computes the planned demands for other months from July 2004 to May2005. The results were as shown in table 5.8.

Table 5.7 Spare quantity for overhaul and C-check task and forecasted demands

Required parts for D-check task		Required parts for C-check task			
P/N	734 (TDD)	P/N	A362 (TAE)	A360R0 (TAN, TAR)	**Planned demands (units)**
522-00-520-50		522-00-520-50			**0**
517-00-315-00		517-00-315-00			**0**
505-00-520-50		505-00-520-50	10		**10**
294-00-345-00	6	294-00-345-00			**6**
280-00-369-00	12	280-00-369-00			**12**
184-00-520-00		184-00-520-00			**0**
142-00-530-00		142-00-530-00			**0**
142-00-307-53AV	6	142-00-307-53AV			**6**

For example, part 517-00-315-00, the planned demand for heavy maintenance between June 2004 and May 2005 is 25+25+25+25+50 = 150 units.

Table 5.8 Planned demand between June 2004 and May 2005

	2004							2005					Total planned demand
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
522-00-520-50	0	0	20	20	0	0	0	20	20	40	0	0	120
517-00-315-00	0	0	25	25	0	0	0	25	25	50	0	0	150
505-00-520-50	10	0	0	20	0	0	0	0	0	0	10	0	40
294-00-345-00	6	6	6	0	0	26	0	6	6	0	0	54	110
280-00-369-00	12	12	12	0	28	50	0	12	12	0	0	152	290
184-00-520-00	0	0	80	0	233	0	0	0	0	0	0	0	313
142-00-530-00	0	0	0	0	0	25	0	0	0	0	0	25	50
142-00-307-53AV	6	6	6	22	0	6	0	22	6	0	6	28	108

Refer to Appendix A10

In conclusion, after the material planners enter aircraft maintenance schedule of interesting period to the database, the program then performs those steps described above to determine planned demand and store in database. Then the program would bring the planned demand, and inventory status to calculate the planned order receipts, and the planned order releases. The result of MRP computation will be the time-phased record and saved in excel format which is shown in a following section.

5.2.2 Result

After computing ordering policy for heavy demand, the output gotten from MRP computation is recorded in excel format as shown in figure 5.18. The output presents part number, lead time (LD), safety stock (SS), week (wk), planned demand (DM), planned order receipt (RC), beginning level (BL), ending level (EL) and planned order released (OR). The top of the report shows the description of the report such as shop, planning period, execution date, etc. The first row represents the concerned shop which is seat shop, and the period of planning which is 12 months period. The second row

represents the ordering policy approach which is part period balancing. The "Response Planner:" filed represents the name of planner who is responsible for this shop. The "Date:" field represents the MRP execution date. The excel format report enables the end users to sort the interesting parts and edit the report for further uses.

Material Requirement Planning: Seat shop Planning Period: July 2004 - June 2005

Ordering Policy: Part Period Balancing Response Planner: MR. THANUN SUKSAWAS Date: 18/12/2005

			June				July				August					September				October					November			
Part Number		Wk	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
83-201D8114-403	LD	DM	0				0				0					35				0					35			
83-201D8114-403	20wks	RC																										
83-201D8114-403	SF	BL	156	156	156	156	156	156	156	156	156	156	156	156	156	156	121	121	121	121	121	121	121	121	121	86	86	86
83-201D8114-403	4unit(s)	EL	156	156	156	156	156	156	156	156	156	156	156	156	156	121	121	121	121	121	121	121	121	121	86	86	86	86
83-201D8114-403		OR												10							20				40			
83-201D7953A40	LD	DM	0				0				0					100				0					100			
83-201D7953A40	28wks	RC																							120			
83-201D7953A40	SF	BL	181	181	181	181	181	181	181	181	181	181	181	181	181	181	81	81	81	81	81	81	81	81	81	101	101	101
83-201D7953A40	0unit(s)	EL	181	181	181	181	181	181	181	181	181	181	181	181	181	81	81	81	81	81	81	81	81	81	101	101	101	101
83-201D7953A401		OR							200								100											
83-201C5283-401	LD	DM	0				0				0					180				0					180			
83-201C5283-401	22wks	RC																										
83-201C5283-401	SF	BL	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1566	1566	1566	1566	1566	1566	1566	1566	1566	1386	1386	1386
83-201C5283-401	0unit(s)	EL	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1566	1566	1566	1566	1566	1566	1566	1566	1566	1386	1386	1386	1386
83-201C5283-401		OR																										
83-201C5134-1	LD	DM	0				0				0					200				0					200			
83-201C5134-1	13wks	RC																										
83-201C5134-1	SF	BL	719	719	719	719	719	719	719	719	719	719	719	719	719	719	519	519	519	519	519	519	519	519	519	319	319	319
83-201C5134-1	0unit(s)	EL	719	719	719	719	719	719	719	719	719	719	719	719	719	519	519	519	519	519	519	519	519	519	319	319	319	319
83-201C5134-1		OR																						300				

Refer to Appendix A11

Figure 5.18 Time-phased record output

5.3 Program Validation

After the proposed system was developed and tested, the material planners and shop planners were formed as a committee to check if the system met the requirement of THAI. The following points were considered:

- The MRP program performs the calculation as expected

  After testing the program, the output was checked if the order quantity conformed to part-period total cost balancing ordering policy and the order releases conformed to a given lead time. As a result, the program calculated properly.

- The program is ease of use and provides sufficient information for the users

  While developing the program, end users or material planners have involved in this stage. They suggested the proper user interface and required fields. For example, the user interface of order releases report, besides the planned order releases can be sorted by supplier, the users should be able to look details of each part such as price, safety stock, lead time, etc. by clicking on it. Moreover, the order quantity calculated by the program can not be used realistically, for instance, the order quantity should be 60 or 70 items instead of 61 items calculated by program which can not be released in reality.

  The latest developed program then has function to adjust the planned order releases to be tenth integer. These ensure that the proposed program is realistically useable and user friendly.

- The program provides accessibility for updating database

  Before running MRP program, the users must be sure that the information in database has been updated correctly, especially, lead time and price because these factors affected directly to the accuracy of the output. Since aircraft spare part is unique, almost parts are produced for THAI configuration only. When time goes by, the manufacturer normally reduces productivity of old-fashioned products because of the increasing of new products. This results in lengthened lead time. The purchasing personnel must continually check lead time with the supplier. Price per unit also is increasing every year because of the exchange rate and the decreasing of the productivity.

  Another factor that affects validation of the program is schedule. Micro schedule which is 4 months plan for heavy maintenance and used as an input for MRP is usually updated every 3 months. The due in date and the due out date always change. The due in date of an incoming task is usually 3-4 weeks late, and the due out dates of both ongoing tasks and incoming tasks are usually 1-2 months late. Therefore, the material planners should reschedule when the new revision of micro schedule is issued. The proposed system can cope with this problem. The users can reschedule and re-execute

MRP computation by using re-execute command which the planned order receipt, planned order releases and projected beginning level gotten from the latest computation are used.

- The system requires Window operating system

  The proposed program is designed for Window OS. Database used in this program then must be supported Window OS, but currently database is stored in the company's mainframe which has been used for 45 years. The user can not sort the interesting data from the enormous database. Only authorized people who had been trained for THAI database programming can sort the interesting data because operating system used in THAI is unique. To implement the proposed program at present then is difficult since the users have to create new database in Window OS which is time-consuming. However, at present THAI is studying and developing the new computer system which uses Window OS in the near future. This will support the proposed program. Therefore, the proposed program can be used when the new system is launched.

5.4 Effectiveness of the Proposed Program

To determine the effectiveness of the proposed program, there are two concerned things: how cost-effective it is and how accurate it is? It will be cost-effective if the number of orders placed and the spare parts held in store are reduced. Besides the improved efficiency, the accuracy of the proposed system was determined since it affected spare part shortage if the planned demand was lower than the actual demand.

5.4.1 Cost-Effectiveness

The ordering policy gotten from the proposed system was simulated with the actual demand to determine incurred cost. This cost would be compared with the actual cost incurred by the current system to find whether it is cost-effective.

Proposed system		Current system	
Cost incurred	<	Cost incurred	**Cost-effective**
Cost incurred	>	Cost incurred	**Non Cost-effective**

Total cost incurred by the current system

To determine the actual total cost incurred, the actual number of orders placed and inventory level at the beginning of the month between June2004 and June2005 were collected by using the enquiry transaction, as shown in table 5.9.

Table 5.9 Number of orders and the beginning level between June 2004 and June 2005

	Number of orders	Inventory level at the beginning of the month												
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
522-00-520-50	2	439	439	664	660	653	648	648	586	586	614	614	614	614
517-00-315-00	2	629	629	603	589	589	589	585	536	536	727	727	720	680
505-00-520-50	1	219	219	219	354	352	391	388	387	387	385	385	384	382
294-00-345-00	1	254	247	240	240	238	211	211	373	372	369	366	313	292
280-00-369-00	1	206	368	368	320	304	250	451	451	451	451	450	450	288
184-00-520-00	3	234	234	156	156	17	17	17	17	182	182	182	299	299
142-00-530-00	0	226	226	226	220	220	205	205	205	203	203	203	203	189
142-00-307-53AV	1	41	39	39	28	4	4	4	4	237	237	237	202	200

Refered to Appendix A12

An approximate quantity of spare parts held in the inventory of each month (Q_x) is equal to an average of the beginning level of that month and the beginning level of the next month.

$$Q_x = \frac{(\text{Beginning level of month}_x + \text{Beginning level of month}_{x+1})}{2}$$

where x = month

Table 5.10 shows the quantity of spare parts held in stock between June 2004 and May 2005. For example, parts 142-00-307-53AV held in June 2004 was equal to (41+39)/2 = 40 items, as shown in table 5.9.

$$Q_{Jun} = \frac{(41 + 39)}{2}$$

$$= 40 \text{ items}$$

Table 5.10 Inventory held in Jun 2004-May 2005 and holding cost related to current ordering policy

P/N	Spare parts held in stock (unit)												Sum	Holding cost per unit per month	Holding cost
	2004							2005							
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May			
522-00-520-50	439	552	662	657	651	648	617	586	600	614	614	614	7,254	68.05	493609.7
517-00-315-00	629	616	596	589	589	587	561	536	632	727	724	700	7,486	23.97	179466.3
505-00-520-50	219	219	287	353	372	390	388	387	386	385	385	383	4,154	63.94	265620.1
294-00-345-00	251	244	240	239	225	211	292	373	371	368	340	303	3,457	35.39	122335.1
280-00-369-00	287	368	344	312	277	351	451	451	451	451	450	369	4,562	17.91	81727.04
184-00-520-00	234	195	156	87	17	17	17	100	182	182	241	299	1,727	115.32	199162.5
142-00-530-00	226	226	223	220	213	205	205	204	203	203	203	196	2,527	62.80	158689.8
142-00-307-53AV	40	39	34	16	4	4	4	121	237	237	220	201	1,157	103.81	120104.1

Refered to Appendix A13

The spare parts held in stock in table 5.10 were used for determining the actual holding cost incurred by the current system as shown in the last column. The actual holding costs were determined by multiplying the sum of spare part held in stock by holding cost per unit per month.

For example, part 142-00-307-53AV, the holding cost per unit per month is 103.81 THB. The holding cost and ordering cost incurring between June 2004 and May 2005 can be determined as follows;

From table 5.10, the sum of spare parts held in stock in every month was equal to

$$= 40+39+34+16+4+4+4+4+237+237+237+202+200$$

$$= 1{,}157 \text{ items}$$

Therefore,

Holding cost = 1,157 x 103.81

= 120,104.1 THB

From table 5.9, there was 1 order placed in June2004-May2005.

Ordering cost = 1x1,653

= 1,653 THB

Using the above calculation, the actual total cost including ordering cost and holding cost were calculated and shown in table 5.11. The total cost incurred by the current system was 4.79 million THB.

Table 5.11 Cost related to current ordering policy

P/N	Number of orders	Ordering cost	Holding cost	Total cost (Jun2004-May2005)
522-00-520-50	2	3,306	493,609.67	496,915.67
517-00-315-00	2	3,306	179,466.32	182,772.32
505-00-520-50	1	1,653	265,620.13	267,273.13
294-00-345-00	1	1,653	122,335.08	123,988.08
280-00-369-00	1	1,653	81,727.04	83,380.04
184-00-520-00	3	4,959	199,162.48	204,121.48
142-00-530-00	0	0	158,689.85	158,689.85
142-00-307-53AV	1	1,653	120,104.10	121,757.10
:	:	:	:	:
Total		**61,161**	**4,728,316.70**	**4,789,477.70**

Refered to Appendix A14

Total cost incurred by the proposed system

The actual demands occurred between June 2004 and May 2005 were gathered by using the enquiry transaction as shown in table 5.12. For example, in June 2004, part 142-00-307-53AV was requested 2 units.

Table 5.12 Actual demand from June2004 to May2005 gotten from the enquiry transaction

P/N	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
522-00-520-50	0	0	4	7	5	0	62	0	20	0	0	0
517-00-315-00	0	26	14	0	0	4	49	0	10	0	7	40
505-00-520-50	0	0	0	2	20	3	1	0	2	0	1	2
294-00-345-00	7	7	0	2	27	0	0	1	3	3	53	21
280-00-369-00	12	0	48	16	54	0	0	0	0	1	0	162
184-00-520-00	0	78	0	139	0	0	0	0	0	0	0	0
142-00-530-00	0	0	6	0	15	0	0	2	0	0	0	14
142-00-307-53AV	2	0	11	24	0	0	0	2	0	0	35	2

Refered to Appendix A15

In table 5.13, the ordering policy gotten from the proposed system in section 5.2.2 or appendix A9 including planned order release (OR) and planned order receipt (RC) were used to simulate with the actual demand. The simulation was run for a year (June 2004 – May 2005). For easy to understand, the ending level and planned order release were not displayed in table 5.13.

The numbers in AD (actual demand) rows represents the actual demand gotten from table 5.12. The numbers in RC rows represents the planned order receipt gotten from appendix A9. For example, part 142-00-307-53AV had planned order receipts in September and February.

The numbers in BL (beginning level) rows represents the beginning level of each month. The beginning level of June 2004 was the actual beginning level gotten from table 5.9. The beginning level of other months was equal to the quantity on hand (planned order receipt plus beginning level) of a previous month subtracting by demand of a previous month.

Table 5.13 The MRP system simulation by using the actual pattern of demand

		2004							2005					
P/N		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
294-00-345-00	AD	7	7	0	2	27	0	0	1	3	3	53	21	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	254	247	240	240	238	211	211	211	210	207	204	151	130
280-00-369-00	AD	12	0	48	16	54	0	0	0	0	1	0	162	
	RC	0	0	0	0	0	0	0	0	0	30	0	120	
	BL	206	194	194	146	130	76	76	76	76	76	105	105	63
184-00-520-00	AD	0	78	0	139	0	0	0	0	0	0	0	0	
	RC	0	0	0	10	100	0	10	0	0	10	0	0	
	BL	234	234	156	156	27	127	127	137	137	137	147	147	147
142-00-530-00	AD	0	0	6	0	15	0	0	2	0	0	0	14	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	226	226	226	220	220	205	205	205	203	203	203	203	189
142-00-307-53AV	AD	2	0	11	24	0	0	0	2	0	0	35	2	
	RC	0	0	0	20	0	10	0	30	0	0	0	30	
	BL	41	39	39	28	24	24	34	34	62	62	62	27	55

Refered to Appendix A16

For example, part 142-00-307-53AV, from table 5.9 the beginning level of June 2004 was 41 items. From table 5.11, demand in June2004 was 2 items. Therefore, the ending level of June 2004 was 41-2 = 39 units which equalled the beginning level of July 2004.. In September 2004, the planned order release of 20 items had been received. Plus the beginning level of 28 items, the spare parts on hand then was 48 items. After subtracting 48 by demand of 24 items, the quantity on hand then was reduced to 24 items in October.

After simulating the actual demand with the proposed system, the spare parts held in inventory in each month (Q_x) were determined by using the following equation.

$$Q_x = \frac{(\text{Beginning level of month}_x + \text{Beginning level of month}_{x+1})}{2}$$

where x = month

For example, 142-00-307-53AV, the quantity held in stock in June was

$$Q_{\text{June 2004}} = \frac{(41 + 39)}{2}$$

$$= 40 \text{ units}$$

The holding cost was determined by multiplying the sum of spare parts held in stock by holding cost per unit per month. For example, 142-00-307-53AV, the holding cost per unit per month is 103.81 THB.

From table 5.14, sum of spare parts held in stock in every month is

$$= 40+39+34+26+24+29+34+48+62+62+44+41$$

$$= 483 \text{ units}$$

Therefore,

$$\text{Holding cost} = 483 \times 103.81$$

$$= 50{,}139 \text{ THB.}$$

The results of spare parts held in stock and holding cost incurred when using the proposed system between June 2004 and May 2005 are shown in table 5.14.

Table 5.14 Spare parts held in inventory (June2004-May2005) and holding cost incurred when using the proposed system

P/N	Spare parts held in inventory from June 2004 to May 2005												Total (Units)	Holding cost (THB)
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		
522-00-520-50	439	439	437	432	426	423	392	361	351	341	341	341	4,722	321,316
517-00-315-00	629	616	596	589	589	587	561	536	531	526	523	499	6781	162,565
505-00-520-50	219	219	219	218	207	196	194	193	192	191	191	189	2427	155,158
294-00-345-00	251	244	240	239	225	211	211	211	208.5	206	178	141	2,562	90,663
280-00-369-00	200	194	170	138	103	76	76	76	76	91	105	84	1389	24,875
184-00-520-00	234	195	156	92	77	127	132	137	137	142	147	147	1723	198,644
142-00-530-00	226	226	223	220	213	205	205	204	203	203	203	196	2527	158,658
142-00-307-53AV	40	39	33.5	26	24	29	34	48	62	62	44.5	41	483	50,139

Referred to Appendix A17

The number of planned order releases was gotten from section 5.2.2 or appendix A9. For example, part 142-00-307-53AV, there were 3 orders placed between June 2004 and May 2005. The ordering cost then was equal to 3x1653 = 4,959 THB. Table 5.15 shows the ordering costs and the total costs gotten incurred by the proposed system between June 2004 and May 2005.

