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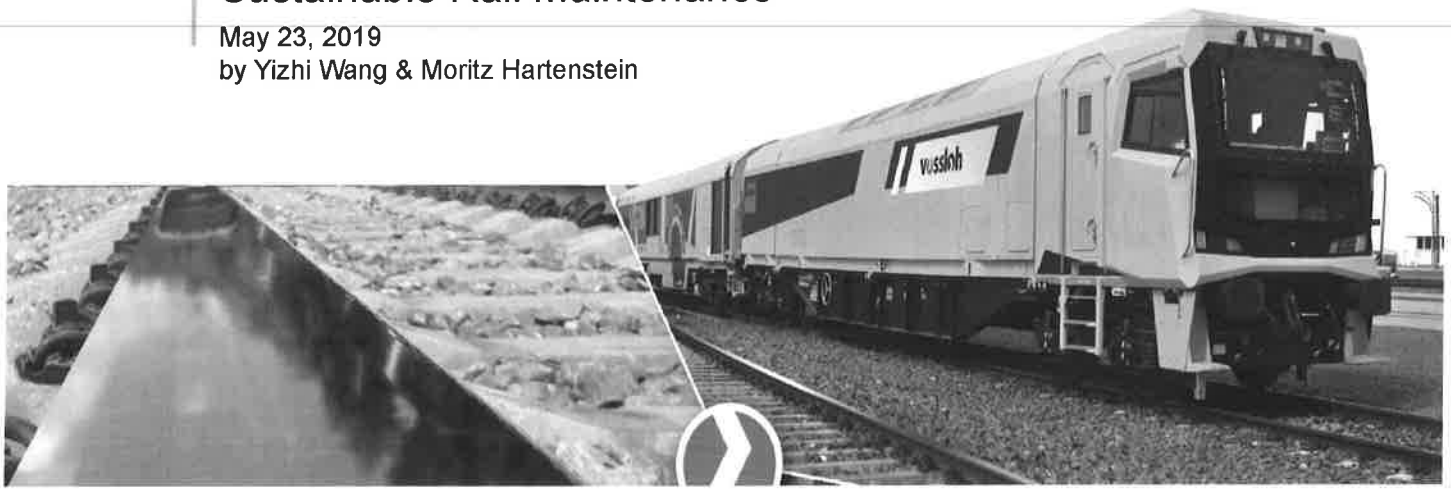
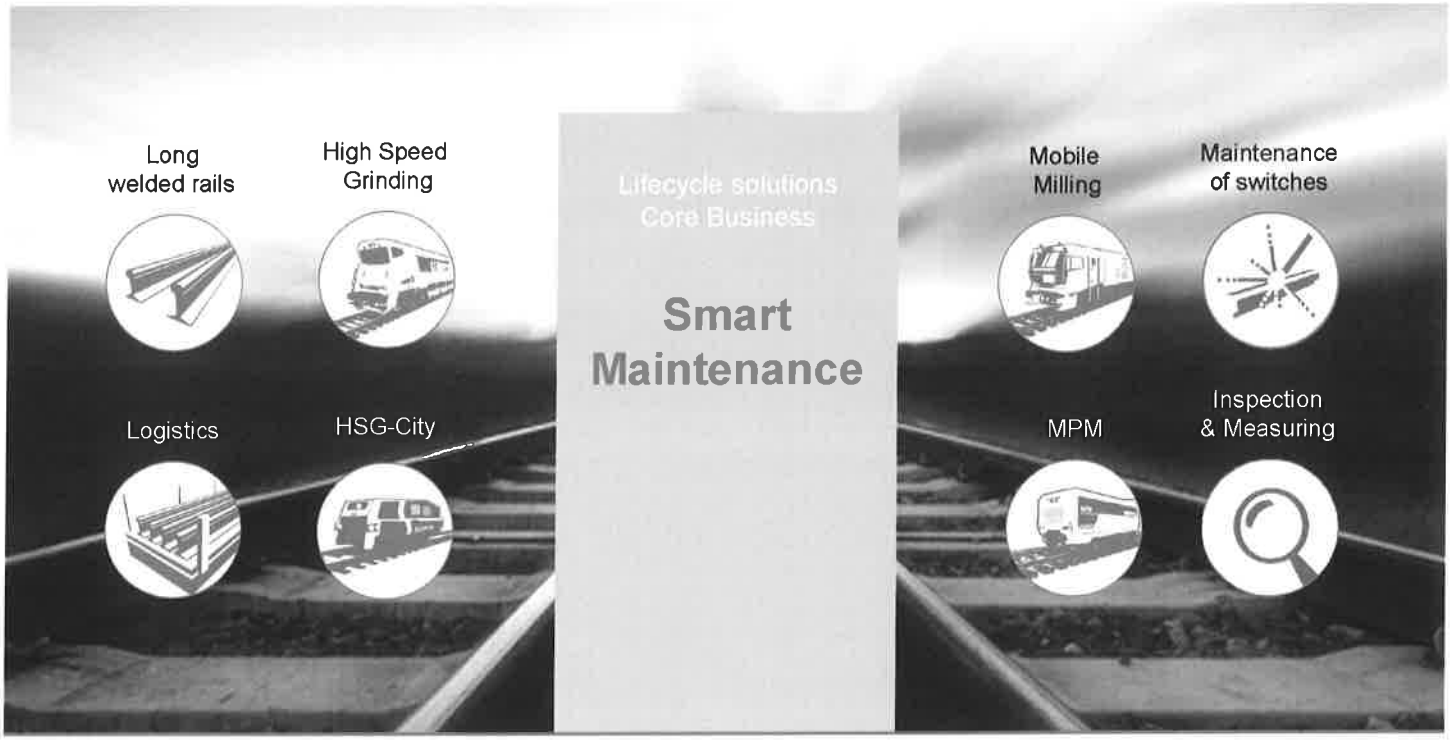
Sustainable Rail Maintenance

May 23, 2019

by Yizhi Wang & Moritz Hartenstein





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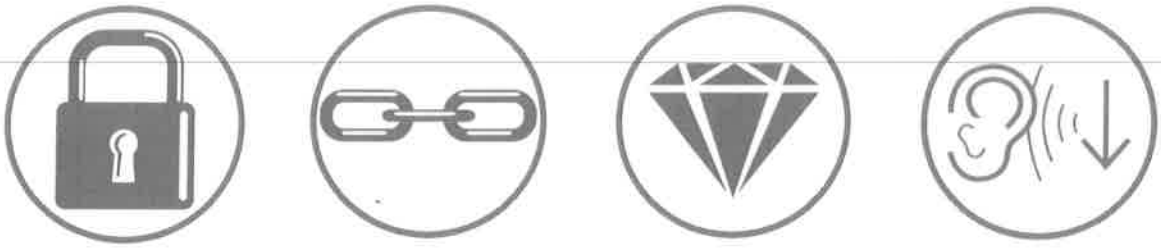
Why?



