Using Prescriptive Maintenance Strategies to Improve the Spare Unit Supply in the Aviation Industry

On the way to post-prognostics decision-making

Robert Meissner
Dr. Kai Wicke
Prof. Dr. Gerko Wende

Institute of Maintenance, Repair and Overhaul (DLR)
Hamburg, Germany

DLR

THROUGH

Without the usage of adapted maintenance strategies, developed technologies for a continuous condition-monitoring will yield only little to no benefit.

A HIGHER

THE AGENDA

Who are we?

Why should you be bothered?

What are current challenges in the planning of maintenance events?

What solutions exist? What is prescriptive maintenance?

What benefits can it deliver? Where can it help you?

Has its potential been shown already?

DLR

OUR INSTITUTE

Key facts

- Founded in June 2017
- Located at ZAL TechCenter in Hamburg-Finkenwerder
- 40 Employees

Departments

- Maintenance and Repair Technologies
- Process Optimisation and Digitalisation
- Product Lifecycle Management

DLR

OUR VISION – OUR MISSION

From Pioneering Ideas to Maintenance Innovations

- We explore key technologies for the maintenance of tomorrow.
- We strive to develop innovative comprehensive solutions, using our extensive system understanding of MRO operations — be it a single component or an entire product lifecycle.
- Driven by the enthusiasm and excellence of our scientists, we combine disruptive ideas and applied research to strengthen the ties between business and science.

DLR

Environmental Footprint

90 %

The aviation-related greenhouse gas emission reduction to be achieved by 2050 within the European Union – compared to 1990’s levels.

European Commission, 2021

Cost Reduction

€ 3,000,000,000

Annual cost saving potential in the airline MRO – mainly through avoidance of operational interruptions, NFF events and inventory reduction.

Groenenboom, 2019

Operational Uptime

51 %

Among 200+ manufacturing companies, the majority is expecting an improvement of their asset's operational uptime through the use of prognostics-based maintenance strategies.

