Aircraft Maintenance Data Evaluation Method Applied to Integrated Product Development Process

Authors:
Fabiana Cristina C. Gonçalves Teixeira
Luís Gonzaga Trabasso
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Agenda

- Motivation;
- Purpose;
- Background – Context;
- Method – Application;
- Results Analysis;
- Conclusion.
Motivation

- Preventive maintenance is placed as a regulation to assure airworthiness condition (FAA, 1998);
- Initial Maintenance Review Board Report (MRBR) uses in service operation experience as a reference to define maintenance tasks intervals;
- Regulatory authorities became more restricted while evaluating preventive tasks interval changes to fleet in operation.
Purpose

- Present a method to evaluate the schedule maintenance tasks accomplishment database;
- Propose reviewed maintenance tasks intervals to systems similar to aircrafts under development;
- Achieve Direct Maintenance Cost reduction; Influence Integrated Product Development process.
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Background – Maintenance Review Board Report (MRBR)

Beginning: Aeronautic bulletin 7E dated on May 15th 1930.

Reason: Maintain the inherent safety and reliability levels of the aircraft and its components.

Historic:

- 1936 - ATA was created by American Airlines in order to establish standard rules;
- 1968 - Maintenance Steering Group 1 (MSG-1) applied to B-747;
- 1970s - Maintenance Steering Group 2 (MSG-2);
- 1980 - Maintenance Steering Group 3 (MSG-3);

References: FAA, 1997; Airworthy, 1930.
Background – MRBR

MSG-3: - Analytical methodology
- ATA property;
- Reviewed by Maintenance Programs Industry Group – MPIG and approved through International MRB Policy Board - IMRBPB (EASA, 2010).

MRBPB (International Maintenance Review Board Policy Board):
- Policies development, procedures and guidelines to operators part of MRB process.
- Subjects related to MRB process through documents called Issue Papers (IP) (EASA, 2016).
Background – Issue Paper 44

- IP-44 – allows commercial aviation manufacturers to evaluate maintenance tasks intervals before EIS (Entry-Into-Service) in accordance to the authorities’ viewpoint;
- Suggests statistical models use to evaluate tasks intervals.
Background – Integrated Product Development

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Proposed Method

1. Select aircraft system
2. Select task
3. Collect task accomplishment field data
4. Apply procedure to optimize task interval from fleet in operation
5. Propose task interval to new aircraft under development
Method – Procedure to optimize intervals

The method consists in:

• Select aircraft system and task;

• Compare system under development and in operation and decide if it is feasible to use field data to apply procedure to optimize task interval from fleet in operation;

• When applicable, use operational performance experience (based on preventive maintenance tasks accomplishment) to define new maintenance tasks before fleet entry into service.
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Selected System: pilot and co-pilot seats;
Task: detailed inspection;
Purpose: check for degradation, damage and wear;
Justification: mandatory tasks in all commercial aircrafts
Method - Application

- **Select System**: pilot and co-pilot seats.

Analysis considerations:

- **System operation type**: regular. It is not expected relevant difference on the system in operation and under development in the same manufacturer.

- **Operation system maturity**: mature, it is expected regular performance.

- **Field data availability/ minimal sample available**: There are more than 780 aircraft in operation with the same system and fleet leader has flown more than 20,000 flight hours.

- **Data collection feasibility**: Field database containing task accomplishment available to manufacturer.
Method - Application

- **Select Task:**
  - <Detailed Inspection>;
  - Essential system to commercial fleet selected and with field data available
  - Tarefa MRBR: 25-11-01-002
  - The task type selected is <Detailed Inspection> because collected data analysis is more objective and does not demand complex analysts’ evaluation.
Método Proposto - Aplicação

- Collect field data related to maintenance task accomplishment in order to optimize intervals:
  - Aircraft serial number;
  - Cumulative Flight Hours and Cycles;
  - Aircraft delivery date;
  - MRBR task number;
  - Task accomplishment result.

Collect task accomplishment field data

Apply procedure to optimize task interval from fleet in operation
Method – Procedure to optimize intervals

- Collect interval recommendations from different sources;
- Classify information according to its degree of confidence:
  - Group 1: low confidence level;
  - Group 2: intermediate confidence level;
  - Group 3: high confidence level.
### Method— Procedure to define new intervals (necessary resource)

<table>
<thead>
<tr>
<th>Information Source</th>
<th>Value</th>
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<tbody>
<tr>
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</tr>
<tr>
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<td>manufacturer)</td>
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Method – Procedure to define new intervals

Start

Collect field data available to system under evaluation. Complete table with recommended intervals.

