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Harmonised Transport Infrastructure Monitoring in Europe for Optimal Maintenance and Safety

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AFTERNOON SESSION

Moderated by A.J. Bigaj-van Vliet (TNO, the Netherlands)

Data-informed structural performance assessment

Contributors:

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Risk assessment and risk-based framework

Contributors:

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Condition state classification & minimum maintenance levels

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RISK ASSESSMENT AND RISK-BASED FRAMEWORK FOR MAINTENANCE MANAGEMENT

a. **16:00-16:30 |** Risk in maintenance management & methods of assessing risk

Q&A

b. **16:30-17:00 |** Maintenance management & maintenance strategies

Q&A

c. **17:10-17:30 |** Condition state classification and minimum maintenance levels for transport infrastructure

Q&A

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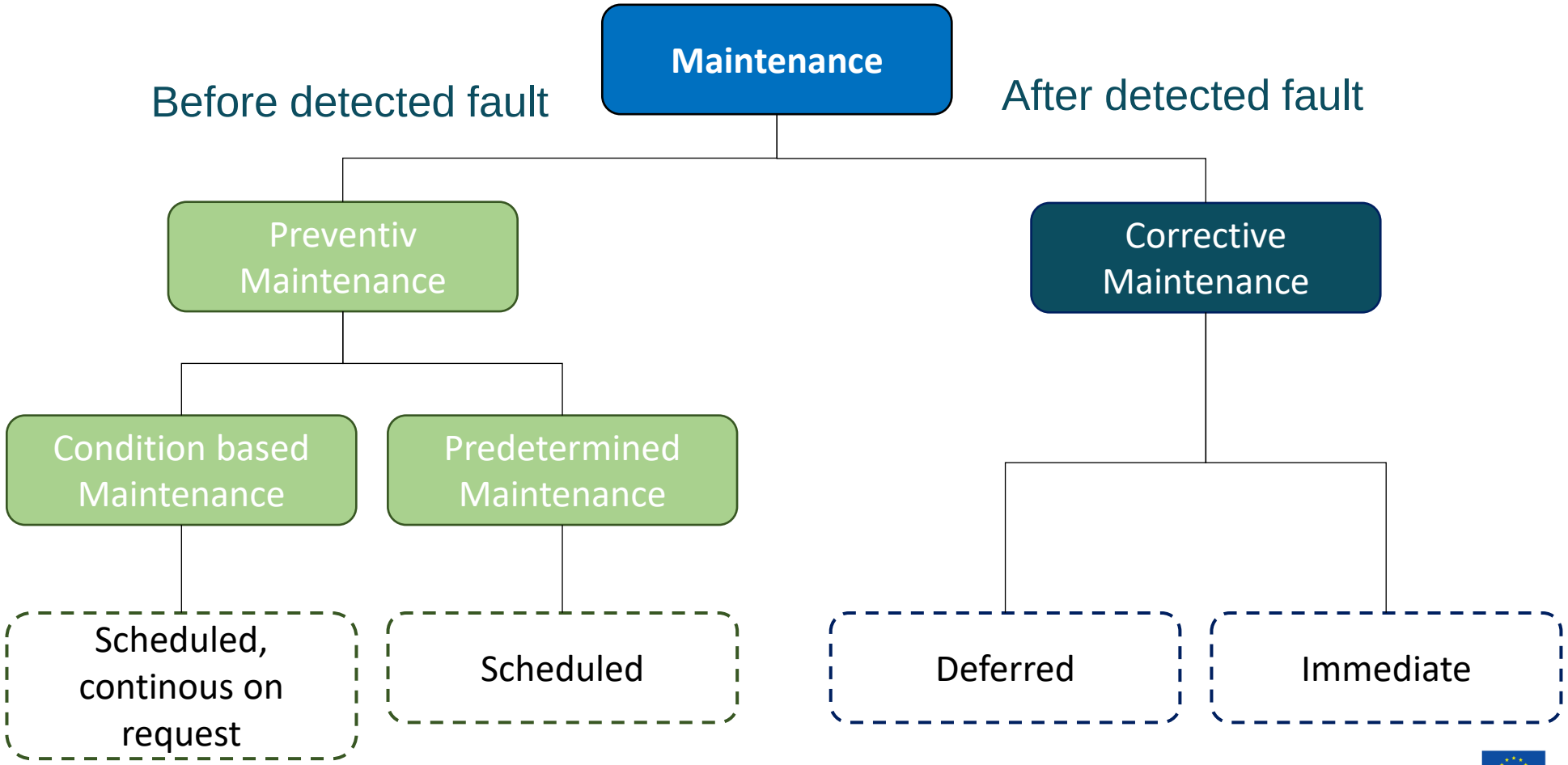
Definition of maintenance levels

