Challenges and opportunities for condition-based adaptive aircraft maintenance planning

Floris Freeman

September 2019

Royal Dutch Airlines

KLM

SKYTEAM

AIRFRANCE KLM

ReMAP

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

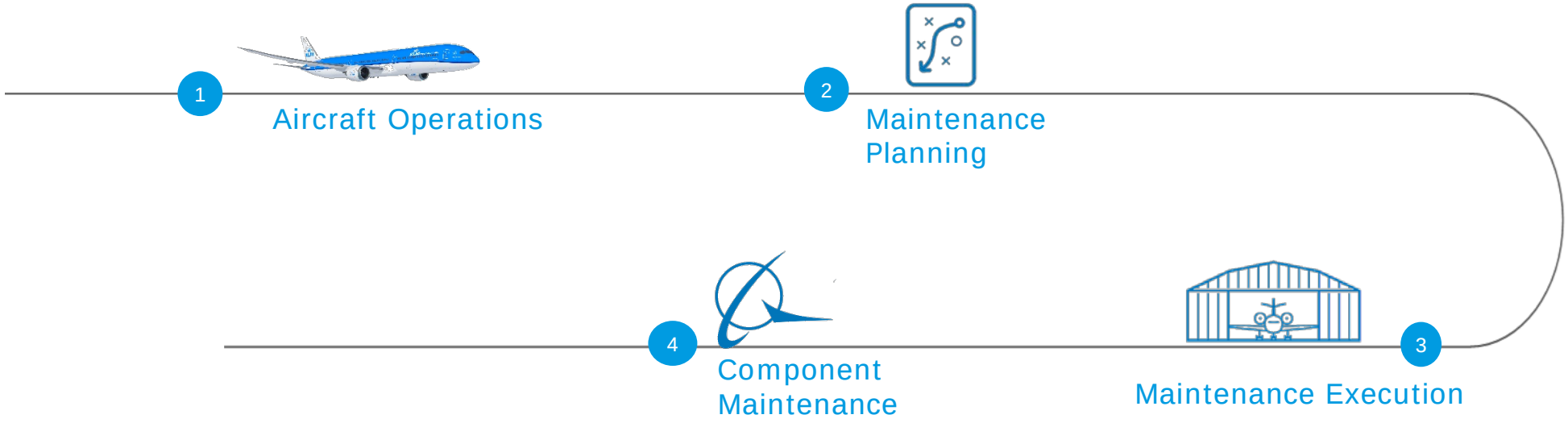
- Role: Research Lead Condition-Based Maintenance
- Education: MSc Aerospace Eng. TU Delft
- Businesses: Shell (2014-2018)
  KLM (2018-current)