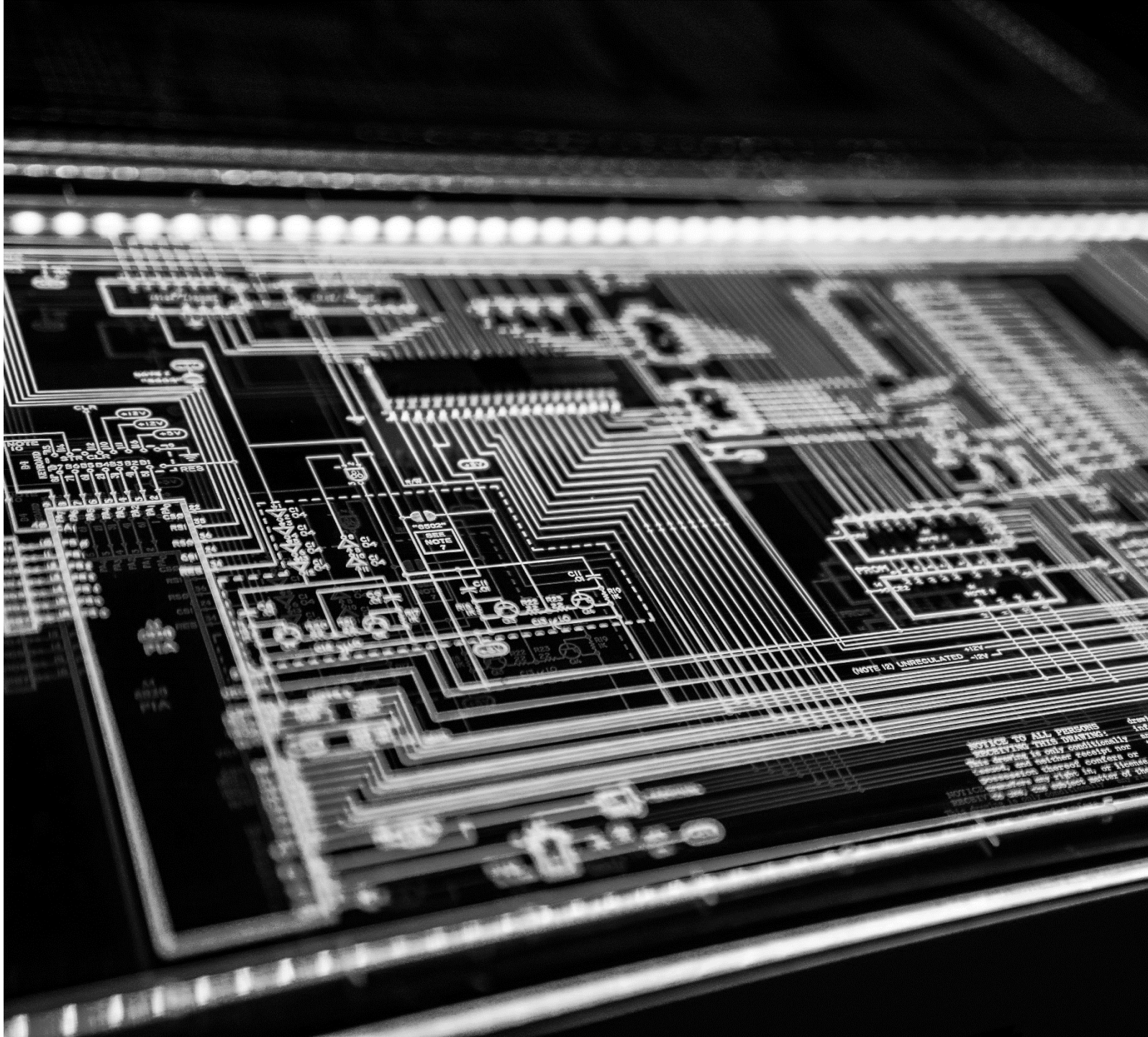
Haarman, 2018

Low Technical Maturity

11 %

Despite being an essential requirement, only a small percentage of companies are capable of a continuous real-time monitoring of their assets.

Haarman, 2018; Hess, 2005



No Viable Business Case

63 %

Companies that are hesitant to invest in the development of prognostics-based maintenance strategies, almost 2/3 state they are lacking a viable business case scenario and deem the approach not relevant.

Haarman, 2018

CURRENT CHALLENGES IN MRO RESEARCH

Asset Centricity

Major focus of existing work has been on the asset (e.g. aircraft engine) itself with insufficient consideration of the ecosystem.

Monetary Values

Predominant focus on the evaluation of monetary aspects of PHM technologies, neglecting other effects (e.g. asset availability, environmental impact, …).

Degradation Extrapolation

Existing PHM technologies often neglect ambient conditions and extrapolate past (observed) degradation into the future, yielding inaccuracies due to changing operating conditions.

PHM Maturity

Post-prognostics maintenance heavily depends on the technical maturity of underlying PHM technology, which needs to be accounted for.