	Maintenance levels is intended to keep a structure as valuable as possible, both in terms of equipment value and in terms of performance and safety. A good practical application of the different maintenance levels allows to achieve an optimal maintenance.
	Cost-effective maintenance limits to optimise operation and maintenance procedures. By so doing, one widens the discussion to include both operational safety and cost-effectiveness for the whole railway transport system. In this study, a cost model is proposed to specify the cost-effective maintenance limits for track geometry maintenance

Maintenance strategies

Basic concepts



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Maintenance limits

Condition state

Overview condition survey intervals

Country	Checking	Inspection	Assessment
Austria	4 Months	2 Years	6 Years (12)
Germany	6 Months	3 Years	6 Years
Switzerland	ongoing	As needed	5 Years
USA	6 Months	2 Years	5 Years
Japan	laufend	2 Years	5 Years
France	12 Months	3 Years	6 Years
England	As needed	2 Years	6 Years
Sweden	6 Months	3 Years	6 Years
South Africa	12 Months	As needed	5 Years

Guidelines bridge survey in Austria (*

	Checking	Inspection	Assessment
Monitoring	4 months	2 years	6 years (12)
Goals	Operational reliability & user safety	Changes in condition since last assessment	Extensive visual survey & measurement
Methods	Check for visual defects & changes	Visual survey with standard form	Extensive documentation
Responsi-bility	Road staff (operator)	Experienced engineers (operator)	Licensed civil engineer (extern)
Results	Short report major defects	Documentation of condition changes	Report on reliability & safety

*) Not for all Assets

Different survey types in Austria

Checking: Visual checking regarding obvious changes in bridge condition (check-list) at least e.g. every 4 months in Austria by road operators

Inspection: Visual assessment regarding bridge and bridge element condition with comprehensive check-list and photos at e.g. least every 2 years in Austria by bridge inspection people from operator

Assessment: Accurate determination and rating of bridge condition with time horizon for necessary maintenance and rehab works at least e.g. every 6 years in Austria by external certified civil engineers with report (four eyes principle)

Classification in Austria

Grading	Restriction	Damages	Measures
5 - very poor	Structural or functional damage	Extreme severe defects	Immediate repair/rehab
4 – poor	Reduced performance or substantial defects	Severe defects	Short term repair/rehab required < 3a
3 – fair	Reduced functional performance	Moderate defects	Medium term repair action required < 6a
2 - good	No restrictions	Minor defects	Maintenance
1 - very good	No restrictions	No defects	No action

Corrective Maintenance

Condition based Maintenance

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Maintenance limits

Corrective Maintenance

Condition based Maintenance

Condition state

Austria: 5–very poor „Immediate repair“; 4–poor „Short term repair < 3a;
3–fair „Medium term < 6a; 2–good „Maintenance“; 1–very good „No action“

Germany: 3,5 – 4,0 insufficient „Immediate repair or renewal“;
3,0 – 3,4 not sufficient „Immediate repair“;
2,5 – 2,9 sufficient „short to midterm repair“;
2,0 – 2,4 satisfying „midterm repair“;
1,5 – 1,9 good „continous maintenance“;
1,0 – 1,4 very good „continous maintenance“;

Denmark: 5–very poor „Immediate repair“; 4–poor „Short term repair“;
3–fair „Medium term (within a few years)“; 2–good „Maintenance (ad-hoc)“; 1–very good „No action“

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Maintenance limits

Condition state at component-system level

Austria: The evaluation in terms of maintenance limits is carried out in Austria at the system level, taking into account the mean value of the component evaluation and the worst component evaluation RVS 13.03.xx "Combined Condition State Factor"

Germany: The evaluation in terms of maintenance limits is carried out in Germany at the system level. Each damage is assigned a component and rated according to RI-EBW-PRÜF. The condition state is calculated using a special algorithm taking into account semantical information of each damage. Both the system grading and the highest component damage are reported. "Combined Condition State Factor"

Denmark: Condition rate at the structural system level is max of element condition rate of those elements that have significant impact on system functionality and durability, typically: superstructure, abutments, intermediate supports and waterproofing.

