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Aircraft Maintenance Data Evaluation Method Applied to Integrated Product Development Process

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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 stablish 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).

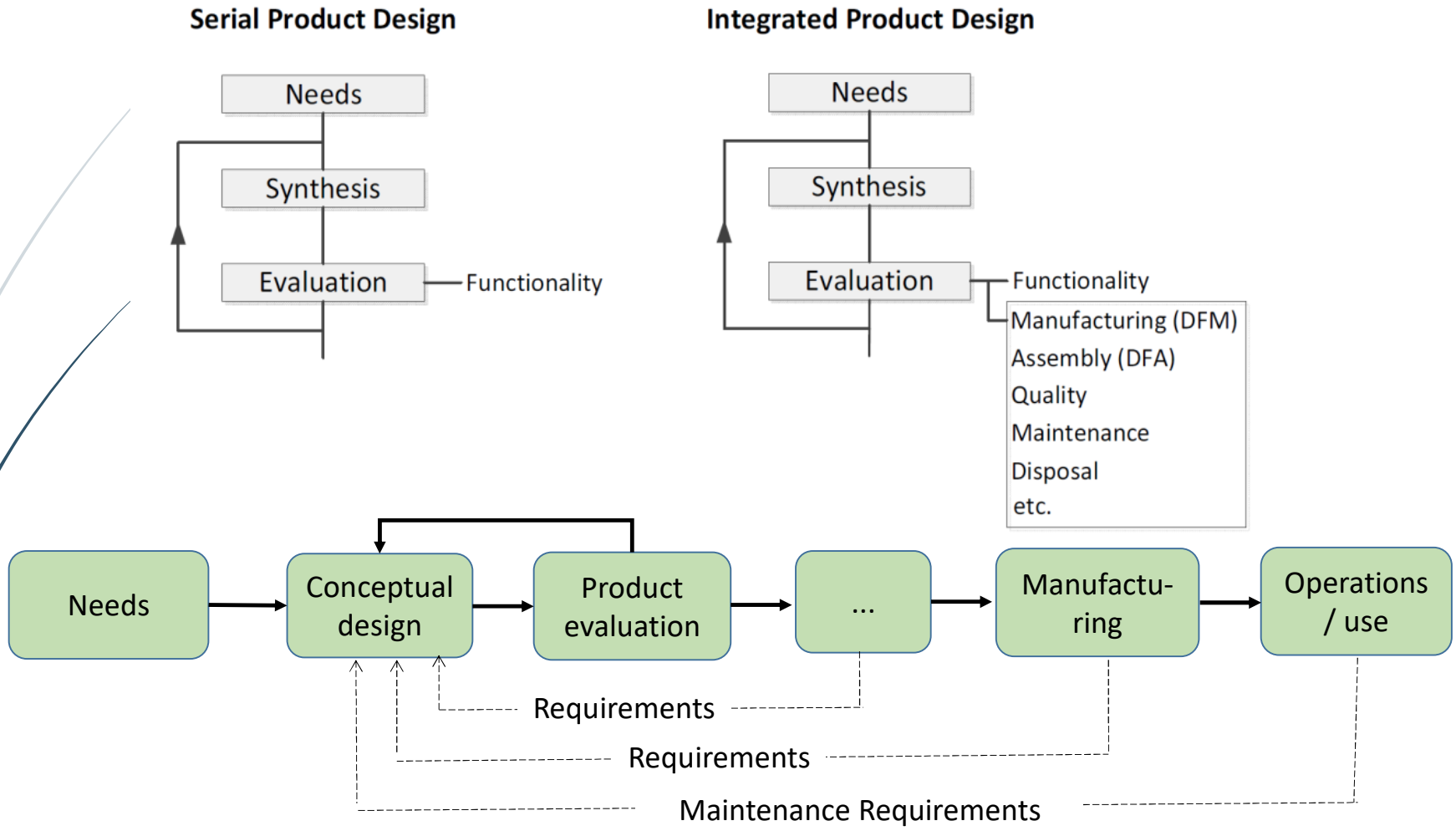
MRBPB (*International Maintenance Review Board Policy Board*):

