CHAPTER (1) BASIC OF RESEARCH

1.1 Introduction

The world was seen continuous change in every facet of life day-by-day. In the wake of industrial revolution, came in technological innovation and today it is the scene of information explosion. The world has shrunk in size to a global village. The aviation is one of modern industry which effect with this global change also aircraft maintenance management was developing in maintenance, safety, and reliability program. Since the Industrial Revolution, maintenance of engineering equipment in organizations has been a challenging issue. Although over the years impressive progress has been made in maintaining equipment.

Aircraft maintenance is important processes to sustainability of aircraft operation with high professional performance, this maintenance must be done under umbrella of the country civil aviation which represent the international civil aviation organization (ICAO), the aircraft maintenance organization has approved maintenance program must follow.

From aviation history all people questions “Why do aircraft crash?" and however, the drive to reduce the accident rate has yielded unprecedented levels of safety. In fact, today it is likely safer to fly in a commercial airliner than to drive a car or walk across a busy City street.

The reliability-centered maintenance (RCM) is based on continuous improvement in maintenance organization, because it leads to reducing cost and increase safety, reliability and profitability of business, in this research we will discuss the Role of RCM improving aircraft maintenance program.

1.2 Objectives

1.2.1 General Objective

The purpose of the present study to add reference guide for aircraft maintenance management, also discuss the relationships between RCM and reliability program and how this develop aircraft maintenance program.

1.2.2 Specific Objectives

The specific objectives of this study are to:

1. Explain the important of RCM in aircraft maintenance.
2. Explain the continuous improvement for aircraft maintenance program through RCM.
3. Spread the concept of reliability engineering and improve the quality and safety in aircraft maintenance management.

1.3 Research Problem

The reliability center maintenance (RCM) in aircraft is direct effect in aircraft maintenance organization that reflects to aircraft performance, the main question here how reliability center maintenance (RCM) is important for aircraft maintenance program. The branches of this question, the following sub questions:

1. What is role of RCM in aircraft maintenance?
2. How RCM work in aircraft maintenance program?
3. Is reliability program preventing aircraft accident?
4. Is applied reliability program enough to leads high quality of service in the processes of aircraft maintenance?

1.4 Research Hypothesis

The hypothesis of this study is:

1. There was significant effectiveness of RCM method in Appling AMP.
2. RCM strategy reducing cost and increase benefits in organization.
3. There was correlation between AMP and aviation accident.
4. Reliability software has positive direct effect to AMP.
5. Reliability training courses increase AMP effectiveness.

1.5 Research Methodology

The researcher will follow the historical and descriptive method to describe the phenomena, gather facts and observation in Sudanese aircraft maintenance organization against the world-class organizations.

1.6 Structure of the thesis

The structure of this thesis is divided into four chapters as follow:

Chapter 1: Basic of Research

Chapter 2: Literature Review

Chapter 3: Methodology & Result

Chapter 4: Conclusion & Recommendation

1.7 Research limitation

Spatial Limits: Sudan-Khartoum Airport.

Time Limits: 2013-2016.

CHAPTER (2) LITERATURE REVIEW

2.1 A/C Maintenance

Technological developments in recent decades prompted the design and production of devices with many components, which are substantially more complex in structure than their earlier versions. Aircrafts are example. Such high technology devices are generally quite expensive and critical in the functioning of the system, it is of utmost importance that they should be highly reliable in design and properly maintained to achieve an extended economically useful lifetime. Since the Industrial Revolution, maintenance of engineering equipment in the field has been a challenge. Over the years, many new developments have taken place in this area. From now on, the importance of maintenance will increase more and more, Many serious accidents have happened in the world where systems have been large-scale and complex, and have caused heavy damage, Maintenance will be more important than production, manufacture, and construction (Süleyman, 2013).

2.1.1 A/C Maintenance History

In those early days of aviation, maintenance was performed (as necessary) and the machines often required several hours of maintenance time for every hours of flying time. Major maintenance activities consisted of overhauling nearly everything on the aircraft on periodic basis. Even though the airplanes and their systems were quite simple at first, maintenance carried out in this manner become quite expensive. With the increasing complexity of aircraft and their onboard systems over the following years, that expense raised accordingly (Smith, 1993).

2.1.2 A/C Maintenance Definition

The industry definition of maintenance generally includes those tasks required to restore or maintain an aircraft's systems, components, and structures in an airworthy condition. Maintenance is required for three principal reasons (Ackert, 2010):

1. **Operational**

To keep the aircraft in a serviceable and reliable condition so as to generate revenue.

2. **Value Retention**

To maintain the current and future value of the aircraft by minimizing the physical deterioration of the aircraft throughout its life.

3. **Regulatory Requirements**

The condition and the maintenance of aircraft are regulated by the aviation authorities of the jurisdiction in which the aircraft is registered. Such requirements establish standards for repair, periodic overhauls, and alteration by requiring that the owner or operator establish an airworthiness maintenance and inspection program to be carried out by certified individuals qualified to issue an airworthiness certificate.

2.1.3 A/C Maintenance Scheduling

Maintenance scheduling is vital to airline organization, as it is the mean of securing safe and efficient operation. Maintenance scheduling secures aircraft airworthiness and achieves optimum serviceability of airplanes by:

1. Selection of suitable maintenance program.
2. Establishing checks long term plans.
3. Clear utilization of check downtime for scheduling routine, non – routine and modification.

4. Clear and well prepared bill of work Aircraft Maintenance Requirements

Fig (1) show Aircraft maintenance requirements fall into two main categories Scheduled and Unscheduled maintenance (Pathirana, 2011).

Scheduled maintenance:

Maintenance done according to (Calendar time - Number of landing - Number of cycle - Flying hours).

Unscheduled maintenance:

Maintenance done according to (ADs - SBs - Modification – Defect Arising-special events).

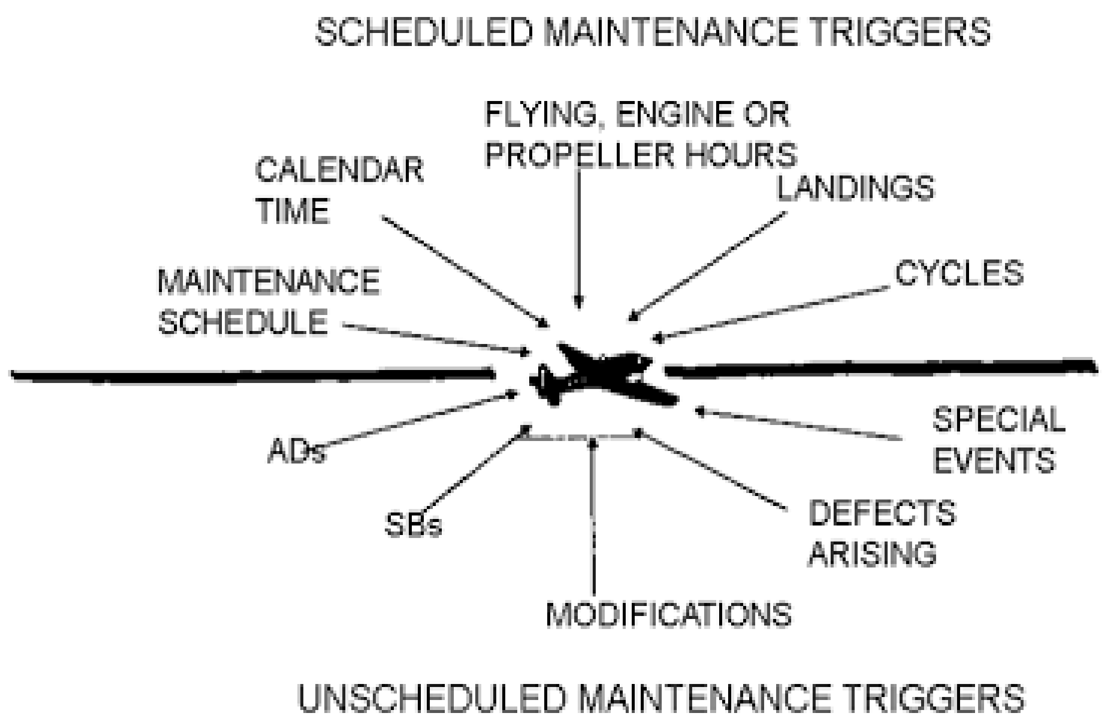

Figure (1) Scheduled and Unscheduled maintenance (Pathirana, 2011)

2.1.4 A/C Maintenance Philosophy

The MSG-3 development A/C Maintenance Philosophy and classified the necessary maintenance of one of three maintenance processes (Ghobbar, 2010):

1. **Hard-Time Limit:** A maximum interval for performing maintenance tasks
2. **On-Condition:** Scheduled repetitive inspections or tests to determine the condition of items.
3. **Condition-Monitoring:** For items that have neither hard-time limits nor on-condition maintenance, condition-monitoring is accomplished by analysing the performance of equipment and developing inspections on an as required basis, fig (2) show maintenance detail.

The analysis system and associated support for a condition-monitored programme are normally only efficient for operators of larger aircraft or larger fleets of aircraft.

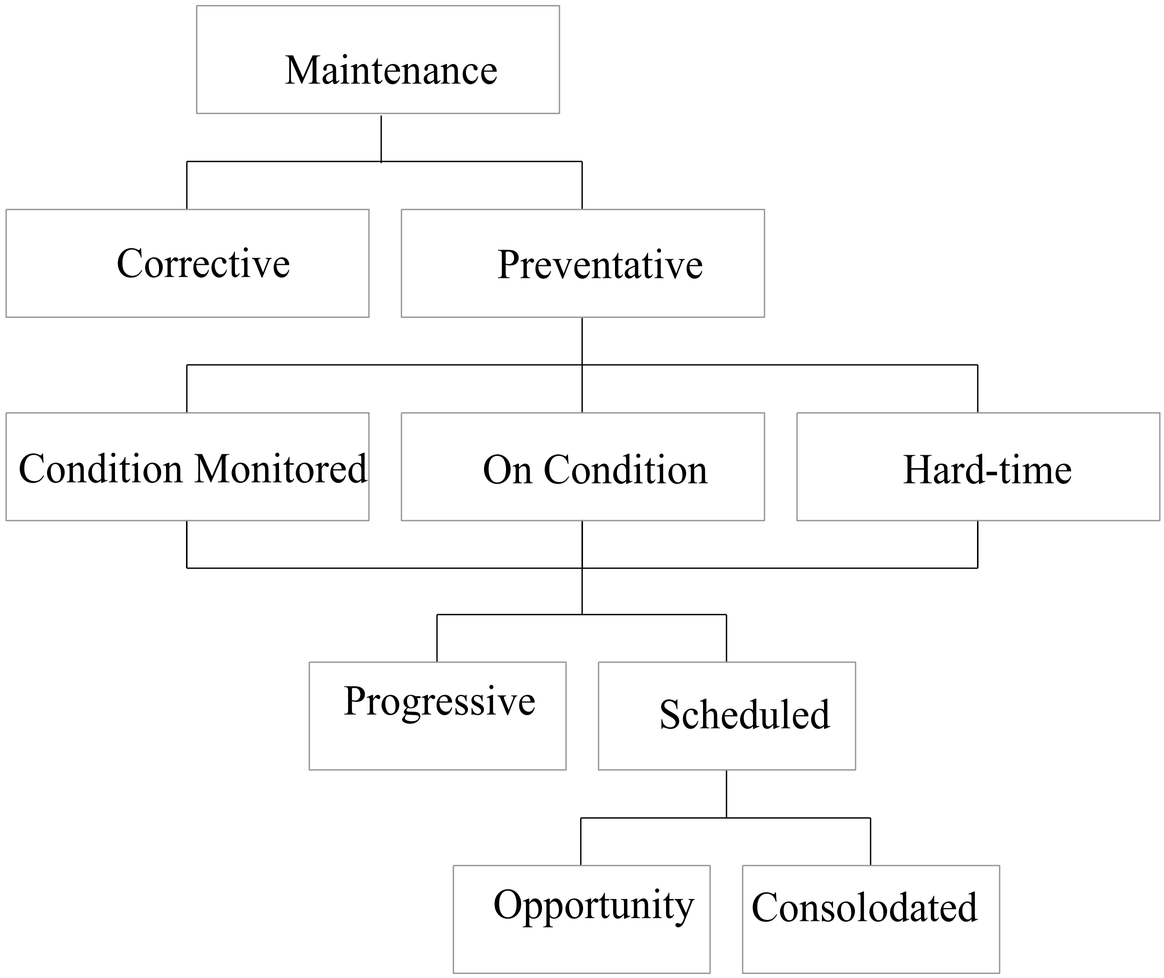

Figure (2) Type of Maintenance Program *(Transport Canada 2011)*

2.2 Reliability centered maintenance (RCM)

2.2.1 History of RCM

RCM evolved during the 1950s in the aircraft industry as a result of a number of major reliability studies concerning complex equipment. In particular, the 1960 FAA / Airline Industry Reliability Program Study was initiated to respond to rapidly increasing maintenance costs, poor availability, and concern over the effectiveness of traditional time-based on preventive maintenance, table (1) show RCM Development History (Kennedy, 2005) .

Table (1) RCM Development History **(Kennedy, 2005)**

Years	**RCM Development**
1950s	Traditional maintenance approaches were found to be inadequate for post war (modern) aircraft.
1960s	FAA / Airline industry reliability program FAA / Manufacturers Maintenance Steering Group (MSG)
1965s	FAA and Commercial Aviation Industry form group to study Preventative Maintenance.
1970s	MSG 1 applied to Boeing 747 MSG 2 applied to DC -10, L -1011
1978s	Reliability Centered Maintenance (Nowlan and Heap) released
1980s	RCM coined by United Airlines (original Decision Diagram published) . MSG 3 developed and applied to B -757, B – 767 (RCM 1: Revised Decision Diagram)
1990s	RCM applied in the nuclear industry RCM being applied in a variety of industries RCM 11: Environment added to Decision Diagram

RCM was first documented in a report written for United Airlines by F.S. Nowlan and H.F. Heap to transform aircraft maintenance as the Boeing 747 was being introduced. The report was published by the U.S. Department of Defense (DoD) in 1978 and was then adapted to industrial maintenance.

2.2.2 RCM Definitions

Reliability centered Maintenance (RCM) is a technique for determining the preventive maintenance and inspection requirements of physical assets. It is a rigorous and thorough process, an essential feature when dealing with aircraft airworthiness issues Reliability Centered Maintenance, or RCM, is a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the desired level of operational reliability of systems and equipment while ensuring their safe and economical operation and support. That is, when no preventive action is effective or applicable for a given item, then that item is run to failure assuming safety or a similarly critical consideration is not at issue. From that perspective, RCM identifies all maintenance. RCM is focused on optimizing readiness, availability, and sustainment through effective and economical maintenance.

RCM is a process used to determine what must be done to ensure that any physical asset continues to do what its users need it for in a certain operating context. RCM analysis provides a structured framework for analyzing the functions and potential failures of physical assets (such as an airplane, a manufacturing/production line, an oil refinery, a telecommunication system, etc.) in order to develop a scheduled maintenance plan that will provide an acceptable level of operability, with an acceptable level of risk, in an efficient and cost effective manner (Vasiu, 2007).

2.2.3 The Objective of RCM

1. The objective of RCM is to achieve reliability for all of the operating modes of a system.
2. Nowlan & Heap RCM objectives (Nowlan, 1978):
    a. Insure realization of the inherent safety and reliability levels of the system/components.
    b. Restore the system/components to these inherent levels when deterioration occurs.

c. To obtain the information and data necessary for design the improvement and adjustments of these items where their inherent reliability start to be inadequate.
d. To achieve these goals at minimum total cost, including maintenance cost, support costs, and economic consequences of operational failure.

2.2.4 RCM Concept

RCM concept is a process of systematically analyzing an engineered system to understand its functions, the failure modes of its equipment that support these functions, how then to choose an optimal course of maintenance to prevent the failure modes from occurring or to detect the failure mode before a failure occurs, how to determine spare holding requirements and How to periodically refine and modify existing maintenance over time (Shipping, 2004).

2.2.5 RCM Strategies

The RCM is maintenance strategy and has four major components are shown in Fig (3) There are reactive maintenance, preventive maintenance, predictive testing and inspection, and proactive maintenance. Each component is described below (Mobley, 2002):

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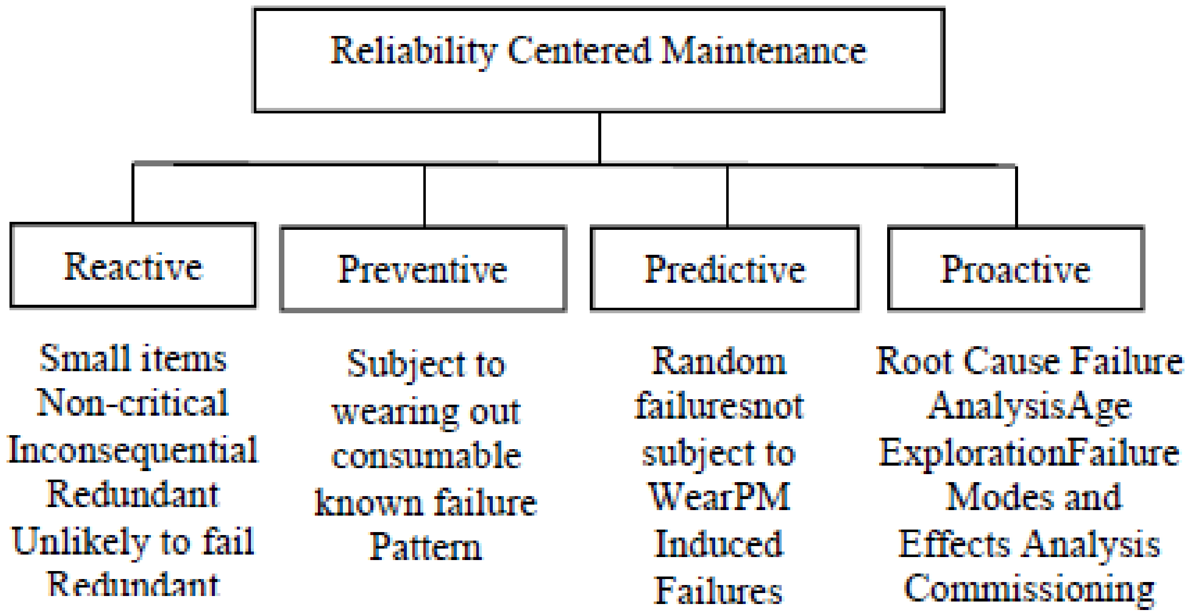

Figure (3) RCM Four strategies (Mobley, 2002)

1. Reactive Maintenance

This type of maintenance is also known as breakdown, fix-when-fail, run-to-failure, or repair maintenance. When using this maintenance approach, equipment repair, maintenance, or replacement takes place only when deterioration in the condition of an item/equipment results in a functional failure. In this type of maintenance, it is assumed there is an equally likely chance for the occurrence of a failure in any part, component, or system. When reactive maintenance is practiced solely, a high replacement of part inventories, poor use of maintenance effort, and high percentage of unplanned maintenance activities are typical. Furthermore, an entirely reactive maintenance program overlooks opportunities to influence equipment/item survivability (Mobley, 2002).

Reactive maintenance can be practiced effectively only if it is carried out as a conscious decision, based on the conclusions of an RCM analysis that compares risk and cost of failure with the cost of maintenance needed to mitigate that risk and failure cost.

2. Preventive Maintenance

Preventive maintenance (PM), also called time-driven or interval-based maintenance, is performed without regard to equipment condition. It consists of periodically scheduled inspection, parts replacement, repair of components/items, adjustments, calibration, lubrication, and cleaning. PM schedules regular inspection and maintenance at set intervals to reduce failures for susceptible equipment. It is important to note that, depending on the predefined intervals, practicing PM can lead to a significant increase in inspections and routine maintenance. On the other hand, it can help reduce the frequency and severity of unplanned failures. Preventive maintenance can be costly and ineffective if it is the only type of maintenance practiced (Mobley, 2002).

3. Predictive Maintenance

Predictive testing and inspections (PTI) is sometimes called condition monitoring or predictive maintenance. To assess item/equipment condition, it uses performance data, nonintrusive testing techniques, and visual inspection. replaces arbitrarily timed maintenance tasks with maintenance that is performed as warranted by the item/equipment condition. Analysis of item/equipment condition-monitoring data on a continuous basis is useful for planning and scheduling maintenance/repair in advance of catastrophic or functional failure. The collected PTI data are used to determine the equipment condition and to highlight the precursors of failure in several ways, including pattern recognition, trend analysis, correlation of multiple technologies, data comparison, statistical process analysis, and tests against limits and ranges. PTI should not be the only type of maintenance practiced, because it does not lend itself to all types of items/equipment or possible modes of failure (Mobley, 2002).