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



KLM Royal Dutch Airlines

CURRENT

REACTIVE MAINTENANCE

1

CURRENT

PREVENTIVE MAINTENANCE

2

REACTIVE MAINTENANCE

CURRENT

1

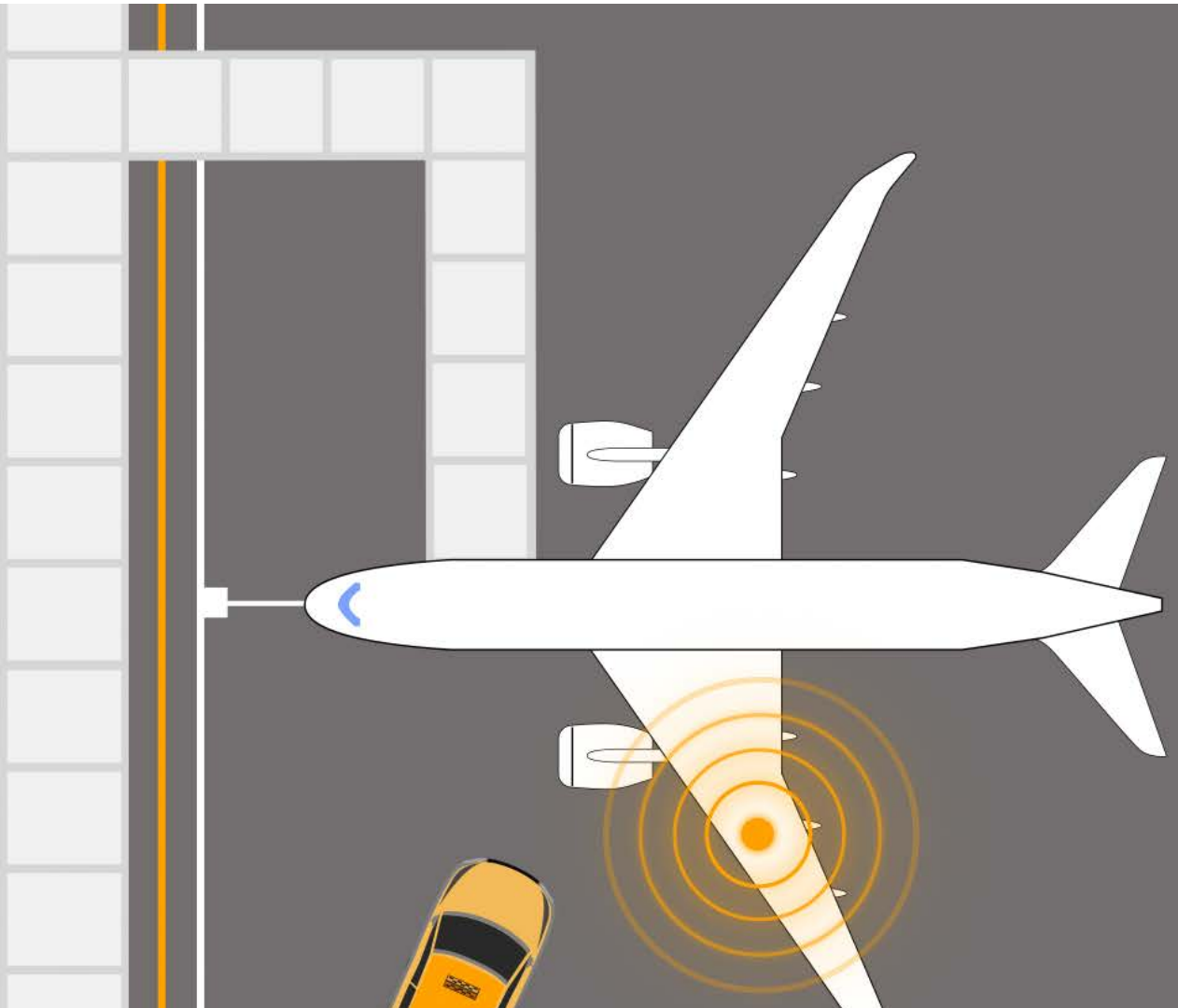
FLIGHT 1

FLIGHT 2

FLIGHT 3

FLIGHT 4

DELAY

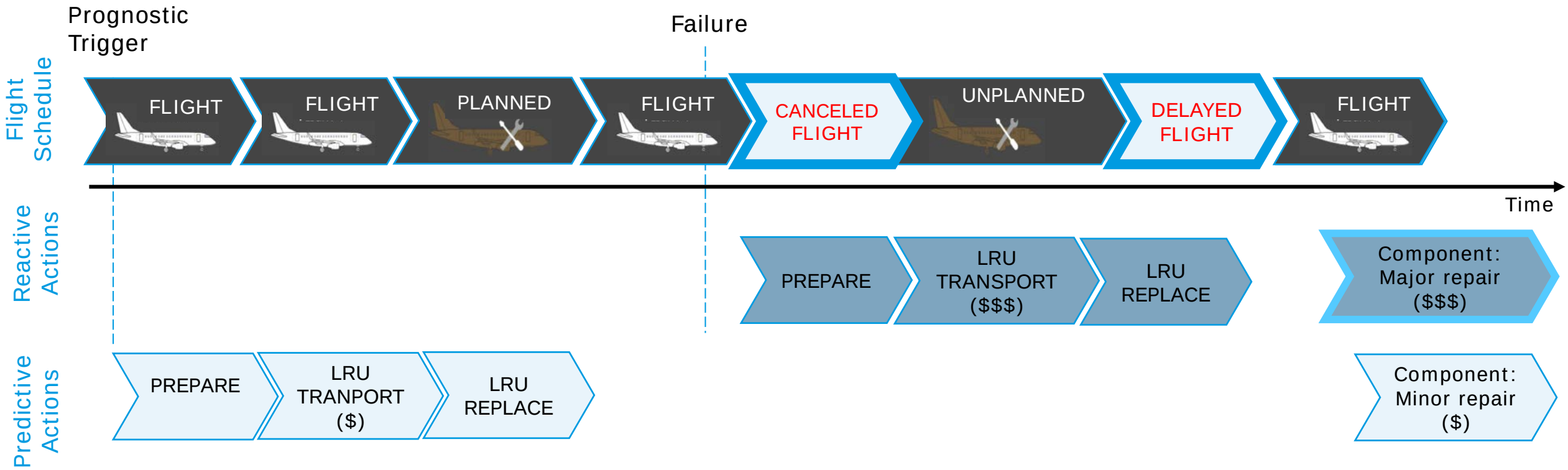


FIX WHEN IT FAILS

MAINTENANCE PERFORMED

WHEN A PART IS DAMAGED

1 Value of predictive maintenance in aircraft operations – unscheduled maintenance



CURRENT

PREVENTIVE MAINTENANCE

2

CURRENT