- 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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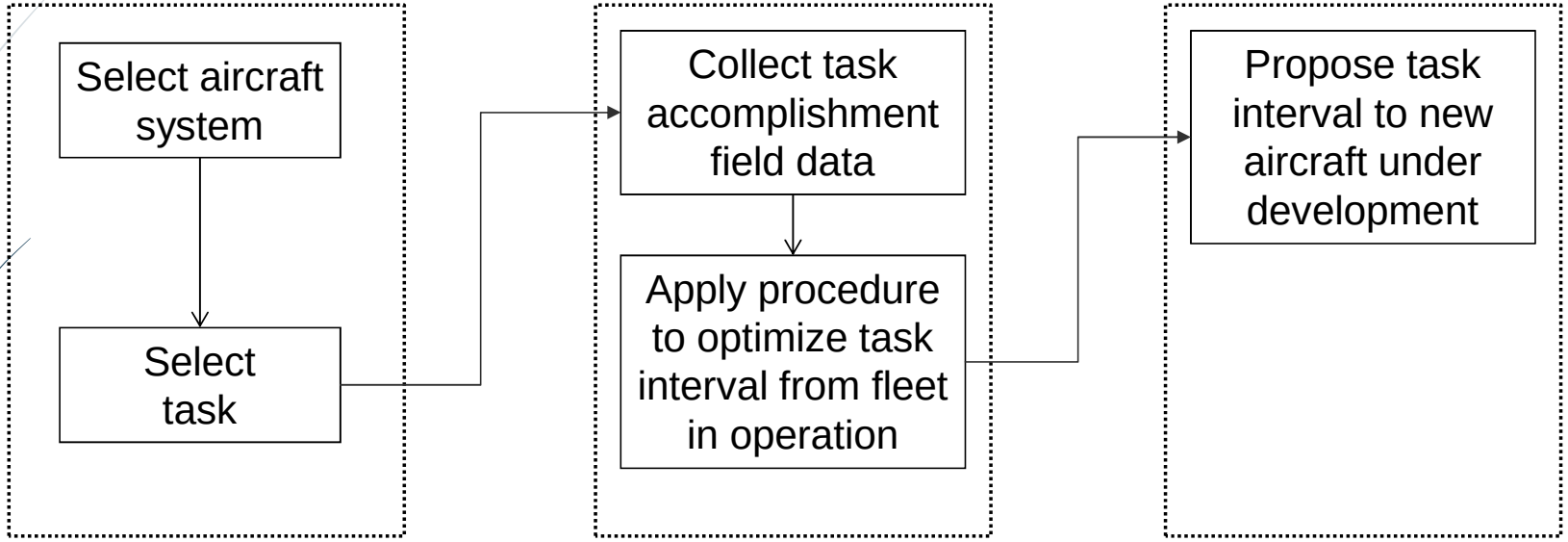
Proposed Method



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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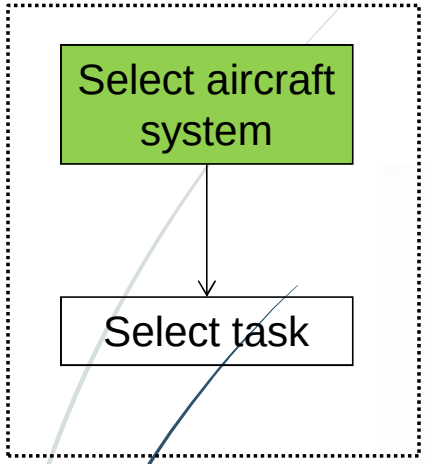
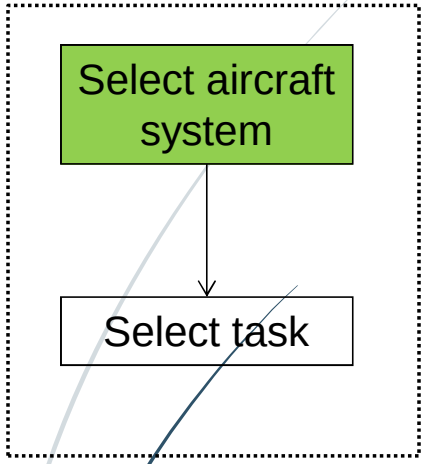
Method - Application



