Keeping Rolling Contact Fatigue under Control

Steel Grade Selection & Appropriate Rail Maintenance

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voestalpine
ONE STEP AHEAD.

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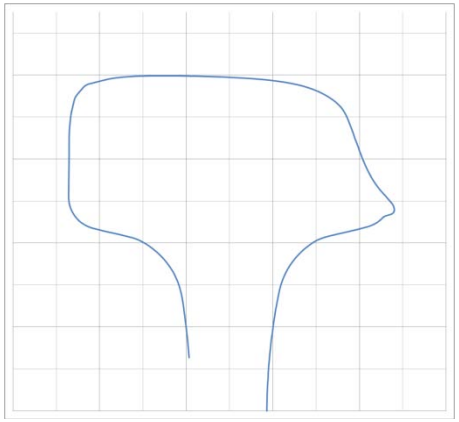
- Damage in the rail wheel contact
- Innotrack – Overview
- Innotrack – Results concerning Wear and RCF
  - European Rail Grade Selection Recommendation
- Innotrack – Results concerning Rail Maintenance
  - Guidelines for Management of Rail Grinding

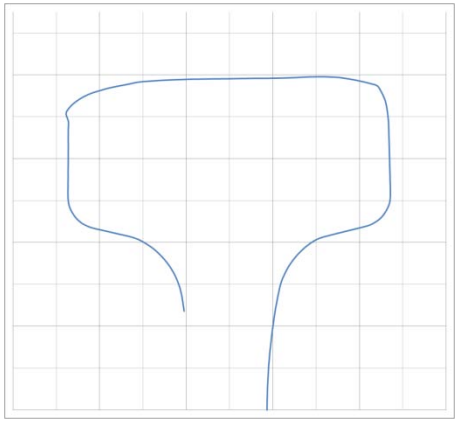
Damage mechanisms - Wear

Sharp curves

Medium curves

Wide curves/ tangent



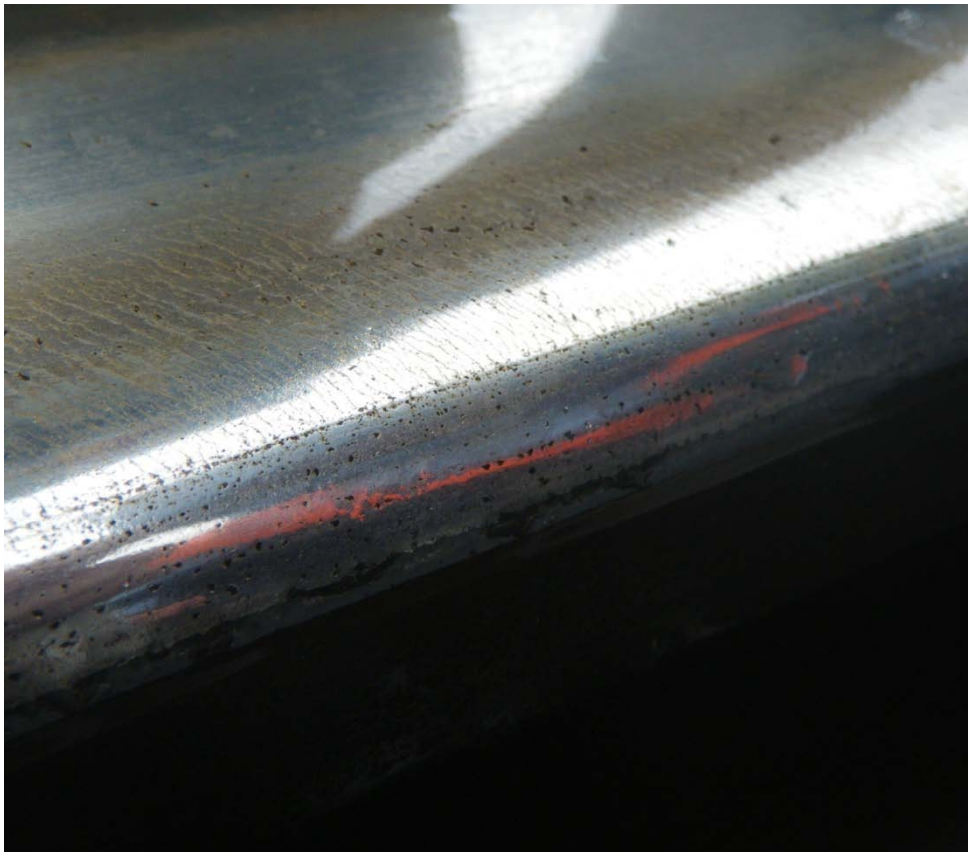


Damage mechanisms - Corrugation

Sharp curves | *Medium curves* | *Wide curves/ tangent*

Damage mechanisms – Head Checks

Sharp curves | *Medium curves* | *Wide curves/ tangent*



Damage mechanisms - Spalling

Sharp curves | *Medium curves* | *Wide curves/ tangent*

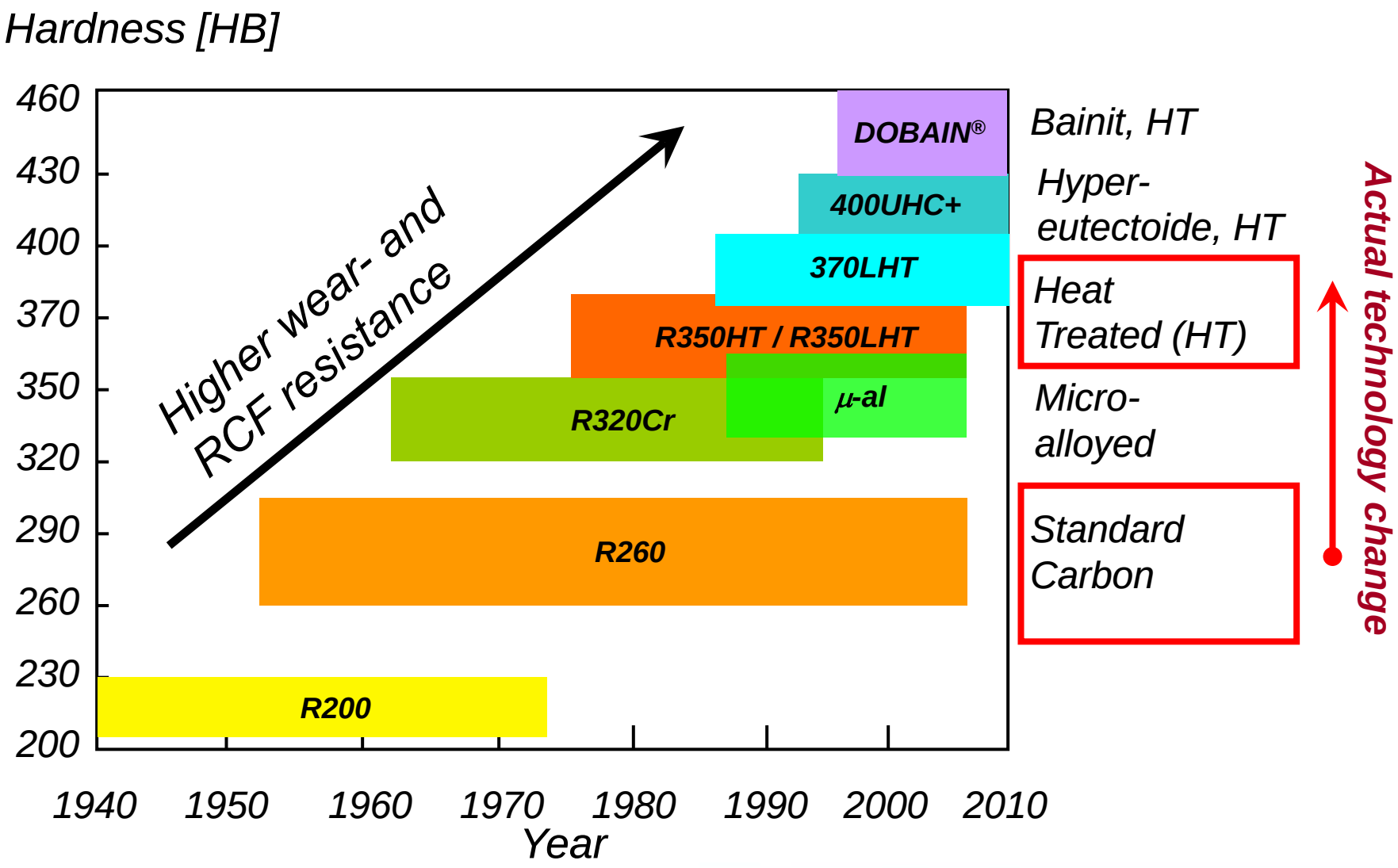
Damage mechanisms - Squats

Sharp curves

Medium curves

Wide curves/ tangent

Trend in rail steel development



Steel grade comparison: AREMA – EN

Steel grades according to prEN 13674-1 and AREMA									
	Chemical composition (%)						Mechanical data		
grade	C	Si	Mn	P_{max}	S	Cr	R_m [Ksi] min	Ellong. [%] min	Hardness [HB]
R260	0.62-0.80	0.15-0.58	0.70-1,20	0.025	0.08-0.025		127	11	260-300
SS	0.74-0.84	0.10-0.60	0.75-1.25	0.020	0.020	0.25	120	10	300
LA	0.71-0.82	0.10-0.50	0.80-1.10	0.020	0.020	0.25-0.40	142	10	300
IH	0.71-0.82	0.10-1.00	0.70-1.25	0.020	0.020	0.40-0.70	147	8	325
R350HT	0.72-0.80	0.15-0.58	0.70-1.20	0.020	0.025		170	10	350-390
R350LHT	0.72-0.80	0.15-0.58	0.70-1.20	0.020	0.025	<0.30	170	10	350-390
HH	0.74-0.84	0.10-0.60	0.75-1.25	0.020	0.020	0.25	171	10	370
LH	0.71-0.82	0.10-1.00	0.70-1.25	0.020	0.020	0.40-0.70	171	10	370
R370CrHT	0.70-0.82	0.40-1.00	0.70-1-10	0.020	0.020	0.40-0.60	185	10	370-410
R400HT	0.90-1.00	0.20-0.40	1.20-1.30	0.020	0.020	<0.30	185	10	400-440

Innotrack – Project

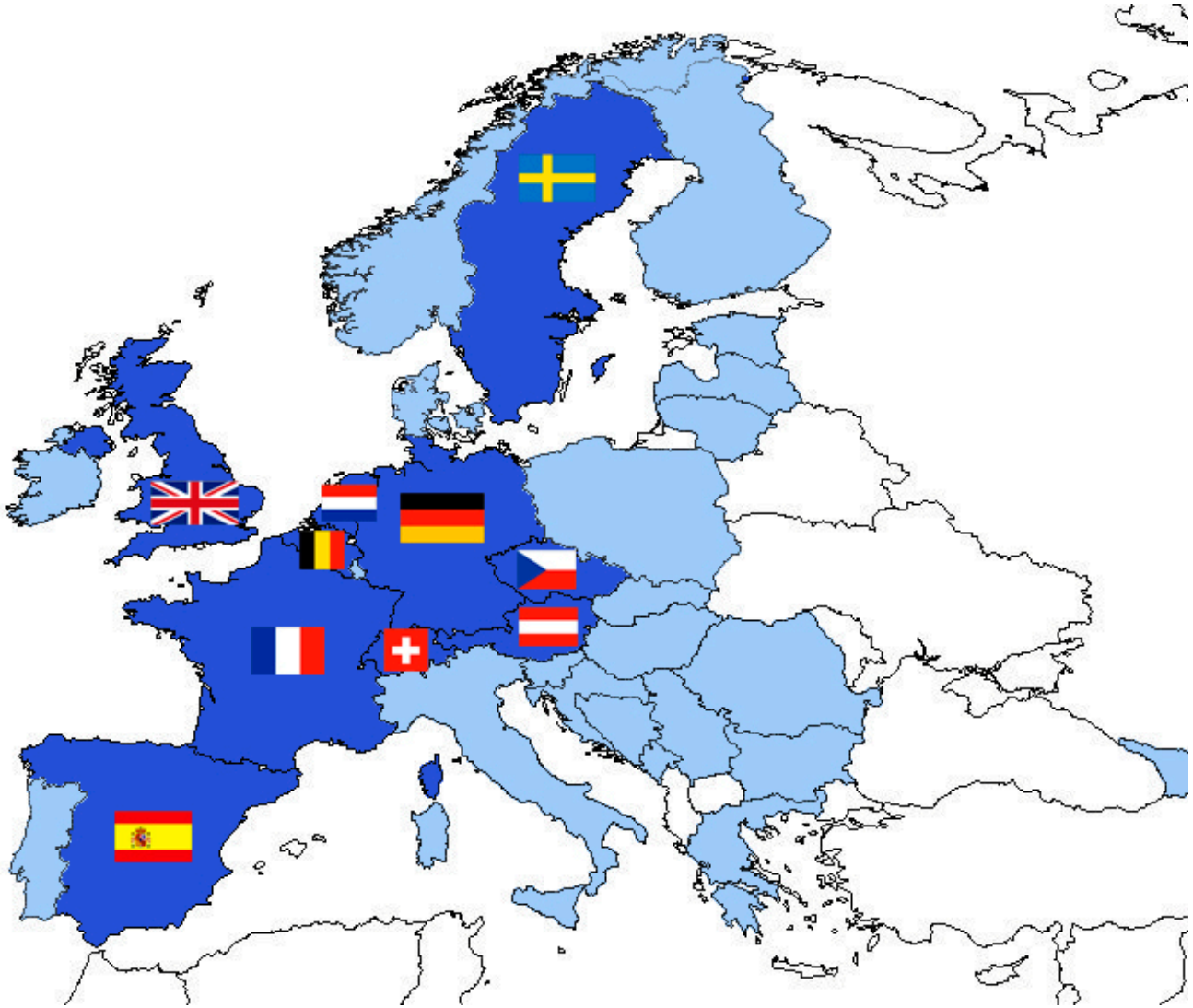
Innovative Track Systems

INNOTRACK

DATE OF PREPARATION:	1st September, 2005
TYPE OF INSTRUMENT:	Integrated Project
ACTION LINE	FP6 - 2005 -Transport - 4
Research area(s):	Development of cost-effective high performance track infrastructure for heavy and light rail systems
Coordinator:	UIC (FR)

