DEVELOPMENT OF A RELIABILITY PROGRAM FOR ADJUSTING AIRCRAFT FUNCTIONAL CHECK TASK INTERVALS

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Abstract. This article introduces a methodology for adjusting aircraft functional check task intervals. The alternatives for collection, monitoring and data analysis during aircraft operation are considered. A data collection system and storage for functional check tasks are being developed so that the quality, integrity, transparency and composition of the information will be guaranteed. Methods to analyze results using the Potential-Functional failure curve are evaluated. Criteria for determining the effectiveness of tasks are under review. Main problems and possible next steps for future works are also presented.

Keywords: aircraft maintenance, reliability program, reliability centered maintenance

1. INTRODUCTION

In the aviation industry maintenance is considered as a key in helping airlines to succeed. It seeks to provide the maximum availability at a low cost attending to safety, operational and environmental requirements. As a result, to maximize the airline's profitability margin it is desirable to operate some components near to their failure point. This goal is achieved through the reliability programs since they contribute to improve operator's programs minimizing their costs.

At the moment there hasn't yet been developed a program for adjusting intervals based on operational observation for the Embraer 190 Class aircraft. This study intends to show the guidelines to modify Maintenance Review Board Report functional check task intervals using Reliability Centered Maintenance concepts.

1.1. Data for Reliability Centered Maintenance

Reliability programs can be defined as a set of rules and practices for managing and controlling a maintenance program. The main function is to monitor the performance of the fleet and their associated equipment to catch attention for corrective action. Identification, calculation, establishment and the determination of what data to track are basic functions.

They are also responsible for collecting, filtering, and displaying this data and performing the preliminary analysis to identify possible changes to the program. As a result any tentative to modify or adjust task intervals must be through a reliability program approved by the aviation regulatory authority.

A data collection system is necessary to obtain reliable data from aircraft in operations to be able to justify an adjustment of intervals. The proposed data collection system requires modifications of the functional check (FNC) related task cards in order to obtain data.

Data integrity is the condition in which data are identically maintained during any operation, such as transfer, storage and retrieval. It is achieved by preventing accidental or deliberate but unauthorized insertion, modification or destruction of data in a database. Data will be managed by Technical Records assuring integrity. The methodology also recommends direct communication between mechanics and engineers to assure data integrity. Method & Standards Department establishes all the procedures, for filling out the task cards and other documents before the Reliability Department obtains them.

To assure data quality it is necessary to have the correct information (such as Aircraft event, Flight hours and landings, LRU removals, Scheduled maintenance) related to the event, in order to perform statistical analysis.

It would be ideal for the manufacturer to have a system (in place) that allows for the collection of data obtained during the operator's task accomplishment and then to enter them in a standardized format into its data collection system. Still this is very difficult to achieve due to external factors (such as different networks, platforms, hardware, etc). In consequence, it is advisable to use in-service data in a standardized format (ATA Spec 2000 Chapter 11 format or equivalent) as deemed acceptable by the regulatory authority to ensure data quality and integrity. This methodology includes the standardization proposed by ATA SPEC 2000 Chapter 11 and Issue Paper 44 Part 5.

2. FUNCTIONAL CHECKS

These tasks evolved from the On Condition process (MSG-2). Their objective is to detect an item's reduction in resistance to failure taking into consideration an interval between the deterioration condition and the presence of a functional failure. Possible outputs of these tasks are:

1. Corrective action must be taken when the inspection reveals a potential failure.

- 2. No action will be taken if there isn't a potential failure condition.
- 3. Only inspection activity will be considered for task evaluation.

2.1. Potential-Functional Failure (P-F) Curve

The behavior of an on-condition item can be represented in general terms as displayed in "Fig. 1."



Figure 1. Typical behavior of an On-condition item

Due to age and failure mode, the item will start to reduce its failure resistance until it reaches functional failure (defined as a % of failure resistance). Then a potential failure condition (B) is determined.

After choosing this point, the next step is to determine the PF interval. Presently, the procedures don't include instructions to monitor the item's deterioration. Instead, inspections executed during the PF interval, lead to one of the three outputs (corrective action, no action or task evaluation) mentioned above.

Tracing the whole curve, it is possible to determine realistic behaviors based on statistical analysis and in consequence to verify (extension and adjustment of) of inspection intervals.

2.2. Multiple Symptoms

Failure modes that have multiple symptoms of the impending failure offer a great deal of flexibility in the choice of tasks to perform for detecting the failure. Each one has a different P-F interval, and it is important not to treat them as equals in the analysis. Every symptom will arise at different times in relation to the functional failure (FF). An example of this would be a bearing failure. The first symptom may be unusual vibration detectable by vibration analysis around six months before FF. The second symptom may be sound detectable at three months using airborne ultrasound. The third symptom may be increased heat detectable at one month prior to the bearing failing. Treating these symptoms as similar P-F intervals and inspection methods can lead to extensive downtime due to the use of the wrong tool at the wrong time. A graphical representation of multiple P-F intervals is shown on "Fig. 2."



Figure 2. Multiple P-F intervals

2.3. M-F Curve

There is another important point often labeled M, that often lies between points P and F and it is set as the minimum time span maintainers have to react after having noticed a failure in progress, before the functional failure takes place with all the undesirable consequences. The concept is shown on "Fig. 3."