PREVENTIVE MAINTENANCE

2

FLIGHT 1

MAINTENANCE

FLIGHT 2

MAINTENANCE

FLIGHT 3

MAINTENANCE

PARTS ARE OFTEN REPLACED WHILE IN GOOD HEALTH

CURRENT

REACTIVE MAINTENANCE

1

CURRENT

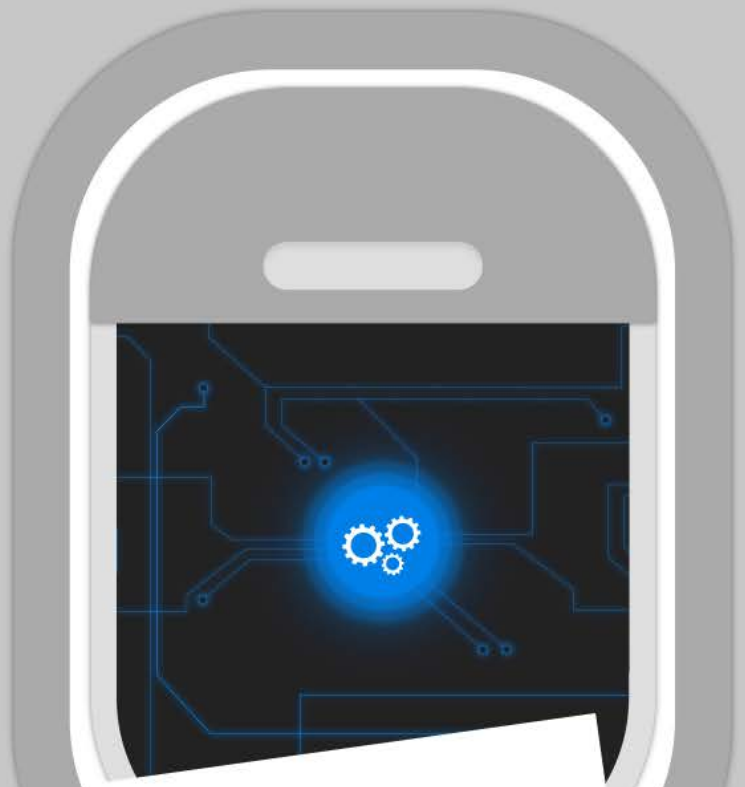
PREVENTIVE MAINTENANCE

2

ReMAP

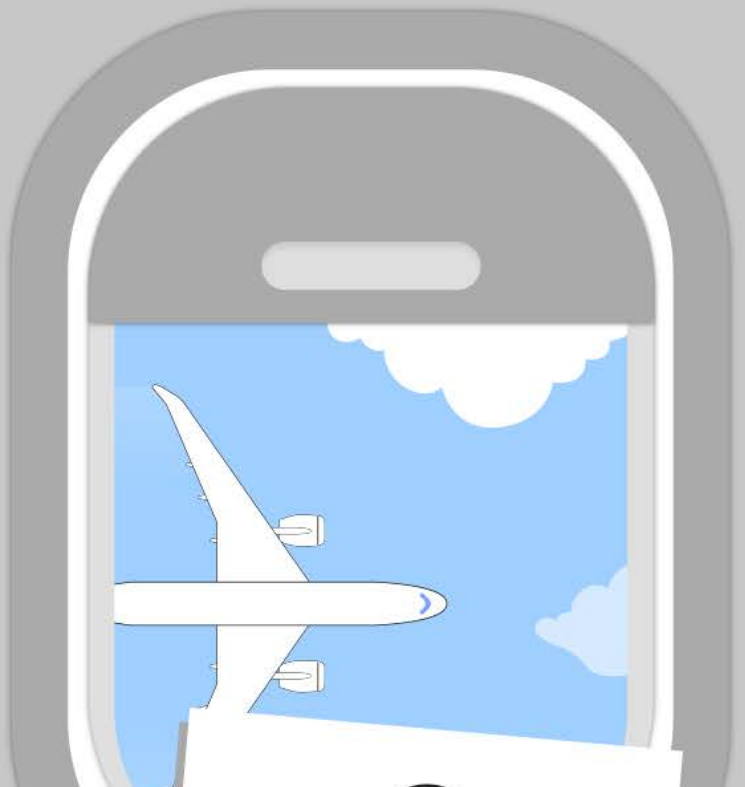
CONDITION-BASED MAINTENANCE

3 Challenges



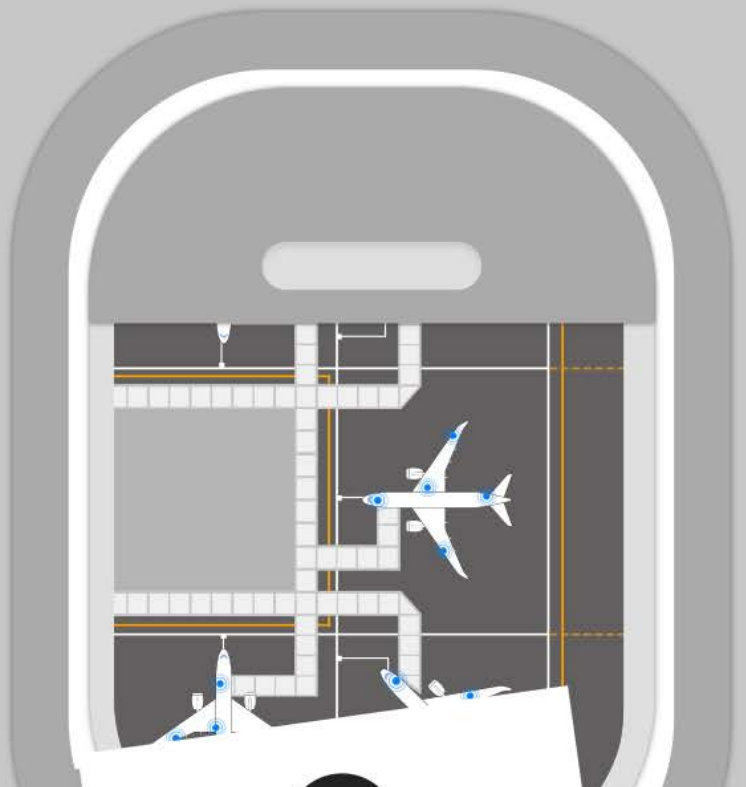
1

TECHNICAL:
DATA ABUNDANCE
FAILURE SCARCITY



2

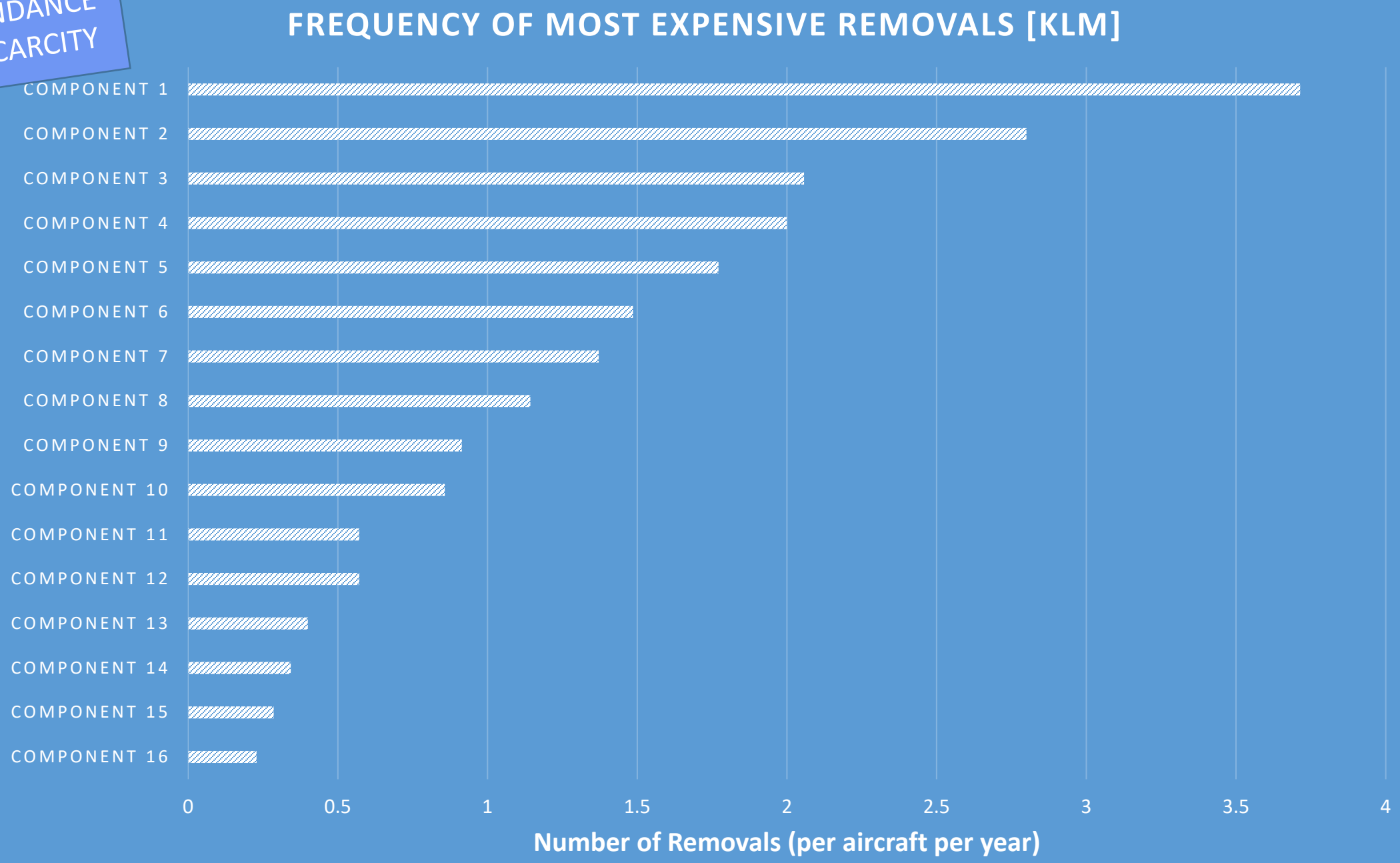
REGULATORY:
CBM NOT AN APPROVED MAINTENANCE STRATEGY



