Shift2Rail

IN2TRACK

WP2: Enhanced Switches & Crossings

GA H2020 - 730841

Shift2Rail

IN2TRACK

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

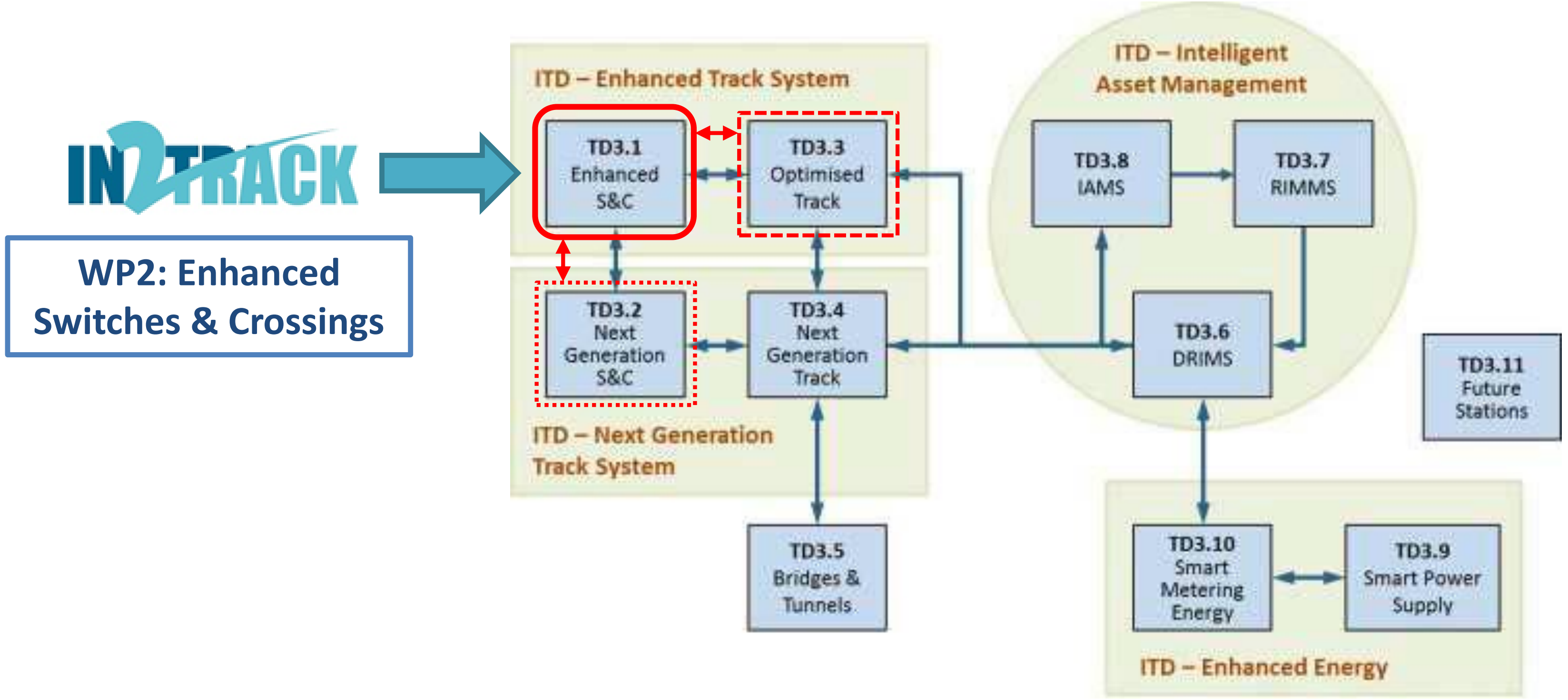
University of HUDDERSFIELD Institute of Railway Research

UNIVERSITY OF BIRMINGHAM

Cranfield University

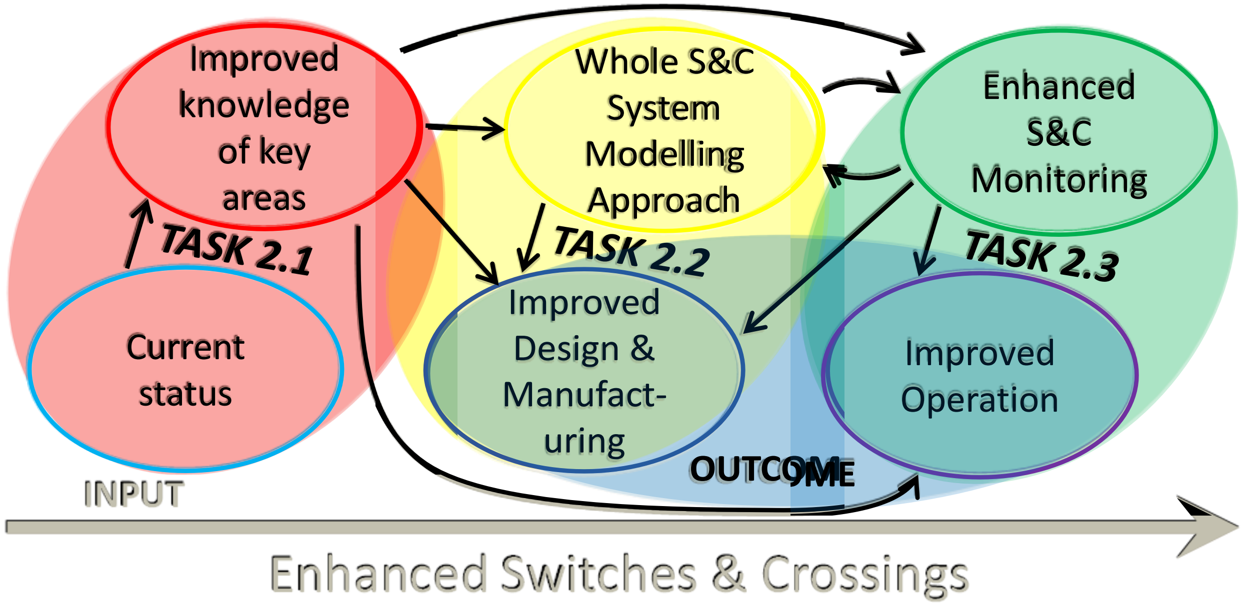
WP2 Objectives

- TD3.1 ‘Enhanced Switch & Crossing System’
- 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



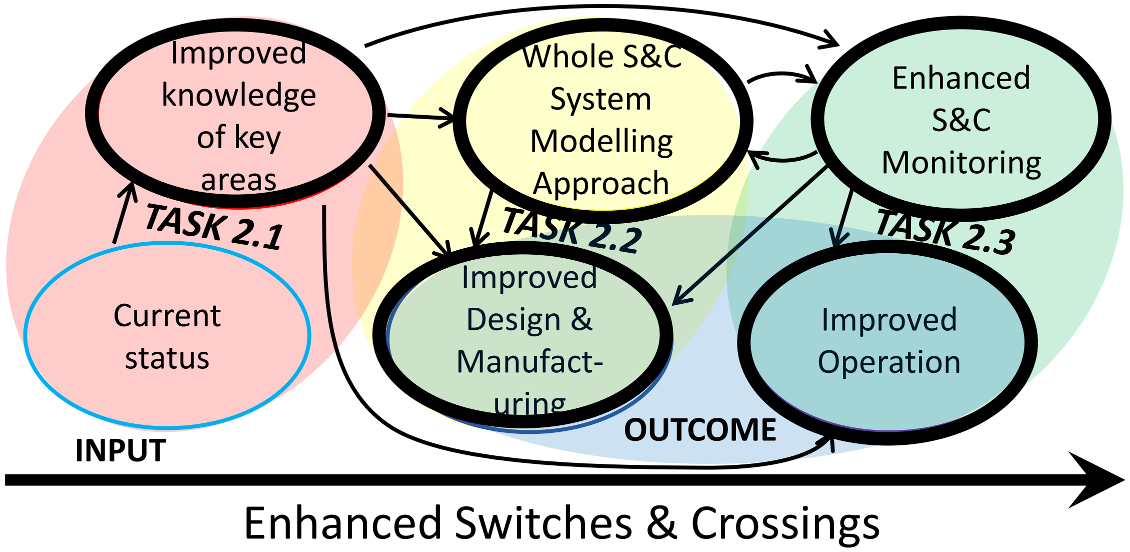
WP2 Focus

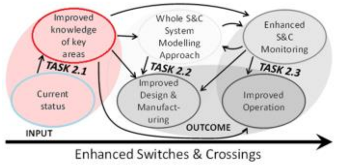
- Task 2.1: Identifying and understanding core S&C issues [TRL 6]
- Task 2.2: Enhanced S&C whole system analysis, design and virtual validation [TRL 5]
- Task 2.3: Enhanced monitoring, operation, control and maintenance of S&C [TRL 4]



WP2: Key Areas of Research

- Improved knowledge of key areas
- Whole system modelling approach
- Improved design and manufacturing
- Enhanced operational abilities





Improved Knowledge of Key Areas (D2.1)

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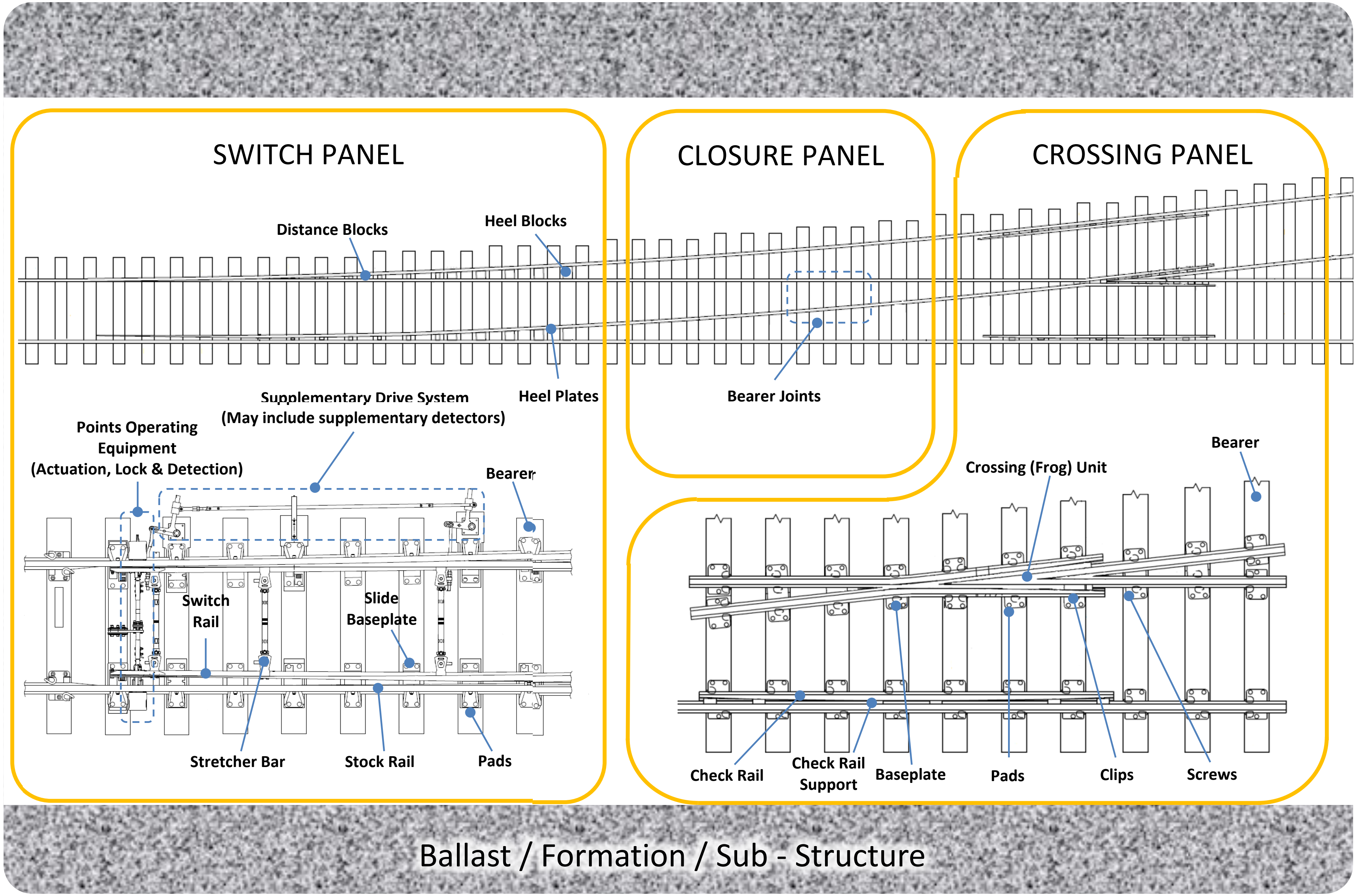
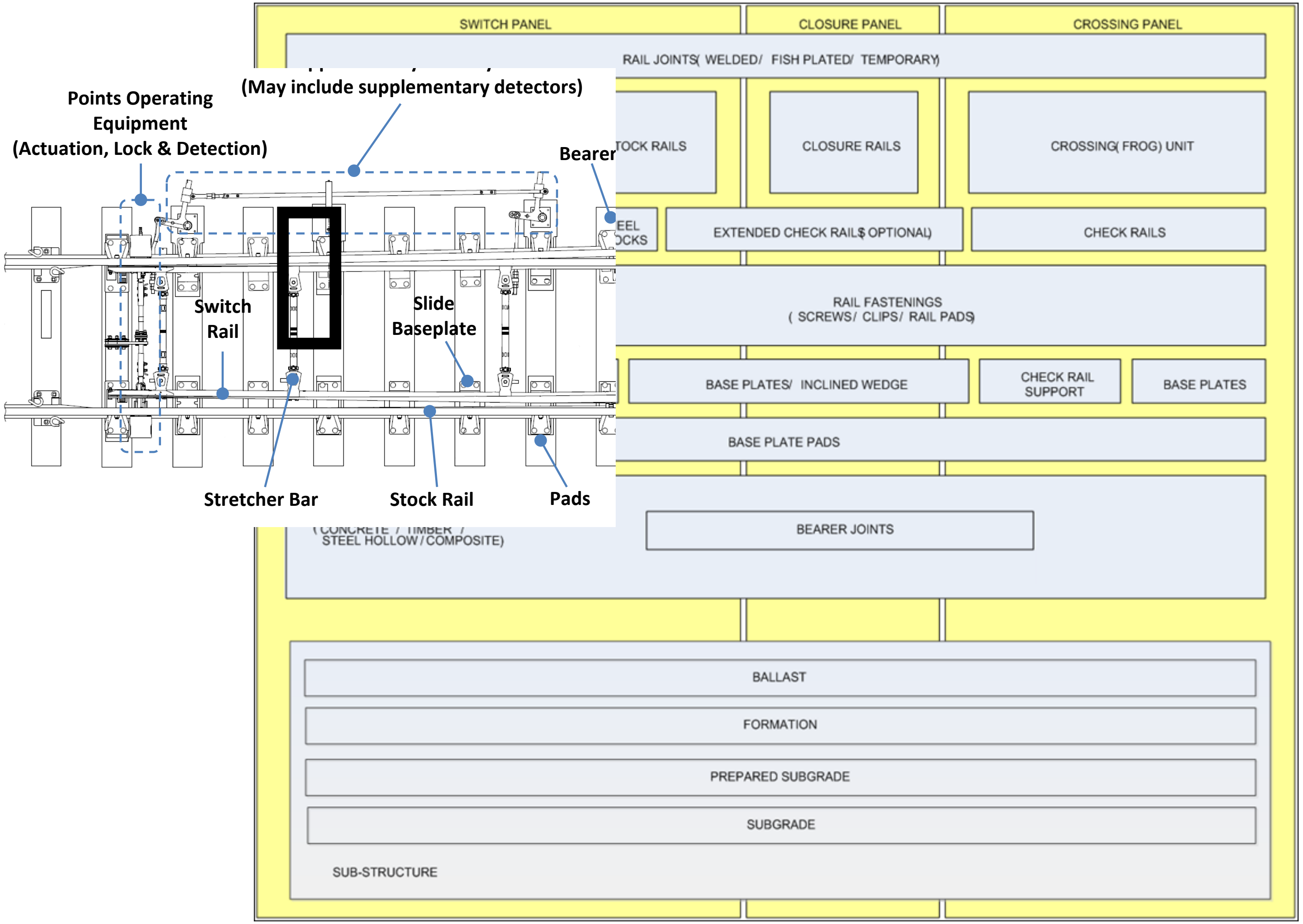
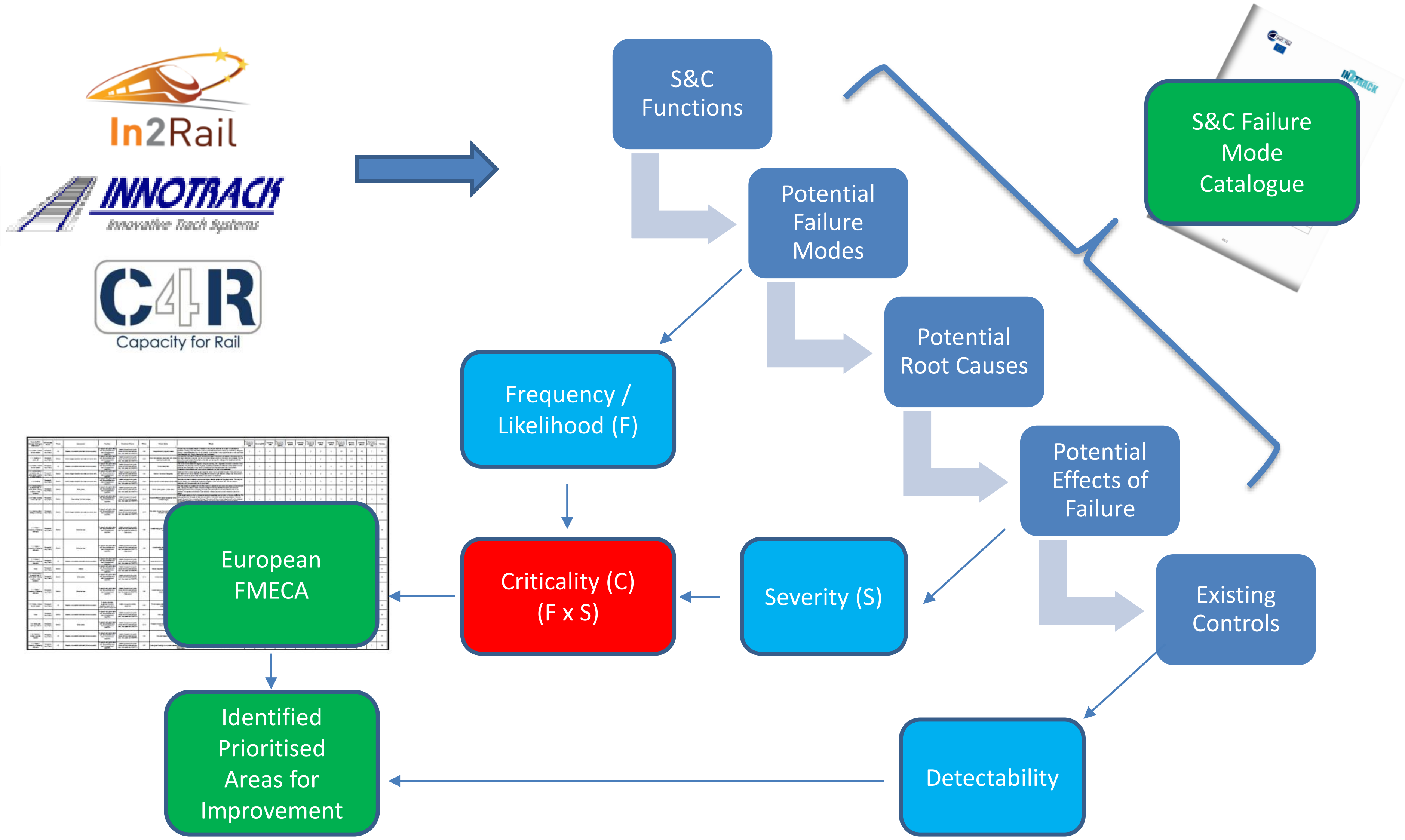
Improved Knowledge of Key Areas



