Mid-Term Conference of the Shift2Rail JU Funded IP3 Projects

IN2TRACK Presentation

Paris 24th of January 2018

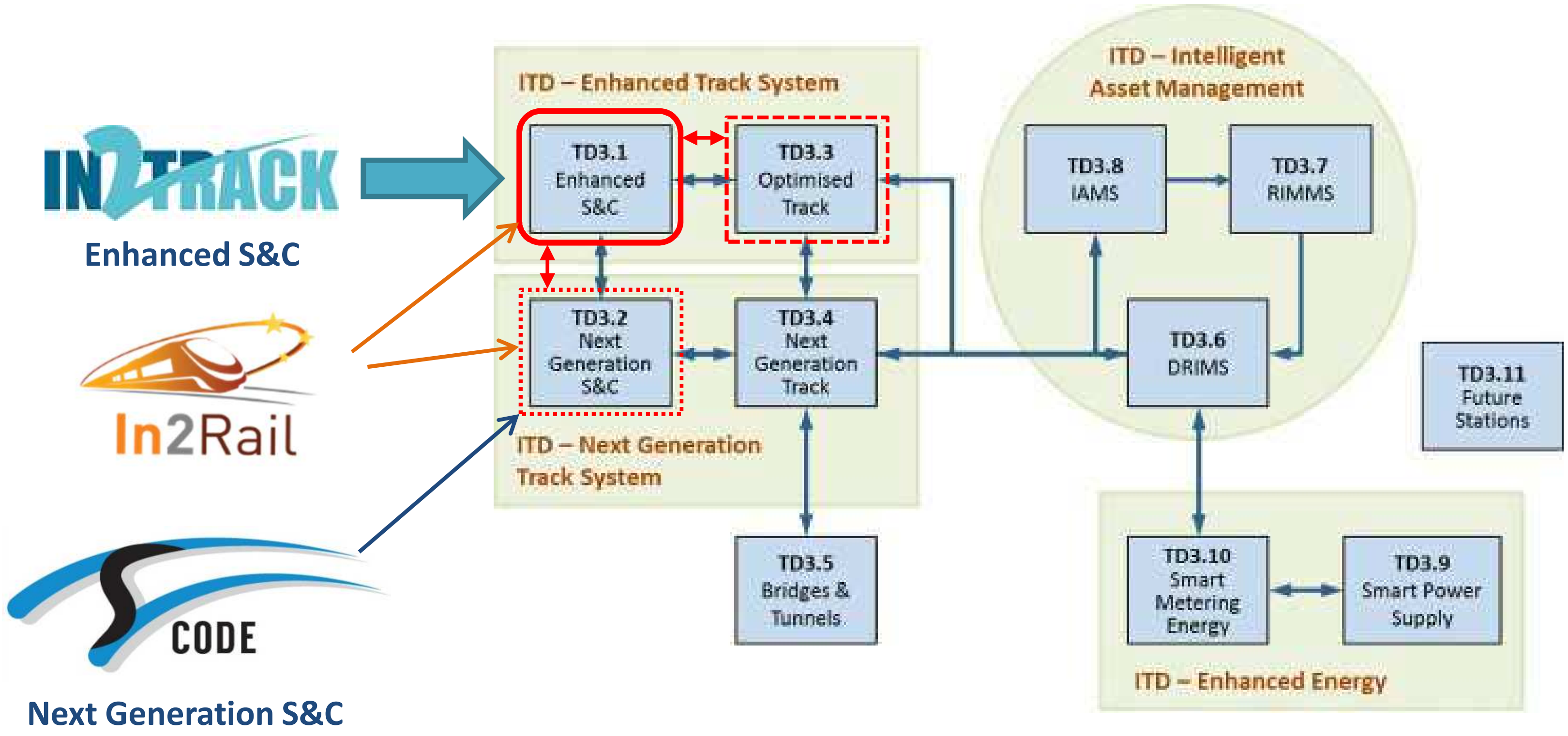
GA H2020 - 730841

WP2: Enhanced Switches & Crossings

GA H2020 - 730841

WP2 Objectives

The main objective of this TD is to **improve the operational performance of existing S&C designs** through the delivery of new S&C sub-systems with enhanced RAMS, LCC, sensing and monitoring capabilities, self-adjustment, noise and vibration performance, interoperability and modularity.



WP2 Partners

European Partners

SNCF RÉSEAU

NetworkRail

TRAFIKVERKET

voestalpine ONE STEP AHEAD.

vossloh COGIFER

BRITISH STEEL

virtual vehicle

EUROC European Rail Operating community Consortium

TECHNOLOGICAL RESEARCH INSTITUTE RAILENIUM

AC²T research

getzner engineering a quiet future

MCL www.mcl.at MATERIALS CENTER LEOBEN

KIRCHDORFER FERTIGTEILHOLDING

Linked 3rd Parties

CHALMERS UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF Southampton School of Engineering Sciences

The University of Nottingham

The University Of Sheffield.

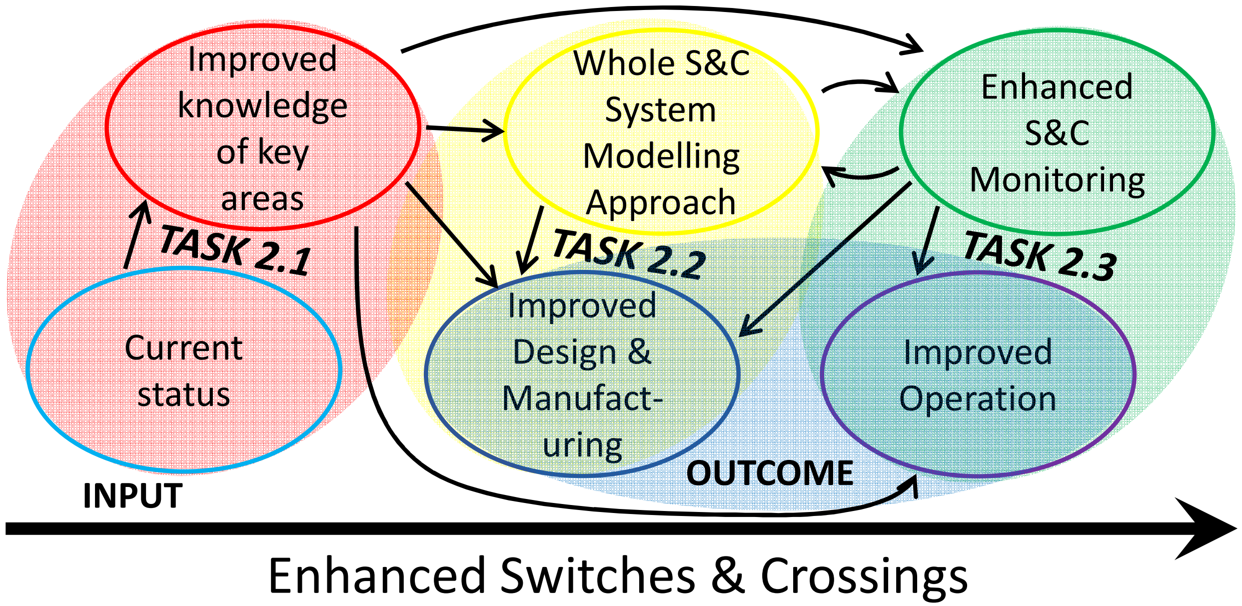
TWI

University of HUDDERSFIELD Institute of Railway Research

UNIVERSITY OF BIRMINGHAM

WP2 Structure

Task #	Description
2.1	Identifying and Understanding Core S&C Issues [TRL 6]
2.2	Enhanced S&C Whole System Analysis, Design and Virtual Validation [TRL5]
2.3	Enhanced Monitoring, Operation, Control and Maintenance of S&C [TRL4]



TASK 2.1 – Core S&C Issues

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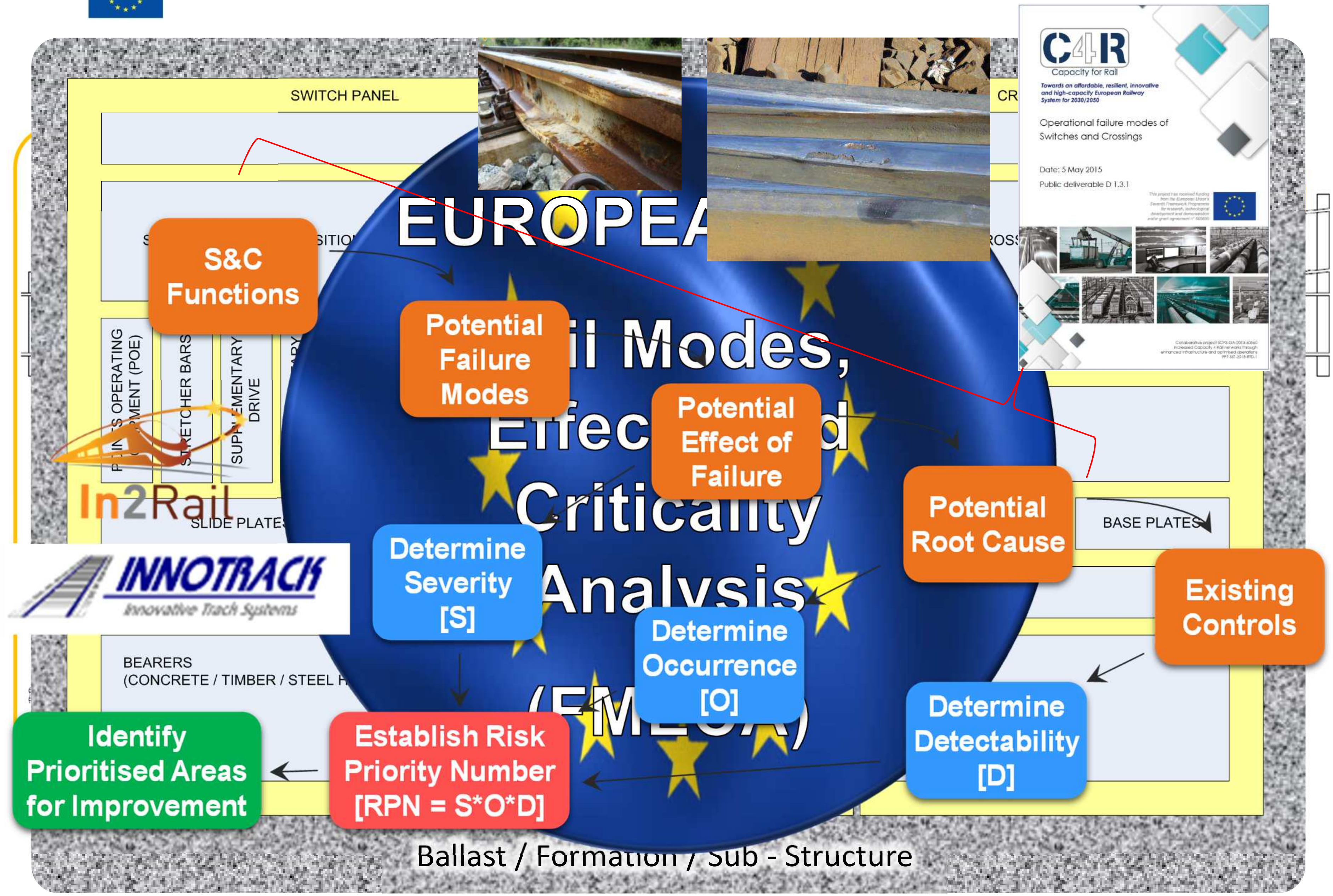
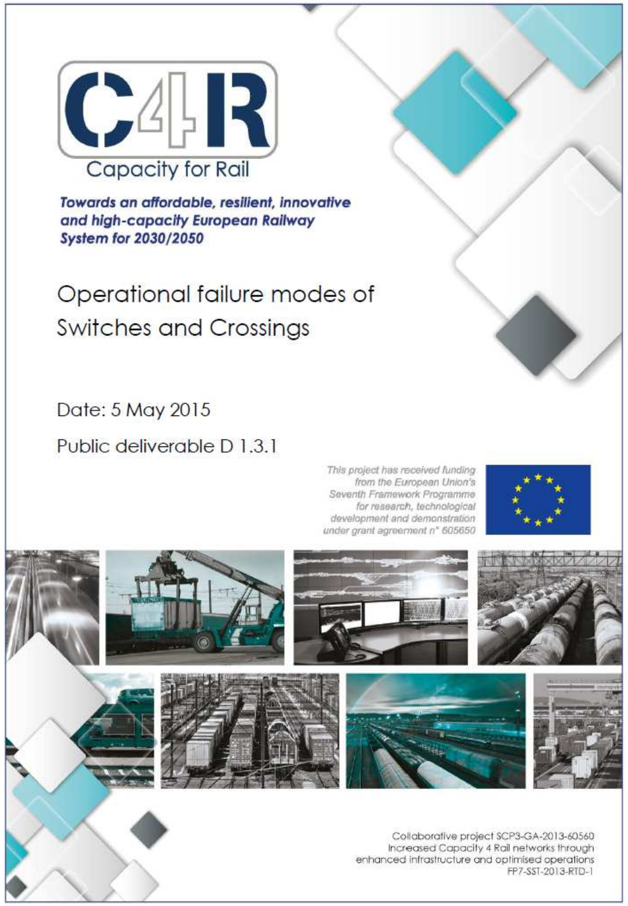
Core S&C Issues



Damage Catalogues

The C4R damage catalogue and UIC documents 712 and 725 shall be used for further application within In2Track.


