Bezin, Yann

Designing future turnouts – where research capabilities meet industry needs

Rail Tech expert series, Paris 26th January 2016
‘Wheel/Rail Interface & Switches’

University of HUDDERSFIELD
Institute of Railway Research

Session 2: ‘’Optimising opposite demands’

Designing future turnouts - where research capabilities meet industry needs

Speaker: Dr Y. Bezin (*IRR Head of Research, Huddersfield, UK)*

Inspiring tomorrow’s professionals

THE AWARDS AWARD WINNER UNIVERSITY OF THE YEAR

theguardian UNIVERSITY AWARDS Winner 2013

2012 THE AWARDS WINNER Entrepreneurial University of the Year

THE QUEEN'S AWARDS FOR ENTERPRISE

Content

University of HUDDERSFIELD
Institute of Railway Research

- Background
  - Key WRI issues at Switches & Crossings
- Key areas of research
  - EU projects landscape
- How to address key challenges
  - Research tools and validation aspects
  - 'Conflicting requirements' for optimisation
- Collaboration
  - Challenges and opportunities

Background

University of HUDDERSFIELD Institute of Railway Research

Complexity

- Large # of parts
- Wide range of possible layout configuration
- Moving parts & exposed mechanisms
- Mechanical interfaces
- Weak structural components

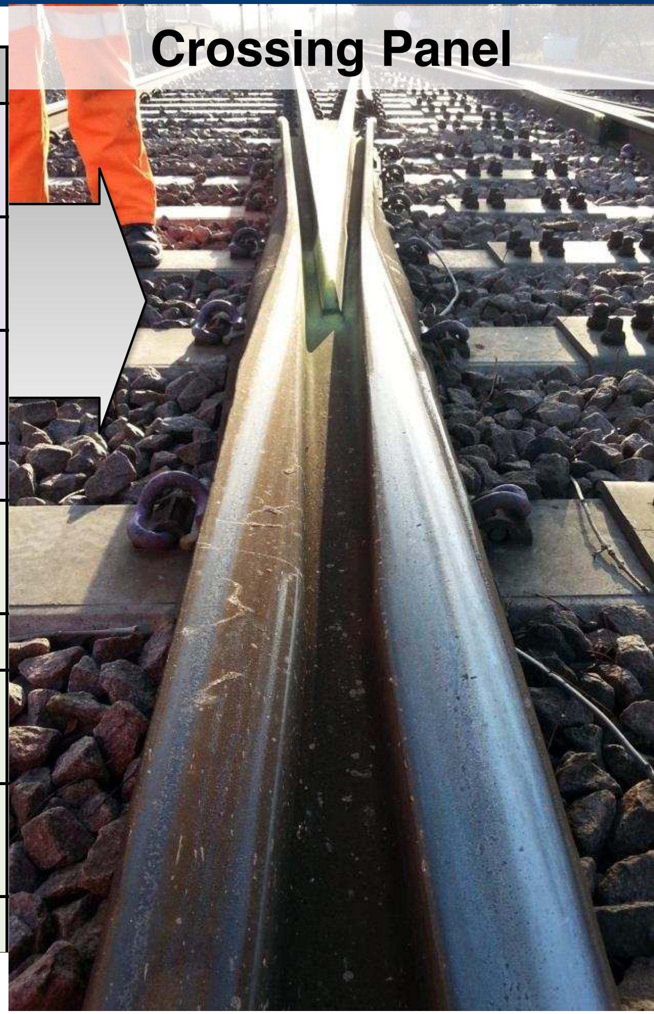
Non-linearities

- Rail cross sections (bearing surface)
- Structural stiffness (rail bending stiffness, bearers length & ballast support)
- Rail inclination
- Track curvature
- Cant deficiency

S&C key components and damages

University of Huddersfield
Institute of Railway Research

Component	*Failures*
Cast manganese Casting	transverse fatigue crack (foot or nose)
Crossing nose	wear, plastic deformation, shelling and spalling
Wing rail	wear, plastic deformation, shelling and spalling
bearers	fatigue cracking, voids
switch rails	lipping, head checks, squats, wear
points	all the above + fracture by fatigue
stock rails	lipping, head checks, squats, wear, spalling
slide plates	poor movement (high friction) and ceisure
bearers	fatigue cracking, voids