4. Proactive Maintenance

This type of maintenance helps improve maintenance through actions such as better design, workmanship, installation, scheduling, and maintenance procedures. The characteristics of proactive maintenance include practicing a continuous process of improvement, using feedback and communications to ensure that changes in design/procedures are efficiently made available to item designers/management, ensuring that nothing affecting maintenance occurs in total isolation, with the ultimate goal of correcting the concerned equipment forever, optimizing and tailoring maintenance methods and technologies to each application. It performs root-cause failure analysis and predictive analysis to enhance maintenance effectiveness, conducts periodic evaluation of the technical content and performance interval of maintenance tasks, integrates functions with support maintenance into maintenance program planning, and uses a life cycle view of maintenance and supporting functions (Mobley, 2002).

2.2.6 RCM Benefits

RCM can be employed to identify functional failures with the highest risk, which will then become the focus for further Analyses. Identify equipment items and their failure modes that will cause high-risk functional failures, also, it can use to Determine maintenance tasks and maintenance strategies that will reduce risk to acceptable levels (Deshpande, 2002).

2.2.7 RCM Seven Questions

An RCM analysis, when properly conducted, should answer the following seven questions (Rausand, 2008):

1. What are the system functions and associated performance standards? (functions)
2. How can the system fail to fulfill these functions?(functional failures)
3. What can cause a functional failure? (failure modes)
4. What happens when a failure occurs? (failure effects)
5. What might the consequence be when the failure occurs?
   (failure consequences)
6. What can be done to detect and prevent the failure?
   (proactive tasks and intervals)
7. What should be done if a maintenance task (**proactive tasks)** cannot be found?

2.2.8 The steps of analysis RCM

From these seven questions emerges a systematic process to determine the maintenance requirements of any physical asset in its operating context, called Reliability Centered Maintenance (Moubray, 1997).

1. Defining the system and/or subsystem boundaries,
2. Defining the functions of each system or subsystem,
3. Identifying functionally significant items (FSI),
4. Identifying the pertinent FSI functional failure causes,
5. Predicting the effects and probability of these failures,
6. Using a decision logic tree to categorise the effects of the FSI failures,

7. Identifying applicable and effective maintenance tasks which comprise the initial maintenance programme,
8. Redesign of the equipment or process, if no applicable tasks can be identified,
9. Establishing a dynamic maintenance programme, which results from the routine and systematic update of the initial maintenance programme and its revisions, assisted by the monitoring, collection and analysis of in-service data.

2.2.9 The Nature of Failure.

Some definitions of Failure:

An unsatisfactory outcome or condition. Webster International 1998

An inability to function. Collins 2000

Break down or ceasing to function. Encarta 1999

RCM Processes classifies the failure consequences into four groups, as follows (MSG):

1. Hidden failure consequences;
2. Safety and environmental consequences;
3. Operational consequences
4. Non-operational consequences.

Equipment Failure a combination of one or more equipment failures and/or human errors causes a loss of system function. The following factors usually influence equipment failure:

1. Design error
2. Faulty material
3. Improper fabrication and construction
4. Improper operation

5. Inadequate maintenance
6. Maintenance errors.

The definition of Failure in aviation engineering application depend on regulation and safety margins fig (4), show aviation failed state.

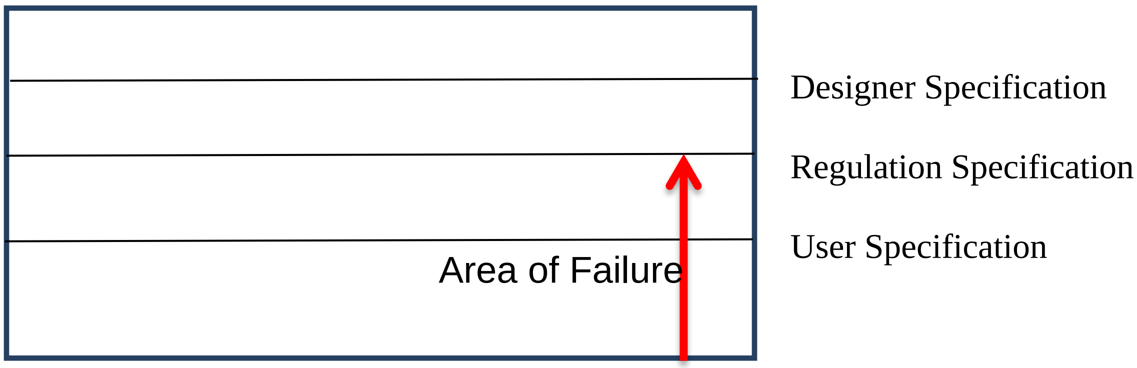

Figure (4) aviation failed state *(researcher)*

Functional Failure: A state in which a physical asset or system is unable to perform a specific function to a desired level of performance" (SAE JA 1011).

Potential Failure: "An Identifiable condition that indicates that a functional failure is either about to occur or is in the process of occurring (JA1011, 1999).

2.2.10 Six Classic Failure Rate Patterns

United States Federal Aviation Administration (FAA) commissioned United Airlines to undertake a study of the effectiveness of time-based overhauls of complex components in the equipment systems of civilian jet aircraft. There was a belief that these time-based overhauls did little to reduce the frequency of failure and were uneconomical. This study was conducted at a time when wide-bodied aircraft were being designed, and the complexity of the equipment systems and their components was increased dramatically over that of prior designs. The key conclusion was that time-based overhauls of complex equipment did not significantly affect positively or negatively the frequency of failure. In some equipment, the frequency of failure was actually higher immediately following the overhaul. This study showed that the so-called bathtub conditional probability of failure versus age curve was only one of six major failure patterns. The most common failure pattern in complex equipment is one which shows a high “infant mortality,” that is, the highest conditional probability of failure occurs in the first few periods of the equipment’s age and then diminishes to a constant rate of failure, there as described in Fig (5).

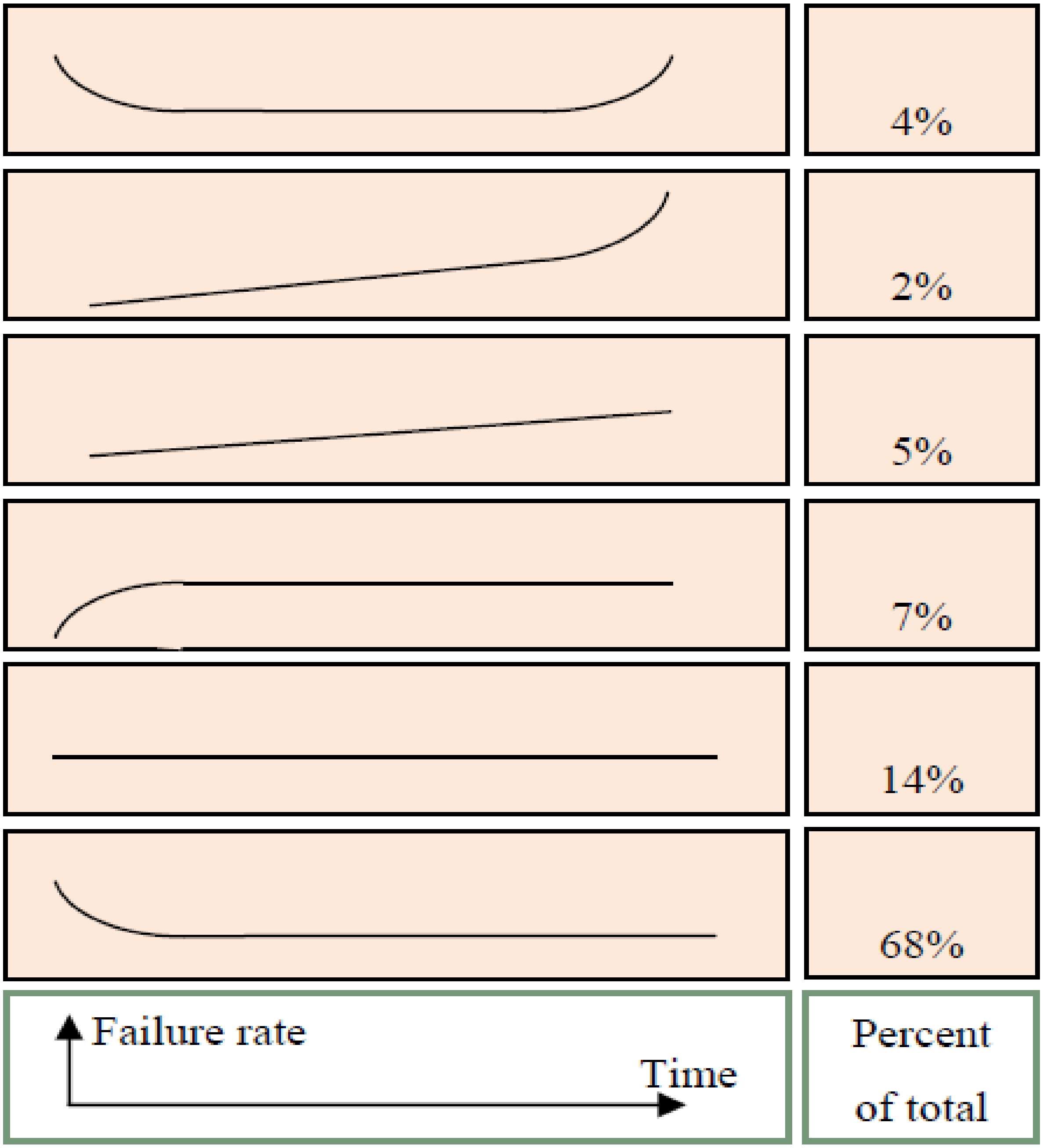

Figure (5) Aircraft failure characteristics (Nowlan and Heap, 1978)

2.2.11 RCM Tools

The following tools and expertise are employed to perform RCM analyses (Ajit Kumar Verma, 2015):

1. Failure modes, effects, and effective analysis (FMEA).

This analytical tool helps answer Questions 1 through 5.

2. RCM decision flow diagram.

   This diagram helps answer Questions 6 and 7.

3. Design, engineering and operational knowledge of the system
4. Condition-monitoring techniques (P-F)
5. Risk-based decision making (e.g., the frequency and the consequence of a failure in terms of its impact on safety, the environment and commercial operations)

1. Potential Failure (P-F) Condition Monitoring (Predictive)

If a potential failure is detected between Point P and Point F, it may be possible to take action to prevent the functional failure (or at least to minimize the effects). Tasks designed to detect potential failure are known as condition-monitoring tasks fig (6).

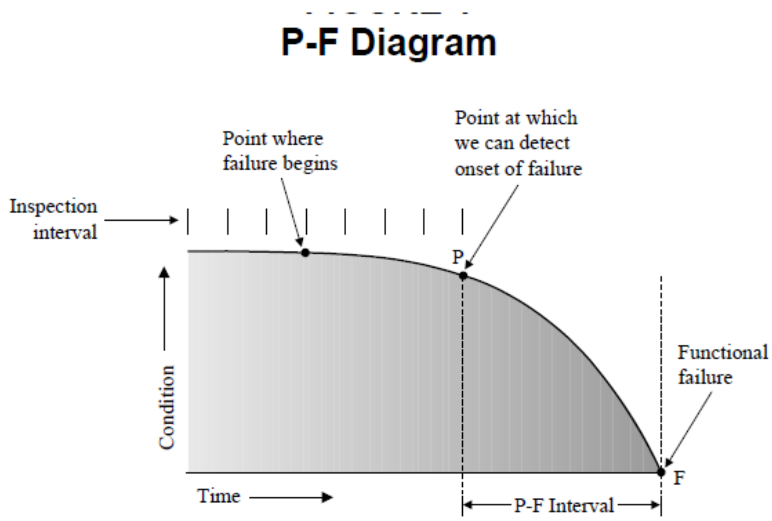

Figure (6) Potential Failure (P-F) Diagram *(RCM Standad,2004)*

2. Failure Modes and Effects Analysis (FMEA)

Failure modes and effects analysis (FMEA) is a basic tool used in reliability engineering to assess the impact of failures. It is a systematic failure analysis technique that is used to identify the failure modes, their causes, and consequently their fallouts on the system function. FMEA analysis rates each potential failure mode and effect based on the following three factors:

1. **Severity:** the consequence of the failure when it happens;
2. **Occurrence:** the probability or frequency of the failure occurring.
3. **Detection**: the probability of the failure being detected before the impact of the effect is realized.

Then these three factors are combined in one number called the risk priority number (RPN) to reflect the priority of the failure modes identified. The risk priority number (RPN) is simply calculated by multiplying the severity rating, the occurrence probability rating, and the detection probability rating.

$$\begin{aligned} \text{RPN} &= (\text{severity rating}) * (\text{occurrence probability rating}) \\ &\quad * (\text{Detection Probability rating}) \end{aligned}$$

FMEA process is usually documented using a matrix similar to the one shown in Fig. (7).

<table>
<tr><th colspan="7">RCM: Systems Analysis (FEMA)</th></tr>
<tr><td colspan="5">Step 5: Failure mode and effect analysis</td><td>Ref no.::</td><td>Date:</td></tr>
<tr><td colspan="4">Functional failure (FF) no.:</td><td colspan="3">FF name:</td></tr>
<tr><td colspan="4">Plant:</td><td colspan="3">Plant ID:</td></tr>
<tr><td colspan="4">System name:</td><td colspan="3">System ID:</td></tr>
<tr><td colspan="4">Team:</td><td colspan="3">Head:</td></tr>
<tr><td rowspan="2">Component</td><td rowspan="2">Failure mode</td><td rowspan="2">Failure cause</td><td colspan="3">Failure Effect</td><td rowspan="2">LTA</td></tr>
<tr><td>Local</td><td>System</td><td>Plant</td></tr>
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Figure (7) Failure Modes and Effects Analysis (FMEA) *(Aviation Safety, 2015)*

3. Logic or Decision Tree Analysis (LTA)

The purpose of the LTA is to prioritize the resources to be committed to each failure mode. The prioritization is based on the impact of the failure mode. RCM processes a simple and intuitive structure for this purpose. The structure utilizes two criteria, i.e., safety and cost, that arise from plant full outage. The LTA has three questions that enable a user, with minimal efforts, to place each failure mode into one of the six categories. Each question is answered as yes or no only. Each category (also known as a bin) forms natural segregation of items of respective importance. The LTA scheme is shown below in Fig. (8).

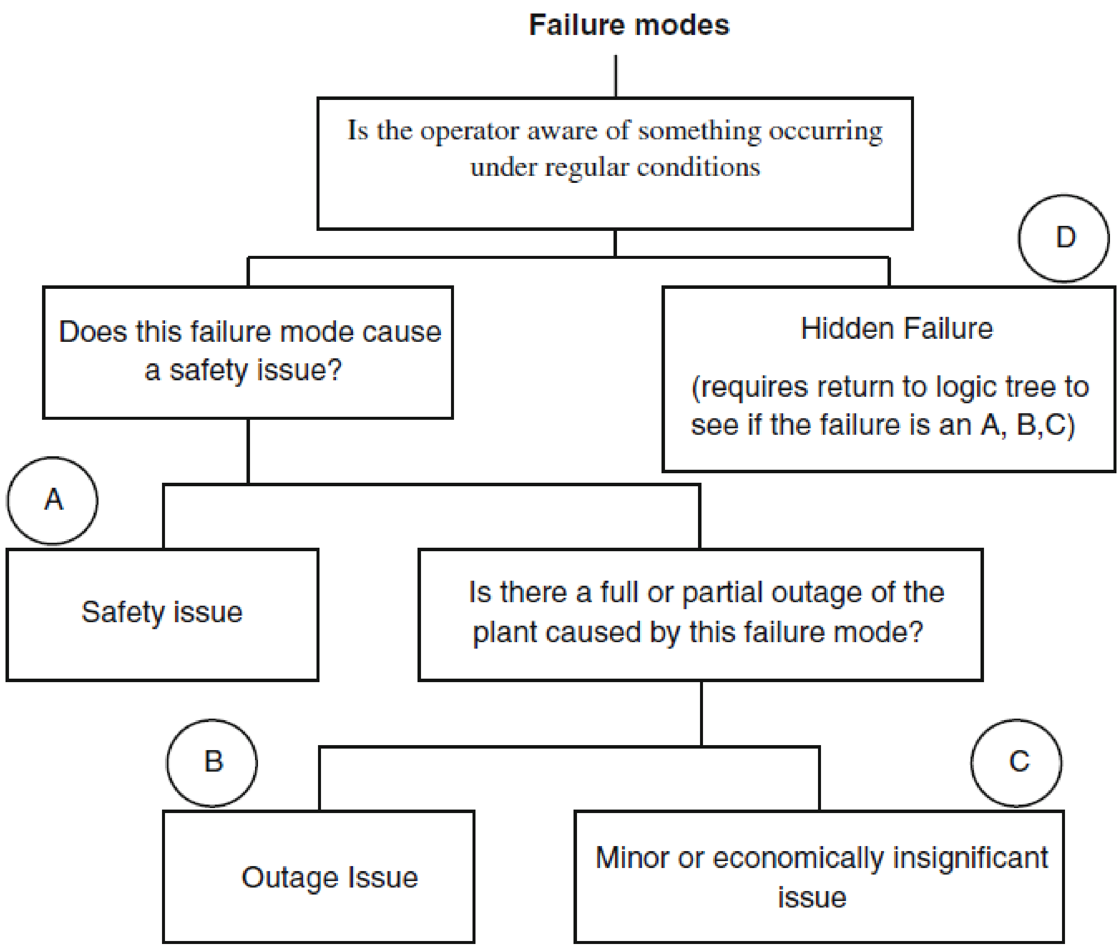


Figure (8) Logic or Decision Tree Analysis (LTA) *(Aviation Safety, 2015)*

The six classification categories for the failures are A, B, C, D/A, D/B, or D/C. For the priority scheme, A and B have higher priority over C when it comes to allocation of scarce resources and A is given higher priority than B. In summary, the priority for PM task goes in the following order: A or D/A , B or D/B; and C or D/C.

2.2.12 RCM Documenting process

Documenting and implementing the following formalize this process:

1. The analyses and the decisions taken
2. Progressive improvements based on operational and maintenance experience
3. Clear audit trails of maintenance actions taken and improvements made

Once these are documented and implemented, this process will be an effective system to ensure reliable and safe operation of an engineered system. Such a maintenance management system is called an RCM system. The following procedures provide guidance for conducting RCM analyses. RCM analyses are to be performed in a step-by-step fashion. The basic elements of an RCM analysis process are as follows:

Identify operating modes and corresponding operating contexts

1. Define vessel systems.
2. Develop system block diagrams and identify functions.

2.2.13 RCM In Industries

The state of the art of RCM techniques in different industries, RCM has been successfully applied to most of them. For each kind of industry:

1. Aircraft And Aerospace Industry
2. Nuclear Industry
3. RCM In Shipping
4. RCM In Chemical Industries
5. RCM Process/Oil & Gas
6. The RCM Experiences In Smalls And Medium Companies
7. RCM Applied In A Hospital

2.2.14 RCM in Aviation Industry

The RCM methodology was developed for the first time by United Airlines Company for the Defense American Department and was published in 1978. In this part, different RCM (MSG-3) applications will be presented in order to show the work already done in this sector. RCM has been used extensively in the military and commercial aerospace sector, together with MSG-3. Examples of industries in this field are airline operators, manufacturers, air traffic management systems, and baggage handling systems.

1- US NAVY RCM approach, to show the RCM military approach.

2- AIR CANADA to show civil usage of RCM tools in airline operators.

2.2.15 RCM Standards

Given the diverse interpretations and practices that have developed from the original RCM report, several government agencies and professional associations have developed standards to define, clarify, and govern their expectations of Reliability and those who offer (reliability) services.

1. RCM International Standard
2. MSG 3 Standard
3. Rams Railway Applications Standard
4. SAE Standard JA1011

2.3 RCM in A/C Maintenance

2.3.1 Evolution Of A/C Maintenance

Since the 1930's, the evolution of aircraft maintenance can be traced through three generations. RCM is rapidly becoming a cornerstone of the Third Generation, but this generation can only be viewed in perspective in the light of the First and Second Generations.