3

OPERATIONAL:
UNCERTAINTY IN MAINTENANCE NEEDS

1 **TECHNICAL:**
DATA ABUNDANCE
FAILURE SCARCITY



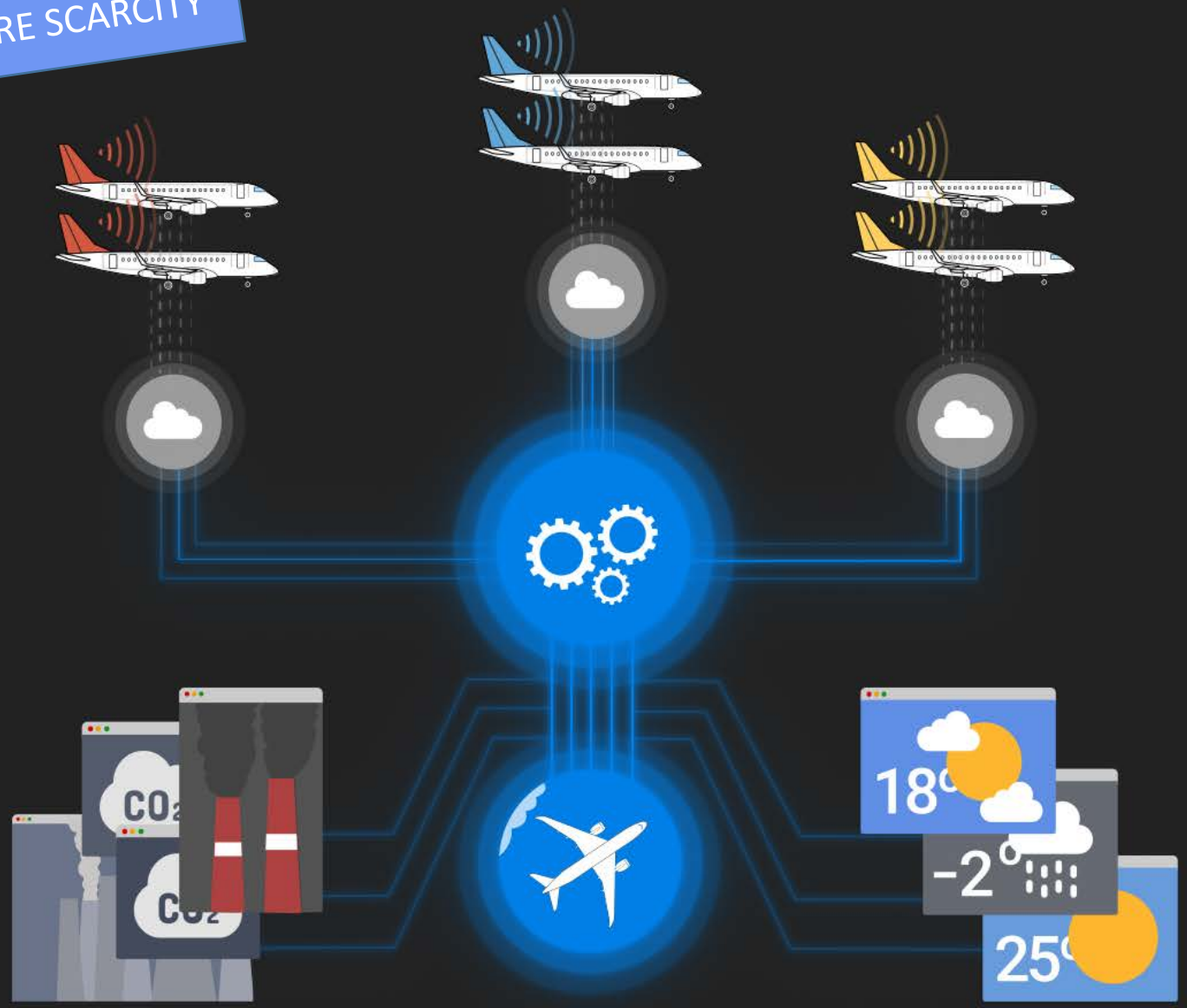
1 **TECHNICAL**:
DATA ABUNDANCE
FAILURE SCARCITY

DIAGNOSTIC AND PROGNOSTIC ALGORITHMS

DATA NEEDS:

- **Sensor data**
- **Maintenance Logs**
- **Shop records**
- **External data**
- **Crew complaints, AC fault messages, etc**