S&C key components and damages

University of HUDDERSFIELD Institute of Railway Research

Spalling of stock rail

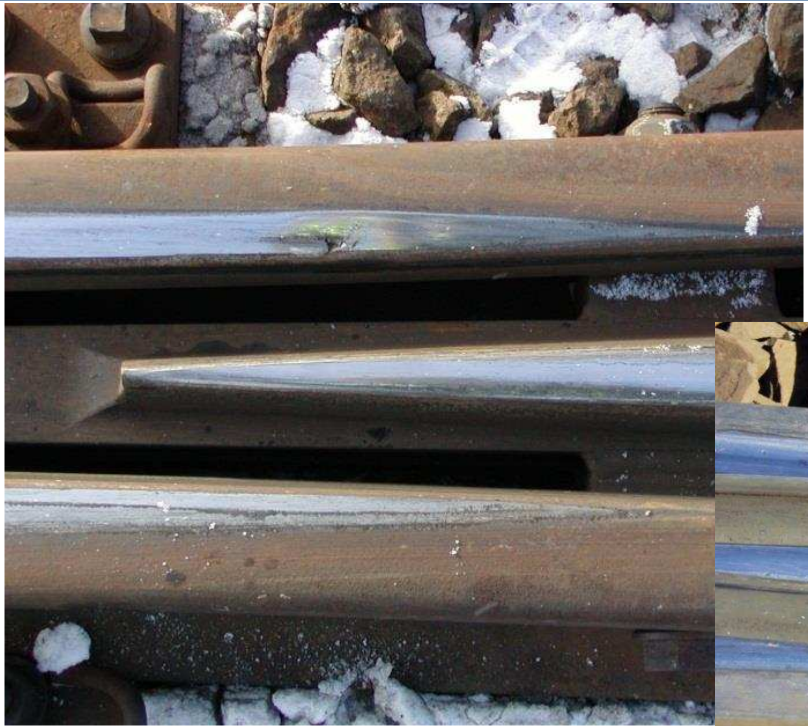
Subsurface initiated fatigue

Lipping of switch/stock rails

Reference: *Capacity4Rail, D131 "Operational failures modes of S&Cs"*

S&C key components and damages

University of HUDDERSFIELD
Institute of Railway Research



Plastic deformation of wing rails

Spalling of crossings

Spalling & plastic deformation of crossing nose

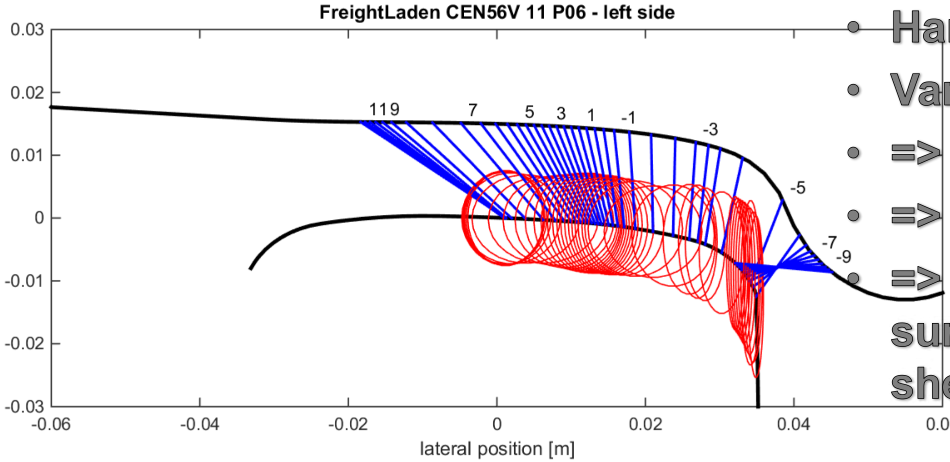
C4R Capacity for Rail

Reference: *Capacity4Rail, D131 "Operational failures modes of S&Cs"*

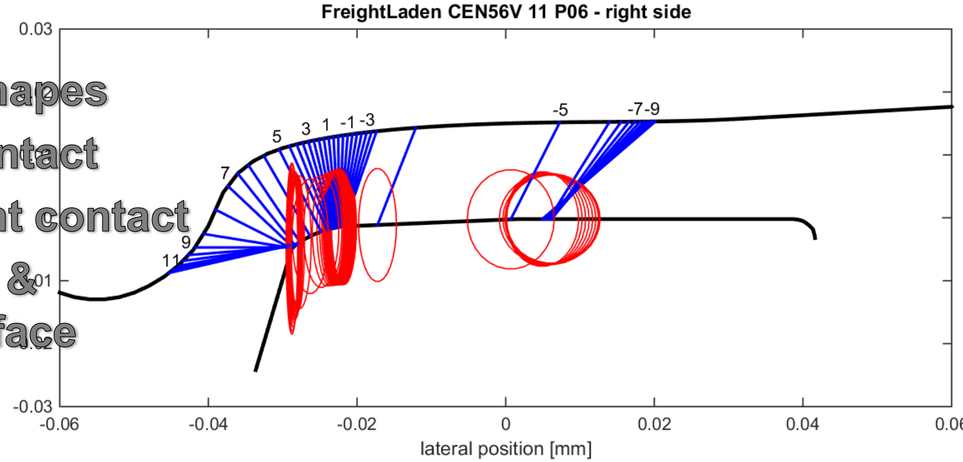
Root causes – dynamic WR Interaction

University of HUDDERSFIELD
Institute of Railway Research

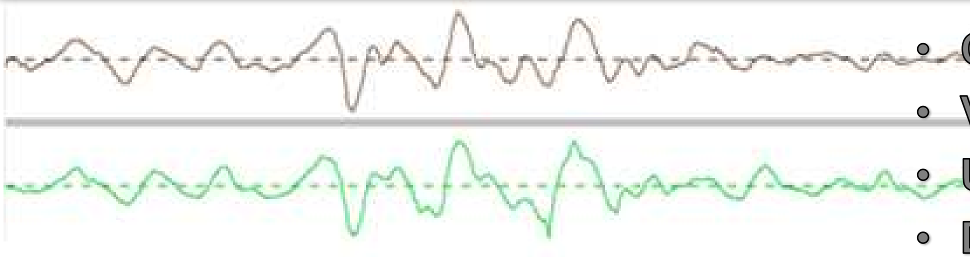
Poor compliance of W-R geometries



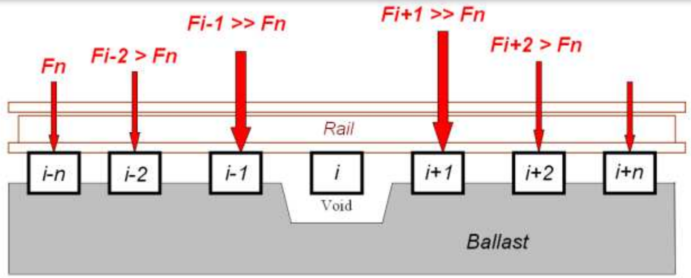
- Harsh interface
- Variable rails shapes
- => Jumps in contact
- => Multiple point contact
- => High normal & surface/subsurface shear stresses



Poor maintenance + support



- Cyclic top/alignment
- Voided/hanging bearers
- Uneven L/R loading
- Differential settlement



Root causes – dynamic WR Interaction

University of HUDDERSFIELD
Institute of Railway Research

Poor compliance of W-R geometries

High rail/sleeper accelerations

↓

Ballast void and settlement

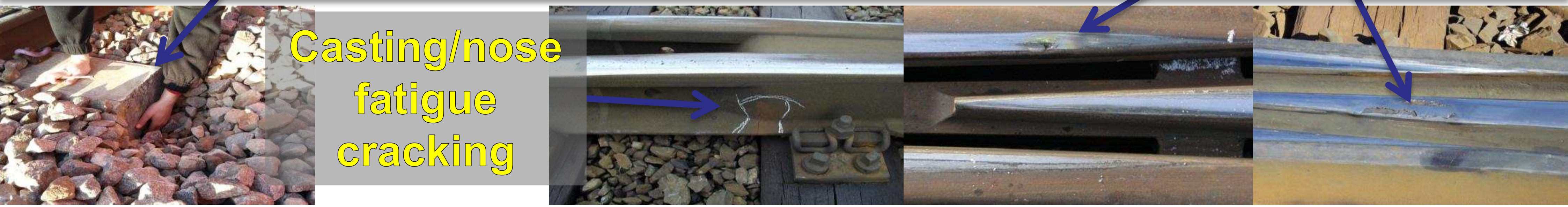
Increased Dynamic Forces

High normal & shear stresses

↓

rail wear, fatigue & deformation

Poor maintenance + support



Root causes – Influential factors

University of HUDDERSFIELD
Institute of Railway Research

- **Design** (system level => vehicle-track…)
- **Environmental** (incl. extreme weather)
- **Installation/set-up** (human factor, tolerances…)
- **Maintenance** (mechanised/manual…)
- **Manufacturing** (processes/tolerances/…)
- **Operational** (speed, loading regime, traffic mix, tonnages…)