- **<u>Selected System</u>:** pilot and co-pilot seats;
- Task: detailed inspection;
- Purpose: check for degradation, damage and wear;
- Justification: mandatory tasks in all commercial aircrafts

Method - Application

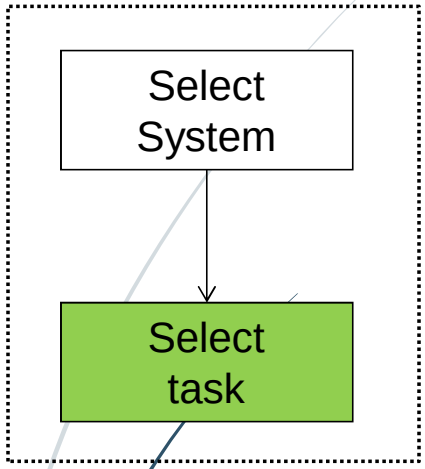


- **Select System**: pilot and co-pilot seats.

Analysis cconsiderations:

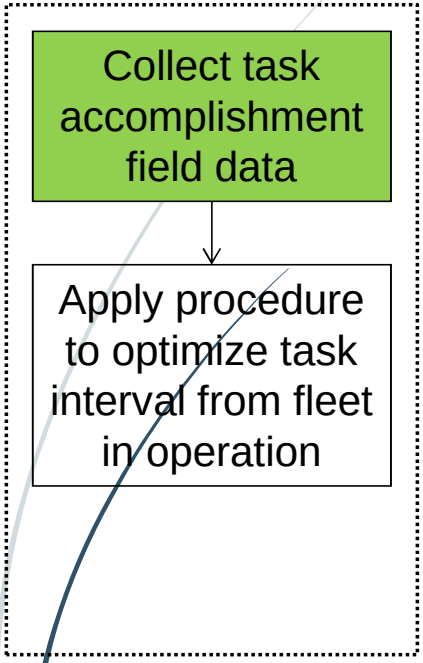
- **System operation type:** regular. It is not expected relevant difference on the system in operation and under development in the same manufacturer.
- **Operation system maturity:** mature, it is expected regular performance.
- **Field data availability/ minimal sample available;** There are more 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



- **<u>Select Task</u>:**
- <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.

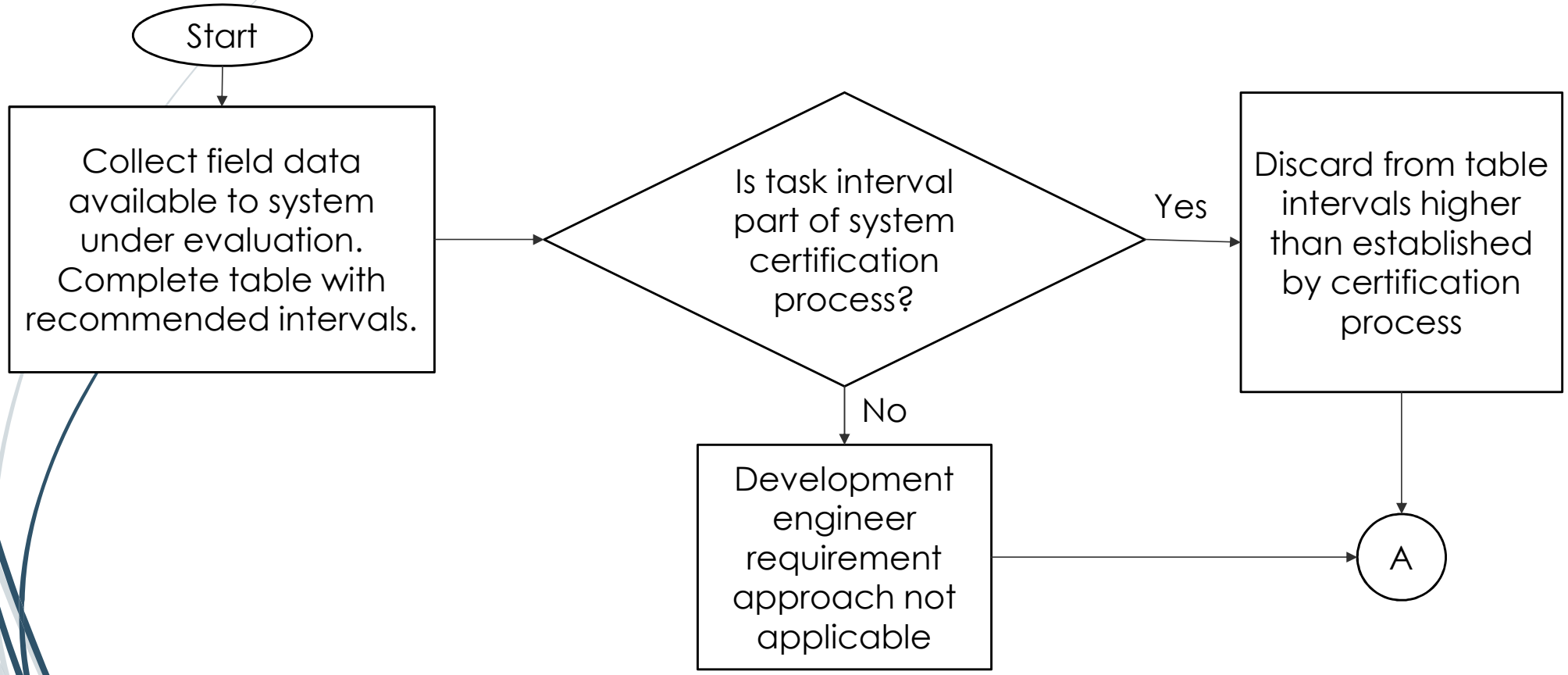
Method – Procedure to optimize intervals