Increased Safety | **Higher Durability** | **Higher Lifespan** | **Reduced Noise**

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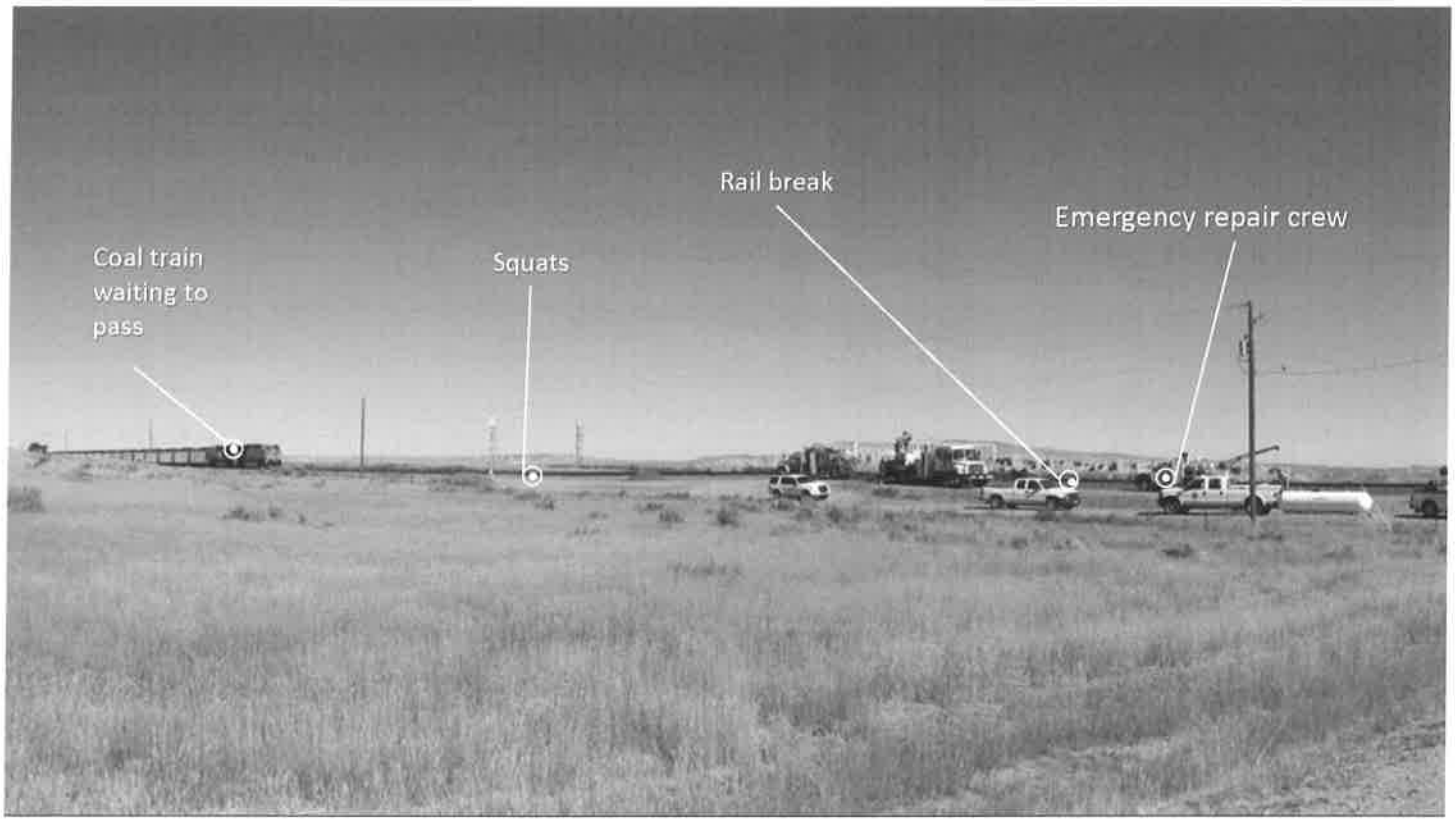
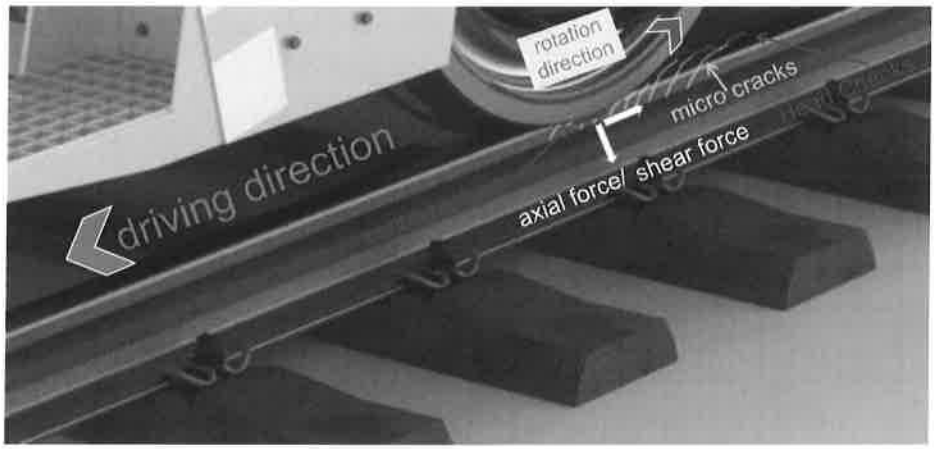
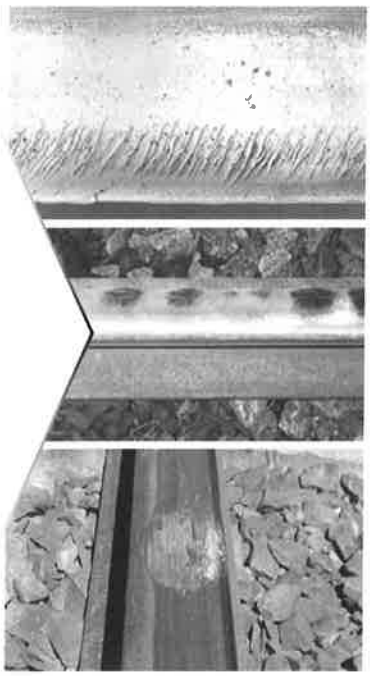


Why ?