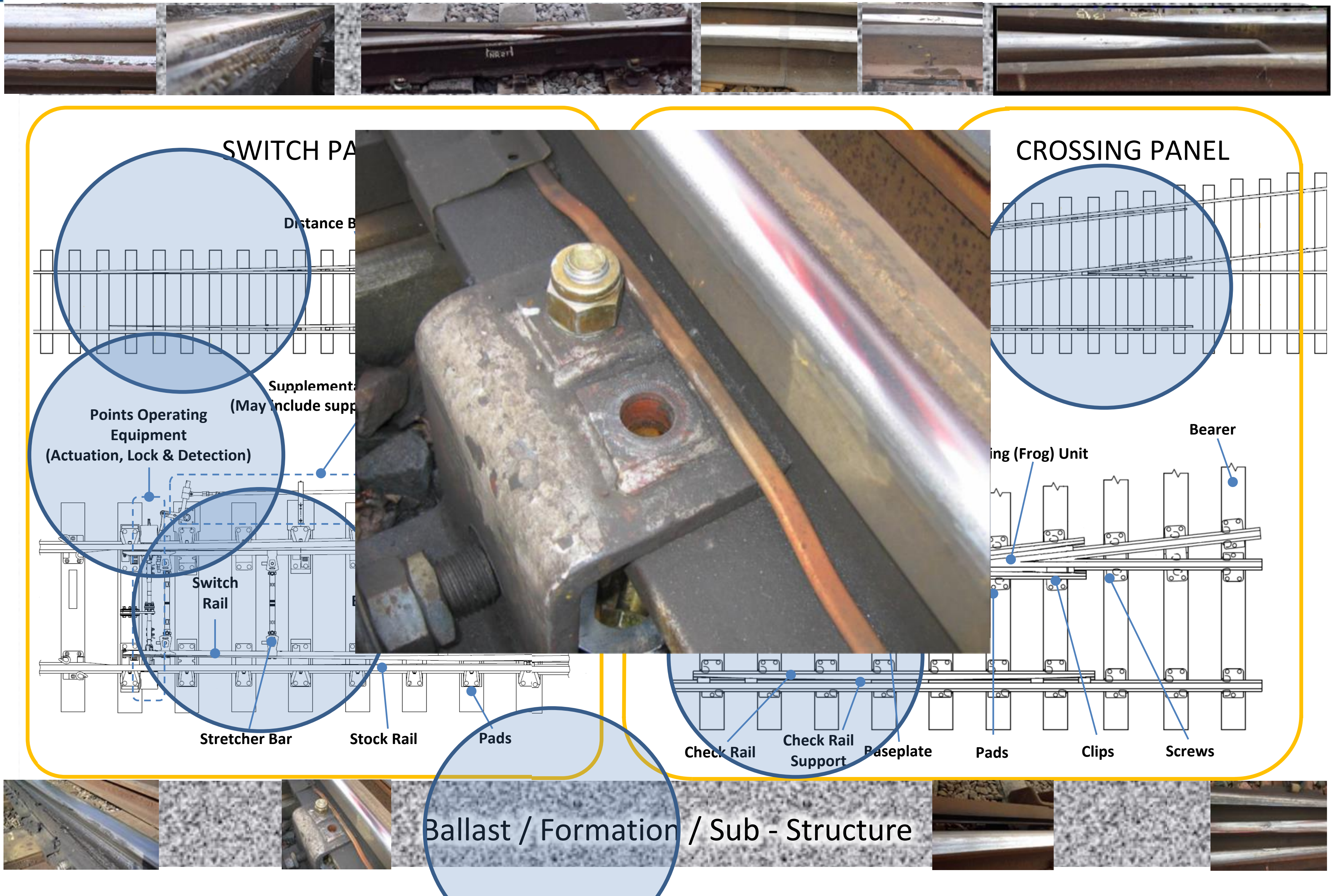
FMEA Scope


SWITCH PANEL
CLOSURE PANEL
CROSSING PANEL
RAIL JOINTS(WELDED/ FISH PLATED/ TEMPORARY)
(May include supplementary detectors)
Points Operating Equipment
(Actuation, Lock & Detection)
Bearer
CLOSURE RAILS
CROSSING(FROG) UNIT
EXTENDED CHECK RAILS(OPTIONAL)
CHECK RAILS
Switch Rail
Slide Baseplate
RAIL FASTENINGS
(SCREWS/ CLIPS/ RAIL PADS)
BASE PLATES/ INCLINED WEDGE
CHECK RAIL SUPPORT
BASE PLATES
BASE PLATE PADS
Stretcher Bar
Stock Rail
Pads
STEEL HOLLOW / COMPOSITE)
BEARER JOINTS
BALLAST
FORMATION
PREPARED SUBGRADE
SUBGRADE
SUB-STRUCTURE

Failure Mode Prioritisation Process

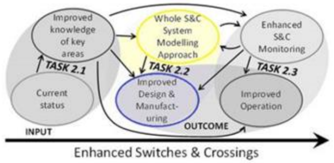


Prioritised Areas for Research



Focus of WP2 Research

- elimination of failures relating to rail deformation, fatigue, wear and Rolling Contact Fatigue, including monitoring and assessment of the switch rail profile
- optimised support stiffness / track elasticity
- monitoring and self-adjusting capability



Whole S&C System Modelling (D2.2)

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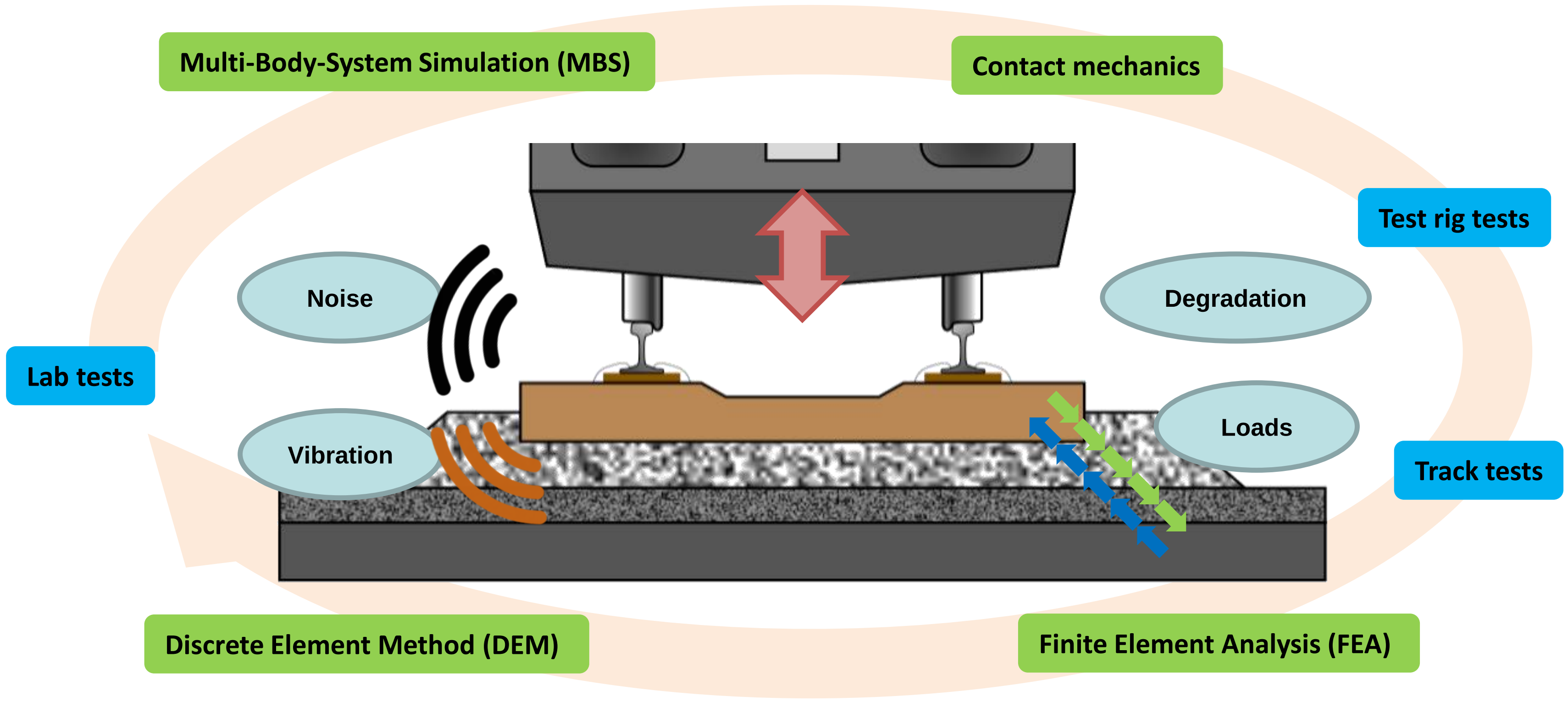
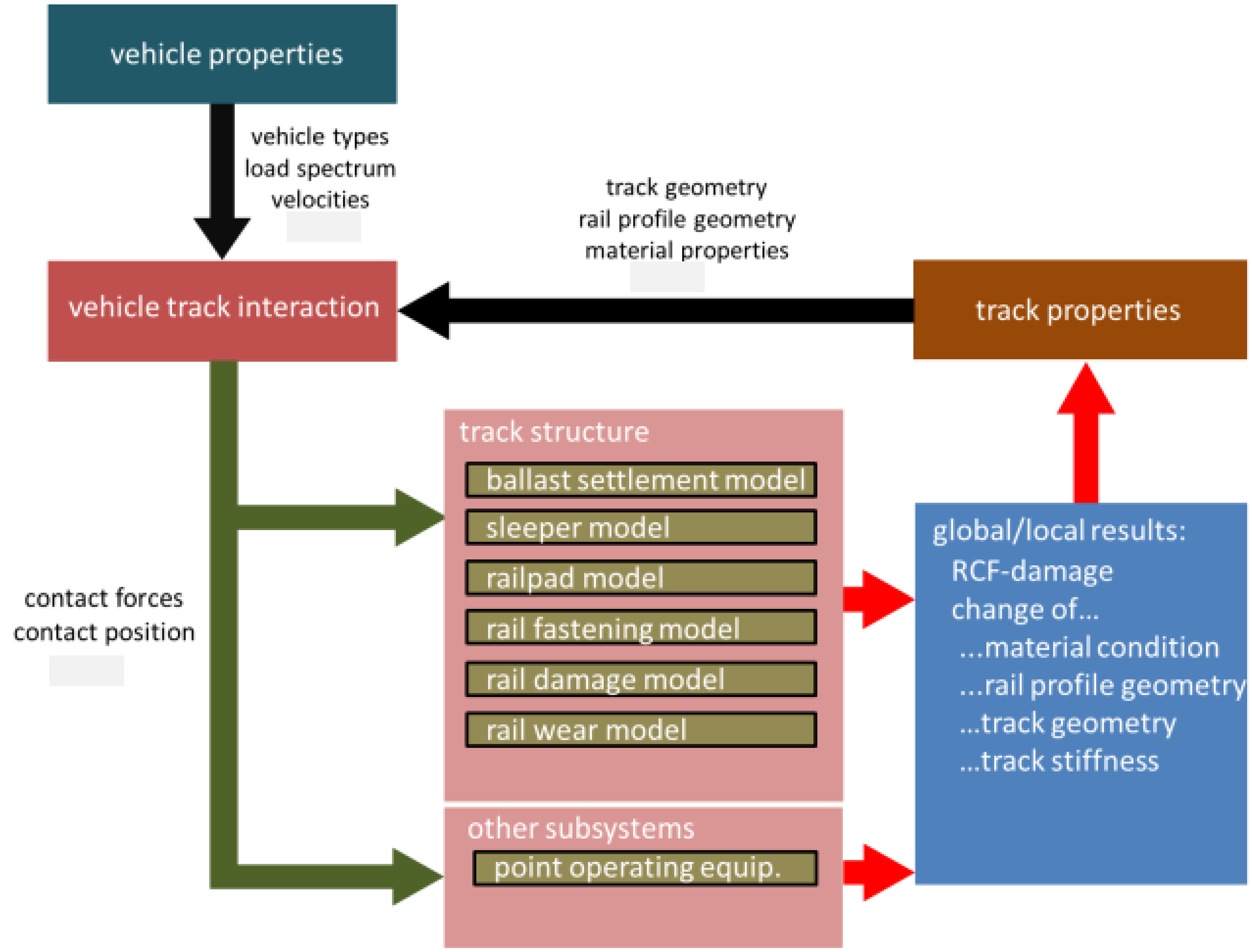
S&C Whole System Modelling

Integrated **whole track system model** approach for design, optimization and certification / authorization of track concepts and components