- 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.

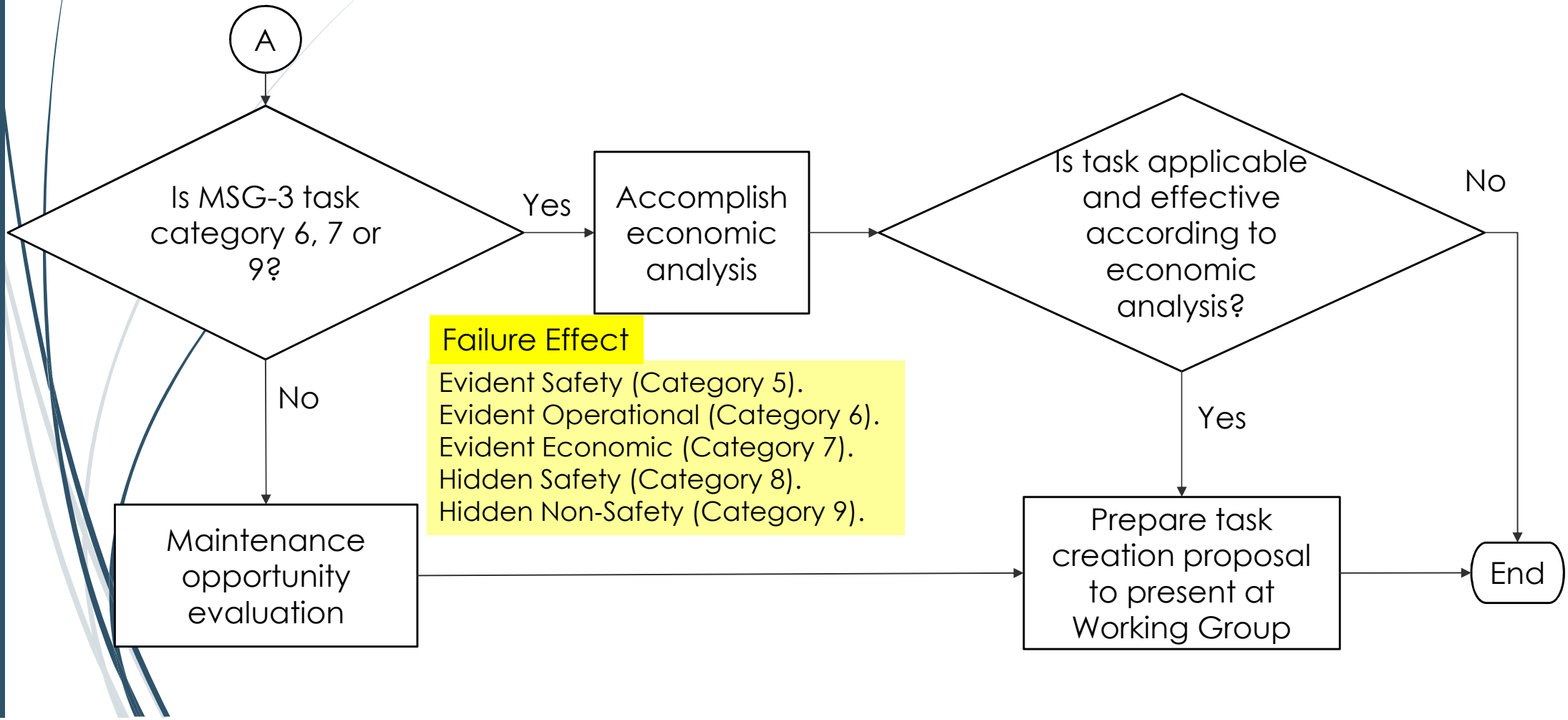
Method– Procedure to define new intervals (necessary resource)