C4R
Capacity for Rail

Towards an affordable, resilient, innovative and high-capacity European Railway System for 2030/2050

Operational failure modes of Switches and Crossings

Date: 5 May 2015

Public deliverable D 1.3.1

This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement n° 605650

Collaborative project SCP3-GA-2013-60560
Increased Capacity 4 Rail networks through enhanced infrastructure and optimised operations
FP7-SST-2013-RTD-1

TASK 2.2 – Enhanced S&C Whole System Analysis, Design and Virtual Validation

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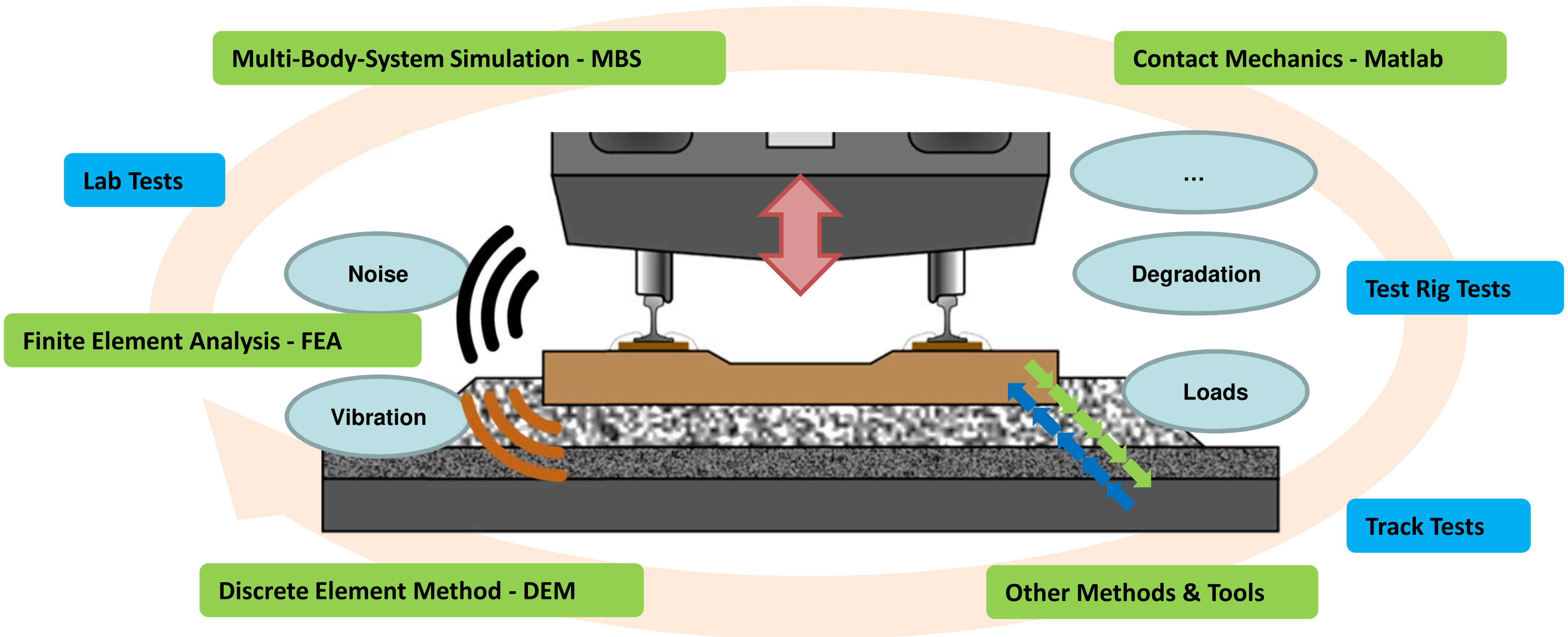
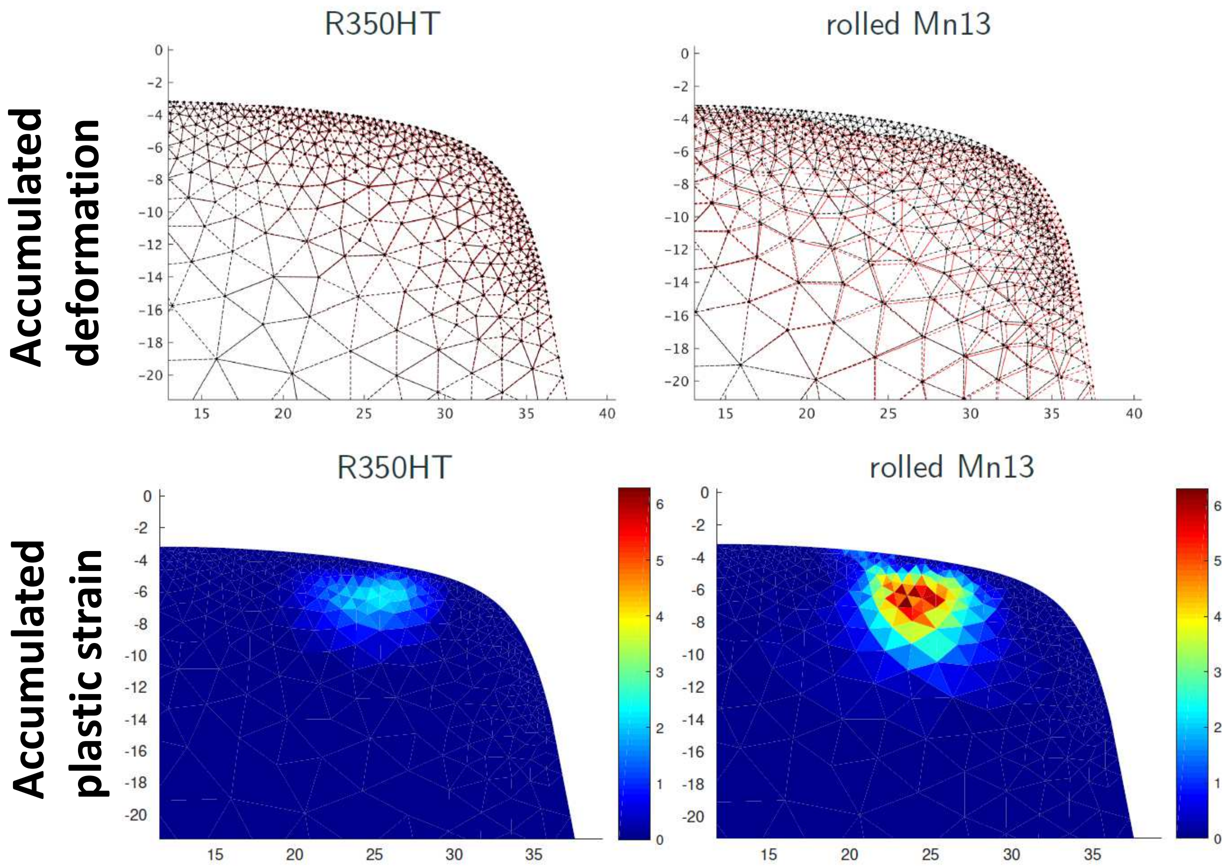
Task 2.2
S&C Whole System Modelling

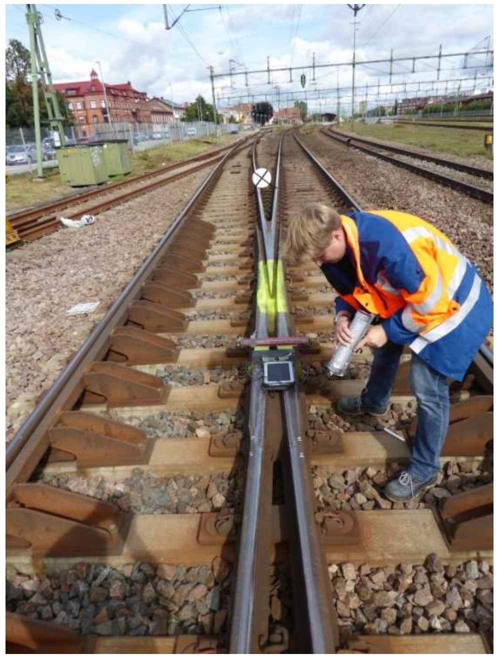
Combine Methods & Tools to an integrated **whole rail system model** framework for design, optimization and certification / authorization of track concepts and components



Task 2.2
S&C Whole System Modelling

Calculations using INNOTRACK simulation scheme improved with meta models in In2Track for shorter simulation times. Load collective accounts for variation in vehicle wheel profile, speed and w/r friction coefficient.

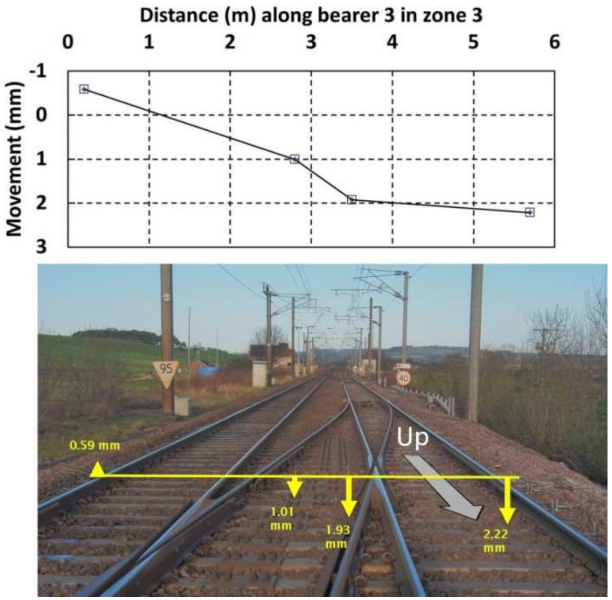




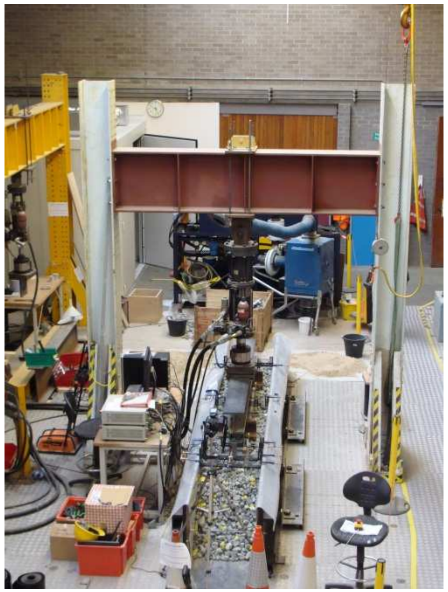
INNOTRACK
Eslöv Sweden

S&C Substructure Interaction

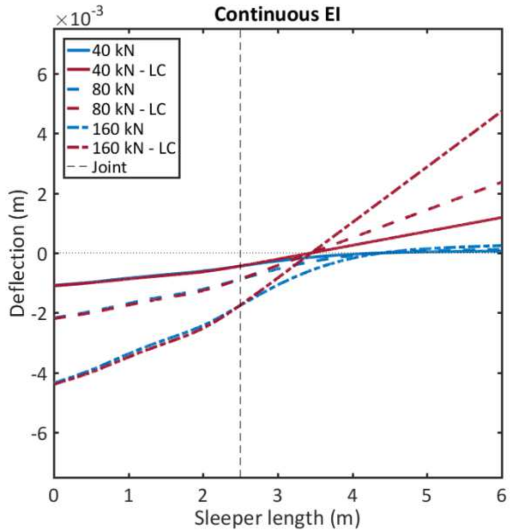
1. *A review of S&C substructure interaction has been carried out.*
2. *A series of tests is planned to look at different designs of S&C jointed bearer behaviour*
3. *A numerical tool has been modified to simulate bearer/substructure interaction*



1. Field measurements from the literature show the asymmetric behaviour of long S&C bearers.



2. An existing testing apparatus will be modified for long bearer testing.



3. A numerical tool is used to simulate different bearer properties and their influence on substructure interaction under idealised conditions

Turnout Cross Section Measurements - Eslöv Sweden

VAE Turnouts installed at the Innotrack project in Eslöv in Sweden in 2009, were inspected and cross section measurement were taken and analyzed. The results gives detailed information about component conditions and provides further information for LCC considerations and maintenance information.

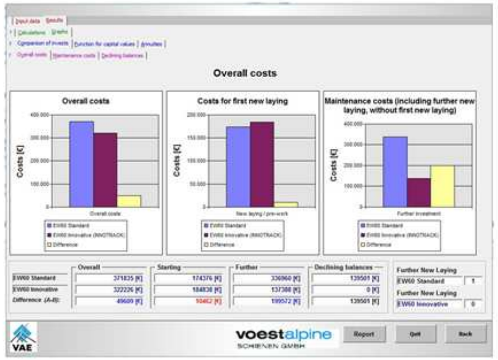


Figure 24 - LCC results (overall costs) of standard and innovative S&C system (INNOTRACK demonstrator)

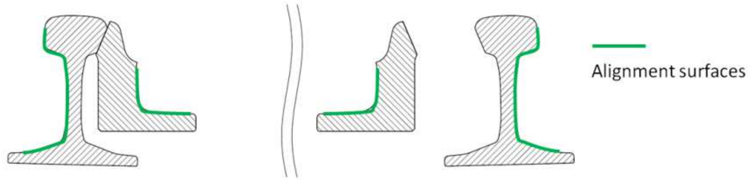


Figure 12: Switch panel measurements and alignment

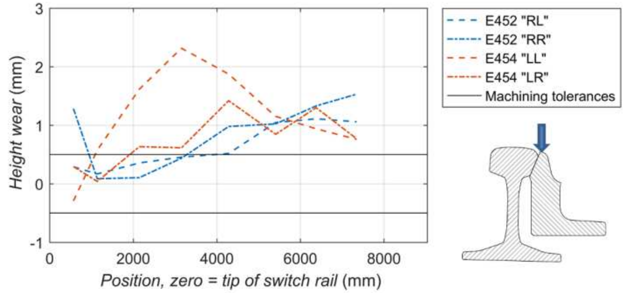


Figure 16: Switch rail height material loss

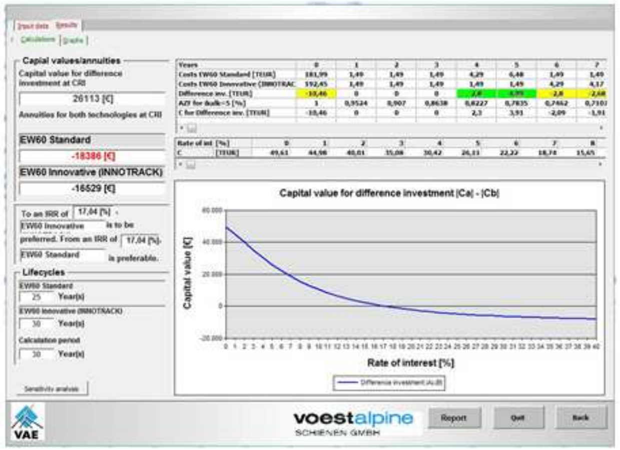


Figure 25 - LCC results (overall costs) of standard and innovative S&C system (INNOTRACK demonstrator)

