Vol. VI No. 2 / October 2011
ISSN: 0973-4503 RNI : UPENG 2006/17831
JOURNAL OF COMMERCE & TRADE
Pp. 100-106

Performance Improvement through Implementation of Lean Maintenance

AUTHORS

S. Kolanjiappan
Research Scholar,
Sathyabama University
Engineering College,
Chennai

Dr. K. Maran
Director of Management studies
Sri Sairam Engineering College,
Chennai

Abstract

Lean Maintenance is a relatively new term, invented in the last decade of the twentieth century, but the principles are well established in Total Productive Maintenance (TPM). Lean Maintenance—taking its lead from Lean Manufacturing—applies some new techniques to TPM concepts to render a more structured implementation path. Tracing its roots back to Henry Ford with modern refinements born in Japanese manufacturing, specifically the Toyota Production System (TPS). Lean seeks to eliminate all forms of waste in the manufacturing process—including waste in the maintenance operation. Plants can accelerate their improvements with much lower risk through the elimination of the defects that create work and impede production efficiency. Optimizing the maintenance function first will both increase maintenance time available to do further improvements and will reduce the defects that cause production downtime. Thus cost reduction and improved production are immediate results from establishing Lean maintenance operations as the first step in the overall Lean Enterprise transformation. This paper discusses the application of lean principles in maintenance of aircraft, and describes some of the lean tools and techniques that are being used to transform maintenance process. This research study was based upon defects occurred on ten aircrafts for the period of three years in one of the private aviation industry. System wise defects data were collected and the effect of the trend of these effects was investigated thoroughly. Key words: Kanban, Total Productive Maintenance (TPM), Predictive Maintenance, Preventive Maintenance, Reliability Centered Maintenance (RCM).

1. INTRODUCTION

Lean practice was developed in Japanese automobile production companies. This is also known as Toyota Production System. Taiichi Ohno was considered as the father of this practice. Once confined to the automotive industry, lean principles are becoming standard operating procedure in many industries today. Simple reason for that is when implemented with a good performance management system, lean principles have a proven track record of operational and strategic success, which ultimately translates into increased value to the end customer. Lean is a principle driven, tool based philosophy that focus on eliminating waste so that all activities/steps add value from customer's perspective. Specifications of value, identification of all the steps in the value stream, smooth flow, pull value, and pursue perfection are the five principles in LEAN practice. Throughout the LEAN practice it targets to reduce the unnecessary overhead activities and outputs as well as wastes from the production line. With this prime norm, LEAN method only activates necessary activities at the latest time that

Vol. VI No. 2 / October 2011
ISSN: 0973-4503 RNI : UPENG 2006/17831

could be performed with minimal/zero defects. LEAN practice is composite with unique methodologies to perform the operational activities. Kanban (Pull) production system is one important method. In that method, throughout the production lines one can schedule the process efficiently, and activates the flow using signaling to each others related to the workflow. In 1953 Toyota applied this logic in their main plant machine shop.

2. LEAN MAINTENANCE DEVELOPMENT

Maintenance plays an indispensable role as a supportive service to production. **"Lean Maintenance**" is basically a reliability factor in maintenance troubleshooting and rectification of defects. Lean Maintenance comes from protecting against the real causes of equipment downtime — not just their symptoms. Over 25 years of experience, Amemco has learned to move client companies through implementation of Lean Maintenance in 30 days (TPM), rather than taking years. Lean Maintenance is maximizing uptime, yield, productivity, and profitability. The key objective of Lean Maintenance is to give your company the near 100% equipment uptime and reliability it demands while cutting your maintenance expense, often by 50% or more. This is done by surveying or analyzing systematically each machine and control system to determine basic stresses affecting each machine over time, and laying out a scheme to protect each machine, computer, or control system when subjected to stresses. This certainly includes but goes far beyond the TPM oil change, filter change preventive maintenance (PM) procedures given in the maintenance manual. One must first understand the three categories of downtime namely Downtime from Operator or Programmer Error, Downtime from inadequate PM procedure or performance and Downtime from chronic wear & stress to circuit boards, hydraulic components and also other system components. Stresses experienced are Heat, Vibration, Oxidation & Corrosion, Dirt build-up, Electrical voltage transients and current surges and Hydraulic contaminations of dirt, water & acids.

