Principle of Predictive Maintenance on Aircraft

Intelligent Maintenance Conference 2024

COMMERCIAL AIRCRAFT

Vincent CHERIERE
AIRBUS Expert in Digital Capabilities for Fleet Performance Services
EPFL, Lausanne, Switzerland, September 3rd 2024

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Voice of predictive maintenance users!

We have been using predictive maintenance for many years now to indicate when parts need to be replaced thereby avoiding technical delays

Published on 22 May 2024

INNOVATION

easyJet opens new AI equipped operations control centre

https://mediacentre.easyjet.com/story/17447/easyjet-opens-new-ai-equipped-operations-control-centre

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easyJet opens new AI equipped operations control centre

We continue to invest in and deepen our knowledge and use of AI, with a rapid deployment team working **on 250 live use cases** across our operations and scheduling, customer service, the booking experience and easyJet holidays.

Johan Lundgren, CEO of easyJet

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Predictive maintenance on aircraft, why is it valuable?

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Increase aircraft operational reliability

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At home base with maintenance people and tools

Less prone to NFF (No Fault Found)

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Do less expensive repairs by removing aircraft parts before severe degradation

Turn unscheduled maintenance into scheduled maintenance

At home base with maintenance people and tools

Less prone to NFF (No Fault Found)

Reduce fuel/oil consumption

By keeping systems performance at best

Aircraft Predictive Maintenance & Decision-Making

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Aircraft Predictive Maintenance & Decision-Making

When

is predictive maintenance decided?

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Who

decides about predictive maintenance?
Who acts?

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How

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is predictive maintenance decided?

Who
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Who acts?

What
are the main decision parameters?

How
do users monitor, detect and decide?

Predictive maintenance within Aircraft Maintenance

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Aircraft Maintenance

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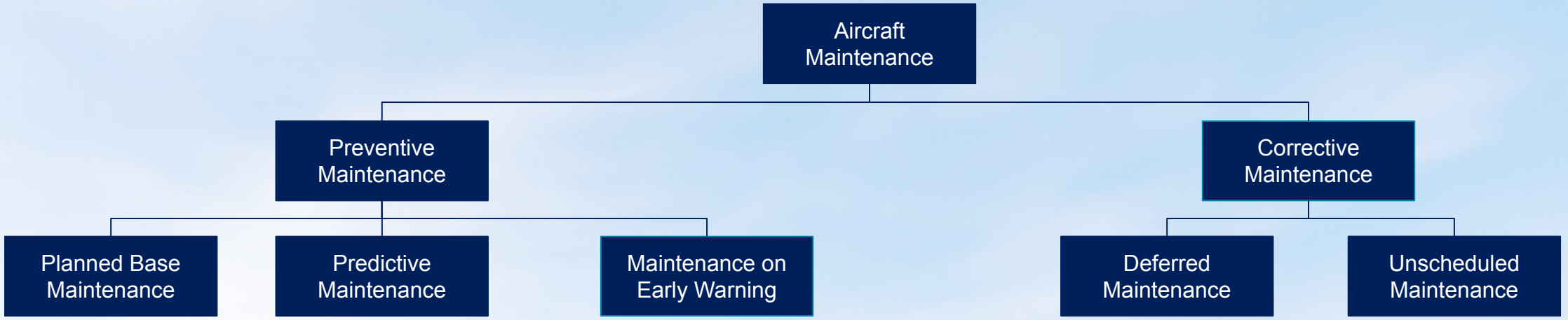

