Creating a world
fit for the future

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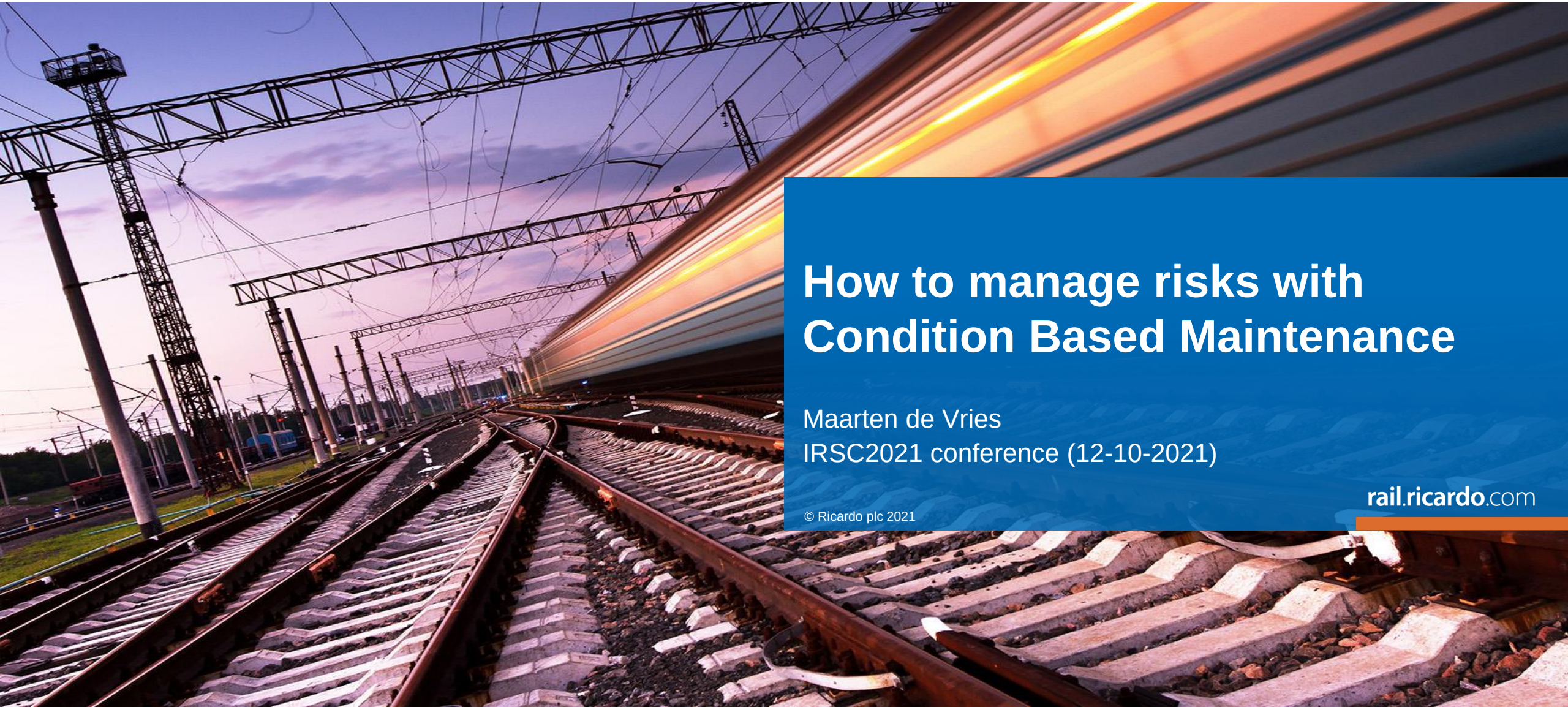


How to manage risks with Condition Based Maintenance

Maarten de Vries

IRSC2021 conference (12-10-2021)

rail.ricardo.com

Ricardo Rail

Experts in critical and complex railway systems

By combining a deep understanding of the rail environment with specialist knowledge of its most critical technologies, we provide responses that deliver tangible outcomes for our clients and their stakeholders.

Systems engineering

Multi-disciplinary expertise that cuts across traditional industry silos.

Design and analysis

Expertise in producing cost-efficient responses to complex engineering challenges.

Asset management and optimisation

Specialist processes and technologies to improve efficiency across rail operations.

Independent assurance

Timely approvals for rail components, products and entire systems.