3. LEAN TOOL IMPLEMENTATION

One of the tools of Lean is **Work to perfection.** In other words it means that it is a ***continual cycle of process improvements.*** For continuous improvement of the system one must have the feeling of its pulse. In our experiment, the pulse of the system is the defects prevailing in the aircraft. In general defects are deviations from the standard procedure or state. Failure rate of the aircraft in terms of defects has to be ascertained in order to achieve a broader concept of the intricacies of the system Defect analysis for the aircraft has to be performed in order to reduce the downtime of the aircraft while it is being serviced. There is a great requirement to identify and analyze statistically the defects and the root cause of the defects. This analysis will help the organization to identify and eliminate the recurrences that are found. This also helps the organization to be proactive rather than reactive in their approach towards better quality. One of the private Aviation industries in Bangalore was experimented to implement one of the lean tools.

4. OBJECTIVES OF INVESTIGATION

The primary aim is to introduce and establish a trend of defects on defective components prematurely withdrawn from service and sent to defect investigation agency. This evaluation of trend of defects helps to identify the root cause of recurring defects and eliminates them. In order to reduce the maintenance cost, a research of analysis of the trend of defects is done to evaluate remedial measures and suggest to manufacturers, overall agency and operators for implementation to reduce the premature withdrawal of components. In this research, an indepth study was carried out based on defects occurred on ten aircrafts for the period of three years in the subject private aviation industry at Bangalore. Study was carried out in depth for defects occurred in three systems namely hydraulic, fuel and air conditioning systems. The contributory factors were studied thoroughly and the remedial measures were suggested to prevent occurrence of such defects leading to the maintenance of the aircraft components to a very high order for enhancing the aircraft maintenance management.

Defects occurred in hydraulic, fuel and air-conditioning system during the year 2006, 2007 and 2008 on 10 aircrafts are collected for defect analysis

- Total Hydraulic defects- 174
- Total Fuel defects-130
- Total Air-conditioning system defects- 41

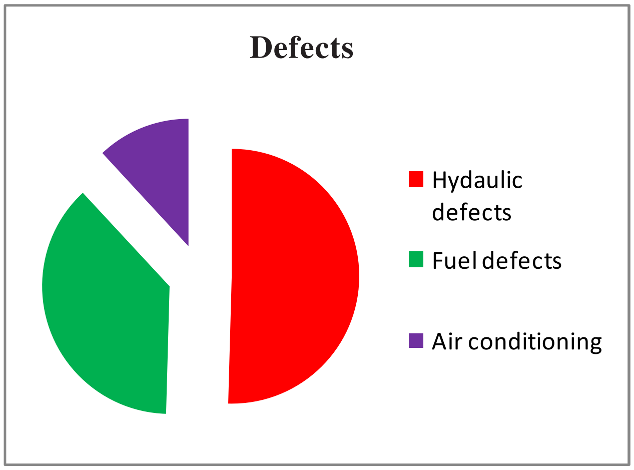


Fig. 1 Breakdown of various defects of Hydraulic, Fuel and Air-conditioning systems