1. The First Generation

The first generation covers the period up to the World War II. In those days, the aircraft industry was not very highly mechanized. This meant that the prevention of failures of aircraft systems/aircraft components was a low priority. At the same time, most aircraft systems/aircraft components were simple and generally over designed. As a result, there was no need for systematic maintenance of any sort beyond simple servicing. The repairs were done as and when required (R, 2004).

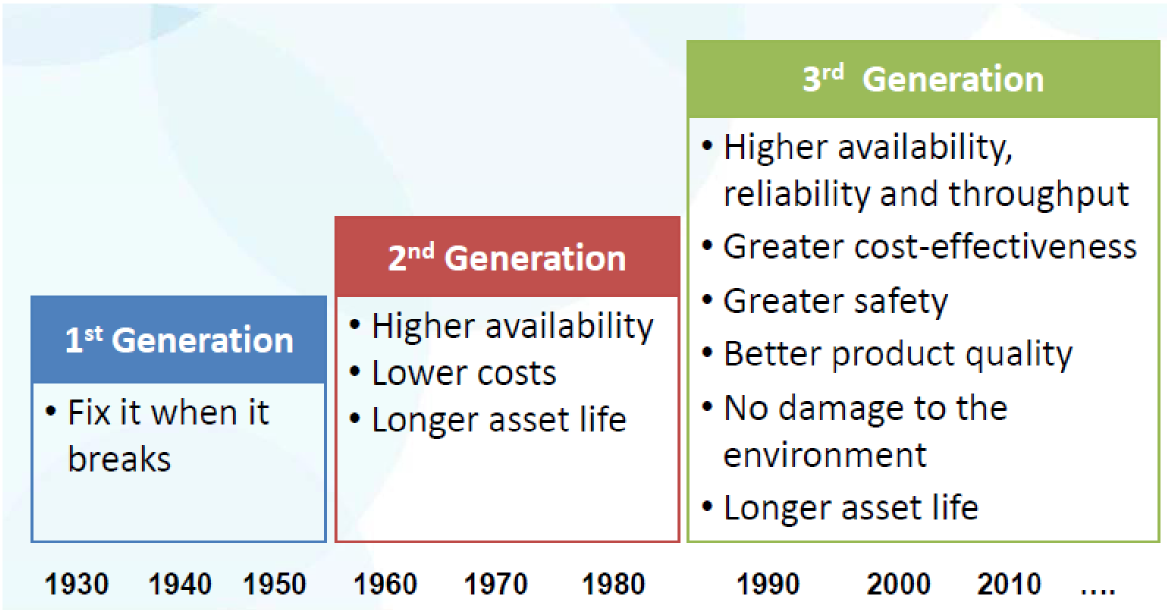


Figure (9) Maintenance Generation *(Internet)*

2. The Second Generation

Things changed dramatically during World War II. By the 1950's aircraft were more numerous and more complex. Industry was beginning to depend on them. As this dependence grew, Aircraft on Ground (AOG) times due failures came into sharper focus. This led to the idea that failures of aircraft systems/aircraft components could be and should be prevented, which led in turn to the concept of preventive maintenance. In the 1960's, this consisted mainly of overhauls of aircraft systems/aircraft components done at fixed intervals. The cost of maintenance also started to rise sharply relative to other operating costs. This led to the growth of maintenance planning and control systems. These have helped greatly to bring maintenance under control, and are now an established part of the practice of maintenance. Finally, the amount of capital tied up in aircraft together with a sharp increase in the cost of that capital led airlines to start seeking ways in which they could maximize the life of the aircraft systems/ aircraft components.

3. The Third Generation

Since the mid-seventies, the process of change in the aircraft industry gathered even greater momentum. These changes can be classified under the headings of new expectations from aircraft maintenance, new research, and new techniques in the aircraft maintenance practices.

4. New Expectations

The figure (9) in the following paragraph show how expectations of aircraft maintenance have evolved. 'Aircraft on Ground' (AOG) times due failures have always affected the aircraft operations by reducing the aircraft availability, increasing operating costs and interfering with flight schedules. By the 1960's and 1970's, this became a major concern to the airlines. The effects of AOG have been aggravated by the world wide move towards 'just in time' inventory management. The stock levels in general have been reduced to the point that minor failures of aircraft systems/aircraft components can now have a major impact on aircraft operations. In recent times, the growth of automation in the aircraft industry has meant that reliability [and hence the aircraft availability] has also become key issue. Greater automation also means that more and more failures affect the ability to sustain satisfactory quality standards. This applies as much to standards of service as it does to product quality. The maintenance of aircraft facilitates the identification of causes of the failures and develops procedures to prevent these failures. Skilled personnel, proper methodologies and tools, and refined technologies are now used to identify, predict and prevent failures. At the same time as the dependence on aircraft is growing, so too is the costs to operate and to own them. To secure the maximum return on the investment that they represent, they must be kept in an airworthy condition and performing with efficiency.

2.3.2 Relationship Of RCM To Aircraft Safety

Public and personnel safety is of primary priority in aircraft operation and maintenance. RCM is applied at aircraft maintenance in a way that is completely in accordance with safety objective. RCM is a process for specifying applicable and effective PM tasks which prevent failure or optimally control the failure modes for important system functions. For all systems, RCM will explicitly evaluate the failure modes and effects for system safety functions. For component failure modes that are determined by RCM to be critical, the RCM logic tree analysis requires a consideration of scheduled maintenance to reduce the risk of function unavailability for all hidden failures, and all evident failures that have a direct and adverse effect on operating safety. Furthermore, RCM task implementation requires that PM task changes undergo a thorough safety review, and that they are consistent with technical specifications, environmental qualifications and other regulatory commitments. Thus, RCM will optimize PM with respect to safety functions, and all RCM recommendations will undergo scrutiny for consistency with other safety programmes.

2.3.3 Maintenance Steering Group (MSG)

In 1968 the Maintenance Steering Group (MSG) was created with a mandate to formulate a decision logic process used for development of the initial scheduled maintenance requirements for new aircraft. The group was composed of participants from various aviation bodies, including the Air Transport Association (ATA), airlines, aircraft manufacturers, suppliers, and FAA representatives.

2.3.4 MSG Versus RCM

MSG/RCM is a decision logic process used to determine what actions need to be accomplished to ensure the availability of physical assets, in their specific operating context, when needed by the operator or user. MSG is commercial aviation's version of RCM. Pre-MSG aircraft were delivered with conservative maintenance programs designed exclusively by the original equipment manufacturer (OEM). These programs were resource intensive and expensive, and lacked the end-user input necessary to realize an efficient maintenance program. The airlines wanted to be involved in building scheduled maintenance programs for the aircraft they operated to improve safety, reliability, availability, maintainability, and reduce rising maintenance costs.

There are several reasons why MSG analysis is superior to standard RCM programs on commercial and military aircraft. First, MSG has evolved over 35 years and was designed specifically for aircraft. Second, MSG concepts incorporate a simple and concise inspection convention with standard and enhanced zonal inspections. Third, MSG-based maintenance programs are compatible with hierarchical maintenance concepts, facilitating a shift of structural inspections to later intervals to capitalize on aircraft downtime. In addition, MSG moves systems inspections to lower level inspection intervals, significantly improving aircraft reliability and availability.

2.3.5 MSG Process Evolutions

MSG has experienced several process evolutions throughout the years:

1. MSG-1, 1968

MSG-1, the "Maintenance Evaluation, and Program Development Document," was specifically designed for the Boeing 747-100. After implementing MSG-1, the airlines who operated the 747 realized an immediate reduction in total maintenance costs by an astounding 25 to 35 percent. This caused the airlines to lobby for removal of 747-100 terminology from the document so all new commercial aircraft maintenance programs could be designed using the MSG-1 process, fig (10).

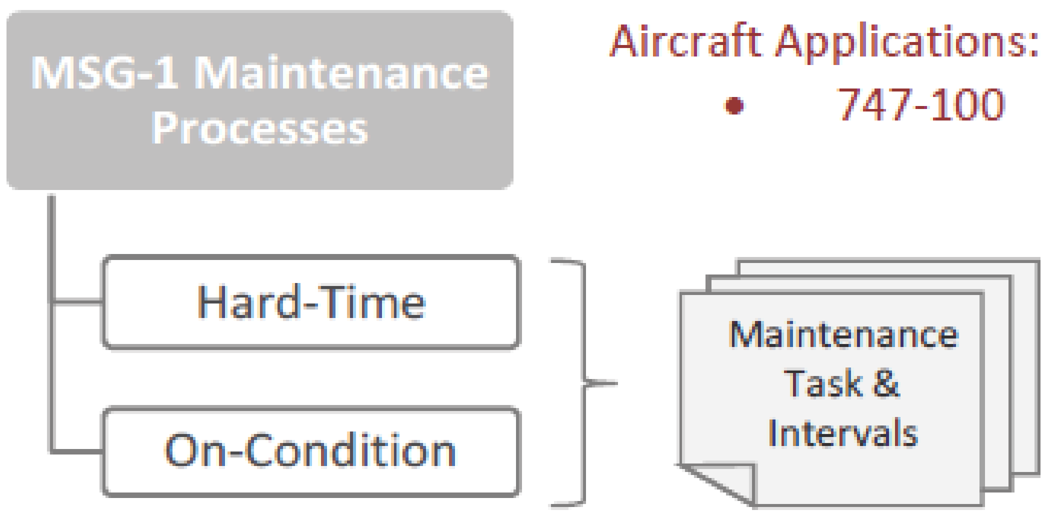


Figure (10) MSG-1 Processes **(Ackert, 2010)**

2. MSG-2, 1970

The airline industry developed and implemented MSG-2, the "Airline/Manufacturer Maintenance Program Planning Document," as a follow-up to MSG-1. They removed Boeing 747 terminology to allow use on other aircraft. The MSG-2 philosophy was parts-driven, bottom-up, and process-oriented. The first MSG-2 aircraft were the Lockheed L-1011 and the DC-10, fig (11).

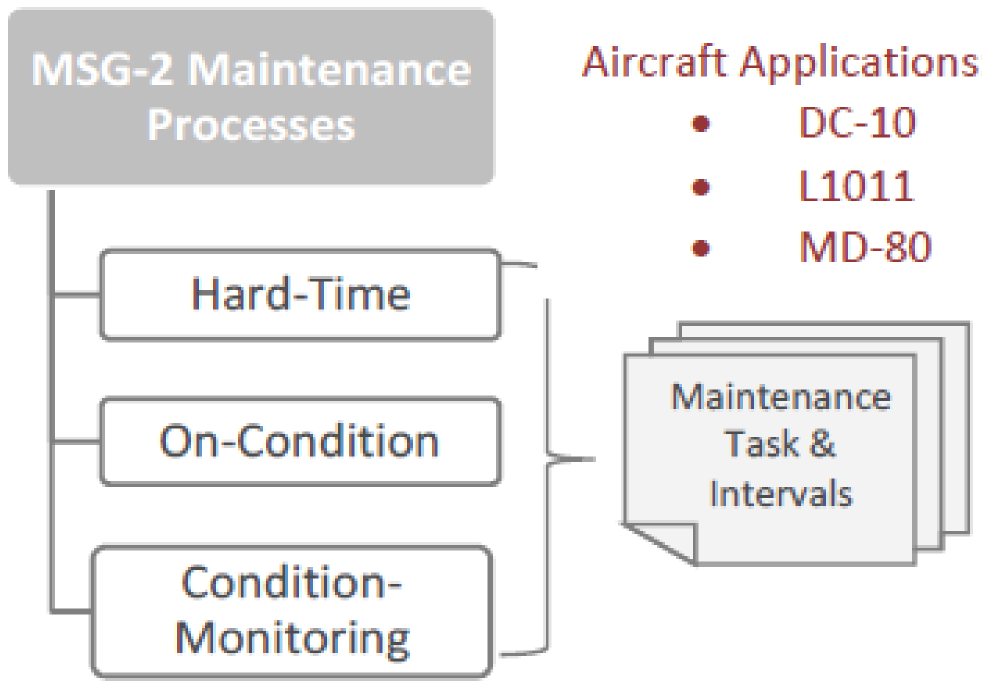


Figure (11) MSG-2 Processes **(Ackert, 2010)**

3. MSG-3, 1979

Nine years after the airline industry developed MSG-2, experience and events indicated an update was necessary. The result was MSG-3, the "Operator/Manufacturer Scheduled Maintenance Development Document." The airlines restructured MSG-3 to be a system-driven, top-down, and task-oriented process. Process-oriented means that on-condition, hard-time, and condition monitoring processes, all RCM terms, were used in MSG-2 to describe inspection tasks. MSG-3 inspection tasks are now written in a specific descriptive format (task-oriented) that is easier to understand, instead of just citing the task process. The Boeing 757 and 767 were the first MSG-3 decision logic designed aircraft, fig (12).

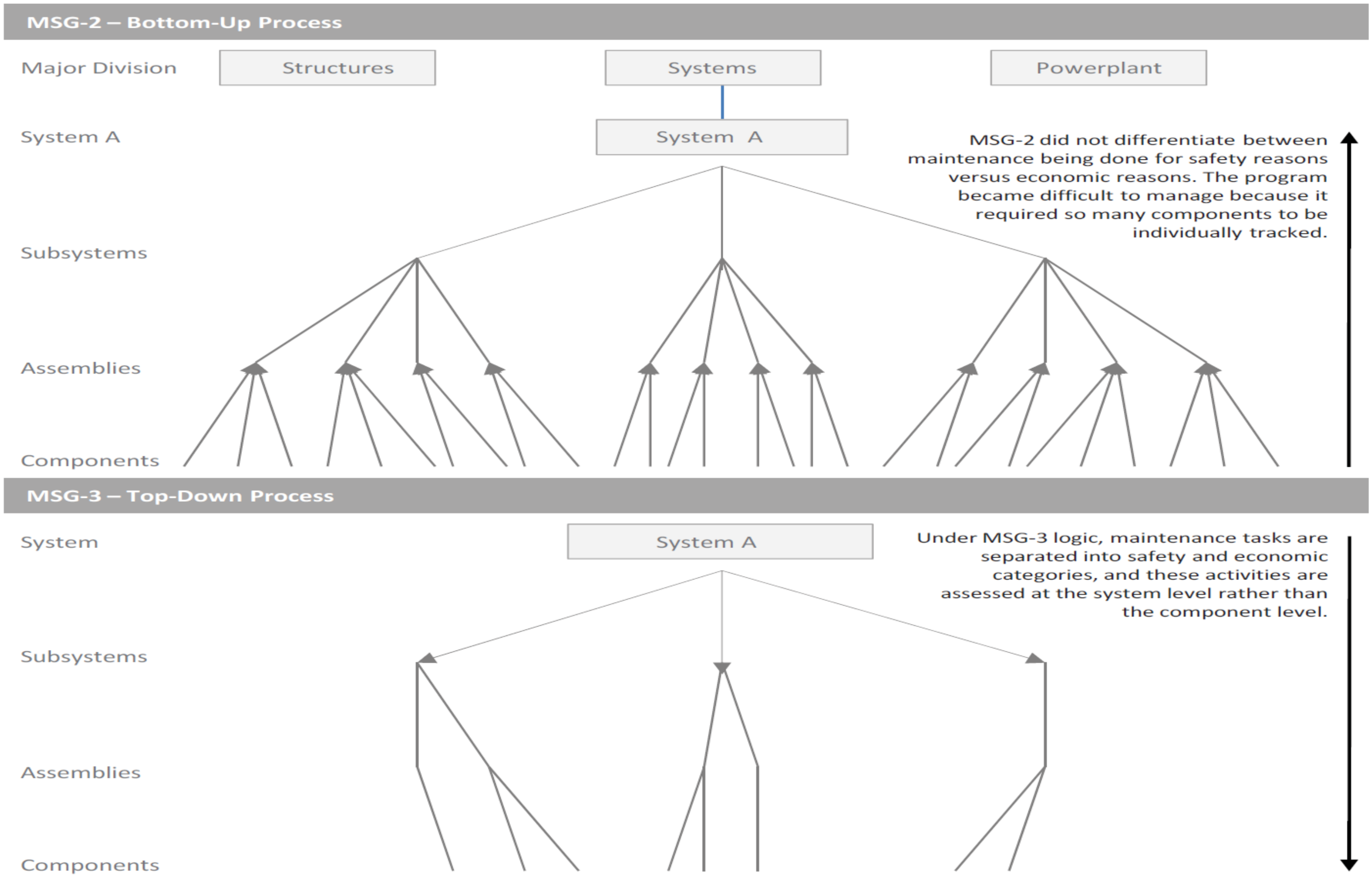


Figure (12) MSG-3 Process (Ackert, 2010)

2.4 A/C Maintenance Program (AMP)

2.4.1 AMP History

Maintenance Program History In the early days of aviation maintenance programs were developed primarily by pilots and mechanics. They assessed an aircraft's needs for maintenance based on their individual experiences and created programs that were simple and devoid of analysis.

The introduction of the airlines as a new method of transport demanded new regulations and broader involvement of the Regulatory Authorities in maintenance requirements. During this era not only were regulations put in place but programs were started to monitor reliability and safety.

Historically, the initial scheduled maintenance programme has been specified in Maintenance Review Board (MRB) Reports. MSG-3 is intended to facilitate the development of initial scheduled maintenance programs. The remaining maintenance, that is, non-scheduled or non-routine maintenance, consists of maintenance actions to correct discrepancies noted during scheduled maintenance tasks, other non-scheduled maintenance, normal operation, or data analysis (ATA, 2003).

2.4.2 AMP Objectives

As part of maintenance philosophy, the objectives of an effective maintenance programme are:

1. To maintain the function in terms of the required safety,
2. To maintain the inherent safety and reliability levels,
3. To optimise the availability,

4. To obtain the information necessary for design improvement of those items, To accomplish these goals at a minimum total life cycle cost (LCC), including maintenance costs and costs of residual failures.
5. Monitoring the condition of specific safety, critical or costly components is very an important action in a dynamic programme.

It is desirable, therefore, to define in some details:

1. The objectives of an efficient maintenance programme,
2. The content of an efficient maintenance programme,
3. The method by which an efficient maintenance programme can be developed.

2.4.3 AMP Content

The Maintenance Program Contents are:

1. Aircraft inspections
2. Scheduled maintenance
3. Unscheduled maintenance
4. Engine, propeller, and appliance repair and overhaul
5. Structural inspection programme
6. Specified inspection items
7. Support, role, and other equipment maintenance

2.4.4 AMP Requirements

The Maintenance Program details should be reviewed at least annually. As a minimum revisions of documents affecting the program basis need to be considered by the owner or operator for inclusion in the Maintenance Program during the annual review. Applicable mandatory requirements for compliance with the requirements of the Authority shall be incorporated into the owner or operator’s Maintenance Program as soon as possible.

The aircraft Maintenance Program should contain a preface which will define its contents, the inspection standards to be applied, permitted variations to task frequencies and where applicable, any procedure to manage the evolution of established check or inspection intervals. The approved aircraft Maintenance Program should reflect applicable mandatory regulatory requirements addressed in documents issued by the TC holder. Repetitive maintenance tasks derived from modifications and repairs should be incorporated into the approved Maintenance Program, civil aviation authority (CAA) has a checklist of for compline AMP requirement (Organization, 1988).

Maintenance programmes are integrated carefully and aspects of programmes can not normally be mixed-and-matched. When utilising a maintenance programme, and particularly a manufacturer's programme, all aspects of the programme must be applied, fig (13).