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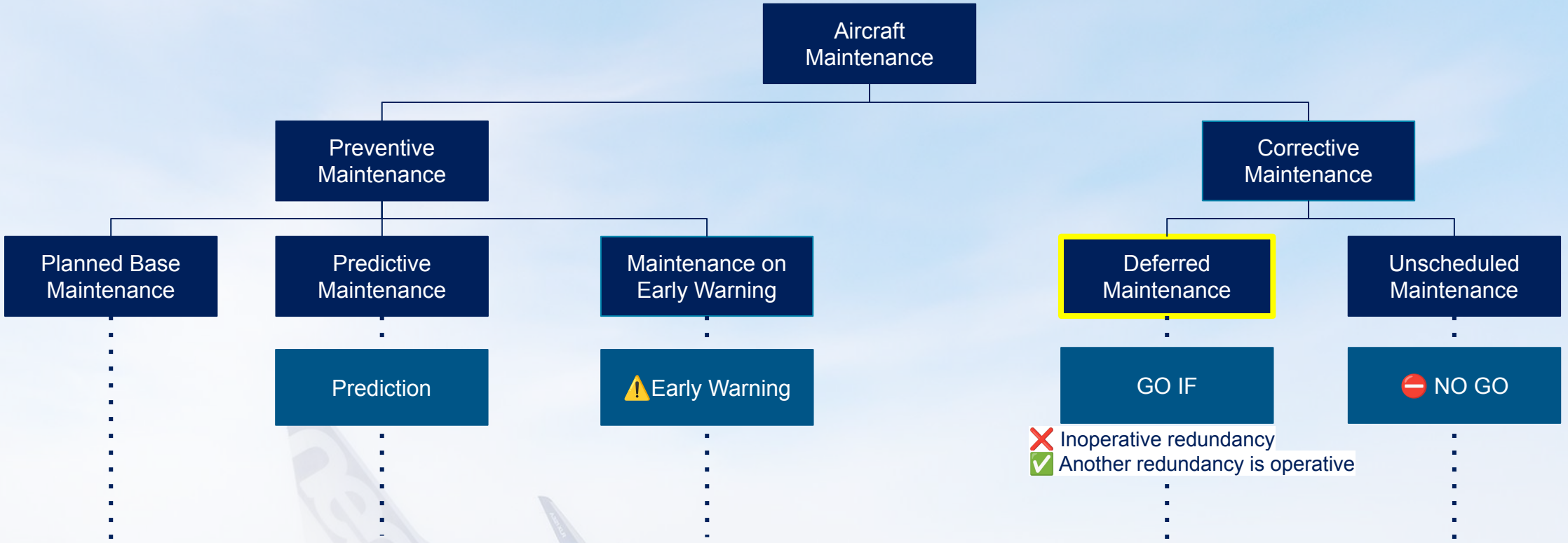

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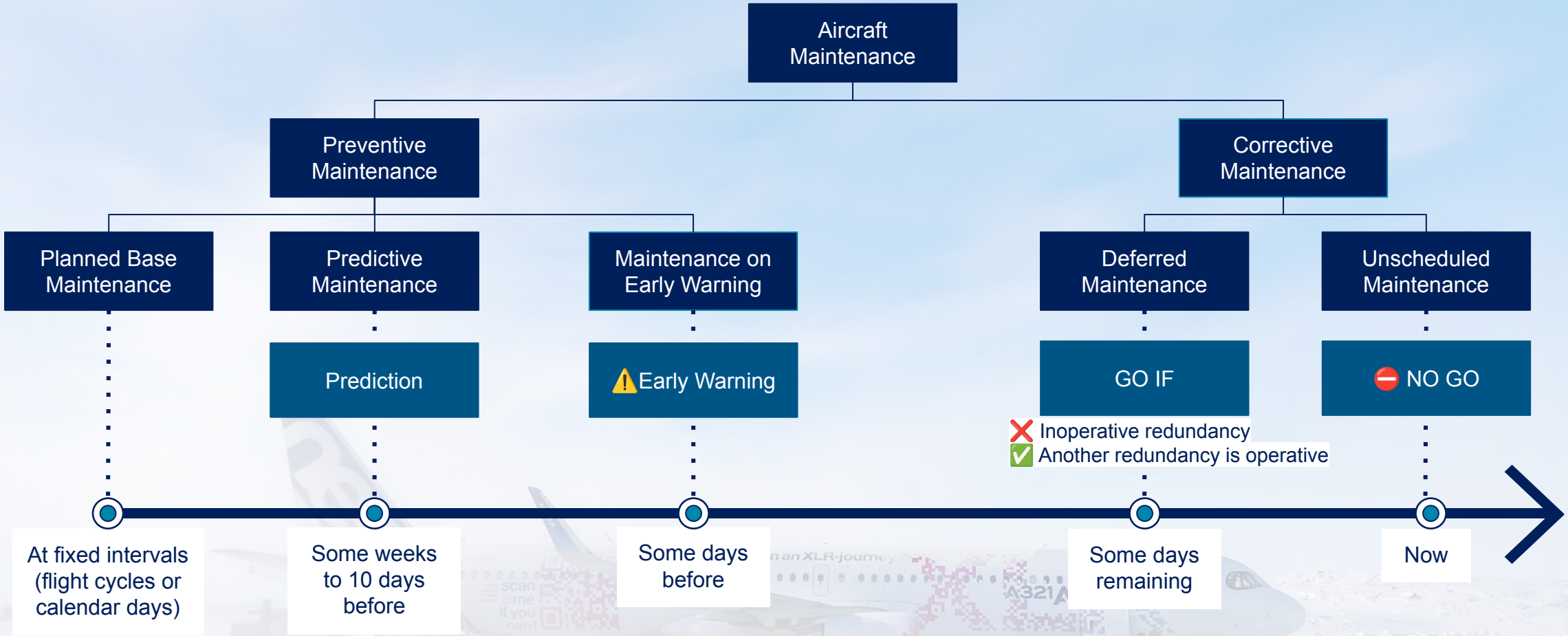