Bridge Inspection, Danish Road Directorate (in Danish - Eftersyn af bygværker, 2019), Reliability-Based Classification of Load Carrying Capacity of Existing Bridges", Report 291, Danish Road Directorate 2004

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Maintenance limits

Preventive rehabilitation

Austria: According to RVS 13.15.11 “Lebenszyklen der Brücken”, preventive rehabilitation for critical infrastructure is carried out after 30, 60, 80, 100, and 120 years

Germany: Preventitive rehabilitation for road bridges is carried out according to the result of technical and economic feasibility studies according to RI-WI-BRÜ, RPE-ING, and LPI-ING. Suggested intervals: 20-30 + 45-55 years or alternatively 30-50 years

Denmark: According to (implicit or explicit) evaluation of life cycle costs for different maintenance strategies. Guideline for design and assessment of bridges, Danish Road Directorate (in Danish - Vejledning til belastnings- og beregningsgrundlag for broer, 2017)

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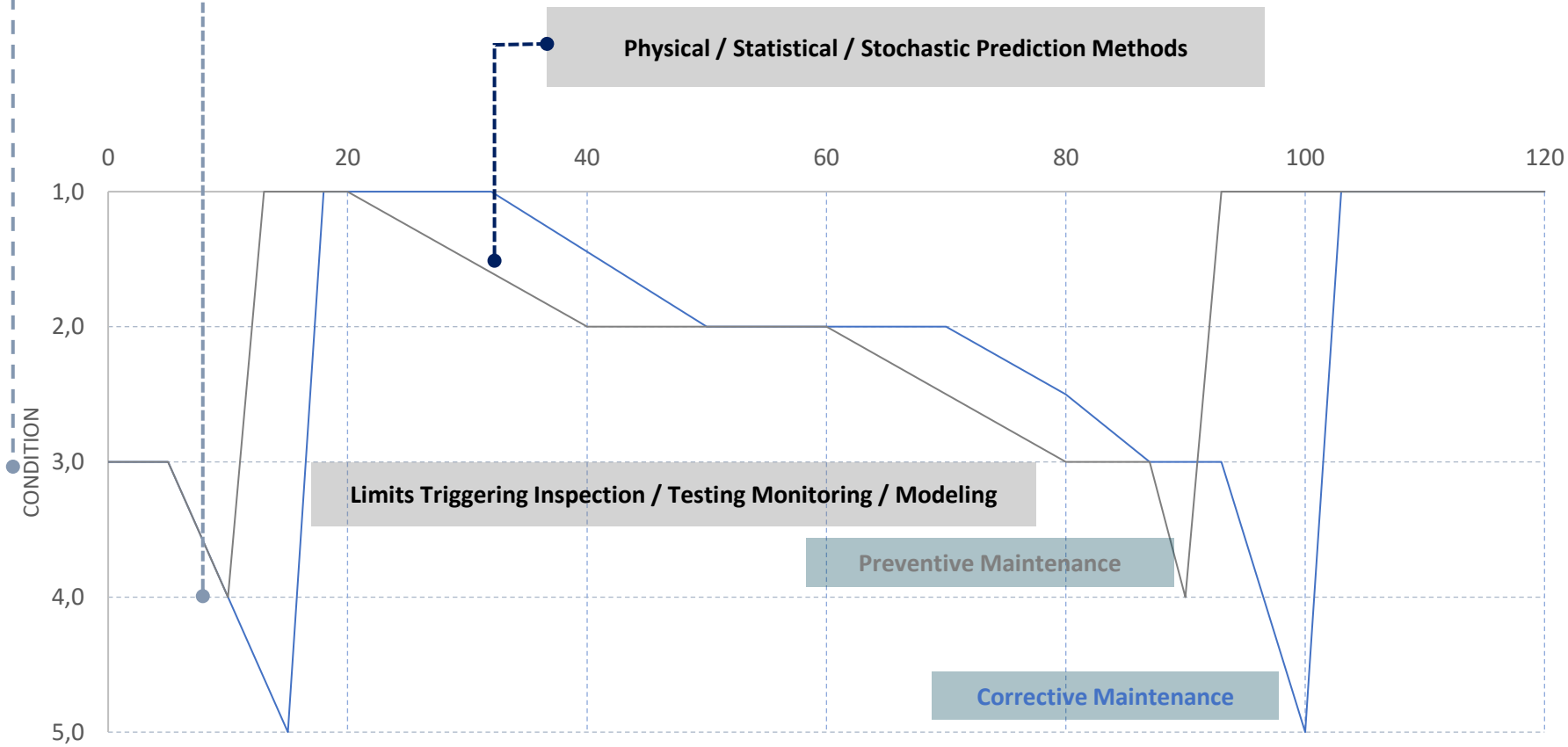
Maintenance limits