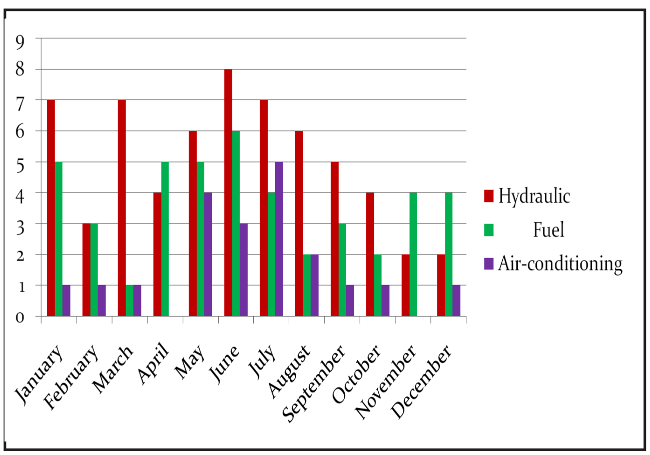


Fig.2. Hydraulic, Fuel & Air-conditioning systems Defects occurred in the year 2006

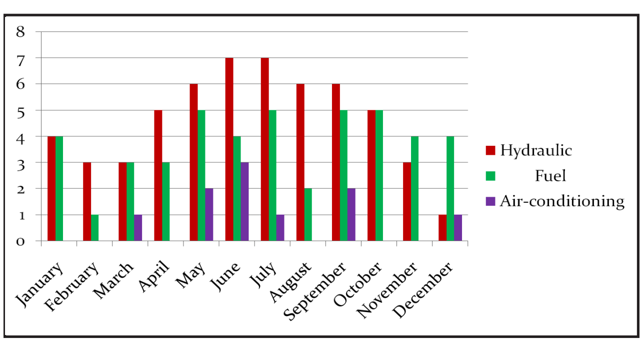


Fig.3. Hydraulic, Fuel & Air-conditioning systems Defects occurred in the year 2007

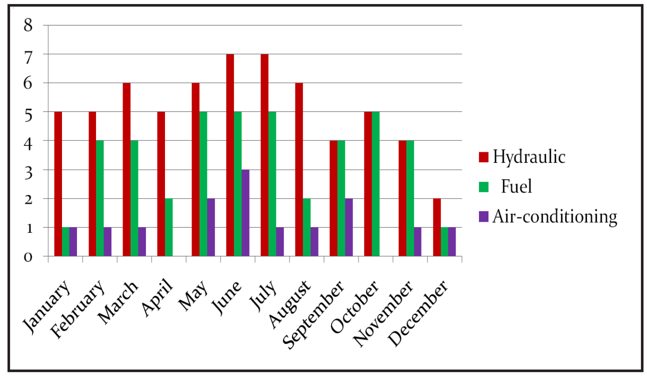


Fig.4. Hydraulic, Fuel & Air-conditioning systems defects occurred in the year 2008