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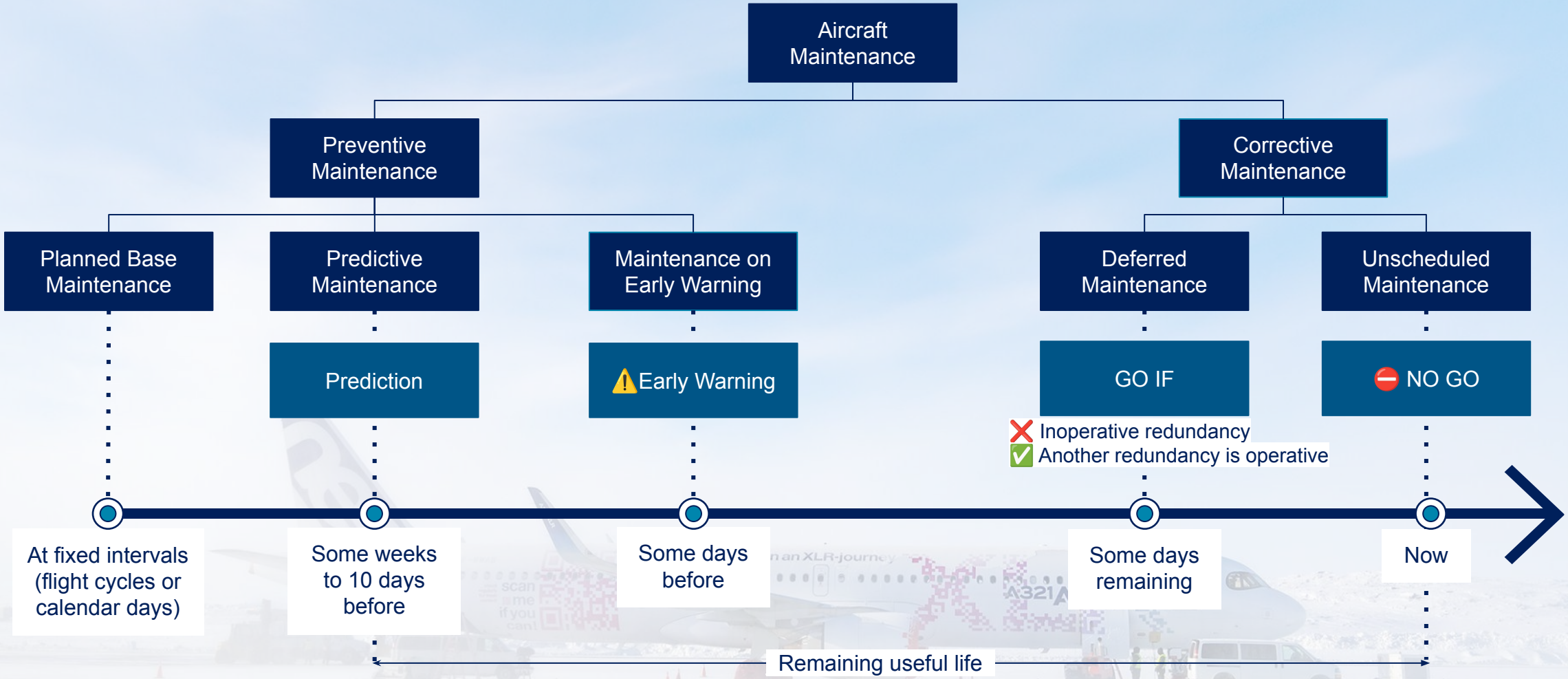