1 **TECHNICAL**:
DATA ABUNDANCE
FAILURE SCARCITY



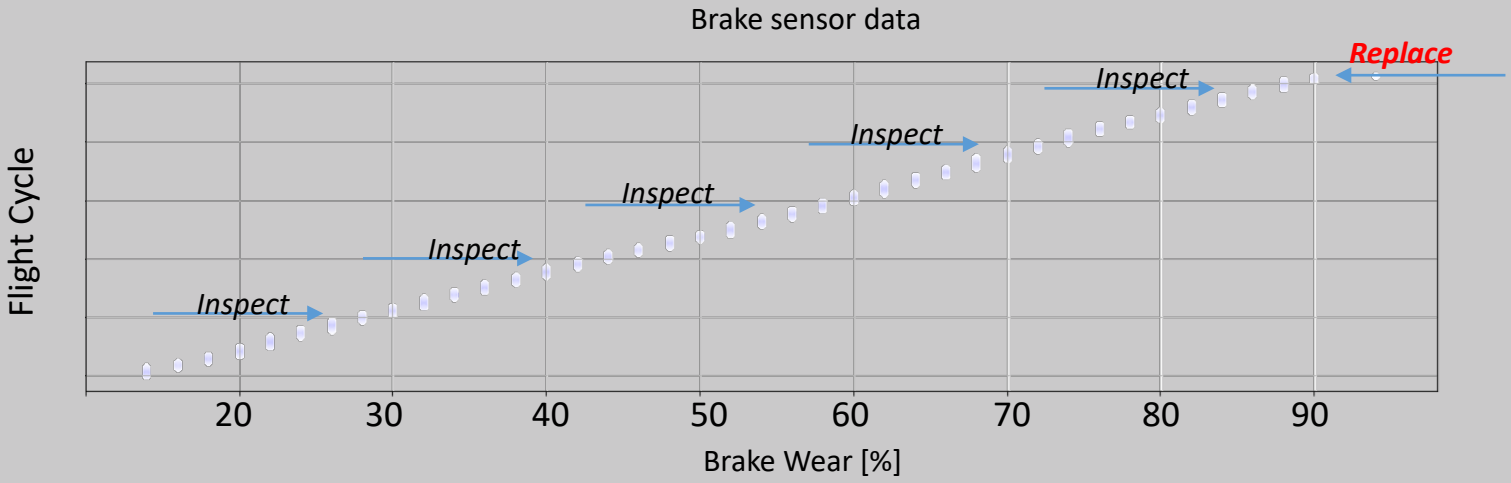
DISTRIBUTED ARCHITECTURE

3 Challenges

2 REGULATORY: CBM NOT AN APPROVED MAINTENANCE STRATEGY

MAINTENANCE PLANNING DOCUMENT

BY AIRCRAFT MANUFACTURER



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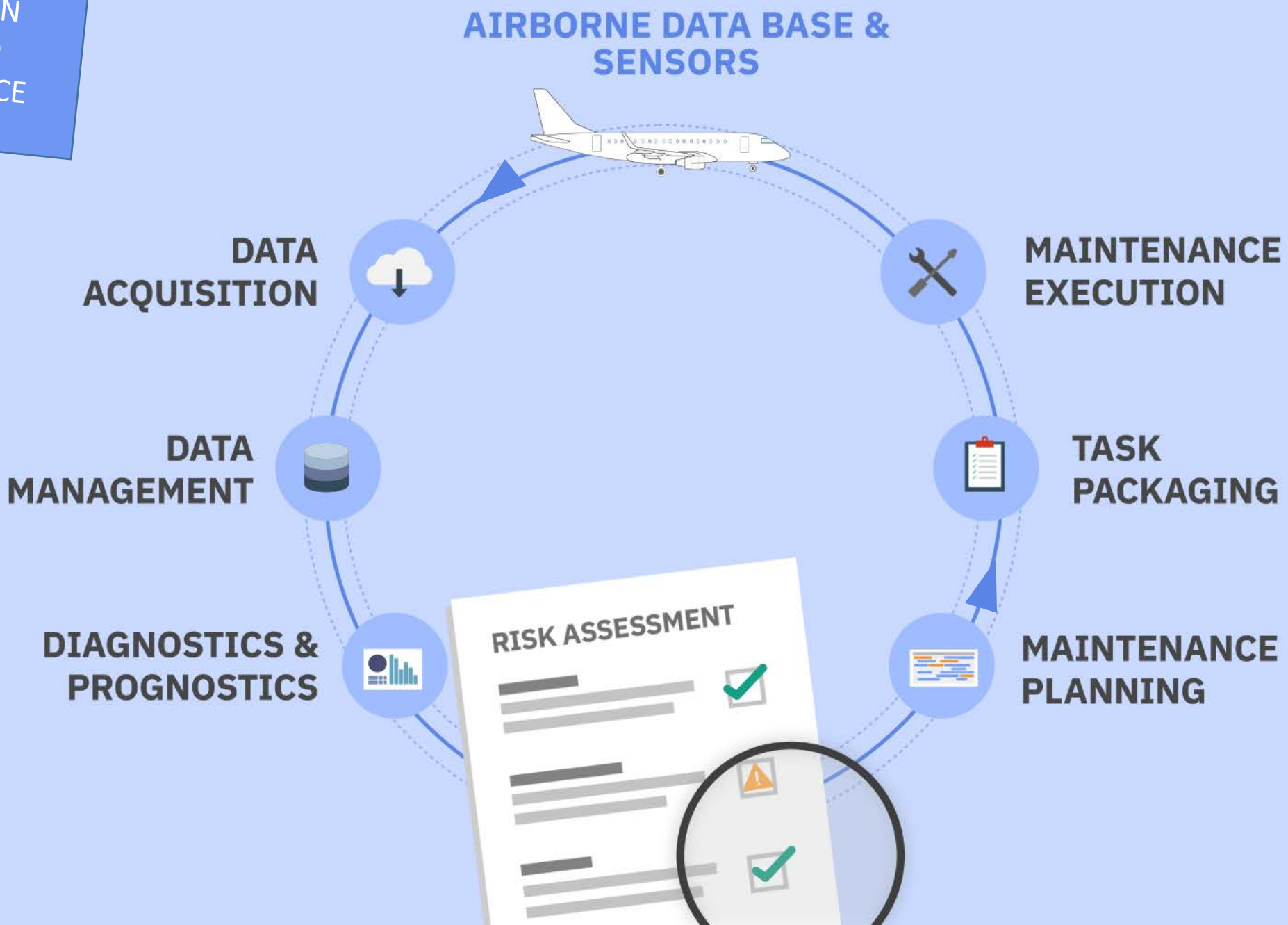
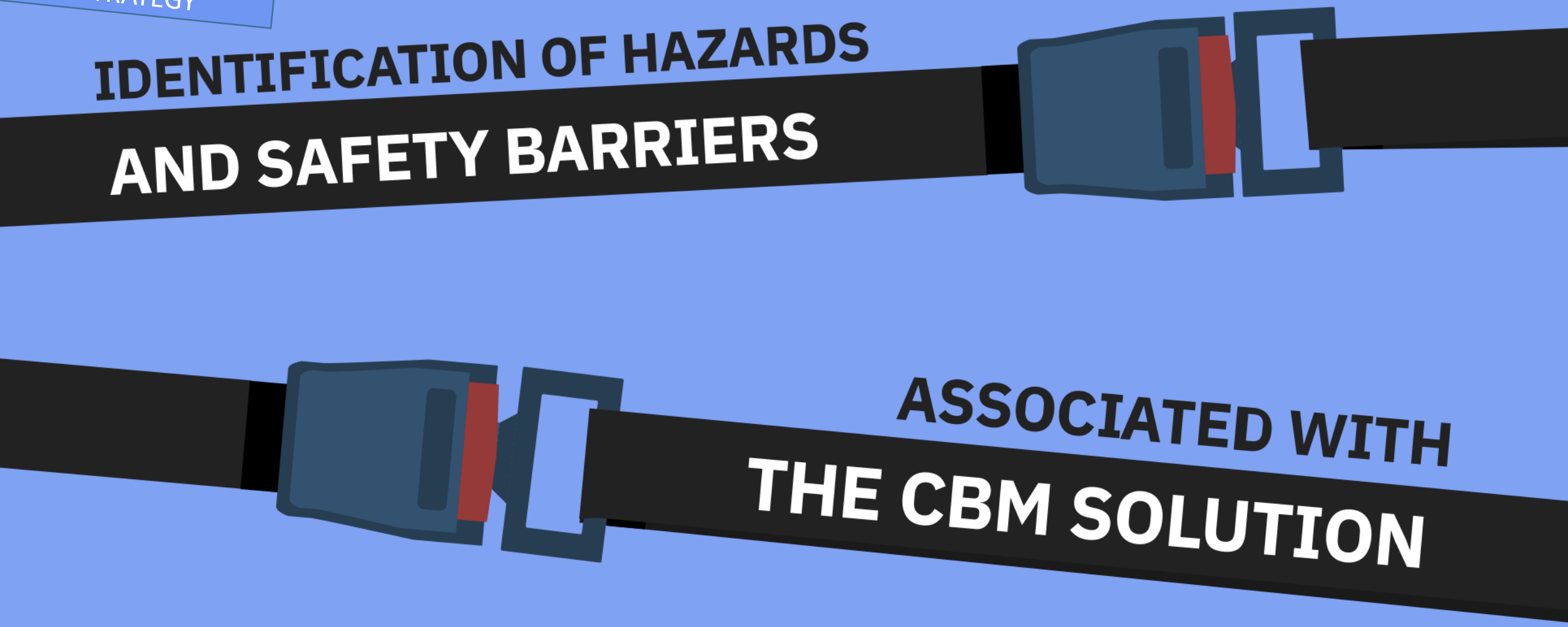