Holistic View

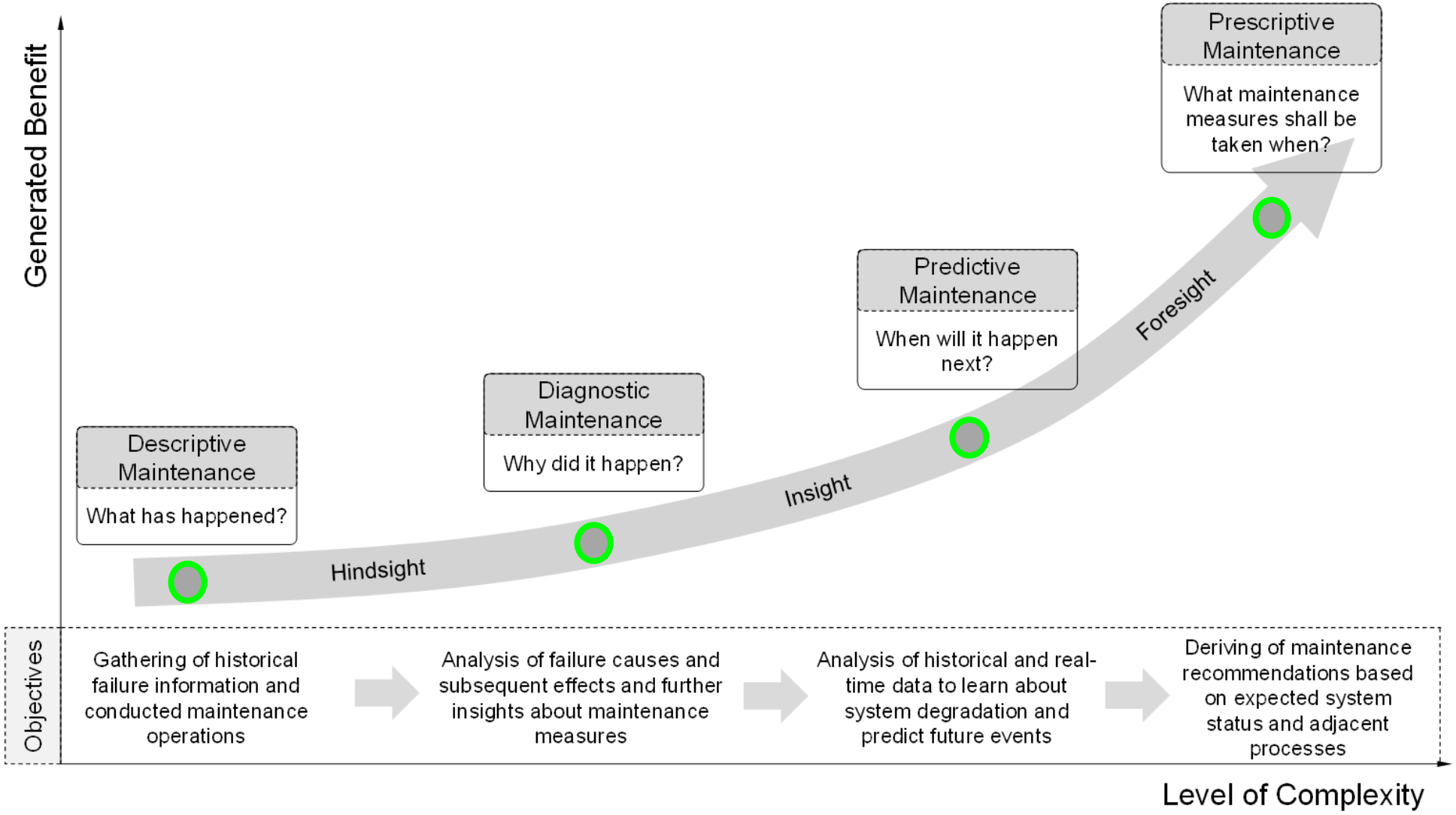
Estimated implications have often been limited to consideration of line maintenance and operations, neglecting effects on aspects such as logistics or shop maintenance.

Stakeholder Modeling

Involved stakeholders posses different, competing optimization objectives that need to be addressed individually to generate excitement to participate.