C4R Capacity for Rail

Reference: D131 Operational failure modes of SCs

Key areas of research & development

University of HUDDERSFIELD
Institute of Railway Research

Eslöv-Sweden test site:
- Kinematic Gauge Optimisation
- Resilient stiffness

Haste-German test site:
- Crossing nose shape (e.g. MaKüDe)
- Material (built-up)

Simulation software:
- Benchmarking
- KGO optimisation
- Support stiffness variation

Simulation of:
- Derailment analysis
- Switch rail shape optimisation
- Impact of wheel shape
- Under sleeper pads
- Innovative structures

Material
- Higher steel grades

Concept evaluation:
- New switch concepts
- New drive and lock devices

FP6
Innotrack

FP7
Sustrail
Rivas
DRail
Capacity4Rail

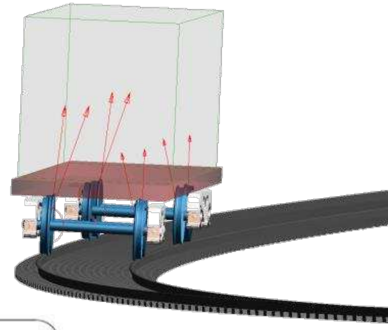
H2020
In2Rail…
…Shift2Rail

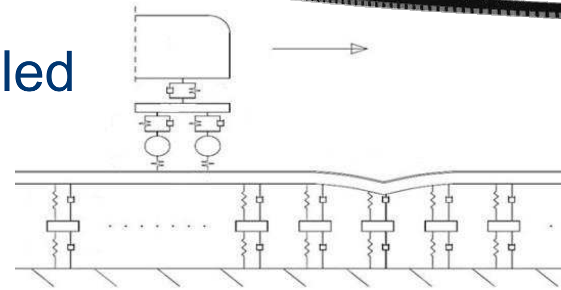
Towards demonstration of key innovations

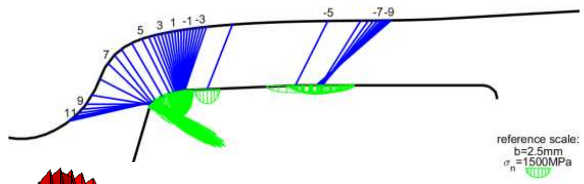
Available simulation technology

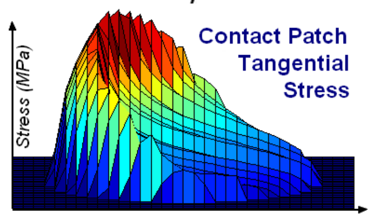
University of HUDDERSFIELD
Institute of Railway Research

- Vehicle multibody system dynamics
  - Prediction of vehicle behaviour and WRI forces
- Vehicle-track interaction dynamics
  - Prediction of WRI forces based on simplified or detailed track response
- Wheel-rail contact conditions
  - WRI forces and contact conditions (normal and tangential)
- Wear/damage prediction & summation
  - Based on any of the above



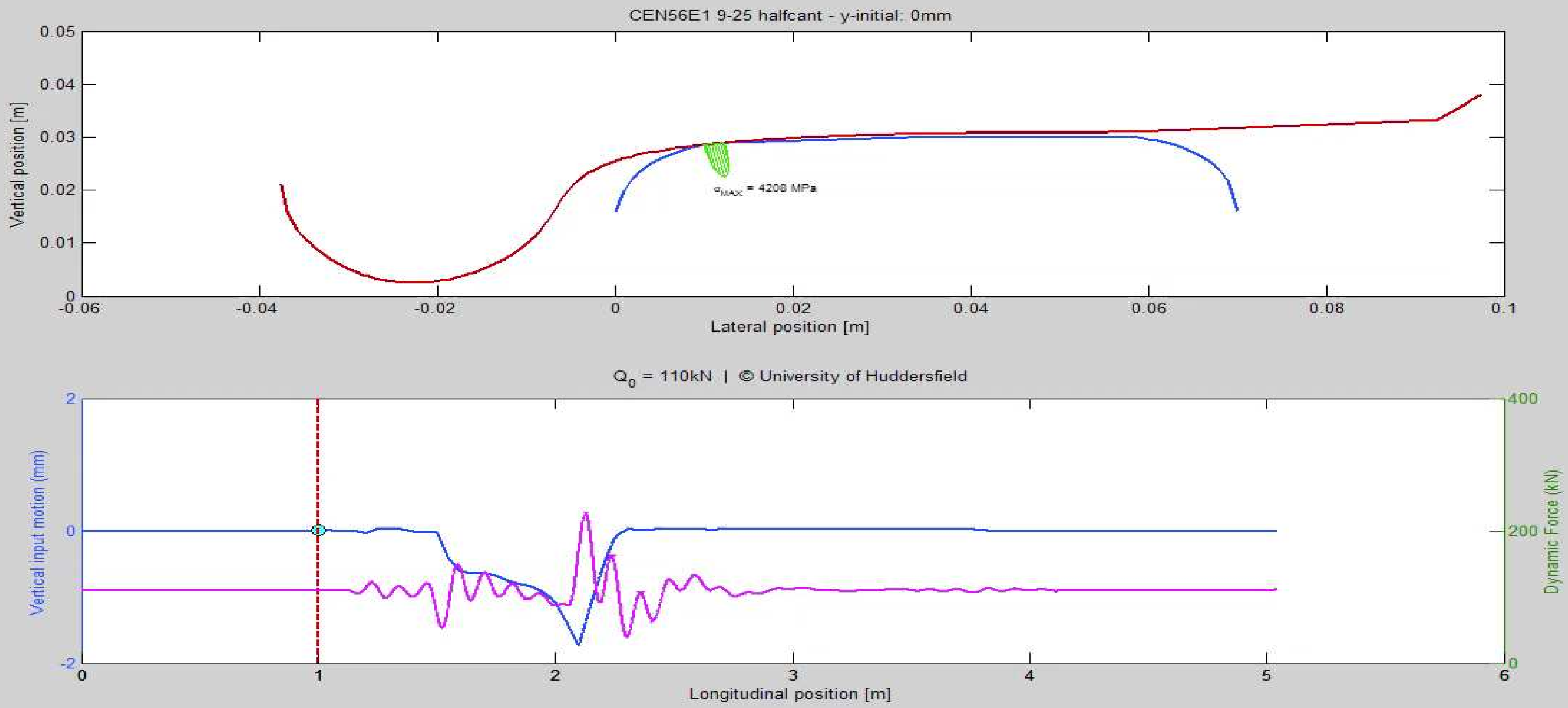






Contact condition and contact stresses

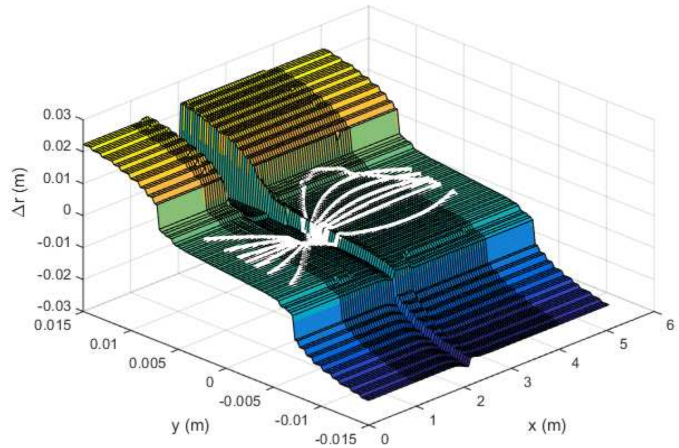
University of Huddersfield
Institute of Railway Research