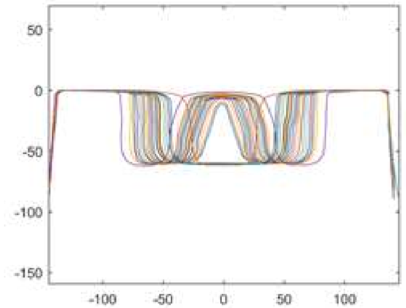


Figure 18: Cross-section measurements

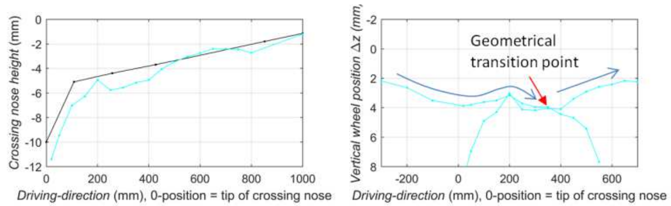
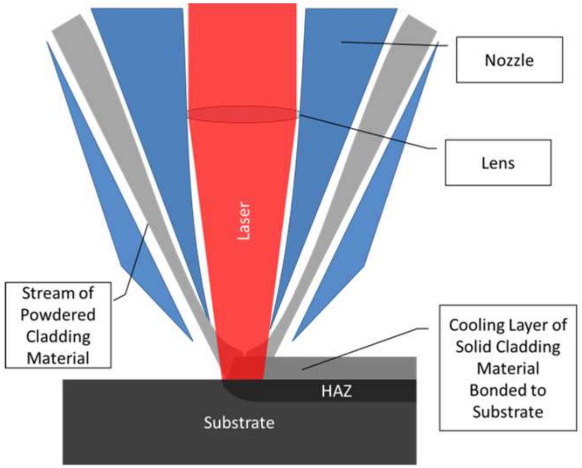
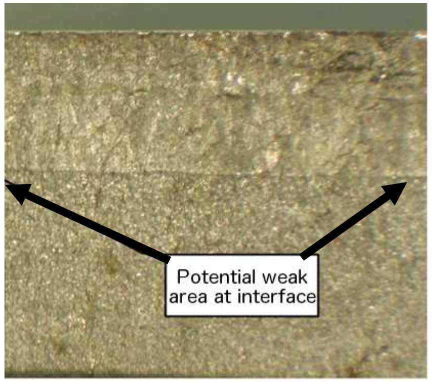


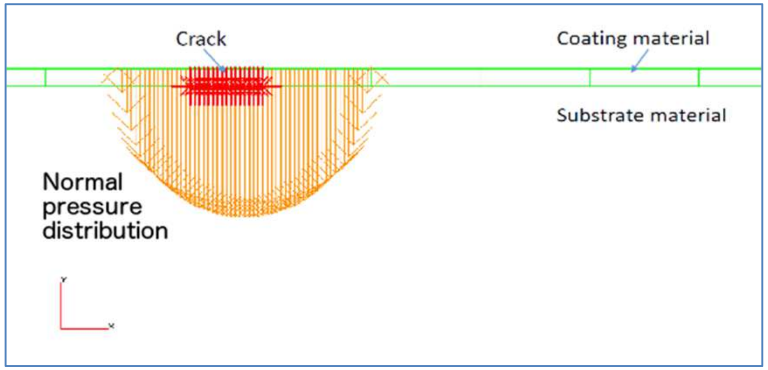
Figure 21: E454 crossing height and wheel position trajectories

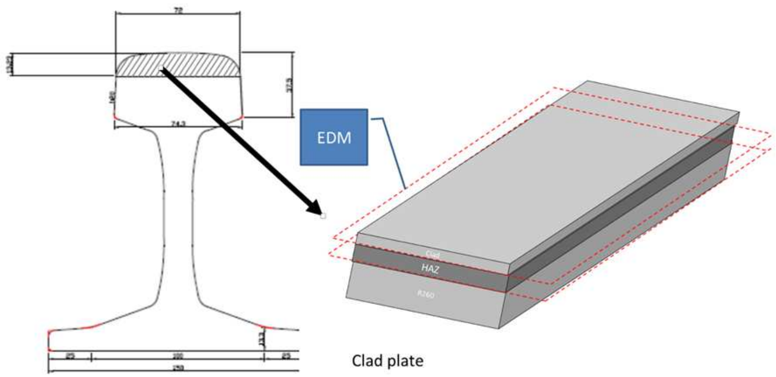
Laser Cladding of S&C

Understanding quality requirements to specify laser clad S&C



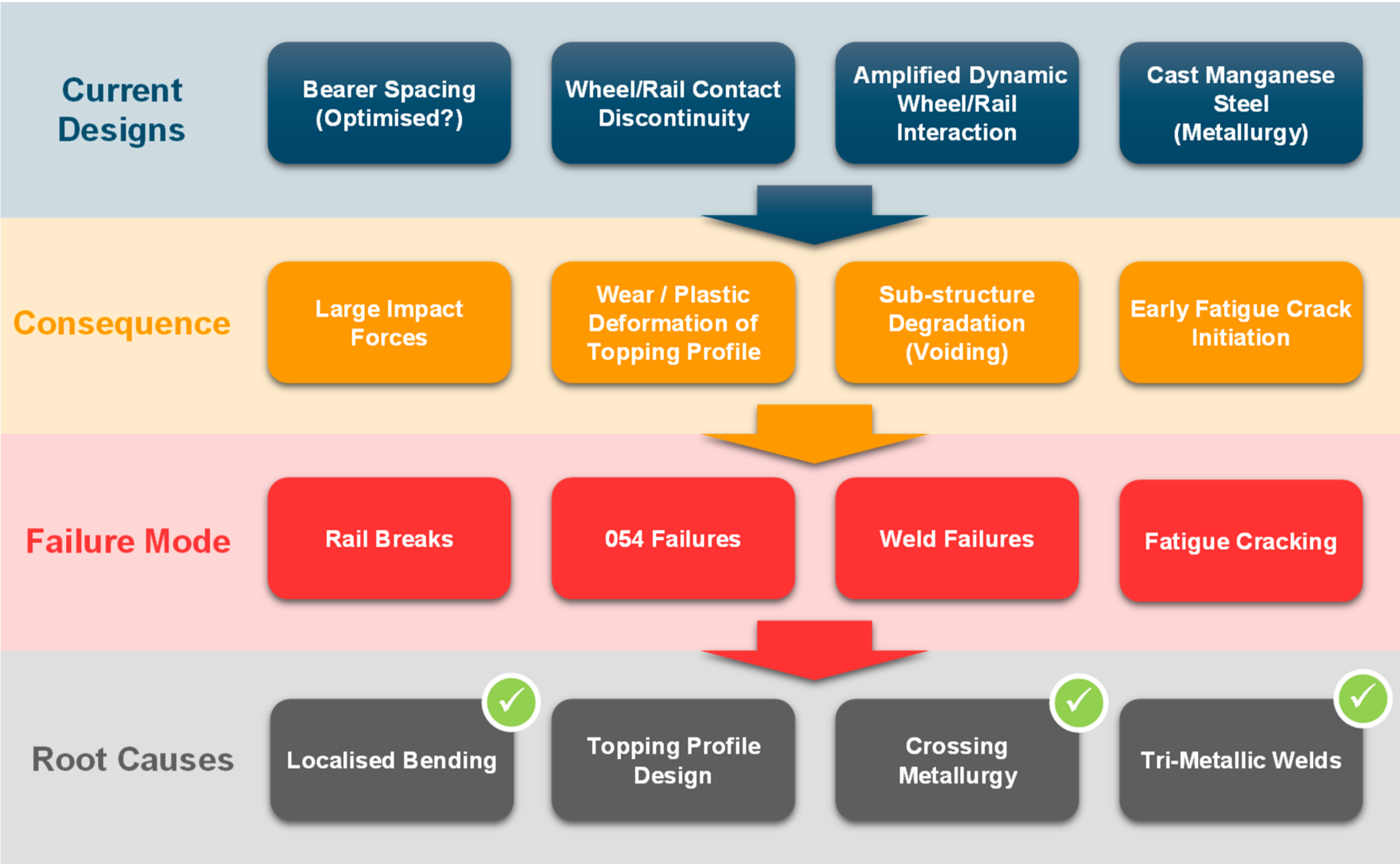






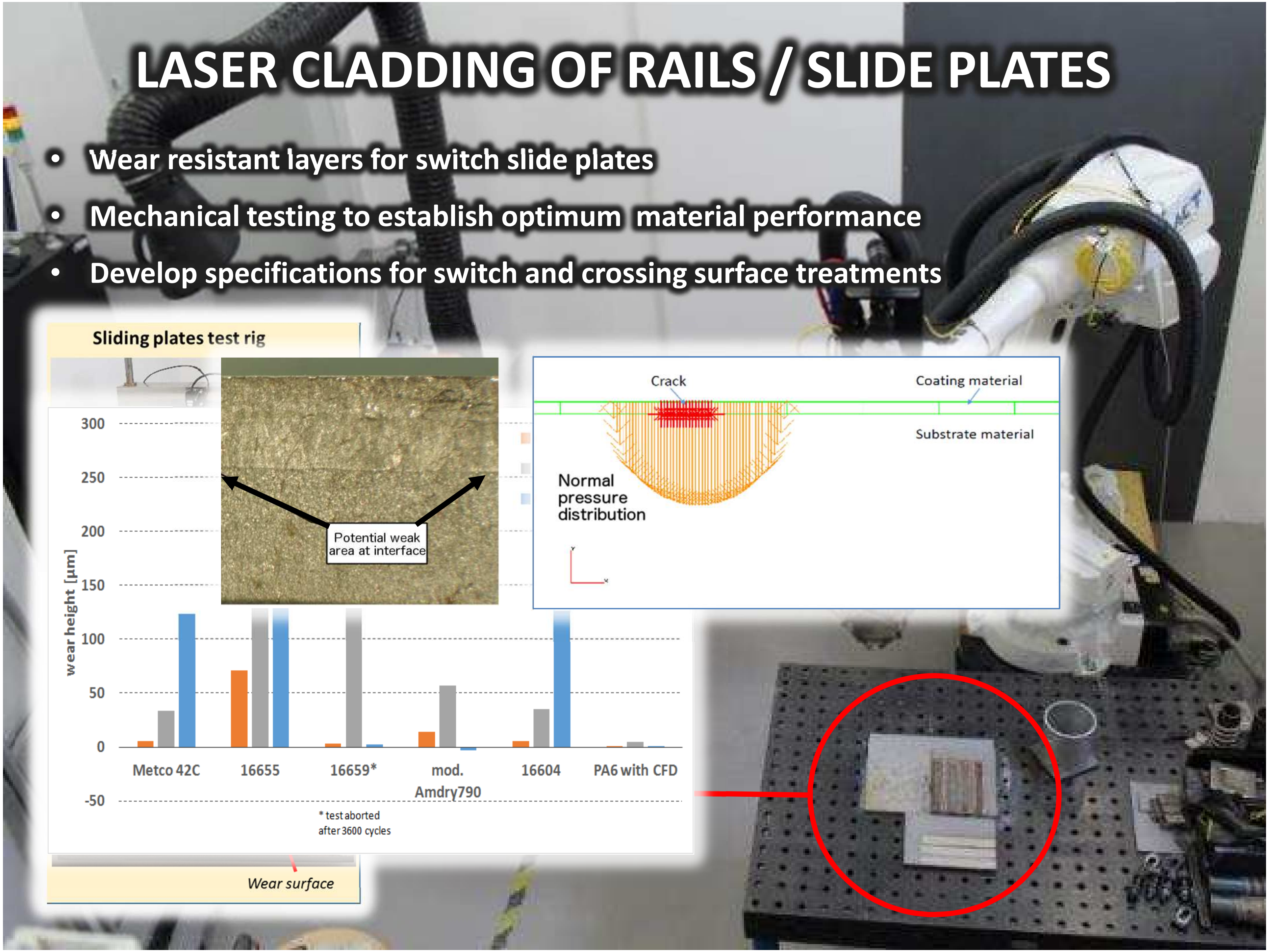
- Previous work on cladding rails has been successful
- New specification needed for S&C:
  - Higher loads and impact forces than for rail
  - Quantify bond strength needed
  - Bond location relative to stress field
  - Tolerance of defects understood
- Modelling work underway, laboratory tests specified for performance Q1 2018

Task 2.2
State-of-the-art Manufacturing



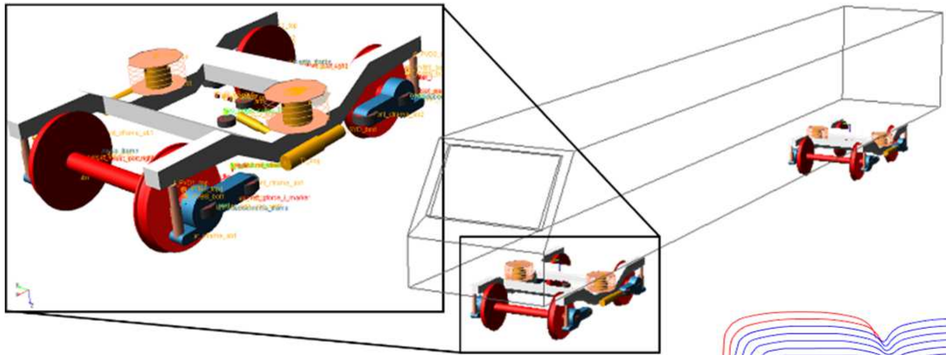
ARC ADDITIVE MANUFACTURING

- Tighter Tolerance?
- Increased Fracture Toughness?
- Optimised Topping Design?
- Eliminate Tri - Metallic Weld?
- Ability to NDT Casting?
- Better Performance under Degraded Track?
- FUTURE: Eliminate Casting?!