10/00

Innotrack – Participating Countries



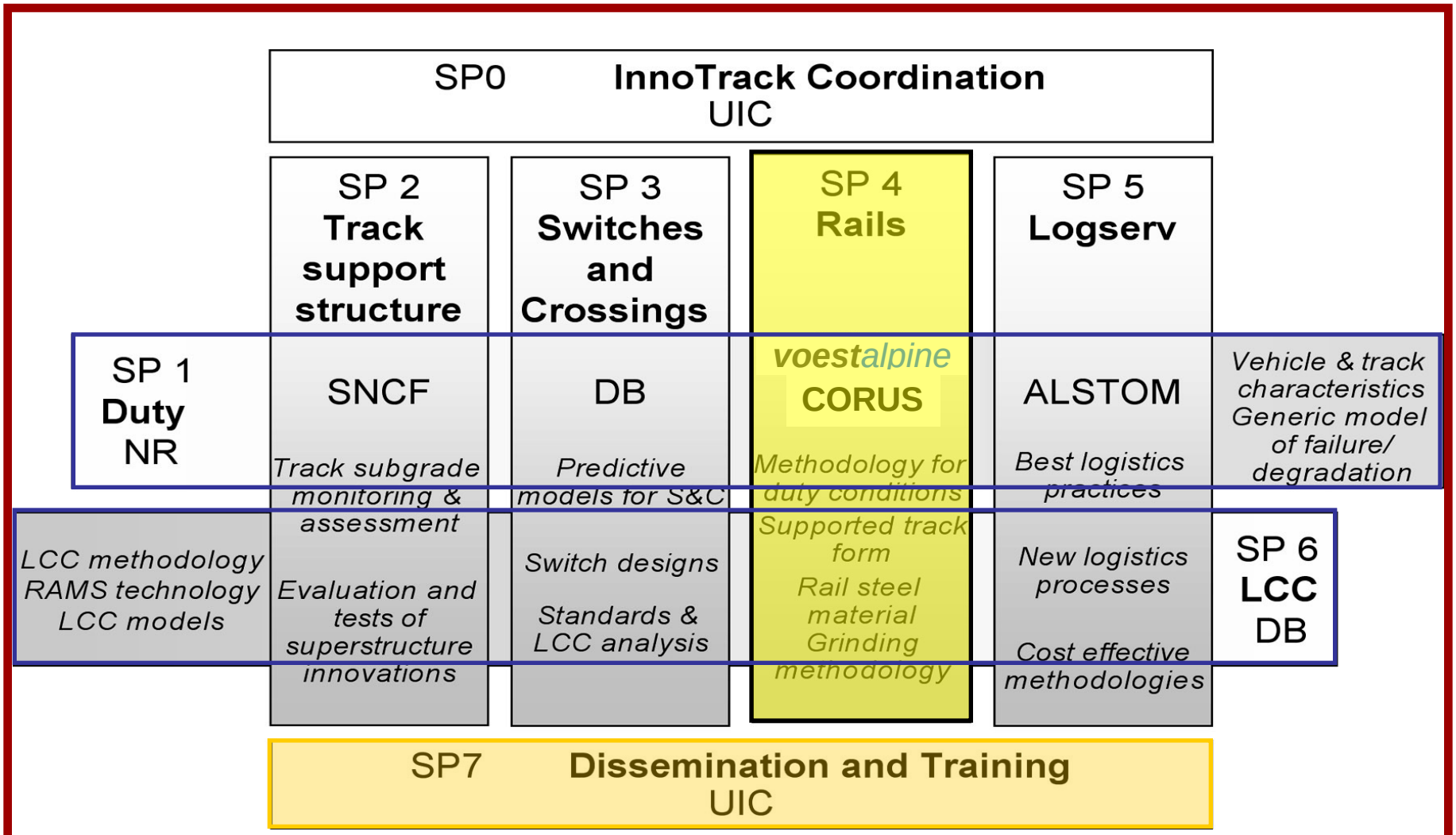
Innotrack – Project Partners

36 project partners…

- 11 infrastructure owners
- 11 railway industry companies
- 3 construction companies
- 8 universities

… from 11 countries

Innotrack – Project Structure



13/00

Innotrack – Project Objectives

- Main objective is to reduce the LCC, while improving the RAMS characteristics (Reliability, Availability, Maintainability and Safety) of a conventional line with a mixed traffic duty

- Implement appropriate changes to specifications and standards to achieve reduced LCC, time to market and cost of safety

- Infrastructure Managers are expecting from Innotrack a 30% LCC reduction of track-related costs

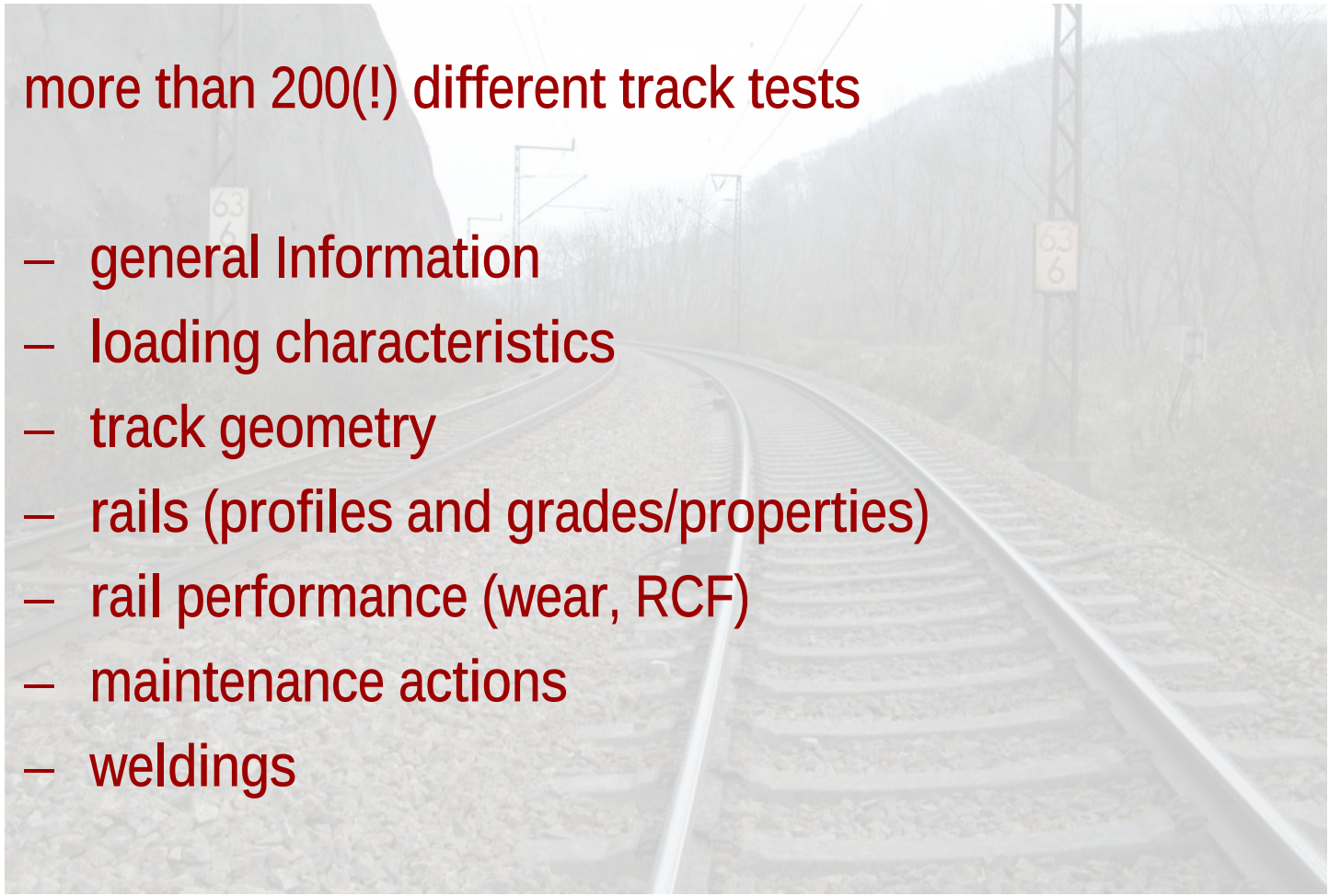
Innotrack – Project Activities

- Identify European track issues that consume a disproportionate budget
- Identify root causes through rigorous scientific analysis
- Further develop, validate & demonstrate innovative products, processes & methodologies proposed by project partners

SP4 Rails: Work Packages

Work Package	Work Package Title
4.1	Study of degradation of actual and new rail steels and joints
4.2	Validation of tolerances and limits for rails and joints
4.3	Innovative laboratory tests of rail steel grades and joints
4.4	Innovative inspection techniques
4.5	Validation of new maintenance processes
4.6	Innovative welding processes

Innotrack – Track Test Database



more than 200(!) different track tests

- general Information
- loading characteristics
- track geometry
- rails (profiles and grades/properties)
- rail performance (wear, RCF)
- maintenance actions
- weldings

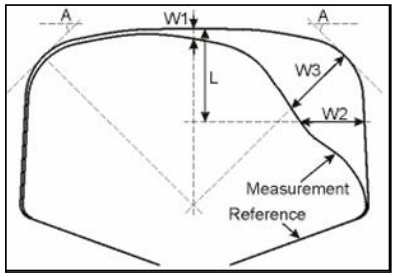
Track Test Example – Rail Wear

DB

Kerzell

R=1400m

(1,25°)



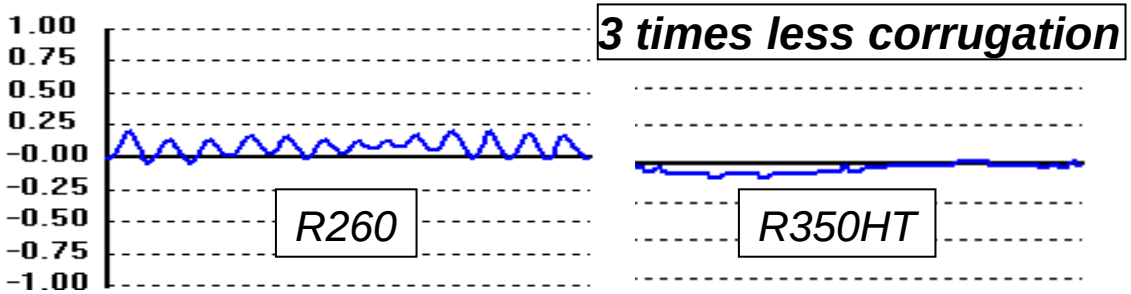
Improvement factor 5 !