2 **REGULATORY:** CBM NOT AN APPROVED MAINTENANCE STRATEGY

IDENTIFICATION OF HAZARDS AND SAFETY BARRIERS ASSOCIATED WITH THE CBM SOLUTION

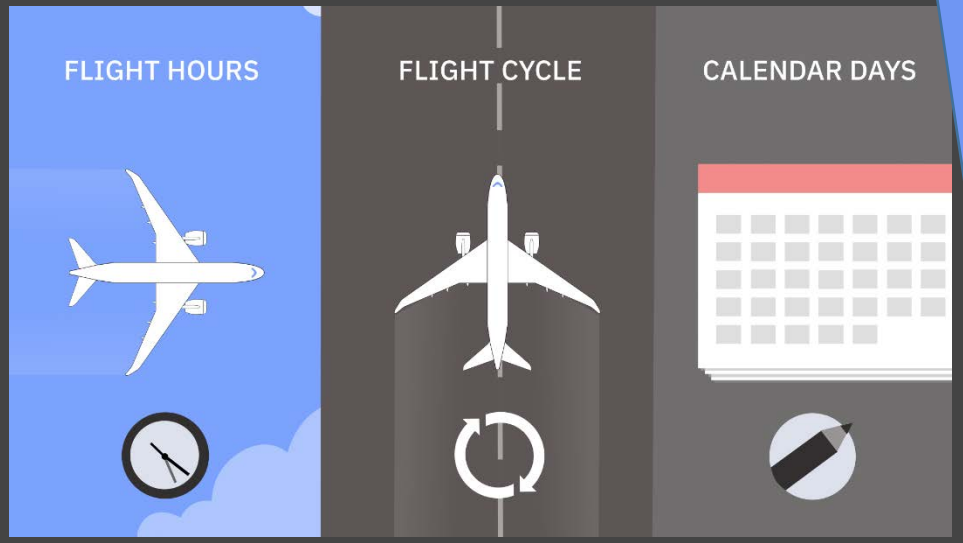


3 Challenges

OPERATIONAL: UNCERTAINTY IN MAINTENANCE NEEDS

3

Maintenance Trigger



Task Packaging

Task Scheduling

OPERATIONAL:
UNCERTAINTY IN MAINTENANCE NEEDS

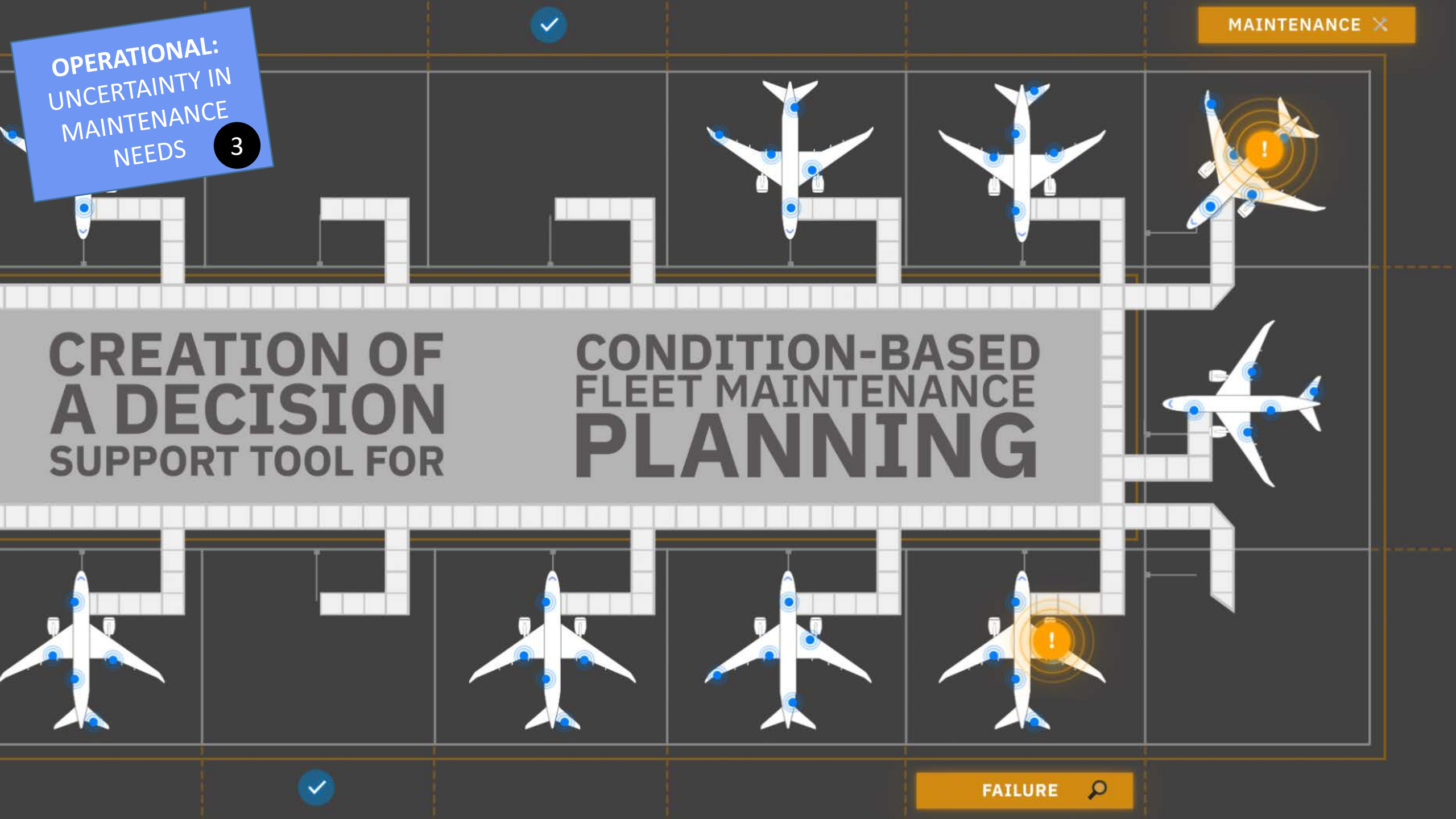
3

Maintenance Trigger

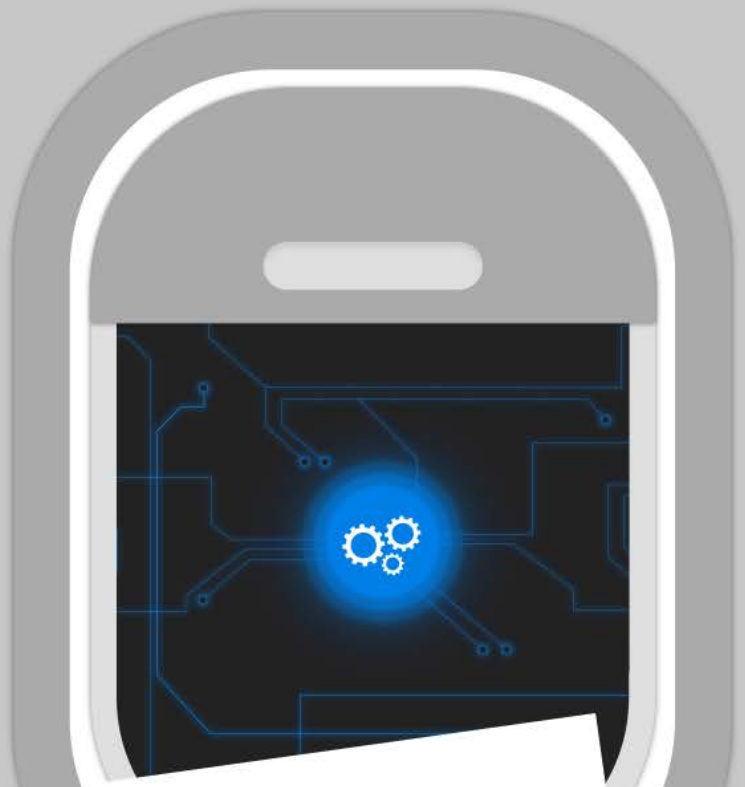