Table 5.15 Costs related to the proposed system (June 2004-May 2005)

P/N	The proposed system (June2004-May2005)			
	Holding cost (Bht)	Number of order	Ordering cost (Bht)	Total cost (Bht)
522-00-520-50	321,316	0	0	321,315.81
517-00-315-00	162,565	0	0	162,564.94
505-00-520-50	155,158	0	0	155,158.22
294-00-345-00	90,663	0	0	90,663.14
280-00-369-00	24,875	2	3,306	28,180.61
184-00-520-00	198,644	5	8,265	206,908.53
142-00-530-00	158,658	0	0	158,658.45
142-00-307-53AV	50,139	3	4,959	55,097.53
:	:	:	:	:
Total	3,323,857		59,508	3,383,365.39

Referred to Appendix A18

Comparison between the current system and the proposed system

After getting costs incurred by the current system in table 5.11 and the proposed system in table 5.15, the comparison between those two methods were shown in table 5.16. Total cost incurred by the current method was 4.8 million THB while total cost incurred by the proposed method was 3.38 million THB.

Table 5.16 Total cost of current system compared to proposed system

P/N	Total cost (Current system)	Total cost (proposed system)
522-00-520-50	496,915.67	321,315.81
517-00-315-00	182,772.32	162,564.94
505-00-520-50	267,273.13	155,158.22
294-00-345-00	123,988.08	90,663.14
280-00-369-00	83,380.04	28,180.61
184-00-520-00	204,121.48	206,908.53
142-00-530-00	158,689.85	158,658.45
142-00-307-53AV	121,757.10	55,097.53
‘ ‘ ‘	‘ ‘ ‘	‘ ‘ ‘
Total cost	**4,789,477.70**	**3,383,365.39**

Referred to Appendix A19

From table 5.16, using the proposed system from June 2004 to May 2005 could save money 1.6 million THB. An amount of reduction in total costs was observed to be 29.4%.

$$\text{Percentage of cost reduction} = \frac{4{,}789{,}478 - 3{,}383{,}365}{4{,}789{,}478} \text{x}100\ \%$$

$$= 29.4\%$$

Keep in mind that in this thesis only 24 spare parts in class A in seat shop were studied. The cost could be saved many millions THB a year. If this proposed system applied to every spare part SPC1 and SPC7 in Technical department, the cost could be saved enormously.

5.4.2 Program Accuracy

In table 5.17, the actual demand, the actual shortage, the planned demand, and the shortage occurred from the proposed were shown. The percent of accuracy was calculated to determine the accuracy of the proposed system.

$$\text{Percent of accuracy} = \frac{(DM - AD)*100}{AD}$$

where DM = planned demand

AD = actual demand

Table 5.17 Percent of accuracy

P/N	Actual		Planning		Percent of accuracy (%)
	Actual demand (unit)	Shortage (unit)	Planned demand (unit)	Shortage (unit)	
83-201D8114-403	169		210		24.26
83-201D7953A401	592		600		1.35
83-201C5283-401	1174		1080		-8.01
83-201C5134-1	1206	82	1200		-0.50
83-201B6823-3	413		600		45.28
83-201B6811-13	243	152	240		-1.23
522-00-520-50	98		120		22.45
517-00-315-00	150		150		0.00
505-00-520-50	31		40		29.03
294-00-345-00	124		110		-11.29
280-00-369-00	293		290		-1.02
184-00-520-00	217		313		44.24
142-00-530-00	37		50		35.14
142-00-307-53AV	76		108		42.11
135-00-850-04AF	27		56		107.41
135-00-612-02	372		403		8.33
135-00-610-16	734	301	864		17.71
135-00-610-06	120		112		-6.67
135-00-450-39AV	448		510		13.84
135-00-265-00AV	694	2	919		32.42
132-00-660-00	128		120		-6.25
132-00-611-00	4		0		-100.00
132-00-608-00	2		0		-100.00
132-00-500-00	78		100		28.21

The planned demand might be greater or smaller than actual demand. Negative percent of accuracy means the planned demand was lower than the actual demand. For the negative percent of accuracy, it may result in shortage if the inventory on hand and the safety stock are insufficient. But it would not be a problem if the safety stock is enough to serve those shortages.

As can be seen in shortage column in the actual column, the actual shortage happened when requesting for heavy maintenance because the shortage was usually a large volume such as 82 items, 152 items, etc. The shortage due to

current system then resulted from delay in order placing. When simulated the inventory with the ordering policy gotten from the proposed system, the shortage was zero as can be seen in table 5.17.

In conclusion, the proposed system gives a higher efficient material planning in term of cost-effective and in term of accuracy, as can be seen in 29.4% reduction in inventory related costs and a reduction in shortage.

5.5 Sensitivity Analysis

The collection of data leading to ordering cost and holding cost could result in error. As mentioned in section 4.2, the ordering cost (K) and holding cost (I) may not includes some hidden costs. The actual ordering cost and holding cost might be greater or smaller than the calculated costs. The error could increase total cost and generate inaccuracy when computing MRP. In this section, the program was computed at different ordering costs (k) and holding costs (i) varying from -50% to +50% to examine the effect of input error on total cost.

$$\text{Percent of differentiate} = \frac{\left|T_{(K,I)} - T_{(k,i)}\right|}{T_{(K,I)}} \times 100 \ \%$$

Where $T_{(K,I)}$ = total costs (THB) at 100% ordering cost and 100% holding cost

$T_{(k,i)}$ = total costs (THB) at each vary ordering cost and holding cost

k = ordering cost varying from 50% to 150% of ordering cost

i = ordering cost varying from 50% to 150% of ordering cost

Figure 5.19 shows the percent of total cost error relative to an input error. The error of a holding cost is more sensitive to the MRP computation than the error of an ordering cost. The result have shown that underestimating holding cost by 50% causes a 1.47% decrease in total cost, and overestimate holding cost by 150% causes a 1.1% increase in total cost. The combined effect could result in a 1.99% error in total cost. This suggests that the result from time-phase record is insensitive to errors in the ordering cost and holding cost parameters.

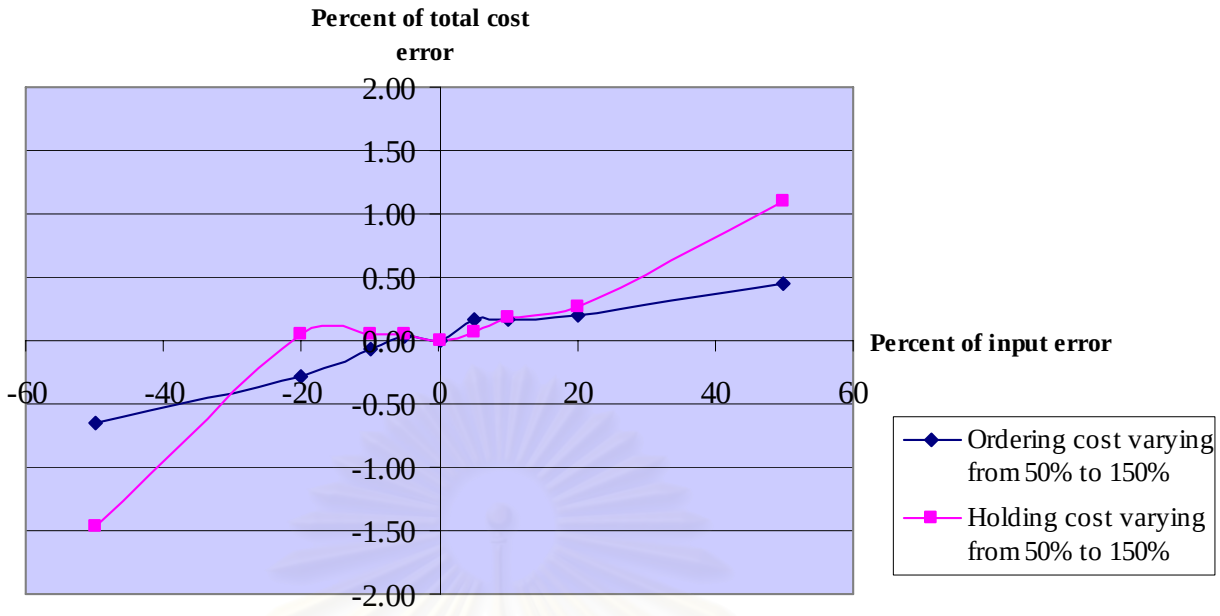


Figure 5.19 The percent of total cost error relative to an input error

CHAPTER VI
CONCLUSION AND RECOMMENDATION

In this chapter, the conclusion and recommendation are demonstrated. The conclusion including method of system development, data accuracy, improved spare part planning work flow and benefits of the new system are concluded in section 6.1. The limitation of the proposed system and the recommendation for further system development are given in section 6.2.

6.1 Conclusion

6.1.1 Method of Development

The method of development of the proposed system is as follows;

- Current system analysis
  - Studying relevant literatures related to material planning
  - Current material planning procedure analysis
  - Current material planning system analysis
- Data collection and analysis
  - Part information collection including lead time, price, demand, etc.
  - Heavy maintenance and line maintenance demand analysis
  - Ordering cost and holding cost determination
- System design
  - Conceptual design
  - Database design
  - User interface design

- Program testing and validation
  - Program testing
  - Program validation
  - Improved efficiency determination
  - Sensitivity analysis

In current system analysis stage, the relevant knowledge including MRP and lot sizing techniques were studied to determine which methods would be used for developing the system. The current material planning procedure and computer system analysis was done in this stage to identify the variables that affect the efficiency of the current system. The data collection and analysis stage includes collection of part information, past demands for heavy maintenance and line maintenance, and general expenses. Data gotten from this stage would be the key variables for MRP computation. This stage took the longest time since the current system was difficult to access to the database.

In the system design stage, the conceptual design of the new system is conducted. It concerns what the new work flow will be look like, how does it ameliorate the problems and who will involve in the new system. Database structure design concerns how to group the necessary information to be uncomplicated and make the program run smoothly. In user interface design, the end users including material planner, shop planner and purchasing personnel have been involved in this stage to make program user friendly.

In the program testing and validation stage, the program was tested and validated to meet the users' requirements. The improved efficiency of the proposed system was determined by comparing total costs with the current system. And finally, the effect of input errors was determined to analyse the program sensitivity.

6.1.2 Data Accuracy

Since the limitation of the current system, past demands of the heavy maintenance and line maintenance are limited in past 2 years. Some parts then have a few record of demand for C-check. It was agreed that the maximum demand for C-check would be used for demand forecasting. As time goes by, the information would be more gathered and planned demand would be more accuracy.

6.1.3 Improved Spare Part Planning Work Flow

If the proposed system is applied to the organisation, the work flow of the spare part planning and control will be improved. Manual work will be reduced. Most of works will be done by the computer. And time spent in procedure is reduced. The material planners work easier. Instead of manual checking item one-by-one with the schedule in the current system, the proposed system enables the material planners to submit schedule into the database once, and the MRP will calculate the optimum ordering policy automatically. The material planners could access time-phased record database to get reports both time-phased record report and planned order releases report. They may consider which part is out-to-date and will be no longer used which may take a half day. The meeting may be conducted as needed. After that, they make a report and inform purchasing personnel to place order. Since the reports for purchasing personnel can be easily made by the proposed system, an hour is enough for preparing reports for purchasing personnel.

The purchasing personnel can work easier since the planned order releases informed by the material planners are already grouped by supplier. The purchasing personnel then do not have to group the order and determine the price by themselves. The consideration and order placing procedure then can be done together within an hour.

6.1.4 Benefits of the Proposed System

The proposed system will give benefit to the company as follows;

- Tangible benefit
  - Reduction in inventory cost

    The major tangible benefit is a reduction in total inventory costs both ordering cost and holding cost. The cost-effective of the proposed system was measured by comparing the total costs incurred by the current system and the total costs incurred by the proposed system in section 5.4.1 “Cost-effectiveness”. Using the proposed system could save cost 29.4%. Since the value of spare parts SPC1 and SPC7 is about one third of total aircraft spare part value, the value of aircraft spare parts SPC1 and SPC7 would be more than one billion THB. If this new system is applied to every SPC1 and SPC7 part, the cost will be saved more than 0.3 billion THB a year.

- Intangible benefit
  - Reduction in error

    Since in the proposed system most of works will be done by computer, the human error, for example, forgettable order, forgettable part, mistake in calculation, etc. will be ameliorated. In the current system, one material planner is responsible for ten thousands spare parts, and there are thousands parts in the list of low inventory and shortage spare parts. They may look over some parts. Although they recognise it later, it may be too late to order. The mistake in calculation is unavoidable because material planning and control is a numerical task. There are ten thousands seat spare parts used in 82 aircrafts. Although the aircrafts are the same type, the seat configurations and required spare parts are not the same.

  - Useful information

    Since the proposed system provides four reports including time-phased record, planned order releases, aircraft maintenance schedule, and monthly demand reports, all stakeholders including managers, material planners,

and purchasing personnel have useful information for supporting their decision-making.

- Reduction in process and time

With the current system, there are hundreds of spare parts listed in low inventory and shortage spare parts list. Investigating parts one by one and conducting meeting between stakeholders which may be several days is very time-consuming.

With the proposed system, the material planners do not need to investigate parts one by one. They just insert a schedule once, and the program will compute and suggest the optimum order quantity, and the right date to place orders for all parts. The meeting between stakeholders may be conducted as needed.

And since most of works are done by computer, the time spent on material planning and control is reduced obviously. The material planners then finish their job earlier and have more time to improve the system.

- Planner works easier

In the current system, the material planners must have high work experience to do their job. They have to know every part in detail and familiar with seat configuration of every aircraft group. They then can plan spare parts quickly. This results in low opportunities for new employed planners to do their job. With the proposed system, material planners just update database such as spare part information, aircraft maintenance schedule, etc., and the MRP computation will produce the useful information for their decision-making. They may have some consideration for determining which part will be no longer used. The job then can be done easier and does not require high experience planner to perform.

- Reduction in shortage

  With the proposed system, the human error will be reduced. The order will be placed at a right time and a right quantity. The shortage then will be reduced. Moreover, the MRP computation will reserve a small amount of spare parts as safety stock to support uncertainty of line demand. The material planners can be convinced that there will be a certain amount of spare part to avoid shortage.

6.2 Recommendation

This thesis focuses on spare part planning and control system for spare parts SPC1 and SPC7 which is non-repairable. To expend MRP system to overall aircraft spare parts in THAI, the procedure and lead time for repairing repairable parts should be improved to be standard. Because currently, most repairing tasks would be performed by rotating mechanics when their routine works are finished. The MRP system could be applied to all spare parts when spare parts are repaired and returned to store in a quicker and predictable manner.

In some case such as after installation of the new components which never been used on THAI aircrafts, the line demand of that component or piece parts will be unstable at the beginning period since it may work improperly and required to replace or modify by the vendor to conform THAI configuration. Therefore, let's it go on for a period until line demand becomes stable which may be a year. It is then could be planned and controlled by the proposed system.

This proposed system does not cover an emergency task since it is unpredictable. For an emergency task, the material planners have to add the additional required spare parts to the monthly demand database themselves.

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APPENDICES

APPENDIX A
PART INFORMATION
AND OUTPUTS

APPENDIX A1 Part Information

Part Number	Name	Price(US$)	Price(THB)	Lead time (week)	Supplier
83-201D8114-403	LOCK ASS	262	9679.2	20	s0319/1
83-201D7953A401	COVER	71.09	2630.7	28	s0319/1
83-201C5283-401	SHELL	78.88	2918.56	22	s0319/1
83-201C5134-1	COVER	51.55	1170.31	13	s0319/1
83-201B6823-3	SHELL	84.21	3115.77	16	s0319/1
83-201B6811-13	COVER	73.74	2728.38	18	s0319/1
522-00-520-50	FOODTRAY	160.5	6154.21	14	c1084/1
517-00-315-00	ARMCAP	58.64	2168.2	10	c1084/1
505-00-520-50	FOODTRAY	156.3	5783.1	14	c1084/1
294-00-345-00	COVER	84.8	3200.5	14	w0945/1
280-00-369-00	ESCUTCHE	43.1	1620.23	15	c1084/1
184-00-520-00	FOODTRAY	281.89	10429.93	13	c1084/1
142-00-530-00	BRCKT.LH	153.5	5679.5	14	c1084/1
142-00-307-53AV	BUMPER	272.4	9388.38	13	w0945/1
135-00-850-04AF	FOODTRAY	1017.1	37632.33	24	c1084/1
135-00-612-02	CUSHION	82.23	3042.51	13	w0945/1
135-00-610-16	CUSHION	81.76	3022.9	12	w0945/1
135-00-610-06	CUSHION	72.8	2692.49	10	c1084/1
135-00-450-39AV	INSERT	49.88	1845.56	15	c1084/1
135-00-265-00AV	COVER	34.98	1294.26	12	c1084/1
132-00-660-00	CUSHION	59.08	2183	12	w0945/1
132-00-611-00	CUSHION	74.4	2752.8	12	c1084/1
132-00-608-00	CUSHION	70.98	2626.26	12	w0945/1
132-00-500-00	BAR	106.8	3951.6	15	c1084/1

APPENDIX A2 Holding Cost per Item per Year (THB)

Part Number	Price (THB)	Holding cost per item per year (I) (THB)
83-201D8114-403	9,679.20	1,284.43
83-201D7953A401	2,630.70	349.09
83-201C5283-401	2,918.56	387.29
83-201C5134-1	1,170.31	155.30
83-201B6823-3	3,115.77	413.46
83-201B6811-13	2,728.38	362.06
522-00-520-50	6,154.21	816.66
517-00-315-00	2,168.20	287.72
505-00-520-50	5,783.10	767.42
294-00-345-00	3,200.50	424.71
280-00-369-00	1,620.23	215.00
184-00-520-00	10,429.93	1,384.05
142-00-530-00	5,679.50	753.67
142-00-307-53AV	9,388.38	1,245.84
135-00-850-04AF	37,632.33	4,993.81
135-00-612-02	3,042.51	403.74
135-00-610-16	3,022.90	401.14
135-00-610-06	2,692.49	357.29
135-00-450-39AV	1,845.56	244.91
135-00-265-00AV	1,294.26	171.75
132-00-660-00	2,183.00	289.68
132-00-611-00	2,752.80	365.30
132-00-608-00	2,626.26	348.50
132-00-500-00	3,951.60	524.38