R350HT compared to R260

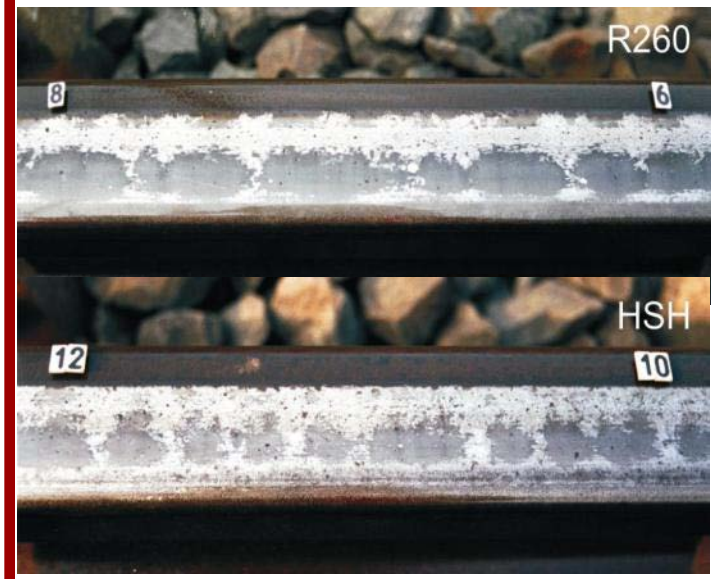
after 125 Mio to

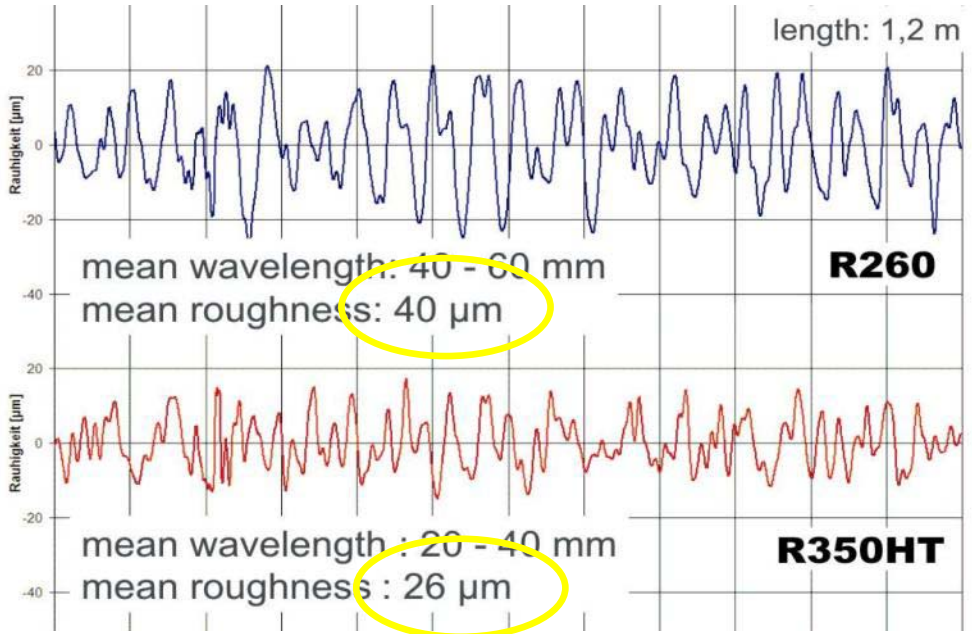
Track Test example - corrugation

DB - ÖBB



3 times less corrugation

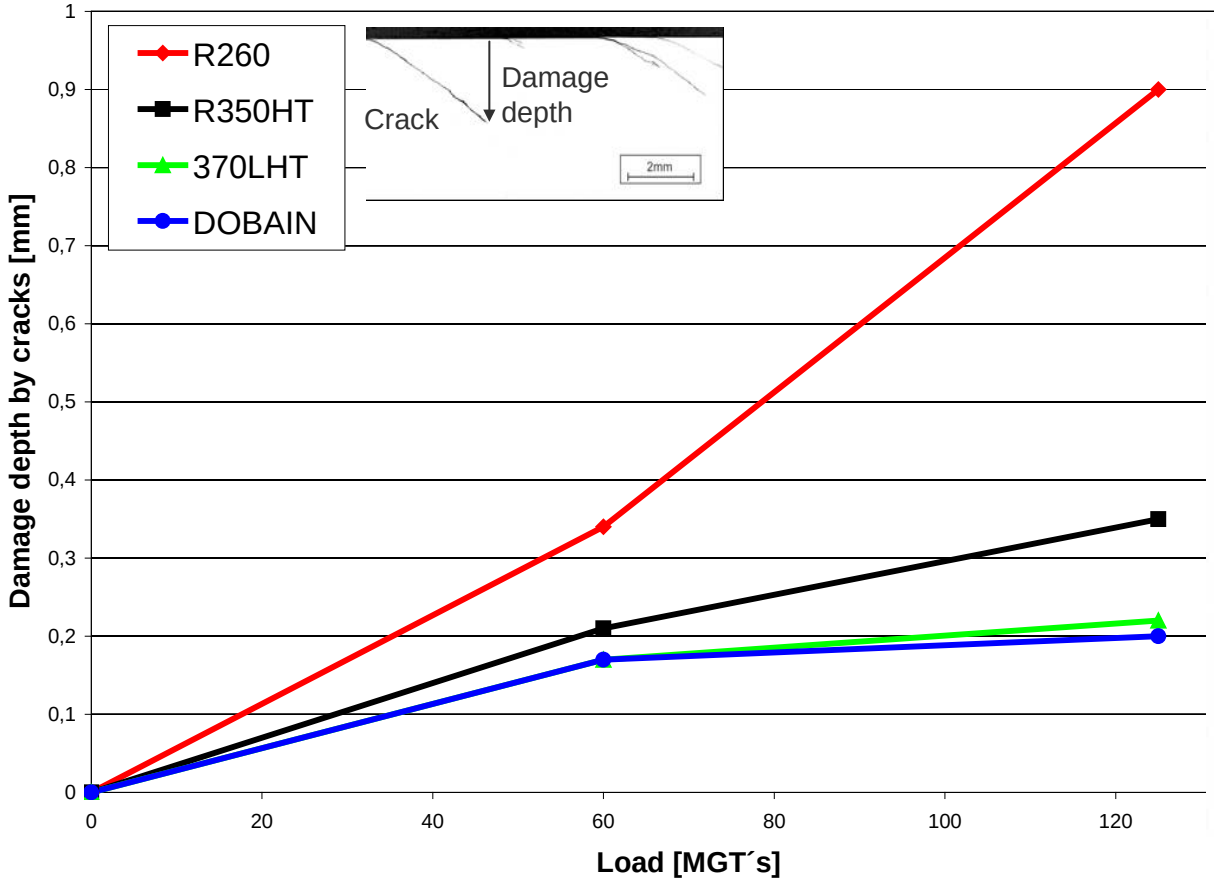


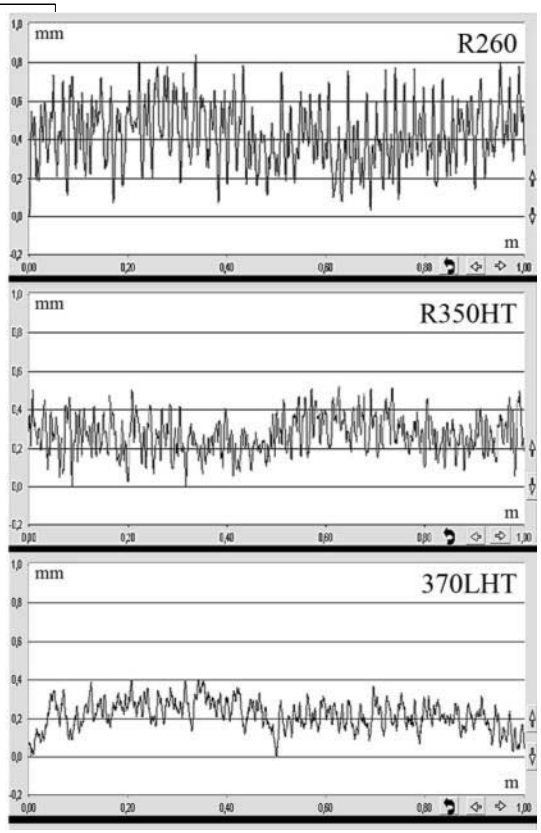


Track Test Example - RCF

***DB** – Kerzell*

R=1400m (1,25°)