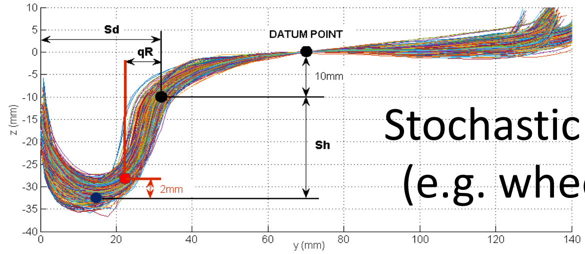


LASER CLADDING OF RAILS / SLIDE PLATES
• Wear resistant layers for switch slide plates
• Mechanical testing to establish optimum material performance
• Develop specifications for switch and crossing surface treatments
Sliding plates test rig
300
250
200
150
100
50
0
-50
wear height [µm]
Metco 42C
16655
16659*
mod. Amdry790
16604
PA6 with CFD
* test aborted after 3600 cycles
Wear surface
Potential weak area at interface
Crack
Coating material
Substrate material
Normal pressure distribution

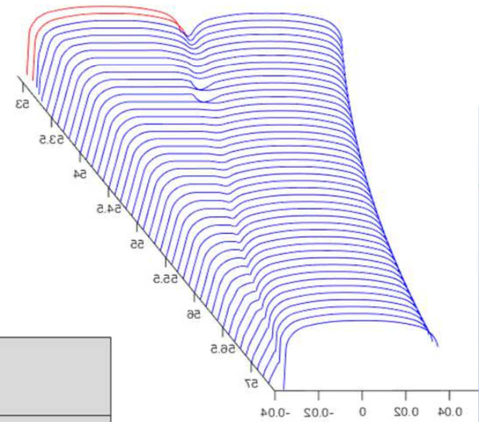
Task 2.2
Enhanced S&C Design



MBS vehicle models



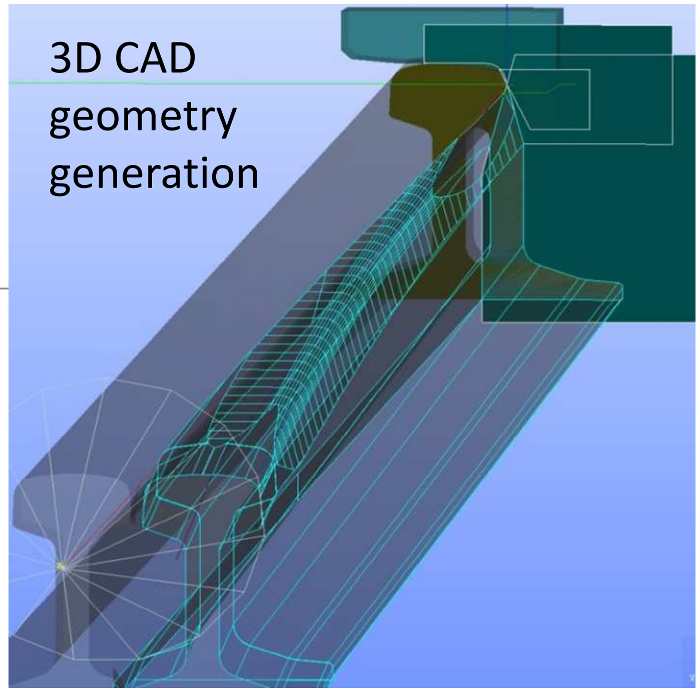
Stochastic MBS input (e.g. wheel shapes)



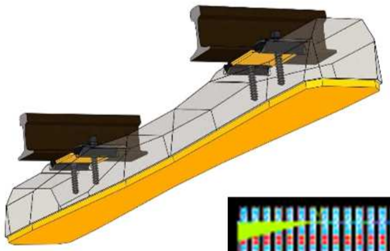
2D cross section input to MBS

Switch families and options

geometry families	intersecting/ secant	tangential	non-intersecting/ clothoidal		
geometry sizes	90/250m	650/760m	1200m	3000m	
stock rail inclinations	vertical	1:20	1:40		
toe relief options	none	toe retraction	65deg relief cut		
topping styles	single slope	double slope	spline		
machining profiles	basic (re-radiussed)	conformal			
switch/ stock interface types	basic (thro' running edges)	inset (tapered 10mm from toe)	augmented (3-5)mm	KGO (tapered to 15mm at centre)	Catfersan
wheel profiles	p8 new	p8 worn	S1002 new	S1002 worn	



Task 2.2
Enhanced S&C Design



Under Bearer Pads

TASK 2.3 – Enhanced Monitoring, Operation, Control and Maintenance of S&C

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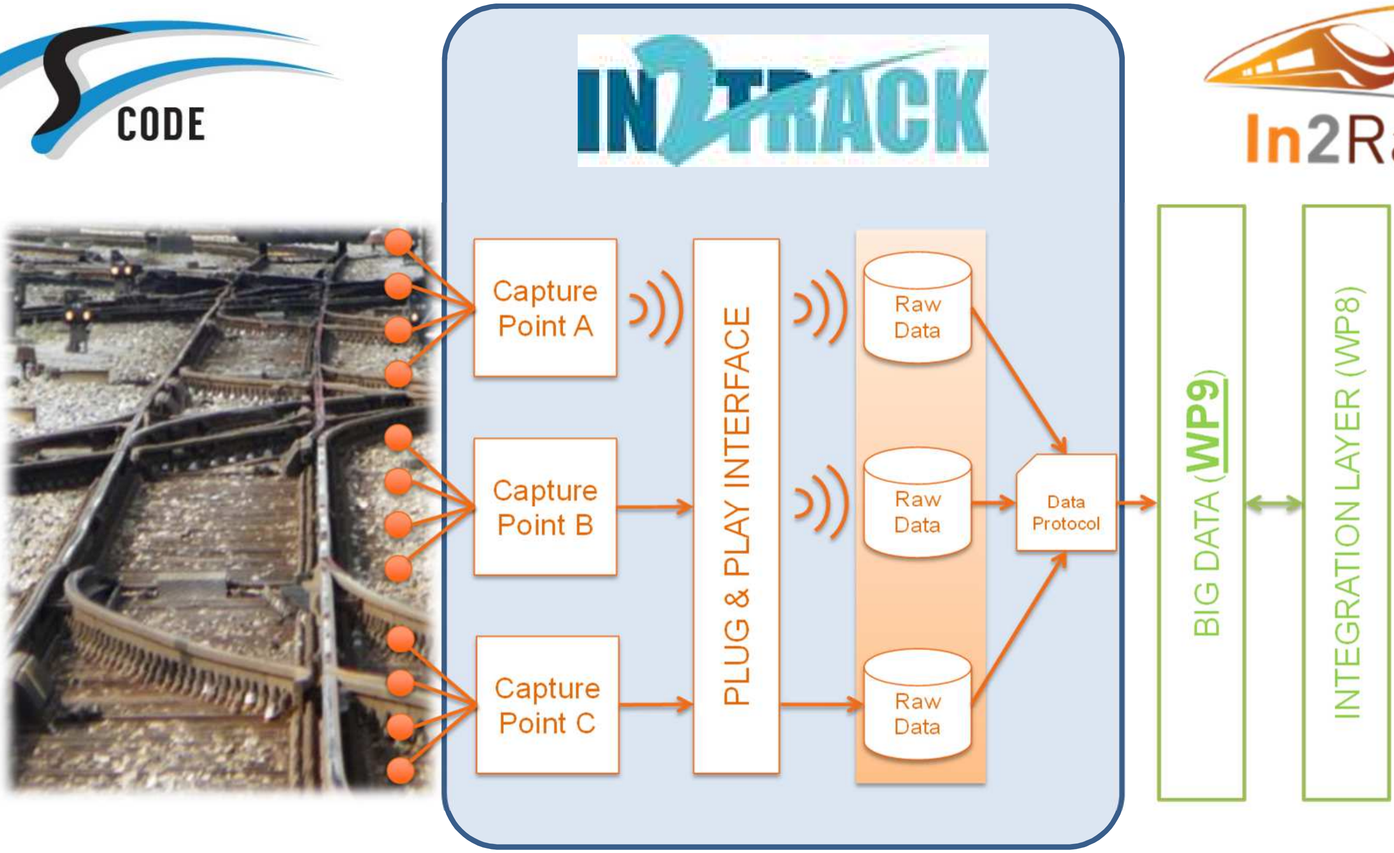
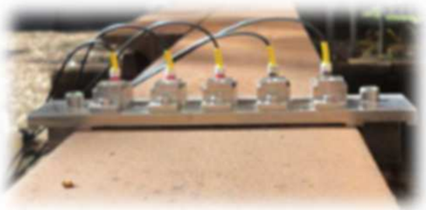
Task 2.3

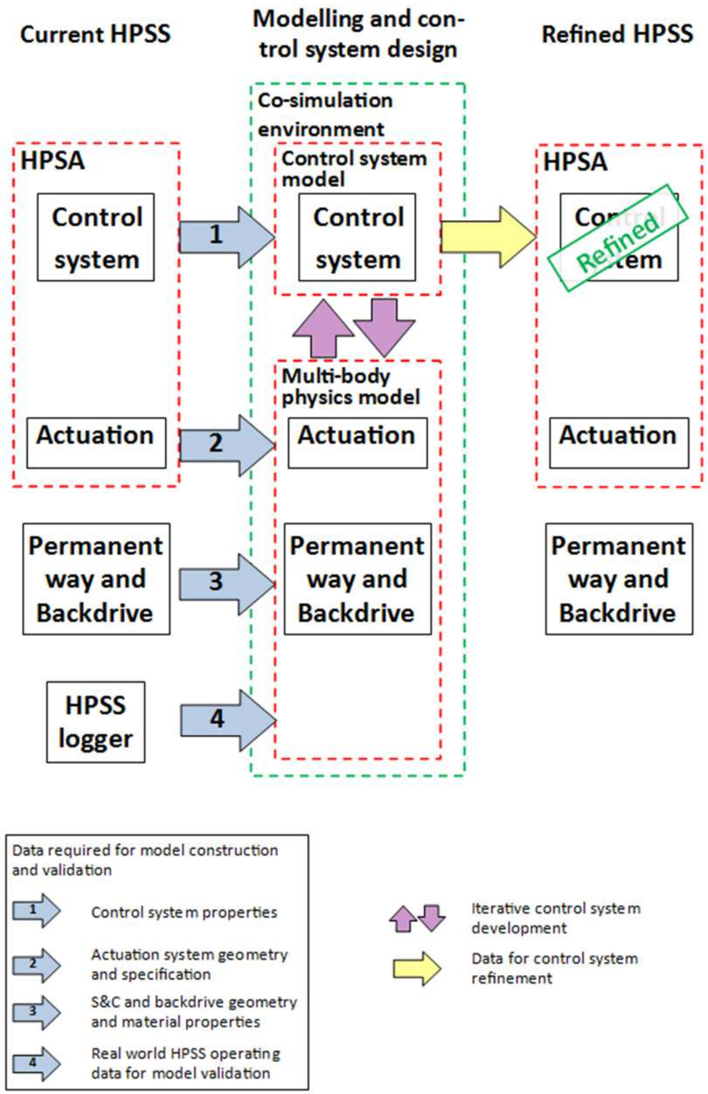
Enhanced Operational Abilities of S&C



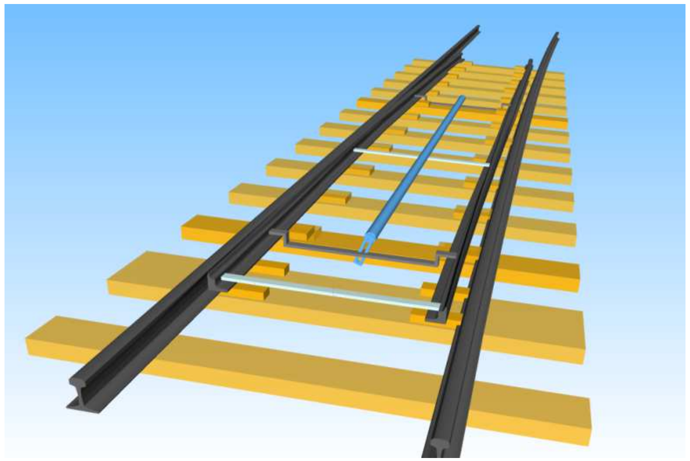


Task 2.3

Enhanced Operational Abilities of S&C

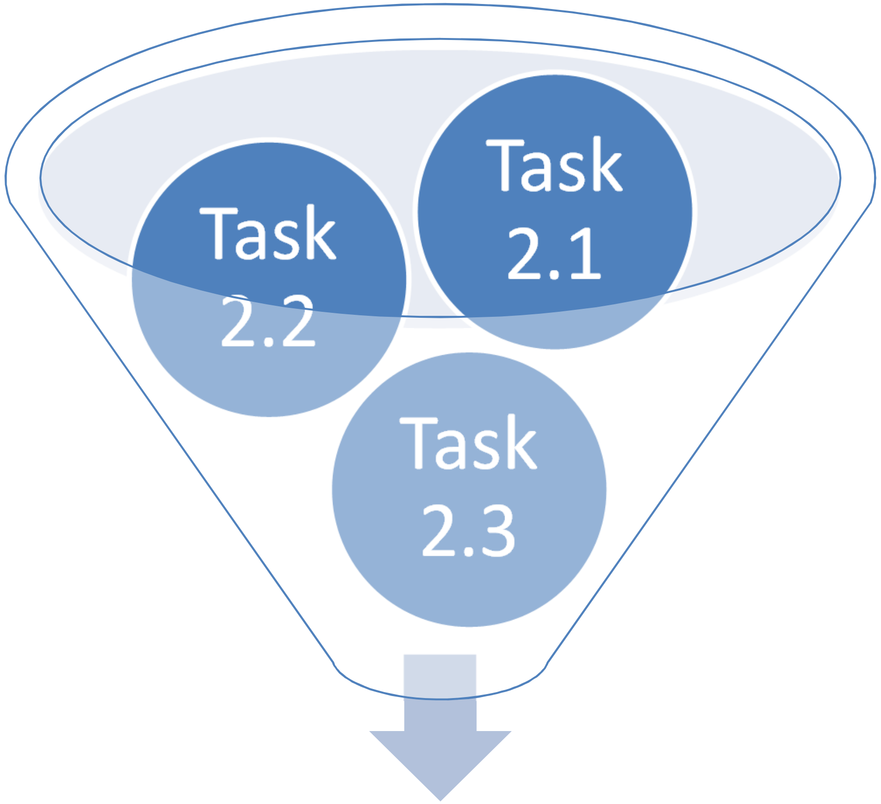


In2Rail



IN2TRACK

Further Work



Specifications / plans for
Enhanced S&C Physical Demonstrators

- **European FMECA**
  - ✓ Final outputs due imminently!
- **Enhanced Whole System Assessment**
  - ✓ Integrated Modelling Approach
- **Prototypes**
  - ✓ Additively Manufactured Crossing
  - ✓ Laser Clad S&C Rails / Slide Plates
  - ✓ S&C Whole System RCM System
- **Enhanced Designs**
  - ✓ Switch Geometry / Rail Profile
  - ✓ Whole System Stiffness / Support
  - ✓ Optimised Rail Grades
  - ✓ Modular Bearer Joints
  - ✓ SoA Points Operating Equipment