APPENDIX A3 Effective Parts list

Aircraft groups						
734	743	7440	7441	7442	A361	A362
703-00-511-00	8247	522-00-520-50	703-00-511-00	703-00-511-00	8247	505-00-315-00
135-00-307-05AW	911-003-01TG	8247	135-00-307-05AW	135-00-307-05AW	287-00-390-00	8247
135-00-610-16	517-00-315-00	132-00-660-00	135-00-610-16	135-00-651-04	911-003-01TG	132-00-660-00
135-00-610-06	364-008-02	273-00-390-00	8247	135-00-610-16	364-008-02	505-00-520-50
273-00-390-00	362-078-01TG	911-003-01TG	273-00-390-00	142-00-651-35	362-078-01TG	287-00-390-00
135-00-381-52AV	300-125-02	517-00-315-00	135-00-381-52AV	142-00-652-35	300-125-02	911-003-01TG
135-00-380-52AV	361-014-01	364-008-02	135-00-380-52AV	8247	361-014-01	364-008-02
135-00-880-05AW	517-00-571-00	362-078-01TG	135-00-880-05AW	273-00-390-00	184-00-520-00	362-078-01TG
135-00-265-00AV	517-00-570-00	300-125-02	911-003-01TG	135-00-381-52AV	280-00-369-00	300-125-02
135-00-850-05AV	294-00-390-00	361-014-01	364-008-02	135-00-380-52AV		361-014-01
294-00-328-00	132-00-611-00	517-00-571-00	362-078-01TG	135-00-880-05AW		505-00-561-00
294-00-329-00	280-00-369-00	517-00-570-00	135-00-450-39AV	911-003-01TG		280-00-369-00
135-00-263-52AV	517-00-520-50	294-00-328-00	300-125-02	364-008-02		132-00-608-00
135-00-263-51AV		294-00-329-00	135-00-265-00AV	362-078-01TG		
142-00-307-53AV		522-00-307-00	361-014-01	135-00-450-39AV		
142-00-306-53AV		522-00-308-00	135-00-850-05AV	142-00-639-55		
135-00-381-53AV		840073-402J	294-00-328-00	300-125-02		
280-00-369-00		132-00-611-00	294-00-329-00	142-00-638-55		
294-00-345-00		280-00-369-00	135-00-263-52AV	135-00-265-00AV		
		840073-404K	135-00-263-51AV	361-014-01		
		142-00-530-00	840073-402J	135-00-850-05AV		
		294-00-345-00	135-00-381-53AV	RDAA6506-08		
			280-00-369-00	135-00-651-05		
			840073-404K	294-00-328-00		
			294-00-345-00	294-00-329-00		
				135-00-263-52AV		
				135-00-263-51AV		
				135-00-381-53AV		
				280-00-369-00		
				142-00-530-00		
				294-00-345-00		

Aircraft groups						
A360R0	A360R1	A360R2	A360R3	A330	A331	MD11
933556	933556	505-00-315-00	135-00-307-05AW	934767	934767	703-00-511-00
135-00-651-04	505-00-315-00	8247	135-00-651-04	83-201C5283-401	83-201C5283-401	135-00-307-05AW
135-00-610-06	8247	132-00-660-00	135-00-610-06	83-201D8114-403	83-201D8114-403	135-00-612-02
715-00-511-00	287-00-390-00	505-00-520-50	8247	83-201B6811-11	83-201C5134-1	273-00-390-00
8247	911-003-01TG	287-00-390-00	287-00-390-00	83-201B6811-12	83-201B6811-11	135-00-381-52AV
287-00-390-00	364-008-02	LL17500-36	LL17500-36	83-201B6811-13	83-201B6811-12	135-00-380-52AV
LL17500-36	362-078-01TG	132-00-500-00	135-00-880-05AW	83-201D7953A401	83-201B6811-13	LL17500-36
911-003-01TG	300-125-02	911-003-01TG	911-003-01TG	83-201B6823-3	83-201D7953A401	135-00-880-05AW
364-008-02	361-014-01	362-078-01TG	364-008-02	934766	83-201B6823-3	135-00-450-39AV
362-078-01TG	933554	300-125-02	362-078-01TG	83-201B6828A401	934766	135-00-850-05AV
300-125-02	933558	361-014-01	135-00-450-39AV	83-201B6828A404	83-201B6828A401	615-00-320-00
361-014-01	505-00-561-00	931742	300-125-02	83-201B6998-401	83-201B6828A404	135-00-651-05
933554	280-00-369-00	505-00-561-00	135-00-265-00AV	135-00-850-05AV	83-201C5134-401	135-00-263-52AV
933558		280-00-369-00	361-014-01		83-201B6998-401	135-00-263-51AV
135-00-850-04AF		132-00-608-00	171384-02			703-00-401-00
280-00-369-00			294-00-328-00			703-00-402-00
			294-00-329-00			142-00-307-53AV
			135-00-263-52AV			142-00-306-53AV
			135-00-263-51AV			135-00-381-53AV
			142-00-307-53AV			280-00-369-00
			142-00-306-53AV			294-00-345-00
			280-00-369-00			
			142-00-530-00			
			171384-01			
			294-00-345-00			

APPENDIX A4 Demands Separated by Maintenance Task

	Demand 2003	Demand 2004	Line demand (2003-2004)			Heavy demand (2003-2004)			Line demand (% of total demand)	Average Line demand per year
			Demand	Avg. quantity / Line demand	Standard deviation of Line demand	Demand	Avg. quantity / Heavy demand	Standard deviation of Heavy demand		
83-201D8114-403	311	295	60	1.8	0.7	546	1.67	1.11	9.90	30
83-201D7953A401	269	237	0	0	0	506	8	2	0.00	0
83-201C5283-401	644	371	0	0	0	1,015	56.7	30.9	0.00	0
83-201C5134-1	742	508	0	0	0	1,250	100	100	0.00	0
83-201B6823-3	112	49	0	0	0	161	2.5	1.5	0.00	0
83-201B6811-13	166	63	0	0	0	223	1.67	0.94	0.00	0
522-00-520-50	298	698	0	0	0	996	2.43	1.12	0.00	0
517-00-315-00	460	676	2	1	0	1,134	2.86	2.5	0.18	1
505-00-520-50	324	422	4	1	0	742	15.43	30.3	0.54	2
294-00-345-00	179	131	6	1	0	304	5.06	7.6	1.94	3
280-00-369-00	384	298	60	1.7	0.72	622	16.05	16.76	8.80	30
184-00-520-00	430	305	68	2.2	0.7	667	80	0.49	9.25	34
142-00-530-00	102	109	0	0	0	211	14.25	8.9	0.00	0
142-00-307-53AV	125	52	0	0	0	177	5.9	7.57	0.00	0
135-00-850-04AF	27	30	0	0	0	57	1.94	0.66	0.00	0
135-00-612-02	469	235	0	0	0	704	127.8	105.66	0.00	0
135-00-610-16	1,267	654	30	1.58	0.97	1,891	99.5	116.1	1.56	15
135-00-610-06	729	833	20	1.18	0.87	1,542	116	79.62	1.28	10
135-00-450-39AV	499	499	0	0	0	998	21.8	39.11	0.00	0
135-00-265-00AV	234	199	0	0	0	433	14	32.79	0.00	0
132-00-660-00	926	1,224	0	0	0	2150	65.4	85.24	0.00	0
132-00-611-00	248	256	20	1.18	0.87	484	8.7	0.76	3.97	10
132-00-608-00	200	200	6	1	0	394	68.33	23.21	1.50	3
132-00-500-00	253	370	0	0	0	623	9.08	15.79	0.00	0

APPENDIX A5 Line Demand per Year

Part Number	Seat model	Number of seats (units)	Line demand per year (units)	Line demand per year per seat (units)
83-201D8114-403	3110-x	3,648	30	0.008
83-201D7953A401	3110-x	3,648	0	0.000
83-201C5283-401	3210-x	660	0	0.000
83-201C5134-1	3210-x	660	0	0.000
83-201B6823-3	3110-x	3,648	0	0.000
83-201B6811-13	3110-x	3,648	0	0.000
522-00-520-50	3152-1	1,914	0	0.000
517-00-315-00	3152-1,3152-3	2,562	1	0.000
505-00-520-50	3153-x	1,450	2	0.001
294-00-345-00	3211-x	1,744	3	0.002
280-00-369-00	315x-x	15,856	30	0.002
184-00-520-00	3154-x	1,870	34	0.018
142-00-530-00	3152-x	5,597	0	0.000
142-00-307-53AV	3211-x	1,744	0	0.000
135-00-850-04AF	3153-x	1,450	0	0.000
135-00-612-02	3212-x	48	0	0.000
135-00-610-16	3211-x	1,744	15	0.009
135-00-610-06	3151-x,3155-x,3153-x	4,418	10	0.002
135-00-450-39AV	3152-x	5,597	0	0.000
135-00-265-00AV	3152-x	5,597	0	0.000
132-00-660-00	3213-x	432	0	0.000
132-00-611-00	3152-2	432	10	0.023
132-00-608-00	3152-2	432	3	0.007
132-00-500-00	3153-1	580	0	0.000

APPENDIX A6 Safety Stock and Economic Order Quantity for Line Demand

	Line demand /year	Holding cost /year	EOQ	Standard deviation	Lead time (week)	б1	Safety stock (SS)	T
83-201D8114-403	30	1,284.43	9	0.7	20	1.57	4	16
83-201D7953A401	0	349.09	0	0	28	0	0	0
83-201C5283-401	0	387.29	0	0	22	0	0	0
83-201C5134-1	0	155.30	0	0	13	0	0	0
83-201B6823-3	0	413.46	0	0	16	0	0	0
83-201B6811-13	0	362.06	0	0	18	0	0	0
522-00-520-50	0	816.66	0	0	14	0	0	0
517-00-315-00	1	287.72	4	0	10	0	0	208
505-00-520-50	2	767.42	3	0	14	0	0	78
294-00-345-00	3	424.71	5	0	14	0	0	87
280-00-369-00	30	215.00	22	0.72	15	1.44	4	39
184-00-520-00	34	1,384.05	9	0.7	13	1.40	4	14
142-00-530-00	0	753.67	0	0	14	0	0	0
142-00-307-53AV	0	1,245.84	0	0	13	0	0	0
135-00-850-04AF	0	4,993.81	0	0	24	0	0	0
135-00-612-02	0	403.74	0	0	13	0	0	0
135-00-610-16	15	401.14	12	0.97	12	1.68	4	42
135-00-610-06	10	357.29	10	0.87	10	1.51	4	52
135-00-450-39AV	0	244.91	0	0	15	0	0	0
135-00-265-00AV	0	171.75	0	0	12	0	0	0
132-00-660-00	0	289.68	0	0	12	0	0	0
132-00-611-00	10	365.30	10	0.87	12	1.51	4	52
132-00-608-00	3	348.50	6	0	12	0	0	104
132-00-500-00	0	524.38	0	0	15	0	0	0

APPENDIX A7 Required Parts for C-Check

	737-400	747-300	B747-400 (0)	B747-400 (!)	B747-400 (2)	A360 (1)	A360 (2)	A360R	A360R (1)	A360R (2)	A360R (3)	A330-300	A330-300 (1)	MD11
83-201D8114-403														
83-201D7953A401														
83-201C5283-401														
83-201C5134-1														
83-201B6823-3														
83-201B6811-13														
522-00-520-50			20											
517-00-315-00		25	25											
505-00-520-50							10			10				
294-00-345-00														
280-00-369-00														
184-00-520-00						80								
142-00-530-00														
142-00-307-53AV	6										8			22
135-00-850-04AF								14						
135-00-612-02														170
135-00-610-16				20	20									
135-00-610-06	14													
135-00-450-39AV				20	20						20			20
135-00-265-00AV	50			5	5						5			
132-00-660-00			20											
132-00-611-00														
132-00-608-00														
132-00-500-00										50				

APPENDIX A8 Required Parts for D-Check

	737-400	747-300	B747-400 (0)	B747-400 (!)	B747-400 (2)	A360 (1)	A360 (2)	A360R	A360R (1)	A360R (2)	A360R (3)	A330-300	A330-300 (1)	MD11
83-201D8114-403												35	35	
83-201D7953A401												60	100	
83-201C5283-401												180	180	
83-201C5134-1													200	
83-201B6823-3												100	100	
83-201B6811-13												40	40	
522-00-520-50			316											
517-00-315-00		406	406											
505-00-520-50							114			201				
294-00-345-00	6	31	31	31	26						14			22
280-00-369-00	12	62	62	62	50	28	28	46	46	46	28			44
184-00-520-00						233								
142-00-530-00			32		25						14			
142-00-307-53AV	6										8			22
135-00-850-04AF								14						
135-00-612-02														233
135-00-610-16	124			30	30									
135-00-610-06	14							197			228			
135-00-450-39AV				120	120						233			150
135-00-265-00AV	88			133	133						211			
132-00-660-00			146				211			187				
132-00-611-00		325	325											
132-00-608-00							233			201				
132-00-500-00										50				

APPENDIX A9 Heavy Maintenance Schedule

	2004							2005												2006			
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan' 05	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan'	Feb	Mar	Apr
D-check task	TDD	TDE	TDF	TEA	TAC	TGY TEC	TEB	TDH	TEE TDJ	TED	TEF	TM D TAL TGZ TDG	-	TME TAK TEM TGE	TAE TAD TAM	TEG TGD	TGO	THE TMG	TAF	TMF	-	-	-
C-check task	TAN TAE TAR	-	TEH TAB TGJ TAP	TAF TGR TGL TGO TMF TAS TAG	-	TD H	TEJ TEL	TAT TGJ TA W	TG M	TGH TGJ	TAH TDK	TGP	TAA TDL TEK	TGN	TGH TGB	TAR TGR TDE	TG M	TGK	TGN	TAG TGW TDD TEA	TAC TGT TGL TDF TEB	TAX TAW TGX TEL TEJ	TGK TAT TED

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APPENDIX A10 Planned demand

Planned demand for year 2004/05

	2004							2005					Demand per year
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	
83-201D8114-403	0	0	0	35	0	35	35	0	35	35	35	0	210
83-201D7953A401	0	0	0	100	0	100	100	0	100	100	100	0	600
83-201C5283-401	0	0	0	180	0	180	180	0	180	180	180	0	1,080
83-201C5134-1	0	0	0	200	0	200	200	0	200	200	200	0	1,200
83-201B6823-3	0	0	0	100	0	100	100	0	100	100	100	0	600
83-201B6811-13	0	0	0	40	0	40	40	0	40	40	40	0	240
522-00-520-50	0	0	20	20	0	0	0	20	20	40	0	0	120
517-00-315-00	0	0	25	25	0	0	0	25	25	50	0	0	150
505-00-520-50	10	0	0	20	0	0	0	0	0	0	10	0	40
294-00-345-00	6	6	6	0	0	26	0	6	6	0	0	54	110
280-00-369-00	12	12	12	0	28	50	0	12	12	0	0	152	290
184-00-520-00	0	0	80	0	233	0	0	0	0	0	0	0	313
142-00-530-00	0	0	0	0	0	25	0	0	0	0	0	25	50
142-00-307-53AV	6	6	6	22	0	6	0	22	6	0	6	28	108
135-00-850-04AF	28	0	14	14	0	0	0	0	0	0	0	0	56
135-00-612-02	0	0	0	170	0	0	0	0	0	0	0	233	403
135-00-610-16	124	124	124	40	0	30	0	124	124	0	0	174	864
135-00-610-06	14	14	14	0	0	14	0	14	14	0	14	14	112
135-00-450-39AV	0	0	0	60	0	120	0	40	0	0	0	290	510
135-00-265-00AV	88	88	88	10	0	183	0	98	88	0	50	226	919
132-00-660-00	0	0	20	20	0	0	0	20	20	40	0	0	120
132-00-611-00	0	0	0	0	0	0	0	0	0	0	0	0	0
132-00-608-00	0	0	0	0	0	0	0	0	0	0	0	0	0
132-00-500-00	0	0	0	50	0	0	0	0	0	0	50	0	100

Planned demand for year 2005/06

	2005								2006				Demand per year
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
83-201D8114-403	0	0	35	0	35	0	35	0	0	0	0	0	105
83-201D7953A401	0	0	60	0	100	0	100	0	0	0	0	0	260
83-201C5283-401	0	0	180	0	180	0	180	0	0	0	0	0	540
83-201C5134-1	0	0	0	0	200	0	200	0	0	0	0	0	400
83-201B6823-3	0	0	100	0	100	0	100	0	0	0	0	0	300
83-201B6811-13	0	0	40	0	40	0	40	0	0	0	0	0	120
522-00-520-50	0	0	20	20	0	20	20	20	0	20	0	20	140
517-00-315-00	0	0	431	25	406	25	25	25	0	25	0	25	987
505-00-520-50	0	0	0	228	0	0	0	114	10	0	0	0	352
294-00-345-00	54	0	53	0	31	31	22	0	22	0	0	0	213
280-00-369-00	152	0	152	102	62	62	44	28	44	0	0	0	646
184-00-520-00	0	80	0	0	0	0	0	0	0	80	0	0	160
142-00-530-00	25	0	0	0	0	0	0	0	0	0	0	0	25
142-00-307-53AV	28	6	22	0	6	0	22	0	28	6	16	8	142
135-00-850-04AF	0	0	0	0	14	0	0	0	0	0	0	0	14
135-00-612-02	233	0	233	0	0	0	233	0	233	0	0	0	932
135-00-610-16	174	0	0	20	20	30	0	0	20	20	20	0	304
135-00-610-06	14	14	0	0	14	0	0	0	14	14	0	0	70
135-00-450-39AV	290	0	150	20	20	120	150	0	170	20	60	20	1,020
135-00-265-00AV	226	50	0	5	55	133	0	0	55	55	15	5	599
132-00-660-00	0	0	20	442	0	20	20	231	0	20	0	20	773
132-00-611-00	0	0	325	0	325	0	0	0	0	0	0	0	650
132-00-608-00	0	0	0	466	0	0	0	233	0	0	0	0	699
132-00-500-00	0	0	0	0	0	0	0	0	50	0	0	0	50