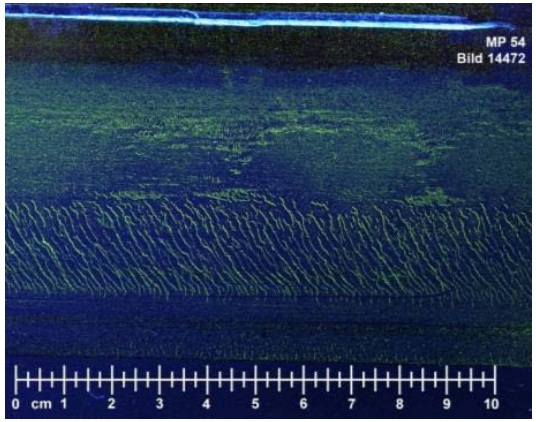


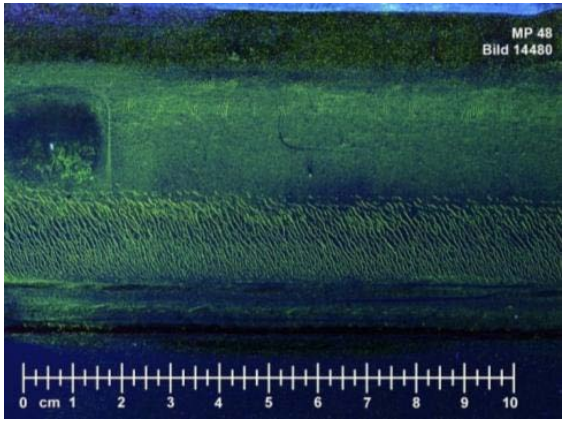


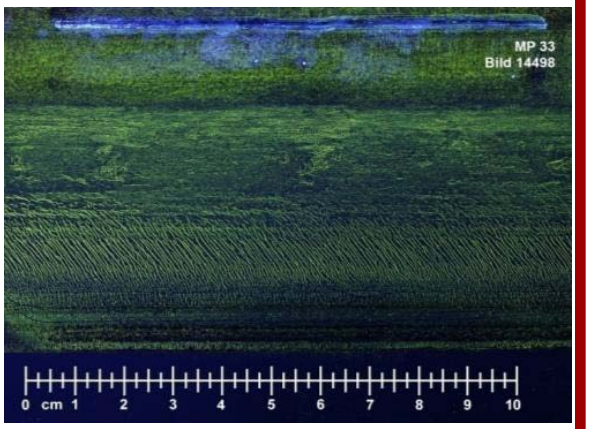
Track Test Example - RCF

– surface damage (*magnetic particle inspection - mpi)*

R260	***R350HT***	***R370CrHT***

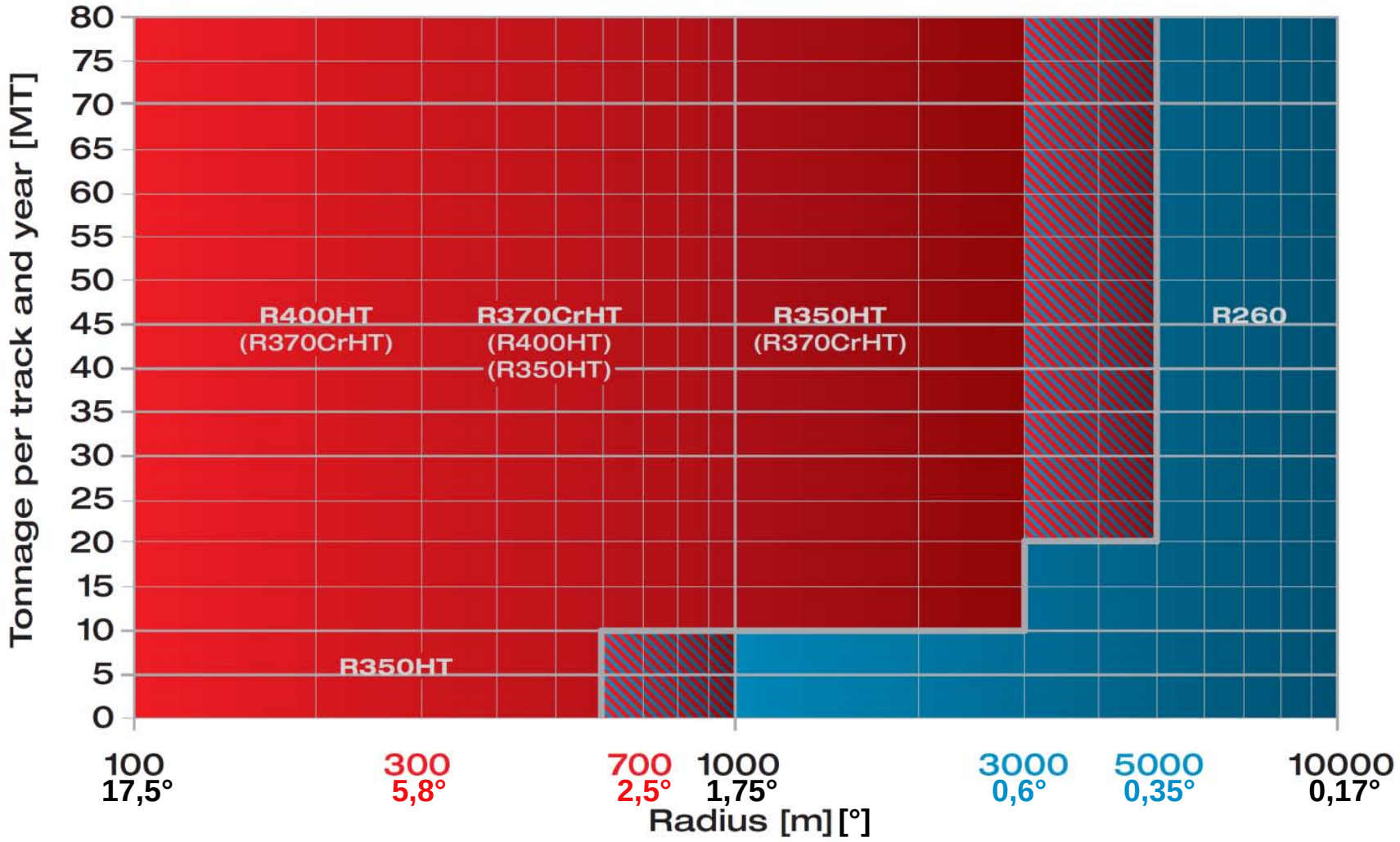






increased rail hardness → finer and shorter Head Checks

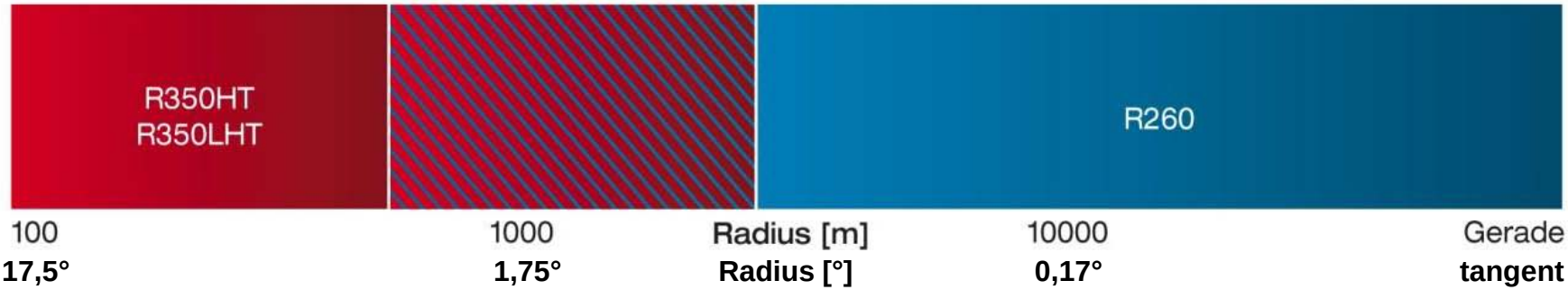
Innotrack Rail Grade Recommendation



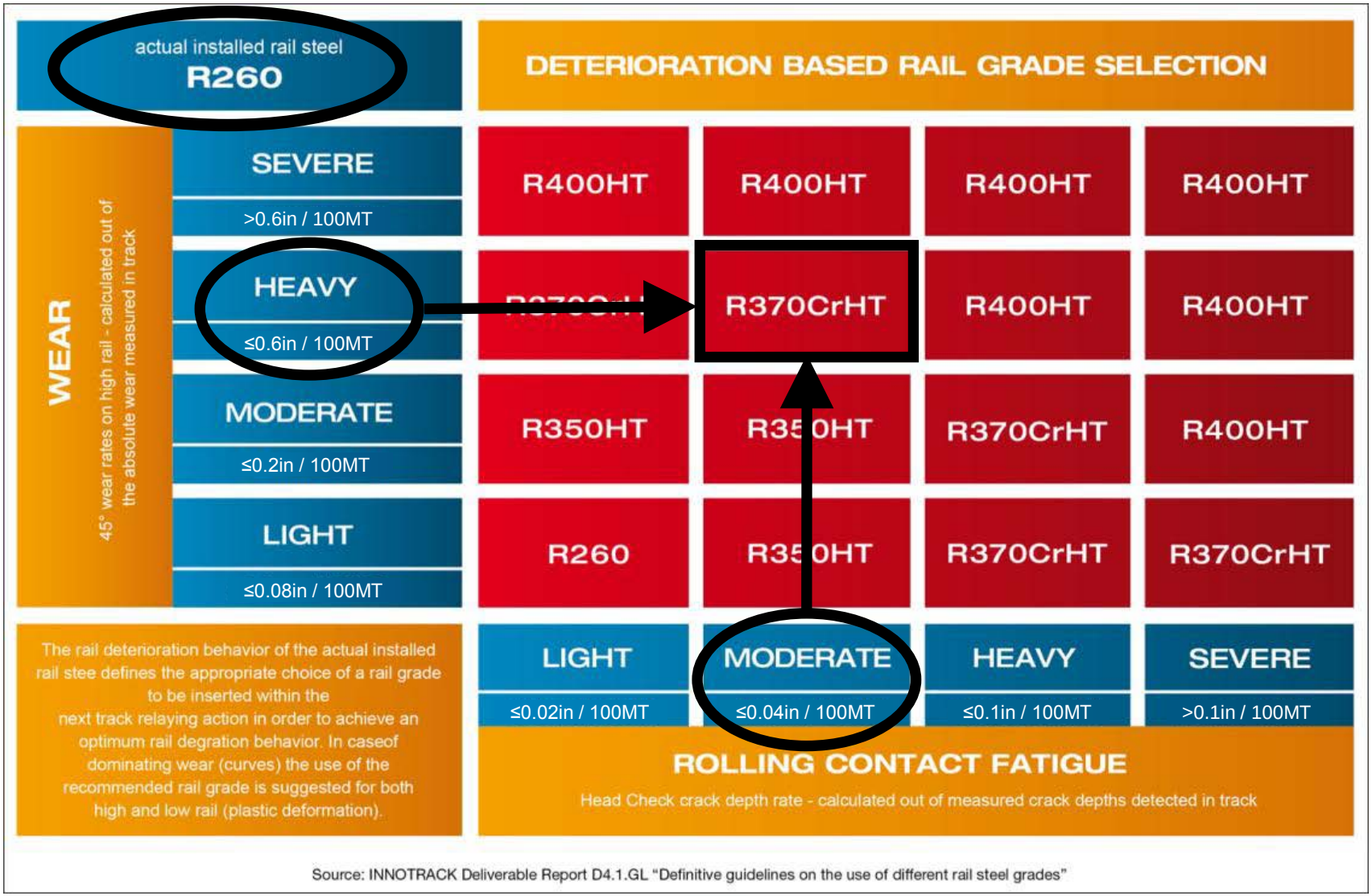
Rail grade recommendation: High speed traffic

– Loads also comparable to mainly passenger service tracks and generally low loaded tracks

High speed traffic



Innovative condition based rail grade selection



Source: INNOTRACK Deliverable Report D4.1.GL "Definitive guidelines on the use of different rail steel grades"

WP 4.5: “Rail Maintenance”

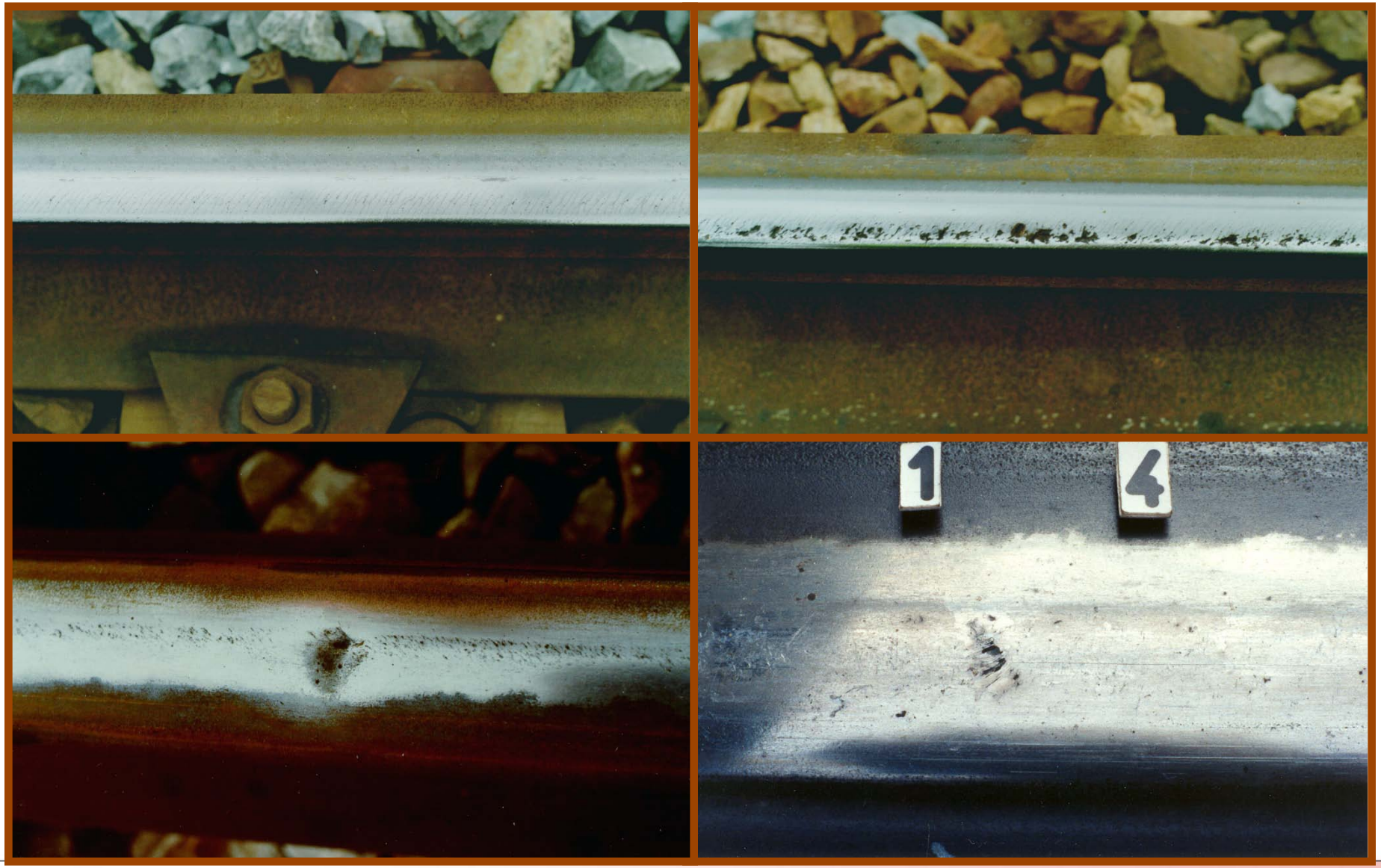
Results

Documents – “Deliverables” (www.innotrack.eu)

- D 4.5.1 Review of Present Maintenance Situation
- D 4.5.2 Target Profiles for Grinding
- D 4.5.3 Grinding strategies
- D 4.5.4 Lubrication, Friction Management

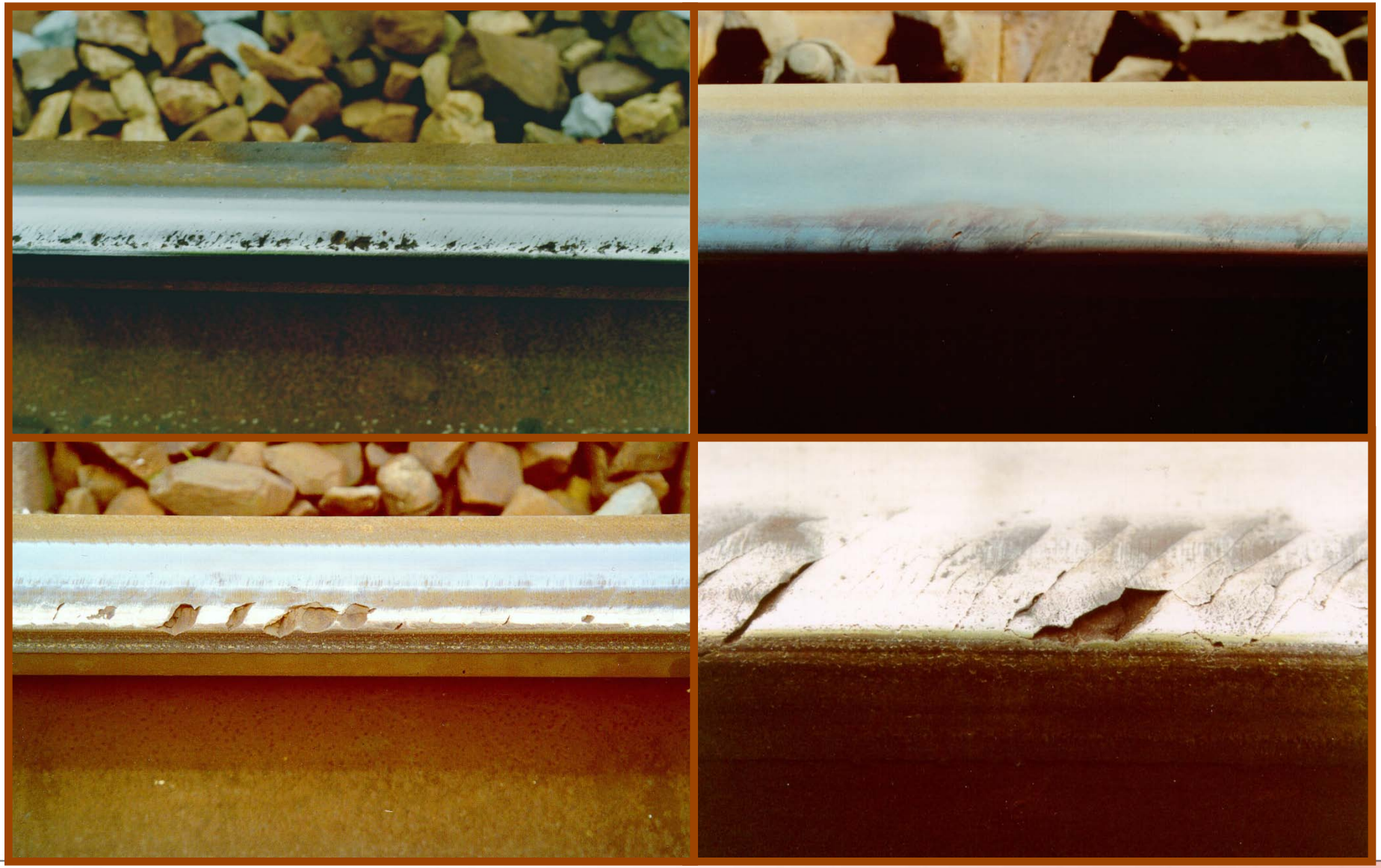
$\Rightarrow$ D 4.5.5 Guidelines for Management of Rail Grinding