Introduction

Maarten de Vries

Consultant Maintenance

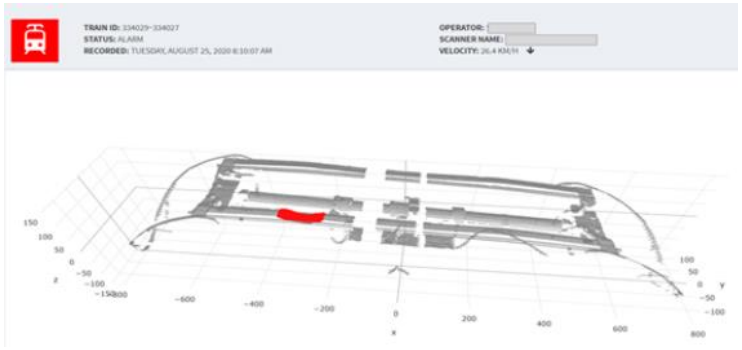
Work experience

- 8 years experience
- Reliability and Maintenance Engineering
- Urban, domestic and high-speed rolling stock
- Implementation of CM / CBM for locomotives and ETCS

Education

- MSc and BSc Maintenance Engineering
- Specialization in Transport Engineering and Logistics
- Specialization in Reliability Centered Maintenance and Condition Based Maintenance.

New technologies



FRMCS
Future Railway Mobile Communication System

5G ADVANCED

LoRa

Bluetooth®

Continuous new developments of sensors and data/communication technology

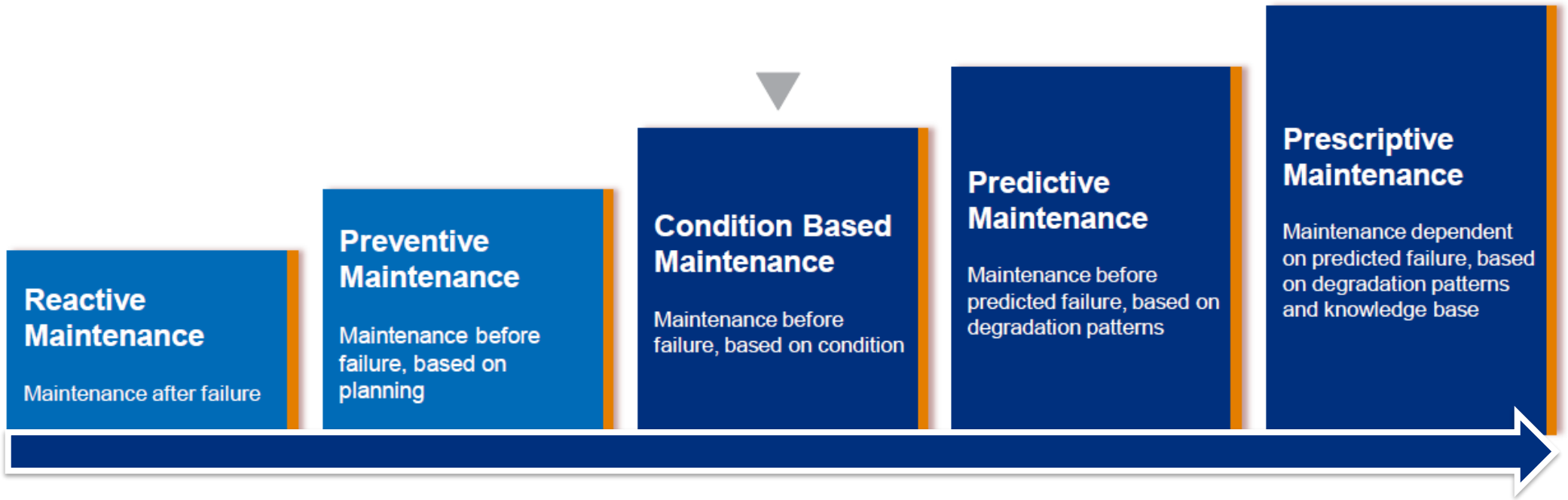
Main driving factors:

- Higher accuracy and reliability possible
- Lower cost technology
- Increasing computational power
- Higher energy efficiency
- Development of network technology

Reasons for application

- Higher demand on reliability, availability, comfort and safety
- Higher requirements on maintenance and risks
- Strong focus on OPEX and CAPEX
- Data communication and storage is a commodity
- Higher availability of data and information of rolling stock
- Development of TCMS / diagnostic systems