Exponential defect growth





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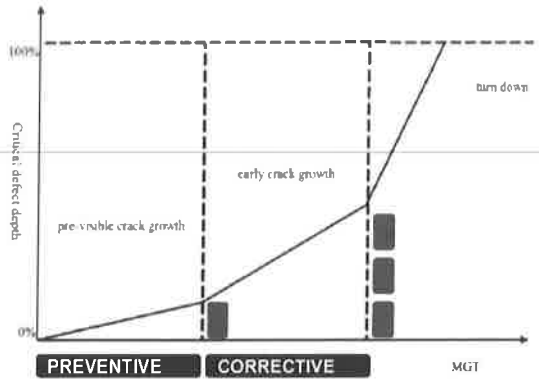
Rail Maintenance

A deeper look: The development of Rolling Contact Fatigue



- Surface defects do not develop linear
- Double of MGT (time) results in triple damage depth
- Hardened surface layer reaches approx. 0,06 mm (max. value).

Source Diagram: Dr. Jaiswal, Jay: International Railway Journal, 2005, vol. 9

Source Hardness zone: UIC Joint Research Project Proactive measures – Remedial and Repair Technology

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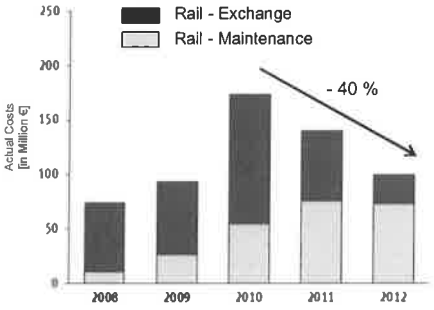
Rail Maintenance Approach

Prolonging Rail Life: Saving Money

Development – Rail Budget



Source: DB Netz AG 2013

- Particularly milling of heavily defective rails relieves the rail renewal budget (Source: DB Netz AG 2013)
- More than 40 % reduction of Budget from 2010 - 2012

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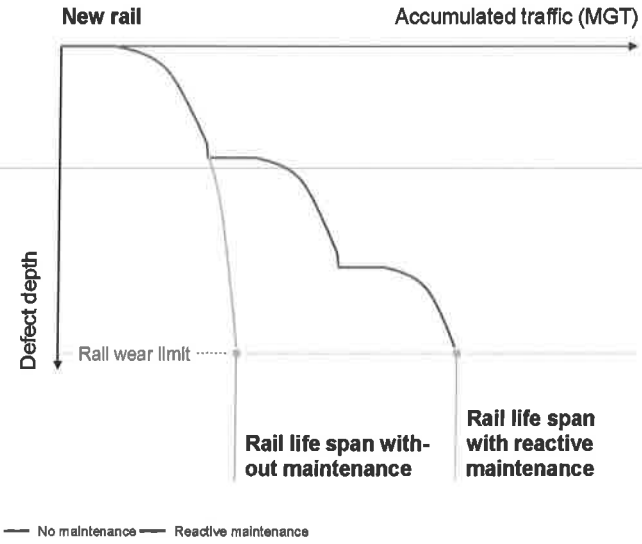
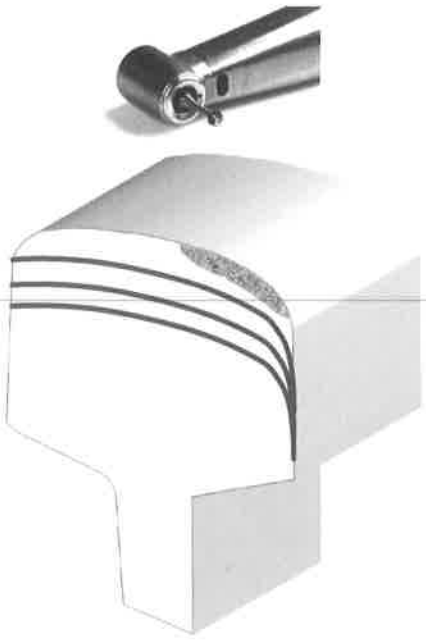
Rail Maintenance

Reactive Maintenance





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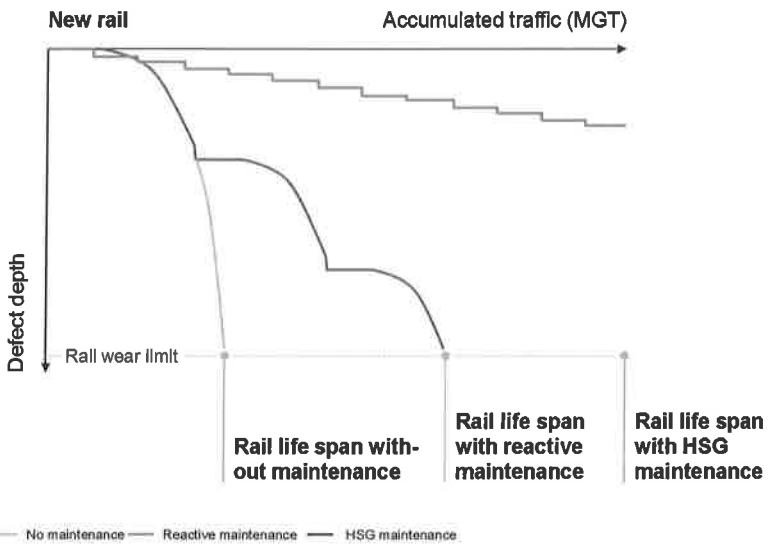
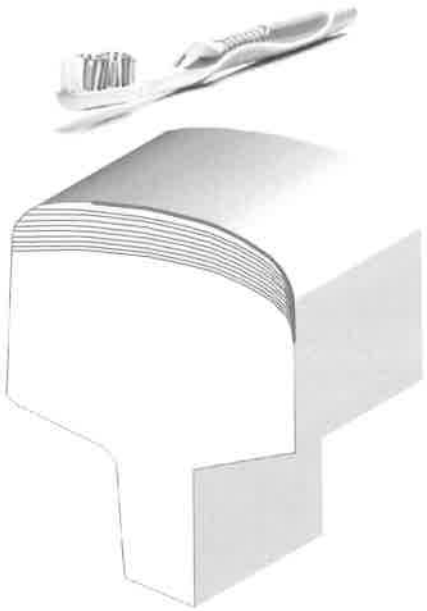
Rail Maintenance