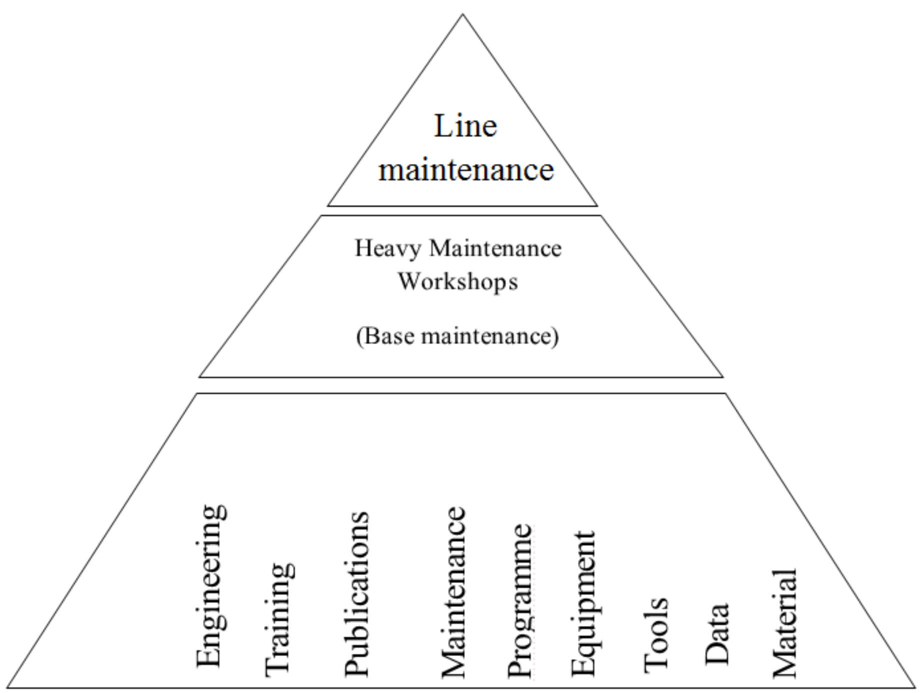


Figure (13) Aspects of AMP *(CASA)*

2.4.5 AMP Customization

1. Maintenance Programme Development

MSG-3 standard It is the objective to present a means for developing a maintenance programme which will be acceptable to the regulatory authorities, the operators, and the manufacturers. The maintenance programme details will be developed by co-ordination with specialists from the operators, manufacturers, and the Regulatory Authority of the country of manufacture. Specifically, this document outlines the general organisation and decision processes for determining scheduled maintenance requirements initially projected for the life of the aircraft and/or powerplant. Development of a maintenance program using the MSG-3 analysis procedure. Any additional requirements developed, using different ground rules and procedures from MSG-3, must be submitted with selection criteria to the Industry Steering Committee (ISC) for consideration and inclusion in the MRB Report recommendation. For the purpose of developing an MRB report, MSG-3 is to be used to determine initial scheduled maintenance requirements. The analysis process identifies all scheduled tasks and intervals based on the aircraft's certificates of operating capabilities fig (14). The organisation to carry out the maintenance programme development for a specific type aircraft shall be staffed by representatives of the airline operators purchasing the equipment, the prime manufacturers of the airframe and power plant, and the Regulatory Authority :

1. Industry Steering Committee
2. Working Groups

It is necessary to develop a maintenance program for each new type of aircraft prior to its introduction into airline service.

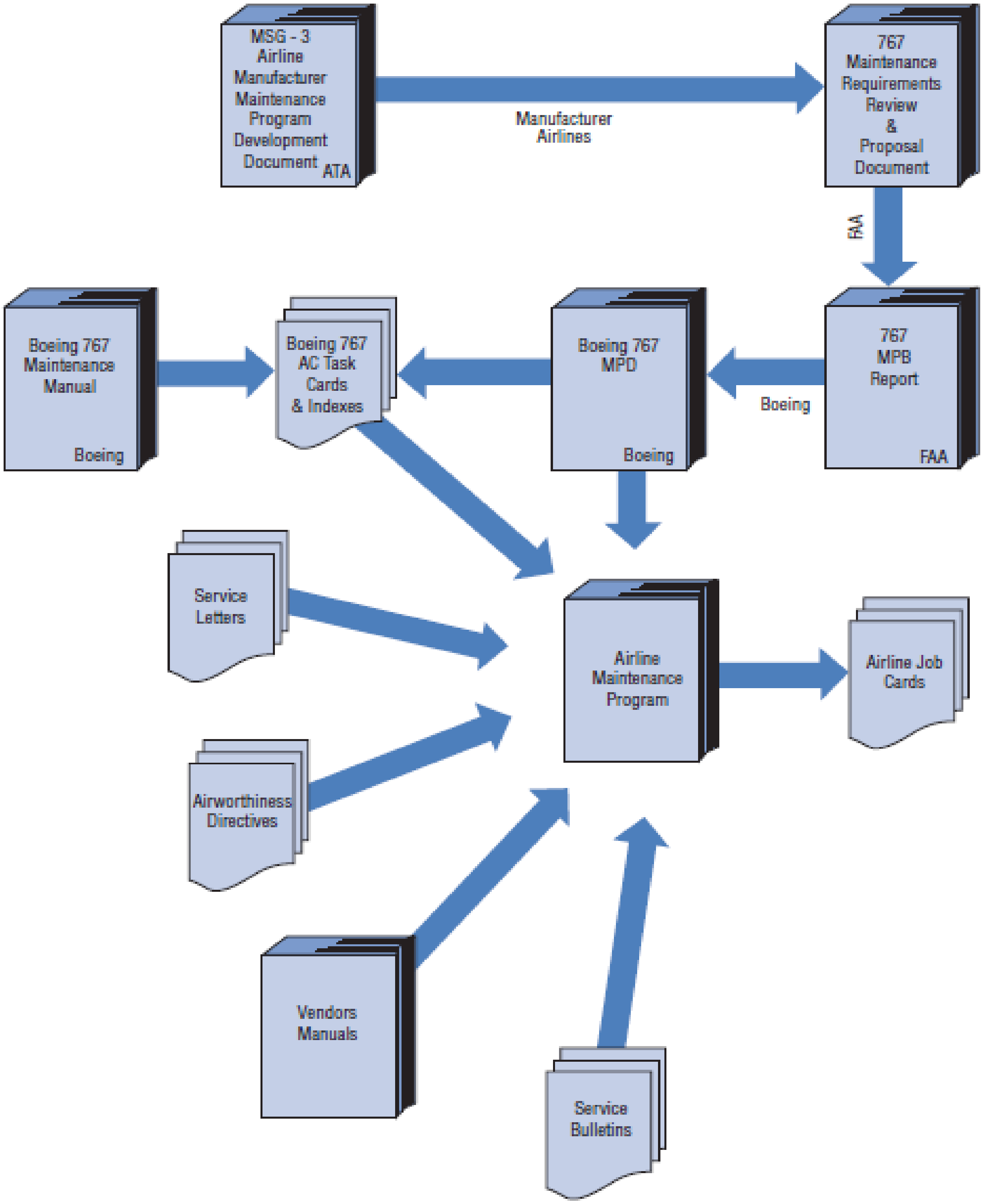


Figure (14) Maintenance Programme Development *(Internet)*

2. Maintenance Planning Document (MPD)

The MRB Report outlines the initial minimum scheduled maintenance and inspection requirements to be used in the development of an approved continuous airworthiness maintenance program. The Maintenance Planning Document (MPD) document contains all the MRB requirements plus mandatory scheduled maintenance requirements that may only be changed with the permission of the applicable airworthiness authority. These supplemental inspection tasks are detailed in the aircraft's Certification Maintenance Requirement (CMR) and Airworthiness Limitation (AWL) documents.

Figure (15) Maintenance Planning Document (MPD) **(Ackert, 2010)**

3. Certification Maintenance Requirements (CMR)

A CMR is a required periodic task established during the design certification of the airplane as an operating limitation of the Type Certificate (TC). CMRs usually result from a formal, numerical analysis conducted to show compliance with catastrophic and hazardous failure conditions. A CMR is intended to detect safety significant latent failures that would, in combination with one or more other specific failures or events, result in a hazardous or catastrophic failure condition. Example of a CMR task is performing a visual inspection of the elevator tab rods and mechanism every 2,000 flight cycles.

4. Airworthiness Limitations (AL)

Airworthiness Limitations (AL) are a regulatory approved means of introducing inspections or maintenance practices to prevent problems with certain systems. Mandatory replacement times, inspection intervals, and related inspection procedures for structural safe-life parts are included in the AL document, and are required by the regulatory authorities as part of the Instructions for Continued Airworthiness. Example of an AL task is performing a detailed inspection of the fuel tank wire bundles to prevent potential wire chafing and arcing to the fuel tank.

5. Operators Approved AMP

The MPD scheduled maintenance tasks should not be considered as all-inclusive. Each individual airline has final responsibility to decide what to do and when to do it, except for those maintenance requirements identified as Airworthiness Limitations (AL) or "Certification Maintenance Requirements (CMR). Additional requirements in the form of Service Letters, Service Bulletins (SB) and Airworthiness Directives are the responsibility of the individual airline to incorporate. Maintenance tasks recommended in engine, APU, and vendor manuals should be considered. Figure (16) illustrates the most common requirements that make up an Operator's Approved AMP.

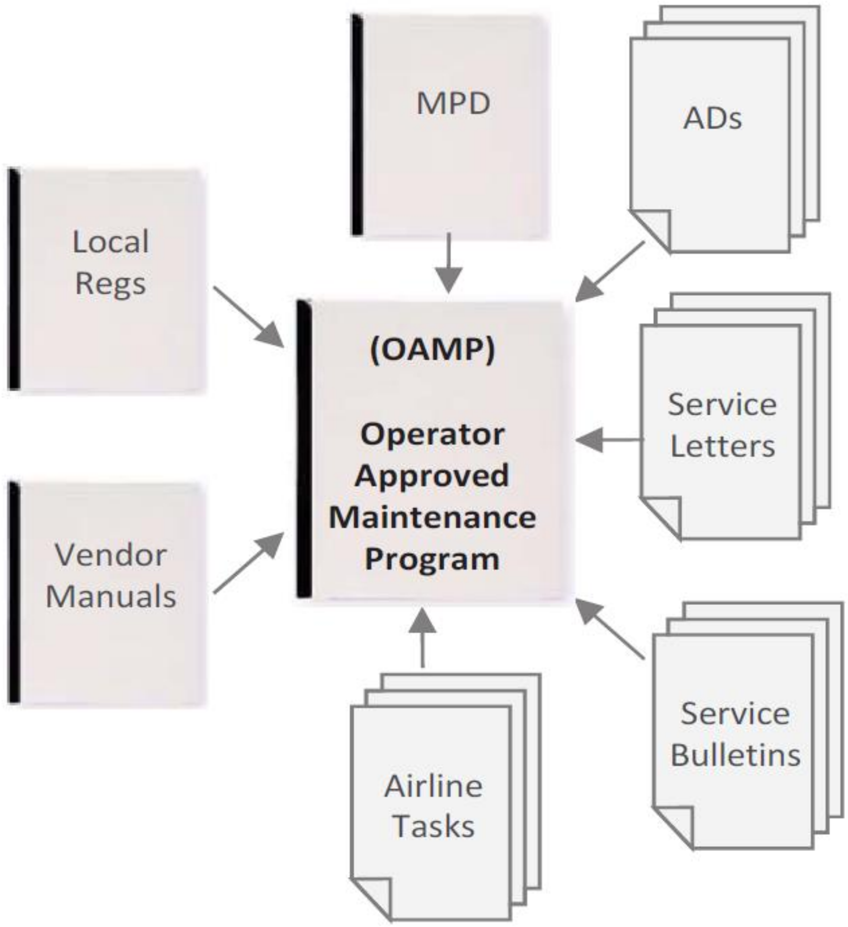


Figure (16) AMP customization (Ackert, 2010)

MPD customization is needed MPD is an envelope document and therefore contains scheduled maintenance tasks for the overall aircraft type. Design standards generally differs from one aircraft to the other, thus, an operator fleet is not concerned by all tasks.

2.5 AMP Improvement

2.5.1 Reliability Program

All operators of large aircraft (a multiengine helicopter or an airplane with Maximum Take Off Mass of more than 5,700 kg), engaged in the commercial operations and commercial air transport, are required to have in place a reliability control program (RCP) or reliability monitoring program (RMP), these programs are built on reliability engineering concept as part of the maintenance program for those aircraft , if any one of the following conditions is met:

1. The aircraft's maintenance program is based on MSG-3 logic process.
2. The aircraft's maintenance program includes condition monitored components.
3. The aircraft's maintenance program does not contain overhaul times for all significant system components.
4. It is required by the Maintenance Review Board (MRB) report.
5. It is required by the manufacturer's Maintenance Planning Document.

For other operators of large aircraft, maintenance reliability programs (or equivalent programs which meet the intent), should depend on the size of the operator, type of operations and other factors.

The Reliability Control Program focuses on maintaining failure rates below a predetermined value; i.e. an acceptable level of reliability.

The term "reliable", as used by the aviation industry, applies to the dependability or stability of an aircraft system or a part thereof under evaluation. A system or component is considered (reliable) if it follows an expected law of behaviour and is regarded "unreliable" if it departs from this expectation. These expectations differ greatly, depending upon how the equipment is designed and operated. A reliability program is a set of procedures aimed at collecting data related to the failure (i.e. not able to perform the function they are designed for, when it is required) of the aircraft, its systems, sub-systems, components and parts. Further analysis of the data thus collected and making meaningful inferences using engineering judgement also forms part of the program. The actions based on those inferences, to improve the maintenance program, is what makes a reliability program beneficial. The intent of the reliability analysis should be to measure the effectiveness of the tasks within the maintenance program by alerting to the systems, components and structures whose performance digresses from their expected levels. Reliability programs form an integral part of an operator's maintenance program, and are state of airworthiness. Accordingly, any operator submitting maintenance program for the CAA approval must also provide relevant reliability program for assessment and approval Maintenance Management Exposition (MME) of an operator should provide an overview of the management of maintenance reliability program.

2.5.2 The Benefits Reliability Program

Properly designed and implemented maintenance reliability programs bring many benefits to the operator, for example:

1. Compliance with the regulatory requirements
2. An increase in the aircraft availability
3. Elimination of redundant and ineffective maintenance practices
4. Reduction in the number of no-fault-found occurrences
5. Reduction in fleet maintenance costs
6. Reduction in maintenance and down time

A reliability program may become an essential decision-making tool for the maintenance management team, because it will provide a summary of aircraft fleet reliability, reflecting on the effectiveness of the maintenance program and the way it is done. It will also help the operator discover real causes of recurrent equipment problems, planning issues, scheduling conflicts, and procedural difficulties. Once the shortcomings are known then an improvement in the reliability may be achieved through changes to the maintenance program or to the practices for implementing it. The overall result of an effective reliability program is the better utilization of the available resources.

2.5.3 AMP Development Through RCM

1. Manufacture Phase Development

A type certificate is issued to signify the airworthiness of an aircraft manufacturing design. The certificate is issued by a regulating body, and once issued, the design cannot be changed. The certificate reflects a determination made by the regulating body that the aircraft is manufactured according to an approved design who have type certified aircraft in have traditionally developed their scheduled maintenance instructions in accordance with either a Maintenance Review Board process (MRB), a Maintenance Type Board process (MTB) or their own internal analytical processes.

Both the MRB and the MTB analytical processes utilize the ATA MSG-3 logic as the basis for their development of initial scheduled maintenance instructions. This analytical logic is developed from the Reliability-Centred Maintenance (RCM) analytical process published by F.Stanley Nowlan and HowardF. Heap of United Airlines in 1978. Type certificate applicants for aircraft other than the transport category have traditionally utilised internally developed processes that are quite varied in approach and which may or may not have followed reliability centred maintenance principles.

2. Operation Phase Development

As a result, the Society of Automotive Engineers, published in August of 1999 the SAE Standard JA1011. It allows organizations developing maintenance instructions to assess their analytical processes and to determine if they meet the criteria to be labelled as reliability centred maintenance.

Transport Canada has assessed MSG-3 using the SAE Standard and considers that maintenance programs derived from MSG-3 conform to reliability-centred maintenance. With certain exceptions, MSG-3 has maintained the criteria necessary to be considered an analytical methodology centred on realizing the inherent safety and reliability levels of aircraft. Where MSG-3 was not shown as fully compliant with the JA1011 standard, the International Maintenance Review Board Policy Board will be used as the medium to ensure that future amendments to the analytical logic will mitigate those issues.

The RCM analyzing processes output represent as actions resulting from a reliability program as necessary may be to:

1. Alter maintenance tasks,
2. Delete maintenance tasks
3. Add maintenance tasks

Any change in a maintenance program of a reliability program will also require the regulatory (CAA) approval.

2.5.4 Reliability Control Program (RCP)

The Reliability Control Program (RCP) can be managed in an airline the existence of a Reliability Control Program is mandated by the Airworthiness Authorities. A well-managed Reliability Control Program has a direct positive impact on the airline operating costs.It has been prepared for Airbus Customer airlines as part of Airbus Customer Services. Reliability Control or for airlines who want to optimize their existing RCP. Implement a streamlined RCP within a Maintenance & Engineering Organization steps (Airbus, 2014):

1. Data Collection
2. Performance Measurement & Display
3. Data Analysis & Corrective actions

Optimizing the organizational structure, to run smoothly the Program and to increase productivity. Understanding the Role of the Reliability Control Program in the context of overall Airline Operations

1. Increase aircraft availability, Improve Dispatch Reliability
2. Minimize costs (Schedule disruptions Check, interval escalation and Sound evaluations for implementation of modifications)
3. Being familiar with the Authorities Requirements.

Reliability Control impacts all Maintenance & Engineering processes, including safety and economics It requires a proper understanding of the overall process which runs across the entire Maintenance & Engineering organization. Mandated by the Regulatory Authorities, which require an Operator to establish a program for continuing analysis & surveillance of its operations. But not yet well accepted in some airline Maintenance &

Engineering organization, that, in addition to above requirements, the Reliability Control Program:

1. Is used to monitor the effectiveness of the Maintenance Program
2. Is an essential Quality System process

Lack of Reliability Control may be more expensive and impact heavily economics, RCP to be viewed in the context of overall airline operations.

Typical systems used in reliability control are fig (17):

1. Data collection
2. Data analysis
3. Corrective action
4. Data display and report
5. Maintenance interval adjustment and process change
6. Program revision.

Figure (17) RCP Steps (Airbus, 2014)

1. Data Collection

The data collection system should provide a specific flow of information from identified sources, and procedures for transmission of data, including the use of forms, computer printouts,. Responsibilities within the operator's organization must be established for each source of data collection. Typical sources of performance information are described below:

1. Pilot reports
2. Mechanical interruptions/delays
3. Engine in flight shutdowns
4. Confirmed failures
5. Miscellaneous reports
6. Aircraft log book & On-Board Maintenance System
    a. Flight information (times, dates, stations)
    b. Complaints
    c. Post Flight Reports
7. Operational interruptions form
8. Technical incidents form
9. Maintenance:
    a. Maintenance complaints
    b. Removal data
    c. Deferred defects
    d. Check findings
10. Workshops Shop findings

2. Data analysis

Data analysis is the process of evaluating mechanical performance data to identify characteristics which indicate a need for program adjustment, revision of maintenance practices or hardware improvement (modification). The initial step in analysis is the comparison of the data to a predetermined standard of performance. This comparison may involve statistical calculations (alert type pro-grams) or other methods (non-alert type programs). With both alert and non-alert type programs, the objectives of data analysis are to verify acceptable levels of performance, to identify trends which may need corrective action, and to indicate those tasks and intervals which may be safely eliminated, modified or extended and Changes in inspection program basis in this stage we use RCM analysis.

RCM Process

The RCM process begins with failure mode, effect and analysis, (FMEA), which identifies the systems failure modes in a systematic and structured manner. Every one of these failure modes is then examined to determine the optimal maintenance task to reduce or avoid the severity of each failure. In this process, most of the following issues have been taken into account, namely cost, safety, and environmental and operational consequences.

The RCM methodology varies within different industrial areas, but the basic steps are however quite common to all applications, including MSG-3. The RCM compromises the following steps:

1. System selection.
2. Perform Failure Modes and Effect Analysis.
3. RCM decision logic process. Identification of failure consequences.
4. Selection of maintenance tasks.

System selection are the first step where the areas which is assumed to benefit most from the analysis are specified, even though all areas would probably draw some benefit from RCM analysis. It is also necessary to identify the level of assembly at which the analysis should be conducted. Questions like:

Will an improvement in preventive maintenance reduce cost and improve reliability and safety?

Does the current maintenance strategy include a large portion of time based maintenance that could be replaced with condition based? Is there a known design problem that is causing failures and results in high maintenance costs?

These are common questions which occur during this phase of the process.