Task Packaging

Task Scheduling

FLIGHT 1 | FLIGHT 2 | FLIGHT 3 | FLIGHT 4 | FLIGHT 5 | FLIGHT 6


OPERATIONAL:
UNCERTAINTY IN MAINTENANCE NEEDS
3
MAINTENANCE
CREATION OF A DECISION SUPPORT TOOL FOR
CONDITION-BASED FLEET MAINTENANCE PLANNING
FAILURE

3 Challenges



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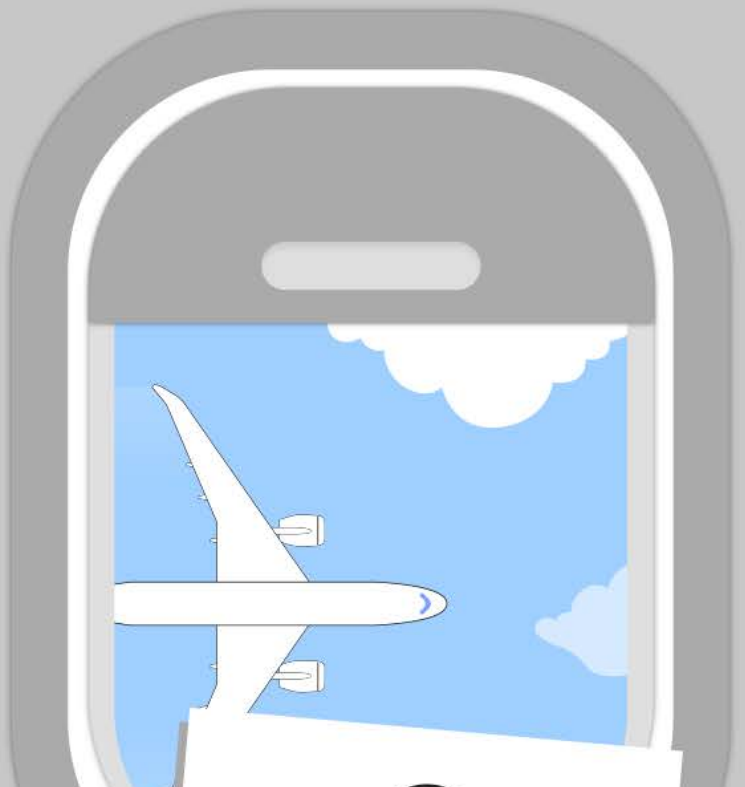

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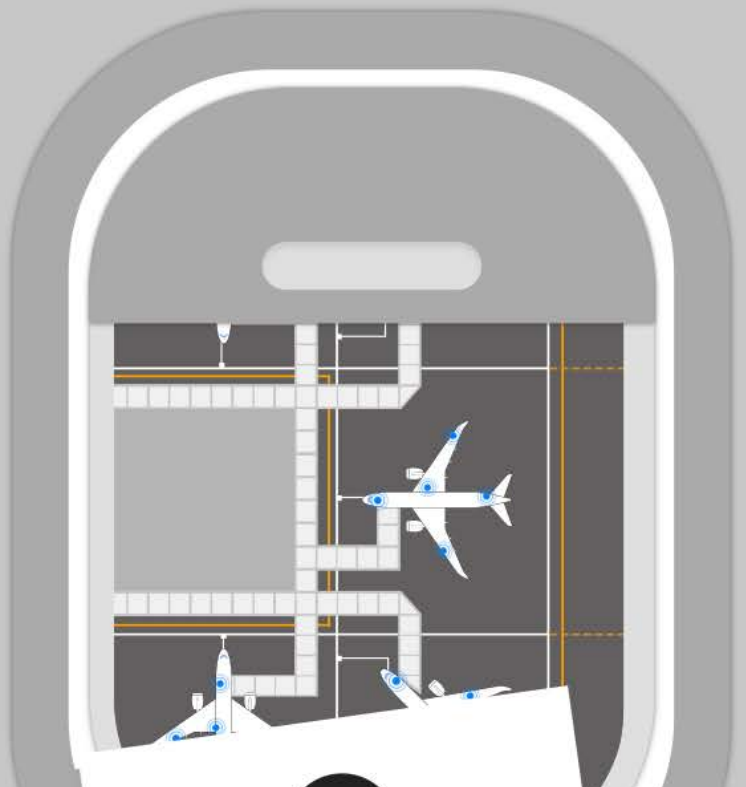