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Predictive maintenance within Aircraft Maintenance

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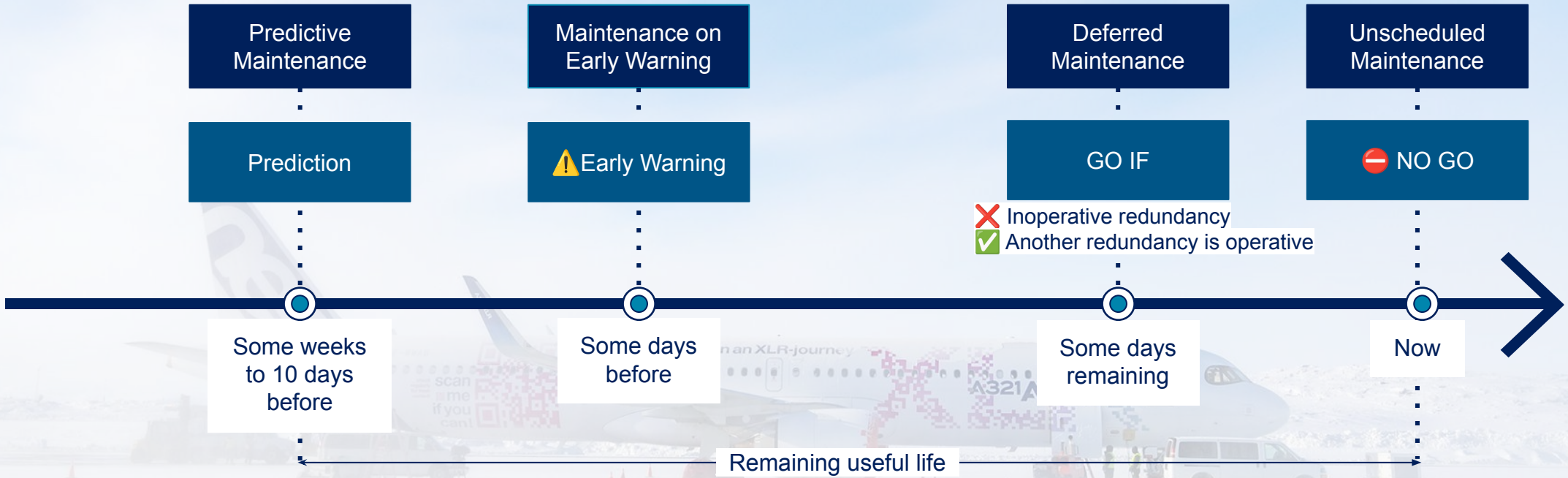

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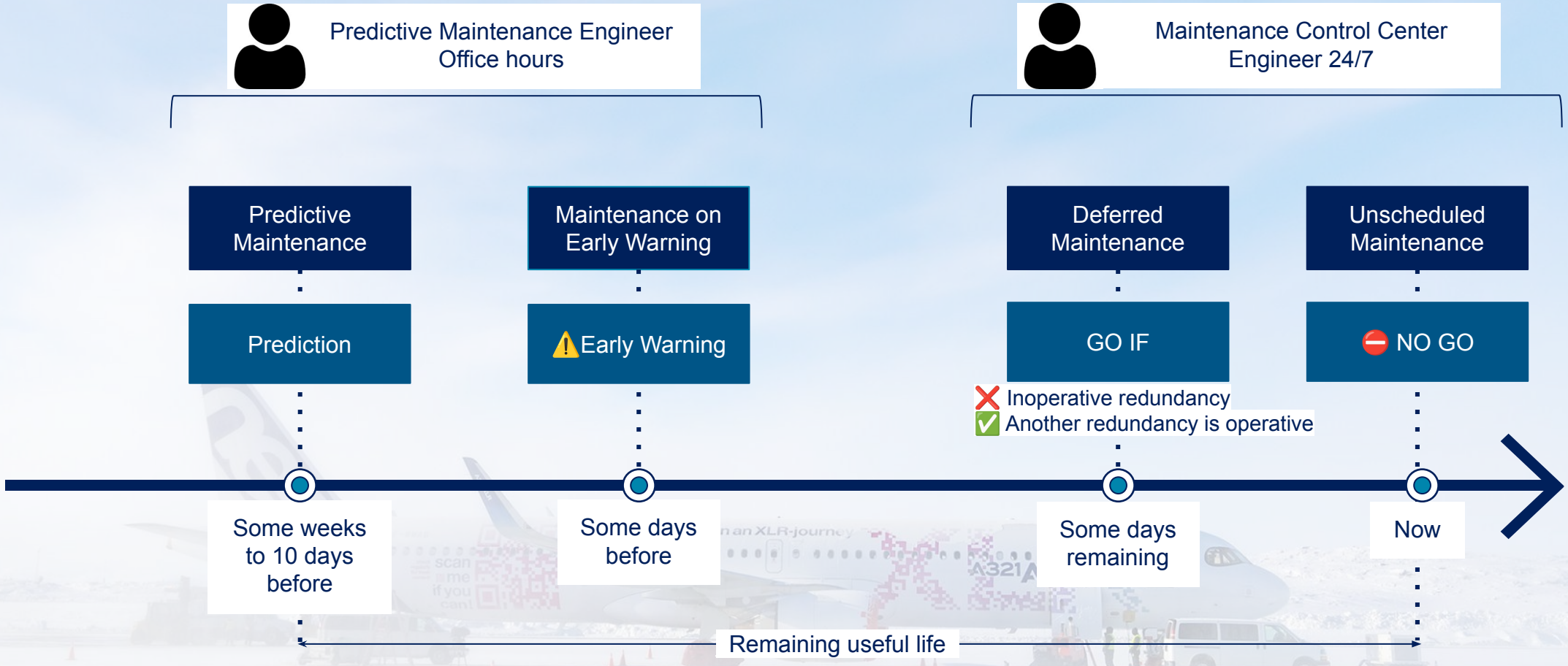