Shift2Rail →

AWP2018
TD3.1 – Enhanced S&C
TD3.2 – Next Generation S&C

IN2TRACK – Midterm event

WP3 – TRACK

2017-01-24

UIC, Paris

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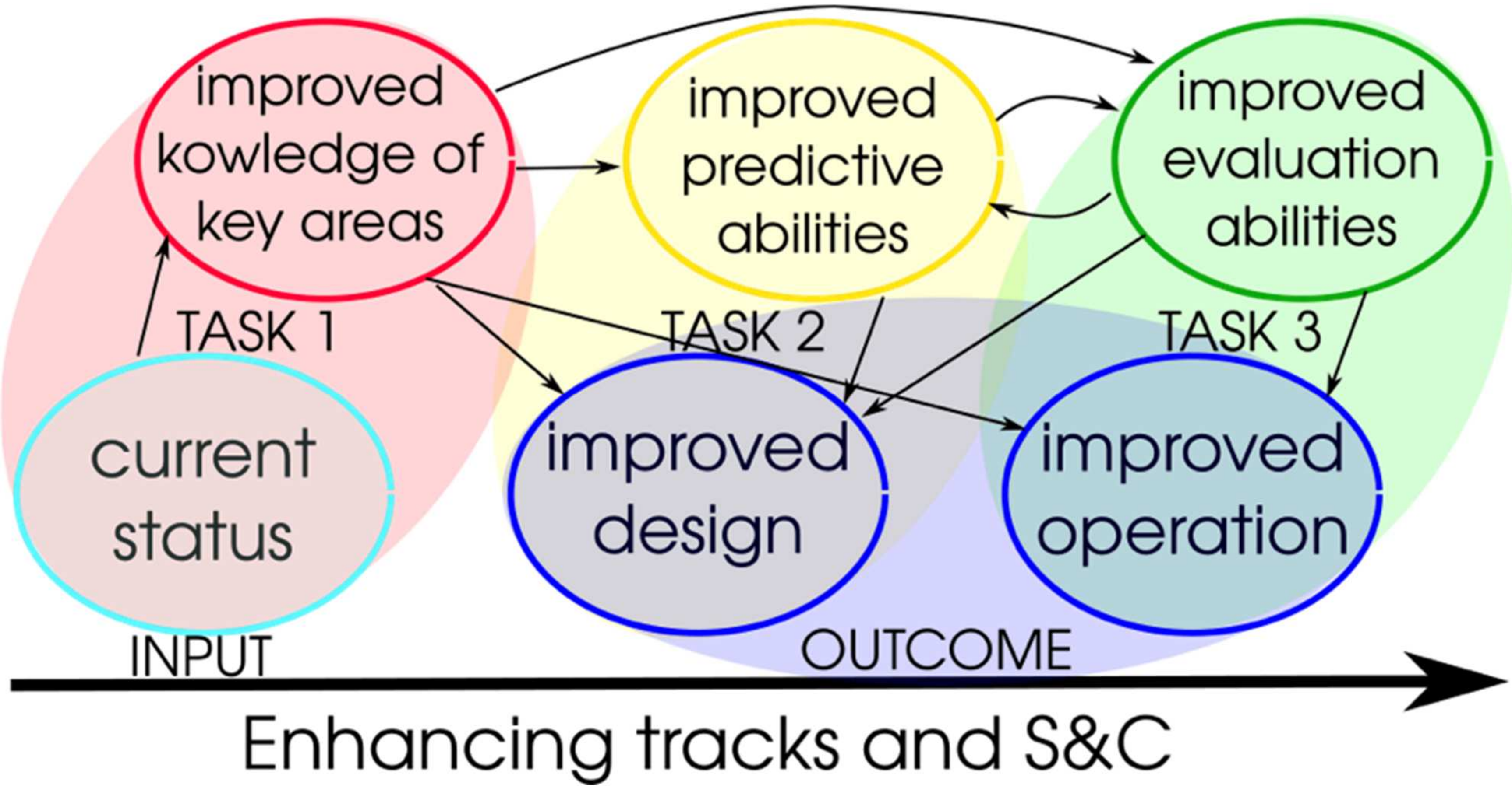
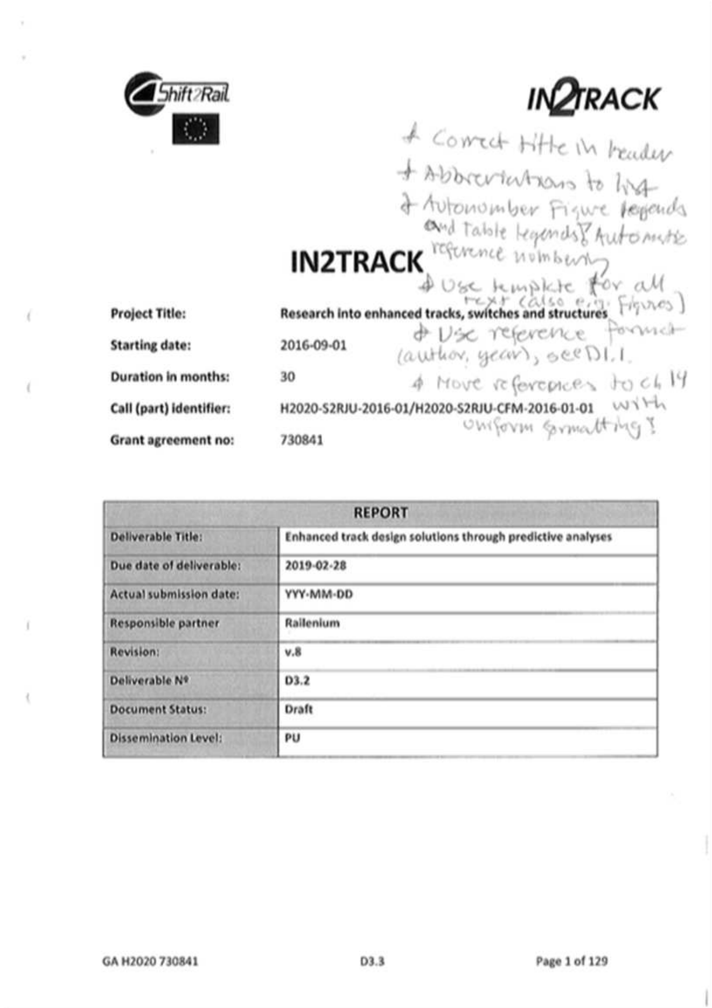
WP3 – TRACK



improved kowledge of key areas
improved predictive abilities
improved evaluation abilities
TASK 1
TASK 2
TASK 3
current status
improved design
improved operation
INPUT
OUTCOME
Enhancing tracks and S&C

Work process

- Personal responsibilities
  - WP-lead
  - Deliverable lead
  - Chapter lead
  - Section lead
- Review of parts
- Compilation of new version
- Review of entire WP



IN2TRACK

+ Correct title in header
+ Abbreviations to list
+ Autonumber Figure legends and Table legends & Automatic reference numbering
+ Use template for all text (also e.g. Figures)
+ Use reference format (author, year), see D1.1.
+ Move references to ch 14 with uniform formatting!

IN2TRACK

Project Title:	Research into enhanced tracks, switches and structures
Starting date:	2016-09-01
Duration in months:	30
Call (part) identifier:	H2020-S2RJU-2016-01/H2020-S2RJU-CFM-2016-01-01
Grant agreement no:	730841

REPORT	
Deliverable Title:	Enhanced track design solutions through predictive analyses
Due date of deliverable:	2019-02-28
Actual submission date:	YYY-MM-DD
Responsible partner	Railenium
Revision:	v.8
Deliverable Nº	D3.2
Document Status:	Draft
Dissemination Level:	PU

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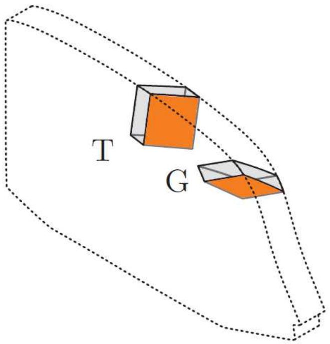
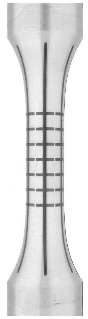
Example – rail steel

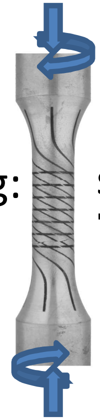


Problem:
Non-homogeneous shear strains.
Not possible to perform bulk experiments.

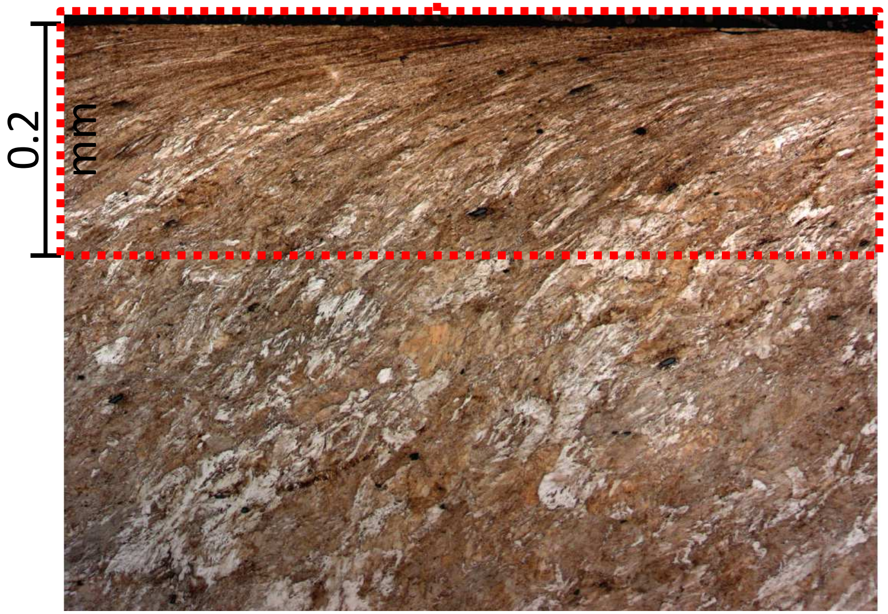
Solution:
Take cylindrical test bars:



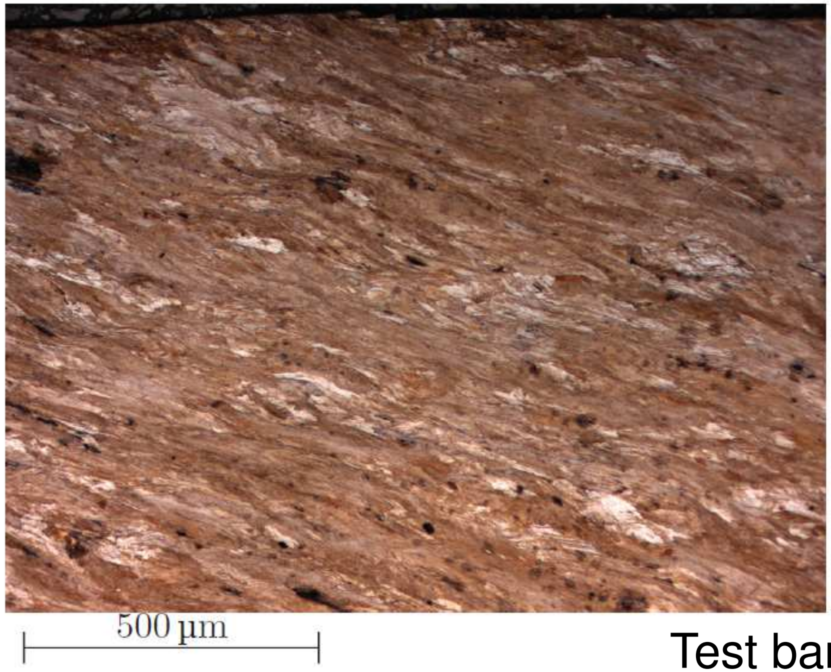
Predeforming:
Compression and torsion



Homogeneous shear strains



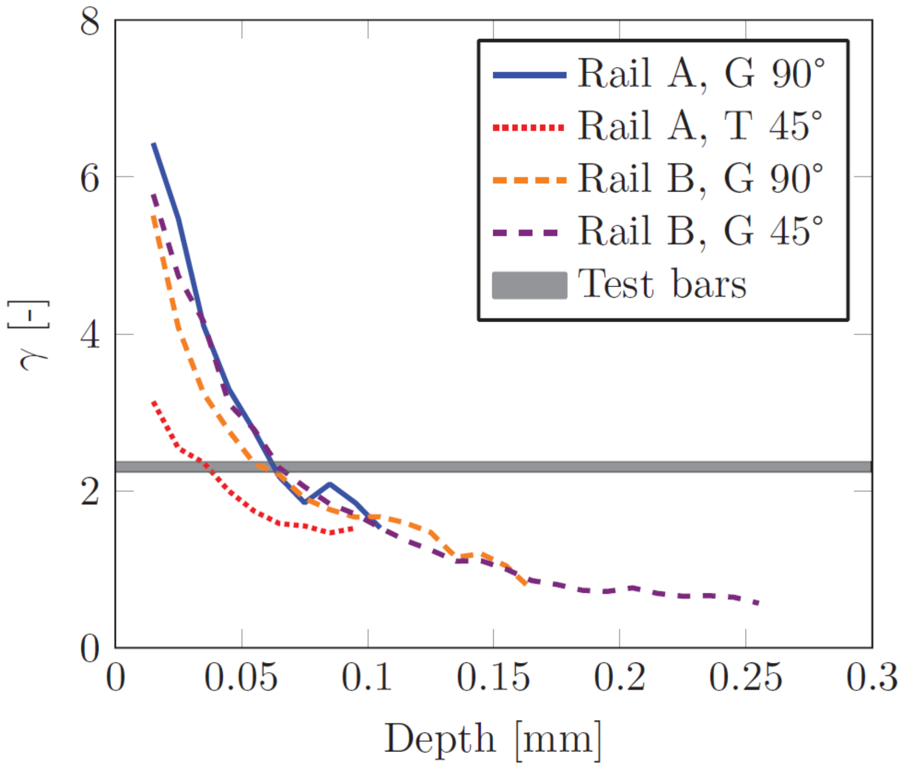
Rail at gauge corner (G)



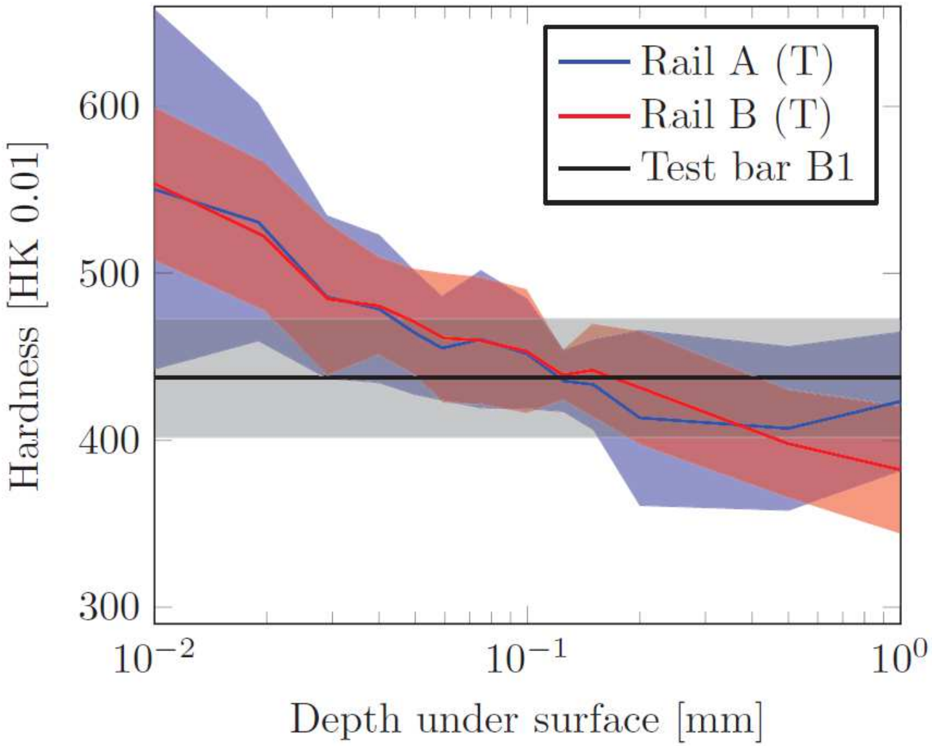
Test bar

Example – rail steel

Similar amounts of shear strain as ca. 0.07 mm below the surface:

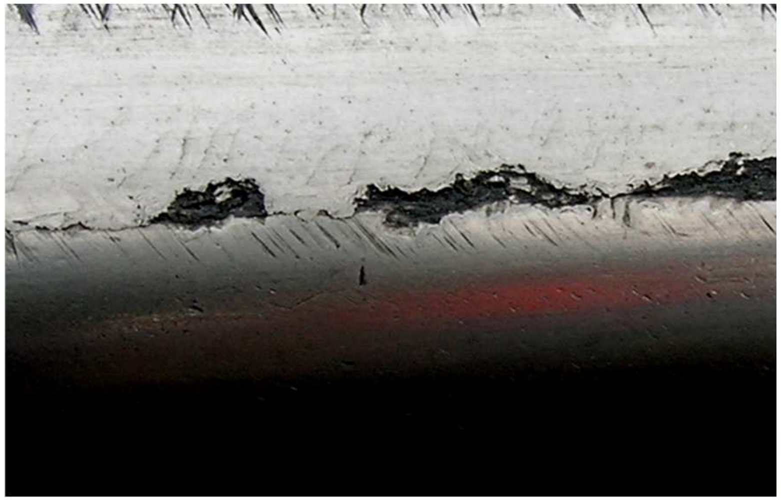


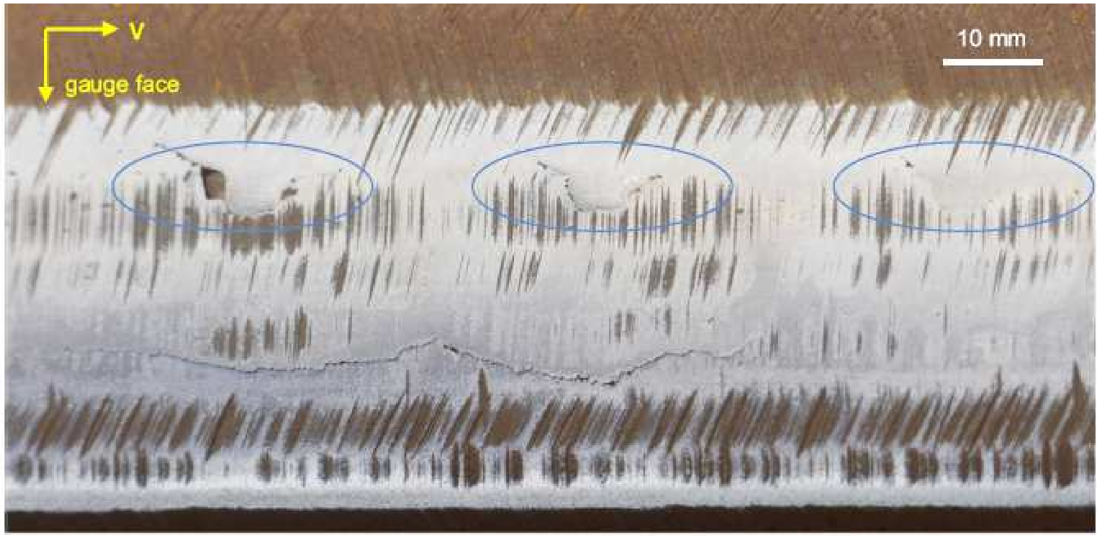
Similar hardness at a depth ca. 0.10 mm below the surface:



Example – grinding

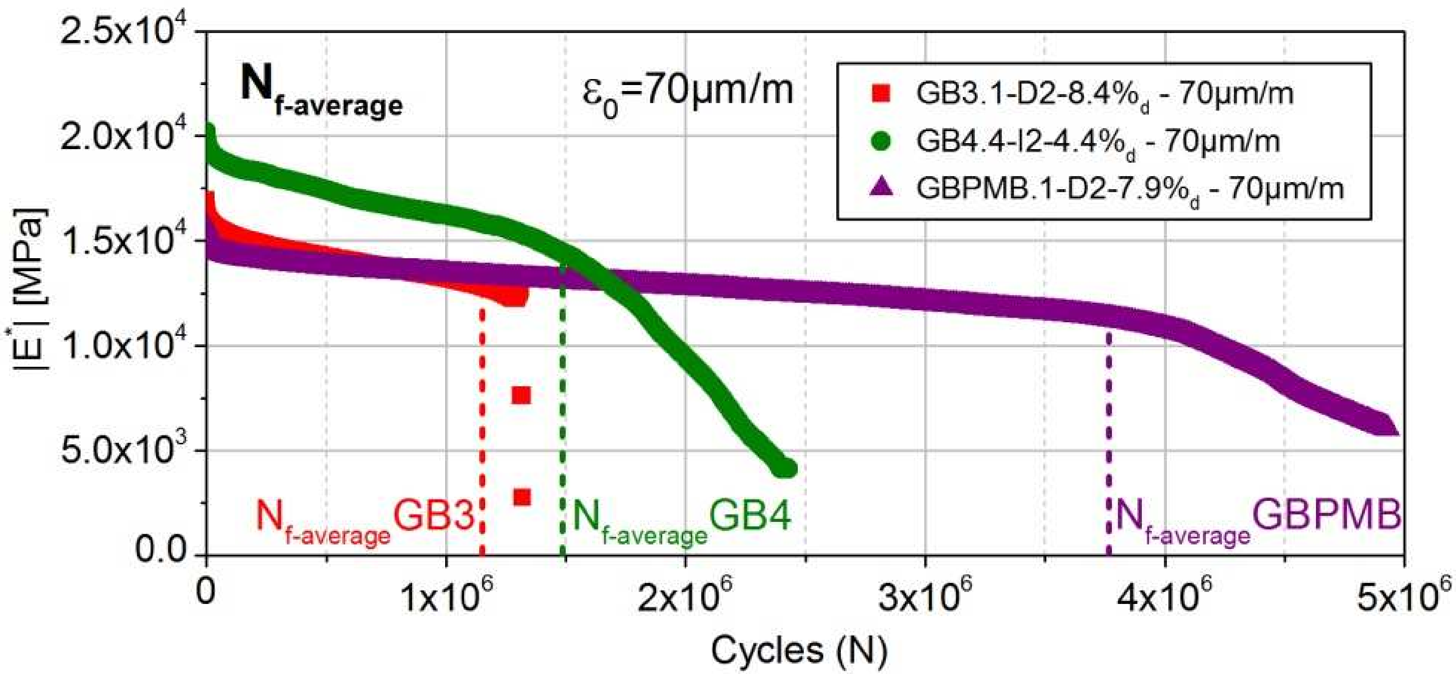
- Grinding induced defects at facets or grind marks
- Different types of damage
- Influence of lubrication, material, welds etc





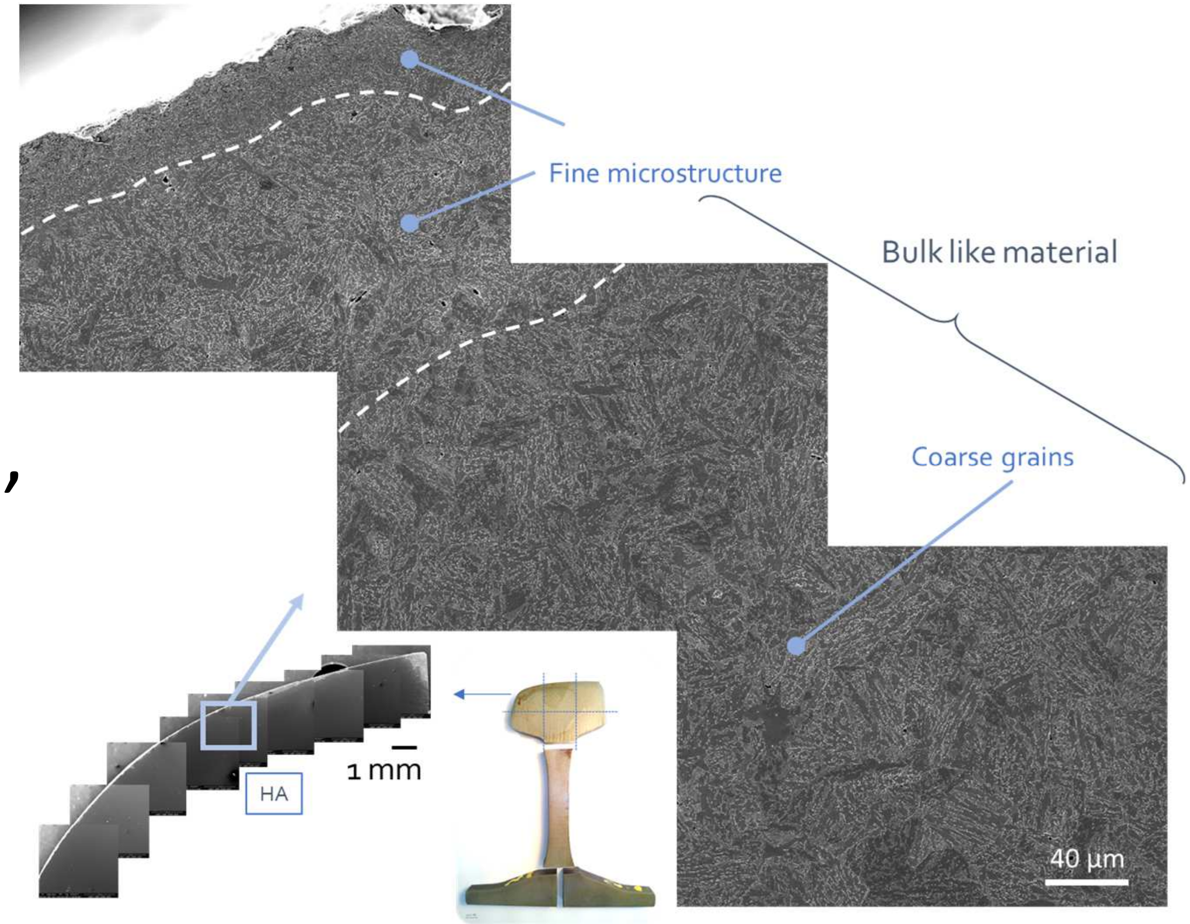
Example – bituminous layer

- Field and lab tests of different mixtures
- Influence of e.g. moisture conditioning
- “Standard” mixture sufficient



Example – Bainitic steels

- Rails used for 10 years in the Eurotunnel (1070 MGT)
- Detailed investigations of properties, microstructure, etc



Example – slab maintenance

- Repair methods for slab tracks
- Microwave heating of fibre reinforced mortar

Future work

- Increase understanding of key phenomena
- Develop new solutions
  - Products, processes and procedures
  - Faster, better and more precise
  - Employ virtual homologation
- Develop operations
  - More precise limits
  - Improved maintenance
  - Better understanding of what works and why

IN2TRACK WP4 highlights

2018-24-01

Paris

Carlos Hermosilla Carrasco

GA H2020 - 730841

Index

- TD 3.5 intro: The bridges and tunnels of tomorrow…
- Objectives
- Tunnel vision
- Bridging the data gap
- It’s not information if you can’t find it
- So, are they working?
- And what if they’re not?
- A new wave in bridge design

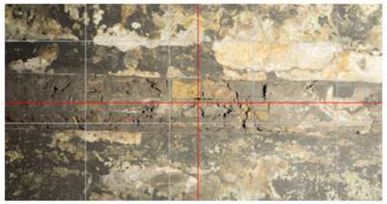
TD 3.5 intro: The bridges and tunnels of tomorrow…

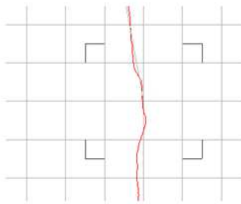
…are, mostly, **those of today!**:

- Line closure is rarely an option
- Replacing all “old” bridges is way too expensive…
- …and tunnels simply cannot be replaced…

…but still, thousands of them are too old, too damaged or too weak for present and future rail demand…

Photo 10 – Area of missing and eroded string course to Down side wall at south end.





or are they?

Objectives

As part of Shift2Rail TD3.5, WP4 strives to:

1. *Develop faster and more accurate methods for inspection and assessment of tunnels and bridges including improved repeatability, reproducibility, quality and effectiveness*

(**Non disturbing**, fast, reliable and continuous **status assessment**)

2. *Develop new repair, strengthening and upgrading techniques which result in reduced traffic disruption and fast installation with short track access time.*

(**Non disturbing**, fast and reliable **capacity upgrade**)

3. *Set the base for future development of noise and vibration damping methods for structures*

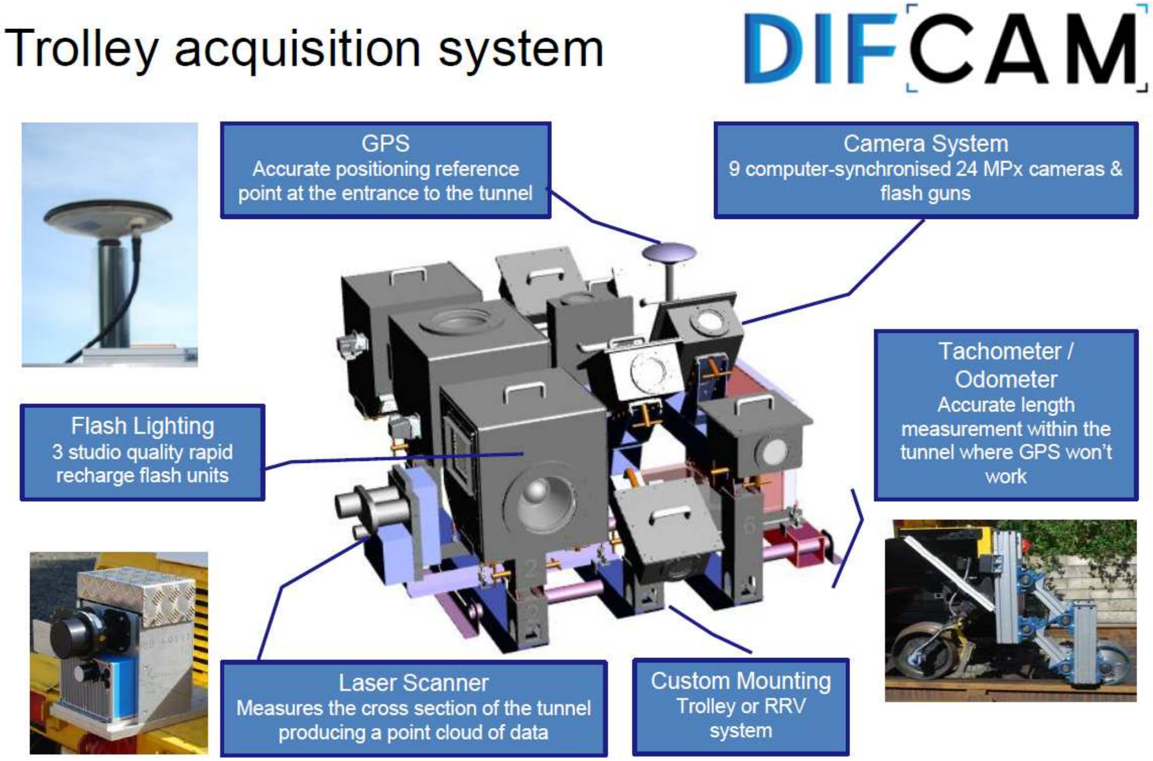
(**Non disturbing** mitigation of **noise and vibration externalities**)

Tunnel vision (I): more than meets the eye

Tunnel activities require **possession time** for **safety** reasons, so how to **lower disruption**?