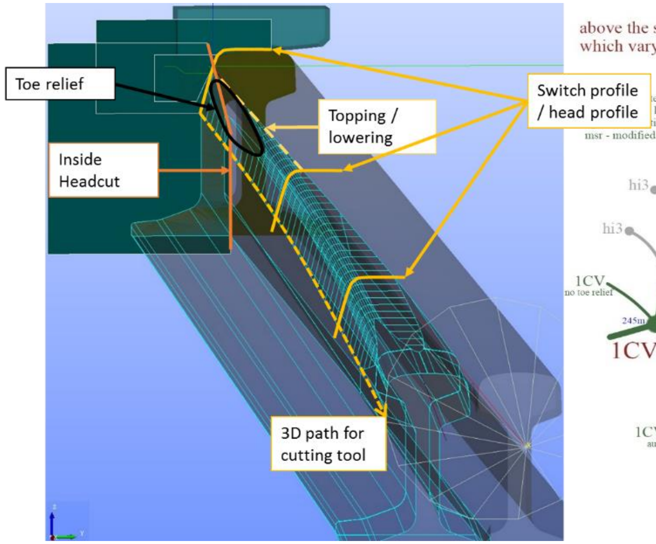


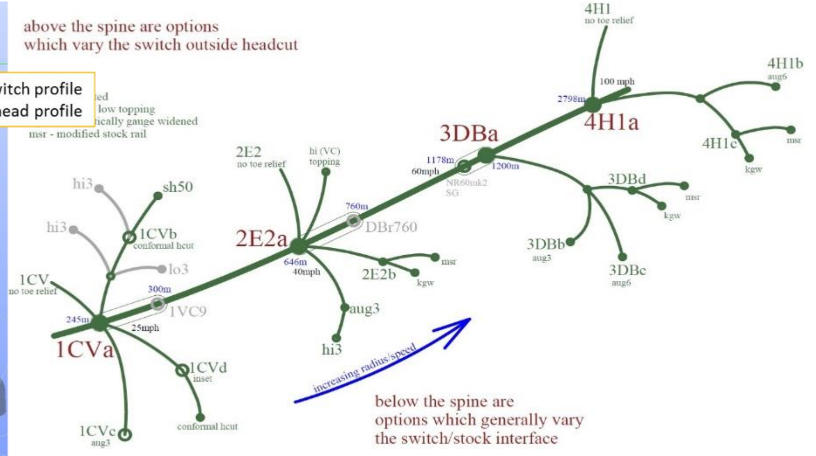
S&C Whole System Modelling



Switch Performance

- *Scientific assessment of the performance of four switch families*
- *Identification of switch-stock interface design effects*
- *Proposal for a design methodology*





	#	Designation	Geometry	size (m)	SumY	Y/Q	Acc	Accrms	Jerk	Tg	Fi-surf	$B_{dyn}max$	Total Score
Weighting assessment values =>					15%	0%	10%	10%	15%	20%	15%	15%	check:100%
	1	1CVa	intersecting/secant	245	0.65	0.41	0.47	0.66	0.63	1.00	0.90	0.92	0.78
	5	1CVb-cf	intersecting/secant	245	0.70	0.33	0.48	0.78	0.72	0.88	0.51	1.00	0.74
	8	1CVc-cfaug3	intersecting/secant	245	0.70	0.33	0.48	0.78	0.72	0.88	0.51	1.00	0.74
	9	1CVd-in	intersecting/secant	245	0.60	0.41	0.38	0.59	0.47	0.80	1.00	0.89	0.70
	10	1CVd-incf	intersecting/secant	245	0.62	0.21	0.43	0.70	0.57	0.61	0.34	0.95	0.61
	13	2E2a	intersecting/secant	646	0.61	0.31	0.43	0.60	0.68	0.28	0.23	0.89	0.52
	16	2E2a-vc1in3	intersecting/secant	646	0.46	0.23	0.32	0.47	0.54	0.16	0.13	0.83	0.41
	17	2E2b-kgw	intersecting/secant	646	0.54	0.27	0.42	0.58	0.43	0.24	0.20	0.89	0.46
	20	3DBa	tangential	1200	0.94	0.88	0.76	0.95	0.77	0.66	0.57	0.87	0.78
	21	3DBb-aug3	tangential	1200	0.94	0.88	0.76	0.95	0.78	0.66	0.57	0.87	0.78
	22	3DBc-aug6	tangential	1200	0.94	0.88	0.76	0.95	0.78	0.66	0.57	0.87	0.78
	23	3DBd-kgw	tangential	1200	0.87	0.78	0.75	0.86	1.00	0.62	0.54	0.87	0.78
	26	4H1a	non-intersecting/cloth	2798	0.87	0.93	0.79	0.83	0.72	0.44	0.29	0.83	0.66
	28	4H1b-aug6	non-intersecting/cloth	2798	0.87	0.93	0.79	0.83	0.72	0.44	0.29	0.83	0.66
	29	4H1c-kgw	non-intersecting/cloth	2798	1.00	1.00	1.00	1.00	1.00	0.59	0.44	0.85	0.81

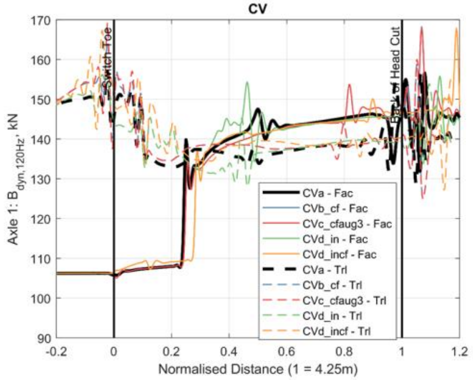
	St. Deviation =	1
weighting	direction | Through =	100%
	direction | Diverging =	0%
	direction | Facing =	100%
	direction | Trailing =	0%

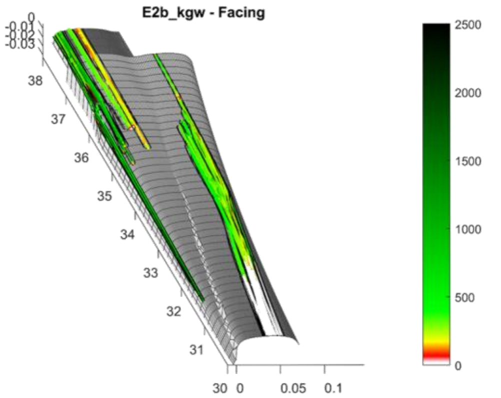
weighting used per category:

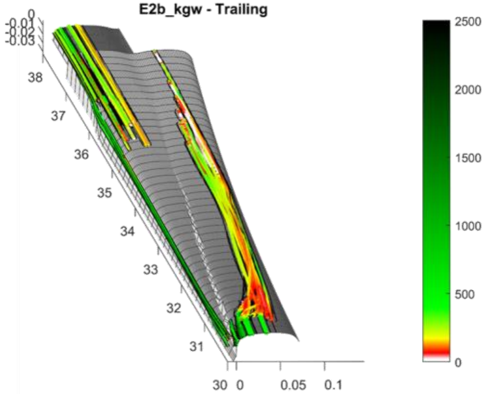
Track forces = 30%
Safety = 0%
Passenger comfort = 35%
Rail Damage = 35%

Scenario 1:

Equal spread across three category with exclusion of safety (as through route only and not foressen WRI issue in new design).
Switch only used in THROUGH FACING direction

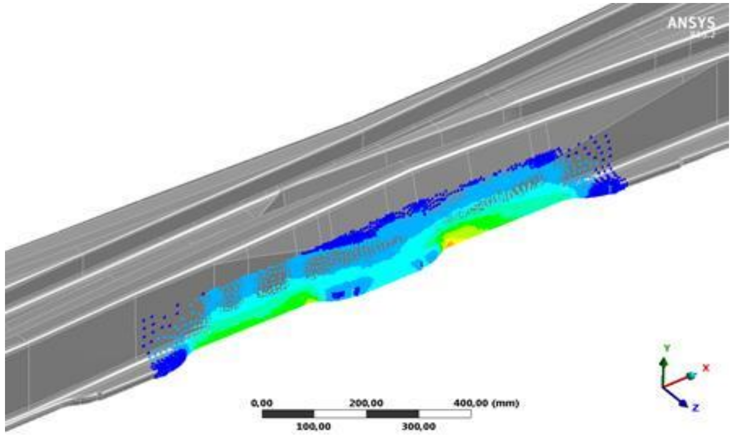




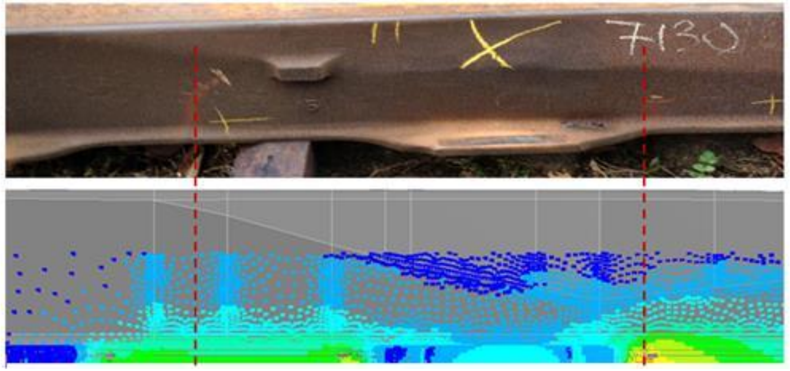


Crossing Fatigue Evaluation

- *3D numerical protocol to evaluate crossing fatigue perfomance*
- *Protocol validated by field measurements*



Fatigue calculation results

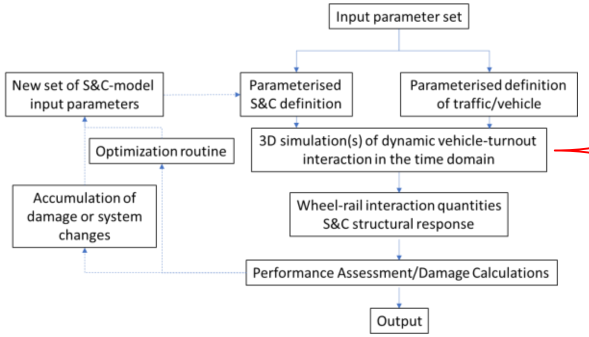


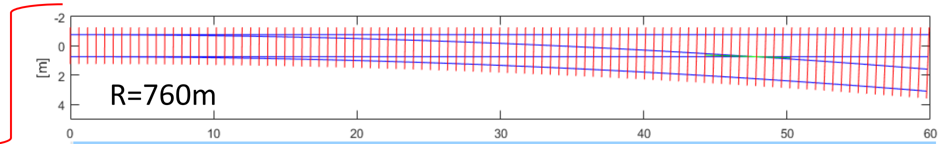
Fatigue calculation results
vs cracked crossing

Whole System Modelling Developments

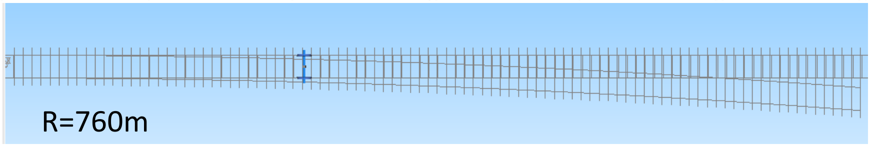
- *Simulation of accumulated plastic rail damage for longer periods of traffic*
- *Greater flexibility in S&C assessment via a script that can generate turnout simulation models for a wide range of configurations and designs*

Whole system modelling scheme

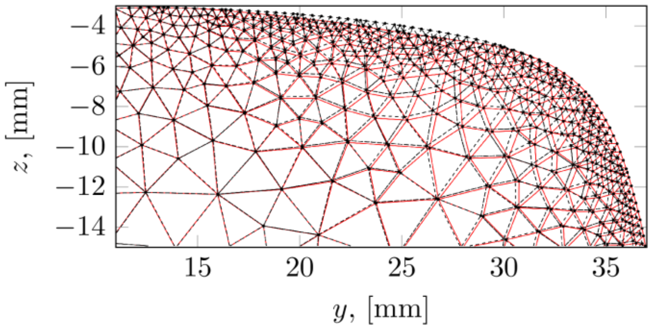




Parameterised track layout in Matlab



Parameterised flexible turnout structure in MBS code SIMPACK

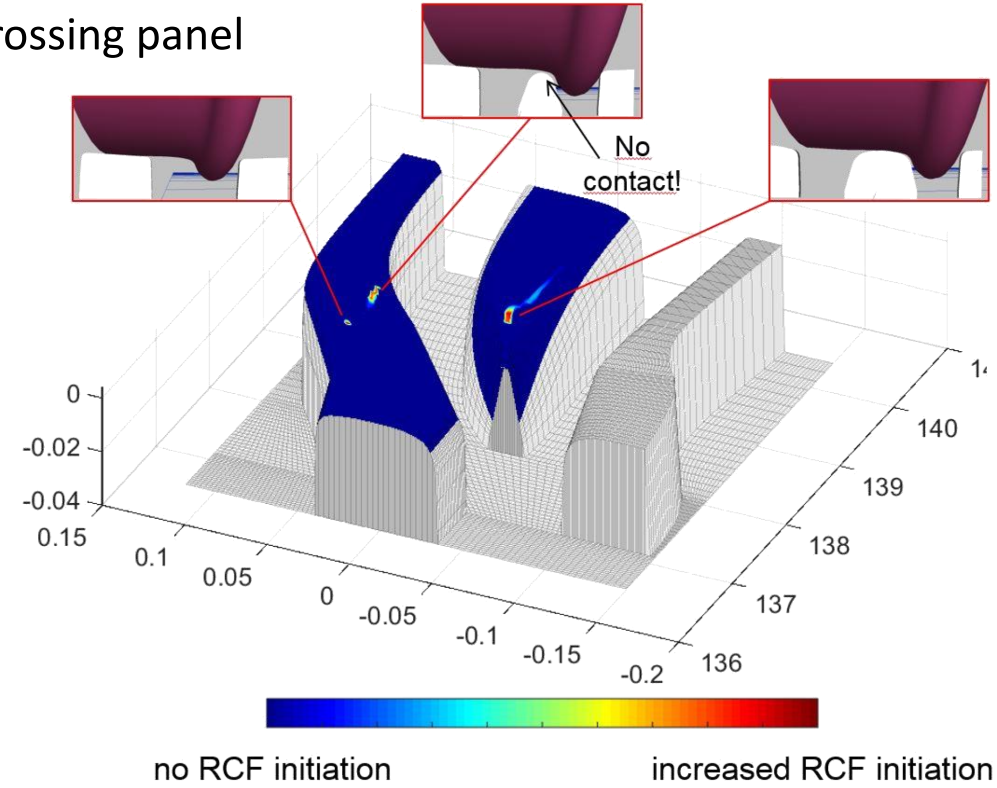


Simulated plastic deformation for a crossing nose section after 150 load sequences corresponding to an accumulated load of 0.8 MGT. The material is R350HT.