Information Source	Value	Information Group
Recommended MTBF (Mean Time Between Failure) through theoretical data		Group 1
Equivalent system's (in operation in different fleets) CMM (not considering the manufacturer)		Group 1
Recommended MTBF by supplier for similar system		Group 2
Field MTBUR (Mean Time Between Unscheduled Removal) for similar system		Group 2
Supplier Recommendation for his own system		Group 2
MTBF based on supplier tests for components under development		Group 3
MTBUR of components of identical system in operation		Group 3
Task interval of identical/ similar system stated in the MRBR or optimized according to intervals optimization procedure.		Group 3
Task Interval recommendation made by the Development Engineering		Group 3
Task Intervals between tasks executions used in order to certify the system with regulatory authorities		Group 3

Method – Procedure to define new intervals



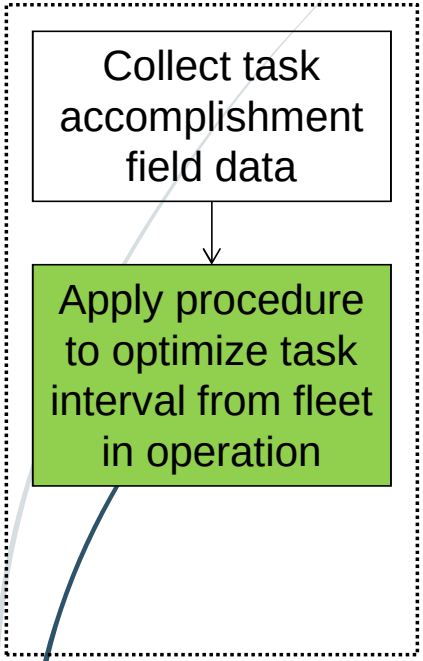
Method – Procedure to define new intervals



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

$$n = \frac{N.p.q.z_{\propto/2}^{2}}{(N-1).e^{2} + p.q.z_{\propto/2}^{2}}$$

where:

n= minimum sample size expected for finite population;

$z_{\propto/2}^{2}$ = critical value of the desired confidence level;

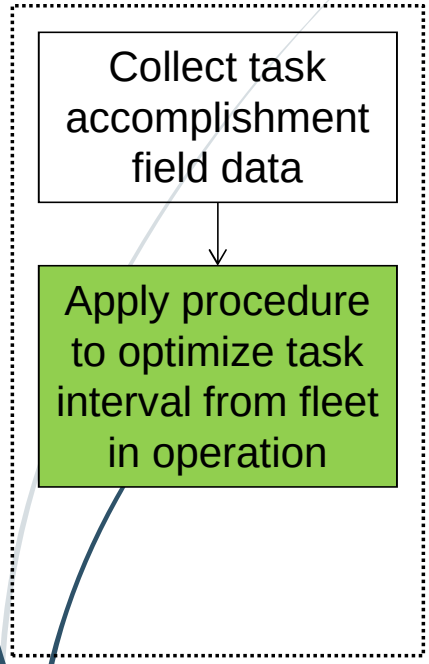
p=expected proportion of favorable results in the population;