DLR

EVOLUTION OF CONDITION-BASED MAINTENANCE



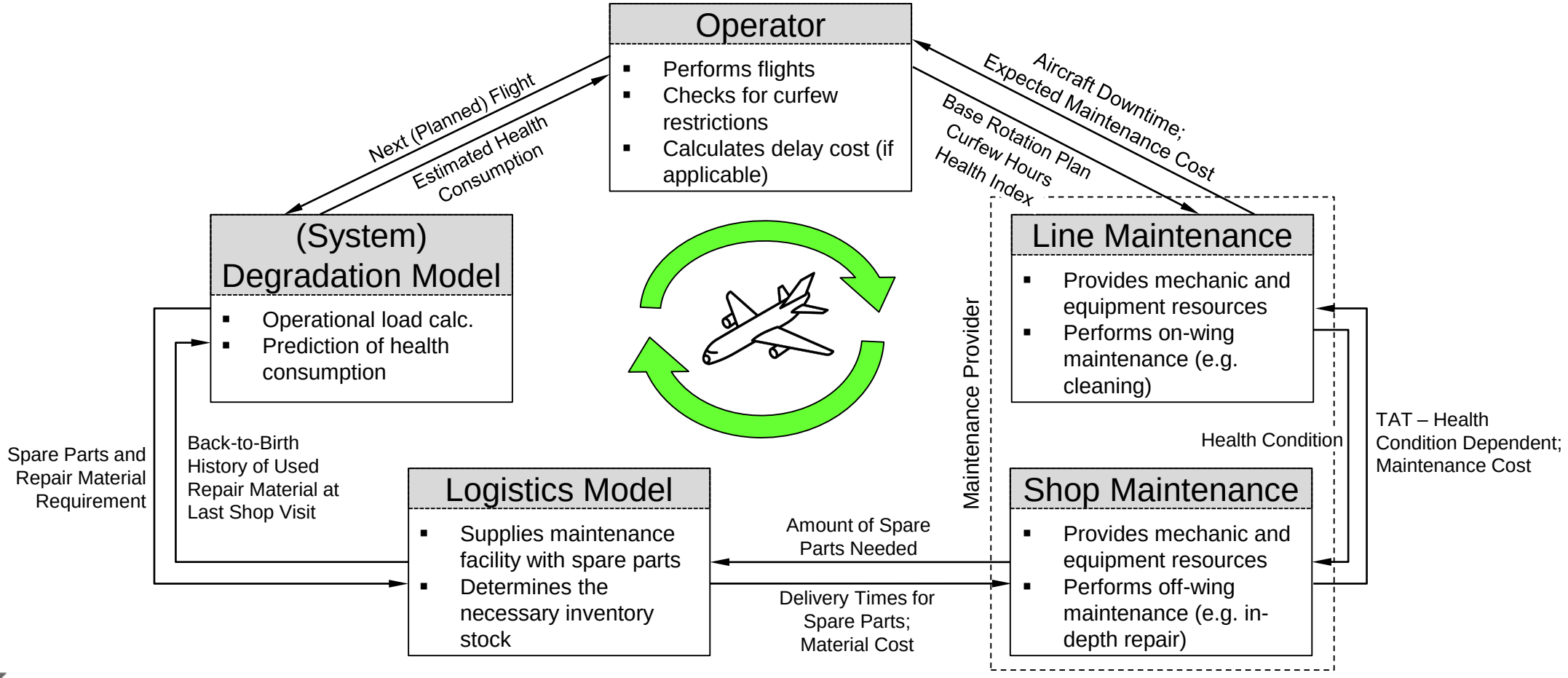
DLR

PRESCRIPTIVE MAINTENANCE

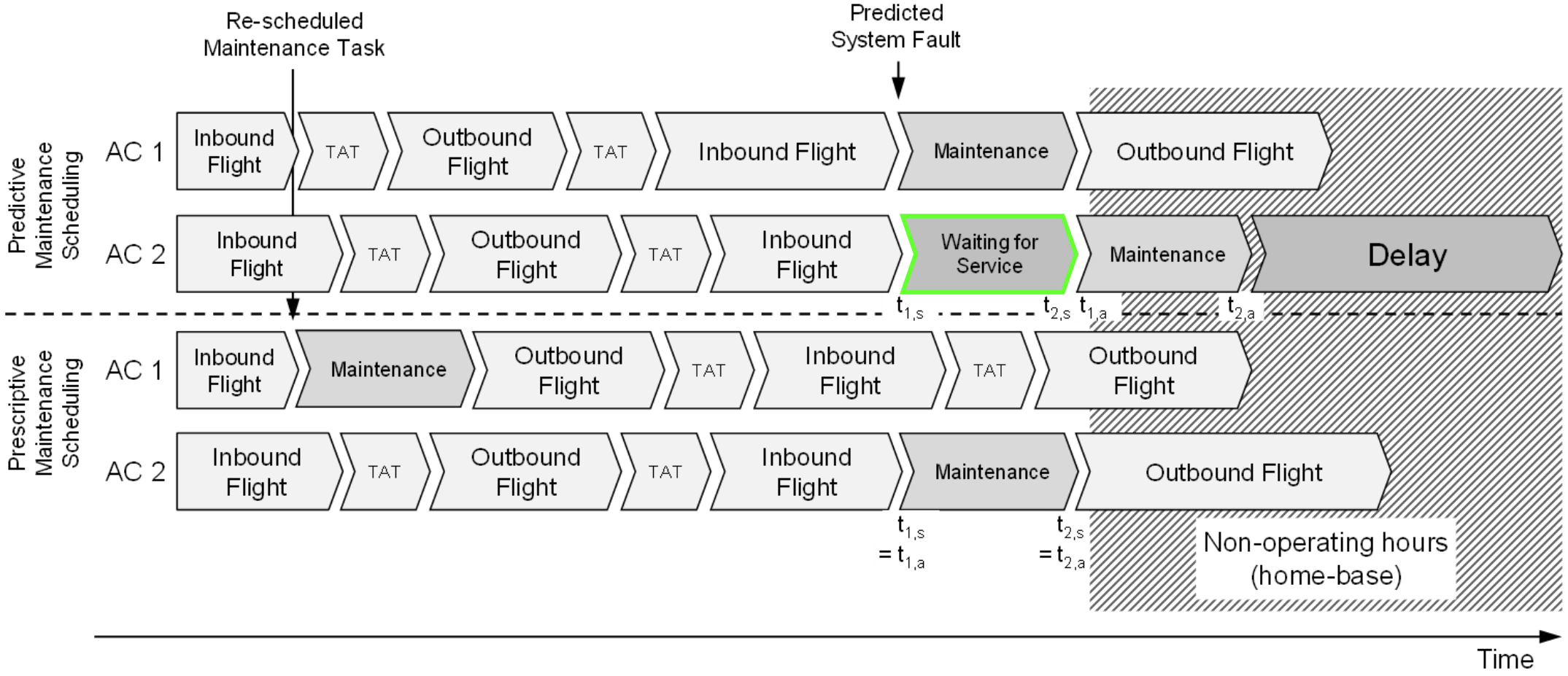
Prescriptive maintenance utilizes a system's failure projection to minimize the adversarial implications for the involved stakeholders by an optimized, proactive scheduling of necessary maintenance restoration tasks. Therefore, it is an evolution of a predictive maintenance approach, which solely forecasts upcoming system failures, and allows a holistic analysis and optimization of maintenance measures.