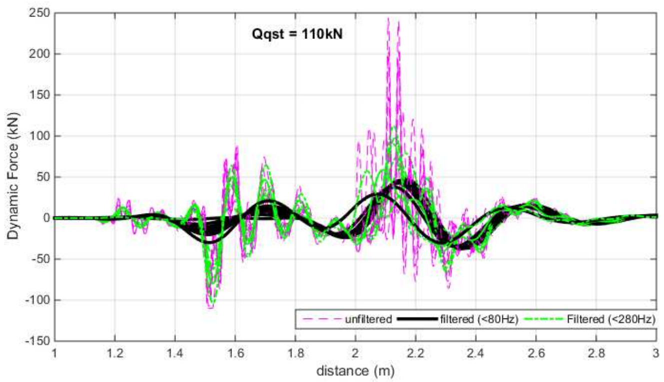


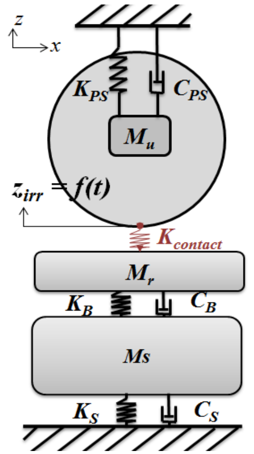
Example key output SUSTRAIL

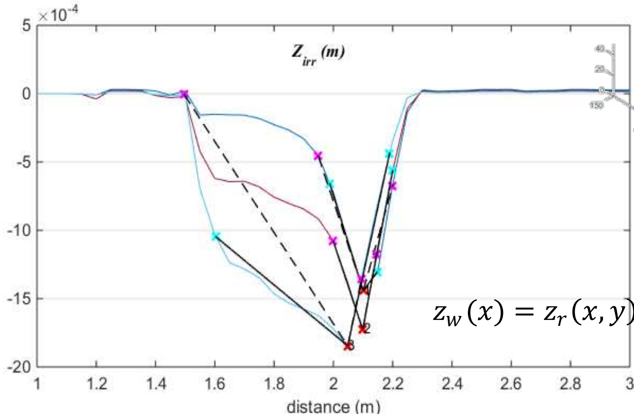
University of HUDDERSFIELD
Institute of Railway Research

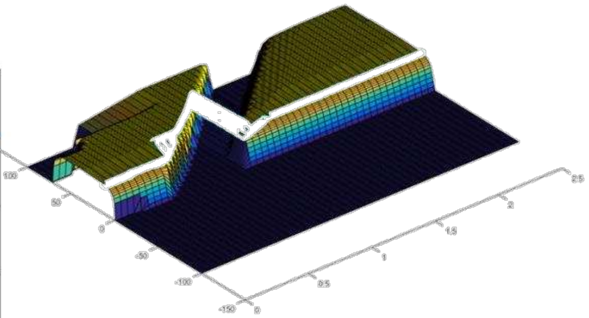
- Axle kinematic motion
- Vertical wheel motion => dip angle
- 3-*dof* wheel-track MBS model
- Dynamic $F_{vertical}$ prediction => P2 force











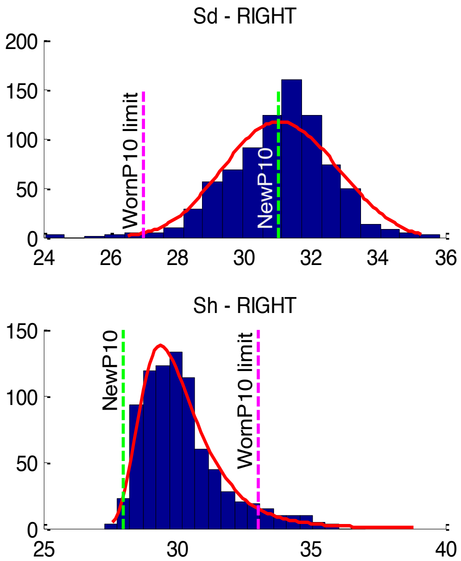
$$z_w(x) = z_r(x, y) + r_0 - \Delta r(x, y)$$