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

$$n = \frac{2487x0{,}9x0{,}1x1{,}96^2}{(2487-1).0{,}04^2 + 0{,}9x0{,}1x1{,}96^2} = 199$$

$z^2_{\propto/2} = 1{,}96$ (equivalent to confidence level of 95%);

p= 90%

q= 10%

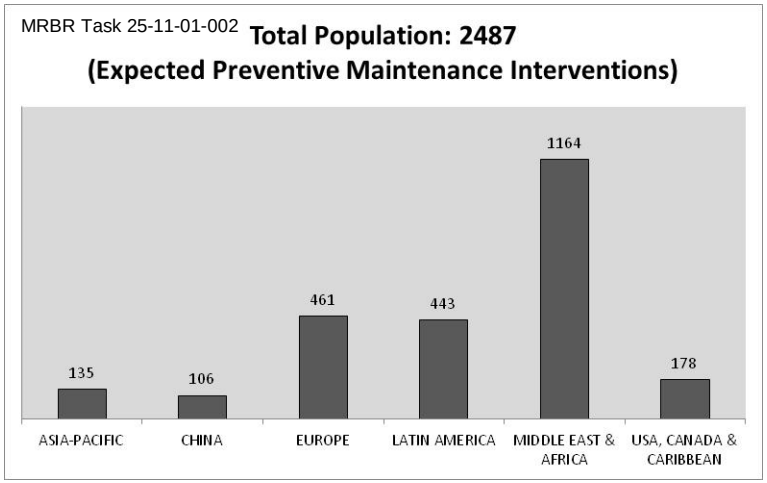
e= 4% (for task category 8)

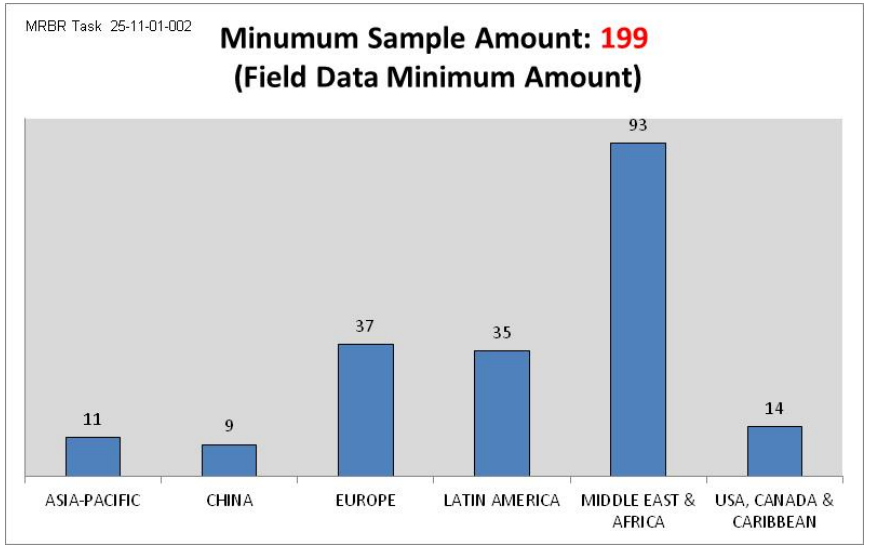
N=2487 (total expected task accomplishment considering fleet operational data from beginning of operation until evaluation date).