Rolling Contact Fatigue



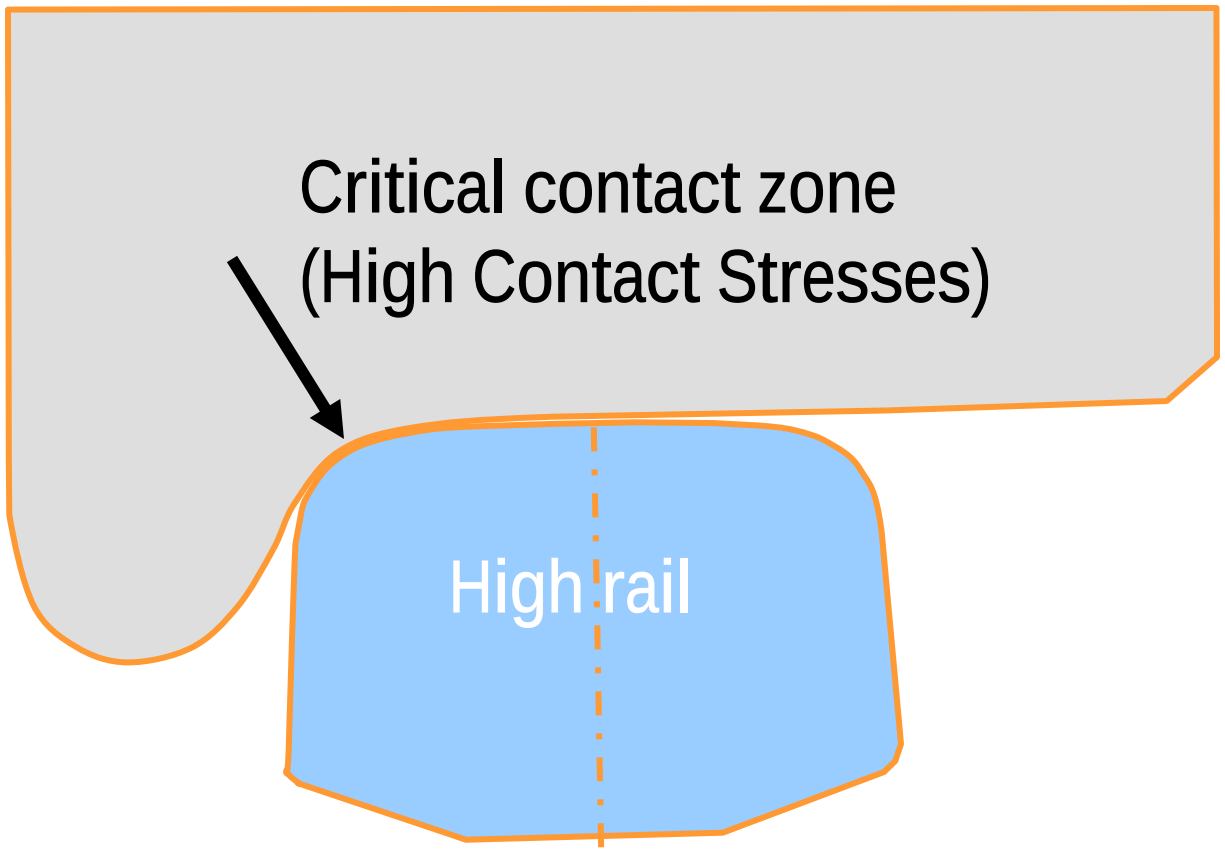
Head checks

Gauge Corner Fatigue



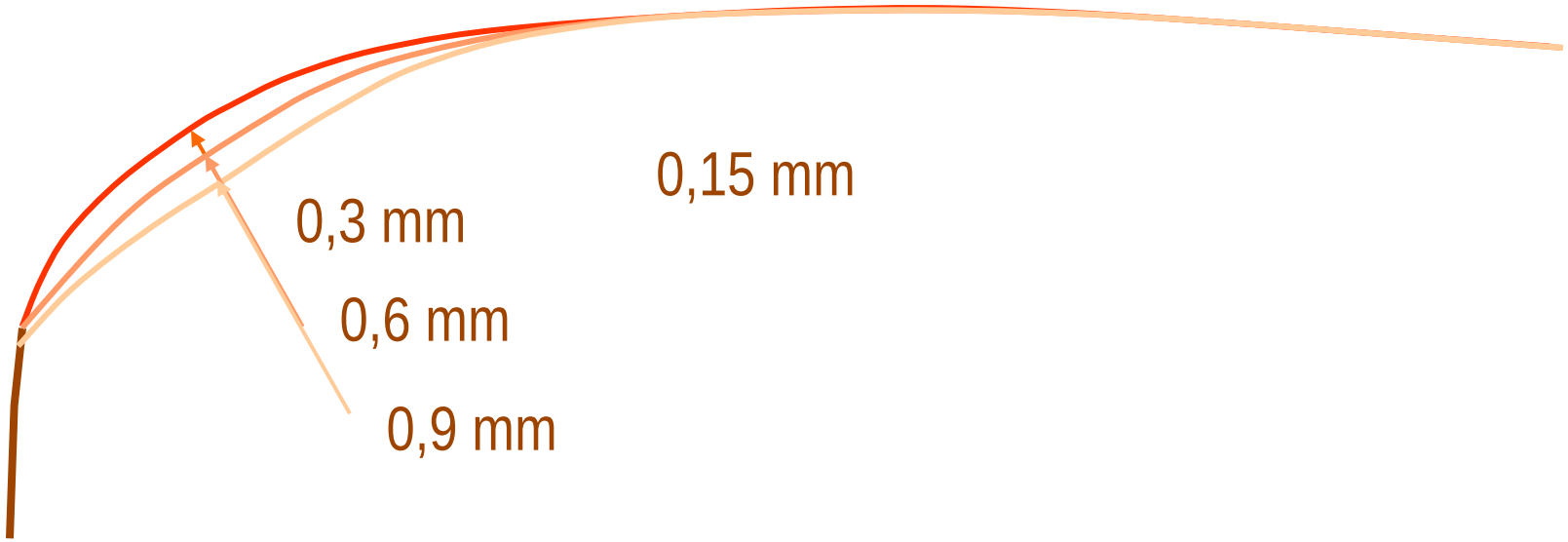
Typical Contact Conditions - HC

Important: Target Profile and Production Tolerances



Strategic Tolerances:

Negative Tolerances Only – DB AG



Limited Metal Removal requirements

D 4.5.2 - Target Profiles For Grinding

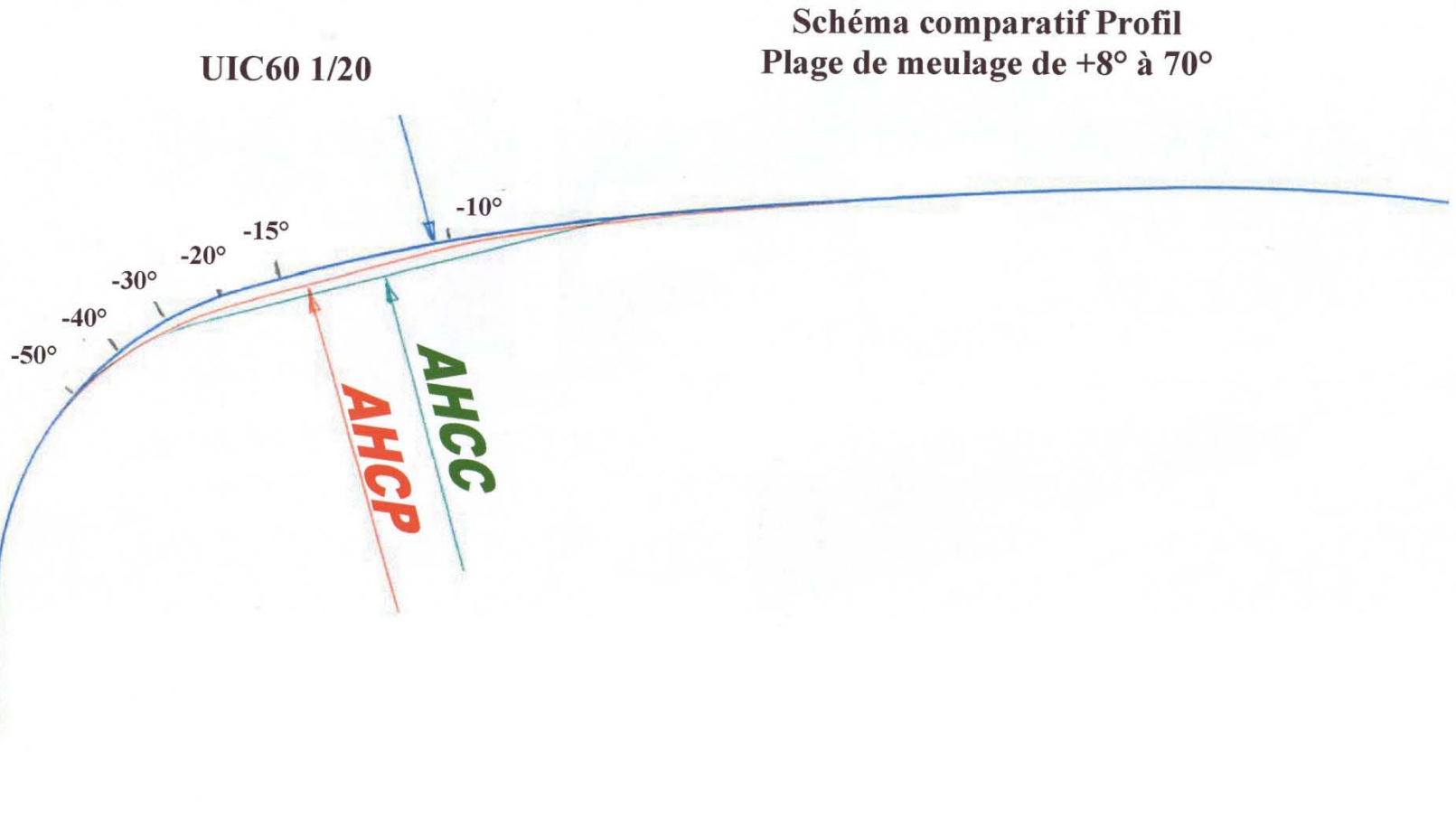
Standard grinding profiles

- 60E1 1:20 - SNCF (France)
- 60E2 1:40 - DB AG (Germany)
- 54E1 1:40 - ProRail (The Netherlands)
- 60E2 1:20 - Network Rail (United Kingdom)
- .....

Profiles for specific purposes

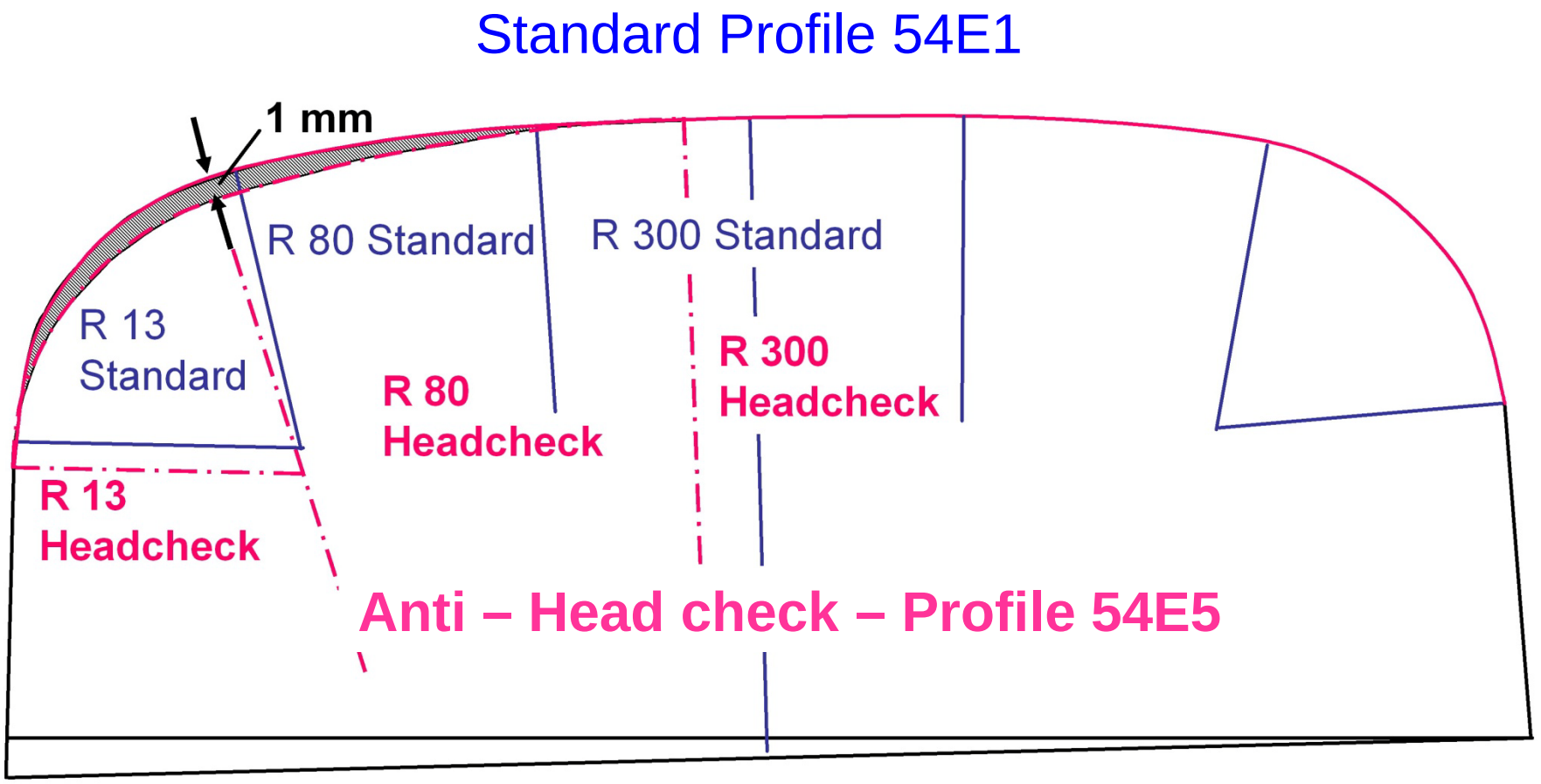
- Asymmetric profiles
- Gauge widening profiles
- Wear adapted profiles
- Anti-head check profiles