Maintenance Maturity



Maturity levels from left to right

Regular approach to identify risks

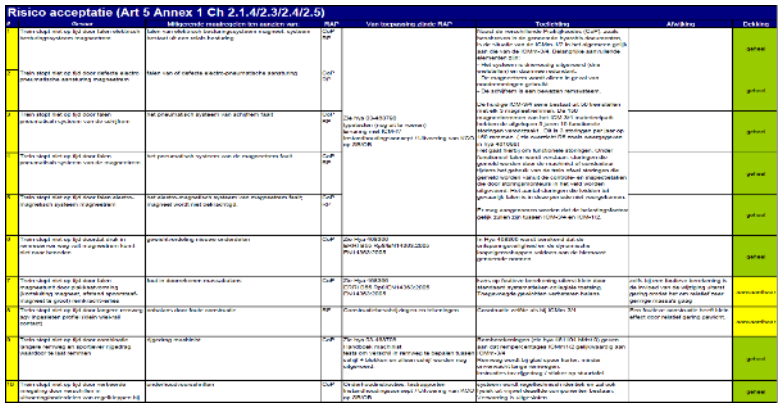
- Reliability Centered Maintenance (RCM2)
- Risk-Based Reliability Centered Maintenance (RCM3)
- Risk Based Maintenance (RBM)

		bijna niet denkbaar	praktisch onmogelijk	zeer onwaar-schijnlijk	onwaar-schijnlijk	waar-schijnlijk	regel-matig	zeer regel-matig
		0,00015	0,0015	0,015	0,15	1,5	15	150
Catastrofaal	200	0,03	0,3	3	30	300	3000	30000
Ernstig	20	0,003	0,03	0,3	3	30	300	3000
Behoorlijk	2	0,0003	0,003	0,03	0,3	3	30	300
Matig	0,2	0,00003	0,0003	0,003	0,03	0,3	3	30
Gering	0,02	0,000003	0,00003	0,0003	0,003	0,03	0,3	3

Functional decomposition → Failure Modes → Failure Effects → Risks → Mitigation

Code	Product group
B	Vehicle Body
C	Vehicle fitting out
E	Running Gear
F	Power system, drive unit
G	Control apparatus for train operations
H	Auxiliary operating equipment
K	Lightning
M	Ancillary operating equipment
N	Doors, entrances
Q	Pneumatic/hydraulic equipment
R	Brakes
S	Vehicle linkage devices

EN15380 Railway applications - Designation system for railway vehicles



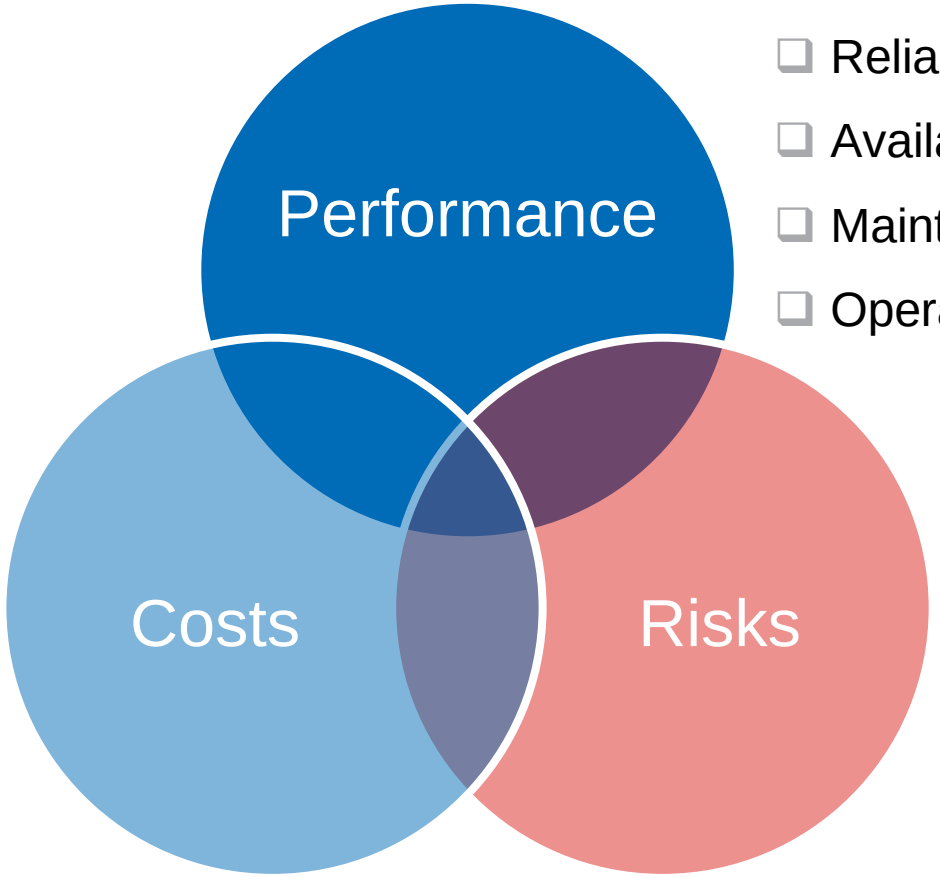
EN60812 Failure modes and effect analysis

