AEROSPACE TECHNOLOGY CONGRESS 2019
SUSTAINABLE AEROSPACE INNOVATION IN A GLOBALISED WORLD
FT2019

AeroLogLab ITA

L8 – 38482 "Prescriptive Maintenance: Building Alternative Plans for Smart Operations"

Henrique Costa Marques – hmarques@ita.br
Alessandro Giacotto – agiacott@ita.br

Context

- Maintenance planning and scheduling
- Commercial aviation
- Line and heavy maintenance
- Reliability Centered Maintenance paradigm
- Focus on the operations performance
- PhD research

Context

Line Maintenance → Turn Around time (TAT)

Heavy Maintenance → Planning and Scheduling

→ Corrective and Preventive Maintenance

→ Non-routine Maintenance

- Time vs Cost
- Pursue to increase efficiency

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Preventive Maintenance

- Preventive Maintenance is based on the assumption that we are capable of maintain a system before the failure occur
- Maintenance schedule based on cycles or flight ours (pure preventive)
- It looks at the supported system, not the maintenance process and resource availability (supporter system)

Preventive Maintenance

- Maintenance is considered a constraint to the operations
- Smart Operations solutions based on Preventive Maintenance are suboptimal given the lack of situation awareness of the supporting system
- We may establish a way to monitor the condition of subsystems and components that will prevent the system from being available, to schedule the maintenance timely (predictive)
  - Such items are the most expensive and/or time-consuming components in logistics terms (maintenance task time and time to acquire a spare part or to repair the item)

Predictive Maintenance

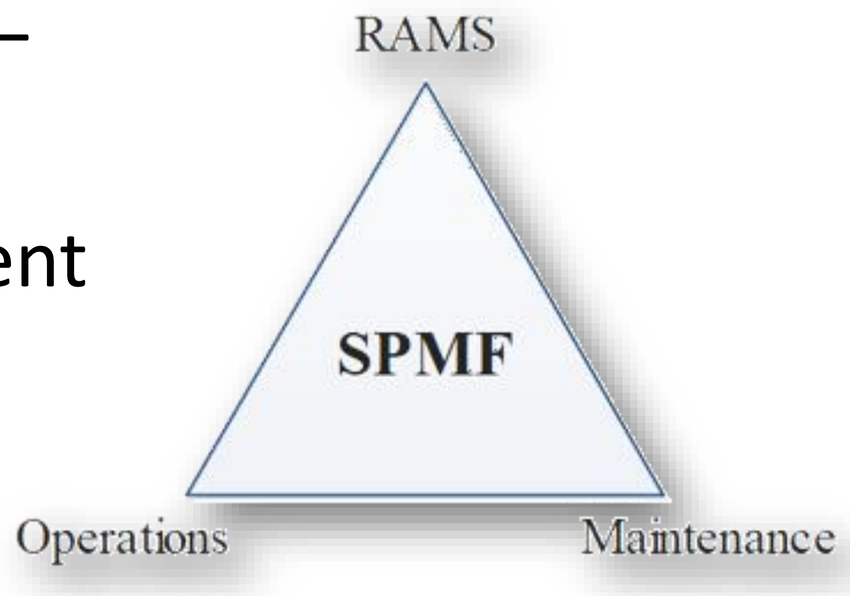
- Predictive Maintenance is the tool to support the Condition-Based Maintenance (CBM) approach
- Makes use of condition monitoring techniques
- To predict is to establish the "when" (Remaining Useful Life) and "why" (failure mode) maintain, given the aspects of a system´s reliability and the perception of its projected future utilization

Prescriptive Maintenance

- Prescriptive Maintenance is context-dependent given the company´s maintenance and operational contexts
- Process powered by IoT (resource management)
- Looks at the “what” (tasks), “where” (shops), and “who” (labor) for maintenance planning and scheduling efficiency
- Smart Operations solutions based on Prescriptive Maintenance may be optimal given the acquired situation awareness of the supporting system