S&C Whole System Model Approach Applied to RCF Damage Assessment

- *"S&C whole system model" approach for RCF damage in crossing panel, combining MBS and "wedge" model*
- *Results showing the applicability of the "whole system model" approach and the feasibility of the applied RCF damage assessment with the "wedge" model*

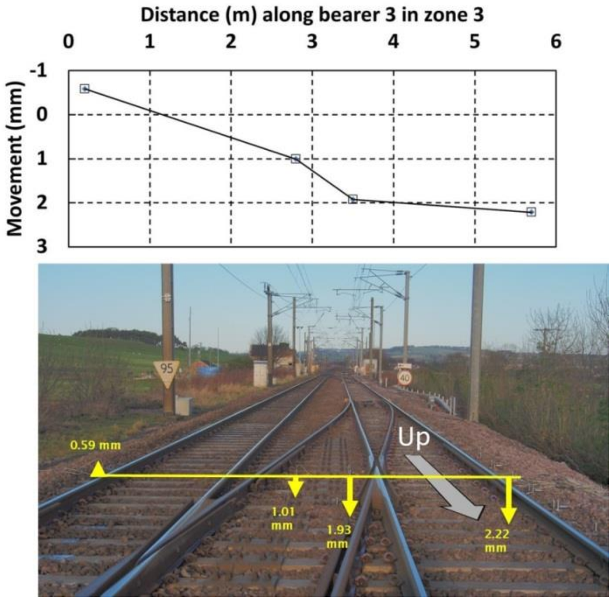
RCF damage distribution in crossing panel



Accumulated normalised RCF damage distribution calculated with the "wedge" model at the crossing panel with the views of the wheel position derived from the SIMPACK simulation

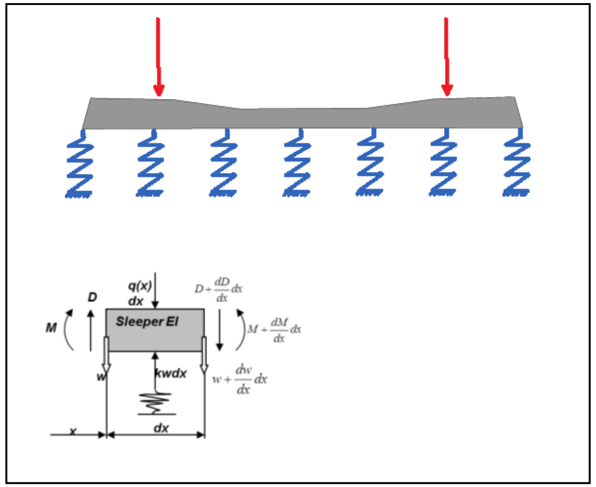
S&C Substructure Interaction

- *Review of S&C substructure interaction carried out and testing to investigate the performance of different S&C jointed bearer designs*
- *A numerical tool has been modified and used to simulate bearer/substructure interaction*



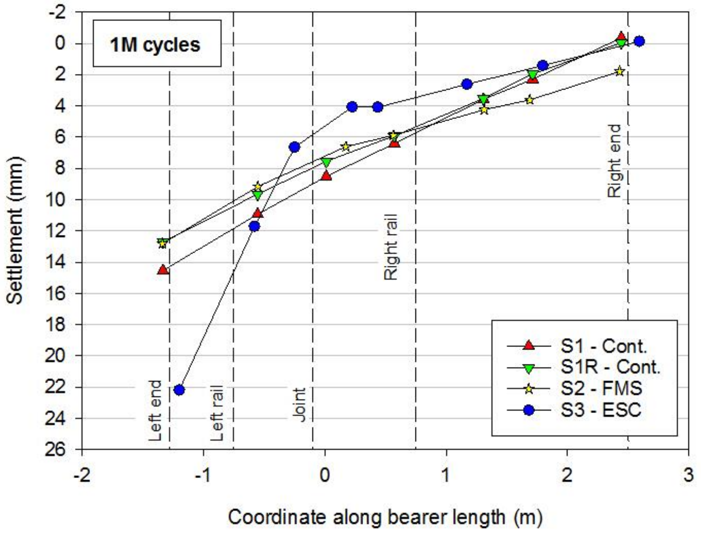
1. Field measurements from the literature show the asymmetric behaviour of long S&C bearers

2. A testing apparatus has been modified for long bearer testing

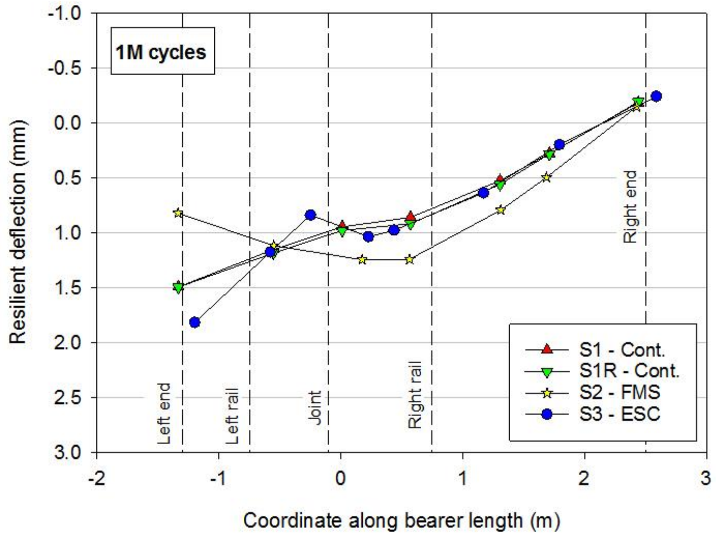


3. An existing numerical tool has been used to simulate different bearer properties and their influence on substructure interaction under idealised conditions

S&C Substructure Interaction

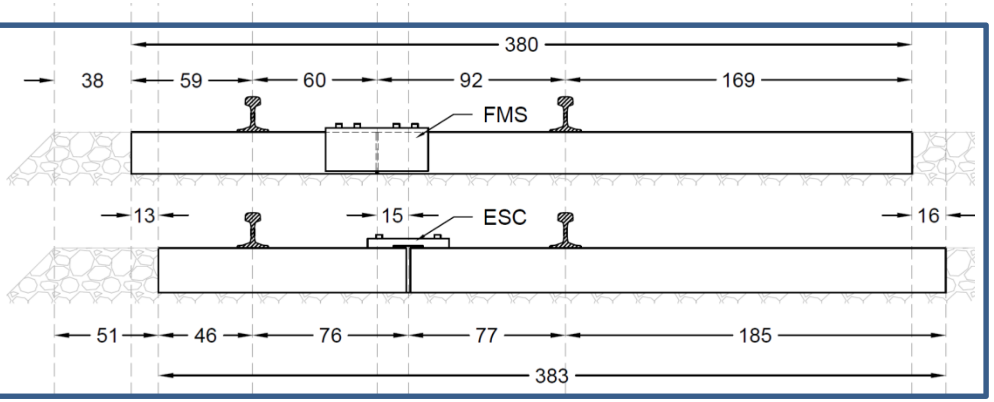


Distribution of permanent deflections along bearer length at 1M load cycles



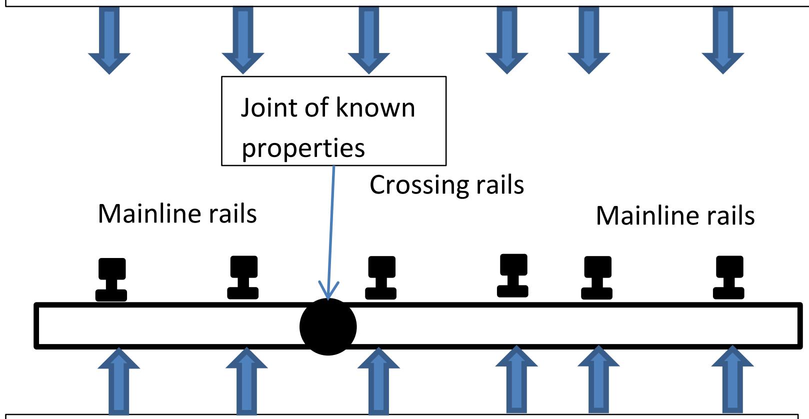
Distribution of resilient deflections along bearer length at 1 M load cycles

General testing arrangement:
(on 300 mm bed of ballast, loads applied as 20 Tonne equivalent axle load evenly distributed onto the rails)



S&C Bearer Modelling Requirements

Wheel/rail loading. Rails and fastenings of known properties and locations

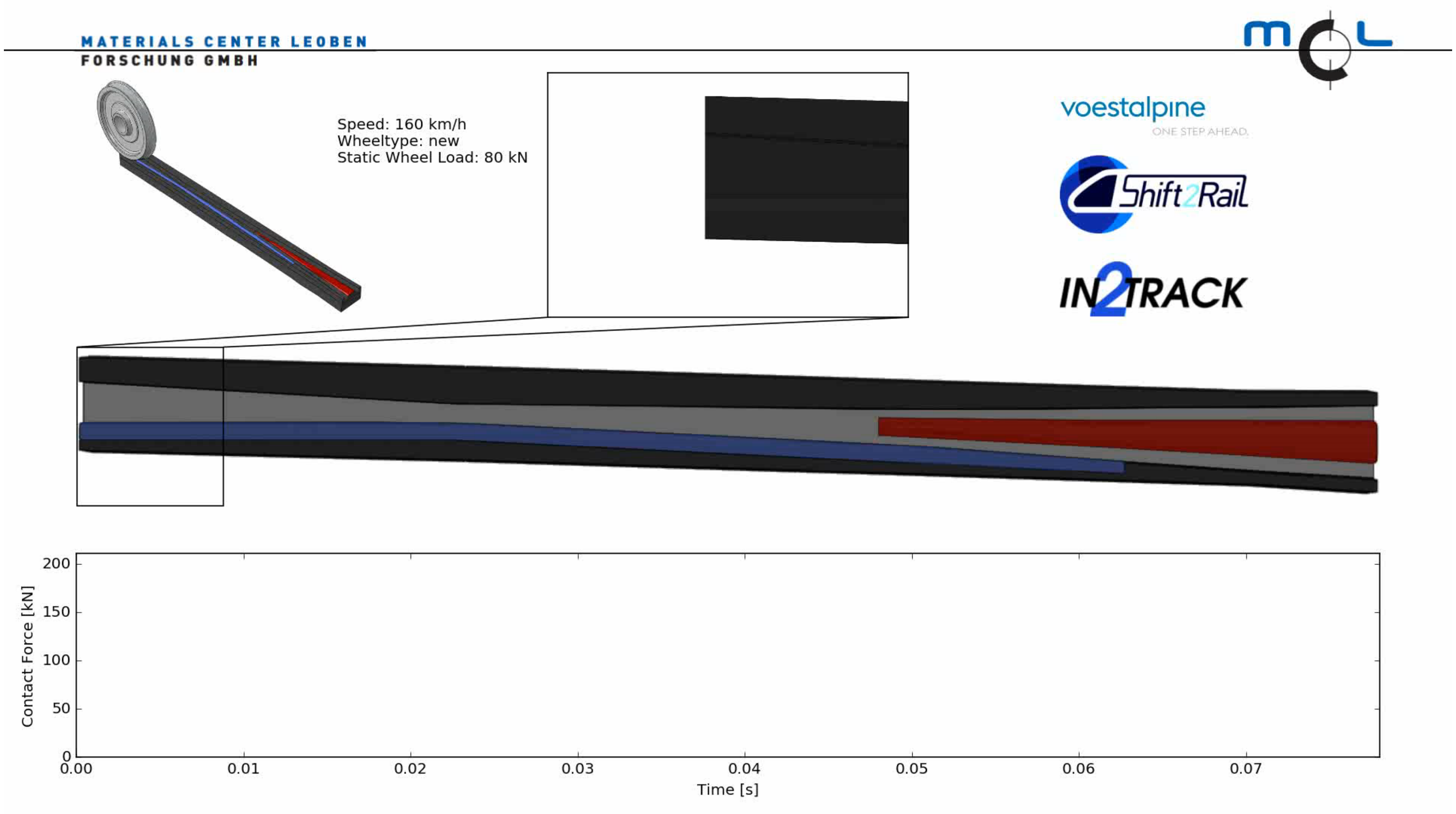


Long bearer of known properties modelled to determine load transfer as function of location along bearer

Response of Substructure (ballast and subgrade) modelled at least below railseats:

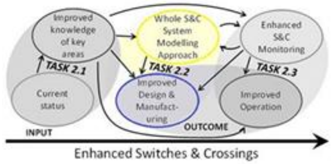
- Load and/or strain dependent accumulation of plastic settlement
- Cycle dependent (taking account of loading history) cyclic plastic settlement increments
- Load dependent resilient (recoverable) response
- Cycle dependent (taking account of loading history) cyclic resilient response

Example: Wheel Passing Over Turnout Common Crossing



Shift2Rail

IN2TRACK



Enhanced Design, Manufacturing and Materials (D2.2)

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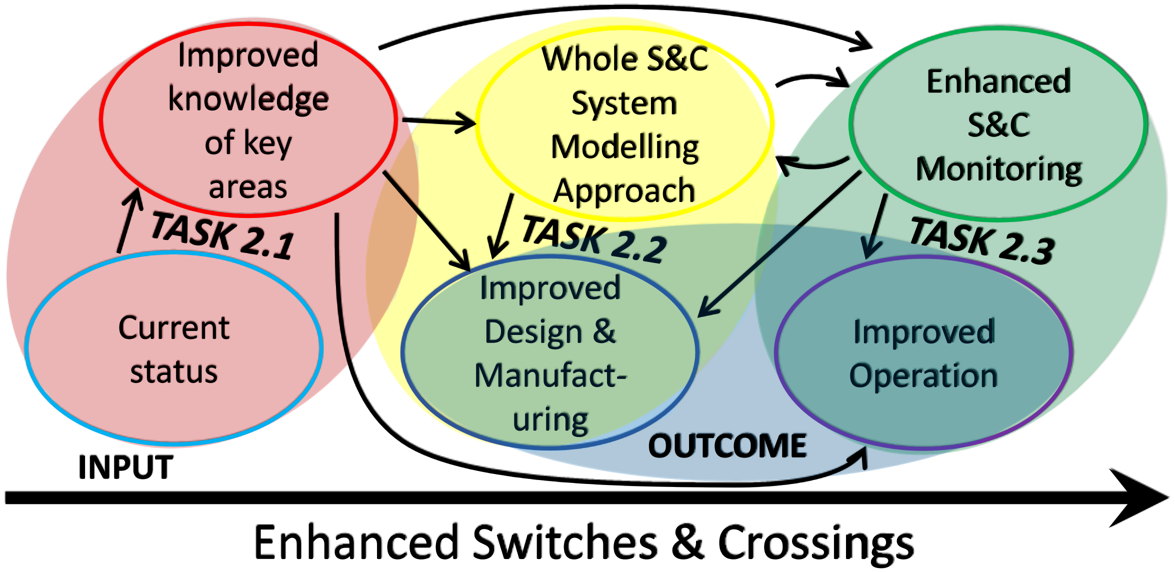
Enhanced Design, Manufacturing and Materials

Key outcomes

- High-grade rail steels
- Modular Continuous Support for S&C
- Additive manufacturing techniques



Enhanced Design:
Steel Grades Used in Turnouts

State-of-the-art steels for turnouts
Testing of enhanced steels for the crossing panel and the switch blade
Specifying optimum material characteristics, negating existing manufacturing constraints

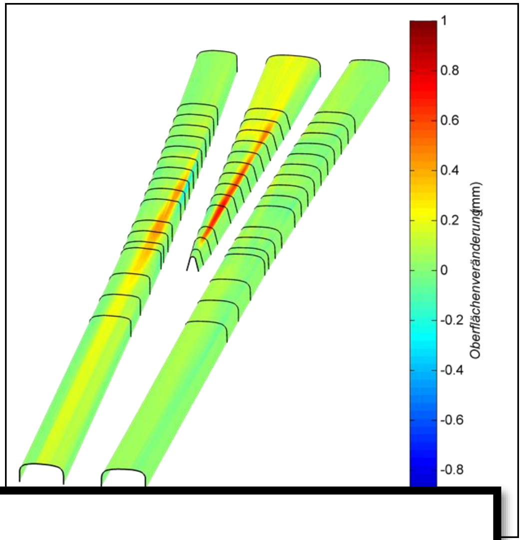
Existing standard rail steels

R260/R350HT

New, high-performance steels

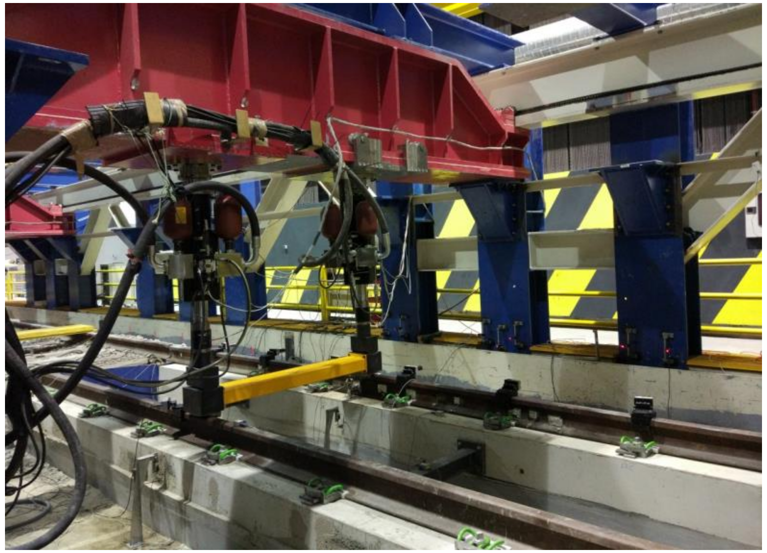
R400HT | **HP335** | **B360**

R400HT wing rails with minimal wear and no fatigue damage (31.6MGT)