…either you *grab all you can as fast as you're able…*

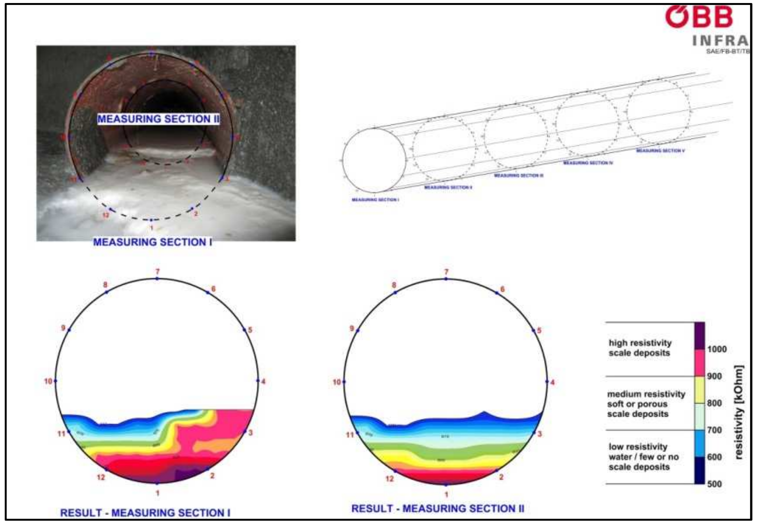
- GPS+IMU+Tachometer for **accurate positioning**
- Synchronized multi-camera system for **Digital Image Correlation** analysis
- Laser scanner produces **accurate point cloud** of inner surface
- Research on **sub-surface defect** detection ongoing

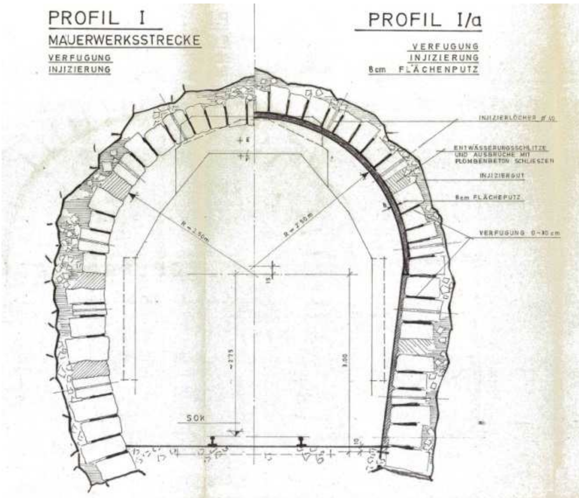


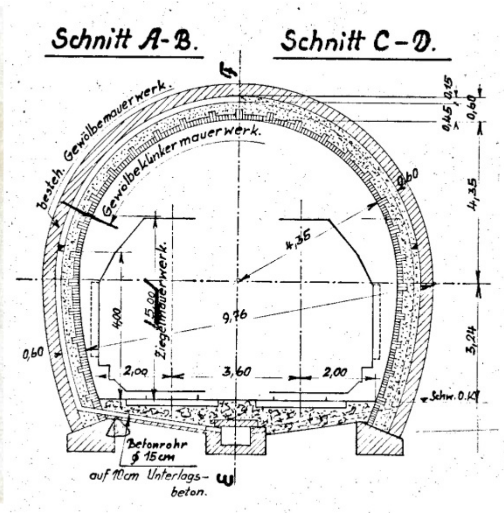
Inspection currently performed at **walking pace**

Tunnel vision (II): undercover data gathering

Tunnel activities require **possession time** for **safety** reasons, so how to **lower disruption**?







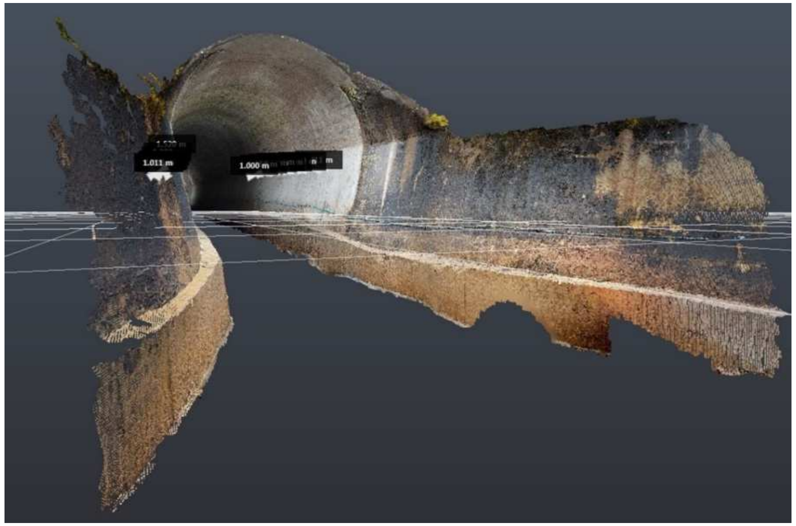
…or you *build a peephole and look once in a while*

- **Permanent drainage monitoring :** resistivity measurements provide data on pipe cross-section availability and hardness of deposits.
- **Monitoring tools for old tunnels:** brittle behavior of masonry and heterogeneous materials shorten reaction span and call for continuous status surveillance.

Bridging the data gap(I): the big picture

Structural behavior of bridges is complex, small defects may be symptoms of big trouble.

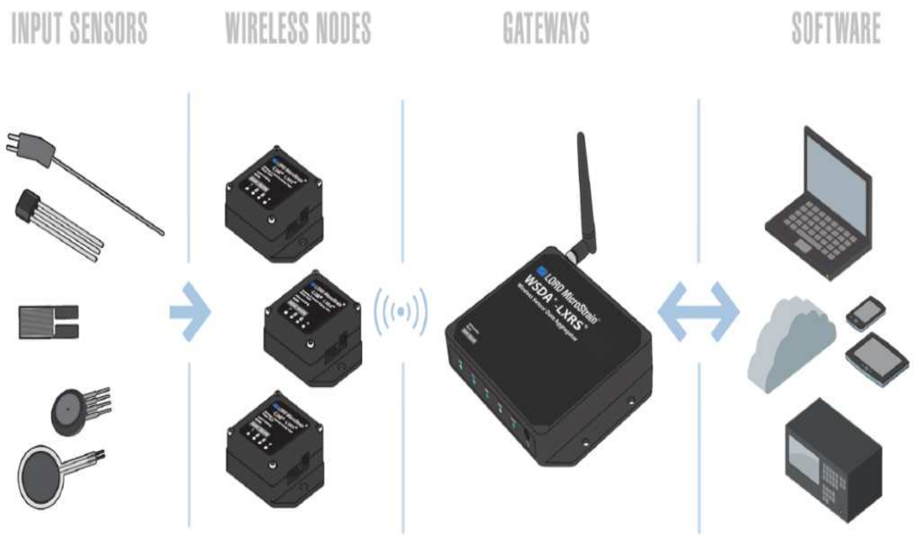
Optical methods provide **pinpoint precision** and **general overviews.**



Resulting digital 3D models may be used for detection of general structural malfunctioning, follow-up of uneven settlements, or as a graphic reference for geolocation of defects.

Bridging the data gap(II): old dogs and new tricks

Technological advances and falling prices in electronics give new strength to old methods

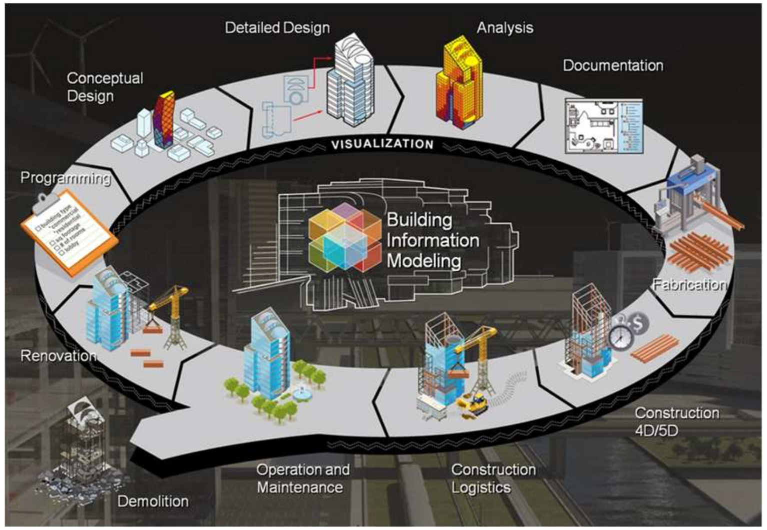


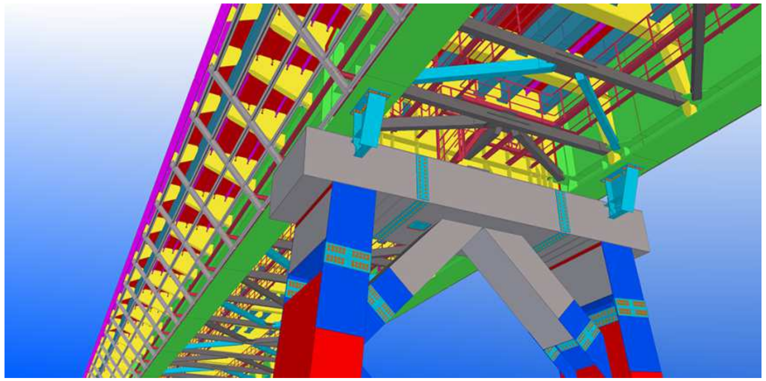
It is now affordable to monitor troublesome bridges on a continuous basis:

- Resilient, long-lived, low-consumption sensors
- Wireless data transmission negates need for cabling (work-intensive, fragile, exposed)
- Advanced batteries and energy harvesting concepts avoid need for continuous power supply
- Data may be gathered remotely via 3G/4G
- Big Data empowers management of continuous data streams

It’s not information if you can’t find it!

Digital twins of bridges & tunnels fit just right in overarching BIM-based asset management





By producing or taking advantage of existing digital twins of assets, new managing options, enhanced follow-up of inspections and better assessment is possible:

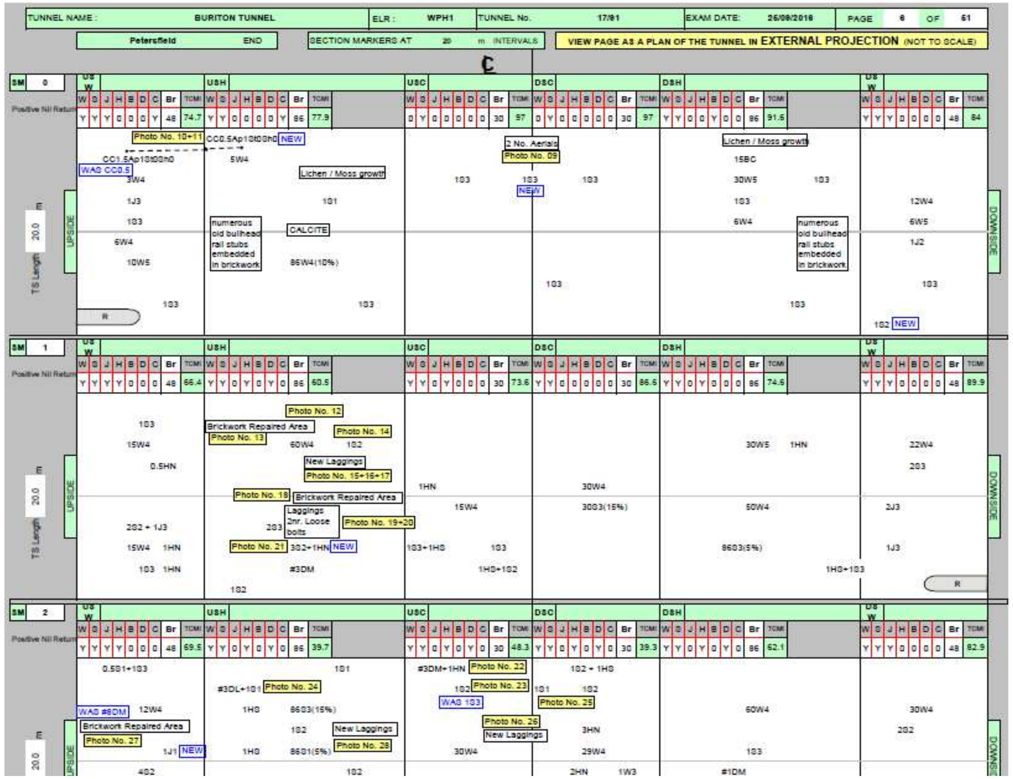
- ➢Defect catalogue may be geolocated within the asset 3D model, easening the location of previously detected problems in subsequent inspections
- ➢Historical information on damage, repairs and upgrades available in a single interconnected information nexus
- ➢Potential for trend detection and decision-support tools
- ➢Pushes information “up the ladder” to larger, less defined digital twin of track section, line, network, etc

So… Are they working? (I): full marks for digital TCMI

Tunnel Condition Marking Index takes a step forward into tunnel status objective assesment

NR's tunnel marking index strives to improve repeatability of assessments and avoid loss of knowledge when old inspectors retire:

- ➢Better directions for locating old defects
- ➢Scoring based on objective KPIs, algorithms and measurements
- ➢Collected data to be used for degradation prediction
- ➢Study of geotechnical, environmental and singular structure contributory factors.