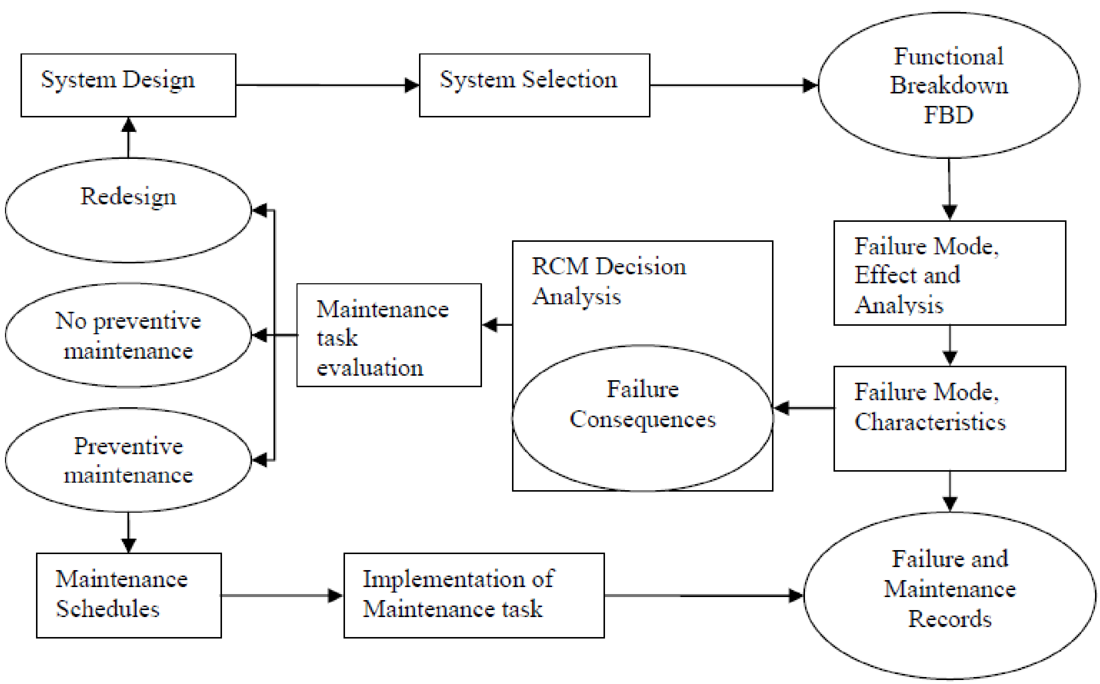


Figure (18) The RCM closed process *(adapted from Kumar et al., 2000)*

Failure Mode and Effects Analysis: is a systematic approach to identify all possible ways in which failure of a system can occur together with its causes and thus the failures potential effect on the system. It is performed to find out how each item in a system is likely to fail and what happens if it does. The FMEA does additionally often include an evaluation of the failure criticality- and assessment of the severity of the failure effect and its probability of occurrence. This is in fact two steps which is called failure mode effect critically analysis (FMECA) when combined.

RCM Decision Logic Process: analyses the consequences of each failure mode and identifies an applicable and maintenance task by using the principle that a maintenance task is worth doing if its deals successfully with the consequences of the failure mode which it is meant to prevent. For each failure mode, there are some questions to be asked:

1. Can the user detect the failure?
2. Does the failure mode have an effect on health of the user?
3. Does the failure mode have an effect on safety and the environment?
4. Is the cost of failure and its consequential damage greater than the cost of preventing the failure?
5. Does the failure mode have an effect on the operational performance?
6. Does the failure mode have an effect on the appearance?

The answers are in the simple “yes” and “no” format which make them easy to record on a RCM decision worksheet. The consequences of each failure are identified based on decision logic.

3. Data display and reporting

All programs will require some means of displaying and reporting the collected data, and should include a periodic reporting system with appropriate data displays, summarizing the activity of the previous period. The reports should cover all aircraft systems controlled by the program, The reports should highlight systems which have fallen short of the established performance standards and discuss any action which has been taken, or is planned, including changes in maintenance and inspection intervals and changes from one process category and/or task to another. Continuing over-alert conditions carried forward from previous reports should be listed, together with details of the progress of any corrective action taken. Some examples of the types of data display used in reliability programs.

4. Responsive action

The actions to be taken in response to the data analysis should be positive enough to achieve the desired level of performance within a reasonable time. The system must include procedures to ensure CAA approval for any proposed changes in the inspection program, and for notification of the organizational element(s) responsible for taking the action. The system should also provide periodic feedback until such time as performance has reached an acceptable level. The procedures of the responsive action system may include work forms, special inspection procedures, engineering orders, etc. Special provision should be made for the control of critical items, the failure of which could impair the airworthiness of the aircraft.

2.5.5 Reliability program amendment

The program should include a description of the procedures for its own revision. fig.(19) show A chart depicting a typical maintenance development organization and data flow sequence is illustrated, adjacent to that for a typical reliability program, to facilitate comparison.

The description should identify the organizational elements involved in the revision process and their authority. approval will be required for any revision affecting

1. Data collection systems
2. Data analysis methods
3. Performance standards
4. Addition or deletion of aircraft types.
5. Procedural and organizational changes concerning the administration of the program.

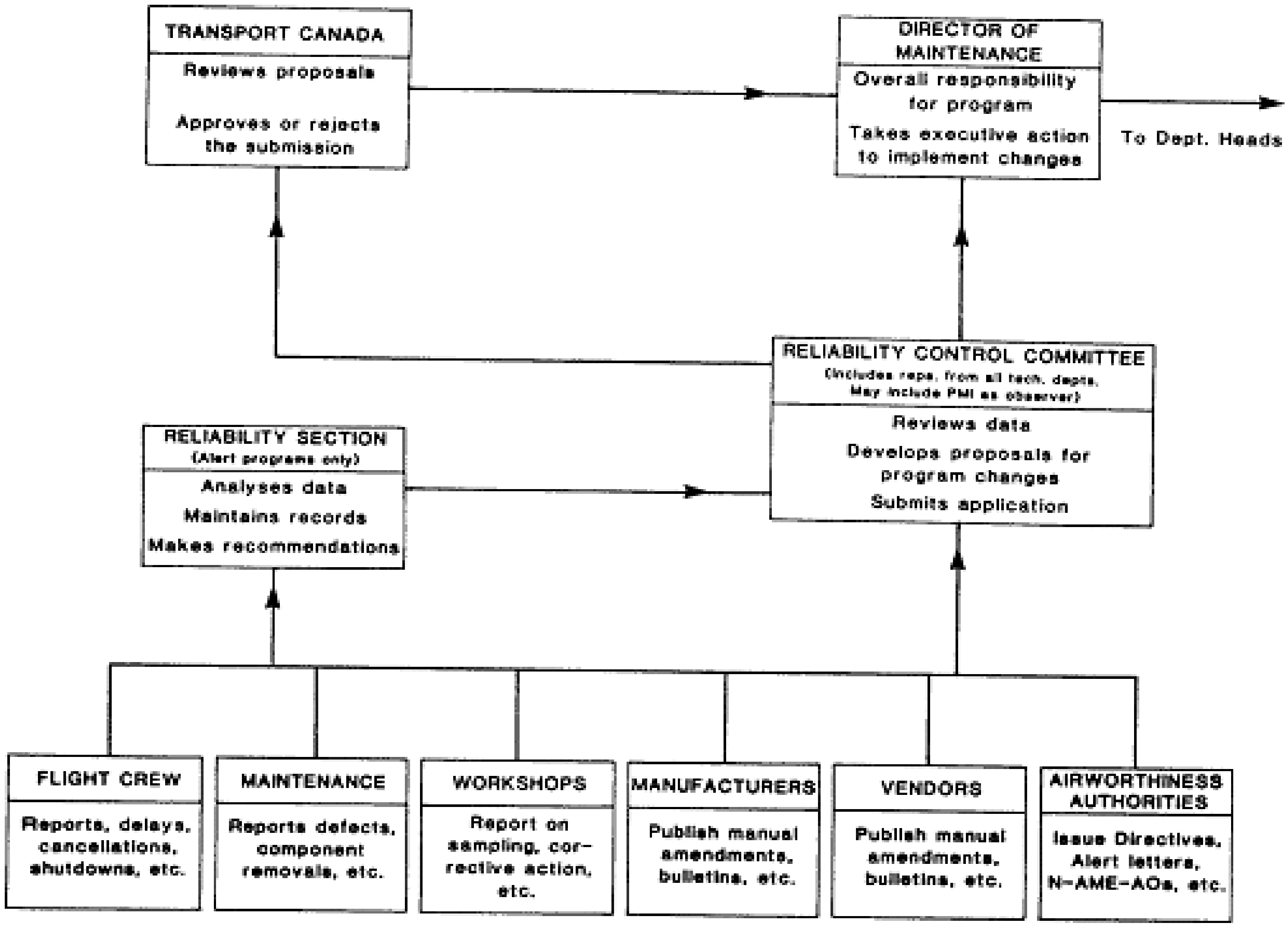


Figure (19) Reliability program flow chart (Canada, 1986)

2.5.6 Reliability Program Document

The operator should develop a document describing the application of reliability control methods this document should include at least the following (Zealand, 2007) :

1. General description of the programme
2. Organizational structure, duties and responsibilities
3. Description of the individual systems
4. Derivation of performance standards
5. Changes to the programme including designation of changes requiring Authority approval.
6. Copy and explanation of all forms peculiar to the system; and
7. Revision control and certification of revisions to the document.

The document should describe the workings of all systems in sufficient detail to provide for proper operation of the programme. It should include in detail how the three maintenance processes are applied. The document should describe the monthly report and any other reports relative to the programme, and include samples of these reports with instructions for their use. The organisational element(s) responsible for publishing reports should be identified and the distribution should be stated. Copies of pertinent reports should be provided to the Authority.

2.5.7 Effectiveness of Reliability Program

In this section we discus step-by-step procedure for identifying problem components and determining the appropriate maintenance process for these components. The first step is to collect data on the component such as Time since Overhaul (TSO) and Time since Inspection (TSI). This can come from practically any source at an aircraft operator’s disposal, from pilot reports to material defect reports. A reliability-based maintenance program should include a specific flow of information, identity of data sources, and procedures for transmission of data, including use of forms, computer runs, etc. Responsibilities within the operator's organization must be established for each step of data development and processing. Typical sources of performance information are pilot reports, in-flight engine performance data, mechanical interruptions/delays, engine shutdowns, and unscheduled removals (Suwondo, 2007).

The first step in collecting data is to identify the number and frequency of failures. For each problem occurrence, as a minimum, the following data should be collected Part number, Serial number, Time since new (TSN), Time since overhaul (TSO), Time since inspection (TSI), Cycles since new (CSN), Cycles since overhaul (CSO), Cycles since inspection (CSI), manufacturer and date of occurrence.

The next step in data collection is to specifically define the problem. This information will generally come from shop findings, tear down reports, and inspection write-ups. This information must be added to the above-mentioned data that was recorded at the initial problem occurrence. Although the previously mentioned failure data can be used alone, it may also be useful to combine this data with regularly scheduled removals in order to calculate the percentage of components that are failing. In addition, the tear down data from these components may be used to justify inspection and overhaul life extensions. These scheduled removals should be distinguished from the non-scheduled removals/repairs. A sample data collection form is shown in Table (2).

Reliability Data Collection Form			
Part Number	206-031-100-102	Date	8/8/07
Serial Number	3245	a/c S/N	45153
Description		a/c Type	206L1
TSN	1420	a/c TT	15786
TSO	125	Dispatch?	YES
TSI	125	Action	Replaced
CSN	1845		
CSO	86		
CSI	86		
Manufacturer	Bell		
Reason			

Table (2) Data Collection Form

Once this data has been collected, a preliminary analysis of the data is performed to determine if the problem appears to be one of component reliability, premature failure, installation or maintenance problem, or material defect. A failure modes and effects analysis is then done in order to evaluate the component’s effect on the safety of the aircraft. With this data, the determination of whether or not to add a component to the maintenance program can be made and a primary maintenance process (HT, OC, CM) can be chosen. These steps are discussed below:

1. **Step 1:** Data pertinent to the reliability of the components are collected.
2. **Step 2:** Data are analyzed in order to determine the cause of the problem. If the problem is due to improper maintenance, installation, usage, or design flaw, the problem is forwarded to engineering for further review and correction. If the problem appears to be caused by normal usage, the process continues on to the next step.
3. **Step 3:** A failure modes and effects analysis is performed in order to determine the component's effect on the overall safety of the aircraft.
4. **Step 4:** A determination is made as to whether or not a component will be included in the maintenance program.
5. **Step 5.** Once it has been determined that a component will be included, a primary maintenance process must be determined. This process will be one of the following. “hard time”, “on condition”, or “condition monitoring”.

   A decision flowchart to summarize the various decision problems is shown in Figure (20).

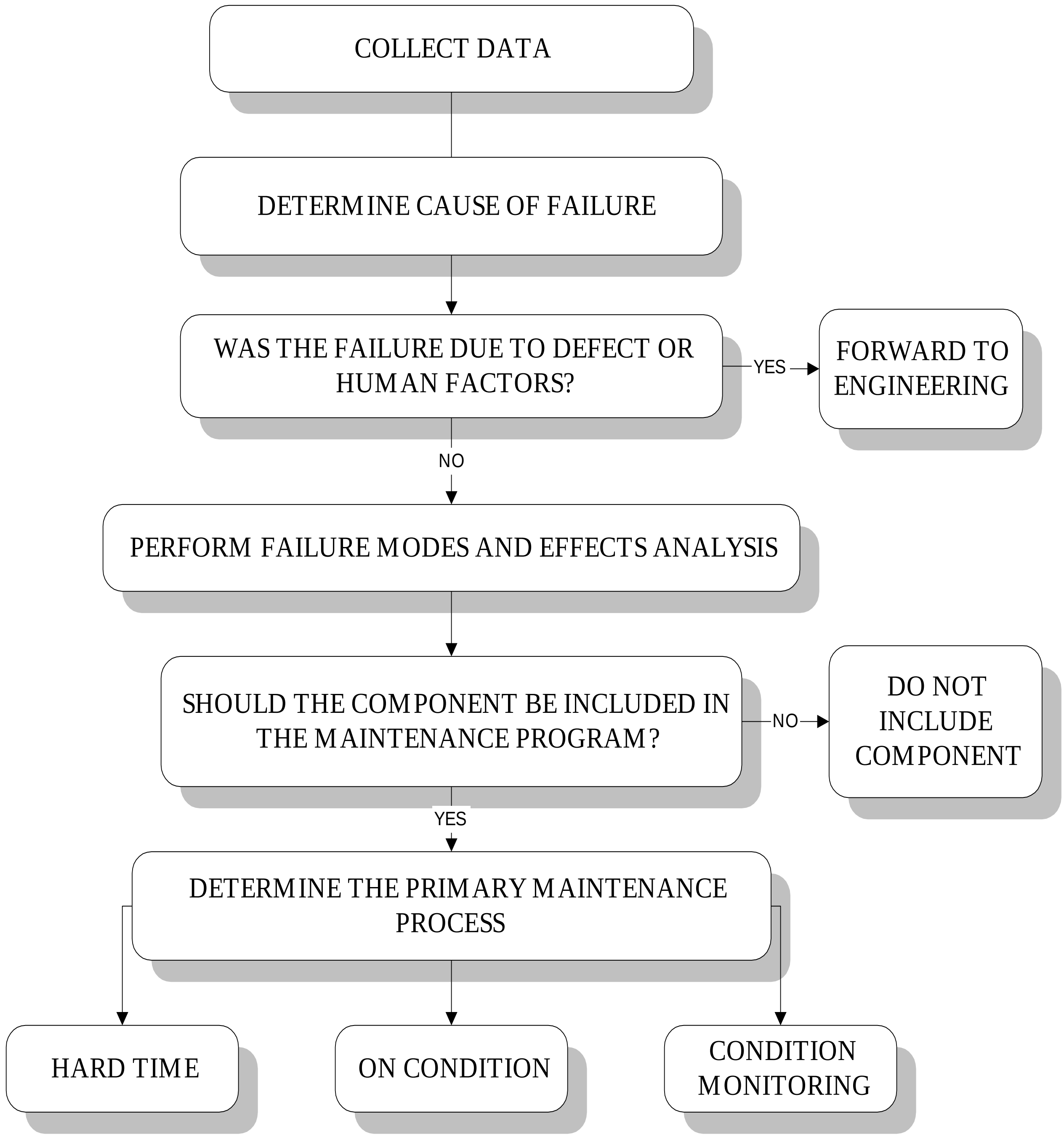


Figure (20) A decision flowchart (Cotaina, 2000)

2.5.8 Air Canada

High repair and maintenance costs presented a challenge to determine the potential benefits of better use of data and information. Studies of the problems encountered by a selected number of fleet operators in the mining, aviation and road transportation industries revealed many similarities. Considering just 10 Canadian industrial sectors, one finds that for every dollar spent on new machinery, an additional 51 cents is spent on maintaining existing equipment. This amount to repair costs of approximately CAN $15.3 billion per year. A strategic decision was made to start with the commercial aviation industry. The Integrated Diagnostic System (IDS) is an applied Artificial Intelligence (AI) project concerned with the development of hybrid information systems to diagnose problems and help manage repair processes of commercial aircraft fleets. The project was initiated in 1992 by the National Research Council (NRC) of Canada after examining the economic importance of diagnosing complex equipment problems correctly. Air Canada's maintenance operations are carried out with the following characteristics: diagnosis is seen as only part of the solution, the scope of a maintenance project should extend to all aircraft systems on all fleet (Air Canada's current fleet size is 134 aircraft and growing), the benefits were conservatively estimated to be in the vicinity of 2% of the entire maintenance budget, decision making is highly distributed, and newer generation equipment produces increasing amounts of potentially useful data. Innovative information technology was required to aid in the integration and interpretation of data (Cotaina, 2000).

A parallel airline market assessment was also carried out. It revealed a potential world market exceeding CAN$1B/year if similar benefits are obtained by other airlines (only fleet size >30 aircraft considered).

Decision making environment at Air Canada shows the following procedures:

1. Line technicians repair aircraft at the gate or on overnight layover, their prime objective is to safety turn aircraft around with minimum disruption.
2. Maintenance Operation Control staff view the entire fleet from a maintenance perspective. They act on any problems reported by the pilot or on-board systems to minimise disruption. They also monitor fleet status, identified trends, deal with persistent and foreseeable problems, and determine maintenance policy.
3. Engineering looks at specific performance indicators of the equipment and will only become involved with difficult immediate concerns, on an as-required basis. They typically have the longest decision horizon.
4. Manufacturers representatives are involved in certain difficult problems.
5. Parts stores personnel must ensure that an adequate supply of spare parts is available from the various production stores both within and external to the airline.
6. System Operations Control personnel keep the entire fleet flying on schedule. They make system-wide decisions on such a factors as disruption due weather or equipment failure and flight crew readiness.

Modern aircraft, such as the Airbus A320 or Boeing B767, have systems on board which can transmit data to ground stations. These data consist of routine performance snapshots (e.g. altitude, temperature, pressures, engine temperatures, valve positions, etc.), pilot messages, aircraft-generated fault messages, and special purpose reports generated when prescribed limits are exceeded. There are many additional databases that support maintenance. They contain descriptions of symptoms and associated maintenance actions (free form text), deferred problems, flight schedules, weather, component reliability, and parts location. There is also a wealth of useful information held at the manufacturer and by people and information systems in the engineering and maintenance operation control departments. This is not widely distributed and thus not available to the line technical in a timely manner.

1. IDS System

The Integrated Diagnosis System (IDS) is a maintenance tool designed to support Air Canada's control operations. IDS was designed to provide information to both line technicians and Maintenance Operation Control staff. Allowing developing their activities across two different decision making time horizon, information needs, work environment, and required skills. However, communication between them is critical to effective fleet management. Line technicians contribute to Maintenance Operation Control's understanding of fleet status and maintenance practices. Additional IDS features are :

1. Complete aircraft maintenance supported (rather than particular subsystems).
2. Low level diagnostic is not the main focus of the system (the trend is towards embedded diagnostics, which are best left to the equipment manufacturer).
3. Existing practices and sources of knowledge are supported/exploited wherever is possible.

Operational Sche**ma**

In broad terms, IDS refines an asynchronous stream of messages of atomic symptom and repair action events into descriptions of complete fault-repair episodes. The process exploits many knowledge sources, some allowing messages to aggregate, others allowing messages (or clusters) to merge, be modified or discarded. The ideal result is clear, concise, complete descriptions of faults events, which unambiguously associate symptoms and correct repair actions.

The starting point of IDS are messages received on-line from different land stations. These stations gather the information from the aircraft when it is in range. These data is transmitted in real-time when the plane is in air, so many diagnostics may be processed before aircraft landing. The major processing blocks, information stores (object sets, databases, case-bases, rules sets), and information flows in IDS are shown in below. Reading down from the top, centre of the diagram you see the message stream (from aircraft embedded diagnostic computers and from the maintenance databases) entering IDS:

1. The first processing step classifies and cleans up these messages to produce IDS Message Objects (IMOs).Classification is performed using case-based reasoning.
2. The second processing step clusters these IMOs into Fault Event Objects (FEOs). This is implemented as a small set of complex rules, which were derived through conventional knowledge acquisition sessions with engineers and maintenance staff.
3. FEO management takes not only an IMO as input but also Troubleshooting Manual (TSM) objects and Minimum Equipment List (MEL) objects.
4. The TSM objects represent clusters of IMOs, which are identified in the MEL manual as indicating that the operation of the aircraft is restricted in

some way because of safety concerns. The MEL knowledge comprises a small set of rules and several large lookup tables.