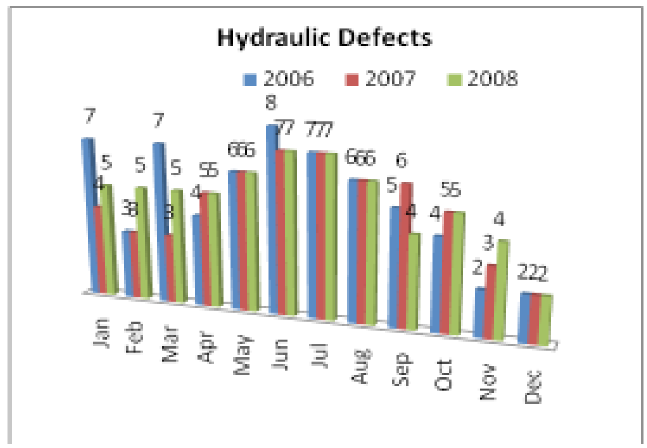


Fig.5 System wise defects-Hydraulics system

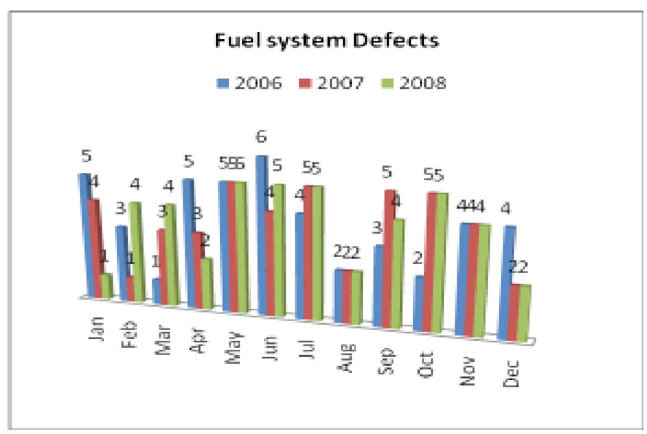


Fig.6 System wise defects-Fuel system

5. DEFECT TREND ANALYSIS

After analyzing the defects occurred in all the three systems of ten aircrafts over a period of three years it was found that the average defects were more in between April to August month. The reasons established are

1. Monthly average flying hours found exceeding more during this period.
2. This period falls during summer season.

JOURNAL OF COMMERCE & TRADE
Vol. VI No. 2 / October 2011
ISSN: 0973-4503 RNI : UPENG 2006/17831

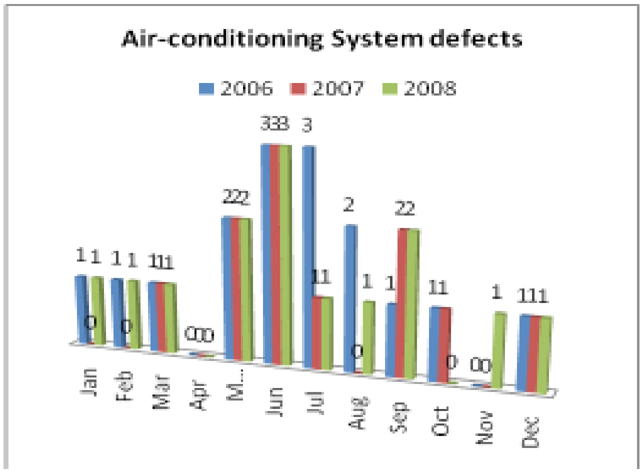


Fig.7 System wise defects - Air-conditioning system

3. During this period normally aircrafts were engaged in cloud seeding operation for artificial raining subjected to undergoing different environment conditions of flying.

6. EFFECT OF INVESTIGATIONS

It is seen that this study has established the trend of defects occurred. Based on the above evaluation, theoretical and experimental investigations were carried out. On the basis of one of the tool of Lean "**Work to perfection",** the following remedial measures are introduced to prevent occurrence of such defects to operator.

1. Initiating Preventive Maintenance (PM) and evaluating its effectiveness
2. Introducing Predictive Maintenance (PdM) Techniques and Procedures
3. Developing Condition Monitoring and Equipment Testing
4. Analysing Preventive Maintenance, Predictive Maintenance, condition Monitoring and Equipment Testing for optimizing Maintenance
5. Extending Equipment life by using Engineering Techniques such as

- Specification for new and rebuilt equipment
- Precision in rebuilding of equipments and in installing equipment
- Failed-part analysis
- Root-cause failure analysis
- Reliability engineering
- Certification for rebuild equipment and verification of certificate for new equipment
- Examining age of the components and controlling recurrence of the defects
- Performing Continuous Evaluation of Maintenance Skills Training
- Performing Selected Elements of Reliability Centered Maintenance (RCM)