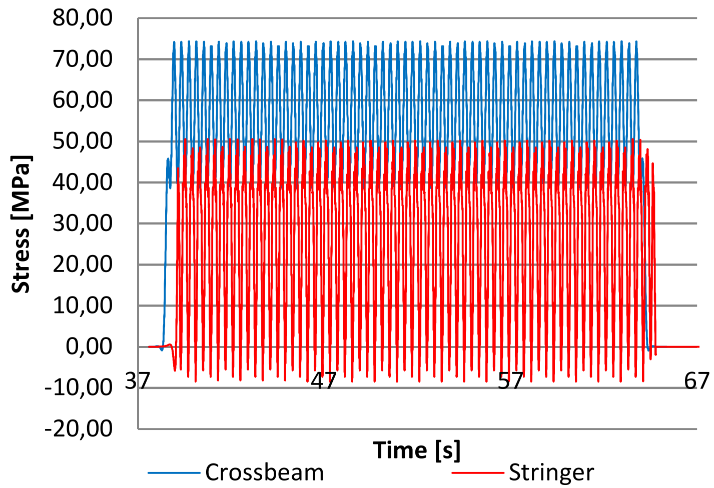
So… Are they working? (II): …and for how long?

Fatigue consumption follow-up technique enhances estimation of remaining life

Calculation and register of stress levels in sensible areas of steel bridges give a more precise insight on remaining fatigue capacity.

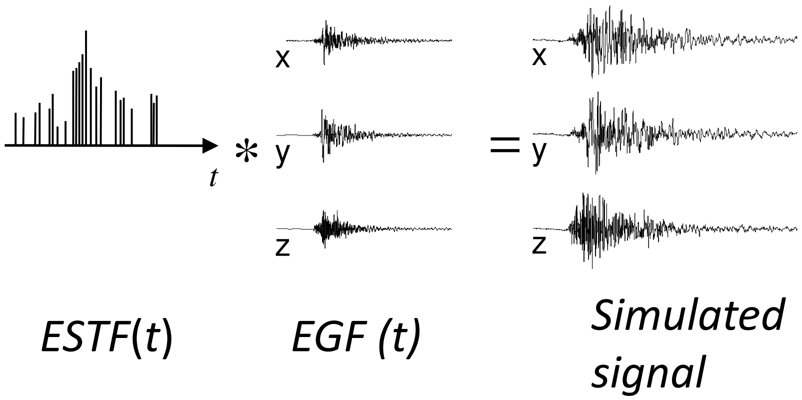
Thus, life of bridges may be extended without further investment and maintaining safety levels

- ➢Reduced sensoring to a few critical spots
- ➢Advanced FE modelling extrapolates stress in all critical areas
- ➢Traffic load data gathered from on-board systems provides input long after model calibration is over



So… Are they working? (III): Will they hold?

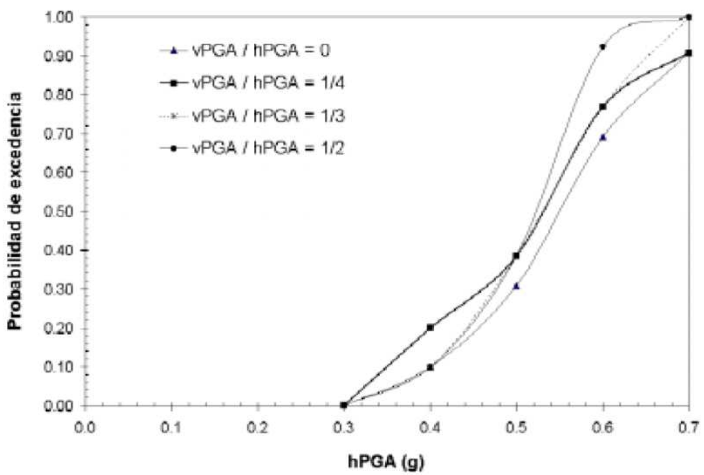
Advanced mathematical prediction of bridge behavior under future load/speed requirements



By applying a semi-empirical approach to bridge behavior simulation through Green's functions, this new technique avoids the need for complex numerical models.
Once calibrated, the representation of the bridge allows for accurate prediction of behavior under different train loads

Through the decomposition of critical failure modes on the different bridge components and the construction of fragility curves, a better assesment of the current state of bridges is achieved.

Semi-empirical update of critical parameters allows assessment of future behavior and reaction to increased speeds/loads/etc



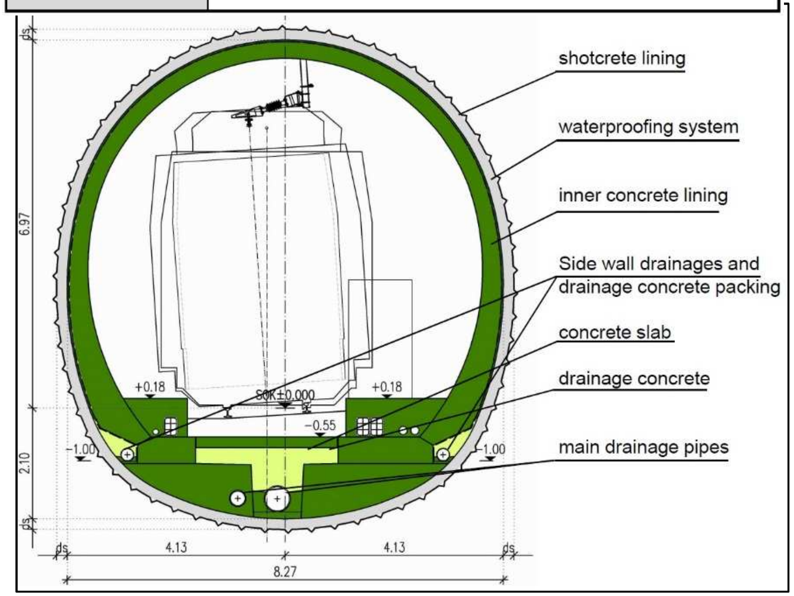
And what if they're not? (I): Cleaning the pipes

Study on calcite precipitation strives to prevent/mitigate/repair drainage pipe blockages

Bezeichnung	Eintrag	Schachtfoto
Blocknummer	*68*	
Drainage	*Ulmendrainage Gleis 1*	
Jahr der letzten Spülung	-	
Probenentnahme	*Wasser- und Feststoffprobe*	
Datum	*21.11.2016*	
Uhrzeit	*09:13*	
Rohrdurchmesser	*DN/ID250*	
Wassertemperatur [° C]	*9,6*	
Elektr. Leitfähigkeit [µS/cm]	*573*	
pH-Wert [-]	*8,35*	
Abstichmaß Wassertiefe im Rohr	*5,5 cm*	
Versinterung im Rohr	*ja*	
Versinterung im Schacht	*ja*	
Mächtigkeit Versinterung	*bis 3,0 cm*	
Zustand Versinterung	*hart*	Foto: Draufsicht Schacht (Fließrichtung von rechts nach links)
Anmerkungen	Fließgeschwindigkeit ca. 0,13 m/s	

Calcite precipitation causes major havoc in drained tunnels, to the point where drainage pipe maintenance is **close to continuous!**

By studying the way in which deposits form, novel, effective ways to **prevent precipitation**, new material applications to **weaken pipe-deposit interface** and **remote, automatized drainage maintenance devices** are being developed



And what if they're not? (II): Print me a spare

New ideas for masonry tunnel repair range from the radically new to revamping the old

Falling masonry is no small issue in many of the old UK railway tunnels.

Deterioration is often not apparent at surface level, and once it is, significant areas of the innermost masonry vault may collapse

Different approaches are under study:

- 3D laser scanning provides accurate geometry of missing elements, while 3D printing provides exactly de required spare part made in alternative materials, and robotic positioning avoids the need for workers in the tunnel
- Single line working train provides protection for workers while allowing operation on the adjacent track
- Enlargement/relining machine provides bigger, better and brand new tunnel lining and cross section

And what if they're not? (II): A stitch and a patch

Using FRP reinforcements to enhance shear and fatigue capacity of railway bridges

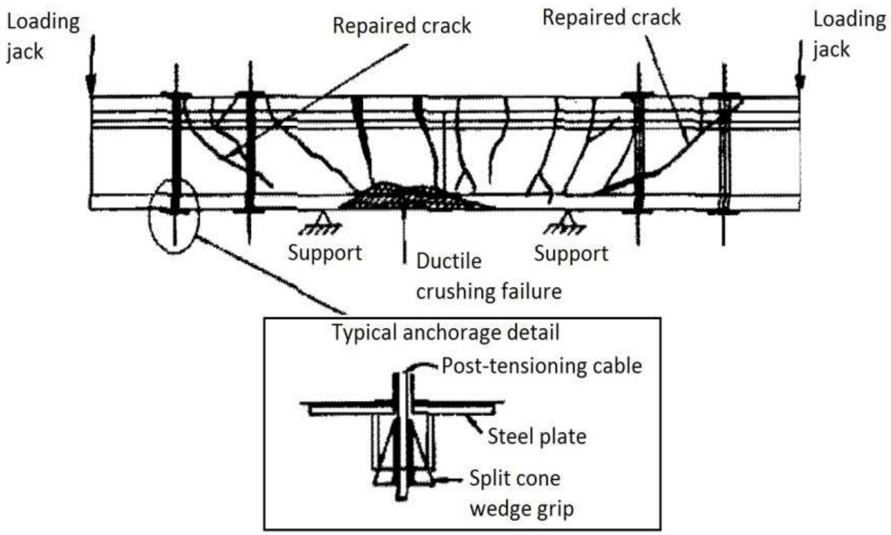
Connections in steel bridges are prone to crack under repeated submaximum stresses.

Fatigue-induced cracks then suffer a high concentration of stresses in a vicious cycle that ends on bridge failure

Fiber-reinforced polymers, with their inherent resistance to fatigue, represent a promising solution

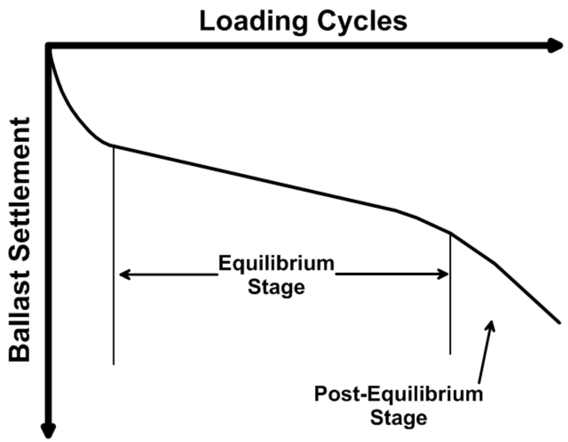
Concrete girders, on the other hand, may suffer from shear problems that their cross-section typology makes difficult to repair

Once again, the flexibility of FRP allows for the development of alternate means to enhance the capacity of these concrete bridges



And what if they're not? (III): why the sudden change?

Understanding the process of transition zone degradation to enhance malfunction diagnostics



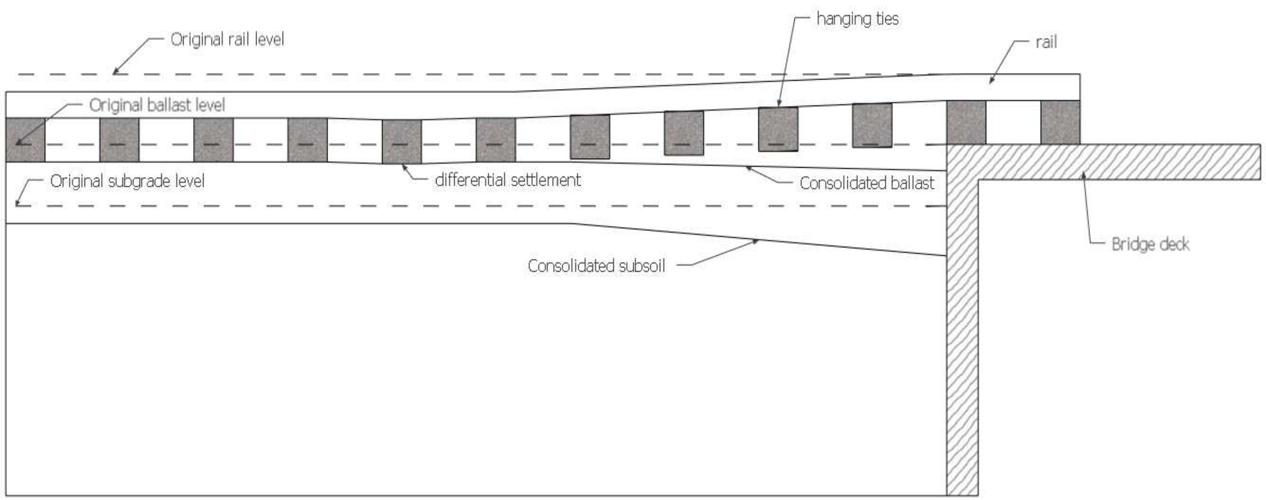
Transitions are a headache more often than not

But **why** does a reasonably functioning transition **suddenly degrade?**

And **why**, once it does, **will it keep on failing** and requiring maintenance more and more often?

By expanding our knowledge of transition zone degradation factors and telltale signals, we shall be able to:

- Design better, more reliable transitions
- Identify what's wrong in a faulty transition zone
- Provide effective remediation



A new wave in bridge design: shaking the house down

Empirical exploration of bridge dynamics evolves current high-speed bridge design regulations

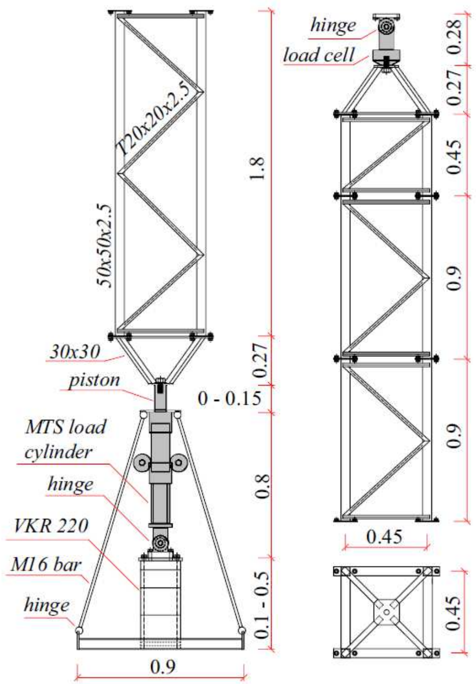
Response of railway bridges to passing trains depends on their dynamic properties: frequencies, damping ratios, etc

BUT, also dynamic soil-structure interaction, boundary conditions and amplitude dependencies.

To understand the real behaviour of bridges, full-scale testing using controlled excitation by a load shaker is necessary.

By recovering valuable data on real dynamic behavior of bridges, more accurate assessment of structural needs for high-speed bridges shall be obtained…

…a crucial input for **future bridge design regulation** with great potential to **reduce costs**



Many thanks for your kind attention!

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