Anti-head check-profiles - SNCF

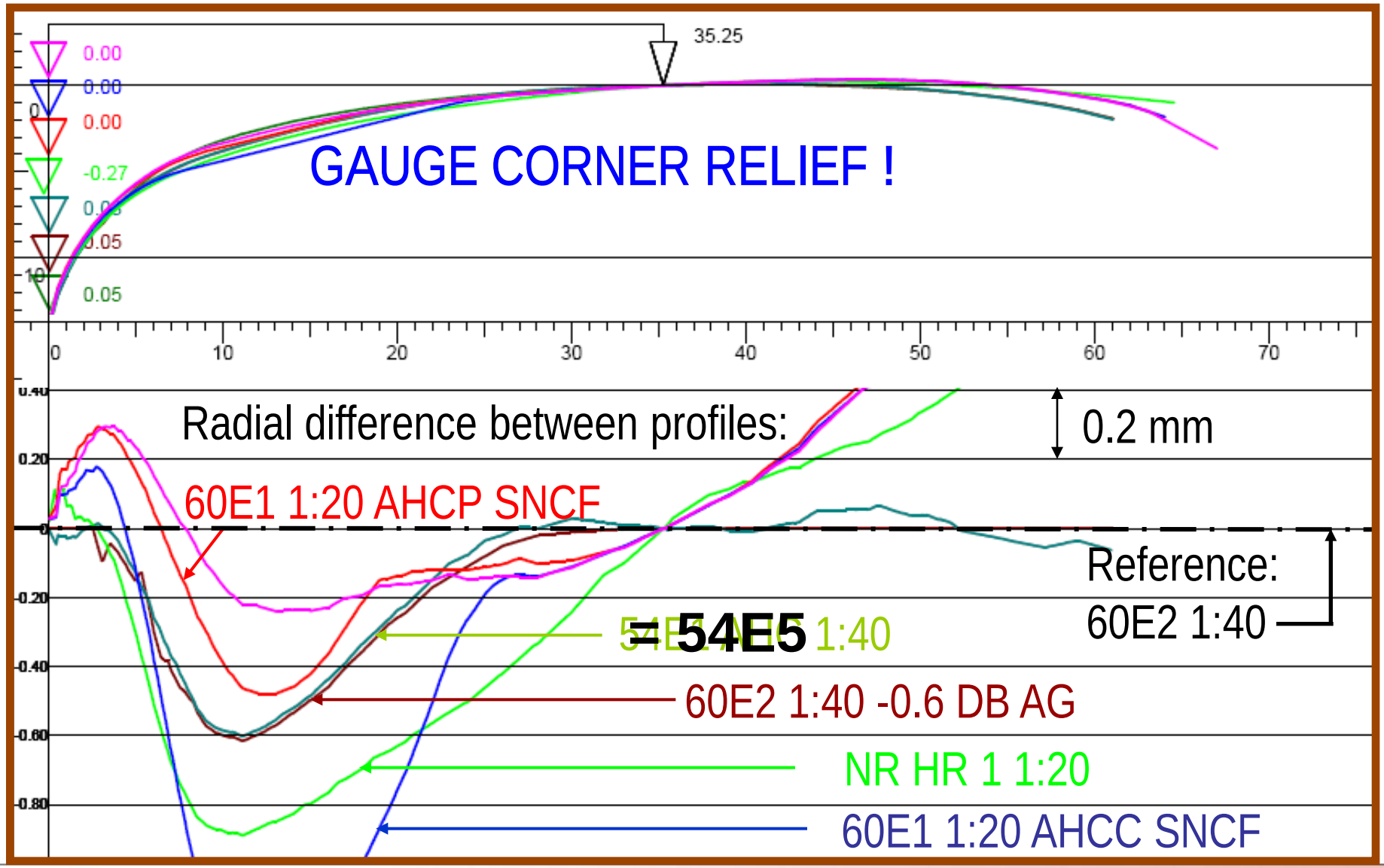


CES PROFILS SONT LA PROPRIÉTÉ DE LA SNCF ET NE PEUVENT ÊTRE UTILISES SANS SON ACCORD

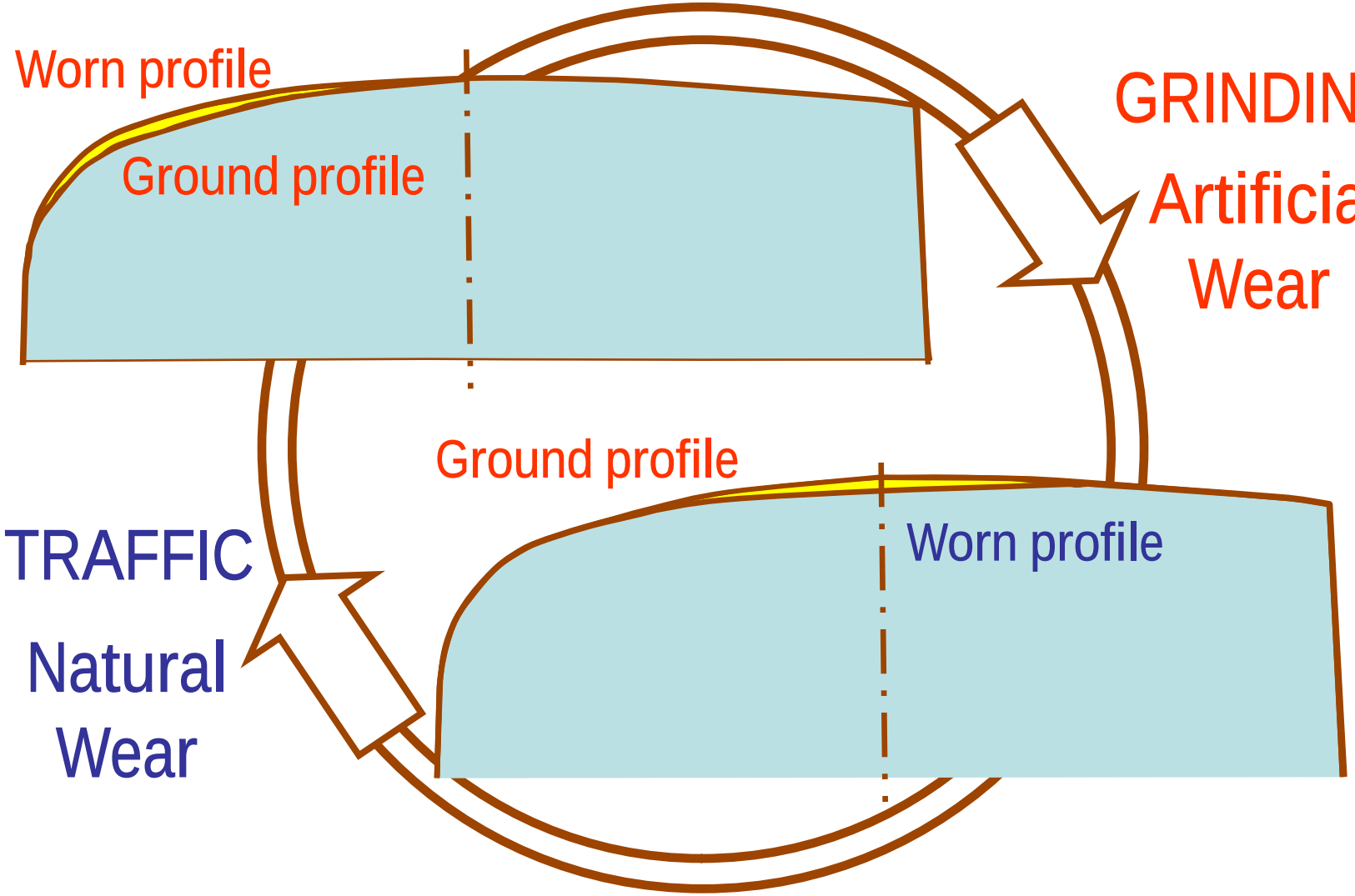
AHC - Profile ProRail (ex 54E1)



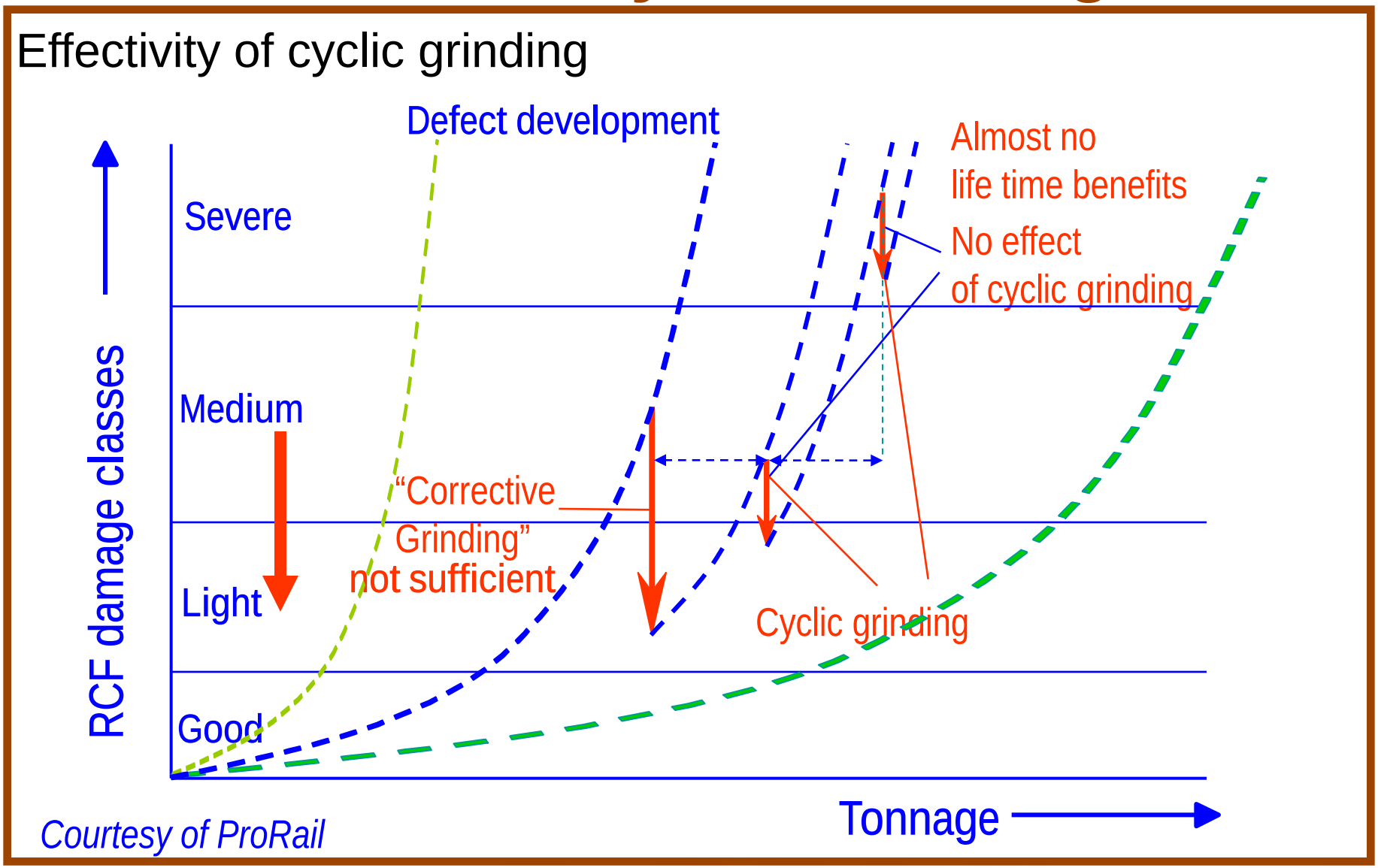
Anti-head check-profiles (“Innotrack”)