Deciding and executing maintenance, how does it work?

Who
decides about predictive maintenance?
Who acts?

data
(satellite
communication,
radio, WiFi, 4G)

24/7 Health Monitoring
and
Predictive Monitoring

Maintenance
Control Center
Shifts 24/7

Defect Monitoring & Predictive
Maintenance Engineer
Office hours

Images sources: https://safetyfirst.airbus.com/

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Control Center
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Defect Monitoring & Predictive Maintenance Engineer
Office hours

Maintenance Work order

Line Maintenance at main base
(typically **Night Stop** or **Weekly Aircraft Check**)

Line Maintenance & Weekly Checks
Shifts 24/7

Images sources: https://safetyfirst.airbus.com/

Connected aircraft for predictive maintenance

How
do users monitor, detect and decide?

data (radio)

data (satellite)

data (WiFi, GSM)

TAXI OUT

TAKE-OFF

CLIMB

CRUISE

DESCENT

APPROACH - LANDING

TAXI IN

Connected aircraft for predictive maintenance

How
do users monitor, detect and decide?

data (radio)

data (satellite)

data (WiFi, GSM)

TAXI OUT | TAKE-OFF | CLIMB | CRUISE | DESCENT | APPROACH - LANDING | TAXI IN

Aircraft data

✓ **Time series data**

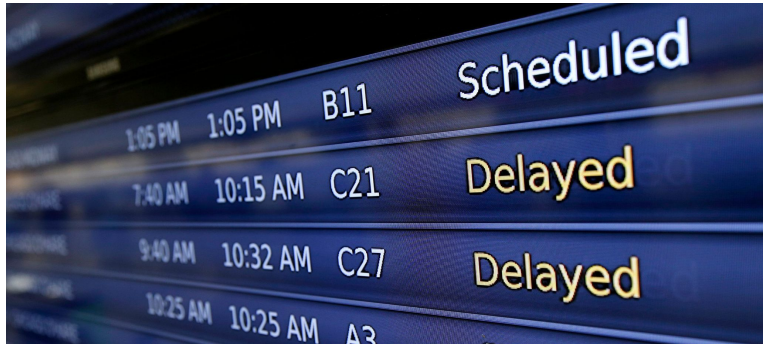
✓ **Diagnostic Booleans**

⇅ Including **uplink request/answer**

CMS: Centralized Maintenance System
ACMS: Aircraft Condition Monitoring System
FOMAX: Ground Flight Operations & Maintenance Exchanger
ACARS: Aircraft Communications Addressing and Reporting System

Other key parameters in the decision - Impact

What
are the main decision parameters?