5. The third stage of refinement associates the symptoms (i.e. messages clusters in the Fault Event Objects) with appropriate repair actions. The resulting Snag (aviation term for an equipment problem) Rectification Objects (SROs) are stored. This matching process exploits a combination of rule-based and case-based reasoning.
6. Finally, suggested repair actions are composed and presented to the user. These are derived from historical maintenance events similar to current FEO (using CBR) and from the Troubleshooting Manual) if the FEO contains a TSM object).

2. Automatic Fleet Monitoring

This process provides support for identifying abnormal situations in a fleet or user selected aircraft. The performance of the aircraft is monitored in real-time and the user is warned when there is evidence of abnormal behaviour. An abnormal behaviour is typically one that is associated with unusual trends in failures of components, subsystems, or performance degeneration.

3. Data Analysis Support

This feature provides support for advanced data analysis. It is particularly for cases when users, such an engineer, have received reports of some problems and are interested in investigating further. This form of data analysis can be used for both component failures and abnormal behavior. Some of the methods available when performing this action are :

a. High-level Problem Selection, that allows the users to define data analysis tasks gathering the data according to high-level conditions, such as engine high fuel consumption, engine #2 high vibration, or specific component failure.

b. Data Analysis Control, that allows the users to exclude certain situations from the analysis procedure, such as a specific aircraft, includes additional features or range a variable period of time.

4. Summery

Air Canada had been succeed in solve the challenge of high repair and maintenance costs by using the RCM strategy the output of this strategy are represented in the integrated diagnostic system (IDS) it is applied artificial intelligence (AI) project, IDS is a RCM maintenance tool and help in maintenance **decision making** this system work as network between aircraft and ground station and help in intelligent data analysis, automatic fleet monitoring, data analysis support.

2.5.9 RCM Software

1. RCM++ software

ReliaSoft's RCM++ software tool facilitates the Reliability Centered Maintenance (RCM) analysis approach for creating scheduled maintenance plans, which is an important aspect of an effective asset management program. The software provides support for the major industry RCM standards (such as ATA MSG-3, SAE JA1011 and SAE JA1012) and also offers extensive configuration options to fit your organization's particular RCM analysis approach. Full-featured FMEA / FMECA functionality is also included RCM++ provides a flexible and intuitive interface for defining your system configuration and recording the functional failure analysis. The software tool includes configurable equipment selection, failure effect categorization, and maintenance task selection capabilities. RCM++ also provides simulation-based calculations that can be used to compare the costs of potential maintenance strategies and a calculator to estimate the optimum maintenance interval for preventive repairs/replacements.

2. RCM MAXIMO

IBM Maximo for Aviation is designed to transform the managing of maintenance, repair, and overhaul activities. To support prognostics and predictive maintenance, supply chain management and other core functions, the product automates the exchange of information among equipment, physical locations and collaborative personnel, helping optimize uptime in highly regulated environments. The product's innovative information exchange platform supports service providers responsible for aircraft safety and reliability, regulatory compliance, and operational efficiency. The team gains visibility into current asset and component configurations, data that can provide the team the information they need to quickly upgrade an airplane's software and /or hardware to ensure up-to-date functionality, for example, to identify signs of wear affecting service landing gear to ensure safety, or to replace a broken coffee maker to insure passenger satisfaction.Creating value for service providers:

Planning and scheduling: Provide visibility into component locations and state of readiness to optimize work forecasting and management of crews and locations

Engineering: Evaluate the impacts of service bulletins and airworthy directives and help manage their implementation to minimize flight disruptions and cost

Version based task management: The ability to transform MPDs into OMPs integrates visibility to the engineering and approval aspects of work package preparation, creating closer alignment between line, base maintenance and quality assurance.

Configuration management: Helps ensure that correct components are installed and properly configured using analytics-based validation of aircraft hardware and software

Resource management: Integrates work stream information about pools of assets, skills and certifications, electronic log books, and supplier contracts

Materials management: Optimizes the purchase and pooling of components to minimize inventory costs and help ensure availability

Maintenance management: Uses analytics to optimize aircraft maintenance schedules based on planned usage; improving management of labor, skills, qualifications and training

3. MPC RCM/MSG-3

ReliaSoft's MPC software is an MSG-3 compliant maintenance program creator for the aircraft / aerospace industry. The software has been designed to assist MSG-3 working groups to perform Systems and Powerplant Analysis, Structural Analysis and/or Zonal-L/HIRF Analysis in accordance with the MSG-3: Operator/Manufacturer Scheduled Maintenance Development guidelines.

MPC facilitates the analysis process, provides flexible data management capabilities, and offers automated report generation in templates that have been accepted for submission to the aircraft industry maintenance review board.

CHAPTER (3) CASE STUDY & RESULTS

3.1 Data Collection

The purpose of the present study to discuss the impact of reliability in aircraft maintenance management, also discuss the relationships between RCM and aircraft reliability program and how this Improve aircraft maintenance program(AMP), The researcher will follow the historical and descriptive method to describe the phenomena and gather facts and observation .

The tool used to collect data is questionnaire based on likert scale, the researcher will design 25 formats of questionnaire in Appendix A. This questionnaire is filled by engineers work in different Sudanese companies their positions are planning mangers, engineer manger, maintenance manager, and technical service manager. The retained filled questioners are 21 records.

3.2 Data Analysis

The respondents answers are analyzed by excel software.

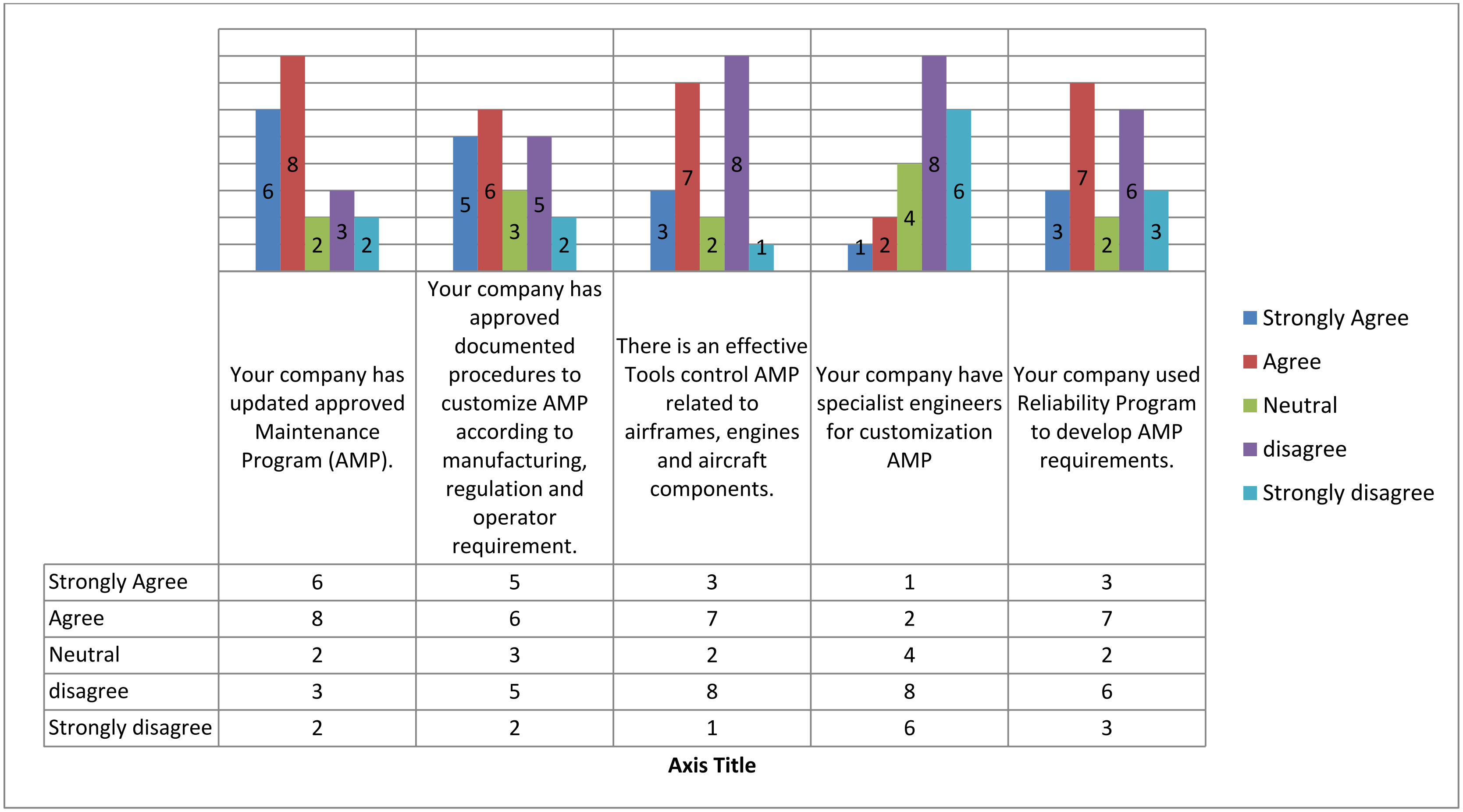
3.3 Results Discussion

The questionnaire coverage seven orientations:

1. Aircraft Maintenance Program (AMP) Customization
2. Reliability Concept
3. Data Collection & Analyzing
4. Corrective Action & Decisions Making
5. Reliability Tools & Software
6. Reliability Training
7. RCM Implementation

3.3.1 Aircraft Maintenance Program (AMP) Customization

All Companies included in this questionnaire had AMP , in this issues we want measure the AMP customization ability. Figure (6-1) show the details of chart AMP Customization the questions result:



	Your company has updated approved Maintenance Program (AMP).	Your company has approved documented procedures to customize AMP according to manufacturing, regulation and operator requirement.	There is an effective Tools control AMP related to airframes, engines and aircraft components.	Your company have specialist engineers for customization AMP	Your company used Reliability Program to develop AMP requirements.
Strongly Agree	6	5	3	1	3
Agree	8	6	7	2	7
Neutral	2	3	2	4	2
disagree	3	5	8	8	6
Strongly disagree	2	2	1	6	3

Figure (6-1) AMP Customization chart

1. Most Companies are update their AMP, but few companies not update result show that:

67% strongly agree, 24 % disagree, 10 % Neutral.

2. The problem here of some companies customizes AMP according to manufacturing, regulation, and operator requirement without documented procedures. Sample result

52 % agrees, 33 % disagree, 14 neutral.

3. Some Companies neglect effective Tools that control AMP related to airframes, engines, and aircraft components.

48 % agree, 43 % disagree, 10 neutral.

4. Figure (6-2) show pie chart show there is lack specialist engineers whom customization AMP in company have

14 % agree, 67 % disagree, 19 neutral.

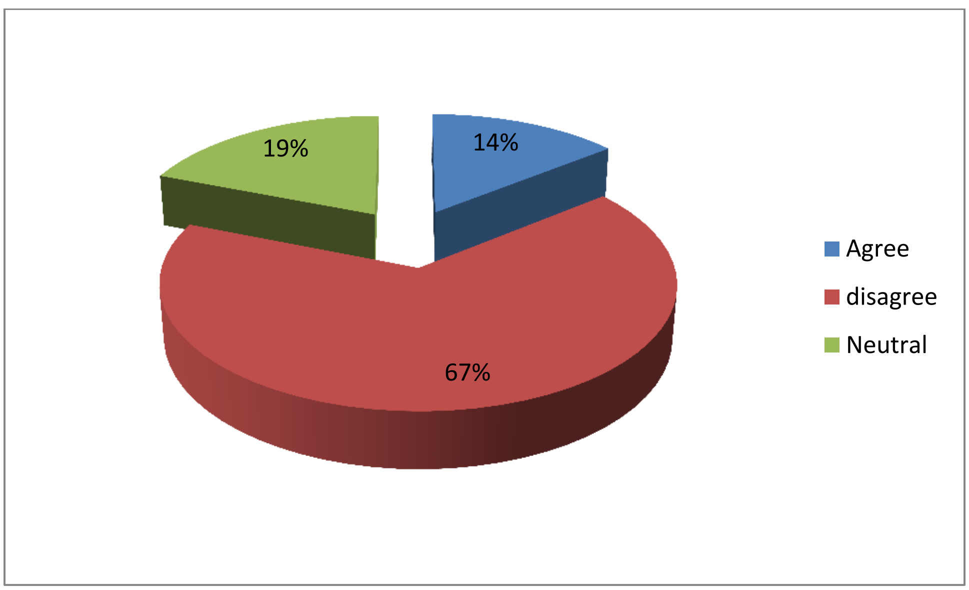


Figure (6-2) your company have specialist engineers for customization AMP

5. In Reliability Program required to develop or improve AMP the result show there was short reliability engineer, fig.(6-3)

48 % agree, 43 % disagree, 10 neutral.

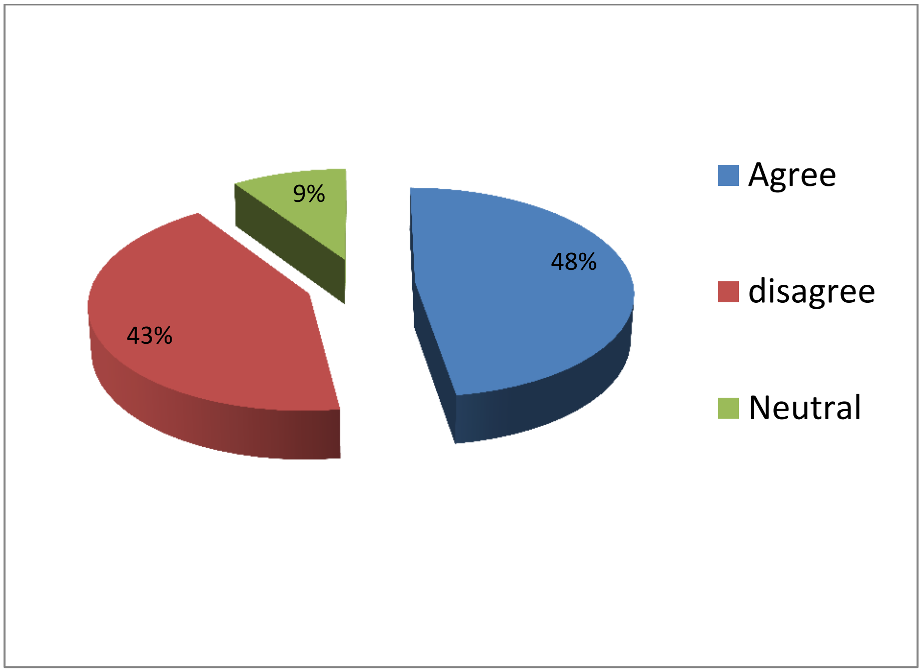


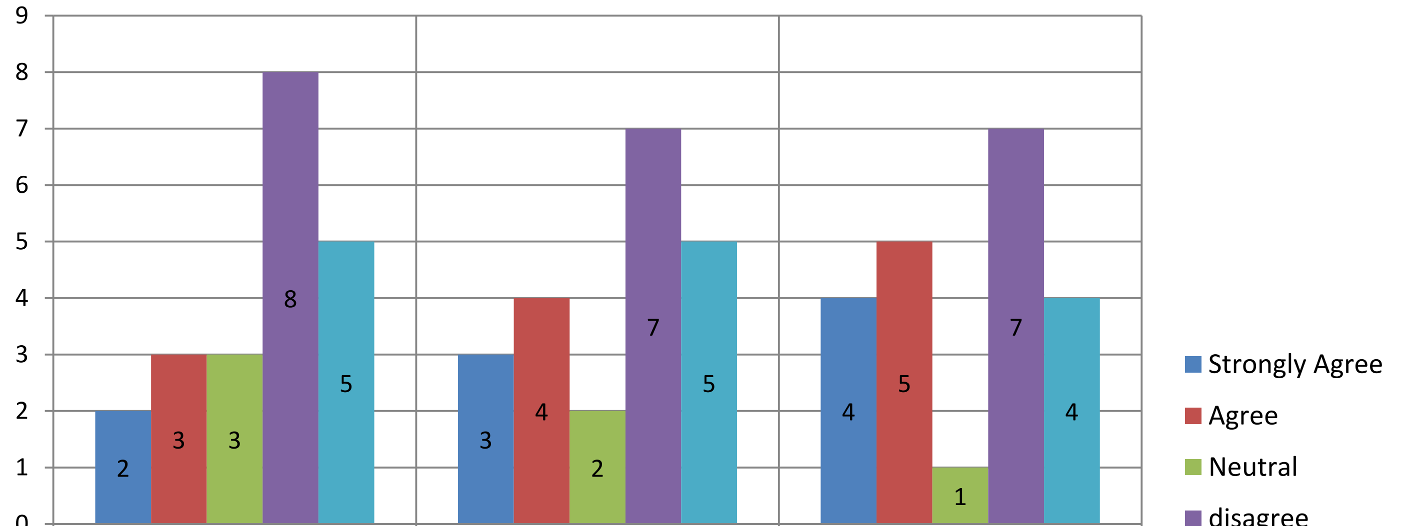
Figure (6-3) your company used Reliability Program to develop AMP requirements.

Notes:

The AMP Customization is very important stage because it is basis of managing aircraft maintenance, that must all companies give this stage high priority.

3.3.2 Reliability Concept

In this issue, we want measure the Reliability Concept figure (6-4) shows that.



	Your senior management understands the significance and impact of reliability in AMP.	your company used reliability control program (RCP) or Reliability Centered Maintenance (RCM) strategy to make effective aircraft maintenance program	Your company has developed its own reliability monitoring program.
Strongly Agree	2	3	4
Agree	3	4	5
Neutral	3	2	1
disagree	8	7	7
Strongly disagree	5	5	4

Figure (6-4) Reliability Concept

1. Figure (6-5) show that there are misunderstanding from senior management (mangers), to the significance and impact of reliability in AMP.

24 % agree, 62 % disagree, 14% neutral.

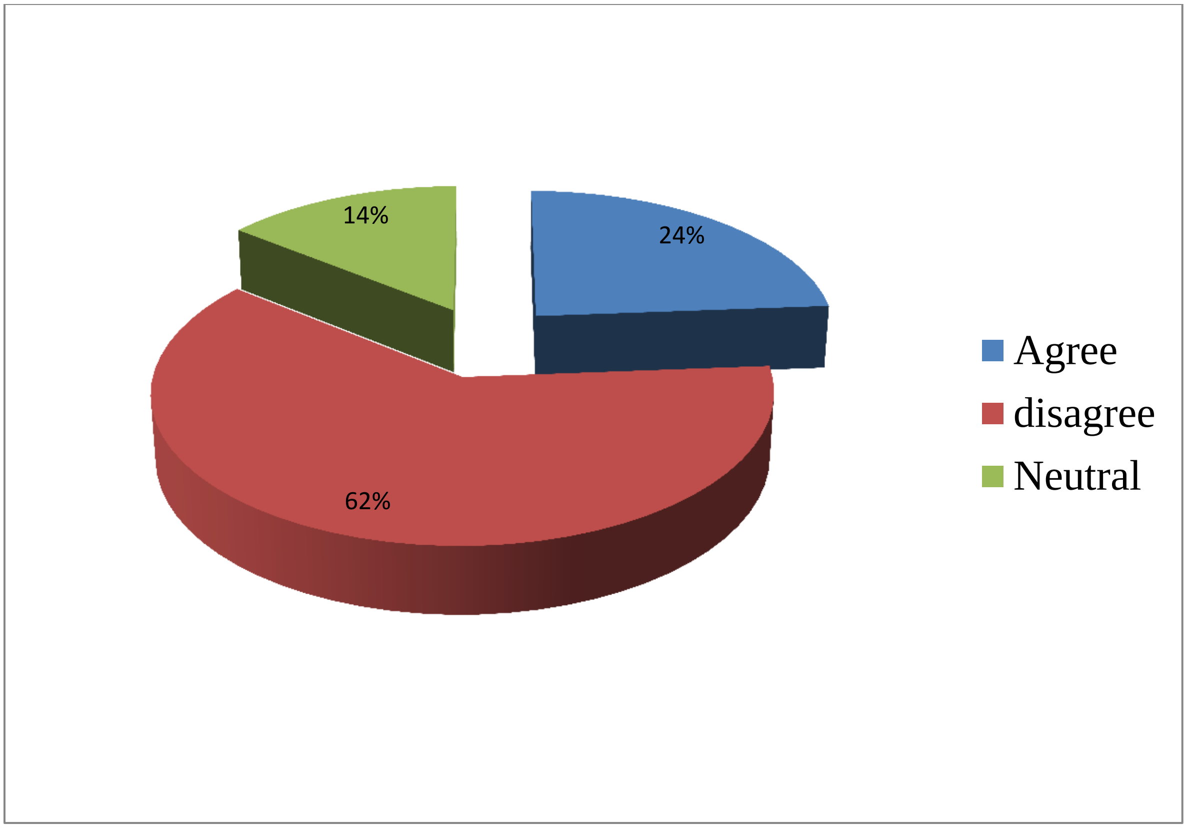


Figure (6-5) Your senior management understand the significant and impact of reliability in AMP

2. Not all companies established reliability control program (RCP) and use Reliability Centered Maintenance (RCM) strategy to make effective aircraft maintenance program. Only one company use RCP but not effective in their all operation,   figure (6-6) show details.