- ✓ Reactive maintenance (‘run to failure’ or ‘corrective’)
- ✓ Preventive maintenance (‘interval based’)
- ✓ **Predictive maintenance (‘condition based’)**

Or:

- ✓ Modification / Revision / Redesign

Performance, Risk, Costs



- Reliability
- Availability
- Maintainability
- Operational Effectiveness

- Operational (OPEX)
- Capital (CAPEX)

- Safety
- Failures
- Unavailability
- Maintainability

Framework for CBM implementation

Framework developed for implementation of Condition Based Maintenance (CBM)

Five stages

1. Strategy selection
2. Preparation
3. Development
4. Implementation
5. Evaluation

Main goal of framework

- ❑ Address all necessary ‘activities’
- ❑ Perform the right activities in each stage
- ❑ Support a positive Business Case

Strategy selection for new technology

Stages	Elements
Strategic level / Tactical level — Strategy selection	Business policy making
	Business Case development
	Risk management
	Use cases and user stories definition
Preparation	Product purchase/tendering
	Certification/CSM
	Design and modification
	Installation
Development	BI & data handling
	Digital Resilience
	Design tooling
	Maintenance Management
	Process development (business, maint., logistics)
	Training and support
Operational level — Implementation	Change management (processes, training)
	Human Factors
	Process integration
	Verification
Evaluation	Validation
	Business Case evaluation
	Continuous improvement / PDCA

Strategy selection

- ❑ Cost driven
- ❑ Performance driven
- ❑ Risk driven
- ❑ Solutions driven

Business case development

- ❑ Assets / systems
- ❑ Goals and benefits
- ❑ Risks and mitigation
- ❑ Contribution to strategy

Use cases

- ❑ Who (users)
- ❑ What (systems, processes)
- ❑ Where (organization)
- ❑ When (applicability)
- ❑ Why (strategy + BC)
- ❑ How (usage)

Preparation to adopt new technology

	Stages	Elements
Strategic level	Strategy selection	Business policy making
		Business Case development
		Risk management
Tactical level		Use cases and user stories definition
	Preparation	Product purchase/tendering
		Certification/CSM
		Design and modification
		Installation
	Development	BI & data handling
		Digital Resilience
		Design tooling
		Maintenance Management
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		Training and support
Operational level	Implementation	Change management (processes, training)
		Human Factors
		Process integration
		Verification
	Evaluation	Validation
		Business Case evaluation
		Continuous improvement / PDCA