What impact
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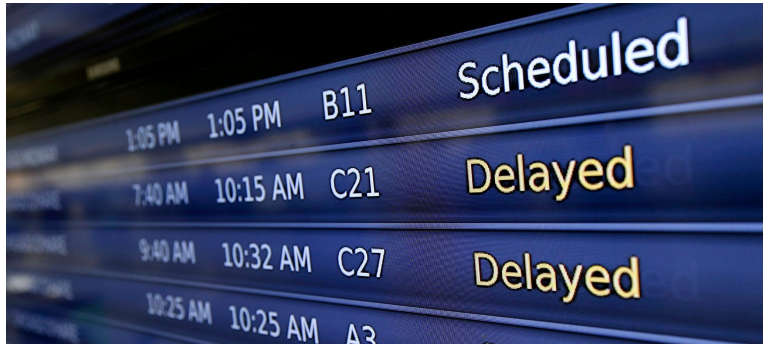

What is the upcoming flight schedule?
Is the aircraft flying back home?
Is the aircraft flying to outstation?

Live fleet flight assignment

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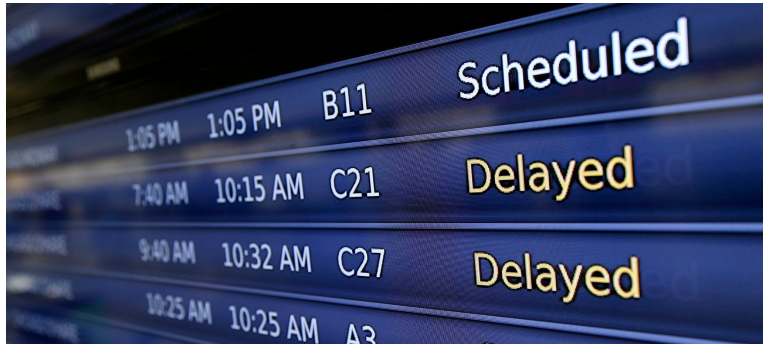

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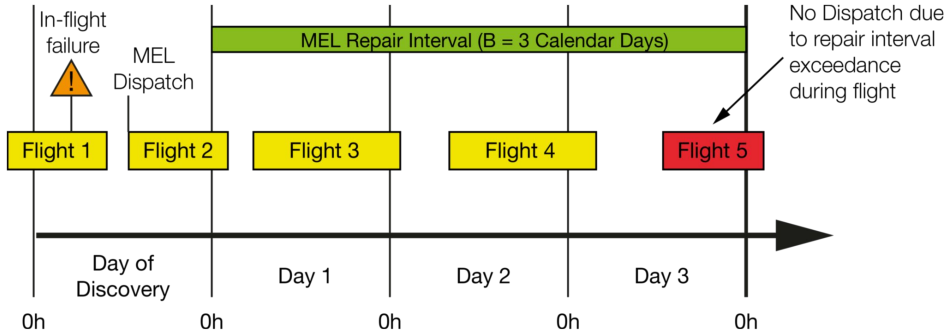
Is there some existing **Deferred maintenance**?

Is the aircraft already flying under **Minimal Equipment List** (MEL)?



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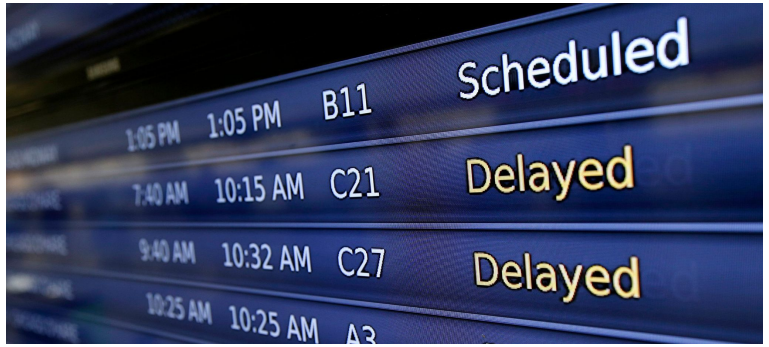

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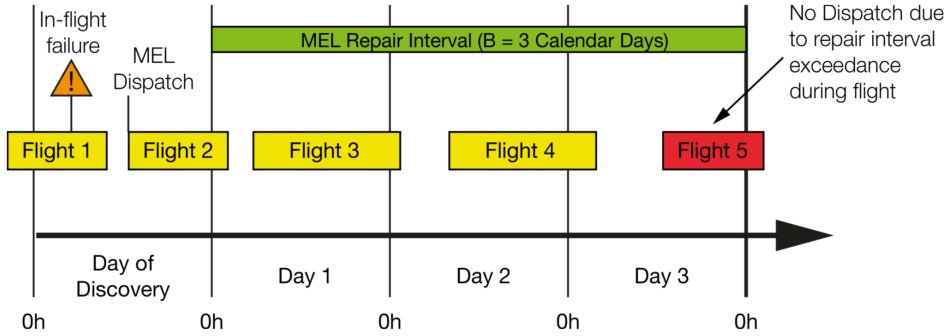

What impact

on airline's operations?