HSG Maintenance





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Rail Maintenance Approach

Rail defects - Evaluation and measures at Deutsche Bahn

- Evaluation according to K-Ril 821.2007A02
- Conclusion

Stage	5	4	3	2	1
Depth	< 0,5 mm	< 1,5 mm	< 2,7 mm	> 2,7 mm o. UT	> 2,7 mm m. UT
Method	Grinding	Milling/ Grinding	Milling/ Grinding	Milling/ Grinding	Rail-exchange
Deadline	18 Months	12 Months	6 Months	3 Months	6 Weeks

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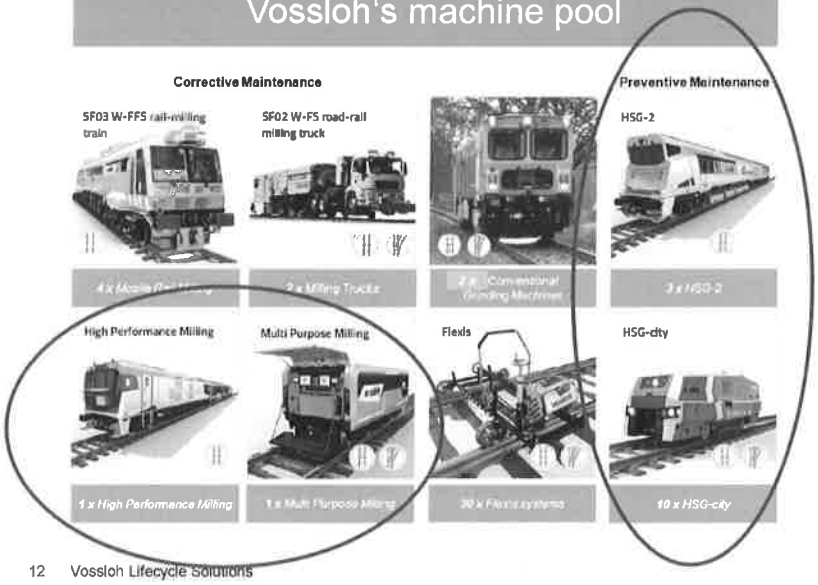
Rail Maintenance

Machine Pool and Experience in Machine Operations

Vossloh's machine pool



Experience

Experience in maintenance:

- Independent from machine manufacturers (spare parts, repair, maintenance)
- Own service teams
- 24/7 deployable workshop cars
- Network of suppliers
- Own after sales organization

Producer of 13+ rail bound maintenance machines

Operator of 15+ rail maintenance machines

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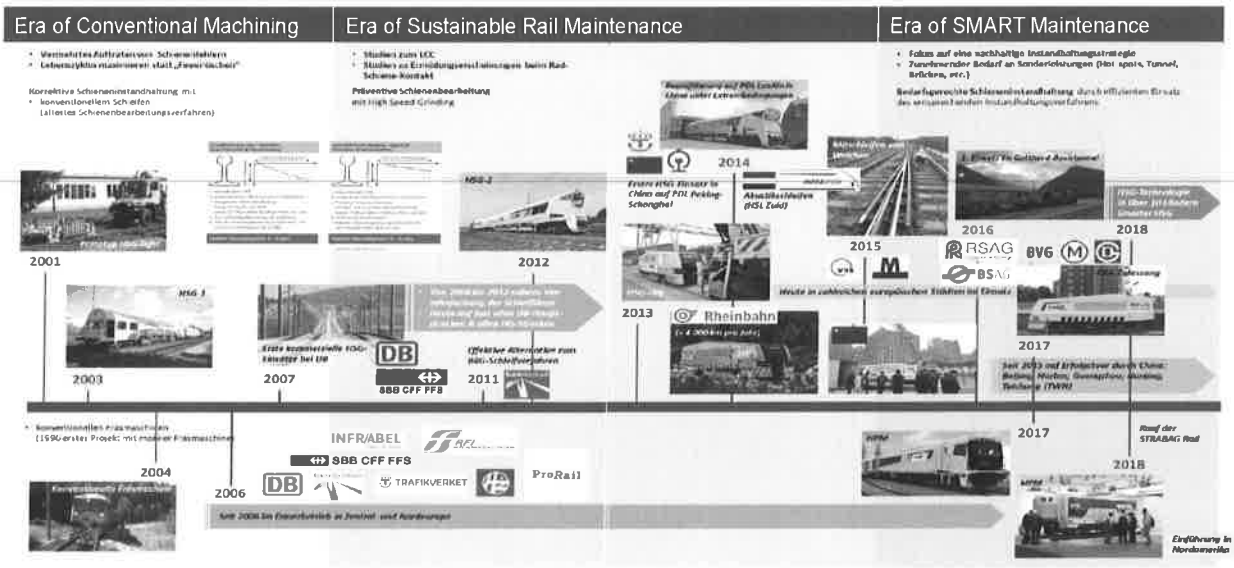
Lifecycle Solutions

Pioneer for condition-based rail maintenance



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Rail Maintenance

Some References

we care for rails

SBB CFF FFS
DB
VVS
北京地铁 BEIJING SUBWAY
INFRABEL
TRAFIKVERKET
BSAG
ProRail
RSAG
上海地铁 Shanghai Metro
BVG

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Rail Maintenance Approach

Preventive vs. corrective maintenance

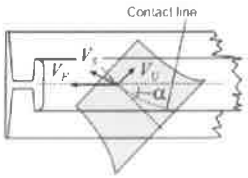
	Preventive (Planned)	Corrective (Planned or Unplanned)
Possible Methods	One Pass Grinding, Two Pass Grinding, **High Speed Grinding**	*Corrective Grinding*, **Milling**, *Rail Exchange*
Procedure	Low metal removal rate, regular grinding cycles, grinding before defects develop, no reprofiling, high working speeds	High metal removal rates, elimination of deep defects, reprofiling, slow working speeds
	Full Service Provider → Discrimination free without product preferences	

Preventive maintenance for mainlines and UTS

High Speed Grinding - Unique Preventive Maintenance

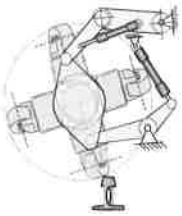
High Speed Grinding - HSG

Grinding principle



- Rotational grinding
- Passively driven grinding stones

- High working speeds
- No facets
- No dismantling of track installations
- Overheating of rails impossible



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Mainline: High Speed Grinding - HSG

- 4 grinding trolleys, **96 stones** on rail
- Automated change of grinding stones
- Grinding speed: **60-80 km/h**
- Preventive grinding: 0.1mm metal removal (in three runs)
- Surface: Ra < 10µ
- Operational range without stop: **40-100 km**

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UTS: Preventive rail maintenance with HSG-city