Appendix A11.1 Time-Phased Record Output

			June				July				August					September				October
Part Number		Wk	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
83-201D8114-403	LD	DM	0				0				0					35				0
83-201D8114-403	20wks	RC																		
83-201D8114-403	SS	BL	156	156	156	156	156	156	156	156	156	156	156	156	156	156	121	121	121	121
83-201D8114-403	4unit(s)	EL	156	156	156	156	156	156	156	156	156	156	156	156	156	121	121	121	121	121
83-201D8114-403		OR												10						
83-201D7953A401	LD	DM	0				0				0					100				0
83-201D7953A401	28wks	RC																		
83-201D7953A401	SS	BL	181	181	181	181	181	181	181	181	181	181	181	181	181	181	81	81	81	81
83-201D7953A401	0unit(s)	EL	181	181	181	181	181	181	181	181	181	181	181	181	181	81	81	81	81	81
83-201D7953A401		OR							200								100			
83-201C5283-401	LD	DM	0				0				0					180				0
83-201C5283-401	22wks	RC																		
83-201C5283-401	SS	BL	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1566	1566	1566	1566
83-201C5283-401	0unit(s)	EL	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1746	1566	1566	1566	1566	1566
83-201C5283-401		OR																		
83-201C5134-1	LD	DM	0				0				0					200				0
83-201C5134-1	13wks	RC																		
83-201C5134-1	SS	BL	719	719	719	719	719	719	719	719	719	719	719	719	719	719	519	519	519	519
83-201C5134-1	0unit(s)	EL	719	719	719	719	719	719	719	719	719	719	719	719	719	519	519	519	519	519
83-201C5134-1		OR																		
83-201B6823-3	LD	DM	0				0				0					100				0
83-201B6823-3	16wks	RC																		
83-201B6823-3	SS	BL	192	192	192	192	192	192	192	192	192	192	192	192	192	192	92	92	92	92
83-201B6823-3	0unit(s)	EL	192	192	192	192	192	192	192	192	192	192	192	192	192	92	92	92	92	92
83-201B6823-3		OR							10				100							
83-201B6811-13	LD	DM	0				0				0					40				0
83-201B6811-13	18wks	RC																		
83-201B6811-13	SS	BL	199	199	199	199	199	199	199	199	199	199	199	199	199	199	159	159	159	159
83-201B6811-13	0unit(s)	EL	199	199	199	199	199	199	199	199	199	199	199	199	199	159	159	159	159	159
83-201B6811-13		OR																		
522-00-520-50	LD	DM	0				0				20					20				0
522-00-520-50	14wks	RC																		
522-00-520-50	SS	BL	439	439	439	439	439	439	439	439	439	419	419	419	419	419	399	399	399	399
522-00-520-50	0unit(s)	EL	439	439	439	439	439	439	439	439	419	419	419	419	419	399	399	399	399	399
522-00-520-50		OR																		
517-00-315-00	LD	DM	0				0				25					25				0
517-00-315-00	10wks	RC																		
517-00-315-00	SS	BL	625	625	625	625	625	625	625	625	625	600	600	600	600	600	575	575	575	575
517-00-315-00	0unit(s)	EL	625	625	625	625	625	625	625	625	600	600	600	600	600	575	575	575	575	575
517-00-315-00		OR																		
505-00-520-50	LD	DM	10				0				0					20				0
505-00-520-50	14wks	RC																		
505-00-520-50	SS	BL	216	206	206	206	206	206	206	206	206	206	206	206	206	206	186	186	186	186
505-00-520-50	0unit(s)	EL	206	206	206	206	206	206	206	206	206	206	206	206	206	186	186	186	186	186
505-00-520-50		OR																		
294-00-345-00	LD	DM	6				6				6					0				0
294-00-345-00	14wks	RC																		
294-00-345-00	SS	BL	249	243	243	243	243	237	237	237	237	231	231	231	231	231	231	231	231	231
294-00-345-00	0unit(s)	EL	243	243	243	243	237	237	237	237	231	231	231	231	231	231	231	231	231	231
294-00-345-00		OR																		
280-00-369-00	LD	DM	12				12				12					0				28
280-00-369-00	15wks	RC																		
280-00-369-00	SS	BL	180	168	168	168	168	156	156	156	156	144	144	144	144	144	144	144	144	144
280-00-369-00	4unit(s)	EL	168	168	168	168	156	156	156	156	144	144	144	144	144	144	144	144	144	116
280-00-369-00		OR																		
184-00-520-00	LD	DM	0				0				80					0				233
184-00-520-00	13wks	RC														10				100
184-00-520-00	SS	BL	221	221	221	221	221	221	221	221	221	141	141	141	141	141	141	141	141	141
184-00-520-00	4unit(s)	EL	221	221	221	221	221	221	221	221	141	141	141	141	141	141	141	141	141	8
184-00-520-00		OR	10				100									10				

Appendix A11.2 Time-Phased Record Output

			October					November				December				January				Febuary	
Part Number		Wk	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6
83-201D8114-403	LD	DM	0					35				35				0				35	
83-201D8114-403	20wks	RC															10				
83-201D8114-403	SS	BL	121	121	121	121	121	121	86	86	86	86	51	51	51	51	51	51	51	51	16
83-201D8114-403	4unit(s)	EL	121	121	121	121	121	86	86	86	86	51	51	51	51	51	51	51	51	16	16
83-201D8114-403		OR		20				40				10									
83-201D7953A401	LD	DM	0					100				100				0				100	
83-201D7953A401	28wks	RC						120												200	
83-201D7953A401	SS	BL	81	81	81	81	81	81	101	101	101	101	1	1	1	1	1	1	1	1	101
83-201D7953A401	0unit(s)	EL	81	81	81	81	81	101	101	101	101	1	1	1	1	1	1	1	1	101	101
83-201D7953A401		OR																			
83-201C5283-401	LD	DM	0					180				180				0				180	
83-201C5283-401	22wks	RC																			
83-201C5283-401	SS	BL	1566	1566	1566	1566	1566	1566	1386	1386	1386	1386	1206	1206	1206	1206	1206	1206	1206	1206	1026
83-201C5283-401	0unit(s)	EL	1566	1566	1566	1566	1566	1386	1386	1386	1386	1206	1206	1206	1206	1206	1206	1206	1206	1026	1026
83-201C5283-401		OR																			
83-201C5134-1	LD	DM	0					200				200				0				200	
83-201C5134-1	13wks	RC																		300	
83-201C5134-1	SS	BL	519	519	519	519	519	519	319	319	319	319	119	119	119	119	119	119	119	119	219
83-201C5134-1	0unit(s)	EL	519	519	519	519	519	319	319	319	319	119	119	119	119	119	119	119	119	219	219
83-201C5134-1		OR					300								200						
83-201B6823-3	LD	DM	0					100				100				0				100	
83-201B6823-3	16wks	RC						10				100								100	
83-201B6823-3	SS	BL	92	92	92	92	92	92	2	2	2	2	2	2	2	2	2	2	2	2	2
83-201B6823-3	0unit(s)	EL	92	92	92	92	92	2	2	2	2	2	2	2	2	2	2	2	2	2	2
83-201B6823-3		OR		100				100				100									
83-201B6811-13	LD	DM	0					40				40				0				40	
83-201B6811-13	18wks	RC																			
83-201B6811-13	SS	BL	159	159	159	159	159	159	119	119	119	119	79	79	79	79	79	79	79	79	39
83-201B6811-13	0unit(s)	EL	159	159	159	159	159	119	119	119	119	79	79	79	79	79	79	79	79	39	39
83-201B6811-13		OR				50															
522-00-520-50	LD	DM	0					0				0				20				20	
522-00-520-50	14wks	RC																			
522-00-520-50	SS	BL	399	399	399	399	399	399	399	399	399	399	399	399	399	399	379	379	379	379	359
522-00-520-50	0unit(s)	EL	399	399	399	399	399	399	399	399	399	399	399	399	399	379	379	379	379	359	359
522-00-520-50		OR																			
517-00-315-00	LD	DM	0					0				0				25				25	
517-00-315-00	10wks	RC																			
517-00-315-00	SS	BL	575	575	575	575	575	575	575	575	575	575	575	575	575	575	550	550	550	550	525
517-00-315-00	0unit(s)	EL	575	575	575	575	575	575	575	575	575	575	575	575	575	550	550	550	550	525	525
517-00-315-00		OR																			
505-00-520-50	LD	DM	0					0				0				0				0	
505-00-520-50	14wks	RC																			
505-00-520-50	SF	BL	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186
505-00-520-50	0unit(s)	EL	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186	186
505-00-520-50		OR																			
294-00-345-00	LD	DM	0					26				0				6				6	
294-00-345-00	14wks	RC																			
294-00-345-00	SF	BL	231	231	231	231	231	231	205	205	205	205	205	205	205	205	199	199	199	199	193
294-00-345-00	0unit(s)	EL	231	231	231	231	231	205	205	205	205	205	205	205	205	199	199	199	199	193	193
294-00-345-00		OR																			
280-00-369-00	LD	DM	28					50				0				12				12	
280-00-369-00	15wks	RC																			
280-00-369-00	SF	BL	144	116	116	116	116	116	66	66	66	66	66	66	66	66	54	54	54	54	42
280-00-369-00	4unit(s)	EL	116	116	116	116	116	66	66	66	66	66	66	66	66	54	54	54	54	42	42
280-00-369-00		OR							30								120				
184-00-520-00	LD	DM	233					0				0				0				0	
184-00-520-00	13wks	RC	100									10									
184-00-520-00	SF	BL	141	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
184-00-520-00	4unit(s)	EL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
184-00-520-00		OR										10									

Appendix A11.3 Time-Phased Record Output

			Febuary				March				April				May				
Part Number		Wk	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
83-201D8114-403	LD	DM	35				35				35				0				
83-201D8114-403	20wks	RC					20				40				*10*				
83-201D8114-403	SS	BL	51	16	16	16	16	1	1	1	1	6	6	6	6	6	6	6	6
83-201D8114-403	4unit(s)	EL	16	16	16	16	1	1	1	1	6	6	6	6	6	6	6	6	6
83-201D8114-403		OR								*10*									
83-201D7953A401	LD	DM	100				100				100				0				
83-201D7953A401	28wks	RC	200								100								
83-201D7953A401	SS	BL	1	101	101	101	101	1	1	1	1	1	1	1	1	1	1	1	1
83-201D7953A401	0unit(s)	EL	101	101	101	101	1	1	1	1	1	1	1	1	1	1	1	1	1
83-201D7953A401		OR																	
83-201C5283-401	LD	DM	180				180				180				0				
83-201C5283-401	22wks	RC																	
83-201C5283-401	SS	BL	1206	1026	1026	1026	1026	846	846	846	846	666	666	666	666	666	666	666	666
83-201C5283-401	0unit(s)	EL	1026	1026	1026	1026	846	846	846	846	666	666	666	666	666	666	666	666	666
83-201C5283-401		OR																	
83-201C5134-1	LD	DM	200				200				200				0				
83-201C5134-1	13wks	RC	300								200								
83-201C5134-1	SS	BL	119	219	219	219	219	19	19	19	19	19	19	19	19	19	19	19	19
83-201C5134-1	0unit(s)	EL	219	219	219	219	19	19	19	19	19	19	19	19	19	19	19	19	19
83-201C5134-1		OR																	
83-20186823-3	LD	DM	100				100				100				0				
83-20186823-3	16wks	RC	100				100				100								
83-20186823-3	SS	BL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
83-20186823-3	0unit(s)	EL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
83-20186823-3		OR																	
83-20186811-13	LD	DM	40				40				40				0				
83-20186811-13	18wks	RC					50												
83-20186811-13	SS	BL	79	39	39	39	39	49	49	49	49	9	9	9	9	9	9	9	9
83-20186811-13	0unit(s)	EL	39	39	39	39	49	49	49	49	9	9	9	9	9	9	9	9	9
83-20186811-13		OR																	
522-00-520-50	LD	DM	20				40				0				0				
522-00-520-50	14wks	RC																	
522-00-520-50	SS	BL	379	359	359	359	359	319	319	319	319	319	319	319	319	319	319	319	319
522-00-520-50	0unit(s)	EL	359	359	359	359	319	319	319	319	319	319	319	319	319	319	319	319	319
522-00-520-50		OR																	
517-00-315-00	LD	DM	25				50				0				0				
517-00-315-00	10wks	RC																	
517-00-315-00	SS	BL	550	525	525	525	525	475	475	475	475	475	475	475	475	475	475	475	475
517-00-315-00	0unit(s)	EL	525	525	525	525	475	475	475	475	475	475	475	475	475	475	475	475	475
517-00-315-00		OR																	
505-00-520-50	LD	DM	0				0				10				0				
505-00-520-50	14wks	RC																	
505-00-520-50	SS	BL	186	186	186	186	186	186	186	186	186	176	176	176	176	176	176	176	176
505-00-520-50	0unit(s)	EL	186	186	186	186	186	186	186	186	176	176	176	176	176	176	176	176	176
505-00-520-50		OR																	
294-00-345-00	LD	DM	6				0				0				54				
294-00-345-00	14wks	RC																	
294-00-345-00	SS	BL	199	193	193	193	193	193	193	193	193	193	193	193	193	139	139	139	139
294-00-345-00	0unit(s)	EL	193	193	193	193	193	193	193	193	193	193	193	193	139	139	139	139	139
294-00-345-00		OR																	
280-00-369-00	LD	DM	12				0				0				152				
280-00-369-00	15wks	RC					*30*								120				
280-00-369-00	SS	BL	54	42	42	42	42	42	42	42	42	42	42	42	42	10	10	10	10
280-00-369-00	4unit(s)	EL	42	42	42	42	42	42	42	42	42	42	42	42	10	10	10	10	10
280-00-369-00		OR																	
184-00-520-00	LD	DM	0				0				0				0				
184-00-520-00	13wks	RC						*10*											
184-00-520-00	SS	BL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
184-00-520-00	4unit(s)	EL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
184-00-520-00		OR						*10*											

Appendix A11.4 Time-Phased Record Output

			June				July				August					September				October
Part Number		Wk	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
142-00-530-00	LD	DM	0				0				0					0				0
142-00-530-00	14wks	RC																		
142-00-530-00	SS	BL	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226
142-00-530-00	0unit(s)	EL	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226	226
142-00-530-00		OR																		
142-00-307-53AV	LD	DM	6				6				6					22				0
142-00-307-53AV	13wks	RC																		
142-00-307-53AV	SS	BL	41	35	35	35	35	29	29	29	29	23	23	23	23	23	1	1	1	1
142-00-307-53AV	0unit(s)	EL	35	35	35	35	29	29	29	29	23	23	23	23	23	1	1	1	1	1
142-00-307-53AV		OR										10								30
135-00-850-04AF	LD	DM	28				0				14					14				0
135-00-850-04AF	24wks	RC														10				
135-00-850-04AF	SS	BL	54	26	26	26	26	26	26	26	26	12	12	12	12	12	8	8	8	8
135-00-850-04AF	0unit(s)	EL	26	26	26	26	26	26	26	26	12	12	12	12	12	8	8	8	8	8
135-00-850-04AF		OR																		
135-00-612-02	LD	DM	0				0				0					170				0
135-00-612-02	13wks	RC																		
135-00-612-02	SS	BL	569	569	569	569	569	569	569	569	569	569	569	569	569	569	399	399	399	399
135-00-612-02	0unit(s)	EL	569	569	569	569	569	569	569	569	569	569	569	569	569	399	399	399	399	399
135-00-612-02		OR																		
135-00-610-16	LD	DM	124				124				124					40				0
135-00-610-16	12wks	RC																		
135-00-610-16	SS	BL	504	380	380	380	380	256	256	256	256	132	132	132	132	132	92	92	92	92
135-00-610-16	4unit(s)	EL	380	380	380	380	256	256	256	256	132	132	132	132	132	92	92	92	92	92
135-00-610-16		OR																		
135-00-610-06	LD	DM	14				14				14					0				0
135-00-610-06	10wks	RC																		
135-00-610-06	SS	BL	697	683	683	683	683	669	669	669	669	655	655	655	655	655	655	655	655	655
135-00-610-06	4unit(s)	EL	683	683	683	683	669	669	669	669	655	655	655	655	655	655	655	655	655	655
135-00-610-06		OR																		
135-00-450-39AV	LD	DM	0				0				0					60				0
135-00-450-39AV	15wks	RC																		
135-00-450-39AV	SS	BL	471	471	471	471	471	471	471	471	471	471	471	471	471	471	411	411	411	411
135-00-450-39AV	0unit(s)	EL	471	471	471	471	471	471	471	471	471	471	471	471	471	411	411	411	411	411
135-00-450-39AV		OR																		
135-00-265-00AV	LD	DM	88				88				88					10				0
135-00-265-00AV	12wks	RC									70									
135-00-265-00AV	SS	BL	210	122	122	122	122	34	34	34	34	16	16	16	16	16	6	6	6	6
135-00-265-00AV	0unit(s)	EL	122	122	122	122	34	34	34	34	16	16	16	16	16	6	6	6	6	6
135-00-265-00AV		OR											280							
132-00-660-00	LD	DM	0				0				20					20				0
132-00-660-00	12wks	RC																		
132-00-660-00	SS	BL	366	366	366	366	366	366	366	366	366	346	346	346	346	346	326	326	326	326
132-00-660-00	0unit(s)	EL	366	366	366	366	366	366	366	366	346	346	346	346	346	326	326	326	326	326
132-00-660-00		OR																		
132-00-611-00	LD	DM	0				0				0					0				0
132-00-611-00	12wks	RC																		
132-00-611-00	SS	BL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00	4unit(s)	EL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00		OR																		
132-00-608-00	LD	DM	0				0				0					0				0
132-00-608-00	12wks	RC																		
132-00-608-00	SS	BL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00	0unit(s)	EL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00		OR																		
132-00-500-00	LD	DM	0				0				0					50				0
132-00-500-00	15wks	RC														40				
132-00-500-00	SS	BL	13	13	13	13	13	13	13	13	13	13	13	13	13	13	3	3	3	3
132-00-500-00	0unit(s)	EL	13	13	13	13	13	13	13	13	13	13	13	13	13	3	3	3	3	3
132-00-500-00		OR																		