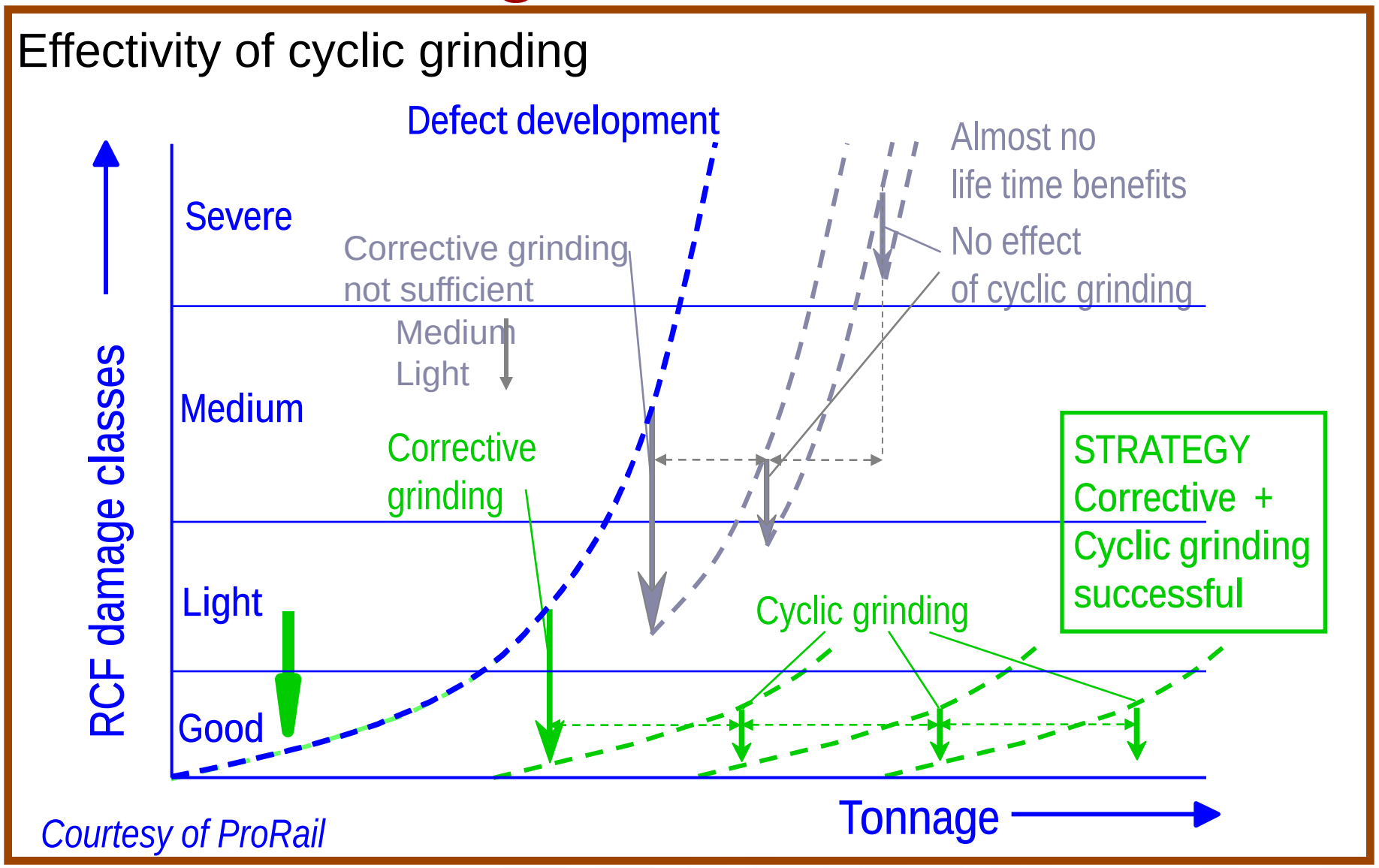
Cycle of Wear: Artificial - Natural



Effectiveness of Cyclic Grinding



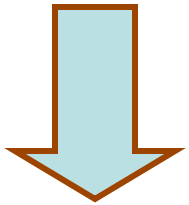
Level of Damage and Maintenance



Proposed Maintenance

Initial grinding

- 0.3 mm metal removal,
- Specific AHC - target profiles (+/- 0.3 mm production tolerance)



Followed by strategic cyclic maintenance

D 4.5.5 – Basic Strategy

"RCF can be effectively controlled when the shape of the rail head profile matches the prevailing wheel profiles and when the fatigued rail surface is regularly removed in appropriate intervals"

- Grinding to be carried out as soon as possible after re-railing in order to introduce or optimize the target profile (wheel-adapted or AHC profiles)

- Consecutive grinding cycles to be programmed from the beginning in order to assure long rail service life and consequently low LCC

Proposed Maintenance

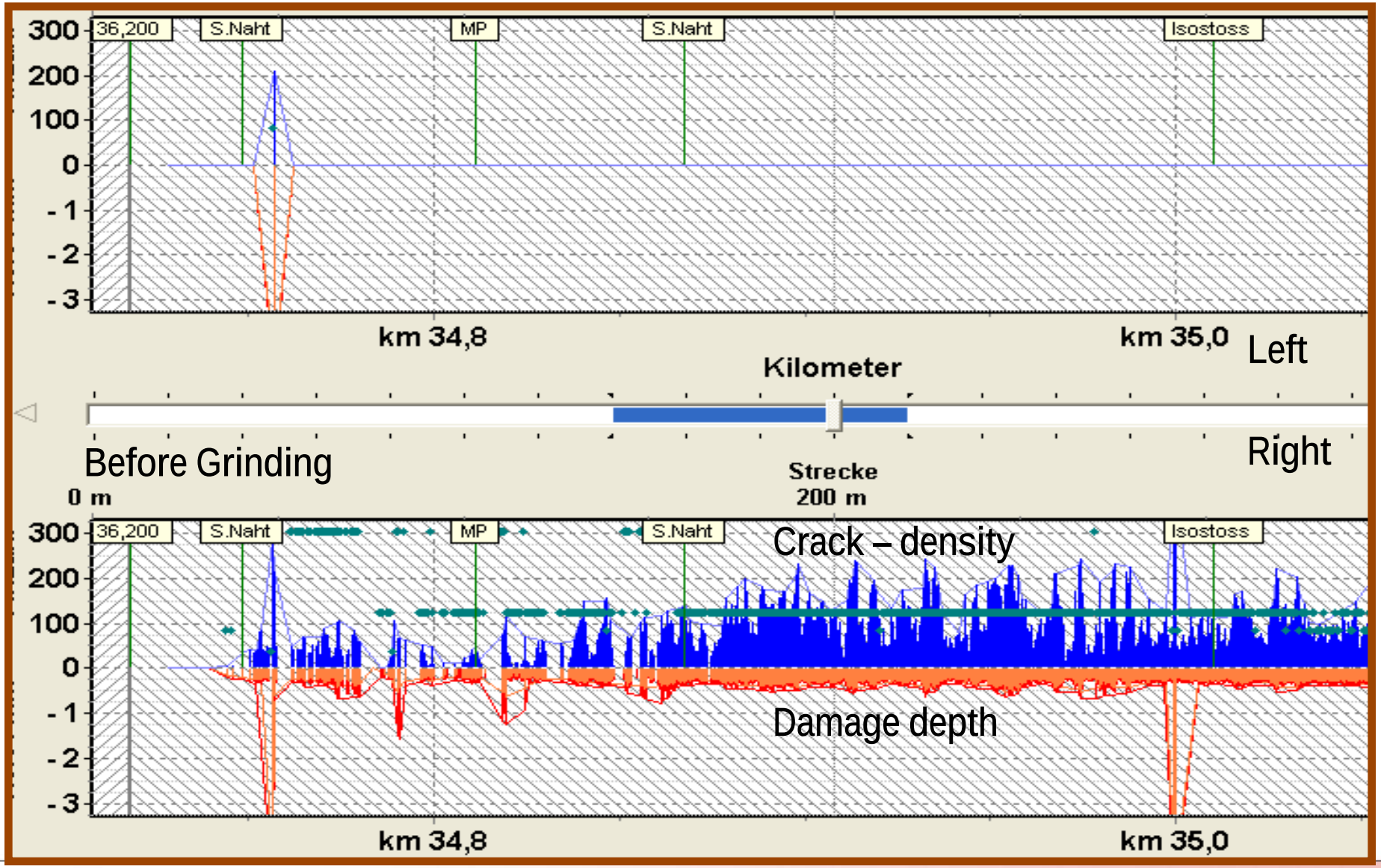
Strategic preventive actions

- Short intervals - Less variation of damage depth
  - Early treatment of other surface problems
- Anti-headcheck-profiles
- Metal removal (defect depth):
  max 0.6 mm at gauge / max 0.2 mm at center
- Defect recording during grinding

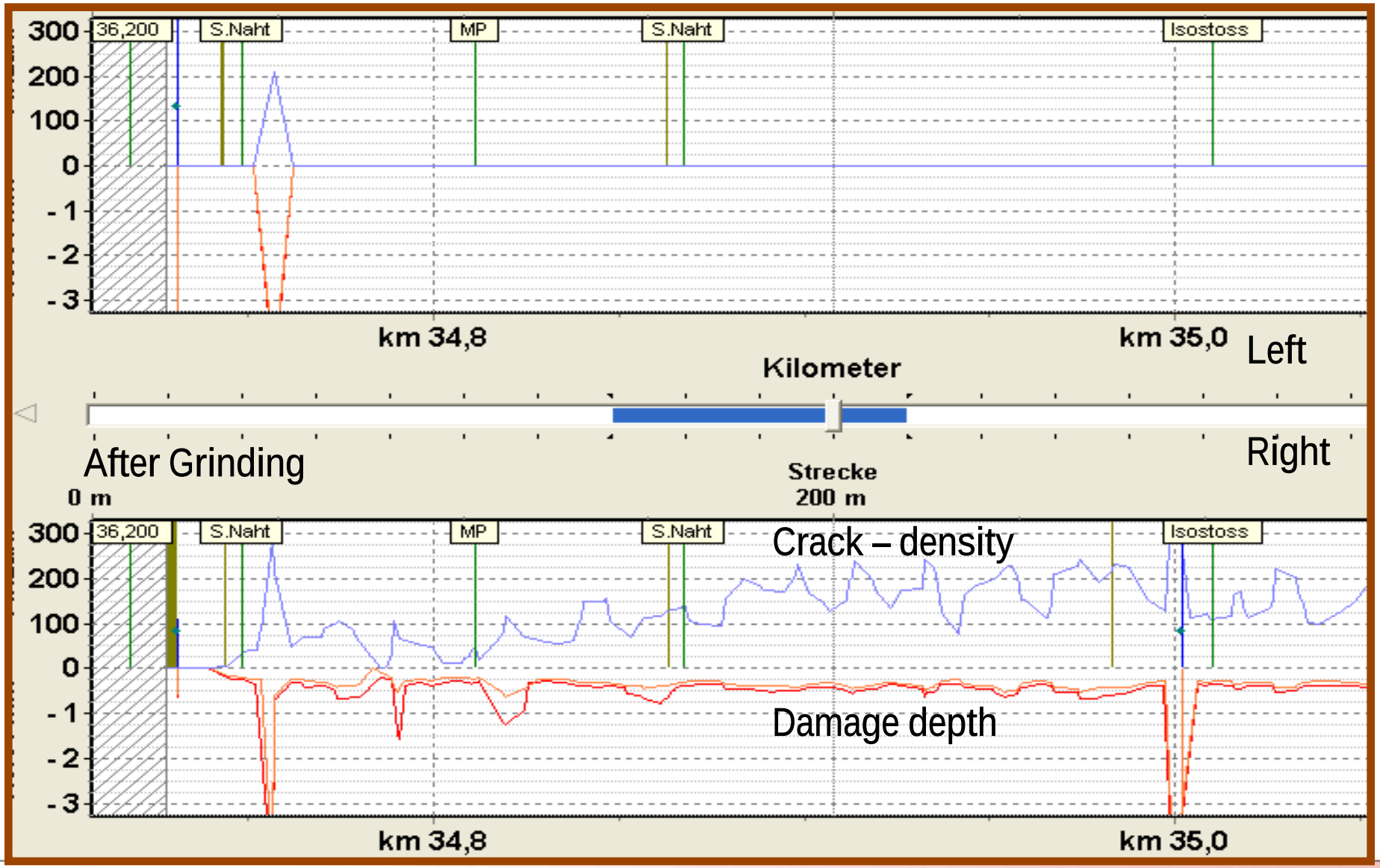
Logistics optimization (Higher production rates)

- Short distances to and between sites
- Long working sections /Possession times
- One-pass-grinding regime

Head check Recording - Before grinding



Head check Recording - After grinding



D 4.5.5 – RCF Control

Head checks at the gauge corner of a high rail

Squat on the running surface in tangent track

D 4.5.5 – Transition Strategy

"In order to implement a preventive cyclic strategy for a given track section, line or network, circumstantial corrective actions are required in order to bring this track section, line or network up to a suitable initial condition regarding grinding requirements before the cyclic strategy can be implemented.

This implies a heavy initial investment in maintenance followed by economically beneficial cyclic measures."