- 1 grinding trolley, **24 stones** on rail
- Automated change of grinding stones
- Grinding speed: **20-60 km/h**
- Preventive grinding: 0.1mm metal removal (in ten runs)
- Surface: Ra < 10µ
- Operational range without stop: **20-30 km**

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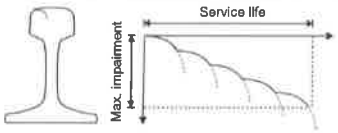
High Speed Grinding - HSG

Deutsche Bahn confirmed operational efficiency

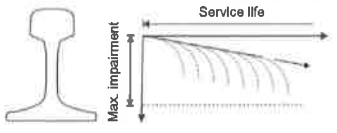
No prevention:
High speed track Cologne – Rhine Main



- Strong head check growth
- Corrective maintenance:
  - Removal: 1.8 mm every two years
  - **Costs: 12 Euro per meter (6 Euro per meter and year)**
- Incomplete removal of head checks
- End of life due to head checks and reach of wear limit after **8 years**

Expected rail life: 8 – 12 years

Immediate prevention:
High speed track Nuremberg – Ingolstadt



- Strong head check growth
- Preventive maintenance:
  - Removal: 0.1 mm three times a year (HSG)
  - **Costs: 1 Euro per meter (3 Euro per meter and year)**
- Prevention of head checks
- End of life due to reach of wear limit not before **15 years**

Expected rail life: 15 – 20 years

Source: DB Netz AG, Oliver Kraft, 07.03.2013;

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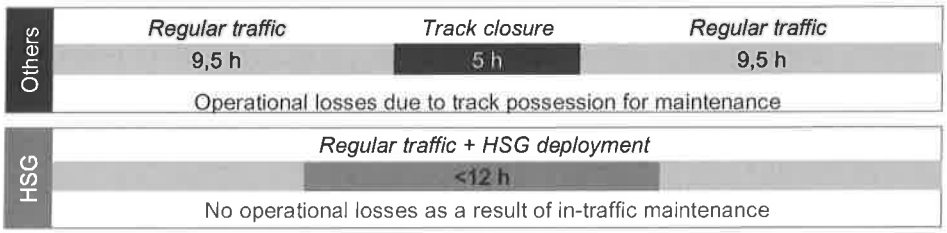
HSG(-city) in Operations

Technical Basics

- Grinding in regular traffic
  - No traffic interruptions, no traffic rescheduling
  - No track closures
  - No planning of possession times
  - No dismantling of signalling devices required
- Full flexibility and control of maintenance activities



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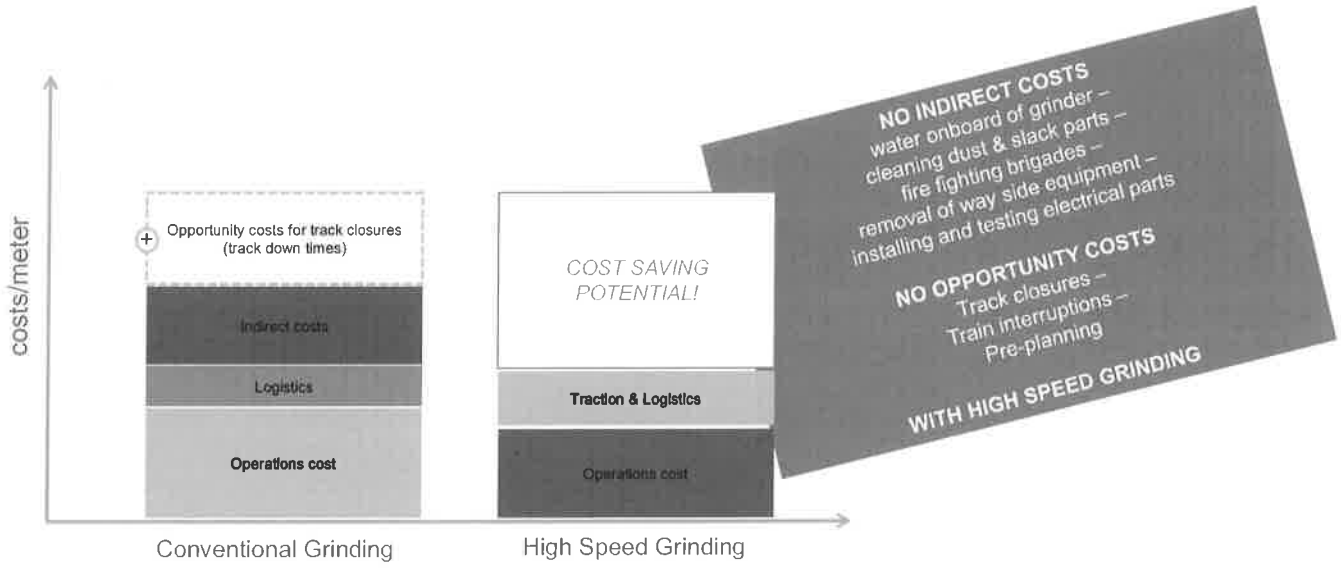
HSG (-city) in Operations

Example business case for defect depth = 0,1mm



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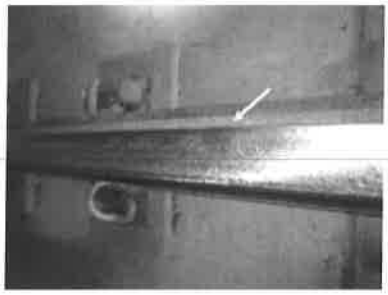
HSG-city in Operation

Corrugation removal for Beijing Metro

Before grinding

0.1 mm removed



0.3 mm removed

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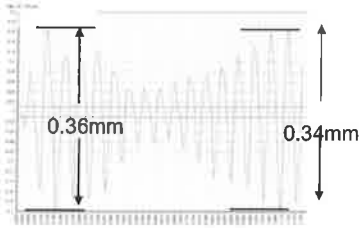
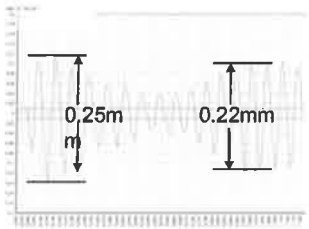
HSG in Operation

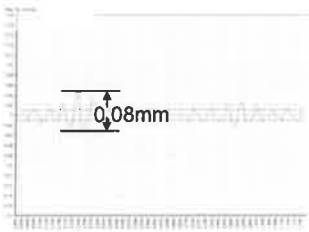
Corrugation removal for Beijing Metro



Before grinding



0.1 mm removed



0.3 mm removed

» Waves were reduced significantly by 0.3 mm

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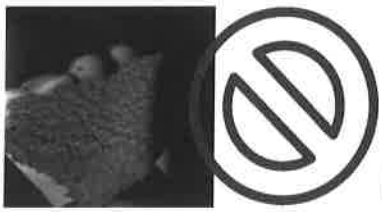
HSG in Operation