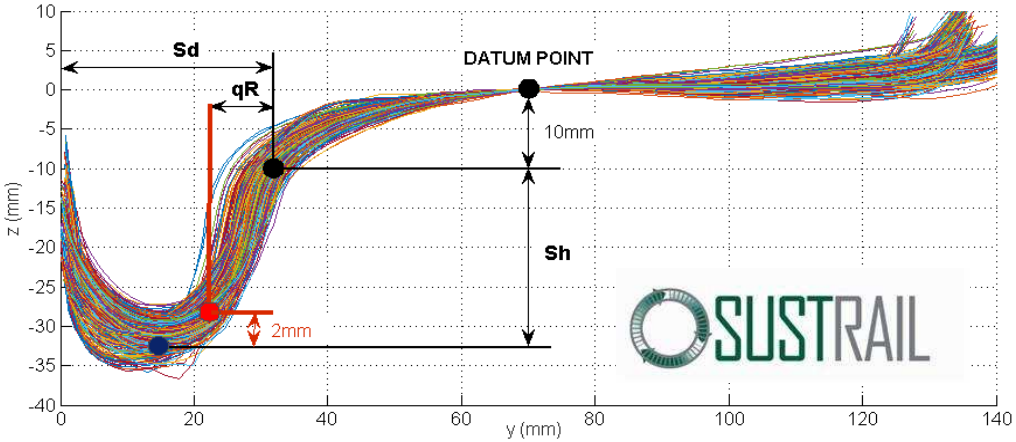
SUSTRAIL

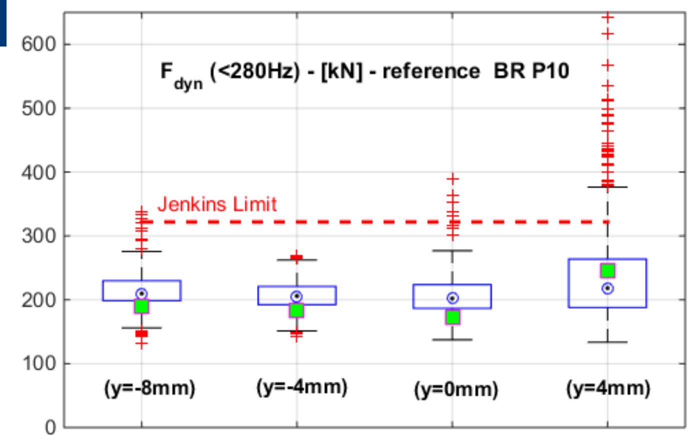
Example key output SUSTRAIL

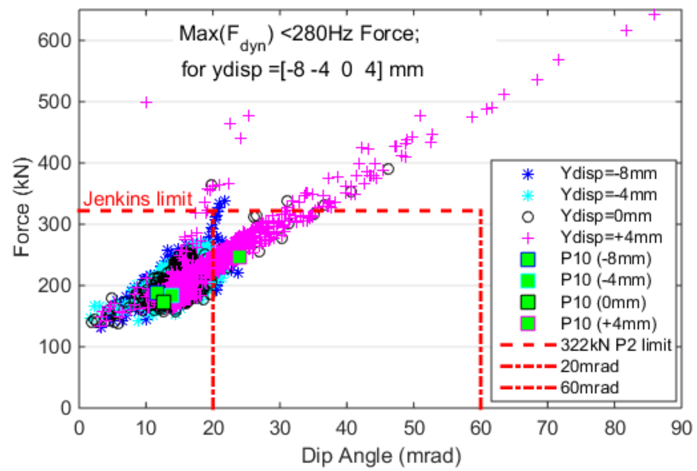
University of HUDDERSFIELD
Institute of Railway Research

- Parametric study: 800+ wheel pairs
  - Prediction of dip angle and P2 force levels









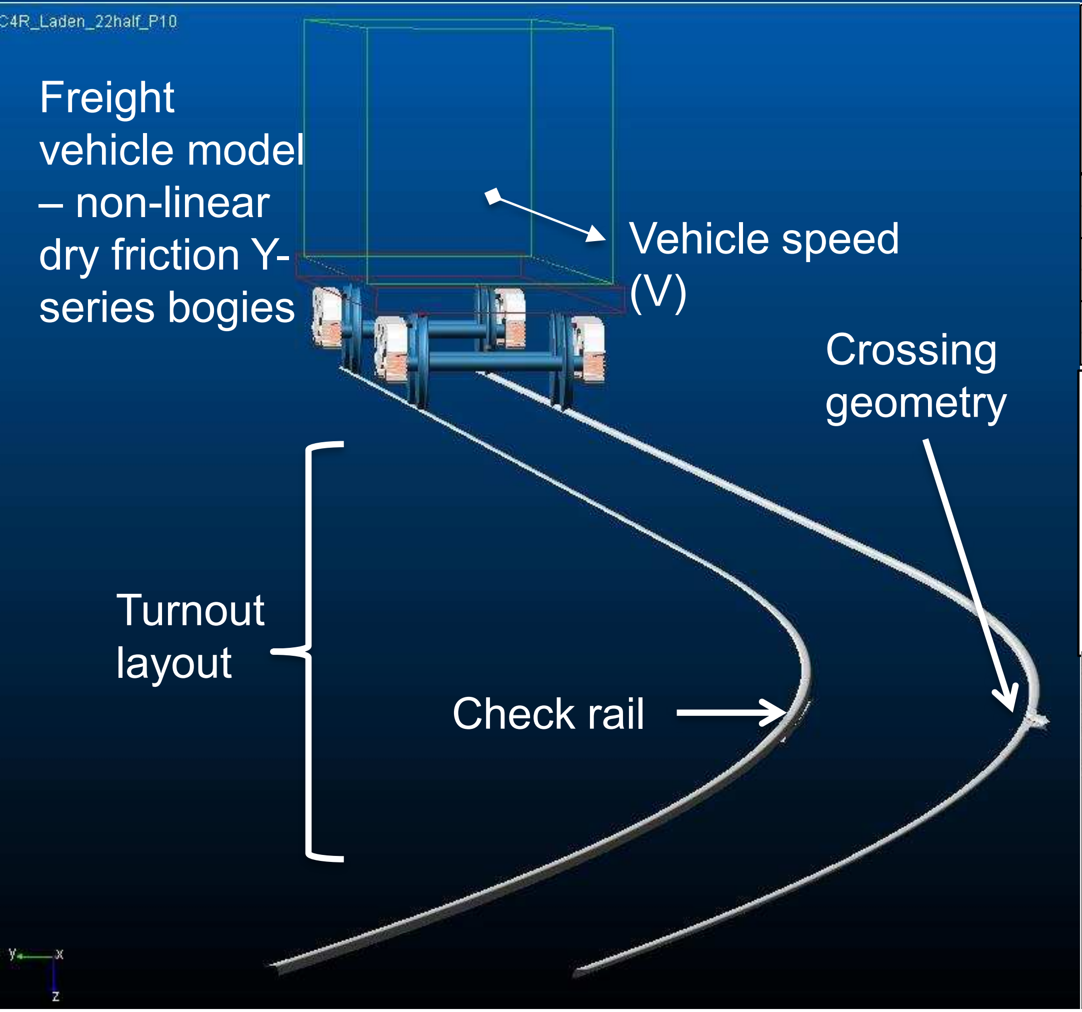
References:

BEZIN, Y., COLEMAN, I., GROSSONI, I., NEVES, S., HYDE, P., BRUNI, S., ALFI, S., RANTATALO, M., JÖNSSON, J., ASLAM, M., LAMBERT, R., BEAGLES, A., FLETCHER, D. & LEWIS, R. 2015. D4.4 Optimised switches and crossings systems, *SUSTRAIL 265740 FP7.*

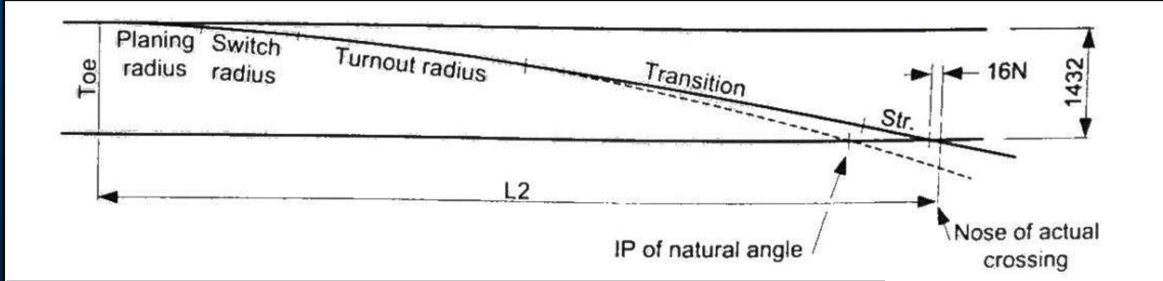
BEZIN, Y., GROSSONI, I. & ALONSO, A. 2014. The Assessment of System Maintenance and Design Conditions on Railway Crossing Performance. *Proceedings of the 2nd International Conference on Railway Technology: Research, Development and Maintenance.* Civil-Comp Press, Stirlingshire, United Kingdom.