Appendix A11.5 Time-Phased Record Output

			October					November				December				January				Febuary	
Part Number		Wk	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6
142-00-530-00	LD	DM	0					25				0				0				0	
142-00-530-00	14wks	RC																			
142-00-530-00	SS	BL	226	226	226	226	226	226	201	201	201	201	201	201	201	201	201	201	201	201	201
142-00-530-00	0unit(s)	EL	226	226	226	226	226	201	201	201	201	201	201	201	201	201	201	201	201	201	201
142-00-530-00		OR																			
142-00-307-53AV	LD	DM	0					6				0				22				6	
142-00-307-53AV	13wks	RC						10								30					
142-00-307-53AV	SS	BL	1	1	1	1	1	1	5	5	5	5	5	5	5	5	13	13	13	13	7
142-00-307-53AV	0unit(s)	EL	1	1	1	1	1	5	5	5	5	5	5	5	5	13	13	13	13	7	7
142-00-307-53AV		OR	30																30		
135-00-850-04AF	LD	DM	0					0				0				0				0	
135-00-850-04AF	24wks	RC																			
135-00-850-04AF	SS	BL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
135-00-850-04AF	0unit(s)	EL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
135-00-850-04AF		OR																			
135-00-612-02	LD	DM	0					0				0				0				0	
135-00-612-02	13wks	RC																			
135-00-612-02	SS	BL	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399
135-00-612-02	0unit(s)	EL	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399	399
135-00-612-02		OR																			
135-00-610-16	LD	DM	0					30				0				124				124	
135-00-610-16	12wks	RC														70				120	
135-00-610-16	SS	BL	92	92	92	92	92	92	62	62	62	62	62	62	62	62	8	8	8	8	4
135-00-610-16	4unit(s)	EL	92	92	92	92	92	62	62	62	62	62	62	62	62	8	8	8	8	4	4
135-00-610-16		OR		70				120							20					170	
135-00-610-06	LD	DM	0					14				0				14				14	
135-00-610-06	10wks	RC																			
135-00-610-06	SS	BL	655	655	655	655	655	655	641	641	641	641	641	641	641	641	627	627	627	627	613
135-00-610-06	4unit(s)	EL	655	655	655	655	655	641	641	641	641	641	641	641	641	627	627	627	627	613	613
135-00-610-06		OR																			
135-00-450-39AV	LD	DM	0					120				0				40				0	
135-00-450-39AV	15wks	RC																			
135-00-450-39AV	SS	BL	411	411	411	411	411	411	291	291	291	291	291	291	291	291	251	251	251	251	251
135-00-450-39AV	0unit(s)	EL	411	411	411	411	411	291	291	291	291	291	291	291	291	251	251	251	251	251	251
135-00-450-39AV		OR															40				
135-00-265-00AV	LD	DM	0					183				0				98				88	
135-00-265-00AV	12wks	RC						280												140	
135-00-265-00AV	SS	BL	6	6	6	6	6	6	103	103	103	103	103	103	103	103	5	5	5	5	57
135-00-265-00AV	0unit(s)	EL	6	6	6	6	6	103	103	103	103	103	103	103	103	5	5	5	5	57	57
135-00-265-00AV		OR						140												220	
132-00-660-00	LD	DM	0					0				0				20				20	
132-00-660-00	12wks	RC																			
132-00-660-00	SS	BL	326	326	326	326	326	326	326	326	326	326	326	326	326	326	306	306	306	306	286
132-00-660-00	0unit(s)	EL	326	326	326	326	326	326	326	326	326	326	326	326	326	306	306	306	306	286	286
132-00-660-00		OR																			
132-00-611-00	LD	DM	0					0				0				0				0	
132-00-611-00	12wks	RC																			
132-00-611-00	SS	BL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00	4unit(s)	EL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00		OR																			
132-00-608-00	LD	DM	0					0				0				0				0	
132-00-608-00	12wks	RC																			
132-00-608-00	SS	BL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00	0unit(s)	EL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00		OR																			
132-00-500-00	LD	DM	0					0				0				0				0	
132-00-500-00	15wks	RC																			
132-00-500-00	SS	BL	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
132-00-500-00	0unit(s)	EL	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
132-00-500-00		OR											50								

Appendix A11.6 Time-Phased Record Output

			Febuary				March				April				May				
Part Number		Wk	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
142-00-530-00	LD	DM	0				0				0				25				
142-00-530-00	14wks	RC																	
142-00-530-00	SS	BL	201	201	201	201	201	201	201	201	201	201	201	201	201	176	176	176	176
142-00-530-00	0unit(s)	EL	201	201	201	201	201	201	201	201	201	201	201	201	176	176	176	176	176
142-00-530-00		OR																	
142-00-307-53AV	LD	DM	6				0				6				28				
142-00-307-53AV	13wks	RC													30				
142-00-307-53AV	SS	BL	13	7	7	7	7	7	7	7	7	1	1	1	1	3	3	3	3
142-00-307-53AV	0unit(s)	EL	7	7	7	7	7	7	7	7	1	1	1	1	3	3	3	3	3
142-00-307-53AV		OR																	
135-00-850-04AF	LD	DM	0				0				0				0				
135-00-850-04AF	24wks	RC																	
135-00-850-04AF	SS	BL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
135-00-850-04AF	0unit(s)	EL	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
135-00-850-04AF		OR																	
135-00-612-02	LD	DM	0				0				0				233				
135-00-612-02	13wks	RC																	
135-00-612-02	SS	BL	399	399	399	399	399	399	399	399	399	399	399	399	399	166	166	166	166
135-00-612-02	0unit(s)	EL	399	399	399	399	399	399	399	399	399	399	399	399	166	166	166	166	166
135-00-612-02		OR																	
135-00-610-16	LD	DM	124				0				0				174				
135-00-610-16	12wks	RC	120							*20*					170				
135-00-610-16	SS	BL	8	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	0
135-00-610-16	4unit(s)	EL	4	4	4	4	4	4	4	4	4	4	4	4	0	0	0	0	0
135-00-610-16		OR	170																
135-00-610-06	LD	DM	14				0				14				14				
135-00-610-06	10wks	RC																	
135-00-610-06	SS	BL	627	613	613	613	613	613	613	613	613	599	599	599	599	585	585	585	585
135-00-610-06	4unit(s)	EL	613	613	613	613	613	613	613	613	599	599	599	599	585	585	585	585	585
135-00-610-06		OR								*10*									
135-00-450-39AV	LD	DM	0				0				0				290				
135-00-450-39AV	15wks	RC													40				
135-00-450-39AV	SS	BL	251	251	251	251	251	251	251	251	251	251	251	251	251	1	1	1	1
135-00-450-39AV	0unit(s)	EL	251	251	251	251	251	251	251	251	251	251	251	251	1	1	1	1	1
135-00-450-39AV		OR																	
135-00-265-00AV	LD	DM	88				0				50				226				
135-00-265-00AV	12wks	RC	140												220				
135-00-265-00AV	SS	BL	5	57	57	57	57	57	57	57	57	7	7	7	7	1	1	1	1
135-00-265-00AV	0unit(s)	EL	57	57	57	57	57	57	57	57	7	7	7	7	1	1	1	1	1
135-00-265-00AV		OR	220																
132-00-660-00	LD	DM	20				40				0				0				
132-00-660-00	12wks	RC																	
132-00-660-00	SS	BL	306	286	286	286	286	246	246	246	246	246	246	246	246	246	246	246	246
132-00-660-00	0unit(s)	EL	286	286	286	286	246	246	246	246	246	246	246	246	246	246	246	246	246
132-00-660-00		OR																	
132-00-611-00	LD	DM	0				0				0				0				
132-00-611-00	12wks	RC																	
132-00-611-00	SS	BL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00	4unit(s)	EL	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233	1233
132-00-611-00		OR						*10*											
132-00-608-00	LD	DM	0				0				0				0				
132-00-608-00	12wks	RC																	
132-00-608-00	SS	BL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00	0unit(s)	EL	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279	279
132-00-608-00		OR																	
132-00-500-00	LD	DM	0				0				50				0				
132-00-500-00	15wks	RC									50								
132-00-500-00	SS	BL	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
132-00-500-00	0unit(s)	EL	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
132-00-500-00		OR																	

Appendix A12 Number of Orders and the Beginning Level between June 2004 and June 2005

	Number of orders	Inventory level at the beginning of the month												
		June	July	August	September	October	November	December	January	February	March	April	May	June
83-201D8114-403	2	169	169	169	136	131	64	64	64	64	0	89	89	378
83-201D7953A401	2	181	181	181	81	81	81	531	531	531	339	239	435	435
83-201C5283-401	1	1746	1746	1746	1556	1556	1196	1196	1196	1096	916	747	747	572
83-201C5134-1	3	719	719	518	518	518	118	115	114	750	450	850	850	650
83-201B6823-3	2	192	192	192	92	89	132	32	32	32	147	147	147	144
83-201B6811-13	3	199	199	198	127	127	87	60	57	0	0	380	380	369
522-00-520-50	2	439	439	664	660	653	648	648	586	586	614	614	614	614
517-00-315-00	2	629	629	603	589	589	589	585	536	536	727	727	720	680
505-00-520-50	1	219	219	219	354	352	391	388	387	387	385	385	384	382
294-00-345-00	1	254	247	240	240	238	211	211	373	372	369	366	313	292
280-00-369-00	1	206	368	368	320	304	250	451	451	451	451	450	450	288
184-00-520-00	3	234	234	156	156	17	17	17	17	182	182	182	299	299
142-00-530-00	0	226	226	226	220	220	205	205	205	203	203	203	203	189
142-00-307-53AV	1	41	39	39	28	4	4	4	4	237	237	237	202	200
135-00-850-04AF	0	54	41	35	33	28	28	28	27	27	27	27	27	27
135-00-612-02	2	569	569	569	569	1365	1365	1365	1365	1363	1363	1363	1163	1363
135-00-610-16	4	520	323	430	430	651	651	631	527	403	403	402	272	228
135-00-610-06	0	711	687	673	673	673	673	672	658	644	644	644	605	591
135-00-450-39AV	2	471	471	469	461	411	287	287	545	521	731	731	491	491
135-00-265-00AV	2	118	282	202	176	237	190	110	70	376	376	351	104	104
132-00-660-00	1	366	843	841	823	820	799	791	768	762	733	730	730	715
132-00-611-00	0	1247	1247	1247	1247	1247	1247	1247	1247	1243	1243	1243	1243	1243
132-00-608-00	1	285	285	285	285	285	285	285	285	283	283	283	283	283
132-00-500-00	1	13	502	502	497	495	485	485	477	476	476	476	476	416

Appendix A13 Inventory Held in Jun 2004-May 2005 and Holding Cost Related to Current Ordering Policy

P/N	Spare parts held in stock (unit)												Total inventory (units)	Holding cost per unit per month (THB)	Holding cost (THB)
	2004							2005							
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May			
83-201D8114-403	169	169	153	134	98	64	64	64	32	45	89	234	1,315	107.02	140,733.99
83-201D7953A401	181	181	131	81	81	306	531	531	435	289	337	435	3,519	29.09	102,358.61
83-201C5283-401	1746	1746	1651	1556	1376	1196	1196	1146	1006	832	747	660	14,858	32.27	479,471.48
83-201C5134-1	719	619	518	518	318	117	115	432	600	650	850	750	6,206	12.94	80,305.72
83-201B6823-3	192	192	142	90.5	111	82	32	32	90	147	147	146	1,404	34.45	48,351.68
83-201B6811-13	199	199	163	127	107	74	59	29	0	190	380	375	1,902	30.17	57,378.50
522-00-520-50	439	552	662	657	651	648	617	586	600	614	614	614	7,254	68.05	493,609.67
517-00-315-00	629	616	596	589	589	587	561	536	632	727	724	700	7,486	23.97	179,466.32
505-00-520-50	219	219	287	353	372	390	388	387	386	385	385	383	4,154	63.94	265,620.13
294-00-345-00	251	244	240	239	225	211	292	373	371	368	340	303	3,457	35.39	122,335.08
280-00-369-00	287	368	344	312	277	351	451	451	451	451	450	369	4,562	17.91	81,727.04
184-00-520-00	234	195	156	87	17	17	17	100	182	182	241	299	1,727	115.32	199,162.48
142-00-530-00	226	226	223	220	213	205	205	204	203	203	203	196	2,527	62.80	158,689.85
142-00-307-53AV	40	39	34	16	4	4	4	121	237	237	220	201	1,157	103.81	120,104.10
135-00-850-04AF	48	38	34	31	28	28	28	27	27	27	27	27	370	416.10	153,956.00
135-00-612-02	569	569	569	967	1365	1365	1365	1364	1363	1363	1263	1263	13,385	33.64	450,281.59
135-00-610-16	422	377	430	541	651	641	579	465	403	403	337	250	5,499	33.42	183,798.22
135-00-610-06	699	680	673	673	673	673	665	651	644	644	625	598	7,898	29.77	235,128.37
135-00-450-39AV	471	470	465	436	349	287	416	533	626	731	611	491	5,886	20.41	120,110.85
135-00-265-00AV	200	242	189	207	214	150	90	223	376	364	228	104	2,587	14.31	37,021.31
132-00-660-00	605	842	832	822	810	795	780	765	748	732	730	723	9,184	24.14	221,676.37
132-00-611-00	1247	1247	1247	1247	1247	1247	1247	1245	1243	1243	1243	1243	14,946	30.44	454,918.33
132-00-608-00	285	285	285	285	285	285	285	284	283	283	283	283	3,411	29.04	99,049.72
132-00-500-00	258	502	500	496	490	485	481	477	476	476	476	446	5,563	43.69	243,061.31

Appendix A14 Cost Related to Current Ordering Policy

P/N	Number of order	Ordering cost (THB)	Holding cost (THB)	Total cost (Jun2004-May2005) (THB)
83-201D8114-403	2	3,306	140,733.99	144,039.99
83-201D7953A401	2	3,306	102,358.61	105,664.61
83-201C5283-401	1	1,653	479,471.48	481,124.48
83-201C5134-1	3	4,959	80,305.72	85,264.72
83-201B6823-3	2	3,306	48,351.68	51,657.68
83-201B6811-13	3	4,959	57,378.50	62,337.50
522-00-520-50	2	3,306	493,609.67	496,915.67
517-00-315-00	2	3,306	179,466.32	182,772.32
505-00-520-50	1	1,653	265,620.13	267,273.13
294-00-345-00	1	1,653	122,335.08	123,988.08
280-00-369-00	1	1,653	81,727.04	83,380.04
184-00-520-00	3	4,959	199,162.48	204,121.48
142-00-530-00	0	0	158,689.85	158,689.85
142-00-307-53AV	1	1,653	120,104.10	121,757.10
135-00-850-04AF	0	0	153,956.00	153,956.00
135-00-612-02	2	3,306	450,281.59	453,587.59
135-00-610-16	4	6,612	183,798.22	190,410.22
135-00-610-06	0	0	235,128.37	235,128.37
135-00-450-39AV	2	3,306	120,110.85	123,416.85
135-00-265-00AV	2	3,306	37,021.31	40,327.31
132-00-660-00	1	1,653	221,676.37	223,329.37
132-00-611-00	0	0	454,918.33	454,918.33
132-00-608-00	1	1,653	99,049.72	100,702.72
132-00-500-00	1	1,653	243,061.31	244,714.31
Total		**61,161**	**4,728,316.70**	**4,789,477.70**

Appendix A15 Actual Demand from June2004 to May2005 Gotten From the Enquiry Transaction

P/N	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
83-201D8114-403	0	0	33	5	67	0	0	0	64	0	0	0
83-201D7953A401	0	0	100	0	0	200	0	192	0	100	0	0
83-201C5283-401	0	0	190	0	360	0	0	100	180	169	0	175
83-201C5134-1	0	201	0	0	400	3	1	0	300	101	0	200
83-201B6823-3	0	0	100	3	2	100	0	0	205	0	0	3
83-201B6811-13	0	1	71	0	40	27	3	57	0	33	0	11
522-00-520-50	0	0	4	7	5	0	62	0	20	0	0	0
517-00-315-00	0	26	14	0	0	4	49	0	10	0	7	40
505-00-520-50	0	0	0	2	20	3	1	0	2	0	1	2
294-00-345-00	7	7	0	2	27	0	0	1	3	3	53	21
280-00-369-00	12	0	48	16	54	0	0	0	0	1	0	162
184-00-520-00	0	78	0	139	0	0	0	0	0	0	0	0
142-00-530-00	0	0	6	0	15	0	0	2	0	0	0	14
142-00-307-53AV	2	0	11	24	0	0	0	2	0	0	35	2
135-00-850-04AF	13	6	2	5	0	0	1	0	0	0	0	0
135-00-612-02	0	0	0	170	0	0	0	2	0	0	200	0
135-00-610-16	197	114	0	0	0	20	104	124	0	1	130	44
135-00-610-06	24	14	0	0	0	1	14	14	0	0	39	14
135-00-450-39AV	0	2	8	50	124	0	0	24	0	0	240	0
135-00-265-00AV	88	80	26	1	47	80	40	60	0	25	247	0
132-00-660-00	0	2	18	3	21	8	23	6	29	3	0	15
132-00-611-00	0	0	0	0	0	0	0	4	0	0	0	0
132-00-608-00	0	0	0	0	0	0	0	2	0	0	0	0
132-00-500-00	0	0	5	2	10	0	0	1	0	0	0	60