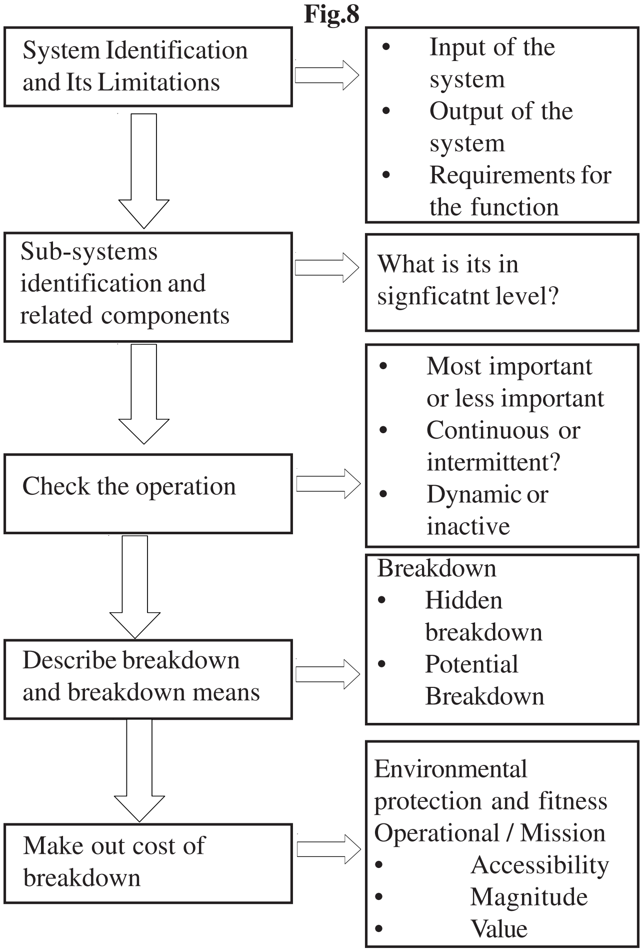
7. ROOT CAUSE ANALYSIS

Root cause analysis (RCA) is another tool used by organizations that practice lean thinking. In this case the primary aim is to address the fifth lean principle of pursuing perfection and practicing continuous improvement. This is achieved by identifying and tackling the root causes of recurrent and destructive problems, rather than fixing their symptoms. RCA is a collection of techniques [3] to identify the root of a problem, and includes both structured and unstructured techniques. Many of these techniques such as tree and fishbone diagrams are the methods for displaying and analysing data, rather than capturing it. RCA has been applied to the issue of hydraulic, Fuel and Air-conditioning system defects. If defects rates could be reduced, there would be a direct reduction in the costs associated with repair, but more importantly it would result in better service for operator.

8. RELIABILITY CENTERED MAINTENANCE

Optimizing maintenance effectiveness is a major objective of Lean Maintenance. The Reliability Centered Maintenance (RCM) process is used to fulfill this precise need. RCM uses a systematic, logic based approach for determining objective evidence for selecting the most appropriate maintenance tasks. RCM generates sound technical rationale and economic justification on which maintenance decisions are based. The process considers operational experience and failure history to generate, validate and support that decisions.RCM is a process used to determine the maintenance requirements of physical assets in their present operating context. A rigorous RCM analysis is based on a detailed Failure Modes and Effects Analysis (FMEA) and includes probabilities of failure and system reliability calculations. The analysis is used to

Fig.8



determine appropriate maintenance tasks to address each of the identified failure modes and their consequences. The considerations of a rigorous RCM analysis are illustrated in Figure.

RCM acknowledges three types of maintenance tasks. These tasks are:

- Time directed (PM)
- Condition-directed (PdM)
- Failure finding

Time-directed tasks are scheduled when appropriate. Condition-directed tasks are performed when conditions indicate they are needed. Failure finding tasks detect hidden functions that have failed without giving evidence of pending failure. Run-to-Failure is a conscious decision and is acceptable for some equipment.