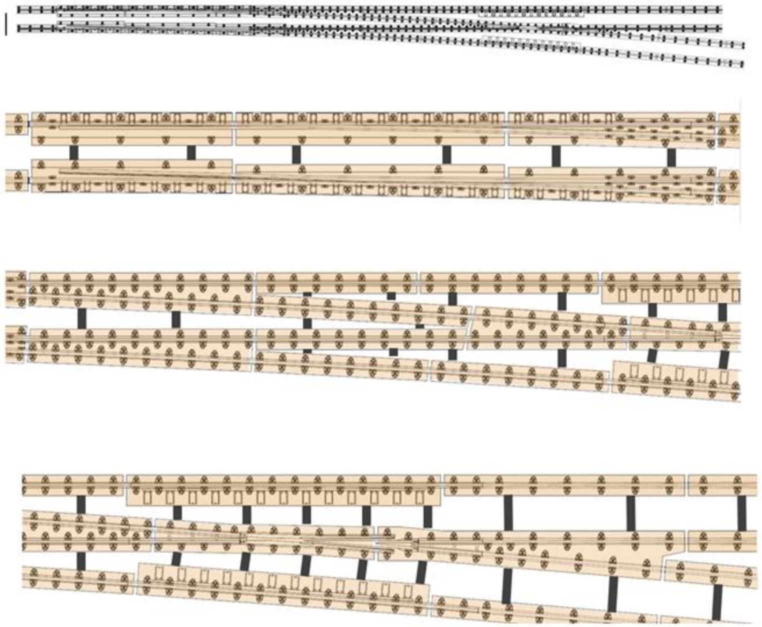


Modular Continuous Support

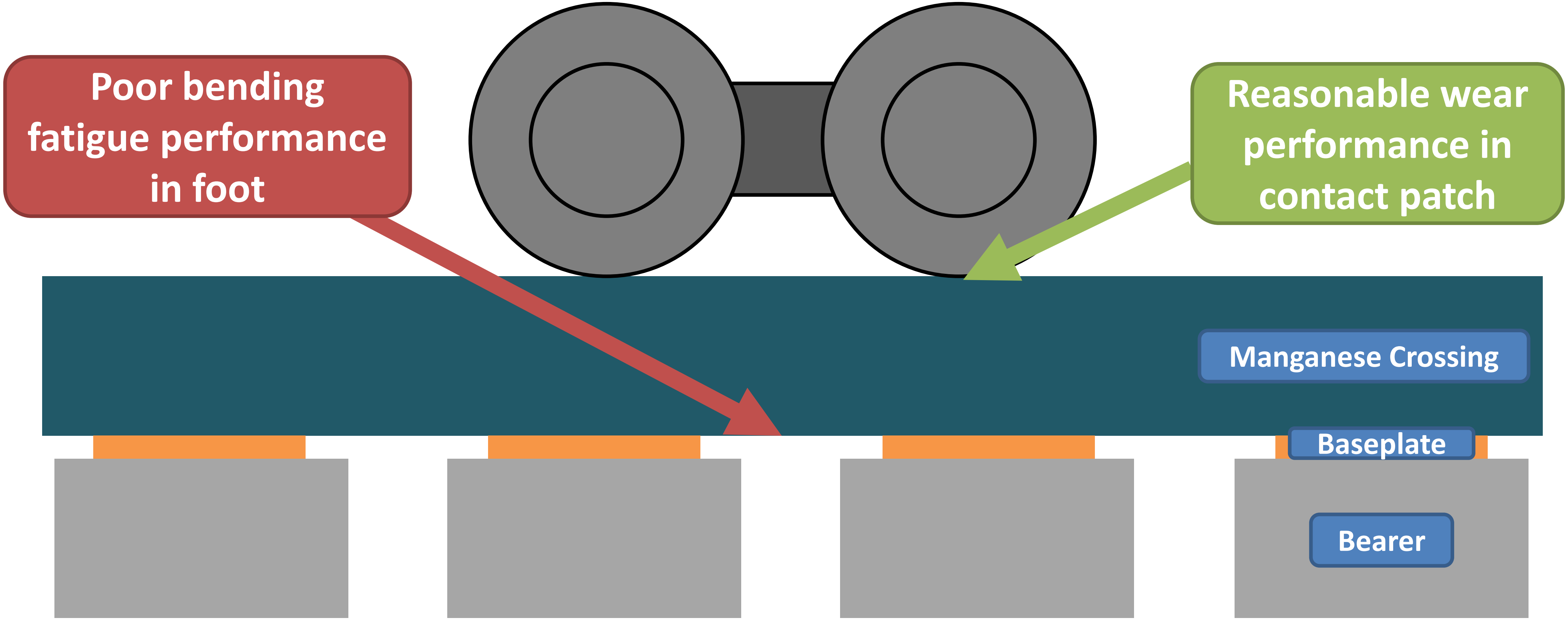
Further detailed development of the Modular Continuous Support (MCS) - based on the fastening system L-Track system developed under Capacity 4 Rail - including outline design of complete turnout and enhancements to adjustable track



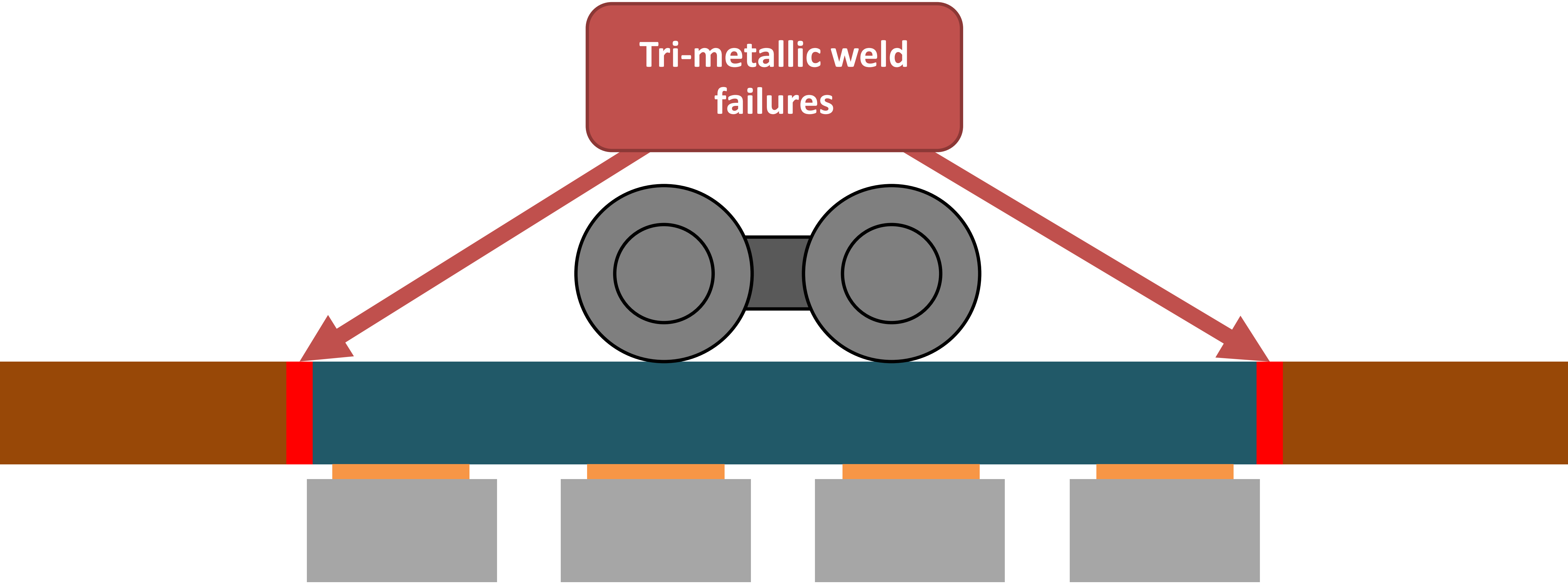
Hydraulic actuators during the static test



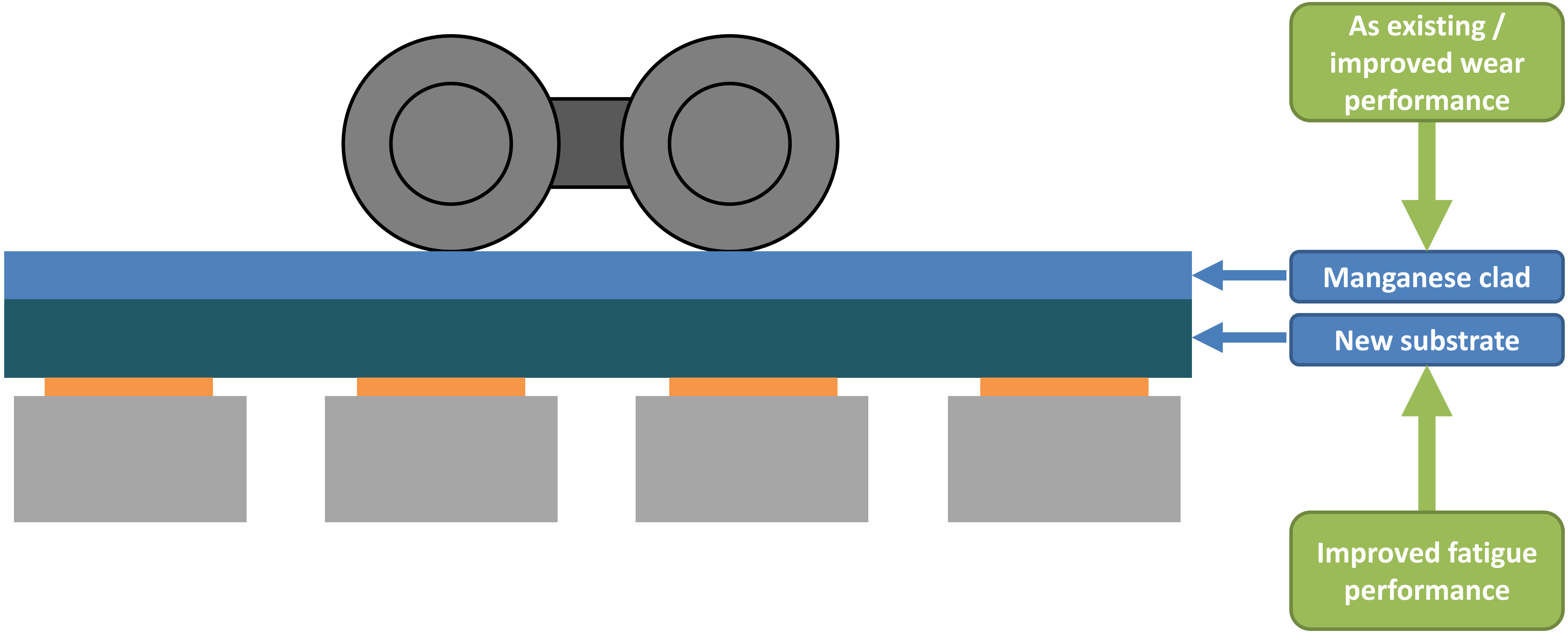
Additive Manufacturing



Additive Manufacturing



Additive Manufacturing



Additive Manufacturing

Arc-Welding

- Practical study
- Wheel-transfer area geometry
- Manganese clad

Laser Powder

- Practical and computational study
- Small-scale twin-disc testing
- Stainless Steel clad

Additive Manufacturing

Metal active gas (MAG) welding process with manganese steel filler wire as a feed stock on a high strength carbon steel substrate.

Mechanical testing undertaken according to EN 15689 (Cast AMS crossings)

With the exception of the impact toughness, the overall as deposited weld quality was acceptable to EN 15689 standard. Weld deposit hardness exceeded the minimum values specified by EN 15689

Photograph of the test block after the deposition trial

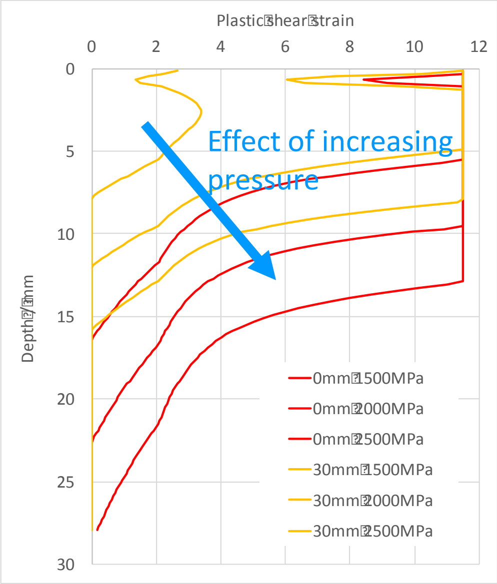
(Top) Plan view
(Bottom) End view

Macro image showing cracking on the deposit weld metal after impact bend testing

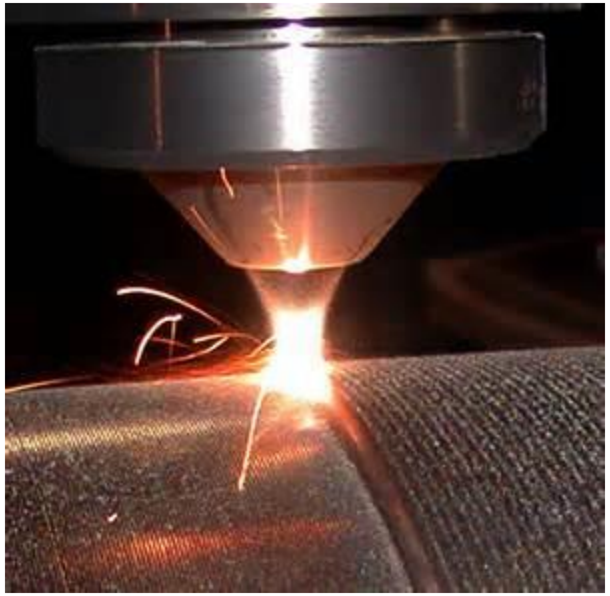
Photograph showing the weld deposition process

Additive Manufacturing

Clad (top, white) to substrate (bottom, grain structure) fully bonded interface



Plastic damage prediction with/without cladding



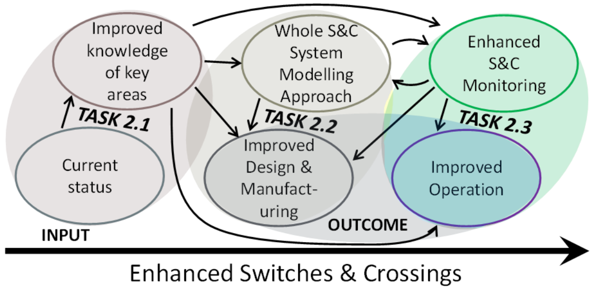
Laser cladding additive manufacture process

Additive manufacture using Laser Cladding was investigated for reduction of wear and fatigue damage in S&C surfaces. Laboratory tests showed:

- Wear life was greatly improved.
- Bend testing demonstrated cladding integrity

Modelling to predict the needs for scale-up to full component demonstration showed:

- The need for thicker coatings.
- The importance of achieving a very high integrity at the cladding to substrate interface to avoid internal defect growth



Enhanced Monitoring, Operation, Control and Maintenance of S&C (D2.3)