3

OPERATIONAL:
UNCERTAINTY IN MAINTENANCE NEEDS

ReMAP

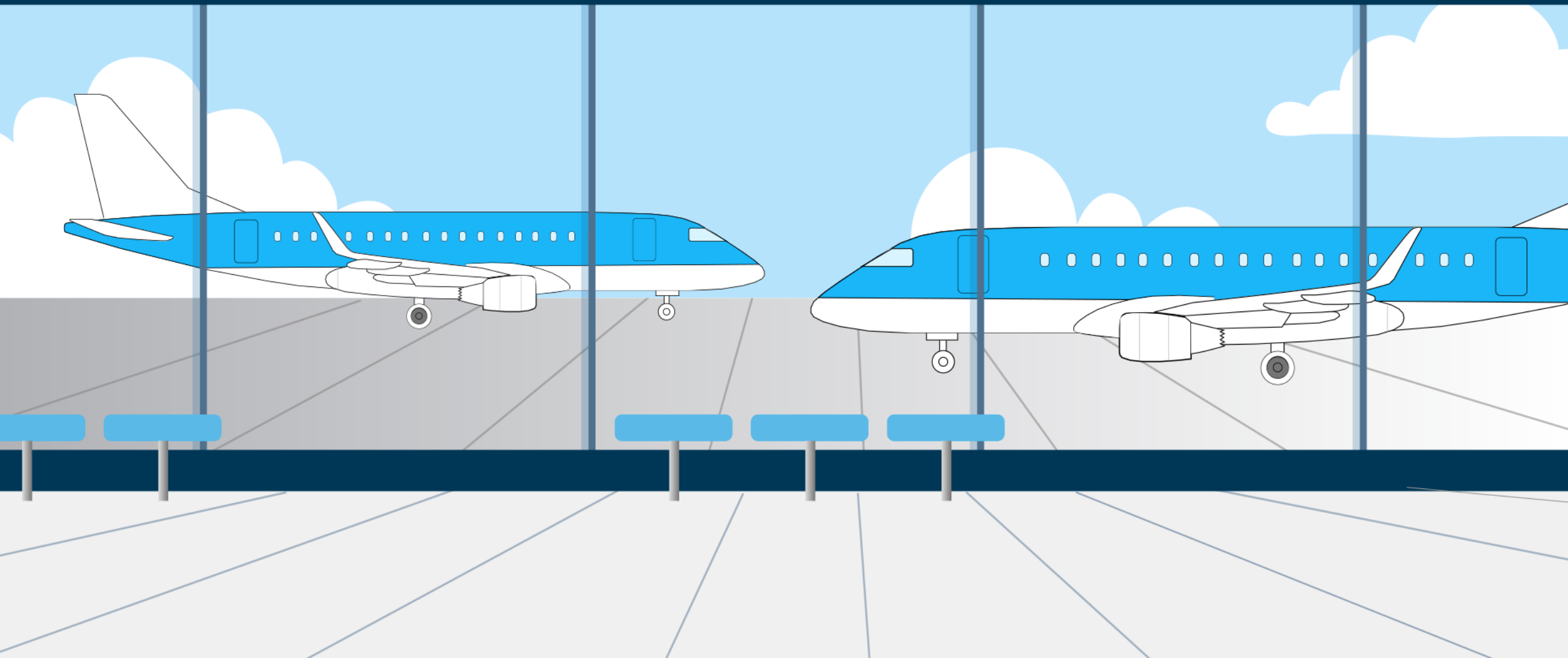
Stakeholders

- **European Union** Funded H2020 Project
- Consortium of **13 partners** from **7 European Countries**
- **8** members of **Advisory Board** (Airbus, EASA, RNLAF, Thales, etc)

TU Delft
ARTS ET MÉTIERS ParisTech
UNIVERSITY OF PATRAS
IPN
Atos
CEDRAT TECHNOLOGIES Innovation in Mechatronics
ONERA THE FRENCH AEROSPACE LAB
OPTIMAL STRUCTURAL SOLUTIONS
SMARTEC
EMBRAER
UNIVERSIDADE DE COIMBRA
United Technologies Research Center

KLM Royal Dutch Airlines

6-MONTH DEMONSTRATION IN RELEVANT ENVIRONMENT BY 2021



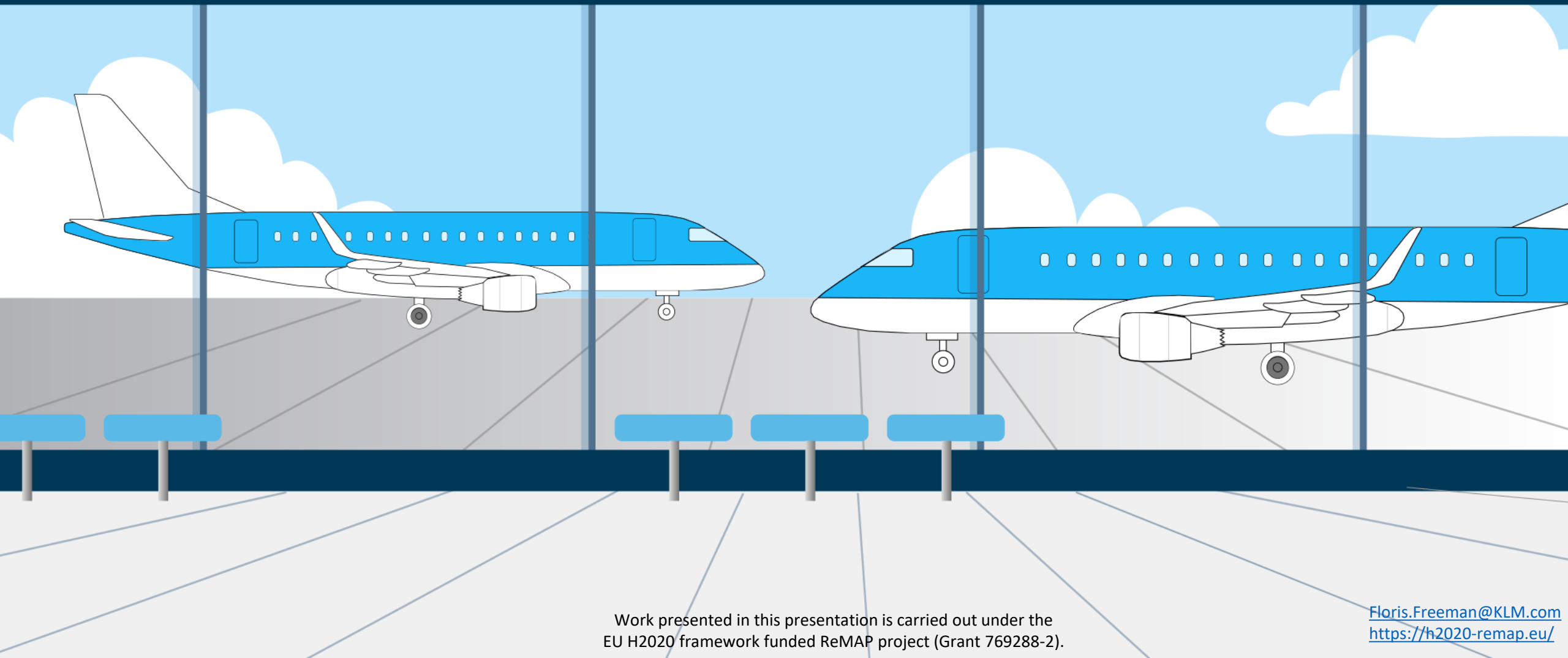
Summary

- 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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Floris.Freeman@KLM.com
https://h2020-remap.eu/