DLR

HOLISTIC MAINTENANCE ASPECTS



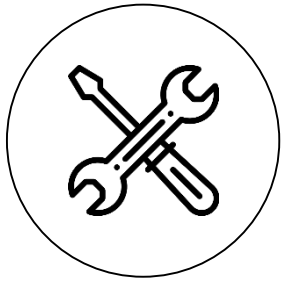
PREDICTIVE VS. PRESCRIPTIVE MAINTENANCE



POTENTIAL BENEFITS

Perform only necessary maintenance

An automated detection of the current degradation will render scheduled maintenance tasks obsolete while avoiding unscheduled maintenance events.



Avoid unnecessary component removals

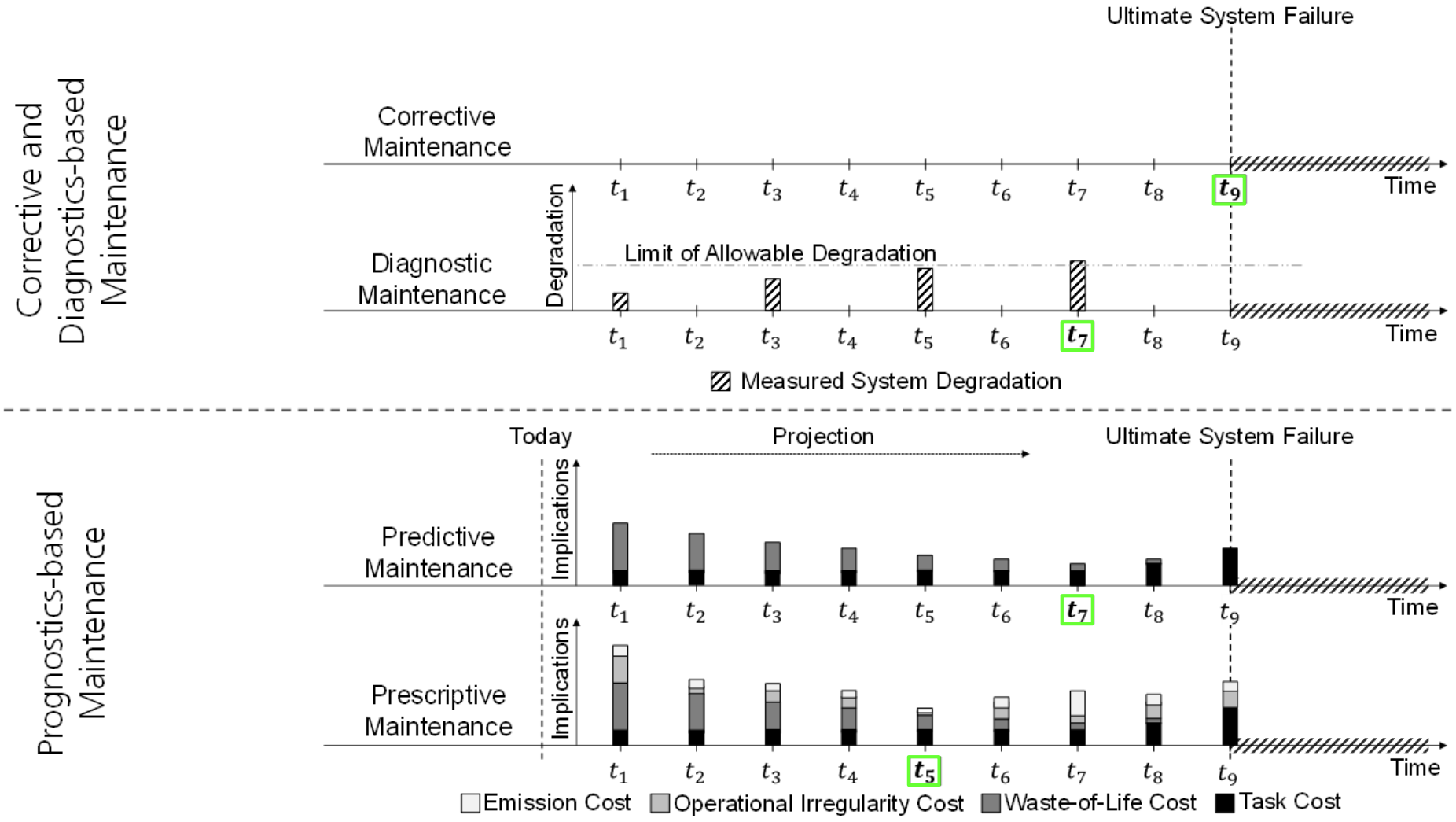
A continuous system monitoring and fault diagnosis will help to timely identify faulty components and to avoid no-failure-found events.