Is task interval part of system certification process?

Yes

Discard from table intervals higher than established by certification process

No

Development engineer requirement approach not applicable

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Method – Procedure to define new intervals

Is MSG-3 task category 6, 7 or 9?

- Yes: Accomplish economic analysis
  - Is task applicable and effective according to economic analysis?
    - No: End
    - Yes: Prepare task creation proposal to present at Working Group

- No: Maintenance opportunity evaluation

Failure Effect
- Evident Safety (Category 5).
- Evident Operational (Category 6).
- Evident Economic (Category 7).
- Hidden Safety (Category 8).
- Hidden Non-Safety (Category 9).
Method – Economic Analysis

- Aircraft panels and access to be removed before task accomplishment;
- Task needs to be performed in line, overnight or only in heavy checks;
- Estimated labor hour to accomplish task. Consider if it is required interior, engine, APU removal etc.;
- Verify multiple tasks intervals values and if it is possible to include task in main packages.
Method - Application

Minimal sample to finite population

\[
n = \frac{N \cdot p \cdot q \cdot z_{\alpha/2}^2}{(N - 1) \cdot e^2 + p \cdot q \cdot z_{\alpha/2}^2}
\]

where:
- \( n \) = minimum sample size expected for finite population;
- \( z_{\alpha/2}^2 \) = critical value of the desired confidence level;
- \( p \) = expected proportion of favorable results in the population;
- \( q = (1-p) \) = (expected) proportion of unfavorable results in the population;
- \( e \) = accepted error;
- \( N \) = finite population size.
Method - Application

Minimal sample to finite population

\[
n = \frac{2487 \times 0.9 \times 0.1 \times 1.96^2}{(2487 - 1) \times 0.04^2 + 0.9 \times 0.1 \times 1.96^2} = 199
\]

\[z_{\alpha/2}^2 = 1.96 \text{ (equivalent to confidence level of 95%);\}
\]

p= 90%
q= 10%
e= 4% (for task category 8)
N=2487 (total expected task accomplishment considering fleet operational data from beginning of operation until evaluation date).

Collect task accomplishment field data

Apply procedure to optimize task interval from fleet in operation
Method - Application

1. Collect task accomplishment field data
2. Apply procedure to optimize task interval from fleet in operation

**MRBR Task 25-11-01-002**

**Total Population: 2487**
(Expected Preventive Maintenance Interventions)

- ASIA-PACIFIC: 335
- CHINA: 106
- EUROPE: 461
- LATIN AMERICA: 443
- MIDDLE EAST & AFRICA: 1164
- USA, CANADA & CARIBBEAN: 378

**Minimum Sample Amount: 199**
(Field Data Minimum Amount)

- ASIA-PACIFIC: 11
- CHINA: 9
- EUROPE: 37
- LATIN AMERICA: 35
- MIDDLE EAST & AFRICA: 93
- USA, CANADA & CARIBBEAN: 14
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Method - Application

Collect task accomplishment field data

Apply procedure to optimize task interval from fleet in operation
Method - Application

Statistical assumptions:
- Normal distribution, \( n \geq 30 \).
- Confidence interval = 95%.
- Reliability adopted: 85%.
- Action tool, a MS Excel™ supplement, was used.
- The indicated value for the task, is approximately \( 20,000 \) flight-hours.
## Method - Application

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Define proposal to define task interval to new aircraft under development

Note: MTBF and MTBUR recommendations were not considered in this analysis because it is not expected pilot and co-pilot seat removals in commercial fleet in operation.
Method - Application

Define proposal to define task interval to new aircraft under development

Maintenance packages:
- 3,000 Flight Hours or multiple

Interval to be proposed to Working Group:
- 12,000 hours
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Results Analysis

- Entry Into Service – field data statistical analysis;
- MSG-3 systems – similar systems established;
- Proposed Method x Industry practice;
- Out-of-phase tasks.
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Conclusions

- Procedures application: feasible and valid;
- Purpose reached: maintenance accomplishment database structured, tasks intervals adequate (DMC reduction), relevant information to IPD process;
Conclusion – cont.

- It was feasible to propose a task interval 100% higher than the reference;
- Fleet entry-into-service with more accurate MRBR, which means cost reduction to operator;
- Unscheduled interventions quantity reduction in the beginning of fleet operation.
Aerospace Technology Congress
11-12 October 2016, Solna, Stockholm

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