Appendix A16 The MRP System Simulation by Using the Actual Pattern of Demand

P/N		2004							2005					
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
83-201D8114-403	AD	0	0	33	5	67			0	64	0			
	RC	0	0	0	0	0	0	0	10	0	20	40	10	
	BL	169	169	169	136	131	64	64	64	74	10	30	70	80
83-201D7953A401	AD	0	0	100	0	0	200	0	0	192	0	100	0	
	RC	0	0	0	0	0	120	0	0	200	0	100	0	
	BL	181	181	181	81	81	81	1	1	1	9	9	9	9
83-201C5283-401	AD	0	0	190	0	360	0	0	100	180	169	0	175	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	1746	1746	1746	1556	1556	1196	1196	1196	1096	916	747	747	572
83-201C5134-1	AD	0	201	0	0	400	3	1	0	300	101	0	200	
	RC	0	0	0	0	0	0	0	0	300	0	200	0	
	BL	719	719	518	518	518	118	115	114	114	114	13	213	13
83-201B6823-3	AD	0	0	100	3	2	100	0	0	205	0	0	3	
	RC	0	0	0	0	0	10	100	0	100	100	100	0	
	BL	192	192	192	92	89	87	-3	97	97	-8	92	192	189
83-201B6811-13	AD	0	1	71	0	40	27	3	57	0	33	0	11	
	RC	0	0	0	0	0	0	0	0	0	50	0	0	
	BL	199	199	198	127	127	87	60	57	0	0	17	17	6
522-00-520-50	AD	0	0	4	7	5	0	62	0	20	0	0	0	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	439	439	439	435	428	423	423	361	361	341	341	341	341
517-00-315-00	AD	0	26	14	0	0	4	49	0	10	0	7	40	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	629	629	603	589	589	589	585	536	536	526	526	519	479
505-00-520-50	AD	0	0	0	2	20	3	1	0	2	0	1	2	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	219	219	219	219	217	197	194	193	193	191	191	190	188
294-00-345-00	AD	7	7	0	2	27	0	0	1	3	3	53	21	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	254	247	240	240	238	211	211	211	210	207	204	151	130
280-00-369-00	AD	12	0	48	16	54	0	0	0	0	1	0	162	
	RC	0	0	0	0	0	0	0	0	0	30	0	120	
	BL	206	194	194	146	130	76	76	76	76	76	105	105	63
184-00-520-00	AD	0	78	0	139	0	0	0	0	0	0	0	0	
	RC	0	0	0	10	100	0	10	0	0	10	0	0	
	BL	234	234	156	156	27	127	127	137	137	137	147	147	147
142-00-530-00	AD	0	0	6	0	15	0	0	2	0	0	0	14	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	226	226	226	220	220	205	205	205	203	203	203	203	189
142-00-307-53AV	AD	2	0	11	24	0	0	0	2	0	0	35	2	
	RC	0	0	0	20	0	10	0	30	0	0	0	30	
	BL	41	39	39	28	24	24	34	34	62	62	62	27	55

P/N		2004							2005					
		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
135-00-850-04AF	AD	13	6	2	5	0	0	1	0	0	0	0	0	
	RC	0	0	0	10	0	0	0	0	0	0	0	0	
	BL	54	41	35	33	38	38	38	37	37	37	37	37	37
135-00-612-02	AD	0	0	0	170	0	0	0	2	0	0	200	0	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	569	569	569	569	399	399	399	399	397	397	397	197	197
135-00-610-16	AD	197	114	0	0	0	20	104	124	0	1	130	44	
	RC	0	0	0	0	0	0	0	70	120	0	20	170	
	BL	520	323	209	209	209	209	189	85	31	151	150	40	166
135-00-610-06	AD	24	14	0	0	0	1	14	14	0	0	39	14	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	711	687	673	673	673	673	672	658	644	644	644	605	591
135-00-450-39AV	AD	0	2	8	50	124	0	0	24	0	0	240	0	
	RC	0	0	0	0	0	0	0	0	0	0	0	40	
	BL	471	471	469	461	411	287	287	287	263	263	263	23	63
135-00-265-00AV	AD	88	80	26	1	47	80	40	60	0	25	247	0	
	RC	0	0	70	0	0	280	0	0	140	0	0	220	
	BL	210	122	42	86	85	38	238	198	138	278	253	6	226
132-00-660-00	AD	0	2	18	3	21	8	23	6	29	3	0	15	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	366	366	364	346	343	322	314	291	285	256	253	253	238
132-00-611-00	AD	0	0	0	0	0	0	0	4	0	0	0	0	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	1247	1247	1247	1247	1247	1247	1247	1247	1243	1243	1243	1243	1243
132-00-608-00	AD	0	0	0	0	0	0	0	2	0	0	0	0	
	RC	0	0	0	0	0	0	0	0	0	0	0	0	
	BL	285	285	285	285	285	285	285	285	283	283	283	283	283
132-00-500-00	AD	0	0	5	2	10	0	0	1	0	0	0	60	
	RC	0	0	0	40	0	0	0	0	0	0	50	0	
	BL	13	13	13	8	46	36	36	36	35	35	35	85	25

Appendix A17 Spare Parts Held in Inventory (June2004-May2005) and Holding Cost Incurred When Using the Proposed System

P/N	Spare parts held in inventory from June 2004 to May 2005												Total (Units)	Holding cost (THB)
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May		
83-201D8114-403	169	169	153	134	78	64	64	69	22	21	50	75	1,067	114,193
83-201D7953A401	181	181	131	81	81	41	1	1	5	9	9	9	730	21,234
83-201C5283-401	1,746	1,746	1,651	1,556	1,376	1,196	1,196	1,146	1,006	832	747	660	14,857	479,439
83-201C5134-1	719	619	518	518	318	117	115	114	114	63.5	113	113	3,440	44,514
83-201B6823-3	192	192	142	91	88	42	47	97	45	42	142	191	1310	45,113
83-201B6811-13	199	199	163	127	107	74	59	19	0	9	17	12	983	29,640
522-00-520-50	439	439	437	432	426	423	392	361	351	341	341	341	4,722	321,316
517-00-315-00	629	616	596	589	589	587	561	536	531	526	523	499	6781	162,565
505-00-520-50	219	219	219	218	207	196	194	193	192	191	191	189	2427	155,158
294-00-345-00	251	244	240	239	225	211	211	211	208.5	206	178	141	2,562	90,663
280-00-369-00	200	194	170	138	103	76	76	76	76	91	105	84	1389	24,875
184-00-520-00	234	195	156	92	77	127	132	137	137	142	147	147	1723	198,644
142-00-530-00	226	226	223	220	213	205	205	204	203	203	203	196	2527	158,658
142-00-307-53AV	40	39	33.5	26	24	29	34	48	62	62	44.5	41	483	50,139
135-00-850-04AF	48	38	34	36	38	38	38	37	37	37	37	37	454	188,700
135-00-612-02	569	569	569	484	399	399	399	398	397	397	297	197	5,074	170,693
135-00-610-16	422	266	209	209	209	199	137	58	91	151	95	103	2,148	71,795
135-00-610-06	699	680	673	673	673	673	665	651	644	644	625	598	7,897	235,099
135-00-450-39AV	471	470	465	436	349	287	287	275	263	263	143	43	3752	76,564
135-00-265-00AV	166	82	64	86	62	138	218	168	208	266	130	116	1,702	24,357
132-00-660-00	366	365	355	345	333	318	303	288	270.5	255	253	246	3,695	89,187
132-00-611-00	1,247	1,247	1,247	1,247	1,247	1,247	1,247	1,245	1,243	1,243	1,243	1,243	14,946	454,918
132-00-608-00	285	285	285	285	285	285	285	284	283	283	283	283	3,411	99,050
132-00-500-00	13	13	11	27	41	36	36	36	35	35	60	55	397	17,346
Total														3,323,857

Appendix A18 Costs Related to the Proposed System (June 2004 - May 2005)

P/N	The proposed system (June2004-May2005)			
	Holding cost (THB)	Number of order	Ordering cost (THB)	Total cost (THB)
83-201D8114-403	114,193	5	8,265	122,457.53
83-201D7953A401	21,234	2	3,306	24,539.81
83-201C5283-401	479,439	0	0	479,439.21
83-201C5134-1	44,514	2	3,306	47,819.64
83-201B6823-3	45,113	5	8,265	53,378.31
83-201B6811-13	29,640	1	1,653	31,292.52
522-00-520-50	321,316	0	0	321,315.81
517-00-315-00	162,565	0	0	162,564.94
505-00-520-50	155,158	0	0	155,158.22
294-00-345-00	90,663	0	0	90,663.14
280-00-369-00	24,875	2	3,306	28,180.61
184-00-520-00	198,644	5	8,265	206,908.53
142-00-530-00	158,658	0	0	158,658.45
142-00-307-53AV	50,139	3	4,959	55,097.53
135-00-850-04AF	188,700	0	0	188,700.13
135-00-612-02	170,693	0	0	170,693.22
135-00-610-16	71,795	4	6,612	78,406.61
135-00-610-06	235,099	1	1,653	236,751.60
135-00-450-39AV	76,564	1	1,653	78,217.03
135-00-265-00AV	24,357	3	4,959	29,315.50
132-00-660-00	89,187	0	0	89,187.09
132-00-611-00	454,918	1	1,653	456,571.33
132-00-608-00	99,050	0	0	99,049.72
132-00-500-00	17,346	1	1,653	18,998.92
Total	3,323,857		59,508	3,383,365.39

Appendix A19 Total Cost Of Current System Compared to Proposed System

P/N	Total cost (Current system) (THB)	Total cost (Proposed system) (THB)
83-201D8114-403	144,039.99	122,457.53
83-201D7953A401	105,664.61	24,539.81
83-201C5283-401	481,124.48	479,439.21
83-201C5134-1	85,264.72	47,819.64
83-201B6823-3	51,657.68	53,378.31
83-201B6811-13	62,337.50	31,292.52
522-00-520-50	496,915.67	321,315.81
517-00-315-00	182,772.32	162,564.94
505-00-520-50	267,273.13	155,158.22
294-00-345-00	123,988.08	90,663.14
280-00-369-00	83,380.04	28,180.61
184-00-520-00	204,121.48	206,908.53
142-00-530-00	158,689.85	158,658.45
142-00-307-53AV	121,757.10	55,097.53
135-00-850-04AF	153,956.00	188,700.13
135-00-612-02	453,587.59	170,693.22
135-00-610-16	190,410.22	78,406.61
135-00-610-06	235,128.37	236,751.60
135-00-450-39AV	123,416.85	78,217.03
135-00-265-00AV	40,327.31	29,315.50
132-00-660-00	223,329.37	89,187.09
132-00-611-00	454,918.33	456,571.33
132-00-608-00	100,702.72	99,049.72
132-00-500-00	244,714.31	18,998.92
Total cost	**4,789,477.70**	**3,383,365.39**

APPENDIX B

Program User Manual

This program requires Window XP OS, and MS Office 2003.

There are 2 groups of functions in a main menu as shown in figure B-1: insert/update function, and report function. In the insert/update function, the end users can insert and update input including aircraft maintenance schedule and part information. In the report function, there are four kinds of reports providing the end users: time-phased record, planned order releases, aircraft maintenance schedule, and monthly demand reports. To close the program, click Close button.

Figure B-1 Main menu

1. Insert and Update Aircraft Maintenance Schedule

1.1 On the main menu, click Maintenance Schedule button in the Insert/Update frame. The Aircraft Maintenance Schedule Insert & Update window will appear as shown in figure B-1.2.

1.2 Click Year box to select year

1.3 Click Month box to select month

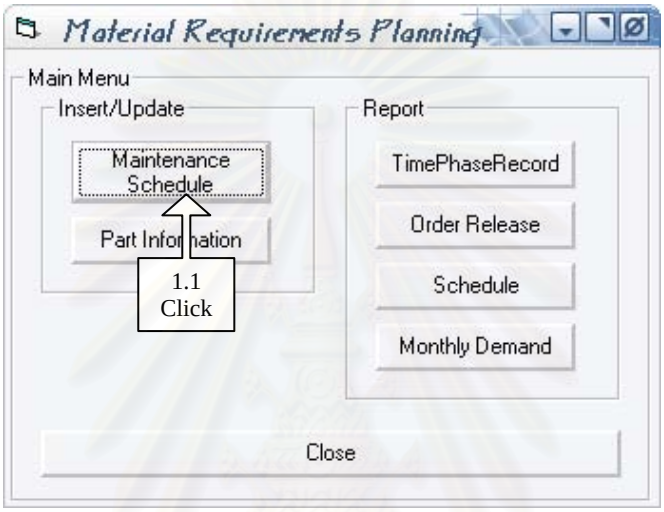


Figure B-1.1 Main menu

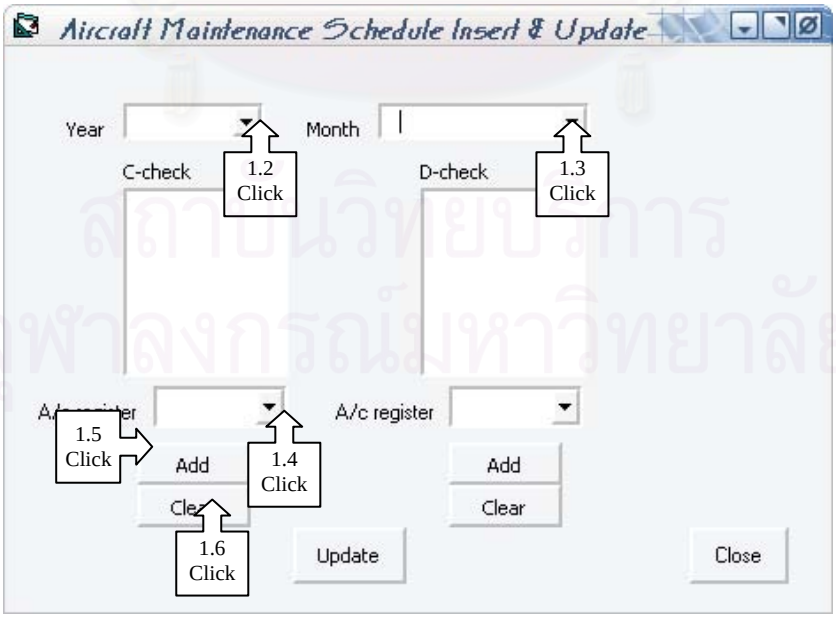


Figure B-1.2 Aircraft Maintenance Schedule Insert & Update window

1.4 To add aircraft register into C-check list, click Aircraft register box under C-check box and select the aircraft register.

1.5 Click Add button to add aircraft register into C-check list.

1.6 Click Clear button if you want to clear all items in the list.

1.7 Do the same method with the D-check list

1.8 Click Update button when finish insert schedule of each month.

1.9 Return to step 1.1 to insert schedule of next month.

1.10 If year or month has not been selected, the warning message will appear as shown in figure B-1.4.

1.11 The number of aircrafts in C-check list and D-check list is limited to 7 aircrafts and 4 aircrafts, respectively. If a number of aircrafts in any list is over limit, the warning message will appear as shown in figure B-1.5.

1.12 Click Close button when finish inserting schedule.

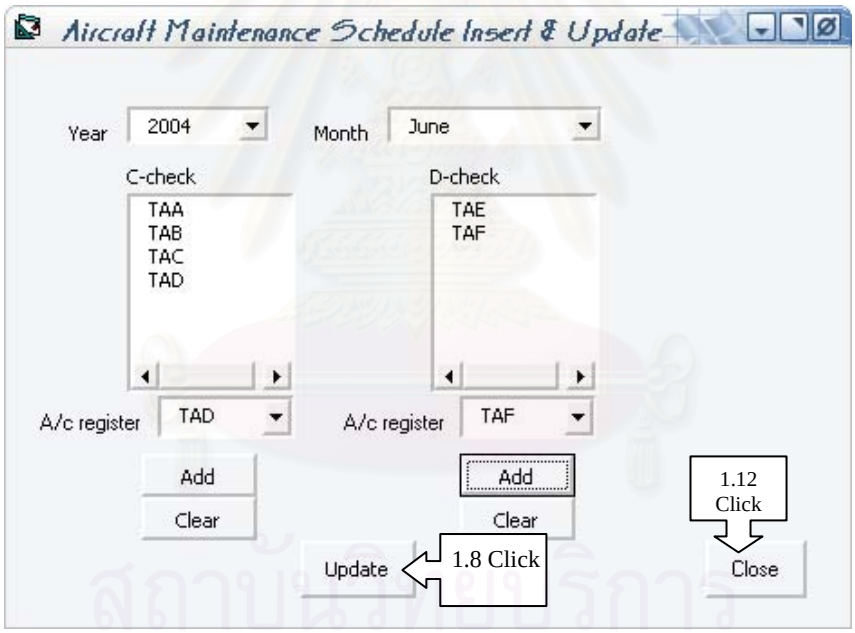
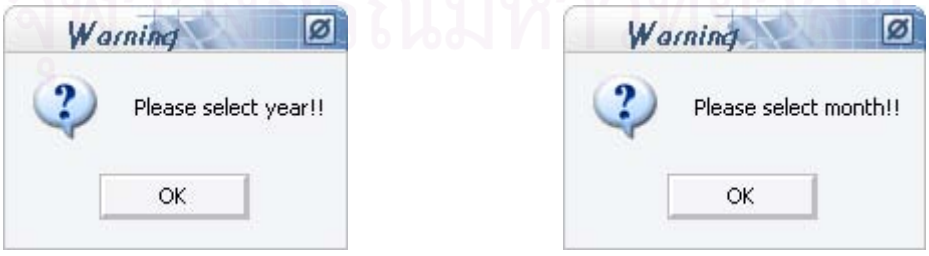


Figure B-1.3 Insert schedule



(a) (b)

Figure B-1.4 Warning messages (a) when year is not selected
(b) when month is not selected

(a) (b)

Figure B-1.5 Warning messages

(a) when the number of aircrafts in C-check list is more than 7

(b) when the number of aircrafts in D-check list is more than 4

2. Aircraft Maintenance Schedule Report

2.1 On the main menu, click Schedule button in the Report frame. The Aircraft Maintenance Schedule Report window will appear as shown in figure B-2.2.

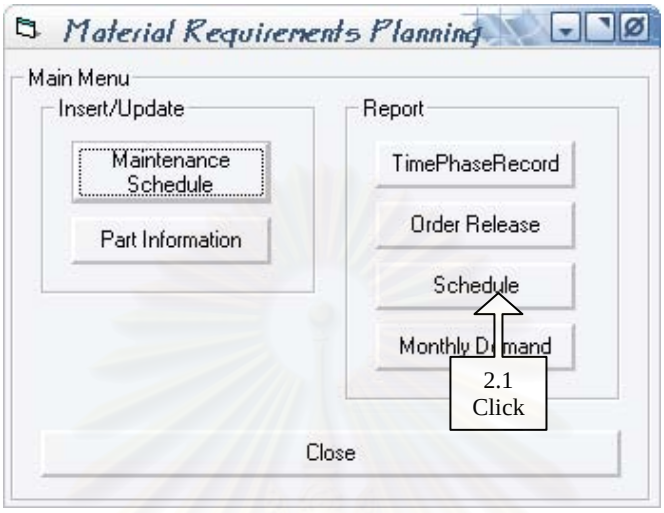


Figure B-2.1 Select Schedule on the main menu

2.2 Click Year box to select year

2.3 Click Month box to select month

2.4 Click Sort button to sort database

2.5 If there any box has not been selected, the warning message will appear as shown in figure B-2.3.

2.6 The schedule of 12 months starting from year and month selected will be displayed as shown in figure B-2.4. The first 7 columns show aircraft registers which have to do C-check. The next 4 columns show aircraft registers which have to do D-check.