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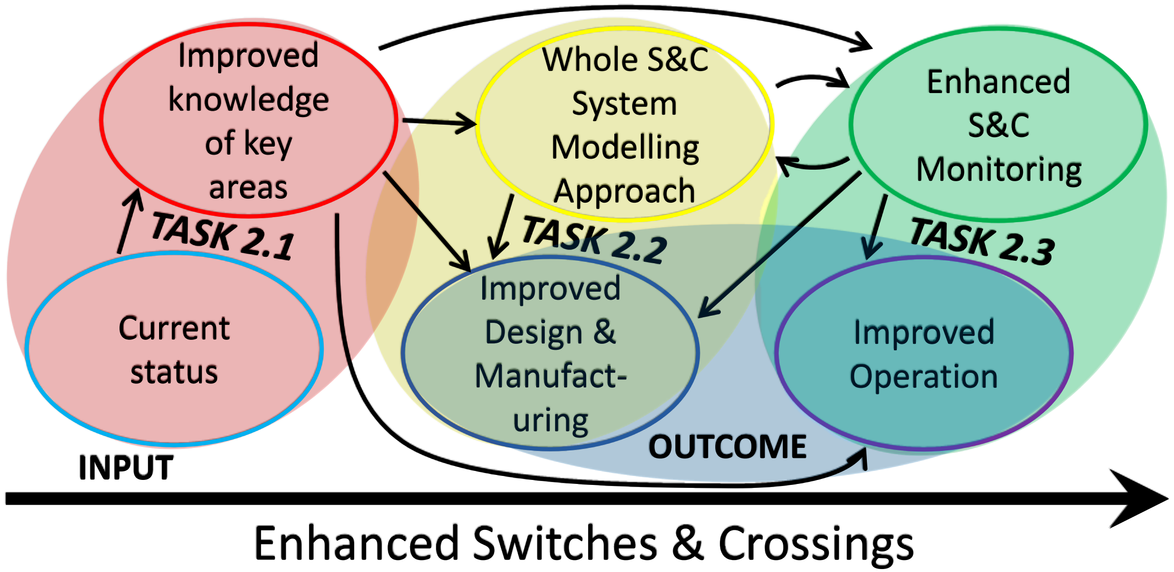
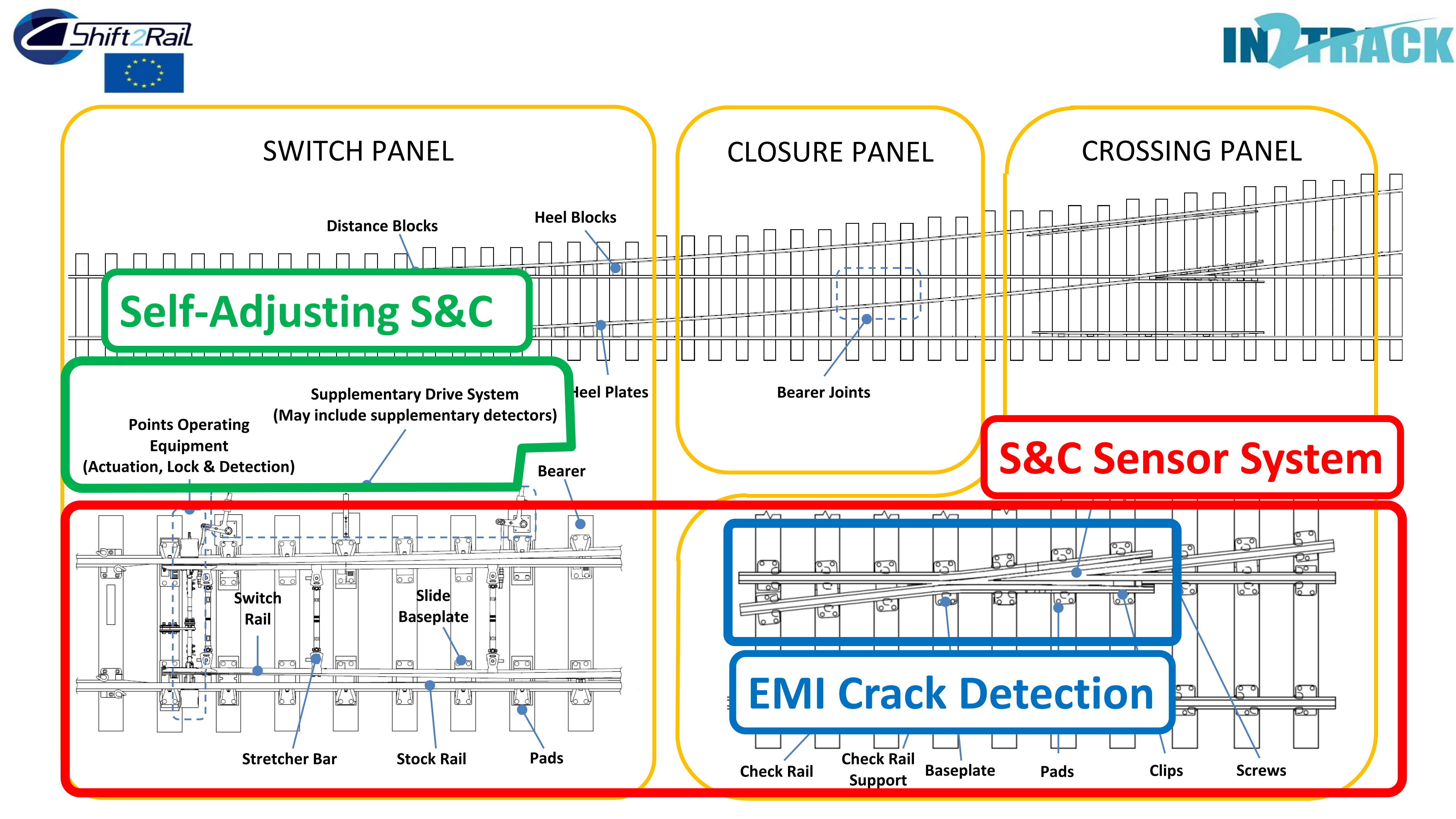
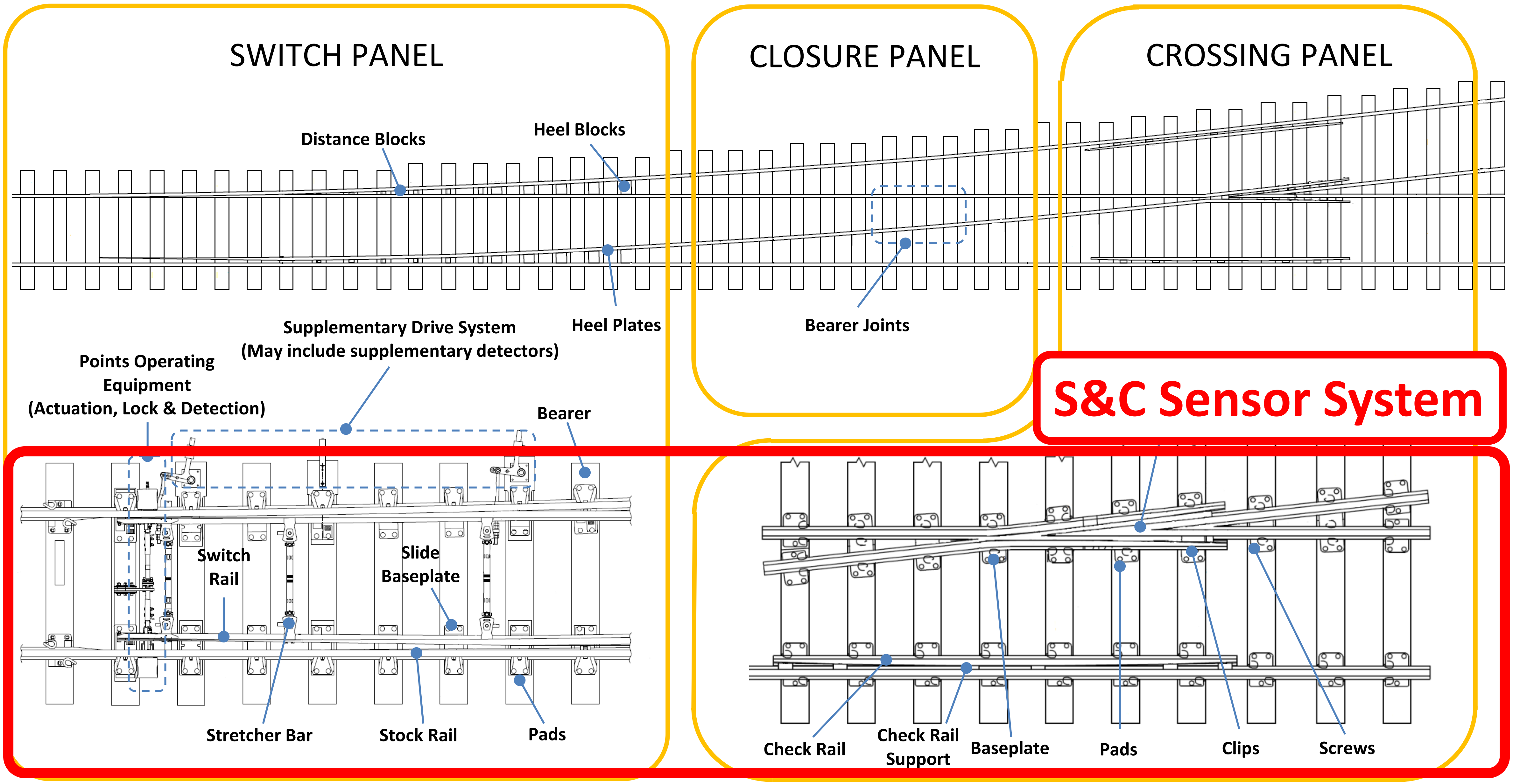
Enhanced Monitoring, Operation, Control and Maintenance of S&C

Key outcomes

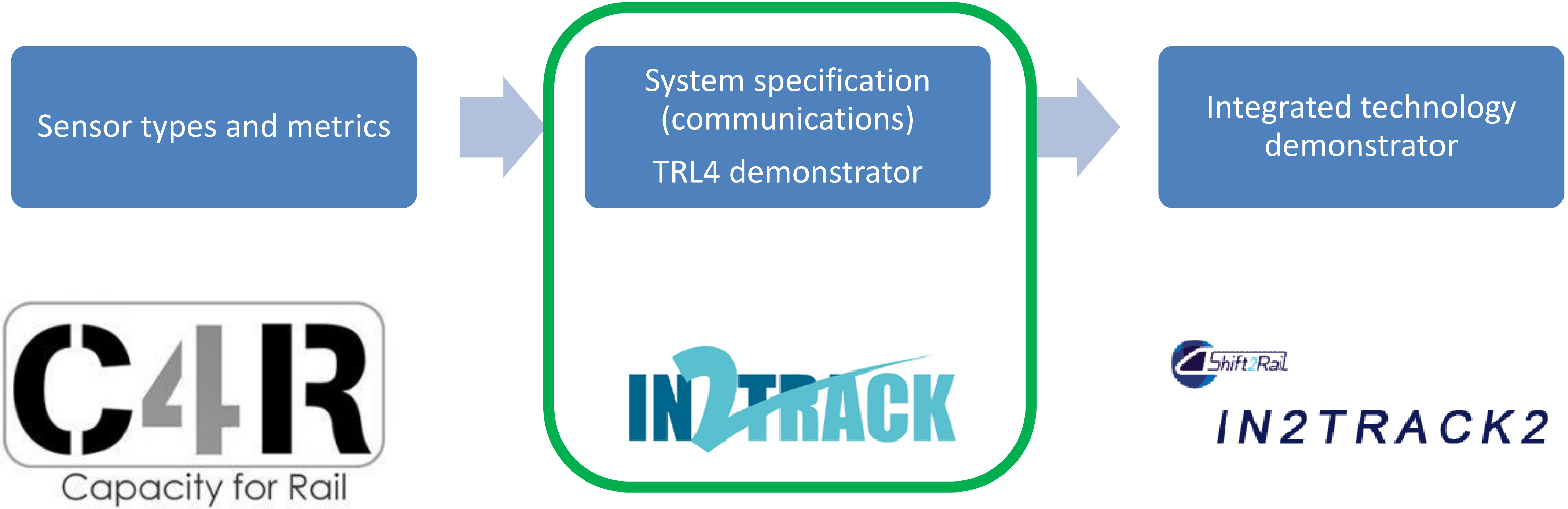
- S&C sensor system specification and demonstrator
- EMI method of crack detection
- Self-adjusting S&C



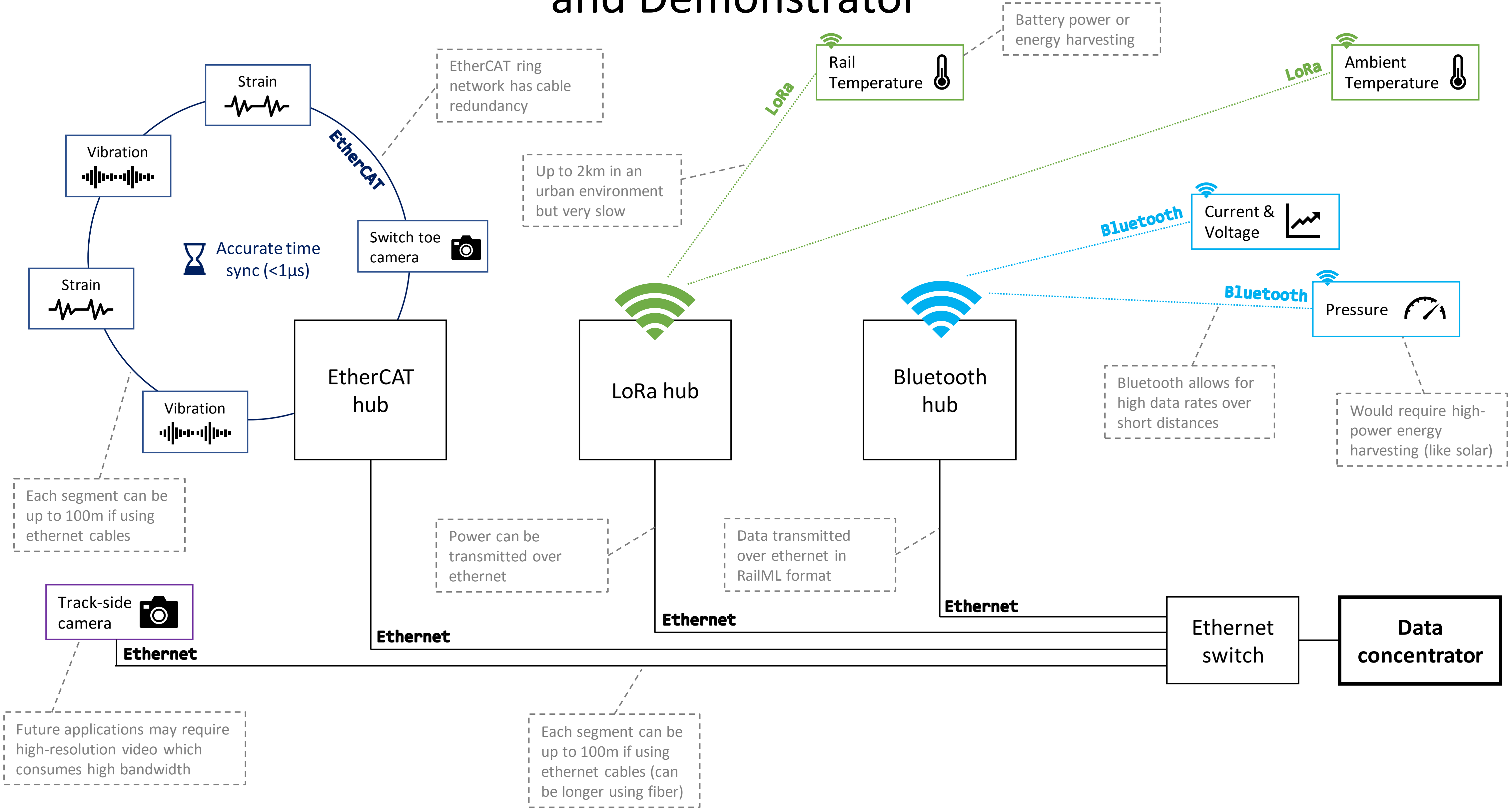

SWITCH PANEL
CLOSURE PANEL
CROSSING PANEL
Distance Blocks
Heel Blocks
Self-Adjusting S&C
Heel Plates
Bearer Joints
Supplementary Drive System
(May include supplementary detectors)
Points Operating
Equipment
(Actuation, Lock & Detection)
S&C Sensor System
Bearer
Switch
Rail
Slide
Baseplate
EMI Crack Detection
Stretcher Bar
Stock Rail
Pads
Check Rail
Check Rail
Support
Baseplate
Pads
Clips
Screws


SWITCH PANEL
CLOSURE PANEL
CROSSING PANEL
Distance Blocks
Heel Blocks
Heel Plates
Bearer Joints
Supplementary Drive System
(May include supplementary detectors)
Points Operating
Equipment
(Actuation, Lock & Detection)
Bearer
S&C Sensor System
Switch
Rail
Slide
Baseplate
Stretcher Bar
Stock Rail
Pads
Check Rail
Check Rail
Support
Baseplate
Pads
Clips
Screws

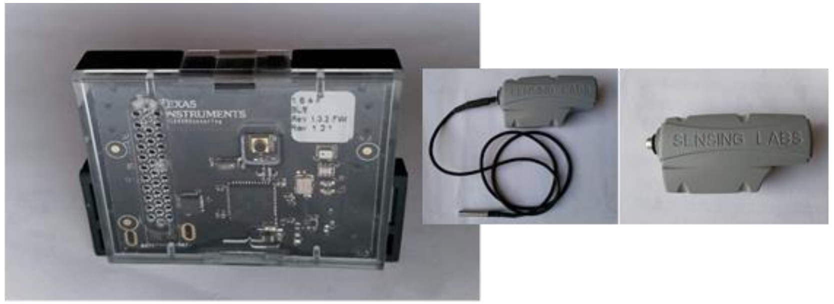
S&C Sensor System Specification, Design and Demonstrator