Method - Application

Collect task accomplishment field data

Apply procedure to optimize task interval from fleet in operation

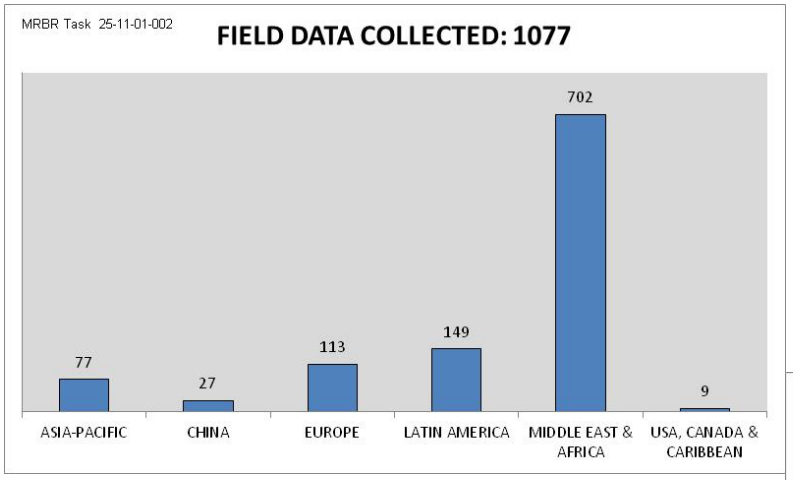


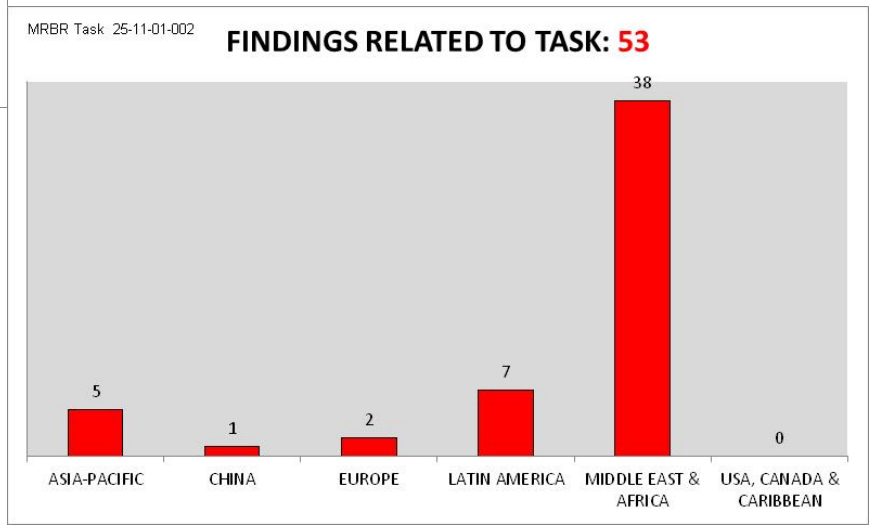


Method - Application

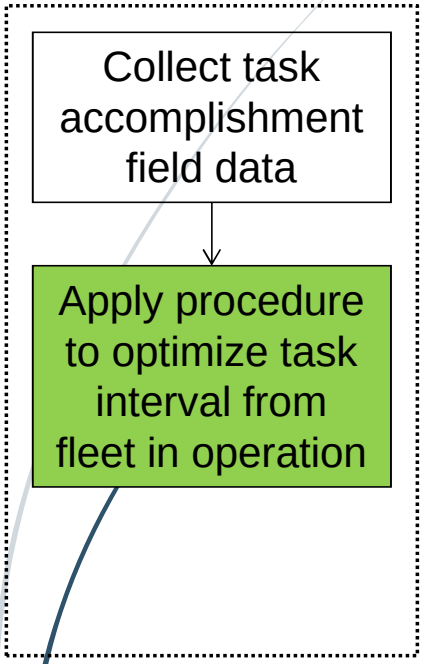
Collect task accomplishment field data

Apply procedure to optimize task interval from fleet in operation



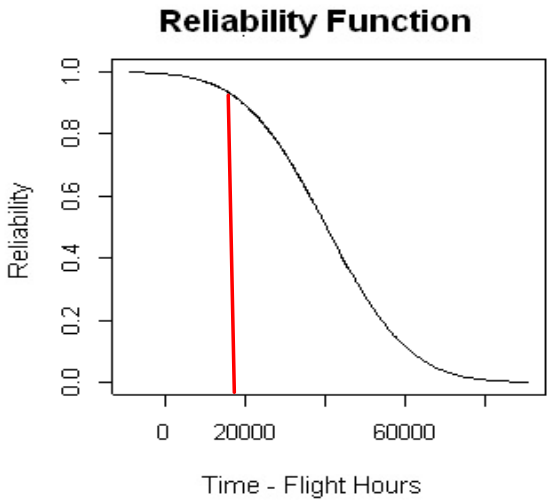


Method - Application



Statistical assumptions:

- Normal distribution, n >=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

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.