RISK

RELIABILITY

CONDITION

Preventive rehabilitation



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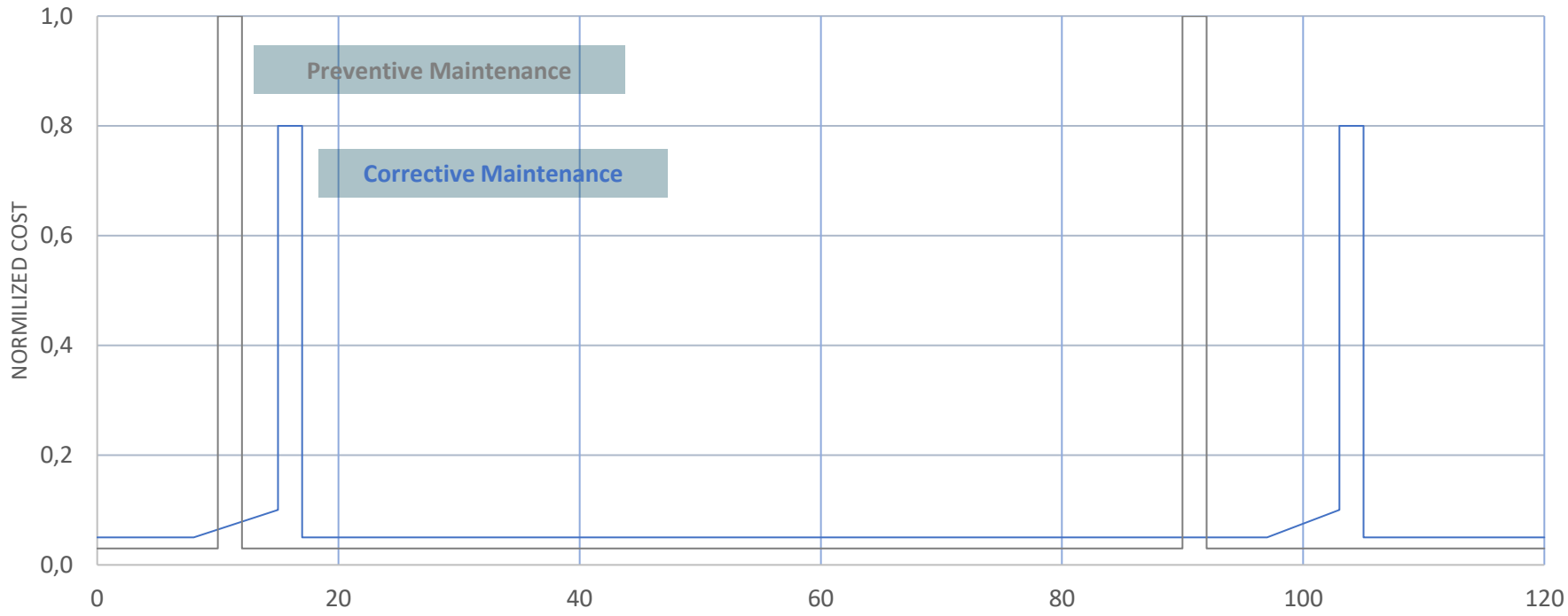
Maintenance limits