Strategy Change - 1

- Measurements and documentation
  of the actual situation (RCF)

- Classification of the track sections in categories:
  - Preventive cyclic work sufficient
  - Corrective work required
  - Heavily damaged (to be replaced in due time)

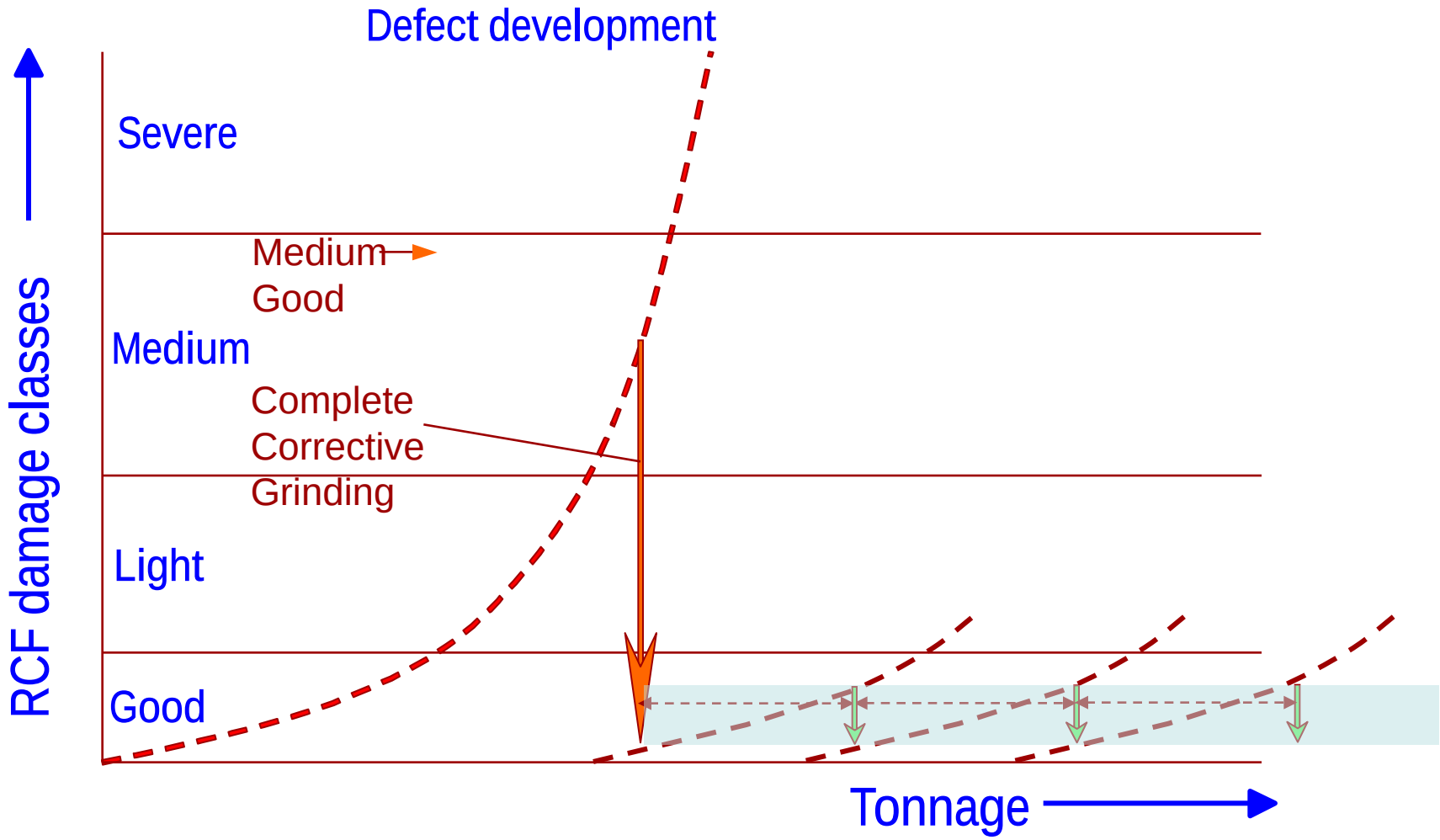
Strategy Change – 2a

Prioritization of required corrective actions:

- Preferred scenario:

  Corrective to zero (preventive) in one step

Alternative 1 – Effective corrective



Strategy Change – 2b

Prioritization of required corrective actions:

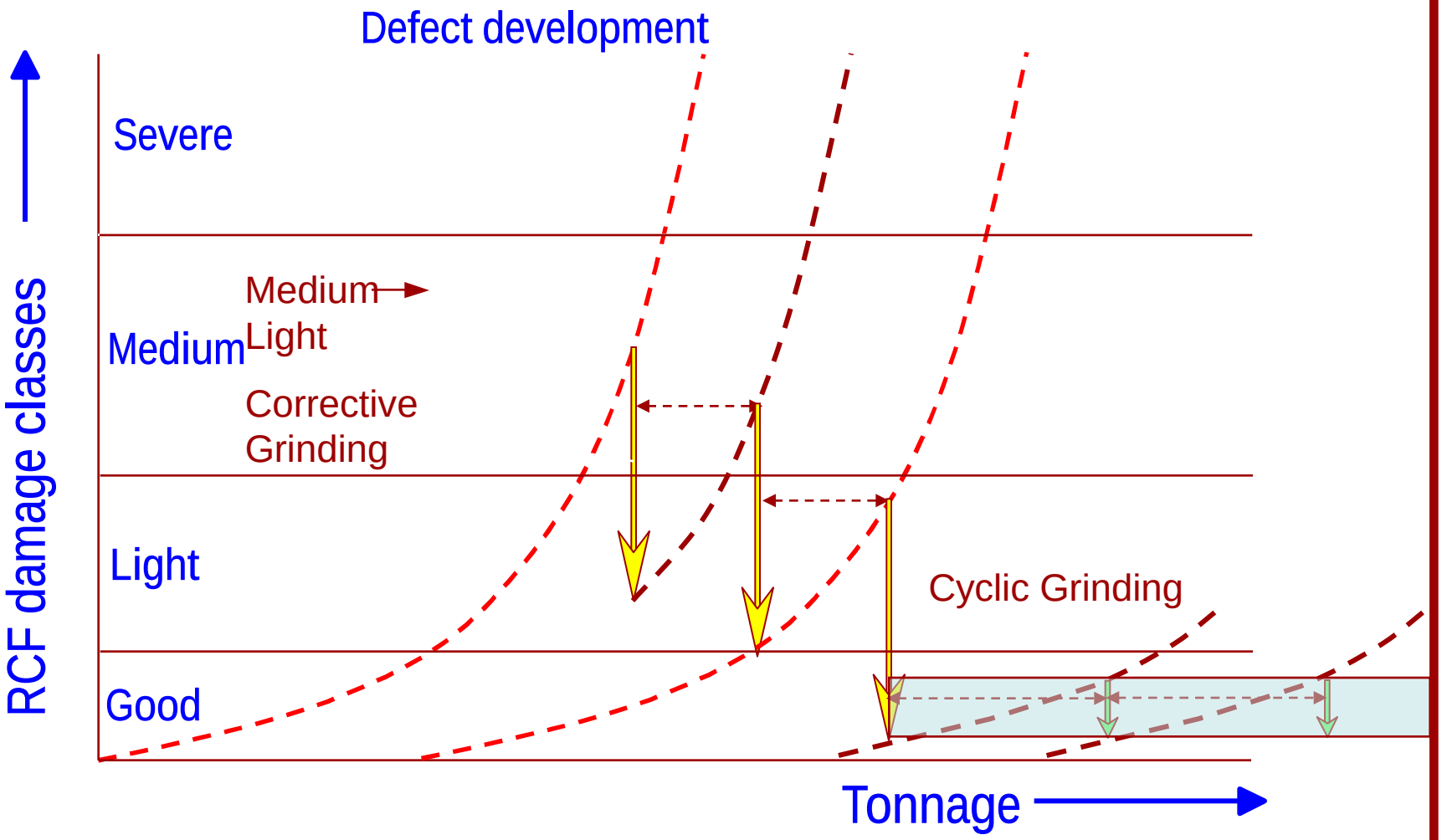
- Preferred scenario:

  Corrective to zero (preventive) in one step

- In case of limited budget or grinding capacity:

  Corrective to zero (gradual preventive) in several steps

Alternative 2 - Corrective progressive

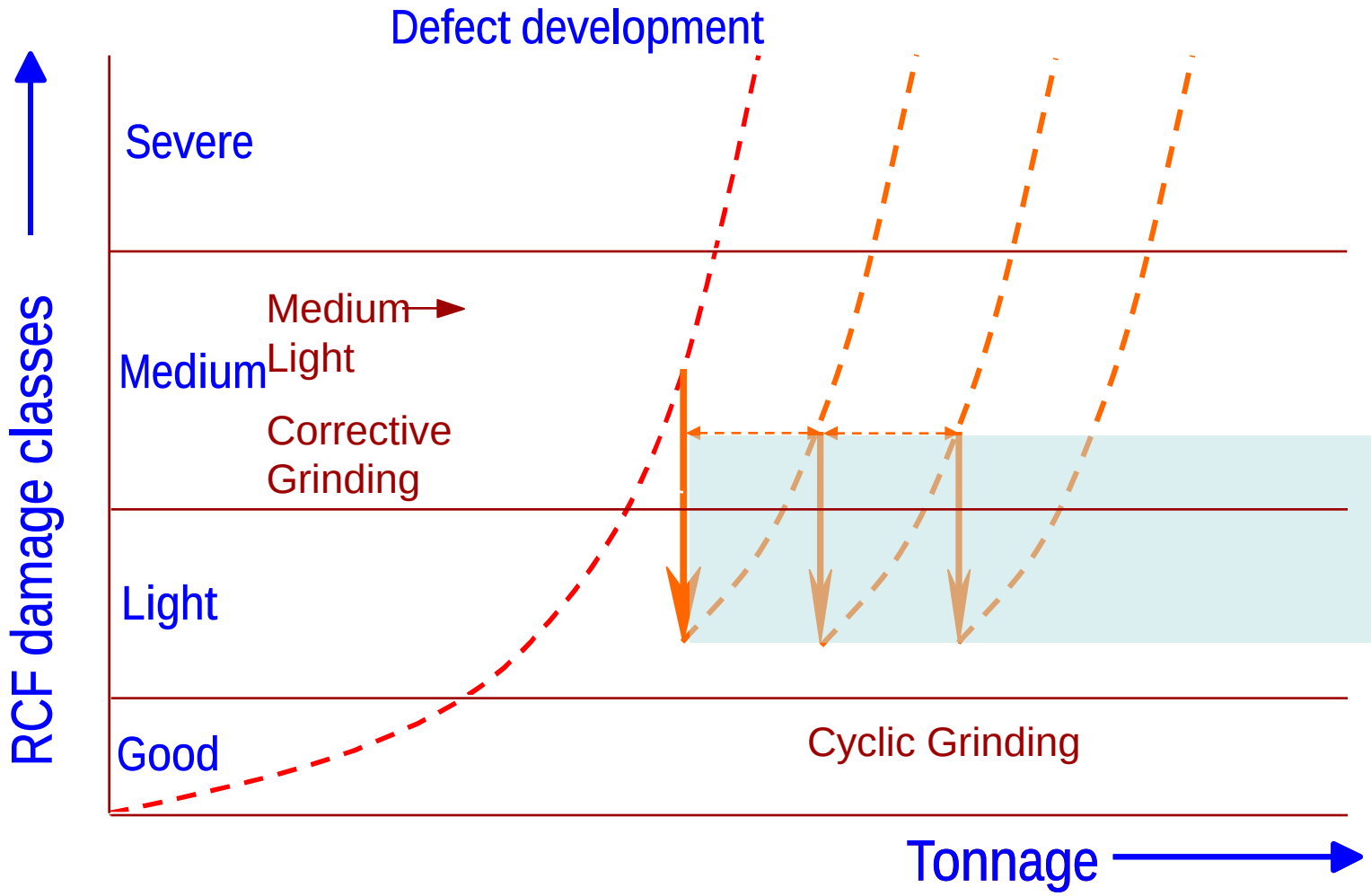


Strategy Change – 2c

Prioritization of required corrective actions:

- Preferred scenario:
  Corrective to zero (preventive) in one step
- In case of limited budget or grinding capacity:
  Corrective to zero (gradual preventive) in several steps
- Minimal solution:
  Keep present situation by “preventive” cyclic interventions

Alternative 3 – Corrective cyclic



Strategy Change - 3

Continued strategic preventive actions:

- All good / corrected sections to be kept in the preventive cyclic mode!

- Switch to a maintenance philosophy that prioritizes preventive cyclic work over corrective actions!

Conclusions -1

- Modern railway traffic operation provokes at many places rail Rolling Contact Fatigue
- Thus, rail maintenance is an inevitable must
- Predictable work (at least in a medium time horizon) organised in a strategic way needs to be defined, in order to profit most from existing technologies and to guide the industry for future development
- Depending on the size of a railway network a certain number and different types of machines may be required
- Any maintenance regime has to assure ideal wheel-rail contact conditions (optimal rail profile within tight tolerances) and ideal metal removal rates (big enough to eradicate defects but as low as necessary in order to keep artificial wear at a minimum)

Conclusions - 2

- The use of specific target profiles featuring gauge corner relief (AHC profile) is recommended

- Repetitive grinding work with easily achievable metal removal rates and the least possible interference with track operations; metal removal of up to 0.6 mm at the gauge area and a maximum of 0.2 mm in the centre of the rail head should be envisaged.

- Optimal rail surface conditions prolong rail life and reduce general track deterioration

- Present maintenance costs (grinding) can be reduced considerably

Conclusions - 3

- The optimal grinding strategy has to take into account the installed rail grade (grinding cycle, metal removal rate)

- If rail change is pending:

  Select the appropriate rail grade according to you rail condition (Tonnage - Radius, Wear - RCF)

Conferences versus In-track Activities

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Thank You For Your Attention!

Dr. Wolfgang Schöch
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voestalpine Schienen GmbH

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ONE STEP AHEAD.