Note that the maintenance analysis process, as illustrated in Figure 9, has only four possible outcomes:

- Perform Condition-Based actions
- Perform Interval (Time- or Cycle-) Based actions
- Perform no action and choose to repair following failure

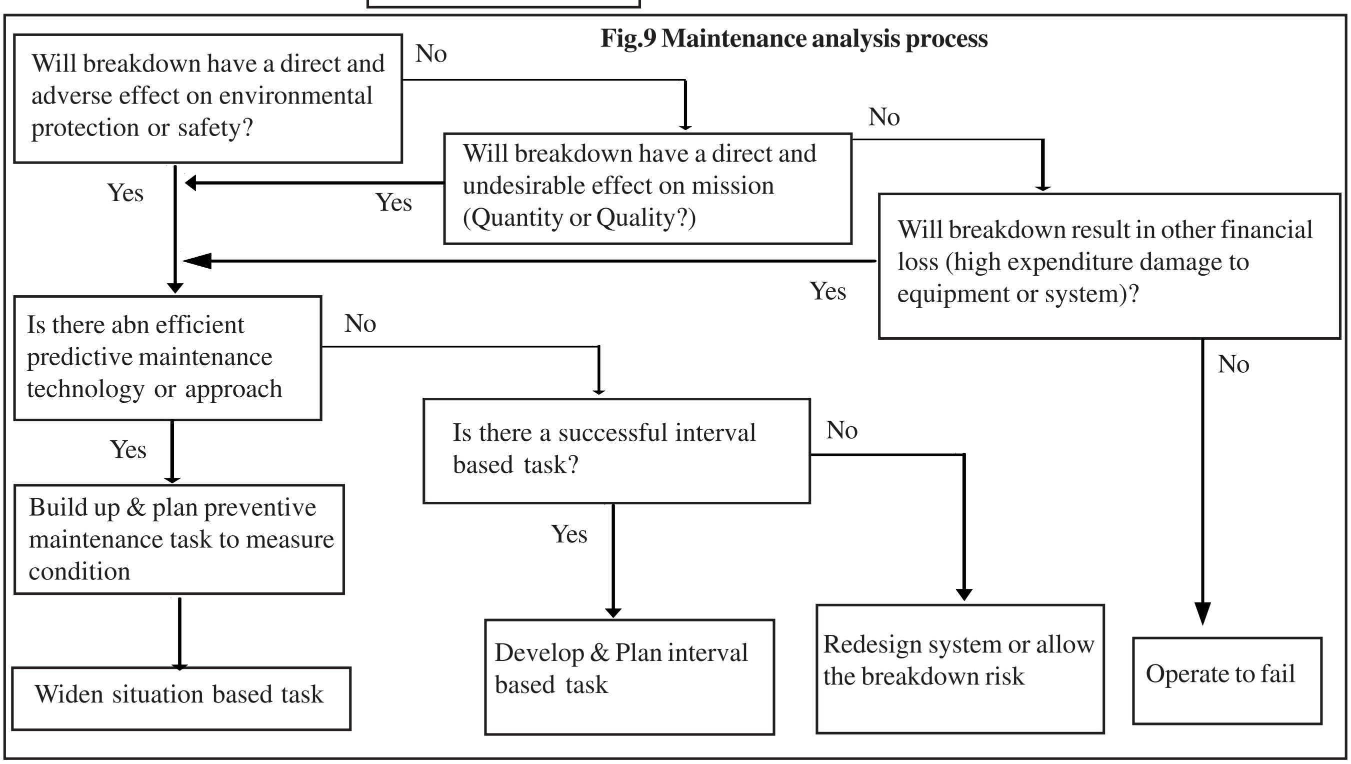


Fig.9 Maintenance analysis process

Vol. VI No. 2 / October 2011
ISSN: 0973-4503 RNI : UPENG 2006/17831

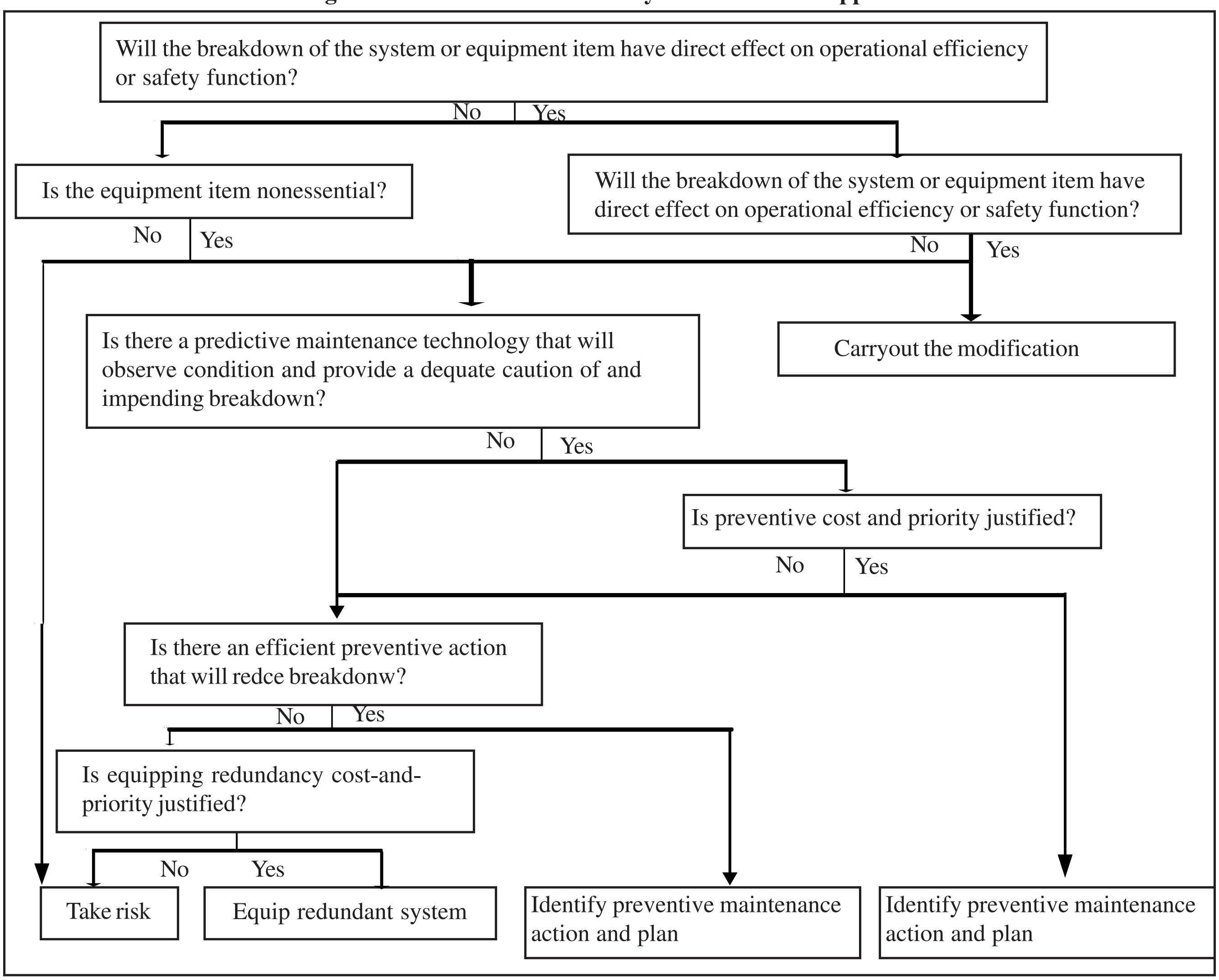
- Determine that no maintenance action will reduce the probability of failure AND that failure is not the chosen outcome (Redesign or Redundancy).

In a formal RCM operation, analysis of each system, subsystem and component is normally performed for all new, unique and/or high-cost systems. An abbreviated decision tree, such as the one illustrated in Figure is used to identify the maintenance approach. Regardless of the technique used to determine the maintenance approach, the approach must be reassessed and validated. At the system level, the determination of whether there is suitable PdM technology available to provide warning of impending failure requires the reliability engineer to break the system down to the component level and further analyze functional failures.