What **if no predictive maintenance** is done?

What is the next end effect? NO GO? Limitations?
What impact on aircraft performance (fuel consumption)
Were previous preventive action helpful?

MEL

Past in-service interruptions

Predictive Maintenance Performance

Images and schematics sources: https://safetyfirst.airbus.com/

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Other key parameters in the decision - Possible maintenance action

What feasible preventive action?

RUL: Remaining Useful Life
AMM: Aircraft Maintenance Manual

Images sources: https://safetyfirst.airbus.com/
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Other key parameters in the decision - Possible maintenance action

What feasible preventive action?

What is/are the suspected parts?

What is the Maintenance Procedure to apply?

Can it be performed in Line Maintenance?
Where is the part located on aircraft?
What tools are needed?

Aircraft data

Predictive Trends & RUL

Recommended AMM task

RUL: Remaining Useful Life
AMM: Aircraft Maintenance Manual

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What is the **recent maintenance history**?

Is this a repetitive failure?
What about the redundant other side of the system?

Maintenance Tech Logs

What feasible preventive action?

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How many other aircraft in the fleet are **affected with the same degradation & risk**?

Is this aircraft the most prior to address?

Aircraft fleet Predictive Trends & RUL

37

RUL: Remaining Useful Life
AMM: Aircraft Maintenance Manual

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Other key parameters in the decision - Part, tools & maintenance slot

What work order to plan?

Images sources: https://aircraft.airbus.com/en/services/maintain, www.satair.com

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Is the aircraft a repetitive troublemaker?

Part removals /installations

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In stock? From the part pool?

Is the level of parts enough to face in-service risks?

Is there some interchangeable part?

Part stock
Part pool

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Part stock Part pool

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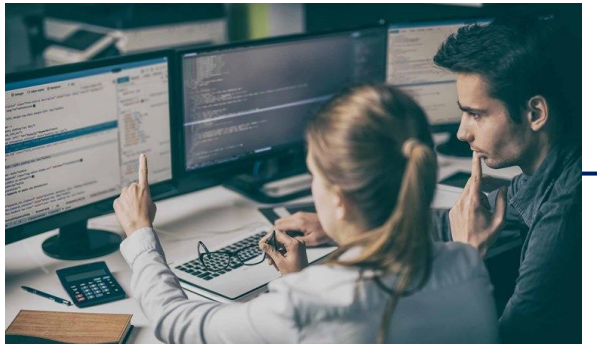
What about the **maintenance planning?**

Is the aircraft having Weekly Check or Check-A soon? Is there an opportunity in the planning?



Short-term Maintenance Planning

Images sources: https://aircraft.airbus.com/en/services/maintain, www.satair.com

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Takeways about Aircraft Predictive Maintenance & Decision-Making

Trend curves and RUL are only one piece of the decision parameters

Float
Integer
Boolean
Aircraft data

Predictive Trends & RUL

Many **other live parameters** are key in a predictive removal decision

Date
String
Live fleet flight assignment

Date
String
Integer
MEL

Free Text
Integer
Past in-service interruptions

Date
Float
Predictive Maintenance Performance

String
Recommended AMM task

Date
Free Text
Maintenance Tech Logs

Date
Free Text
Part removals /installations

Date
Free Text
Part stock Part pool

Date
Free Text
Short-term Maintenance Planning

Relying on human oversight and human experience
It is and will remain human centric, as per EASA AI concepts

A **play area for new AI technologies** (TLP, LLM, RAG, ReAct…)
to connect unstructured data, sum-up data and generate advice

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https://www.easa.europa.eu/en/document-library/general-publications/easa-artificial-intelligence-concept-paper-issue-2

EASA: European Union Aviation Safety Agency
RUL: Remaining Useful Life

Thank you