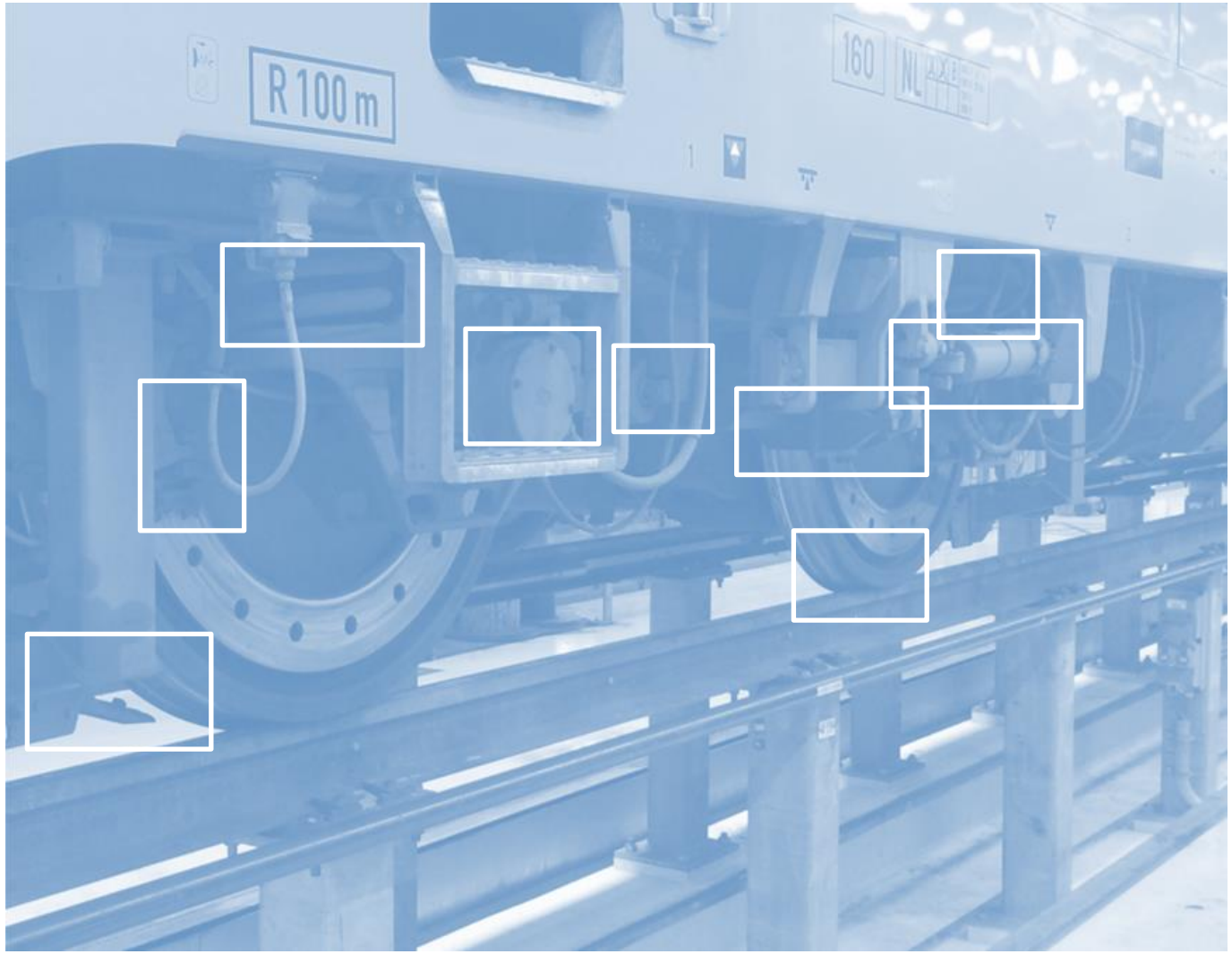
Product purchase/tendering

- ❑ New technologies
- ❑ Most suitable and cost-effective solutions

Certification

- ❑ Risk analysis for implementation design / process change(s)
- ❑ Common Safety Method (CSM)

Managing Risks with Framework for CBM



Main advantages of managing risks with this framework

- Clear and **structured** approach
- **Scope** and boundary conditions defined
- **Focus** on necessary activities

- **Strategy** and **business case** drives adaptation of new technology

- **Risk mitigation** in maintenance and processes will be **effective** and **efficient**

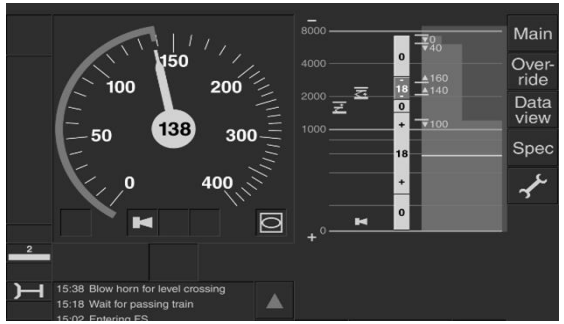
Examples

TRAXX locomotives on high-speed infrastructure

- ❑ Mitigating risks of operational delays (>3 min)
- ❑ Monitoring performance of various on-board systems in real-time with new installed hardware

ICE high-speed rolling stock

- ❑ Mitigating risks of train cancellations
- ❑ Monitoring performance of critical systems required for operation based on TCMS data



ERTMS monitoring specification

- ❑ Mitigating risks of operational delays
- ❑ Specification of monitoring and diagnostic system and data for future use

Best practices in implementation

5 best practices in implementation

- Not only focus on systems with high costs and/or risks, but also address **practical issues** to raise commitment on operational level
- Involve stakeholders on all levels of the organization – create **ownership**
- **Start small** (small part of fleet, one system, one shift of operators/mechanics)
- Focus on **continuous improvement** to secure benefits on the long term
- **Communicate** on progress, achievements and experiences on frequent basis

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