Clean operation

NO Manual cleaning after grinding

NO Dust cakes



NO blueing

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Rail Maintenance Approach

If the toothbrush simply won't work

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Corrective Milling for Mainlines and UTS

Rails as good as new - Discover easy maintenance

HPM - High Performance Milling

MPM – Multi Purpose Milling

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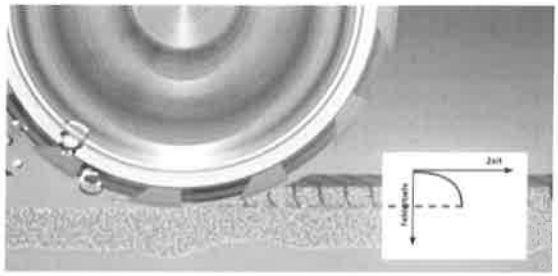
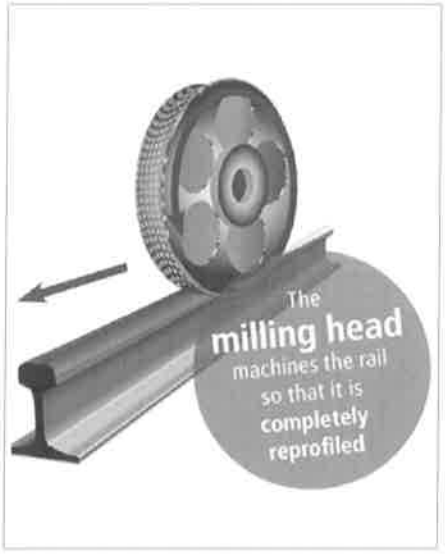
Field of work

HOW does it work?





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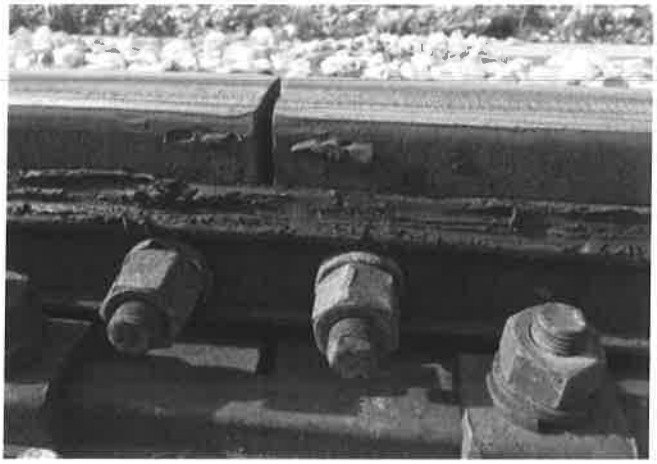
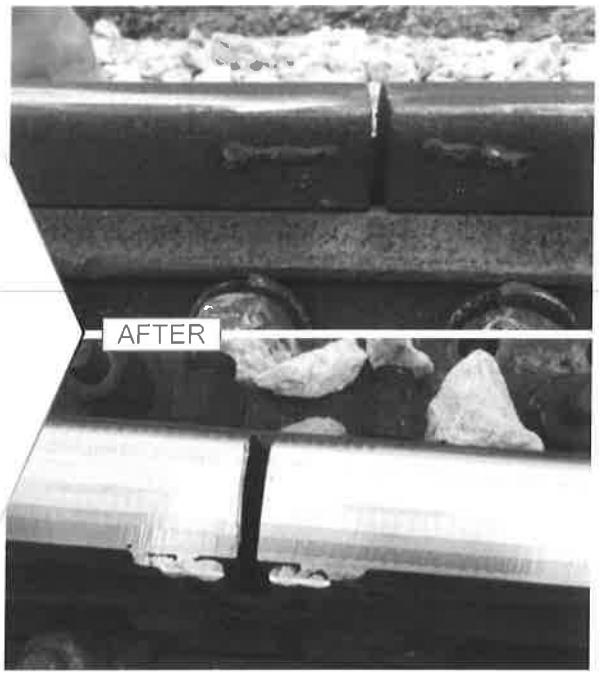
Scenarios where milling is preferred

Which results can be achieved?

BEFORE





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Scenarios where milling is preferred

Accuracy

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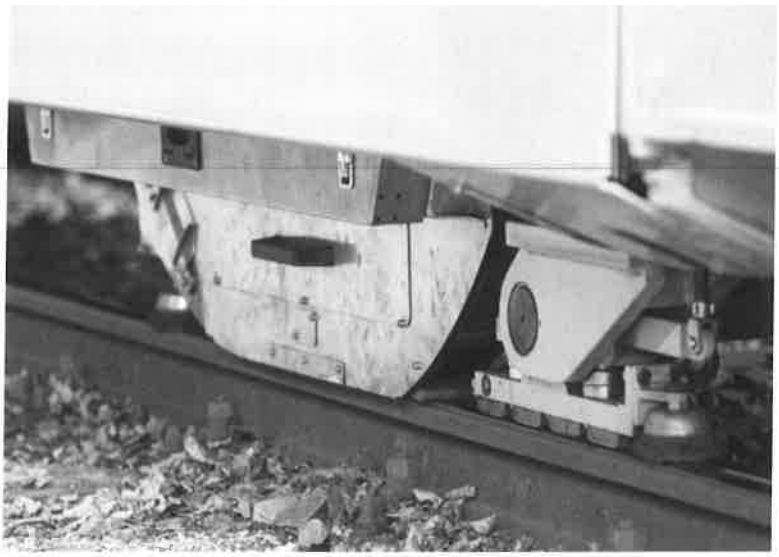
Scenarios where milling is preferred

Dust and fire protection



Bridges

Tunnel

Fire sensitive Areas

Sources: Edmonton Sun, Munich Underground, Youtube

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Mainlines – High Performance Milling (HPM)

Unique Rail Milling Performance

Performance Overview

Max. metal removal (one pass)	Surface	3 mm
	Gauge corner	6 mm
Max. working speed	Removal = 0,5 mm	2.000 m/h
	Removal = 1,5 mm	1.200 m/h
Surface quality (Roughness)		< 3 µm

- Milling wheel diameter: **1.400 mm**
- Rail gauge: **1.435 – 1.676 mm**
- Min. Radius: **150 m (milling)**
- Patented finishing system
- Modular-flexible concept
- Automatic tool changing system

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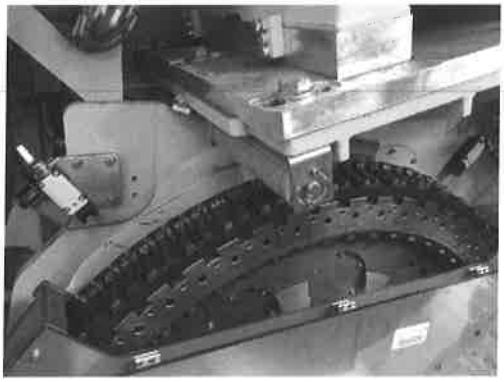
Mainlines – High Performance Milling (HPM)

WHAT is special?