Support performance-based services

An stakeholder-integrated maintenance planning with a reliable failure projection allows the selection of suitable maintenance opportunities.

DLR

EXEMPLARY SCENARIOS AND USE-CASES



EXEMPLARY SCENARIOS AND USE-CASES

How does the cost savings potential of a prognostics-based maintenance strategy change for different Prognostic Horizons (as expressions of technological maturity)?

Key Findings

- Dependency of cost savings potential from technical maturity
- High improvements for additional developments with low level of technical maturity until saturation point
- Changes in the maintenance procedure necessary to fully exploit the PHM technology's potential

Meissner, R., Meyer, H. and Wicke, K. (2021) Concept and Economic Evaluation of Prescriptive Maintenance Strategies for an Automated Condition Monitoring System. International Journal of Prognostics and Health Management, 12 (3). DOI: 10.36001/ijphm.2021.v12i3.2911

DLR

EXEMPLARY SCENARIOS AND USE-CASES

How does the cost savings potential of a prognostics-based maintenance strategy change for different utilization degrees within the aircraft fleet?

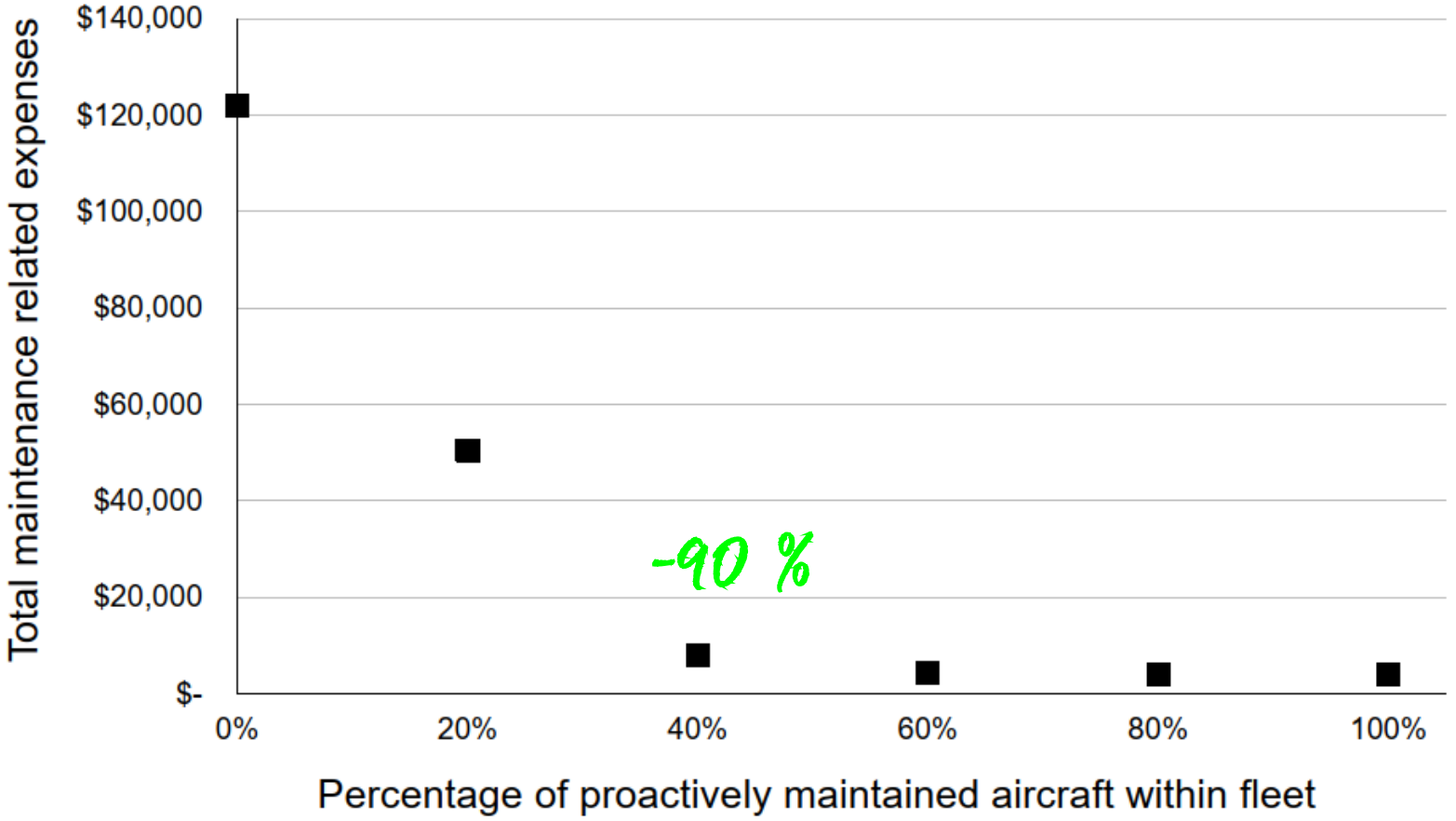
Key Findings

- Dependency of cost savings potential from fleet utilization degree
- High improvements for additional PHM-equipped aircraft for low levels of fleet utilization until saturation point
- Excessive maintenance cost mainly caused by operational irregularity cost, i.e. flight delays or cancellations

Meissner, R., Rahn, A. and Wicke, K. (2021) Developing prescriptive maintenance strategies in the aviation industry based on a discrete-event simulation framework for post-prognostics decision making. Reliability Engineering & System Safety, 214. Elsevier. DOI: 10.1016/j.ress.2021.107812

DLR

EXEMPLARY SCENARIOS AND USE-CASES



DLR

THANK YOU FOR YOUR ATTENTION!

German Aerospace Center
Institute of Maintenance, Repair and Overhaul
Hein-Saß-Weg 22
21129 Hamburg

www.dlr.de/mo

REFERENCES

J. Groenenboom, “The changing MRO landscape,” Athens, Greece, Sep. 18 2019. Accessed: Apr. 3rd 2022. [Online]. Available: https://www.iata.org/contentassets/81005748740046de878439e6c54f2355/d1-1100-1130-the-changing-mro-landscape_icf.pdf

European Commision. “European Green Deal and the EU Emission Trading System”. 2021. Accessed: June 21st 2022. [Online]. Available: https://ec.europa.eu/clima/eu-action/european-green-deal/delivering-european-green-deal/aviation-and-eu-ets_en.

M. Haarman et al., “Predictive Maintenance 4.0: Beyond the Hype,” 2018. Accessed: Sep. 19th 2021. [Online]. Available: https://www.pwc.nl/nl/assets/documents/pwc-predictive-maintenance-beyond-the-hype-40.pdf

A. Hess, G. Calvello, and P. Frith, “Challenges, Issues, and Lessons Learned Chasing the "Big P". Real Predictive Prognostics. Part 1,” in 2005 IEEE Aerospace Conference proceedings: March 5-12, 2005, [Big Sky, Montana], Big Sky, MT, USA, 2005, pp. 3610–3619.