Preventive rehabilitation



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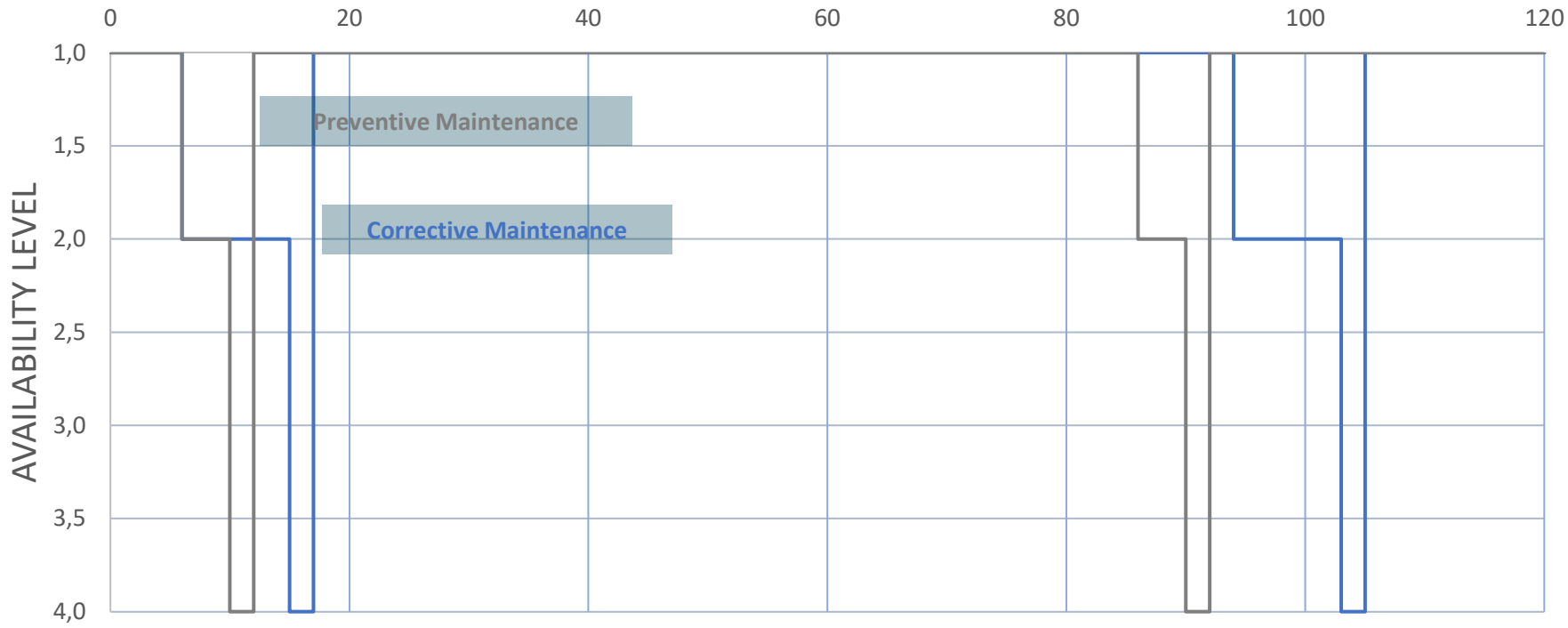
Maintenance limits

Preventiv rehabilitation



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Maintenance limits

Key figures

The aim is to record the maintenance share of the value added in the entire production process. With big data and comprehensive data analysis, it is possible to carry out maintenance and servicing even more precisely and quickly - on the basis of various key performance indicators (KPI).

MTBF = Mean Time Between Failures

MTBF refers to the mean time between failures of repairable units. The measured value is highly dependent on the operating conditions prevailing at the site (ambient temperature, maintenance intervals, etc.). MTBF thus represents an indicator of the reliability of a system - the higher the MTBF value, the more reliable the system.

MTTR = Mean Time To Repair

The average repair time after a system failure. This indicates how long it takes on average to detect and localize a fault and replace the defective component. The MTTR figure thus provides important information about general system availability. The MTTR value should be as small as possible.

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Maintenance limits

Maintenance limit factors

MDT = Mean Down Time

The mean Fault duration describes the average time required to eliminate the failure after a system failure. In contrast to MTTR, MDT includes all times for repair and maintenance as well as all delays due to start-up and delivery times, spare parts logistics or failed attempts at unplanned maintenance. During MDT, the system is not operational. The MDT value should therefore also be as small as possible.

OEE = Overall Equipment Effectiveness

The indicator of overall system effectiveness allows conclusions to be drawn about the productivity and value added of a plant, but also about unplanned losses in the measured operating time without planned shutdowns. Overall system effectiveness is determined as the product of the factors availability, performance and quality. However, since operating resources and processes differ greatly from company to company, the OEE figure is only meaningful for the individual plant and cannot be generalized. Measures to improve the OEE value are not necessarily accompanied by an increase in efficiency and yield - it is important to ensure that the effort and benefit are in a sensible relationship to each other.

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Maintenance limits

Key figures

Important KPR for maintenance

Key performance indicators are increasingly being used not only for business management, but also for the technical area and maintenance of facilities - because here, too, they open up a wide range of opportunities for identifying and exploiting potential for improvement. Facility operators can find initial indications of which key performance indicators are important for maintenance in the European standard DIN EN 15341 (Essential performance indicators for maintenance) and in DIN 31051 (Fundamentals of maintenance).With the right key figures, it is not only possible to identify potential for improvement, but also to implement comprehensive maintenance controlling.

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Questions and Answers

Questions

- Do condition maintenance limits apply in your country?
- Are reliability maintenance limits applied in your country?
- Are risk-based maintenance limits applied in your country?

Questions for discussion:

- Do you use any of the presented factors to adjust maintenance limits, or which factors are important for you to adjust maintenance limits or strategies?

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Thank you all for attending, questions, input, etc.

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