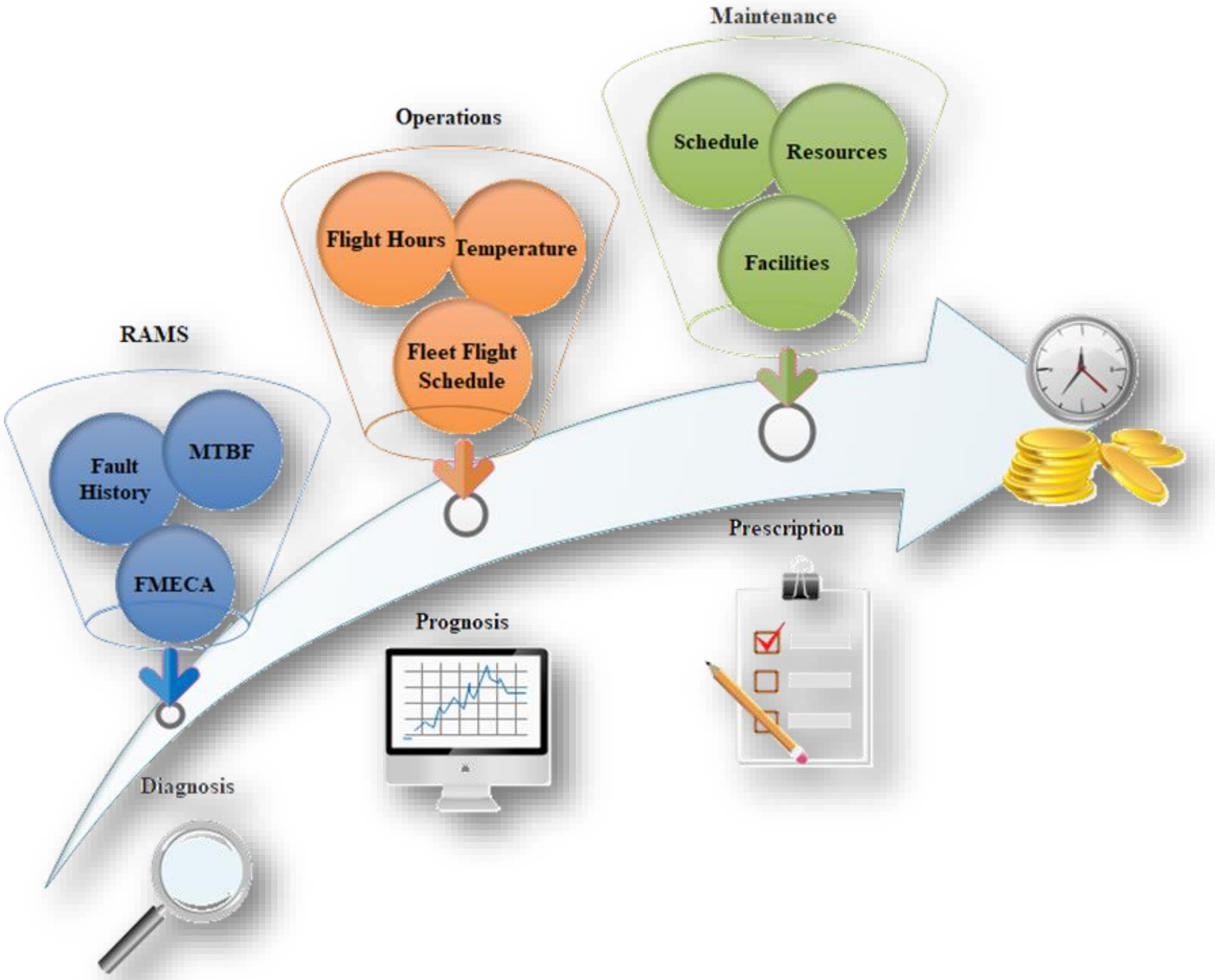
Smart Prescriptive Maintenance Framework

1. **Reliability, Availability, Maintainability, and Safety** (RAMS) – Based on the systems´ design
2. **Operations** – Operational environment and requirements
3. **Maintenance** – Maintenance environment and capabilities