Figure 3. M-F Interval

For example, considering the case of a sealing gasket of a water pump whose failure mode of concern is leakage due to erosion; if this is set to 1 liter per day as the maximum allowable (the standard according to RCM) and it takes about one day to plan the maintenance task (switching to another pump without too much inconvenience), the M-F interval would be set to 1 day. In this case point P illustrates the condition when the leakage becomes evident to the operator crew under normal circumstances, (one drop per day perhaps). To estimate this value, it is important to know about preventive and corrective maintenance actions, times, etc; of each item. Maintenance crews are also a valuable source of information.

3. METHODOLOGY

A methodology is necessary to help manufacturers and operators during the whole process. It is divided in 18 steps. One output of this work will be the On Condition Task Evaluation Card (OCTEC); this card will offer a systematic way to identify; record, analyze and decide which tasks can be adjusted.

3.1. General Steps

- 1) Identify which task from the MRBR can be included in the program.
- 2) Identify the item that is involved in the task.
- 3) Give a brief description of the task.
- 4) Record the preliminary task interval.

5) Record the failure category consequence.

- 6) Record the on condition characteristic to be measured.
- 7) Record the inspection technique.
- 8) Record the potential failure limits and units.
- 9) Record the functional failure limits and units.
- 10) Define the optimized P-F interval given by the analysis.
- ** Procedures 11 to 13 for safety consequences or 14 to 17 for non-safety consequences **
- 18) For each case (safety or non-safety), determine if the new interval is cost effective.

3.2. For Safety consequence tasks

11) Estimate the acceptable probability of failure.

12) Calculate the number of inspections required N.

13) Calculate the probability of failure achieved.

3.3. For Non - Safety consequence tasks

14) Determine if the failure involves operational consequences.

- 15) Determine if the failure involves high repair costs or expensive operational costs.
- 16) Record the number of required inspections n.

17) Determine if applicable data show desirability of the proposed task.

4. ANALYSIS: GUIDELINES

The study starts with the identification of tasks from the Maintenance Review Board Report Manual (MRBR) of the Embraer 190 aircraft whereby the methodology can be applied.

The experiment is being carried out at a mid-sized airline that operates 15 Embraer 190 aircraft with different flight hours and operational conditions. One task has been chosen for the case study. Based on that task, the methodology is being applied, starting with the selection of the right inspection technique. Different values for probabilities of detection (POD) are specified depending on the technique used.

Due to the company's policies, the respective task card won't be modified during maintenance tasks, however a new card will be proposed for the moment until the airline decides to include this methodology in actual maintenance practices.

On the other hand, procedures indicating when, how and what to measure are going to be specified in order to obtain reliable data from fleet operation. Different types of curves will be analyzed. This data is going to be used to plot P-F curve (potential and functional failure limits) using information from maintenance crew. Using Microsoft Office Excel Software is it possible to obtain graphical options such as a trend line of the curve. It is going to be used to establish a predictive equation and its level of correlation. Different curve fitting methods may become necessary as new results are obtained. "Fig. 4" below represents a partial P-F curve deduced with the data obtained from May 1st, 2009 to present time (August 15th, 2009).



Figure 4. Estimated P-F Curve (until August 25th, 2009)

As the data was taken from aircraft with different flight hours operating under variable conditions, some scatter in the measurements is observed in the results above. The variation is expected to diminish when data from individual aircraft is analyzed separately.

Using this kind of curve it is possible to obtain the interval P-F, and the next step will be to estimate the number of inspections "n".

Procedures to determine if this new interval is cost effective will then be stipulated.

5. CONCLUSIONS

The study is still under way. The goal of the present work is to demonstrate that it is possible to use measurements in operations to reach more realistic intervals. In this way two objectives can be achieved: the extension of the intervals and the reduction of maintenance costs. The proposed method can be used with any of the identified tasks from the MRBR. More conclusions are going to be set after obtaining the final results.

5.1. Main Problems

The two main problems found until now are:

- 1. The difficulty to demonstrate to the operators that these kinds of methods can offer a new possibility for saving costs.
- 2. The problem of convincing mechanics and maintainers to take "additional" steps when executing tasks.

5.2. Next Steps

So far, four key steps to continue with this study have been identified:

- 1. Embraer Analysis: It would be interesting to present this work to related departments in Embraer so they can include other feasible improvements that will help to make this methodology a standard when developing new versions of the maintenance manuals.
- Include other tasks from the MRBR: Another proposed step is to continue this study using the other tasks from the MRBR, including Servicing, Restore, Discard and Operational Check tasks. Data from operation will be desirable to change task intervals in order to minimize costs.
- 3. Fleet Campaign: A fleet campaign can be established in the airline or any other interested operator in order to obtain more data of related items that are used in different operations
- 4. Scheduled Work Data: Finally this work can help as a reference to implement a new system for sharing scheduled maintenance data between operators and Embraer. Until now only data from non-scheduled work is sent to Embraer.

6. REFERENCES

Air Transport Association - ATA MSG-3, 2007, "Operator/Manufacturer Scheduled Maintenance Development", Revision 2007.1".

Firoozmand, Farhad, 2008, "Reliability Centered Maintenance", Embraer-PEE Program, ProgConfiabilidade.pdf, S.Paulo, Brazil, 85 p.

International Maintenance Review Board Policy Board, April 2008, "Evolution / Optimization Guidelines" Issue Paper 44, 13 p.

Kinnison, Harry, 2004, "Aviation Maintenance Management, USA, 295 p.

7. RESPONSIBILITY NOTICE

The authors are the only responsible for the material included in this paper.