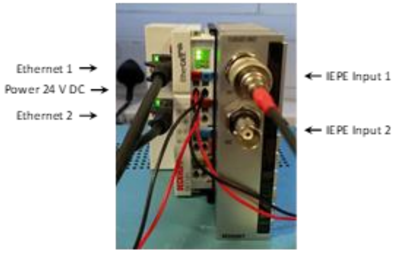


S&C Sensor System Specification, Design and Demonstrator



S&C Sensor System Specification, Design and Demonstrator



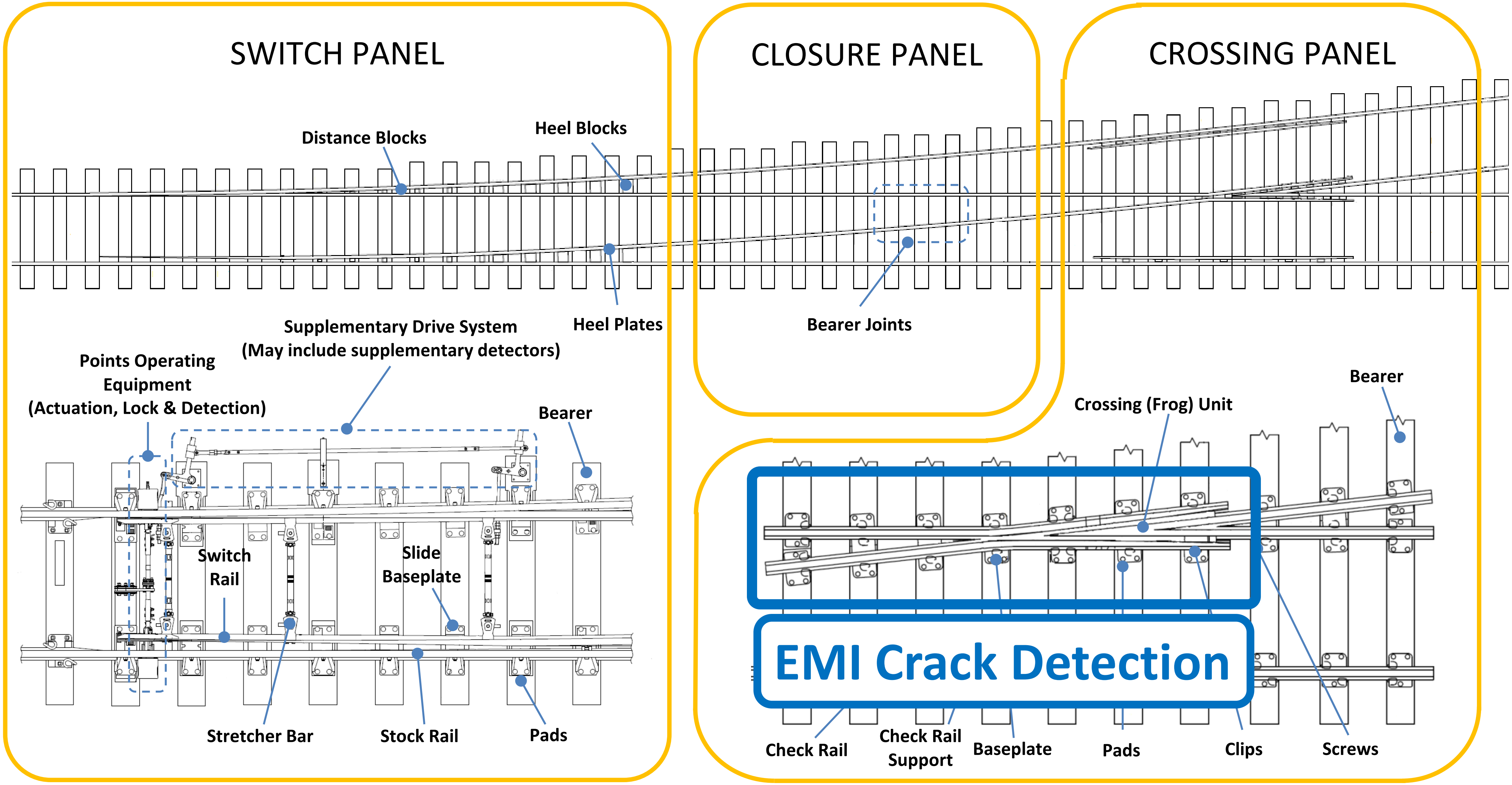


Outputs delivered through all three communications mediums

Difficulties in configuring COTS devices for data collection

railML/SensorML difficult to implement in plug-and-play environment

Further definition in IN2TRACK2


SWITCH PANEL
CLOSURE PANEL
CROSSING PANEL
Distance Blocks
Heel Blocks
Heel Plates
Bearer Joints
Supplementary Drive System
(May include supplementary detectors)
Points Operating
Equipment
(Actuation, Lock & Detection)
Bearer
Switch
Rail
Slide
Baseplate
Stretcher Bar
Stock Rail
Pads
Bearer
Crossing (Frog) Unit
EMI Crack Detection
Check Rail
Check Rail
Support
Baseplate
Pads
Clips
Screws

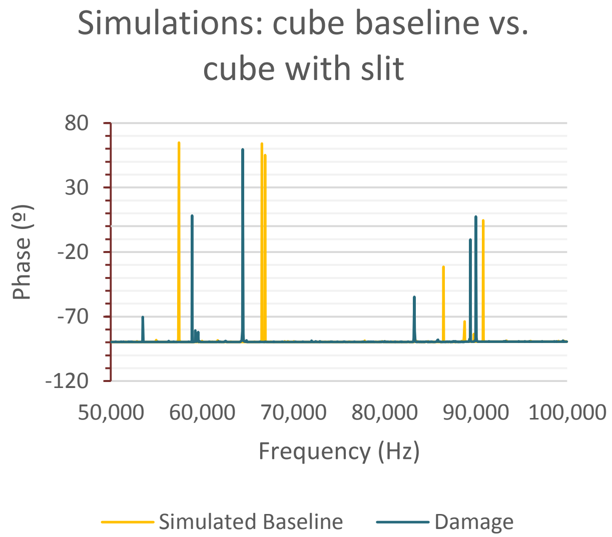
Assessment of EMI Used for the Detection of Discontinuities in Work Hardened Mn13 Frog Tips.

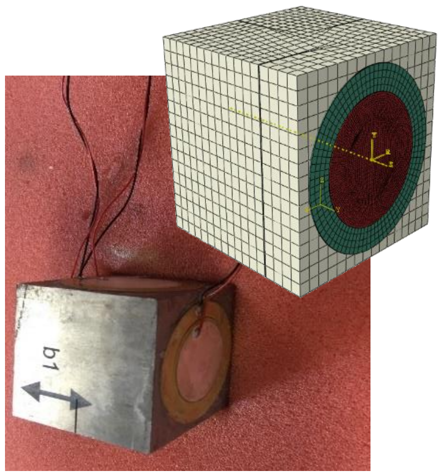
Existing NDT methods unsuitable for manganese steels

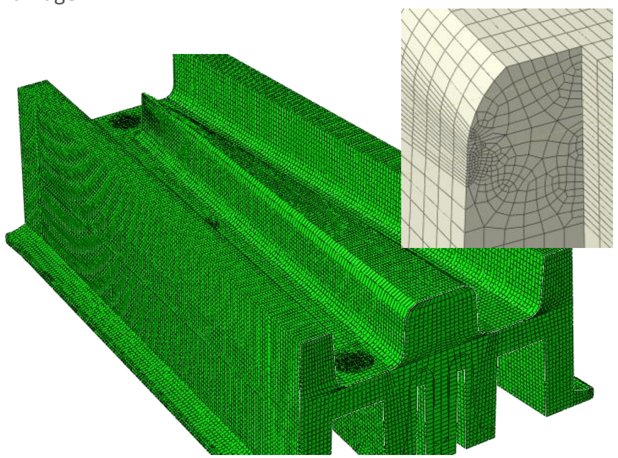
Difficulty in detecting defects in AMS frogs

Electro-Mechanical Impedance (EMI) technique developed for defect detection in manganese steels

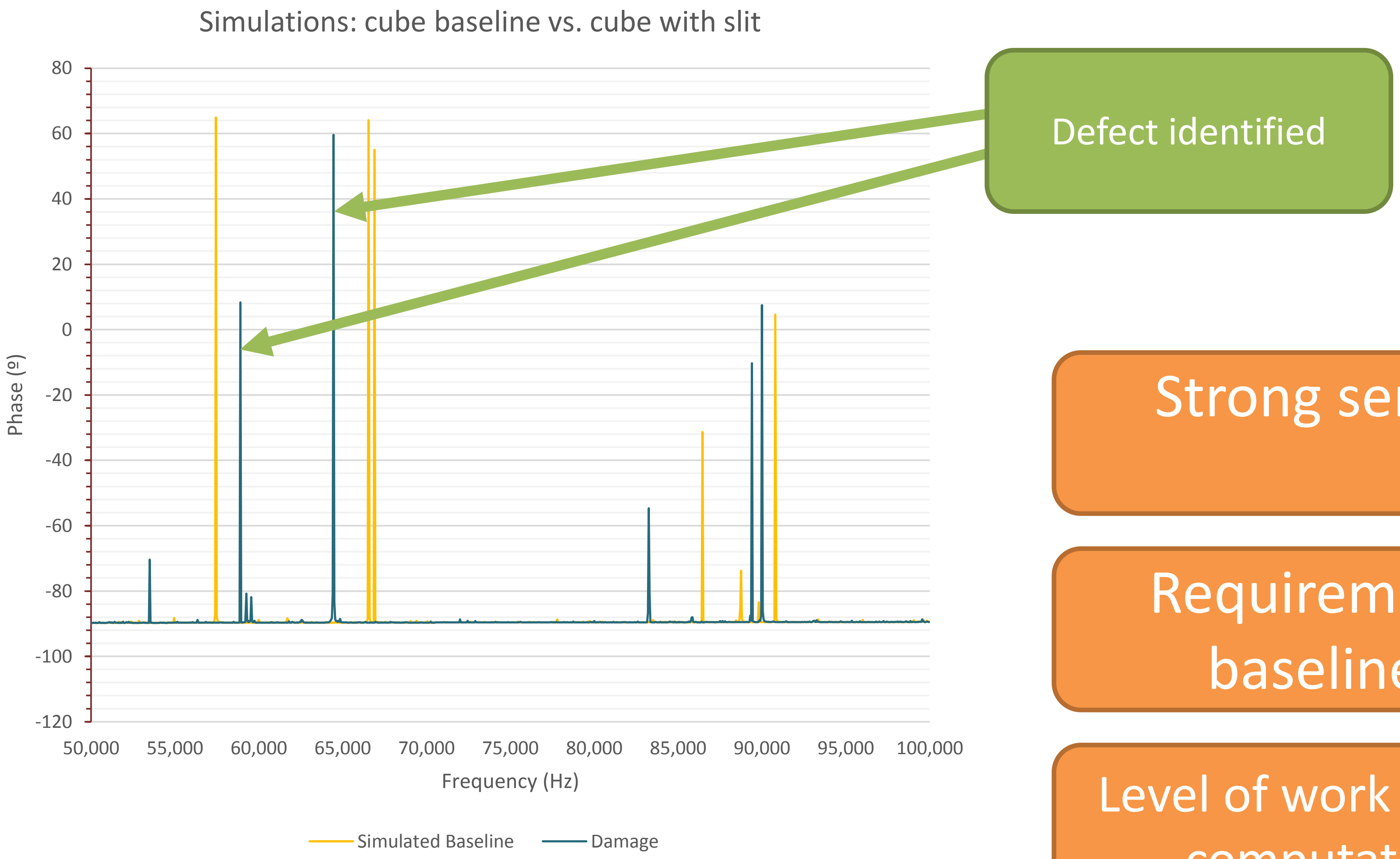
Physical tests complimented by computational modelling of the technique







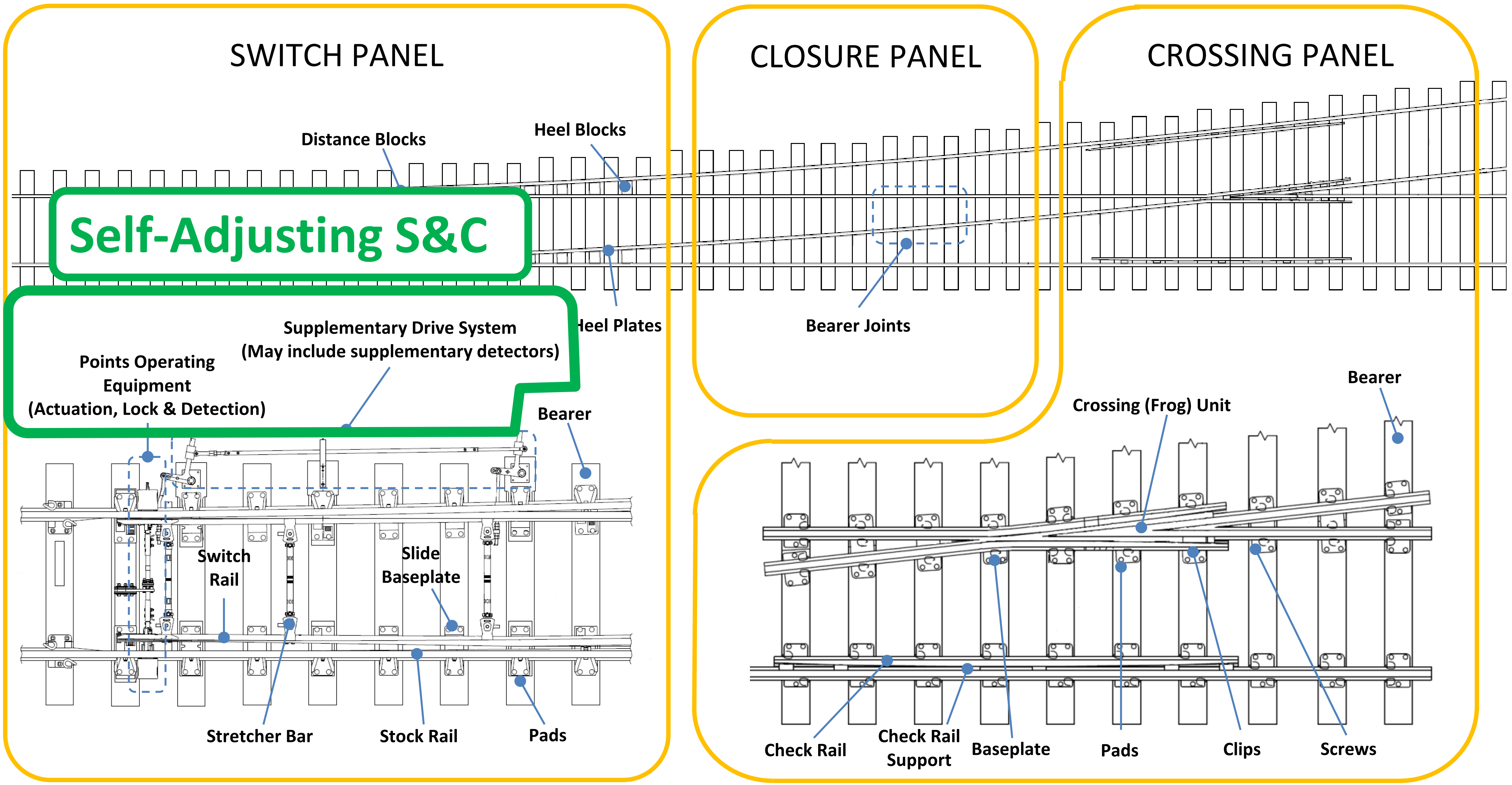
Assessment of EMI Used for the Detection of Discontinuities in Work Hardened Mn13 Frog tips.



Strong sensitivity to sensor location

Requirement for pre-defect baseline measurement

Level of work hindered by significant computational requirements

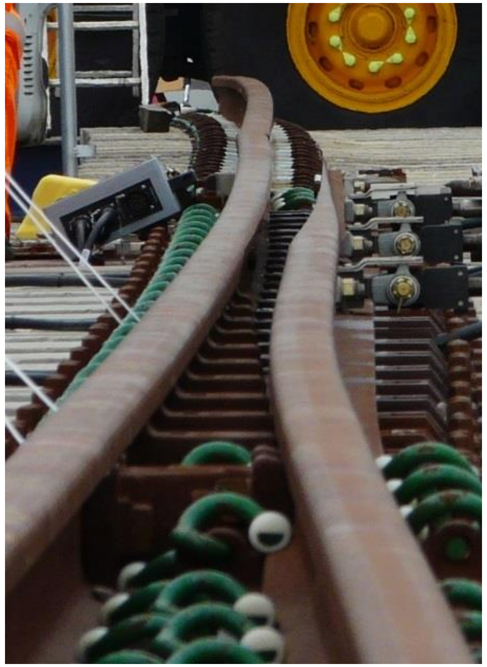

SWITCH PANEL
CLOSURE PANEL
CROSSING PANEL
Distance Blocks
Heel Blocks
Self-Adjusting S&C
Heel Plates
Bearer Joints
Supplementary Drive System
(May include supplementary detectors)
Points Operating
Equipment
(Actuation, Lock & Detection)
Bearer
Switch
Rail
Slide
Baseplate
Stretcher Bar
Stock Rail
Pads
Bearer
Crossing (Frog) Unit
Check Rail
Check Rail
Support
Baseplate
Pads
Clips
Screws

