Challenges and opportunities for condition-based adaptive aircraft maintenance planning

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Royal Dutch Airlines
Introduction

KLM
• Established: 1919
• Passengers: 34 million p/y
• Destinations: 160
• Fleet size: 120 aircraft
• Employees: 33,000
• Businesses:
  • Passengers
  • Cargo
  • Engineering & Maintenance

Floris Freeman
• Role: Research Lead Condition-Based Maintenance
• Education: MSc Aerospace Eng. TU Delft
• Businesses: Shell (2014-2018)
  KLM (2018-current)
Introduction

Topics
• The rise of Big Data in aircraft maintenance
• Value of predictive maintenance in airline operations
• What is next: 3 enablers for Condition Based Maintenance
Rise of Big Data in Aircraft Maintenance

1. Aircraft Operations
2. Maintenance Planning
3. Maintenance Execution
4. Component Maintenance

- Aircraft Operations
- Maintenance Planning
- Maintenance Execution
- Component Maintenance
FIX WHEN IT FAILS

MAINTENANCE PERFORMED WHEN A PART IS DAMAGED
Value of predictive maintenance in aircraft operations – unscheduled maintenance

1. Flight Schedule

- Prognostic Trigger
- Flight
- Planned
- Flight
- Failure
- Canceled Flight
- Unplanned
- Delayed Flight
- Flight

2. Time

3. Reactive Actions

- Prepare
- LRU Transport ($)
- LRU Replace

4. Predictive Actions

- Component: Major repair ($$$)
- Component: Minor repair ($)

5. Flight Schedule

- Ground
- Planned
- Canceled
- Unplanned
- Delayed
- Flight
3 Challenges

1. **Technical**: Data Abundance Failure Scarcity
2. **Regulatory**: CBM Not an Approved Maintenance Strategy
3. **Operational**: Uncertainty in Maintenance Needs
FREQUENCY OF MOST EXPENSIVE REMOVALS [KLM]

Number of Removals (per aircraft per year)
DATA NEEDS:
- Sensor data
- Maintenance Logs
- Shop records
- External data
- Crew complaints, AC fault messages, etc

TECHNICAL:
DATA ABUNDANCE FAILURE SCARCITY
Enabler 1: Data sharing and Digital Marketplace

DISTRIBUTED ARCHITECTURE
3 Challenges

1. TECHNICAL: DATA ABUNDANCE FAILURE SCARCITY
2. REGULATORY: CBM NOT AN APPROVED MAINTENANCE STRATEGY
3. OPERATIONAL: UNCERTAINTY IN MAINTENANCE NEEDS
Visually check for brake wear, every 100 FC

**Flight Cycle**

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**Brake sensor data**

- Inspect
- Replace
REGULATORY:
CBM NOT AN APPROVED MAINTENANCE STRATEGY

IDENTIFICATION OF HAZARDS AND SAFETY BARRIERS

ASSOCIATED WITH THE CBM SOLUTION
3 Challenges

1. TECHNICAL: DATA ABUNDANCE
   FAILURE SCARCITY

2. REGULATORY: CBM NOT AN APPROVED MAINTENANCE STRATEGY

3. OPERATIONAL: UNCERTAINTY IN MAINTENANCE NEEDS
MAINTENANCE PLANNING DOCUMENT
BY AIRCRAFT MANUFACTURER

FLIGHT HOURS

FLIGHT CYCLE

CALENDAR DAYS

OPERATIONAL:
UNCERTAINTY IN
MAINTENANCE
NEEDS
PROGNOSTICS & DIAGNOSTICS

Maintenance
Trigger

Task
Packaging

Task
Scheduling

OPERATIONAL:
UNCERTAINTY IN MAINTENANCE NEEDS

FLIGHT 1
FLIGHT 2
FLIGHT 3
FLIGHT 4
FLIGHT 5
FLIGHT 6
CREATION OF A DECISION SUPPORT TOOL FOR CONDITION-BASED FLEET MAINTENANCE PLANNING
3 Challenges

1. TECHNICAL: DATA ABUNDANCE FAILURE SCARCITY
2. REGULATORY: CBM NOT AN APPROVED MAINTENANCE STRATEGY
3. OPERATIONAL: UNCERTAINTY IN MAINTENANCE NEEDS
ReMAP

Stakeholders

• European Union Funded H2020 Project
• Consortium of 13 partners from 7 European Countries
• 8 members of Advisory Board (Airbus, EASA, RNLAF, Thales, etc)
6-MONTH DEMONSTRATION IN RELEVANT ENVIRONMENT BY 2021
Summary

- Aircraft data generates value by minimizing **unscheduled** maintenance costs
- Next step: optimize **scheduled** maintenance by addressing 3 challenges:
  
  - **Technical** :: Airlines and OEMs to share data in a fair and compliant way
  - **Regulatory** :: Policies for substituting interval-based tasks by CBM methods
  - **Organizational** :: Prognostics triggers requires adaptive maintenance planning

- In ReMAP, OEMs, OAMs, SMEs, airlines and academia are joining forces to pave the way for condition-based maintenance in airline operations
Questions?

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