33 % agree, 57 % disagree, 10 neutral

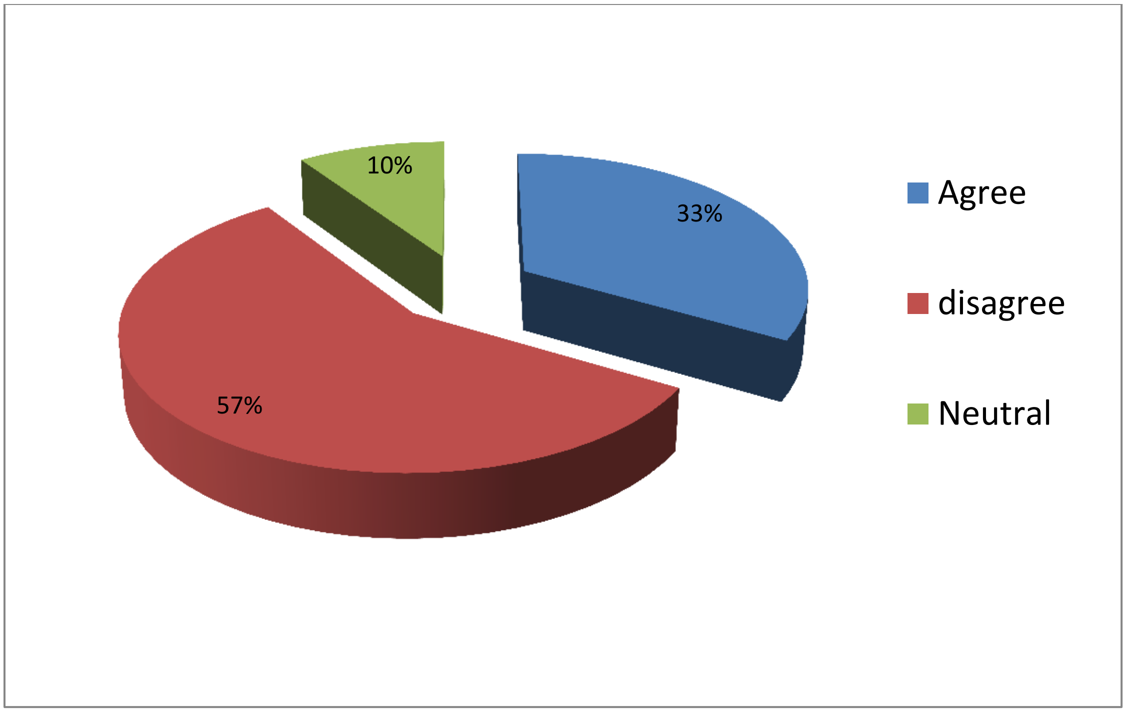


Figure (6-6) your company used reliability control program (RCP) and Reliability Centered Maintenance (RCM)

3. Some companies take reliability-monitoring program from others companies and change titles and logo only, this is big mistake, the instrument measures

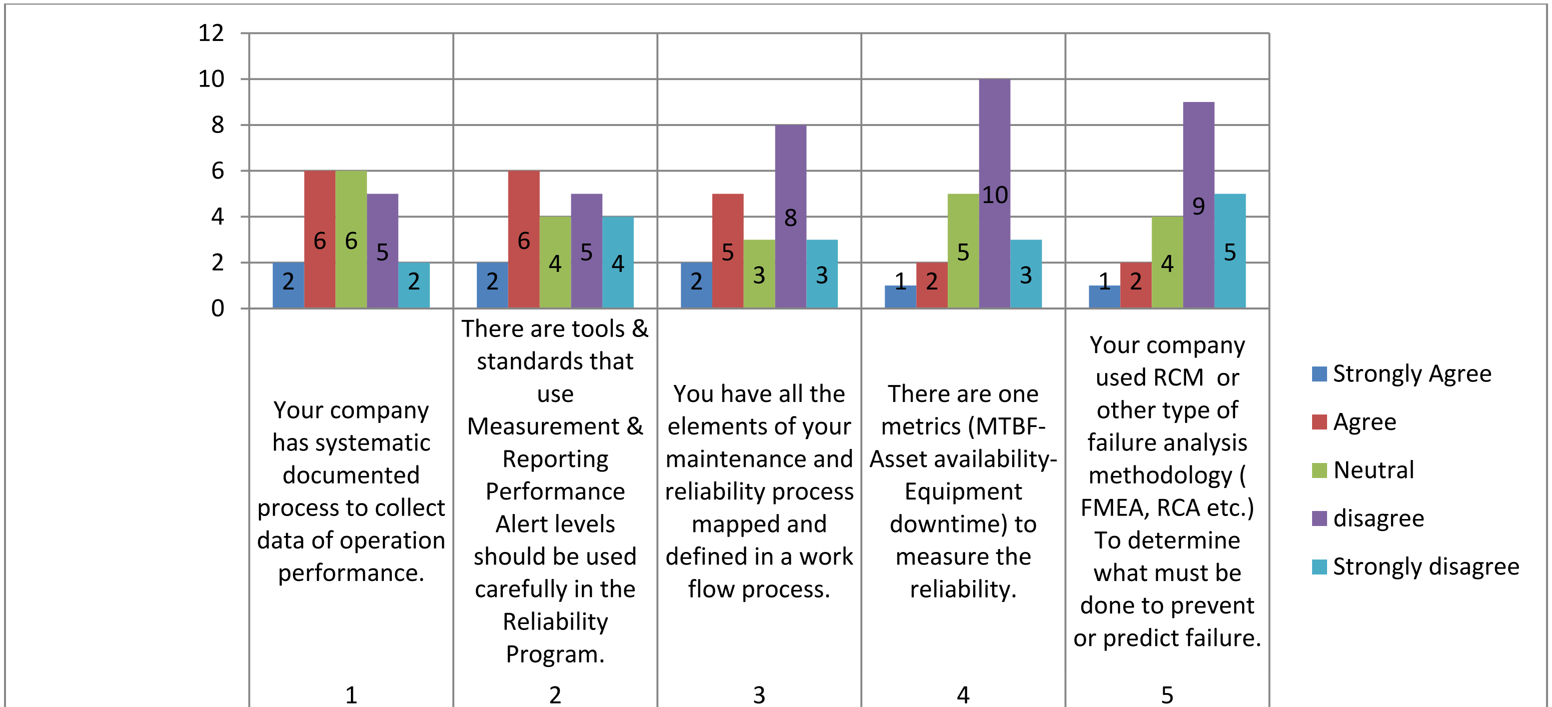
43% agree, 52 % disagree, 5% neutral.

Notes:

There was lack in concept of reliability engineering.

3.3.3 Data Collection & Analyzing

In this issue, we want to know the techniques Data Collection & Analyzing figure (6-7) shows details



	1	2	3	4	5
Strongly Agree	2	2	2	1	1
Agree	6	6	5	2	2
Neutral	6	4	3	5	4
disagree	5	5	8	10	9
Strongly disagree	2	4	3	3	5

Figure (6-7) Data Collection & Analyzing

1. There was lack in system of maintenance management system that reflect to the techniques of Data Collection processes and systematic operation , some companies say they get data verbal the measuring, Fig (6-8)

38% agree, 33 % disagree, 29 neutral.

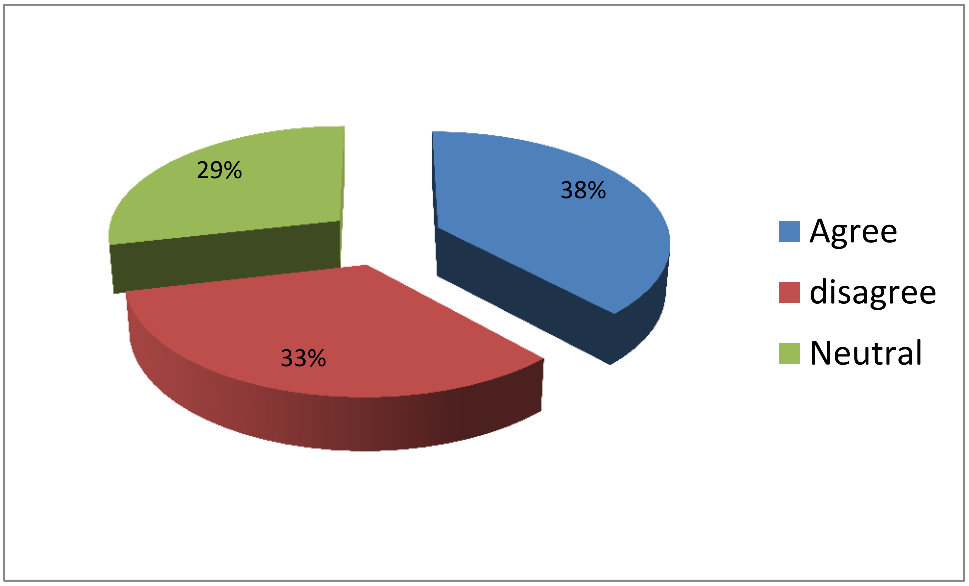


Figure (6-8) Your company has systematic documented process to collect data

2. There are old tools used in Measurement & Reporting Performance Alert levels in few companies the result show that

38% agree, 43 % disagree, 19 neutral.

3. There was no clear procedure explain process mapped the maintenance and reliability in most company, that no company implement any management system .

33% agree, 52 % disagree, 14 neutral.

4. There was lack in reliability engineering also lack in how measure reliability . No scale found except a few equation uses in a few company, fig (6-9).

14% agree, 62 % disagree, 24 neutral.

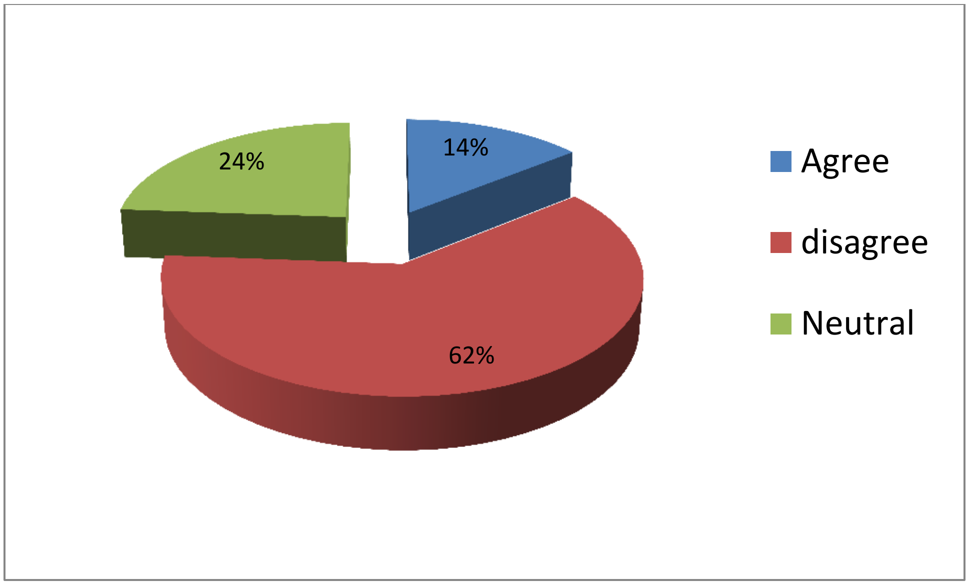


Figure (2-9) There are metrics to measure the reliability

5. There was no reliability section o For all companies that make except quality oriented to regulation only department and technical service most of them said this is first hear about it.fig.(6-10)

14 % agree, 67% disagree, 19 neutral.

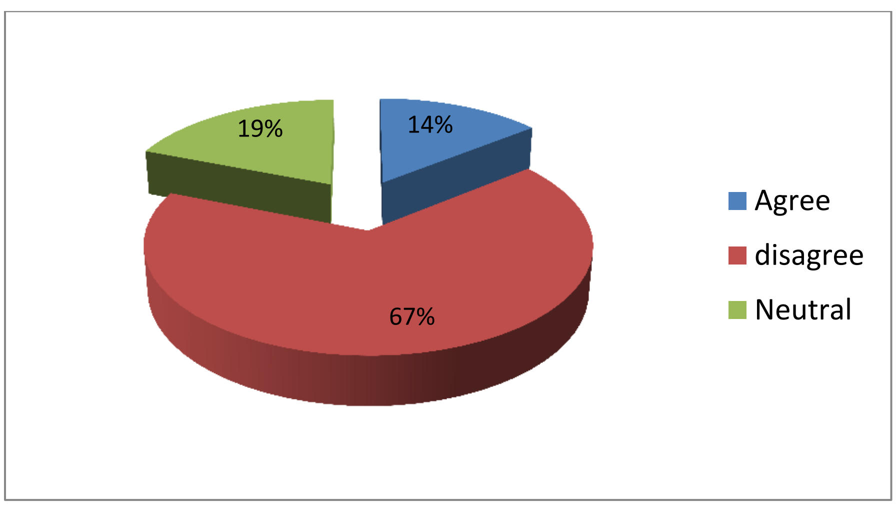
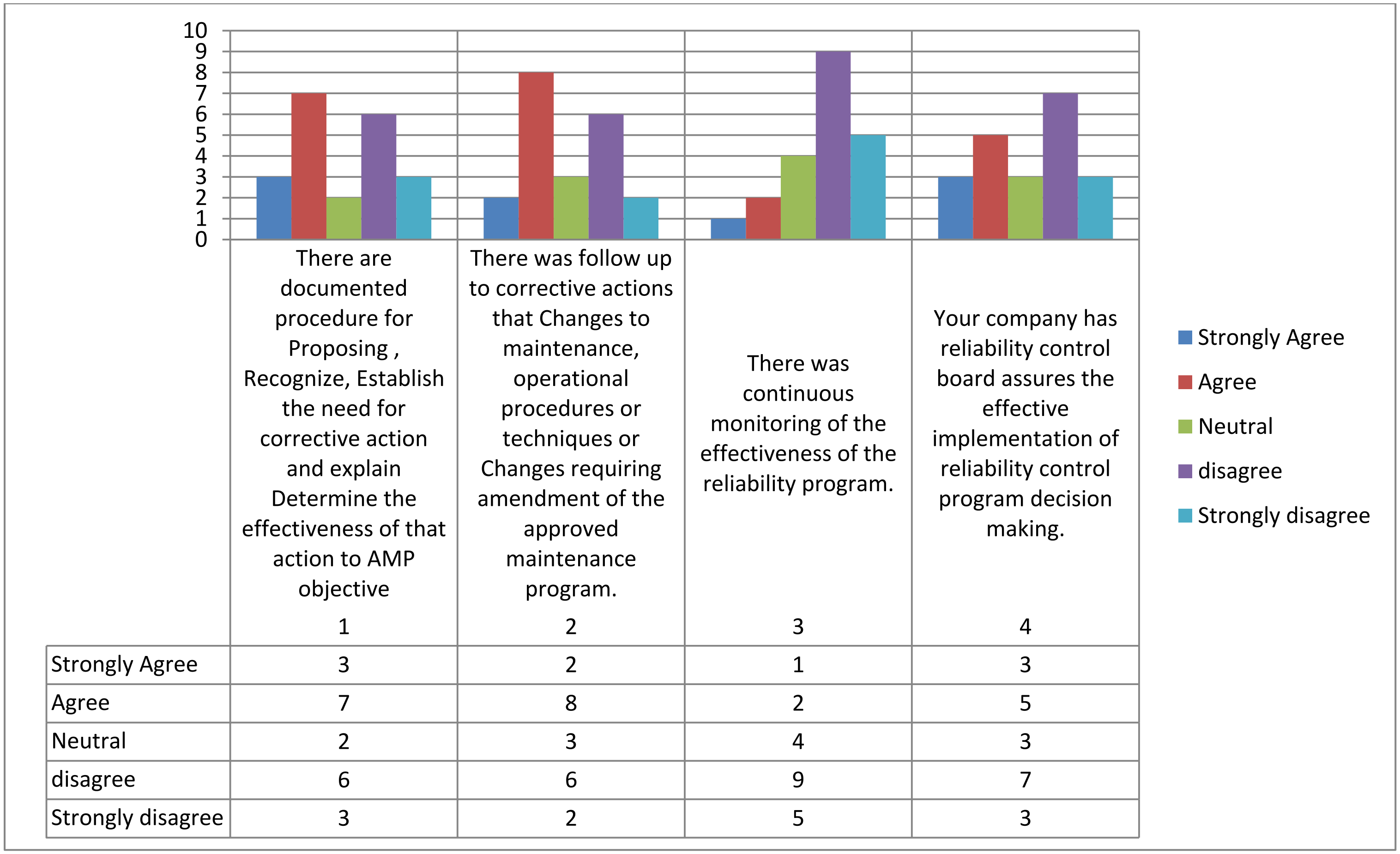


Figure (6-10) Your company used RCM or other type of failure analysis methodology

3.3.4 Corrective Action & Decisions Making

In this issue, we want to know the implementation Corrective Action and how Making Decisions figure (6-11) shows details



	1	2	3	4
Strongly Agree	3	2	1	3
Agree	7	8	2	5
Neutral	2	3	4	3
disagree	6	6	9	7
Strongly disagree	3	2	5	3

Figure (6-11) Corrective Action & Decisions Making

1. There was problem in procedure in some companies

48 % agree, 43 % disagree, 10 neutral.

2. All companies have not reliability section and The quality section oriented to regulation

48 % agree, 38 % disagree, 14 neutral.

3. There was no continuous monitoring of the effectiveness of the reliability program. In all companies. Fig.(6-12)

14 % agree, 67% disagree, 19 neutral.