Self-adjusting S&C

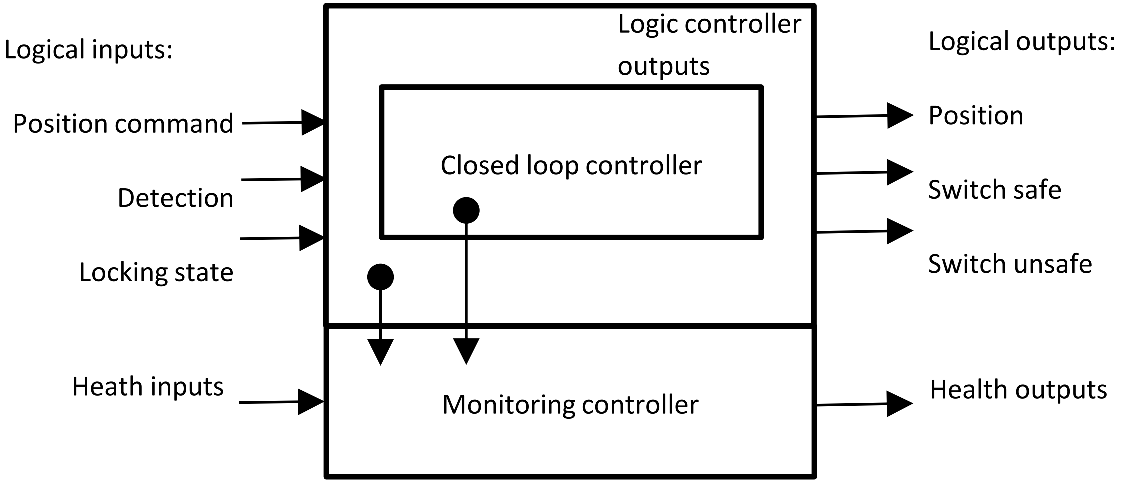
Review of operation and degradation of Actuation, Locking & Detection equipment

Design study of retrofit technology for self-adjusting control and monitoring

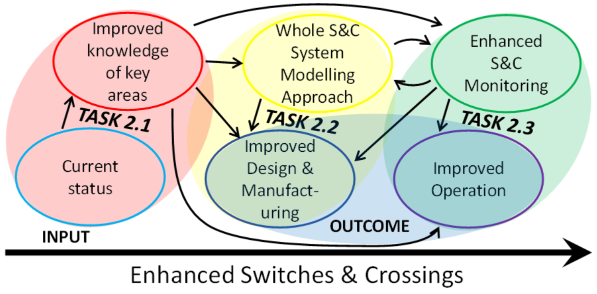
Cost Benefit Analysis examining return on investment



Features of the switch rail gap



Schematic of the control and monitoring system design



Prototypes and Enhanced S&C System Demonstrator Specifications (D2.2 and D2.3)

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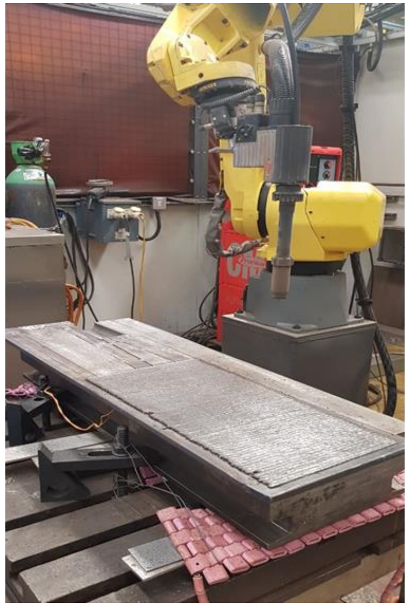
Prototypes and Enhanced S&C System Demonstrator Specifications

Delivered in WP2:

- Whole system modelling approach

- Prototypes :
  - ❖ Additively manufactured crossing sample
  - ❖ Laser clad S&C rails
  - ❖ Optimised rail steel grades, components & transition zones
  - ❖ Modular continuous support track
  - ❖ Whole S&C sensor system

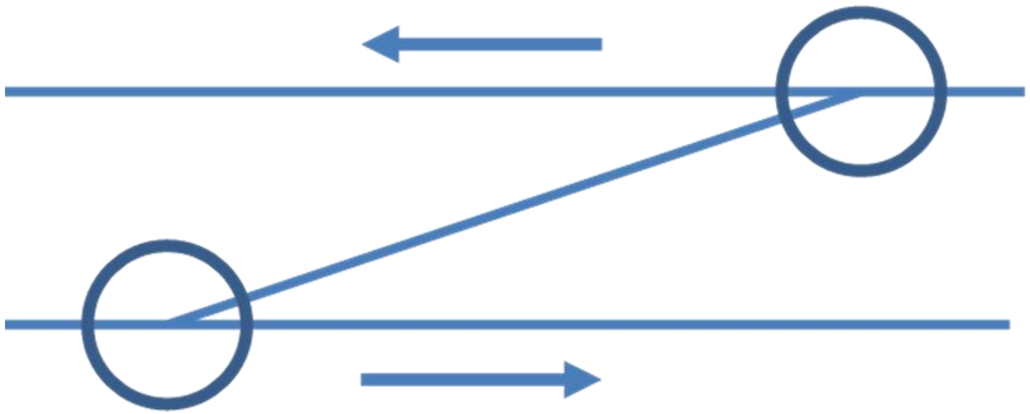


- Demonstrator specifications:
  - ❖ Additively manufactured crossing
  - ❖ Modular continuous support turnout
  - ❖ Integrated optimised turnout
  - ❖ Enhanced monitoring

Additively Manufactured Crossing

Additively manufactured crossing demonstrator specification:

- Process: Cold Metal Transfer (CMT) most promising for this application
- Material selection: substrate with improved fatigue performance and AM material similar to existing AMS used in cast crossings
- Post process work: utilise techniques to improve surface hardness prior to demonstrator installation

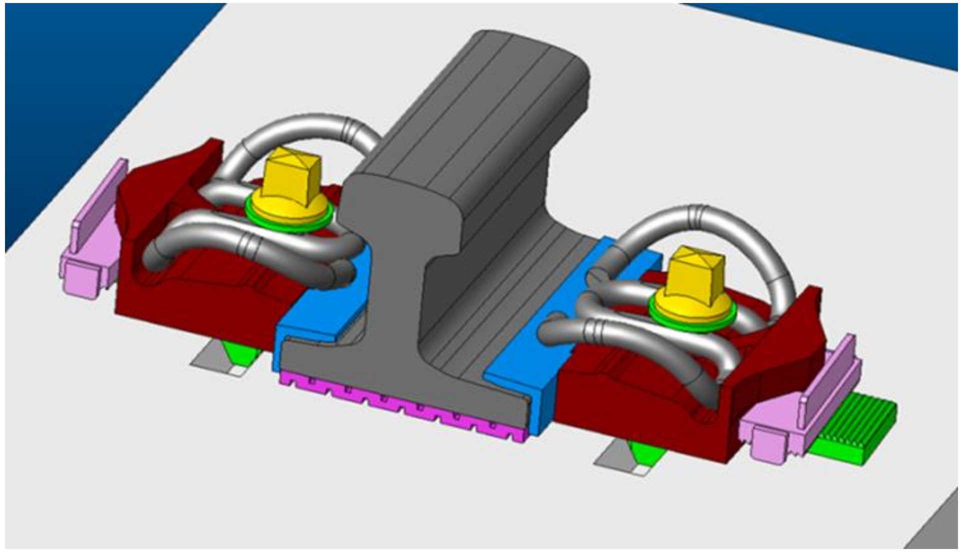


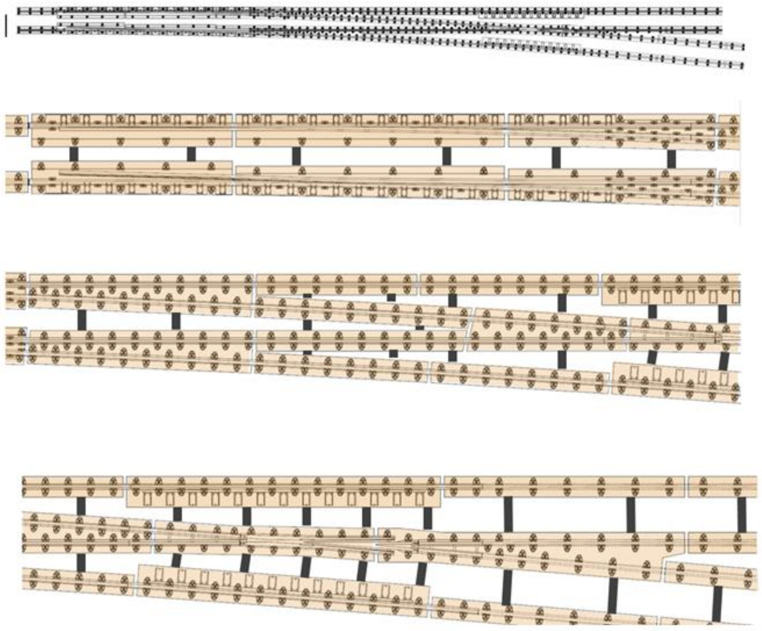
Site configuration: location to allow for comparison between the AM crossing and a ‘traditional’ cast-crossing used as a control sample:

- ❖ Common location
- ❖ Common track bed conditions
- ❖ Common traffic and line speed
- ❖ Common crossing geometry

Modular Continuous Support

Outline design of complete turnout and enhancements to adjustable track

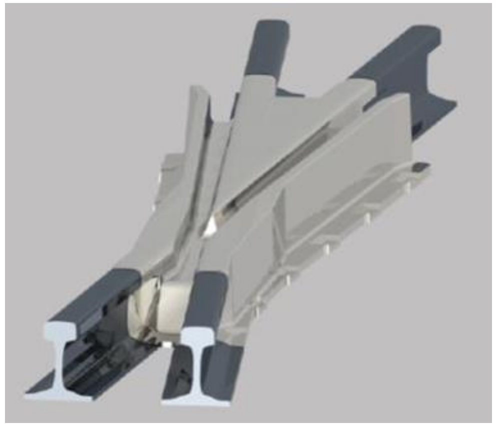




Optimised Turnout

Turnout demonstrator : planned installation mid 2020 in Austria

Standard Turnout BA15



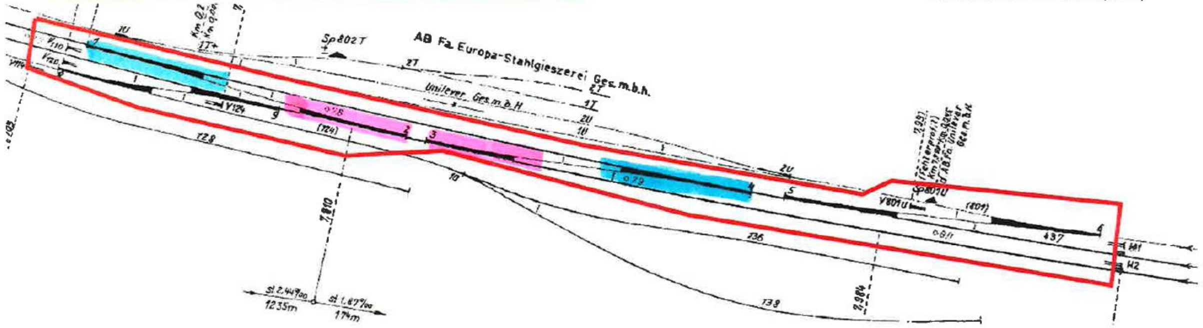
New Shift2Rail Turnout Demostrator: T/O #1 and #4

ÖBB Standard Turnout BA15: T/O #2 and #3

Einbaustelle

- Liesing Nord

Fipsy-Projektnummer	Fipsy Projektbezeichnung	Antragsnummer	Region	Rahmenplanstrecke	TFK	DB776	VZG	Strecken-belastung je Gleis [BT/T]	Einbauzeit [Monat/Jahr]	Weichen-geometrie
SAT116	Wien Hetzendorf - Wien Atzgersdorf; WN+PLV W 1 - W 6, km 7,700 - km 8,100; Bau	14-112913	SAERL Ost 1	016 - Wien Hbf (e) - Wiener Neustadt Hbf (a)	Weichenneulage (WN) m. Planumsverbesserung	2052	120	86.000	05/2020	W 1: ABW-60E1-500-1:12-Fschz-Be(besohlt) W 2: IBW-60E1-500-1:12-Fschz-Be(besohlt) W 3: IBW-60E1-500-1:12-Fschz-Be(besohlt) W 4: ABW-60E1-500-1:12-Fschz-Be(besohlt) W 5: IBW-60E1-500-1:12-Fschz-Be(besohlt) W 6: ABW-60E1-500-1:12-Fschz-Be(besohlt)

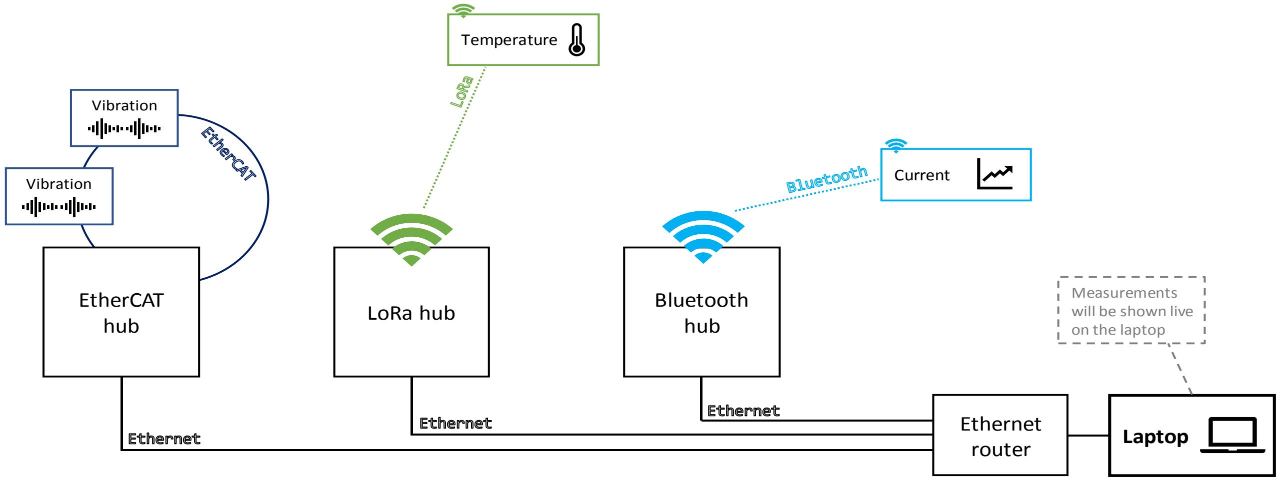


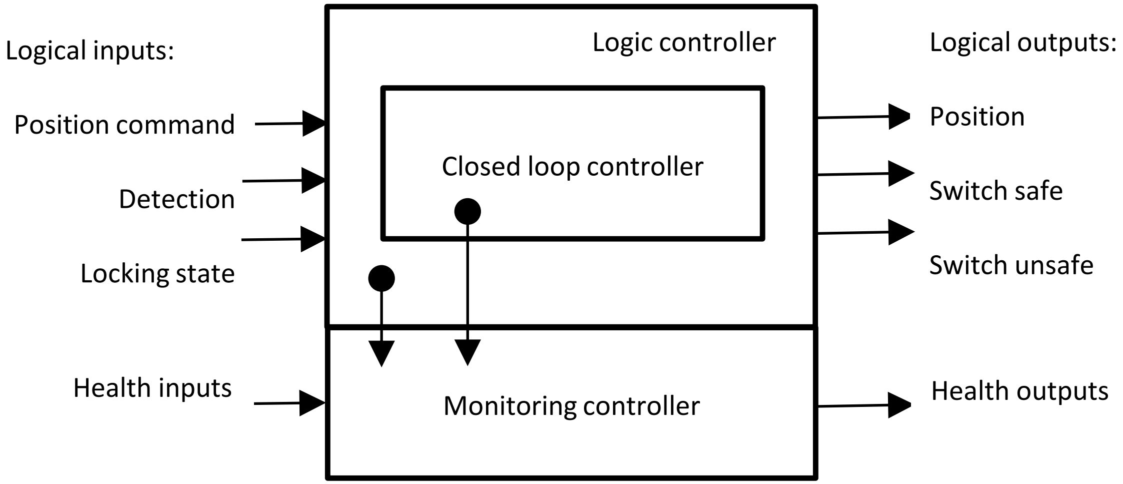
Location for installation of two S2T-Demonstrators and two Standard Turnouts BA15 for evaluation of improvement

Enhanced Monitoring Demonstrator

Live rail demonstrator

Laboratory environment demonstrator





WP2 – Conclusion

WP2 Key Outputs

European FMEA

- FMECA
- Failure mode catalogue

Whole System Modelling

- Integrated modelling approach

Enhanced design

- Switch geometry / rail profile
- Whole system stiffness / support
- Optimised rail grades
- Modular bearer joints
- Self adjustment capability

Prototypes

- Additively manufactured crossing
- Laser clad S&C rails
- Optimised rail steel grades, components and transition zones
- Modular Continuous Support
- Whole S&C sensor system

Specifications / plans for

Enhanced S&C Physical Demonstrators:

- ✓ *Additively manufactured crossing*
- ✓ *Modular continuous support turnout*
- ✓ *Integrated optimised turnout*
- ✓ *Enhanced monitoring*

IN2TRACK2

WP1: Enhanced S&C

WP2: Next Generation S&C

Many thanks for your attention!

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