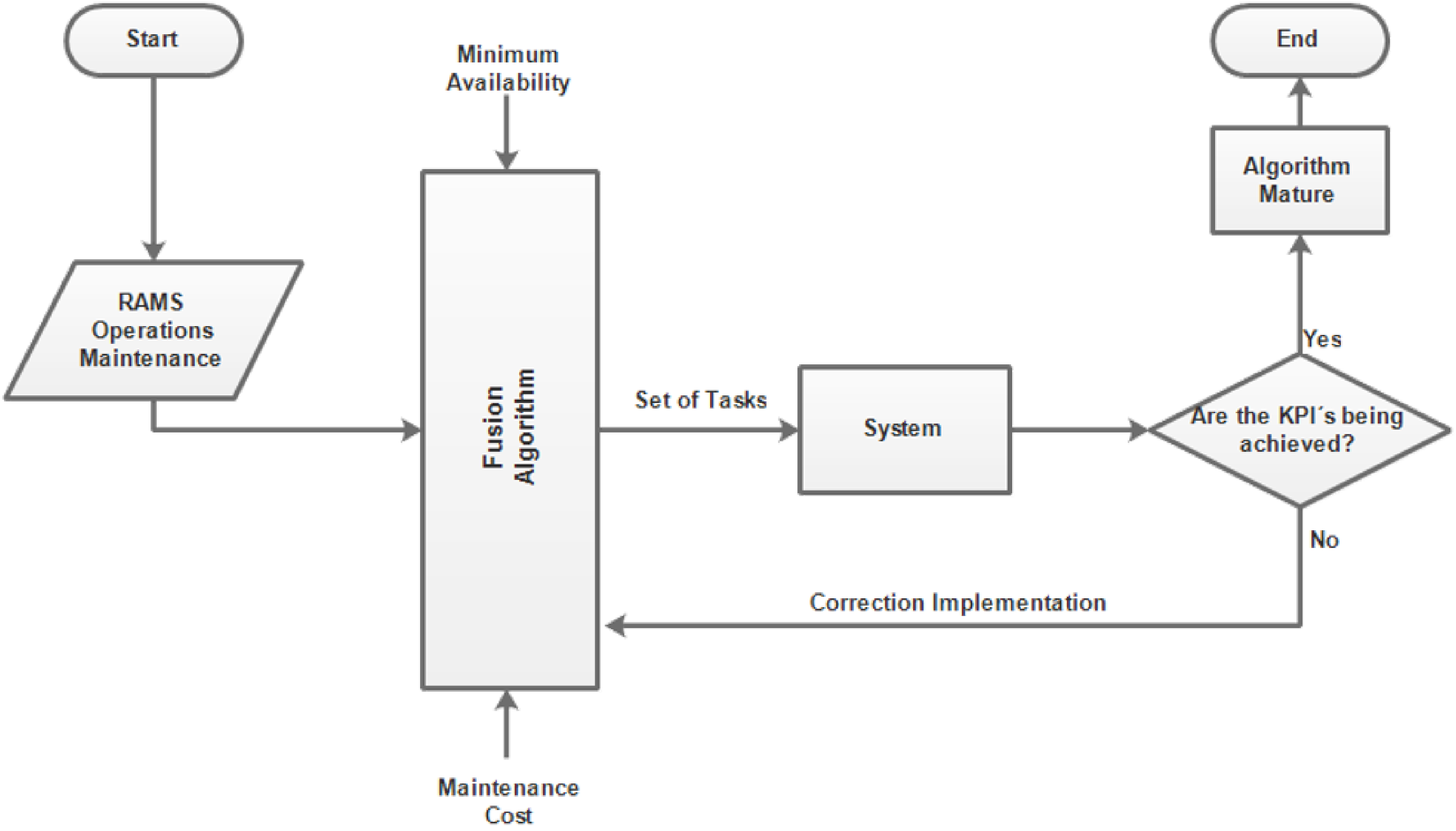


Information Fusion

- **Diagnosis** – identify the potential failure
- **Prognosis** – operational context gives the expected flight hours and environmental conditions to assess the Remaining Useful Life
- **Prescription** – maintenance context gives the maintenance capabilities to manage and execute the necessary maintenance tasks