2.7 Click Close button to close the window and back to the main menu.

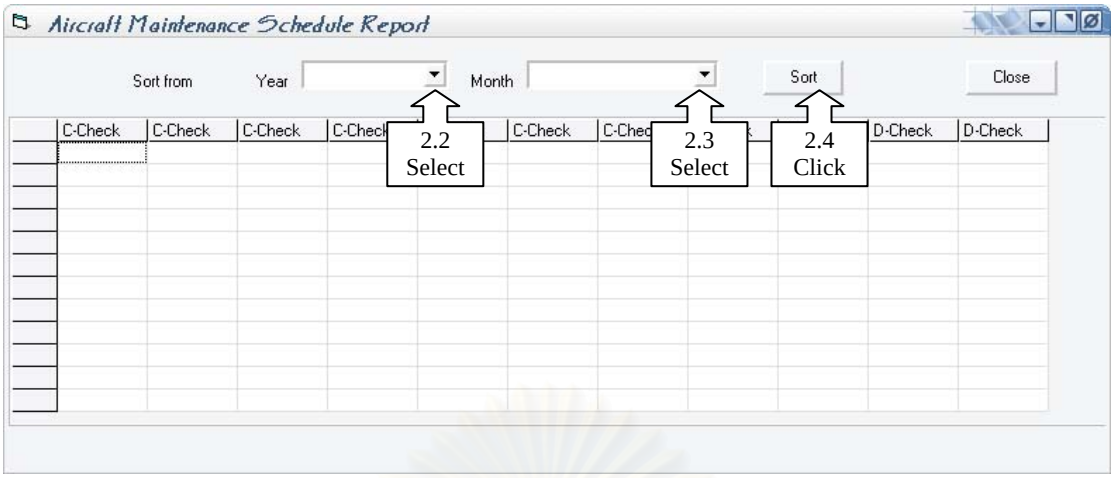
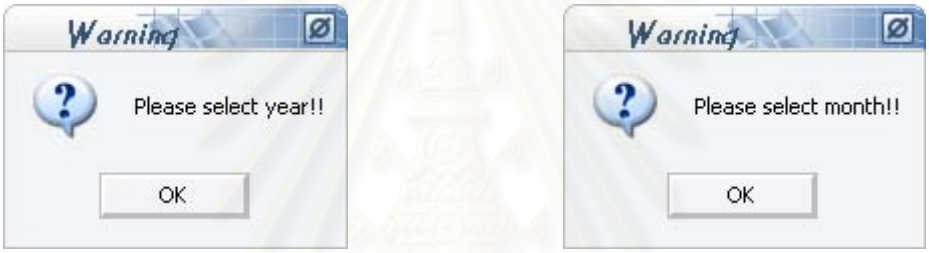


Figure B-2.2 Aircraft Maintenance Schedule Report window



(a) (b)

Figure B-2.3 Warning messages (a) when year is not selected

(b) when month is not selected

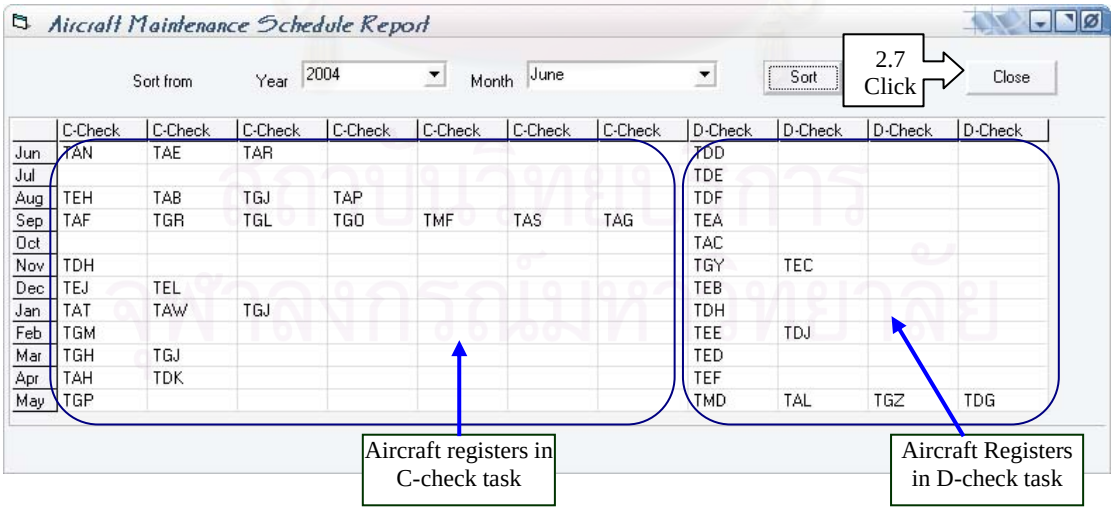


Figure B-2.4 Aircraft maintenance schedule report shows scheduled maintenance tasks for 12 months starting from selected month

3. Insert and Update Part Information

3.1 On the main menu, click Part Information button in the Insert/Update frame. The Part Information Update window will appear as shown in figure B-3.2.

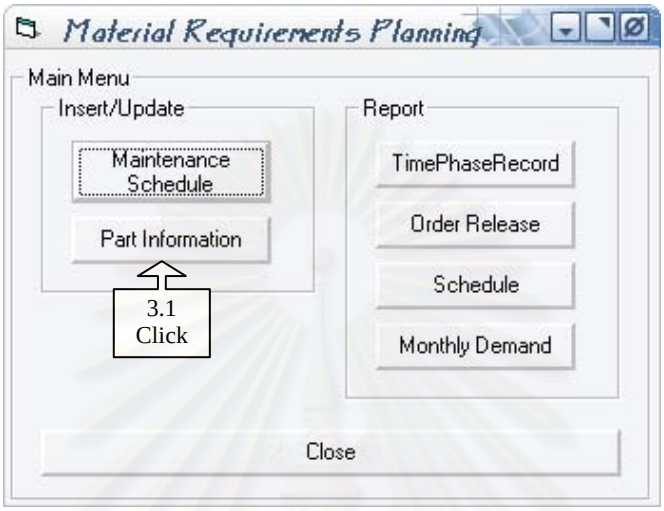


Figure B-3.1 Select Part Information on the main menu

3.2 The information of each part in the part information database will be displayed as shown in figure B-3.2. The record number and the total records number are displayed at the bottom of the window. The user can select part by click the Record Select buttons.

3.3 To add a new part to the database, click Add button. All part information boxes will be clear.

3.4 Insert new part information into the boxes. And then click Save to save a new part to the database. If the Part Number box is empty, the warning message will appear as shown in figure B-3.4

3.5 Or click Cancel to cancel adding new part and back to the part information display mode.

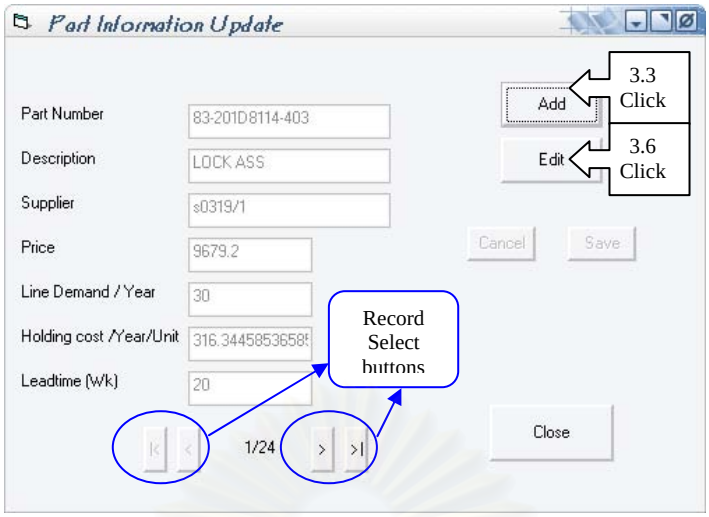


Figure B-3.2 Part Information Update window

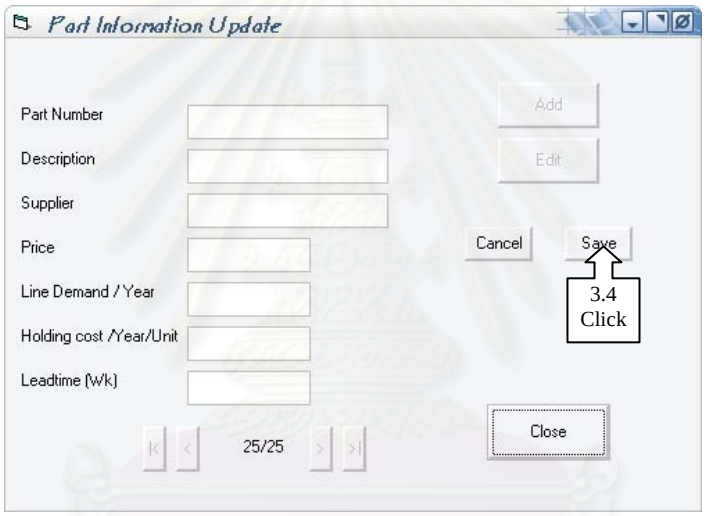


Figure B-3.3 Add a new part to a database

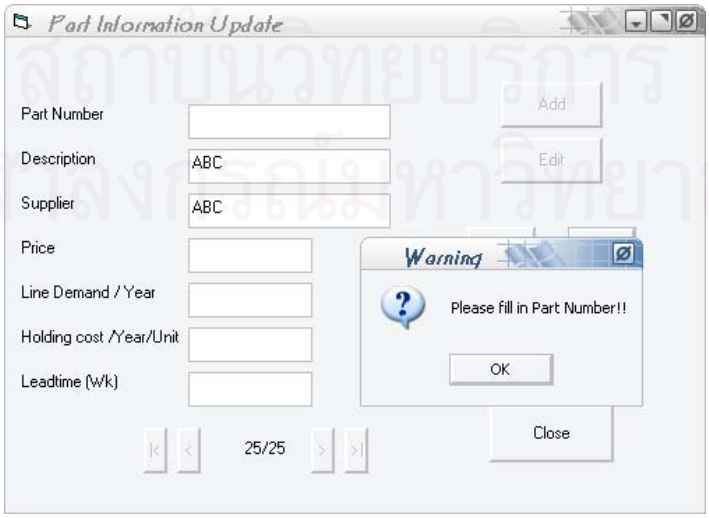


Figure B-3.4 Warning message appeared when the part number box is empty

3.6 To edit the existing part information, click Record Select buttons to select the interesting part. And then click Edit.

3.7 Edit part information in the boxes.

3.8 Click Save to save to the database. Or click Cancel to go back to the part information display mode.

3.9 Click Close to leave Part Information Update window and back to the Main menu.

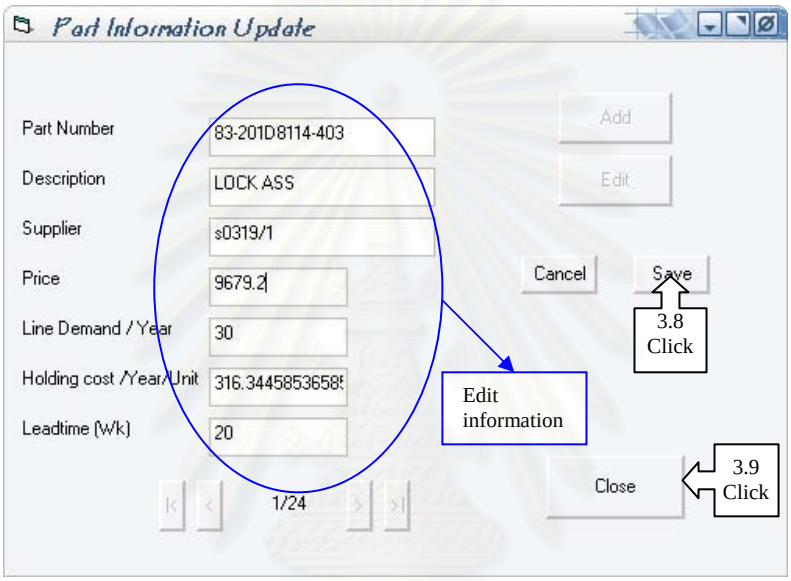


Figure B-3.5 Edit part information

4. MRP Computation

4.1 On the main menu, click TimePhaseRecord button in the Report frame. The MRP window will appear as shown in figure B-4.2.

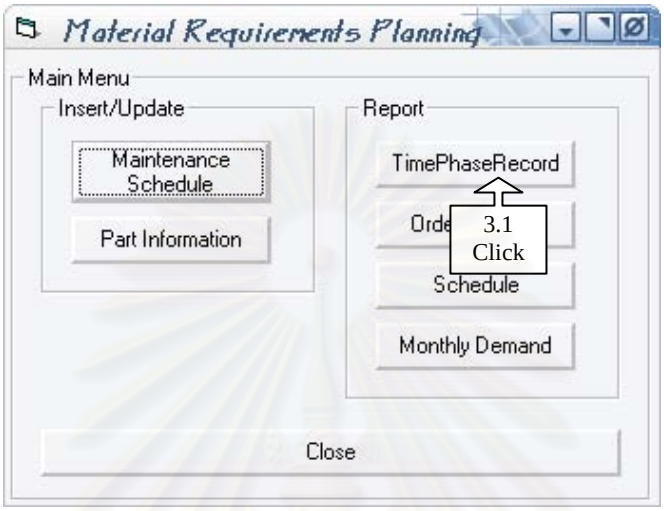


Figure 4.1 Select TimePhaseRecord on the main menu

4.2 Click Year box to select starting year

4.3 Click Month box to select starting month

4.4 Select the required mode. If there is no selection, the default will be normal mode.

- Normal mode

Select normal mode when the user wants to run the MRP by starting from current month. Therefore, if this mode is selected, the Year box and Month box will be automatically set to the current month. The beginning level of the first week in time-phased record will equal the exact current stock level minus the safety stock.

- Re-execute mode

Select re-execute mode when the user have updated the schedule or part information. The user can select any month as the first month in the planning, but the month selected must have ever been computed at least once. The beginning level of the first week in time-phased record will equal the

computed beginning level stored in the database gotten from the previous MRP computation.

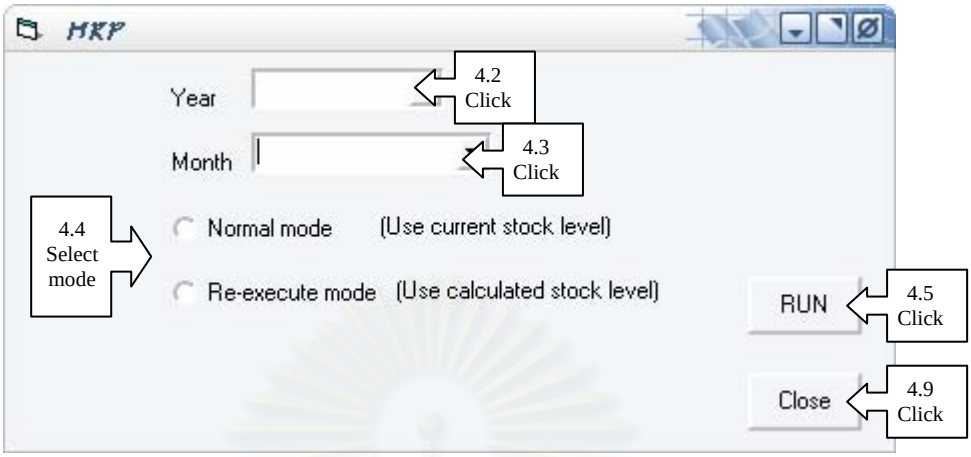
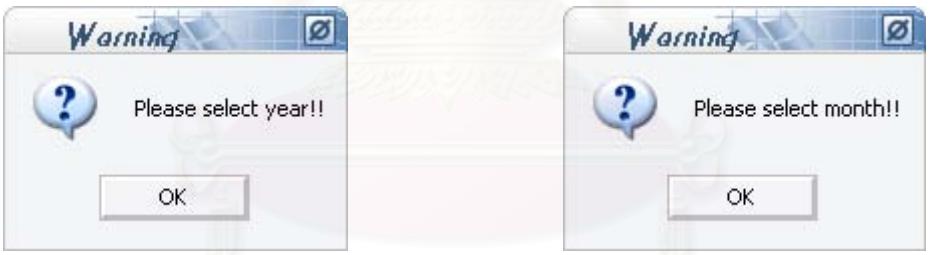


Figure B-4.2 MRP window

4.5 Click RUN to run the MRP computation. The program will calculate the output by starting from the first week of the selected month to the last week of the next 12 months.