9. DISCUSSION

This paper has systematically evaluated the defects occurred on aircrafts. Specifically, we have examined defects occurred in critical systems such as hydraulic, fuel and air-conditioning systems. Our study has also shown that the situations in which defects were occurred. When the aircraft flying environment shifts to the unpredictable one aircraft performance drops to a level much lower than that of flying in normal environment. This finding has important implications for organization. To the extent that an organization wants to avoid a particular kind of defects, one has to pay attention to the shifting

Fig. 10 Decision tree used to identify the maintenance approach



nature of the environment and the operating conditions. Defects on aircraft usually imply costs. Thus, to the extent that costs of a particular kind of defects are high, organization should carefully examine the kind of environments and operating conditions. Another contribution of the present study is highlighting the importance of Lean tools and Lean maintenance approach. A method is presented through which judgments and decision making in aircraft maintenance are integrated. Thus, the lean organization is made full use of its design and has an effective adaptation to the environment and maintains a high performance.

10. CONCLUSION

Many companies followed these lean practices have reaped the benefits of increased customer and employee satisfaction, shorter lead times, reduced inventories, fewer defects, and lower operating costs. Maintenance organizations which adopt lean thinking have the potential to

- Improve their maintenance service by focusing on what the needs of the service rather than what is most convenient for the organization.
- Reduce operating costs by reducing inventory and removing the need for rework,
- Increase the degree of flexibility to provide new services through adaptable processes.

Aircraft maintenance is continuing to make great strides along the route towards leanness, and this paper has described some practical ways in which lean principles can be applied to maintenance of the aircraft. It is a proven fact from manufacturing industry that a major competitive advantage can be gained by adopting lean principles. Further a lean thinking may prove to be a prerequisite for survival in a future market of rapid technological advance and rising customer expectations.

REFERENCES

1. Womack J.P and D.T. 'Lean Thinking', Simon and Schuster (1996)
2. T.Ohno, Toyota production system, Beyond large scale production, productivity press 1988 pp.25-29
3. "Lean Maintenance" - Reduce cost, improve quality and increase market share by Ricky Smith and Bruce Hawkins
4. M. Poppendieck, Principles of LEAN thinking, Onward-17th Annual ACM Conference on Object-Oriented Programming, Sys. Languages and Applications, Washington 2002.
5. A. Smalley, Lean and the Law of Unintended Consequences, Super factory www.lean.org. (2005)
6. Womack J.P, Jones DT, Roos D (1990) The machine that changed the world, Machmillan, New York.
7. Lee-Mortimer A (2006) A Lean route to manufacturing survival, Assem Autom 26(4); 265-272
8. Holweg M (2007). The genealogy of lean production. J.Oper Manag 25(2);420-437 doi;10,1016/j.jom.2006.04.001
9. Morgan J and J.K. Liker. 'The Toyota product Development system: Integrating people, process and Technology, New York. Productivity press 2006.
10. Rother. M and Shook J: Learning to see: Value stream mapping to add value and Eliminate MUDA Brookline: Lean enterprise Institute, 1999.
11. Schuh, G: Lean Innovation- Die Handlungsanleitung in 4th Lean management summit- Aachener management Tage, G Schuh and B Wiegend, Ed, Aahen: Apprimus-Verlag,2007
12. Adams E.K. and Willetts K.J. 'The lean communication provider McGraw-Hill (1996)
13. Wilson P, Dell.L and Anderson G ' Root cause analysis - a tool for total quality management.' ASQC Quality press 1993.
14. Mayhew A J and Stockton DJ 'Cost-reduced cable delivery for the 21st century', B.T Technol J, 16, No.4 PP22-100 (1998).
15. Krause.D & Temple V 1998, Maintenance management In: 'Water system operation and maintenance workshop, Session notes, Denver, Co.