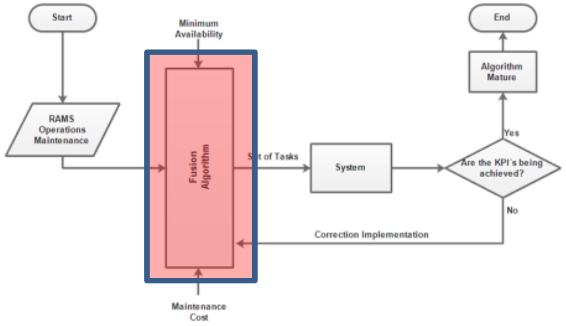
Framework Workflow



Inputs

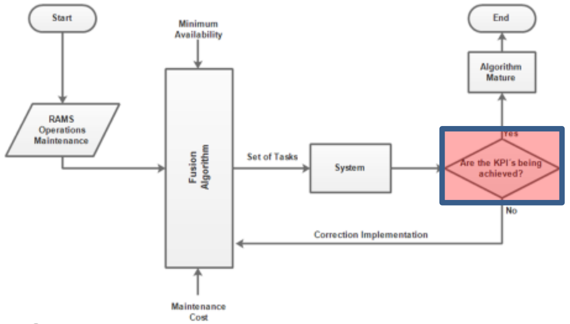
Input	Description
Manufacturer Maintenance Plan	Initial maintenance plan provided by the manufacturer at the aircraft entry into service. It is developed according to MSG-3 principles, and it is updated yearly depending on the commercial agreement between the airliner and the operator
Flight Hour || Flight Cycle	The number of flight hours (FH) or flight cycles (FC) represent the usage of the aircraft, system or specific equipment. These parameters are useful since, very often, the reliability of the equipment is a function of the system usage
Temperature || Humidity	Environmental parameters have to be considered since operational conditions influence the failure rate of the equipment in use
Remaining Useful Life	The remaining useful life (RUL) curve of each aircraft of the fleet should be predicted, based on the expected fleet flight schedule. Thus, some prognostics and health management (PHM) system has to be present in the aircraft to help plan the maintenance schedule. If not present, the fusion algorithm would rely on fault history, making forecastings
"Tribal" Knowledge	"Tribal" knowledge is any information gathered from experience and lessons learned by the team who is responsible for the maintenance execution. This subset of data is often unstructured
Fault History	Historical data of all the equipment faults
Failure Mode and Criticality Analysis	Failure mode and criticality analysis (FMECA) particularly helpful to support inductive AI approaches
Mean Time Between Failures	The mean time between failures (MTBF) represents the expected time between failures of a system, during normal operation
Minimum Equipment List	It details which equipment is allowed to be inoperative without grounding the aircraft
Maintenance Cost	The maintenance cost, which includes man-hour and material related to all aircraft maintenance activities
Fleet Flight Schedule	The schedule of all the company´s flights to be accomplished

Fusion Algorithm



- Artificial Intelligence (AI) problem-solving agent
- Once all the inputs are informed, the algorithm starts to search for the **most probable effective action or sequence of actions** to solve the maintenance problem
- Once the actions are selected, the algorithm recommends the best scheduling according to the minimum fleet availability requirement and the constraint of the direct (DMC) and indirect maintenance cost (IMC), providing, thus, the output of the fusion step

Efficiency Check



- After the implementation of the tasks over the system, the algorithm itself verifies, during the efficiency check, if the maintenance actions are practical, the fleet availability is according to customer's requirement and maintenance costs minimized
- If at least one of the above conditions is not satisfied, then the probability attached to each task is redistributed, and a new set of actions is proposed in the next iteration.

Key Indicators

- Fleet availability and minimization of the system's maintenance cost
  - Is the fleet availability above the threshold aligned with the operator`s intent?
  - Are the DMC and IMC contained in comparison to historical maintenance cost or operator estimates?
- Other performance indicators defined by the user

Extensibility

- Initially the Medical field
- Other possible implementations are being considered

Conclusions

- Work in progress research
- Different configurations in terms of metaheuristics and KPIs to be analyzed

Questions


WHAT?
WHY?
WHERE?
WHEN?
HOW?
WHO?
WHICH?
WHOSE?
WHAT?
WHO?
WHERE?
HOW? WHO?
HOW?

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