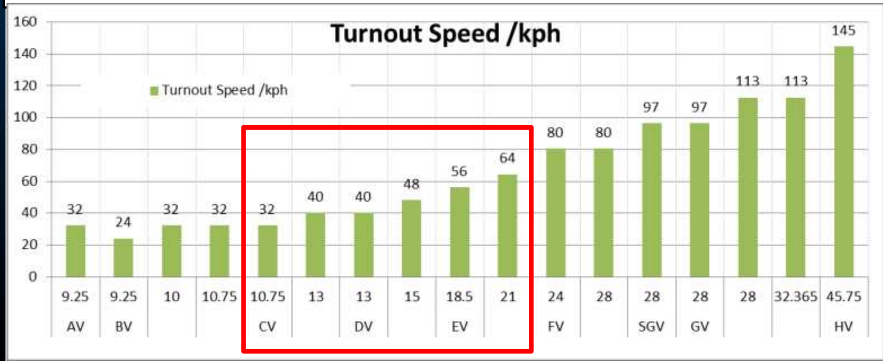
Example key activities Capacity4Rail

University of HUDDERSFIELD
Institute of Railway Research



Switch	Crossing 1in~		Lead Lengths			Radii			Length			Turnout Speed /kph
	Natural	Actual	Lead L2 Toe to nose	nose across a 1970 interval	Toe to toe	Planing radius	Switch radius	Turnout radius	Length of Plannin g P	Length of transiti on	Length of straight to nose	
CV	9.25	10.75	25448	5360	56256	287251	245767	245767	4250	7366	584	32
	9.25	13	27007	6513	60526	287251	245767	245767	4250	13000	3271	40
DV	10.75	13	30125	6513	66762	367038	331687	331687	5200	10630	964	40
	10.75	15	31713	7533	70960	367038	331687	331687	5200	17455	2534	48
EV	15	18.5	42017	9315	93349	739696	645116	645116	7000	16255	1560	56
	15	21	44066	10585	98718	739696	645116	645116	7000	24555	3605	64