Main Milling Units



- Diameter: 1.400 mm
- Semi-automatic tool exchange
- Flexible tool system (cassettes)
- All operational steps to be handled from inside the train

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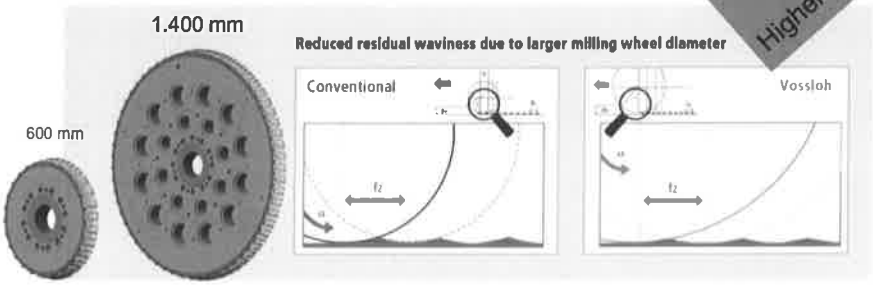
Mainlines – High Performance Milling (HPM)

WHAT is special?

Surface effect in detail



- Flat cutting angle
- Less forces on carbides

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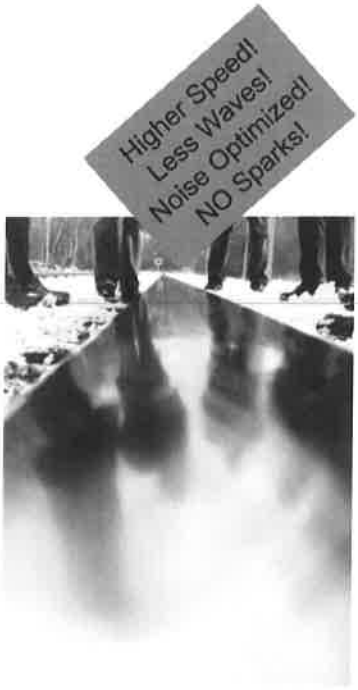
Mainlines – High Performance Milling (HPM)

WHAT is special?



Refinement – Finishing Process

- Face milling process for surface refinement without grinding
- Flexible profile adaption
- Removal of residual waves after main milling
- Optimization of surface after main milling process
- Tool exchange during operation on the fly

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UTS - Multi Purpose Milling (MPM)

Reduced to the max

- **Re-profiling:**
  - Refurbishment of target rail profile for optimum wheel-rail contact
- **Defect removal and gauge correction:**
  - Removal of RCF related defects of → **Up to 2 mm per pass**
  - Gauge widening to target track gauge → **Up to +5mm**
- **Increase Surface Quality:**
  - Minimize surface roughness → **Ra < 3µm**
  - Eliminate corrugation and waves. Optimize longitudinal profile → **EN 13231-3 quality standards**

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UTS - Multi Purpose Milling (MPM)

Technical Data

Milling process	Both Rails
Working Speed	average 200 m/h (max. 300 m/h)
Operations plattform	Open back plattform AND wireless remote
Max. Removal	max. 2 mm
Milling Wheel Size	360 mm
Weight (Axle Load)	16 t (8 t)
Max. Wheel diameter	570 mm
Transport Mode	External traction pulled (max. 60 km/h)
Track gauges	1,000 – 1,676 mm
Energy supply	Internal (diesel-electric)
Integrated bunker	Yes (0,5 m3)
Integrated finish grinding	Optional adapable system

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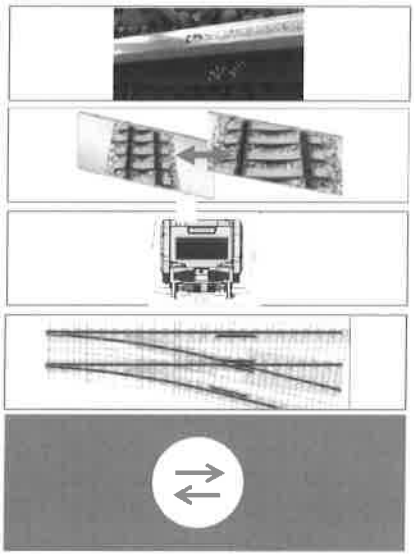
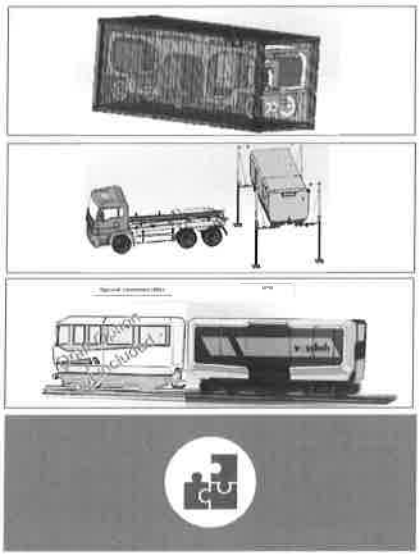
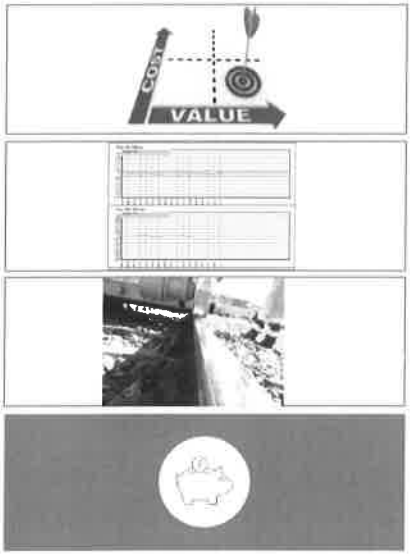
UTS - Multi Purpose Milling (MPM)

Variability, Compact & Modular, Efficiency







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Rail Milling in Operation

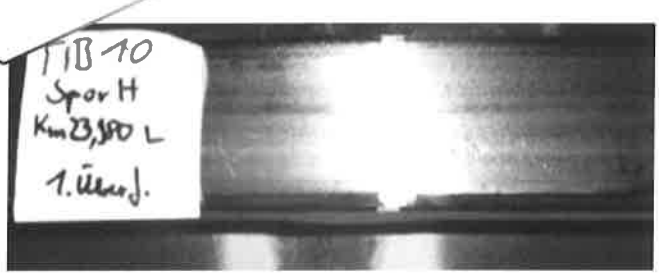
WHICH results can be achieved?