Information Source	Value (FH)	Information Group
Recommended MTBF (Mean Time Between Failure) through theoretical data		Group 1
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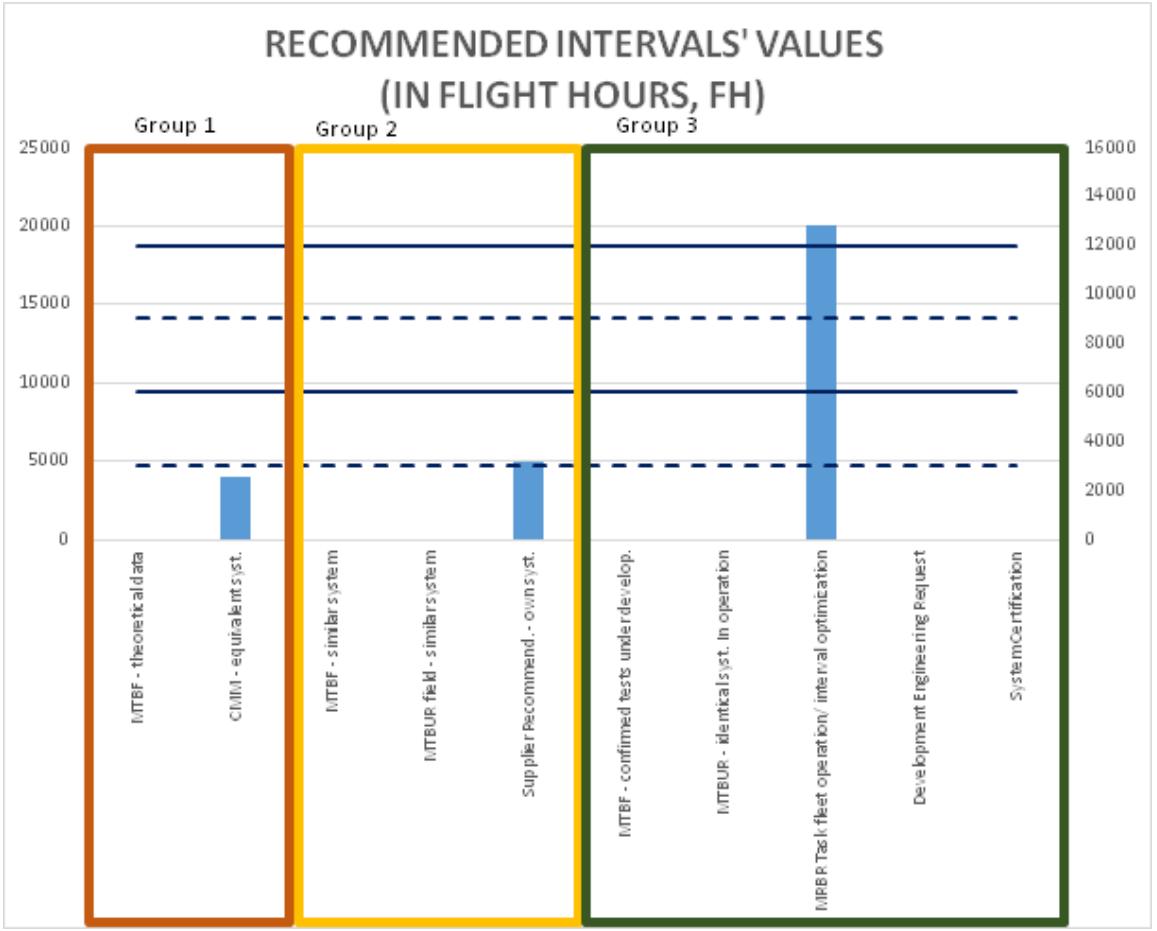
Define proposal to define task interval to new aircraft under development



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.

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