4.6 If ear or month has not been selected, the warning message will appear as shown in figure B-4.3.



(a) (b)

Figure B-4.3 Warning messages (a) when year is not selected
(b) when month is not selected

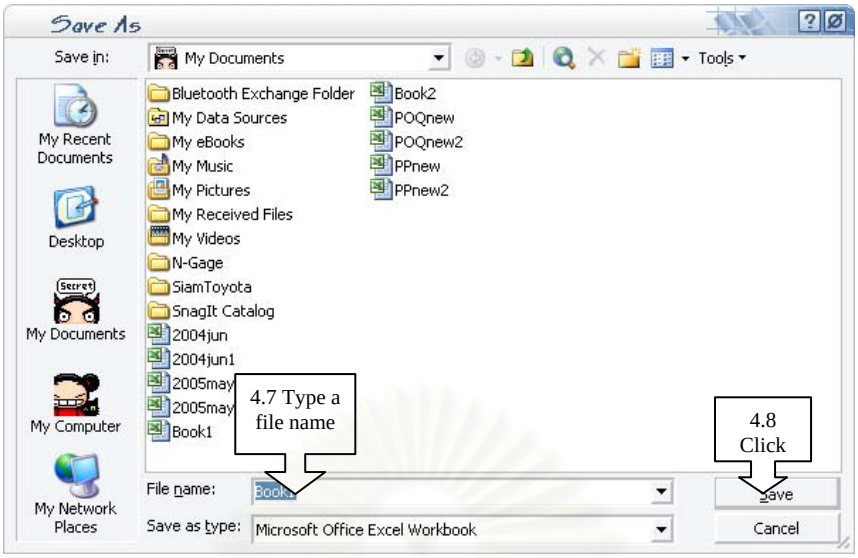


Figure B-4.4 Save As window

4.6 The MRP computation will take about a half day to complete the calculation on a thousand spare parts. After that, the Save As window will appear to enable the user to save the report as shown in figure B-4.4.

4.7 Type the file name

4.8 Click Save to save the time-phased record report.

4.9 Click Close to close the MRP window and back to the main menu

4.10 Open the saved file to see the output. The output will be time-phased record in excel format as shown in figure B-4.5.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1				Material Requirement Planning: Seat shop														Planning Period: July 2004 - June 2005											
2				Ordering Policy: Part Period Balancing														Response Planner: MR. THANUN SUKSAWAS									Date: 18/12/2005		
3					June				July				August					September				October					November		
4	Part Number			Wk	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
5	83-201D8114-403	LD		DM	30				0				0					35				0					35		
6	83-201D8114-403	20wks		RC																									
7	83-201D8114-403	SF		BL	149	119	119	119	119	119	119	119	119	119	119	119	119	84	84	84	84	84	84	84	84	84	49	49	49
8	83-201D8114-403	20unit(s)		EL	119	119	119	119	119	119	119	119	119	119	119	119	119	84	84	84	84	84	84	84	84	84	49	49	49
9	83-201D8114-403			OR															30				30				40		
10	83-201D7953A401	LD		DM	0				0				0					100				0					100		
11	83-201D7953A401	28wks		RC																							170		
12	83-201D7953A401	SF		BL	131	131	131	131	131	131	131	131	131	131	131	131	131	131	31	31	31	31	31	31	31	31	31	101	101
13	83-201D7953A401	50unit(s)		EL	131	131	131	131	131	131	131	131	131	131	131	131	131	31	31	31	31	31	31	31	31	31	101	101	101
14	83-201D7953A401			OR							200								100										
15	83-201C5283-401	LD		DM	0				0				0					180				0					180		
16	83-201C5283-401	22wks		RC																									
17	83-201C5283-401	SF		BL	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1476	1476	1476	1476	1476	1476	1476	1476	1476	1296	1296
18	83-201C5283-401	90unit(s)		EL	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1656	1476	1476	1476	1476	1476	1476	1476	1476	1476	1296	1296	1296
19	83-201C5283-401			OR																									
20	83-201C5134-1	LD		DM	0				0				0					200				0					200		
21	83-201C5134-1	13wks		RC																									
22	83-201C5134-1	SF		BL	619	619	619	619	619	619	619	619	619	619	619	619	619	619	419	419	419	419	419	419	419	419	419	219	219
23	83-201C5134-1	100unit(s		EL	619	619	619	619	619	619	619	619	619	619	619	619	619	419	419	419	419	419	419	419	419	419	219	219	219
24	83-201C5134-1			OR																						400			

Figure B-4.5 The output from MRP computation

5. Order Release Report

5.1 On the main menu, click Order Release button in the Report frame. The Order Release Report window will appear as shown in figure B-5.2.

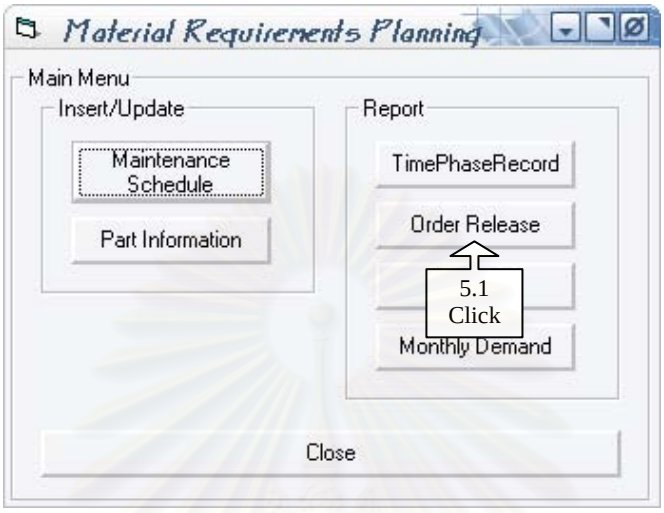


Figure B-5.1 Select Order Release on the main menu

5.2 Click Year box to select starting year

5.3 Click Month box to select starting month

5.4 Click Supplier box to select supplier

5.5 Click Sort to start sorting data from database. The result will be displayed as shown in figure B-5.3. Click an interesting part number to see its information.

5.6 If spare part has more than one order in a year period, the others orders will show in the next row of that part number.

5.6 If the user does not select any box, the warning message will appear to remind the user as shown in figure B-5.4.

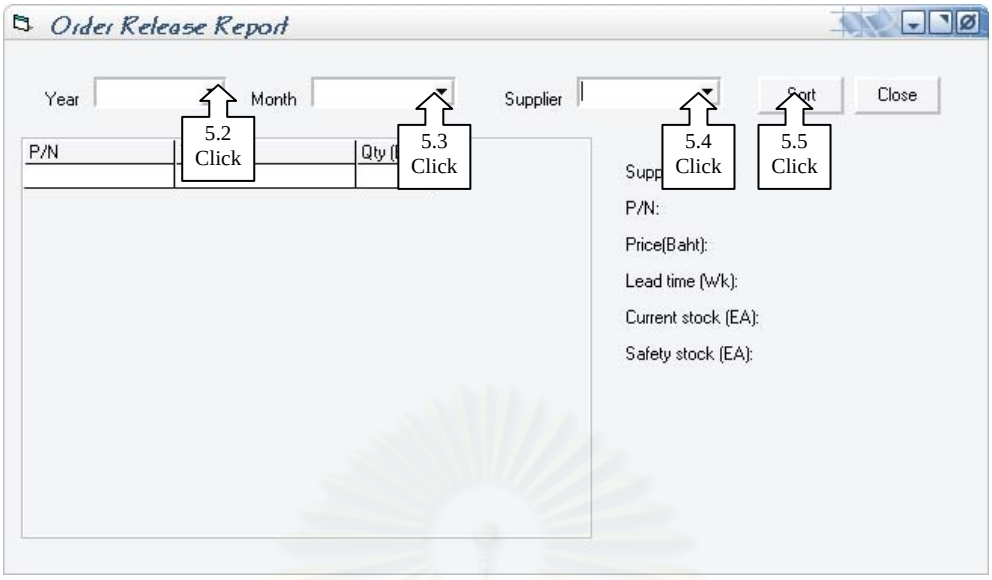


Figure B-5.2 Order Release Report window

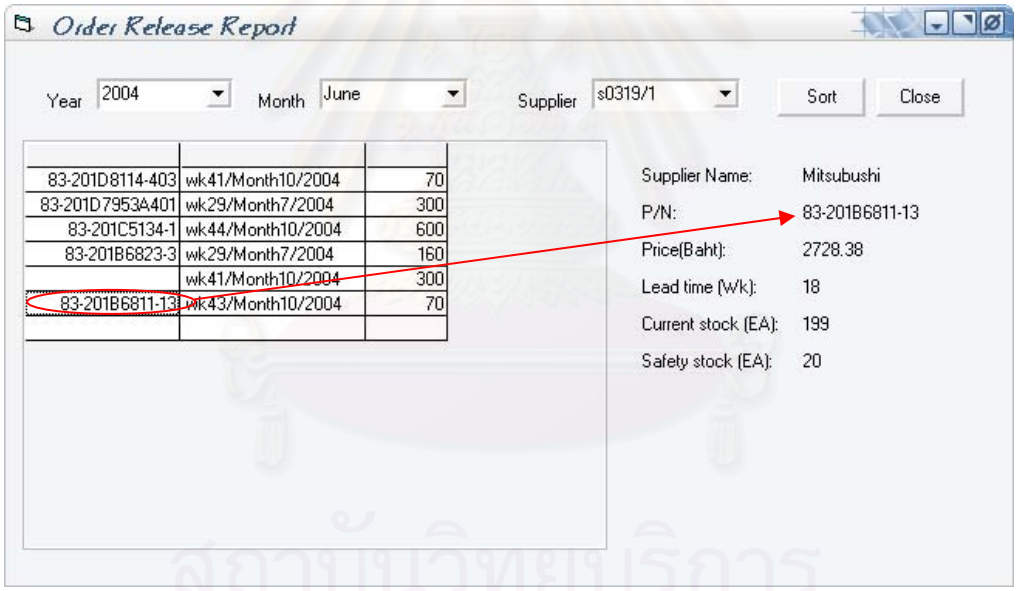
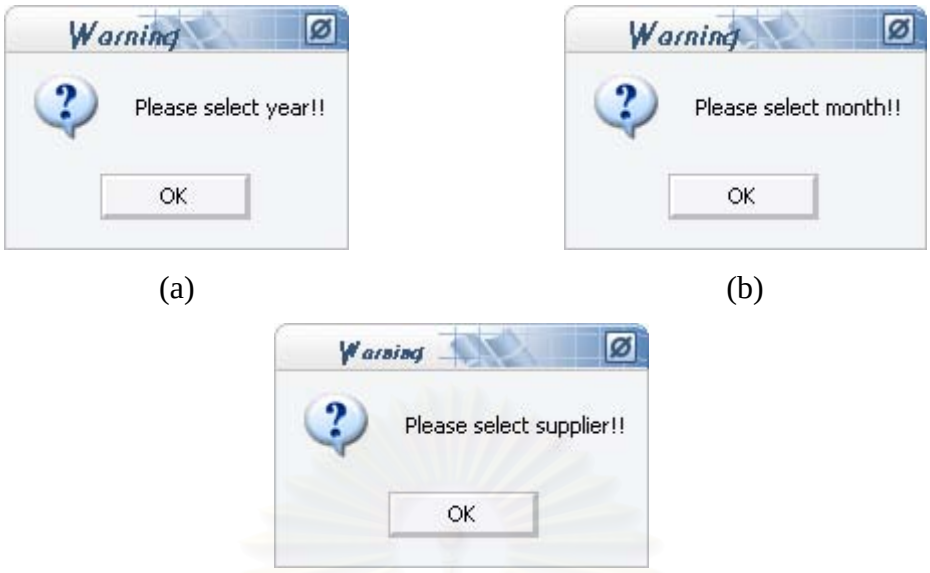


Figure B-5.3 Order release report sorted by supplier



(a) (b)

(c)

Figure B-5.4 Warning messages (a) when year is not selected
(b) when month is not selected
(c) when supplier is not selected

6. Monthly Demand Report

6.1 On the main menu, click Monthly Demand button in the Report frame. The Monthly Demand Report window will appear as shown in figure B-6.2.

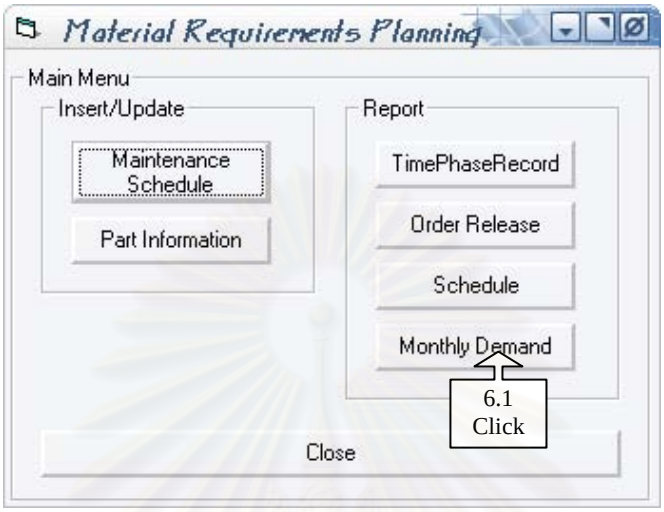


Figure B-6.1 Select Monthly Demand on the main menu

6.2 Click Year box to select starting year

6.3 Click Month box to select starting month

6.4 Click Sort to start sorting data from the database. The planned monthly demand for 12 months starting from selected month will be displayed as shown in figure B-6.3.

6.5 If any box is not selected, the warning message will appear to remind the user as shown in figure B-6.4.

6.6 Click Close to close the Monthly Demand Report window and return to the main menu.

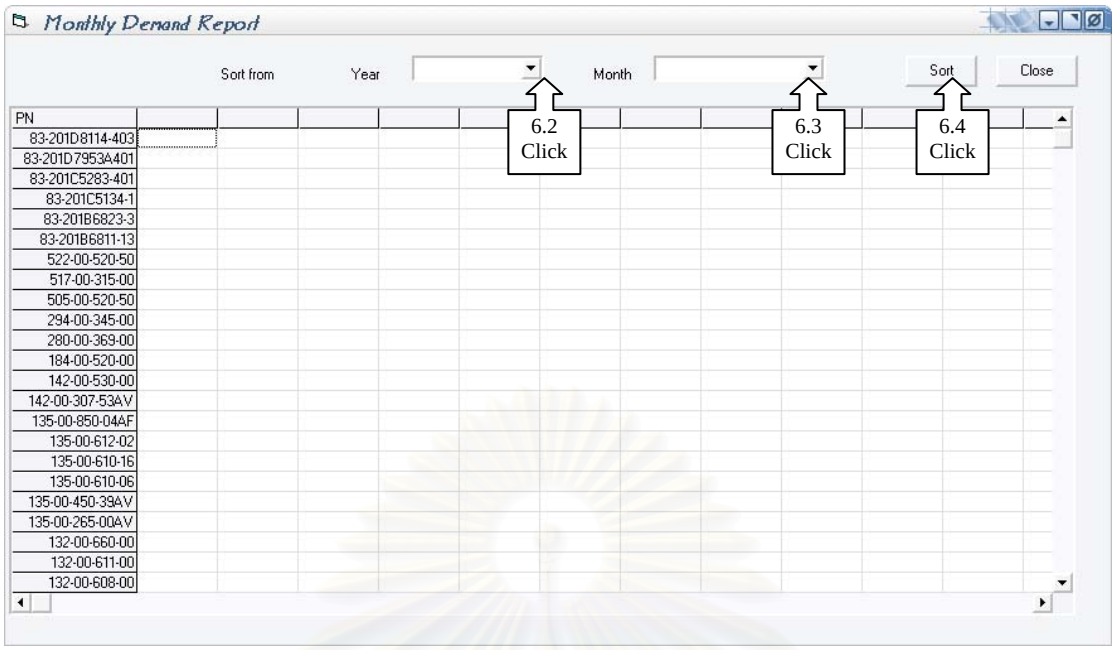


Figure B-6.2 Monthly Demand Report window

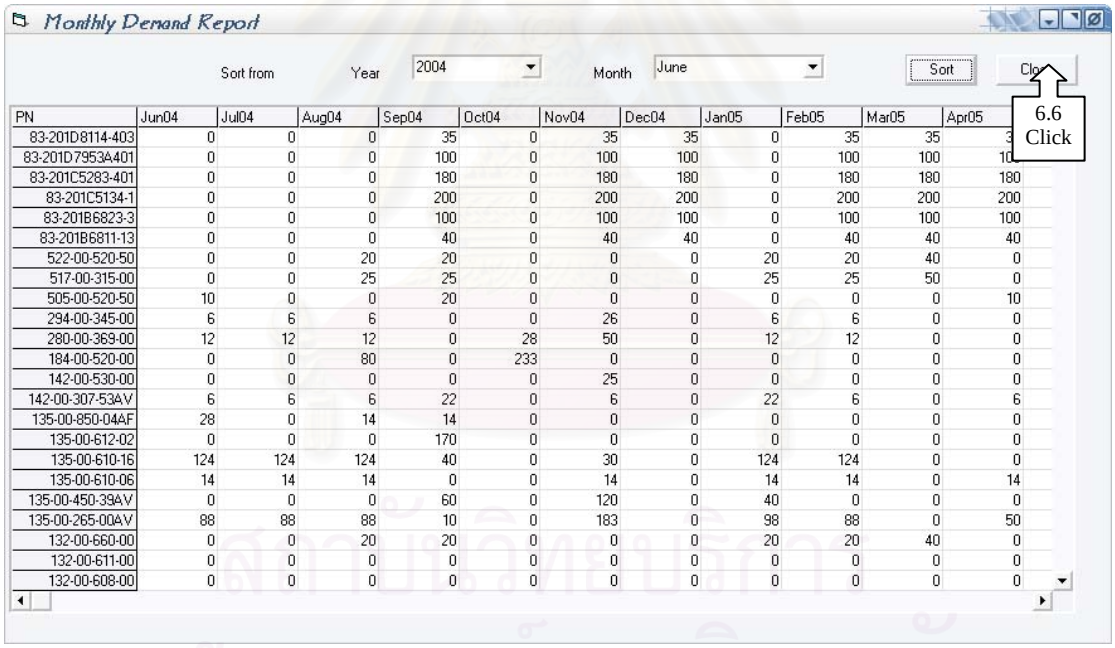


Figure B-6.3 Monthly Demand Report for 12 months starting from selected year and month

(a) (b)

Figure B-6.4 Warning messages (a) when year is not selected
(b) when month is not selected

BIBLIOGRAPHY

Sirin Ruangdist was born in Bangkok on May 8, 1982. She completed her secondary education at Nawamintrachinutis Satrivittaya II School in 1999. Then, she studied at Kasetsart University, and received a Bachelor Degree in Aerospace Engineering in 2003. In October 2003, she enrolled on the Master Degree course at the Regional Centre for Manufacturing Systems Engineering, Chulalongkorn University. In August 2004, she worked for Thai Airways Public Company Limited as a production engineer of the Aircraft component overhaul department.