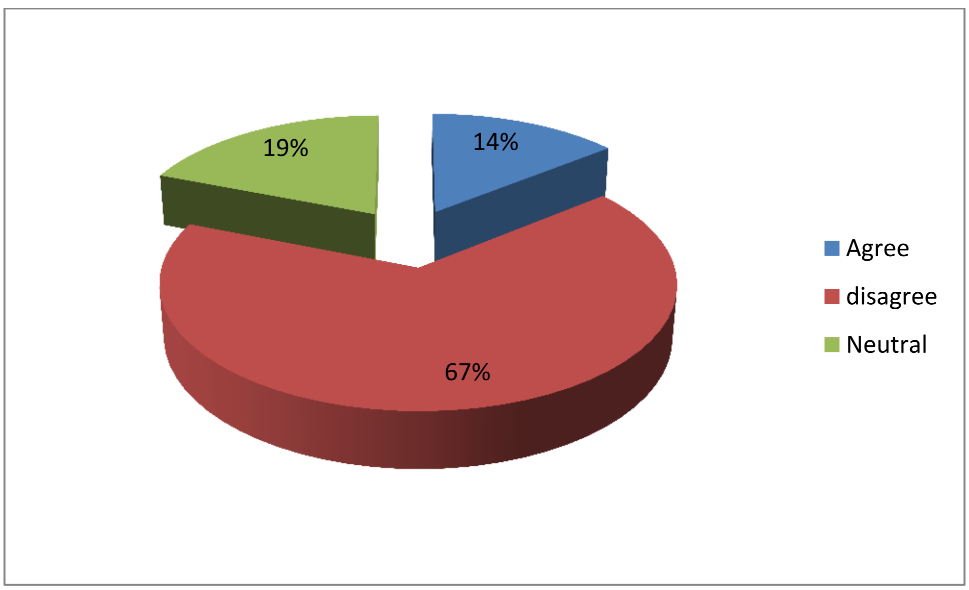


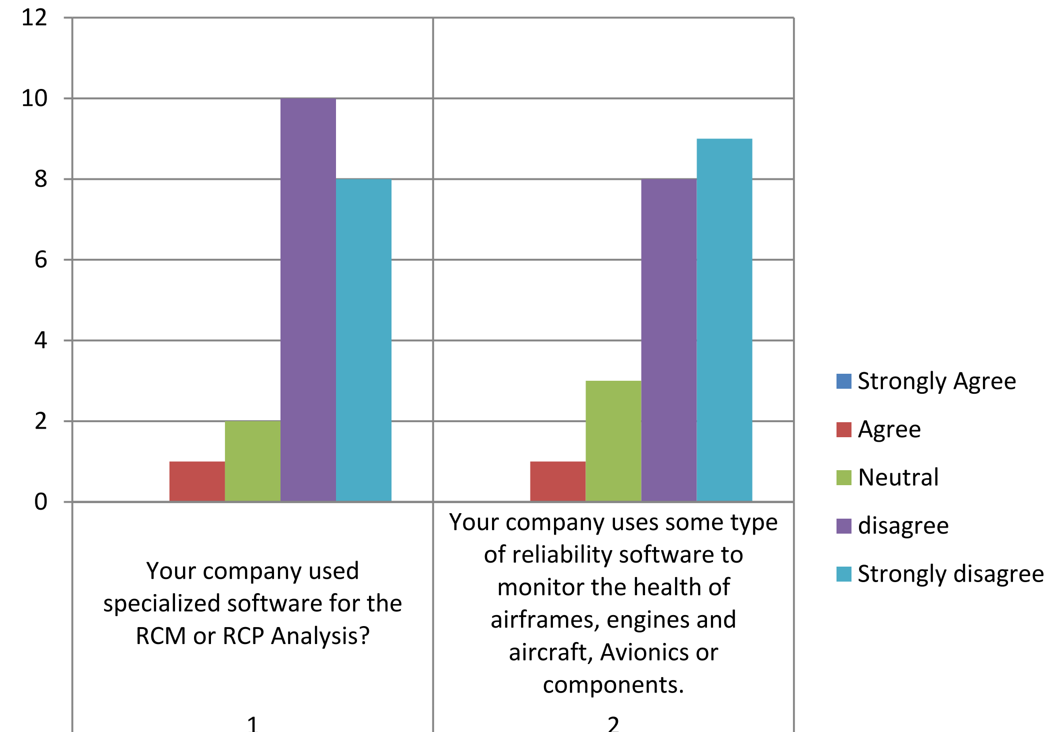
Figure (3-12) There was continuous monitoring of the effectiveness of the reliability program

4. Only one company has reliability control board assures the effective implementation of reliability control program decision making., but not effective.

38 % agree, 48 % disagree, 14 neutral.

3.3.5 Reliability Software

In this issue, we want to measure information & communication technology figure (6-13) shows details



	1	2
Strongly Agree	0	0
Agree	1	1
Neutral	2	3
disagree	10	8
Strongly disagree	8	9

Figure (6-13) Reliability Software

1- There was no company any computerize maintenance management system also reliability software not found. Only use office pacage.

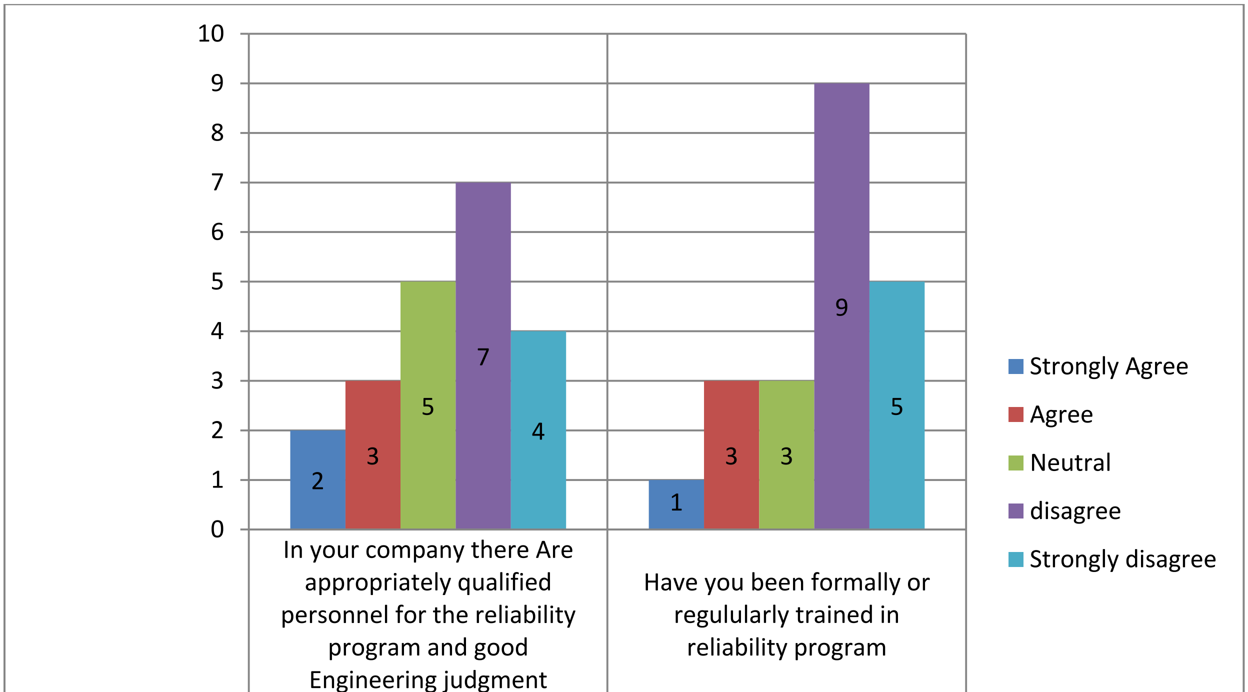
5 % agree, 86 % disagree, 10 % neutral.

2- In addition, there was no company use modern aircraft use computer in maintenance to measure reliability of aircraft system & component.

6. 5 % agree, 81 % disagree, 14 % neutral.

3.3.6 Reliability Training

In this issue, we want to measure reliability of engineer figure (6-14) shows details



	In your company there Are appropriately qualified personnel for the reliability program and good Engineering judgment	Have you been formally or regulularly trained in reliability program
Strongly Agree	2	1
Agree	3	3
Neutral	5	3
disagree	7	9
Strongly disagree	4	5

Figure (6-14) Reliability Training

1. Some companies have genius engineer have excellent experience in aircraft maintenance, but they have not experience or knowledge in reliability engineer .

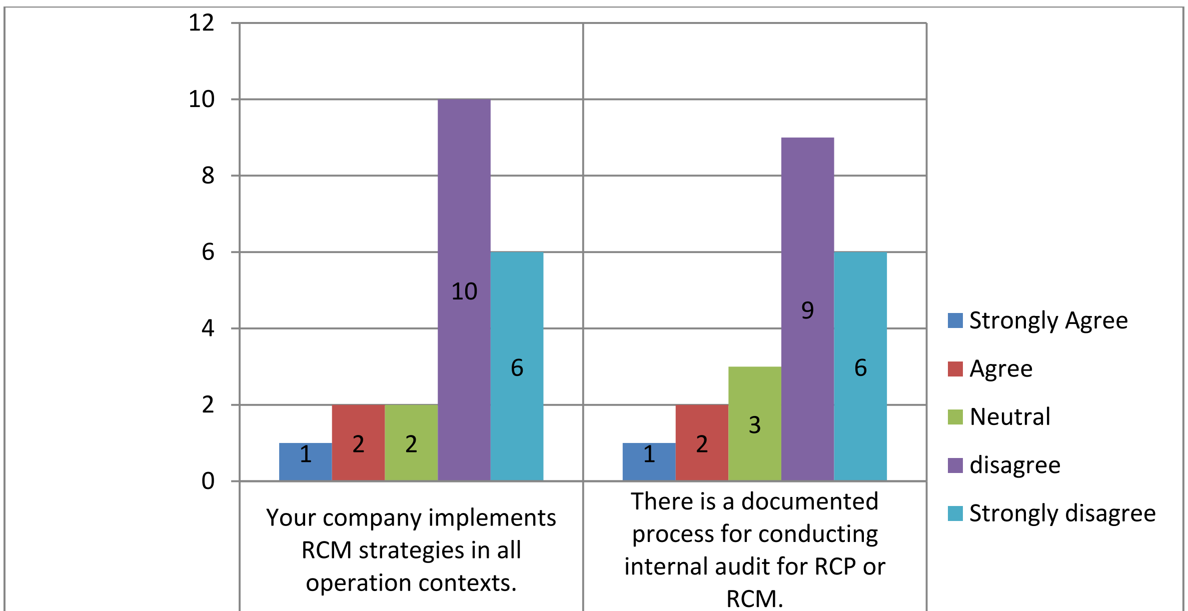
24 % agree, 52 % disagree, 24 % neutral.

2. There was few person has got courses in reliability engineer but they not implement because they forget it.no countinuous training

19 % agree, 67 % disagree, 14 % neutral.

3.3.7 RCM Implementation

In this issue, we want to know RCM location figure (6-15) shows details



	Your company implements RCM strategies in all operation contexts.	There is a documented process for conducting internal audit for RCP or RCM.
Strongly Agree	1	1
Agree	2	2
Neutral	2	3
disagree	10	9
Strongly disagree	6	6

Figure (6-15) RCM Implementation

1. No company found implement RCM

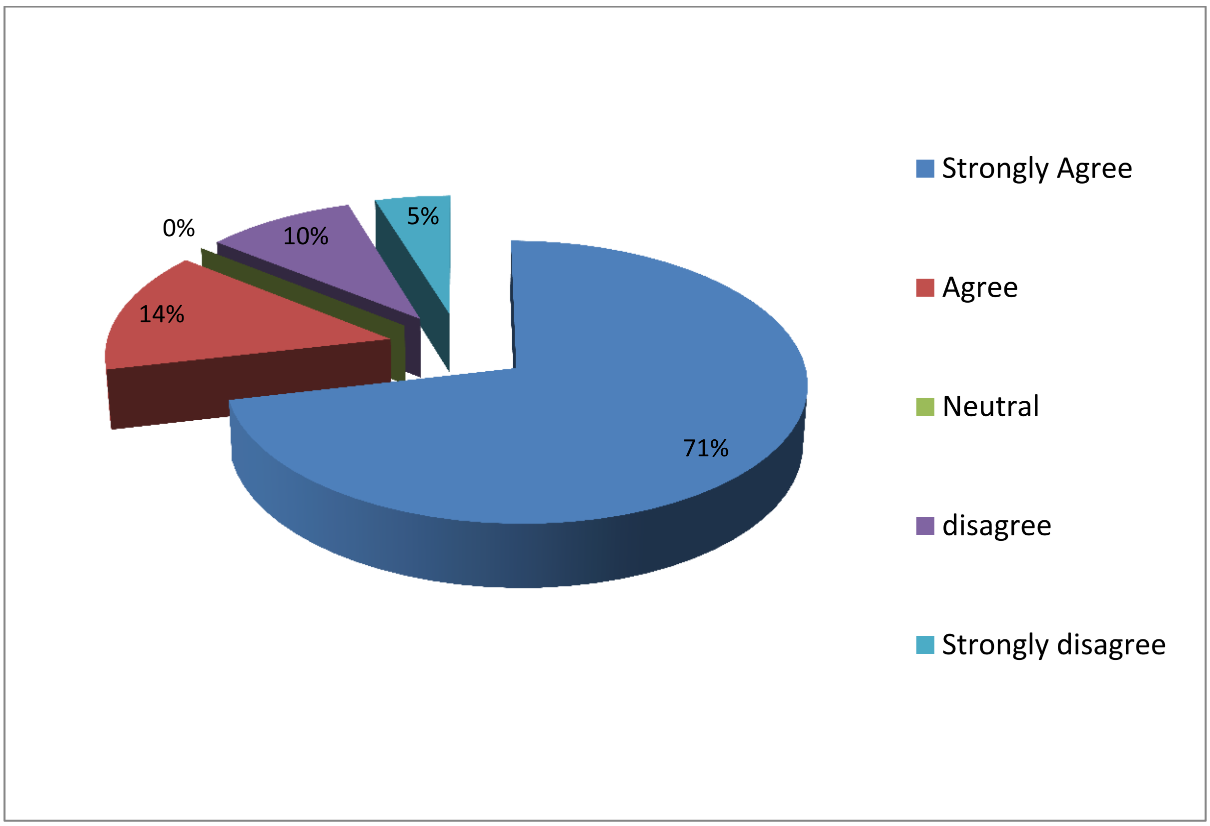
14 % agree, 76 % disagree, 10 % neutral.

1. In addition, there was no internal audit for reliability for improve AMP.

14 % agree, 71 % disagree, 14 % neutral

2. Most of person fill the question are Saied they need copy from research when end that main every person need to change to the pest practice processes .

86 % agree, 14 % disagree, 0 % neutral



3.4 Result summery

1. lack in Aircraft Maintenance Program (AMP) Customization

a. A few Companies are not updating their AMP.

b. Some companies customize AMP according to manufacturing, regulation, and operator requirement without documented procedures.

c. Some Companies neglect effective Tools that control AMP related to airframes, engines, and aircraft components.

d. There was lack in specialist engineers whom customization AMP in companies.

e. In Reliability Program required developing AMP the result show there was short reliability engineer.

f. The AMP Customization is very important stage because it is basis of managing aircraft maintenance, that must all companies give this stage high priority.

2. lack Reliability Concept

a. Lack in management responsibility . There was lack in understanding the significance and impact of reliability in AMP. Moreover, the causes are senior management.

b. Not all companies established reliability control program (RCP) or Reliability Centered Maintenance (RCM) strategy to make effective aircraft maintenance program. Only one company use RCP but not effective in their operation.

c. Some companies take reliability-monitoring program from others companies and change titles and logo only, this is big mistake.

3. lack in Data Collection & Analyzing

a. There was lack in system of maintenance management that reflect to the techniques of Data Collection processes and systematic operation , some companies say they get data verbal .

b. There are old tools used in Measurement & Reporting Performance Alert levels in few companies.
c. There was no clear procedure explain process mapped the maintenance and reliability in most company, that no company implements any management system.
d. There was lack in reliability engineering and how measure reliability no scale found except a few equations uses in a few companies.
e. There was no reliability section for all companies.

4. Lack in Corrective Action & Decisions Making

a. There was problem in procedure in some companies
b. Some companies the quality section oriented to regulation only.
c. There was no continuous monitoring of the effectiveness of the reliability program in all companies.
d. Only one company has reliability control board assures the effective implementation of reliability control program decision making but not effective.

5. Lack in Reliability Software

a. There was no company used any computerize maintenance management system also reliability software not found. Only use basic office package.
b. In addition, there was no company use modern aircraft use computer in maintenance to measure reliability of aircraft system & component.

6. lack in Reliability Training

a. Some companies have genius engineer have excellent experience in aircraft maintenance, but they have not experience or knowledge in reliability engineer.

b. Training for reliability not found in most company, there was few persons have courses in reliability engineer but without implementation in their company, and then they forget it. no continuous training.

7. lack RCM Implementation

a. No company found implement RCM **.**

b. In addition, there was no internal audit for reliability to improve AMP.

8. Opportunity for improvement

Most of those who filled the questionnaire asked for a copy of the final research in the framework of improvement to the pest practice **processes.**

CHAPTER (4) CONCLUSION & RECOMMENDATION

4.1 Conclusions

The conclusions of result we conclude that airlines should keep the spirit of MSG-3/RCM, continue to monitor the performance situation of aircraft and develop the prompt and efficiency maintenance program to keep the aircraft in the best flight performance. The research introduced the improvement of AMP in operation phase with RCM tools implementation that done with example. RCM enables the reliability program with pest practice and excellent maintenance by added value to the AMP. RCM supported Reliability Analysis and deliver Mean Time between Failures, Removals, and Unscheduled Removals for parts Determining discrepancies per Airframe .RCM is a logical, structured process used to determine the optimal failure strategies for any system. RCM based on system reliability characteristics and the intended operating context. Reducing the costs, improving the safety. Increasing the reliability of maintenance. RCM is not maintenance strategies only but also it is strategies for determining the risk of operational consequences of failures, which play a vital role in selecting an applicable and effective decision, improve the availability .

The study shows that world-class maintenance depends on the computerize maintenance management, air Canada model is the best practice of RCM implementation that they realize High-level solved Problem and decision making with integrated and automated maintenance management.

4.2 Recommendation

As results that we suggested some recommendations:

We recommend that all Sudanese maintenance organizations should follow implementing RCM, also recommend effective training culture for all organization in reliability engineering courses.

In addition, recommended formation of formal board at each airline responsible on the improvement of reliability programs.

The necessary use technology like computer maintenance software in Maintenance Engineering (RCM Reliability Analysis, Flight Hours, Configuration Management Maintenance Management).

The study concluded that RCM has important role toward improving aircraft maintenance program especially in large aircraft maintenance centers.

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APPENDIX: A

بسم الله الرحمن الرحيم

Sudan University Of Science And Technology

POSTGRADUATE COLLEGE

M.sc In Management Of Quality Excellence

Propose Of Supplementary Research To Obtain Master's Degree In Management Of Quality Excellence.

The Role of Reliability Center Maintenance (RCM) in Improving Aircraft Maintenance Program

QUESTIONNAIRE FOR INTERESTING PARTY

Dear Sir,

This Questionnaire is designed to explain The Role of Reliability Centered Maintenance (RCM) in Improving Aircraft maintenance program in Sudanese company, the reflection of this Questionnaire in how well they did or did not follow the RCM maintenance strategies.

1. Company: ....
2. Name: ....
3. Designation: ....
4. Aircraft type:...
5. The purpose of the Aircraft usage..........................

No	Aircraft Maintenance Program (AMP) Customization	Strongly Agree	Agree	Neutral	disagree	Strongly disagree
1	Your company has updated approved Maintenance Program (AMP).					
2	Your company has approved documented procedures to customize AMP according to manufacturing, regulation and operator requirement.					
3	There is an effective Tools control AMP related to airframes, engines and aircraft components.					
4	Your company have specialist engineers for customization AMP					
5	Your company used Reliability Program to develop AMP requirements.					
No	**Reliability Concept**	**Strongly Agree**	**Agree**	**Neutral**	**disagree**	**Strongly disagree**
1	Your senior management understands the significance and impact of reliability in AMP.					
2	your company used reliability control program (RCP) or Reliability Centered Maintenance (RCM) strategy to make effective aircraft maintenance program					
3	Your company has developed its own reliability monitoring program.					
No	**Data Collection & Analyzing**	**Strongly Agree**	**Agree**	**Neutral**	**disagree**	**Strongly disagree**
1	Your company has systematic documented process to collect data of operation performance.					
2	There are tools & standards that use Measurement & Reporting Performance Alert levels should be used carefully in the Reliability Program.					
3	You have all the elements of your maintenance and reliability process mapped and defined in a work flow process.					
4	There are one metrics (MTBF-Asset availability-Equipment downtime) to measure the reliability.					
5	Your company used RCM or other type of failure analysis methodology (FMEA, RCA etc.) To determine what must be done to prevent or predict failure.					
No	**Corrective Action & Decisions Making**	**Strongly Agree**	**Agree**	**Neutral**	**disagree**	**Strongly disagree**
1	There are documented procedure for Proposing , Recognize, Establish the need for corrective action and explain Determine the effectiveness of that action to AMP objective					
2	There was follow up to corrective actions that Changes to maintenance, operational procedures or techniques or Changes requiring amendment of the approved maintenance program.					
3	There was continuous monitoring of the effectiveness of the reliability program.					
4	Your company has reliability control board assures the effective implementation of reliability control program decision making.					
No	**Reliability Software**	**Strongly**	**Agree**	**Neutral**	**disagree**	**Strongly**

		Agree				disagree
1	Your company used specialized software for the RCM or RCP Analysis?					
2	Your company uses some type of reliability software to monitor the health of airframes, engines and aircraft, Avionics or components.					
	Reliability training	**Strongly Agree**	**Agree**	**Neutral**	**disagree**	**Strongly disagree**
1	In your company there Are appropriately qualified personnel for the reliability program and good Engineering judgment					
2	Have you been formally or regularly trained in reliability program					
NO	**RCM Implementation**	Strongly Agree	Agree	Neutral	disagree	Strongly disagree
1	Your company implements RCM strategies in all operation contexts.					
2	There is a documented process for conducting internal audit for RCP or RCM.					
3	Would you like a copy of the thesis once the survey is complete					