In Total:

» 1 milling pass
» 1.5 mm material removed
» Defects removed
» Rail re-profiled

BEFORE

AFTER



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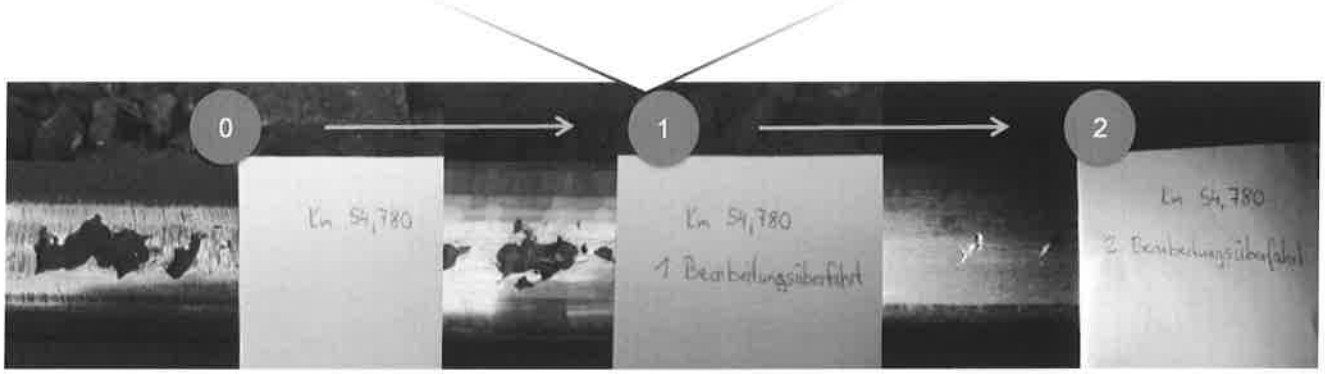
Rail Milling in Operation

WHICH results can be achieved?

In Total:

» 2 milling passes
» 3.6 mm material removed
» Defects removed
» Rail re-profiled



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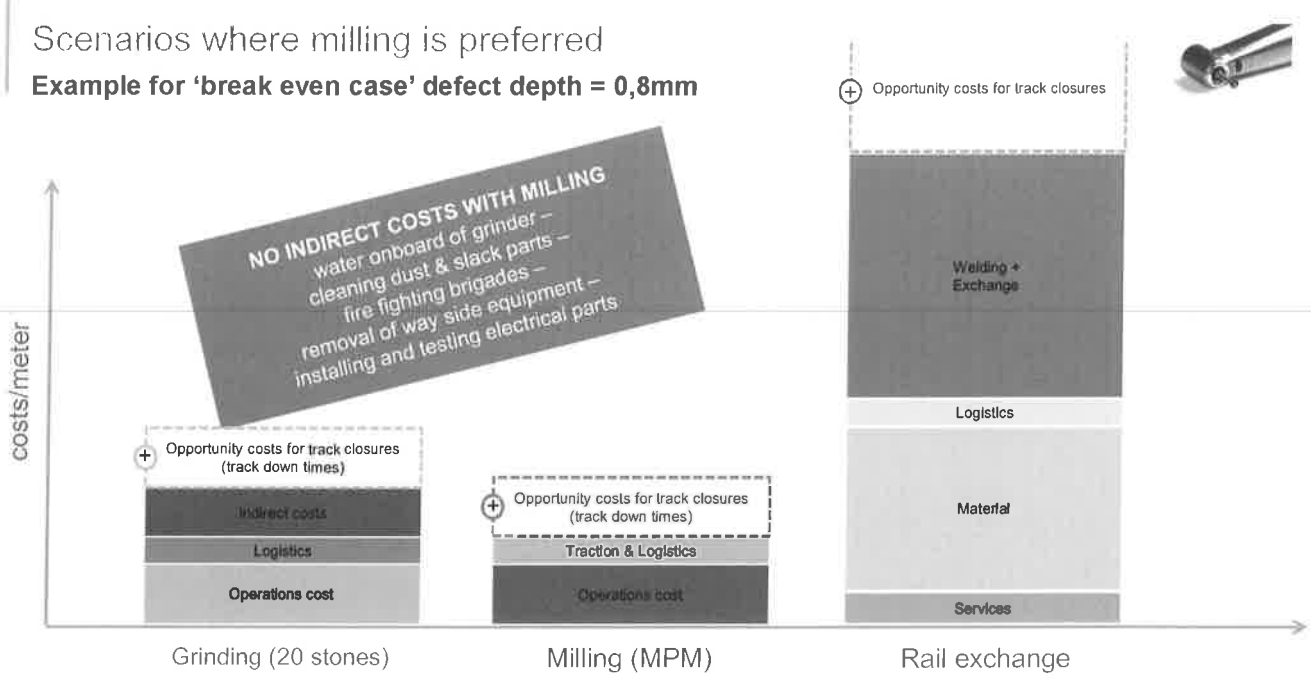
Scenarios where milling is preferred

Example for 'break even case' defect depth = 0,8mm



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Rail Milling for Mainlines and UTS

Summary High Performance Milling and Multi Purpose Milling

- High Performance Milling (HPM)
- Mainline, High Speed Lines, Freight Lines
- Exact reprofiling
- 3 mm material removal in single pass
- Milling with up to 2 kph
- No sparks, no dust

- Multi Purpose Milling (MPM)
- Hot Spots, Urban Transport Systems, Light Rail, Short-Haul
- Exact reprofiling
- 2 mm material removal in single pass
- No sparks, no dust
- Gauge convertible

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High Speed Grinding for Mainlines and UTS

Summary

» Mainline, High Speed Lines, Freight Lines
» Working speed of up to 80 kph
» Rail life extended by factor 2
» No track closures
» Suitable for tunnels
» Noise reduction up to 10 dB/A

» Urban Transport Systems, Light Rail, Short-Haul
» Working speed of up to 60 kph
» Rail life extended by factor 2
» No track closures
» Suitable for tunnels
» Noise reduction up to 10 dB/A

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