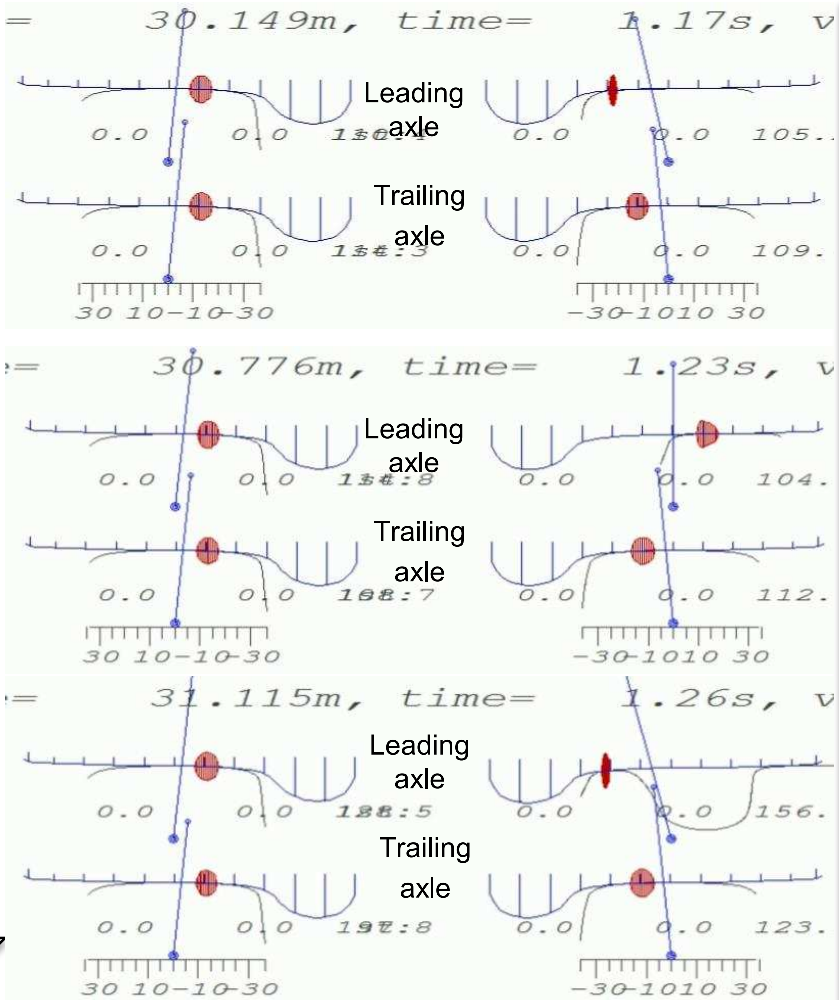


C4R
Capacity for Rail

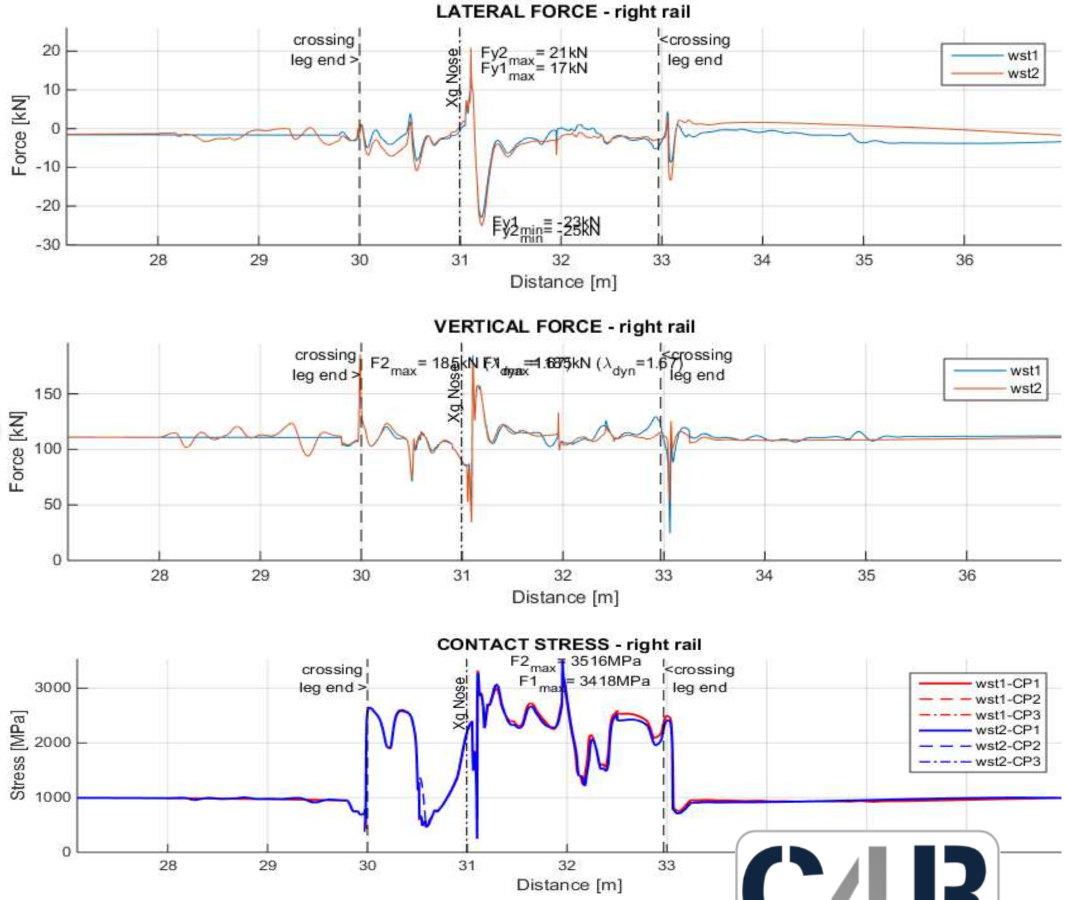
Example key activities Capacity4Rail

University of HUDDERSFIELD
Institute of Railway Research

Time simulation



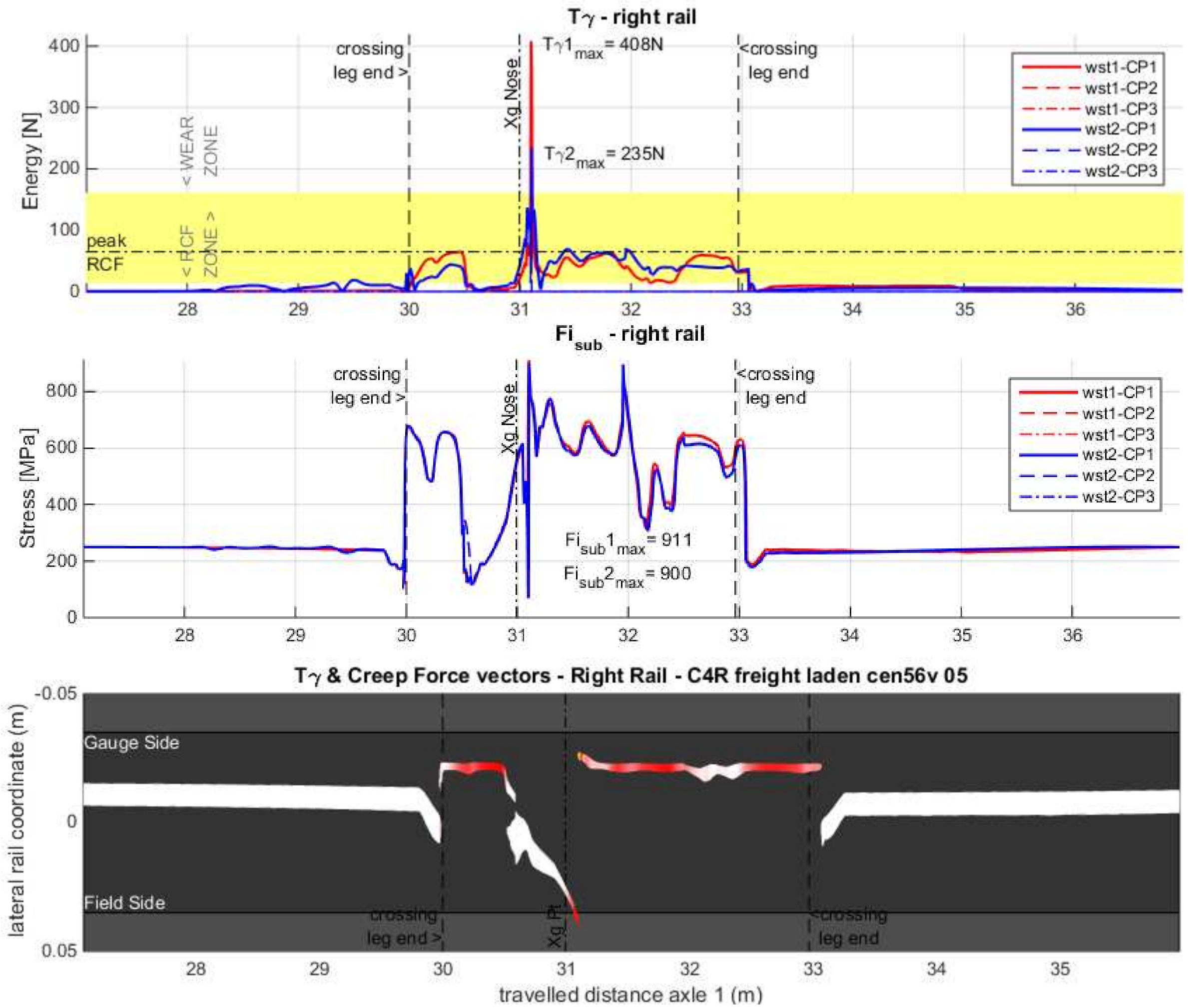
Prediction of contact condition using multi-Hertzian non-elliptical contact



C4R Capacity for Rail

Example key activities Capacity4Rail

University of HUDDERSFIELD
Institute of Railway Research

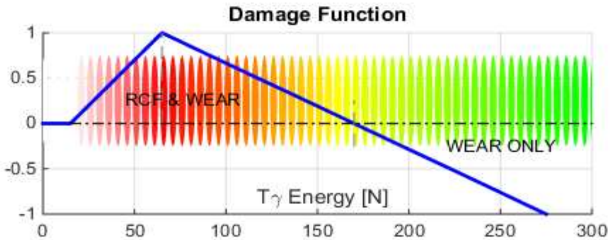


Damage indices prediction along crossing panel:

- Equivalent Hertzian pressure,
- Fi-surf,
- Fi-sub,
- Tγ damage (RCF/wear)

Visualisation of contact conditions and damage level:

- Position and size of contact patch(es),
- Colour coded damage level,
- Creep vectors,



C4R
Capacity for Rail

Key conflicting requirements

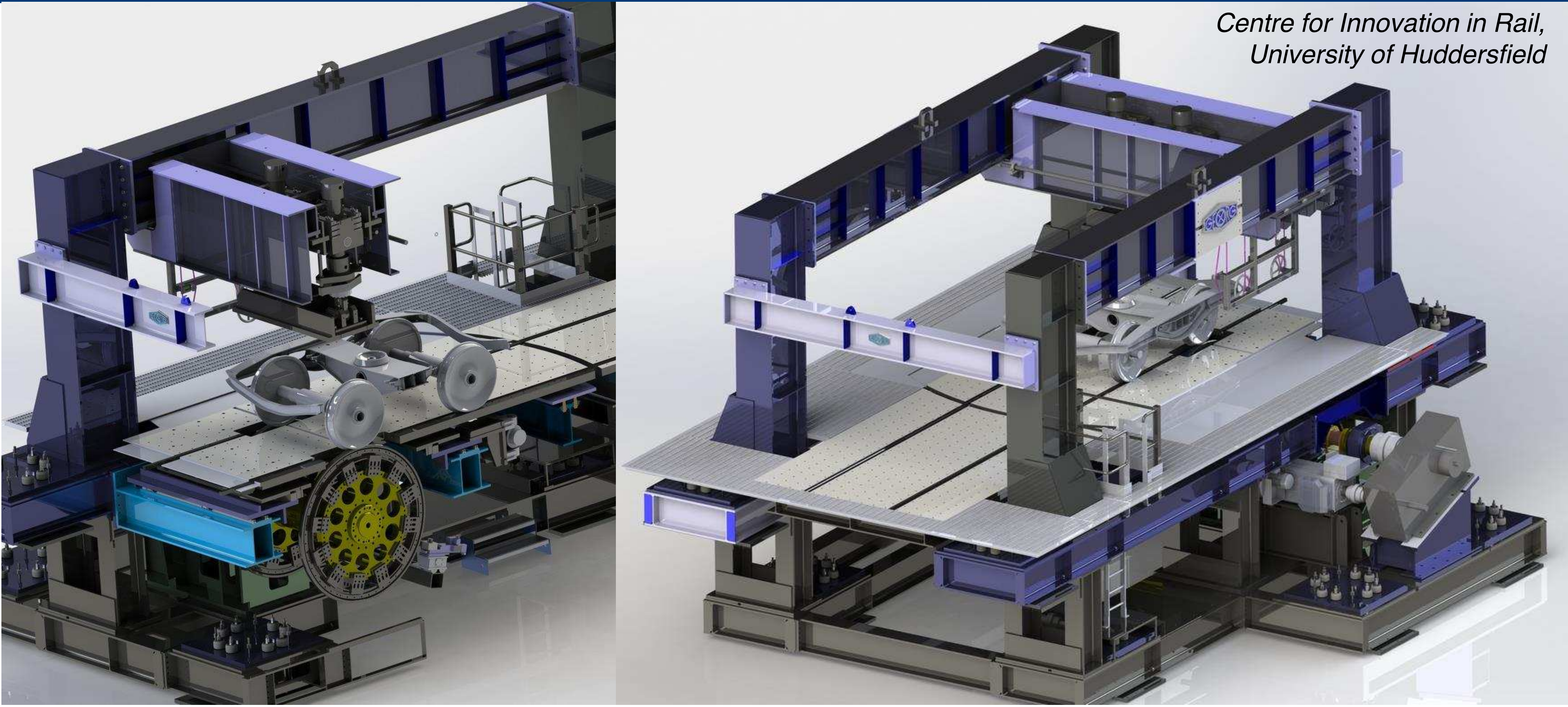
- Engineering design vs cost
  - Highly engineered material specification (at what cost?)
  - Resilient track construction (at what cost)?
  - Standardisation versus customisation?
- Through vs diverging route
  - Traffic mix consideration in design vs generic design!
  - Trade-off in rail shapes and layout geometry optimisation
- Facing vs trailing move
  - Trade-off in rail shape and layout geometry optimisation
- Wear vs RCF
  - Competing phenomena

Validation Challenges

- Validation of rail damage prediction
  - Based on specific site observation + stochastic data collection
  - Fast and reliable data collection (vehicle inspection vehicles?)
- Material characterisation data and experiments
  - Twin disc rigs for:
    - Wide range of traction and normal pressure
    - full scale where possible…
    - Replicating S&C 'harsh' conditions (high curvature)
    - Replicating S&C materials (cast Mn, EDH, hardened steel e.g. 350HT)
  - Plastic deformation
  - Residual strains in highly stressed contained material
- Full scale testing for close to reality WRI conditions…

Validation Challenges

University of HUDDERSFIELD
Institute of Railway Research



Centre for Innovation in Rail,
University of Huddersfield

University of HUDDERSFIELD
Institute of Railway Research

Few words of conclusion

- Key damage mechanisms in S&C relate to wheel-rail interface => *heavily strained interface!*
- Key areas of collaborative research are *geometry/shape optimisation* and *improved support stiffness* (upgrade to ballasted & novel track forms)
- Available simulation techniques enable *predicting key damages* (location, intensity and accumulation)
- exchange of *data* and *testing resources* is key to validation as a first step towards innovation selection and evaluation
- This is a system - consider both sides of the interface!
- Successful innovations depend on *exchange*, *collaboration*, *openness*, as well as individual/corporate *motivation to achieve a common goal*

University of HUDDERSFIELD
Institute of Railway Research

Thank you for your attention.

Contact: Yann Bezin (y.bezin@hud.ac.uk)

Acknowledgements:
Support from European Grants SCPO-GA-2011-265740 (SUSTRAIL), SCP3-GA-2013-60560 (Capacity4Rail) are gratefully acknowledged.
Software used: Vi-Rail (www.vi-grade.com) and ArgeCare (argecare.com)

SUSTRAIL

C4R Capacity for Rail

Inspiring tomorrow's professionals

THE AWARDS AWARD WINNER UNIVERSITY OF THE YEAR

theguardian UNIVERSITY AWARDS Winner 2013

2012 THE AWARDS WINNER Entrepreneurial University of the Year

THE QUEEN'S AWARDS FOR ENTERPRISE