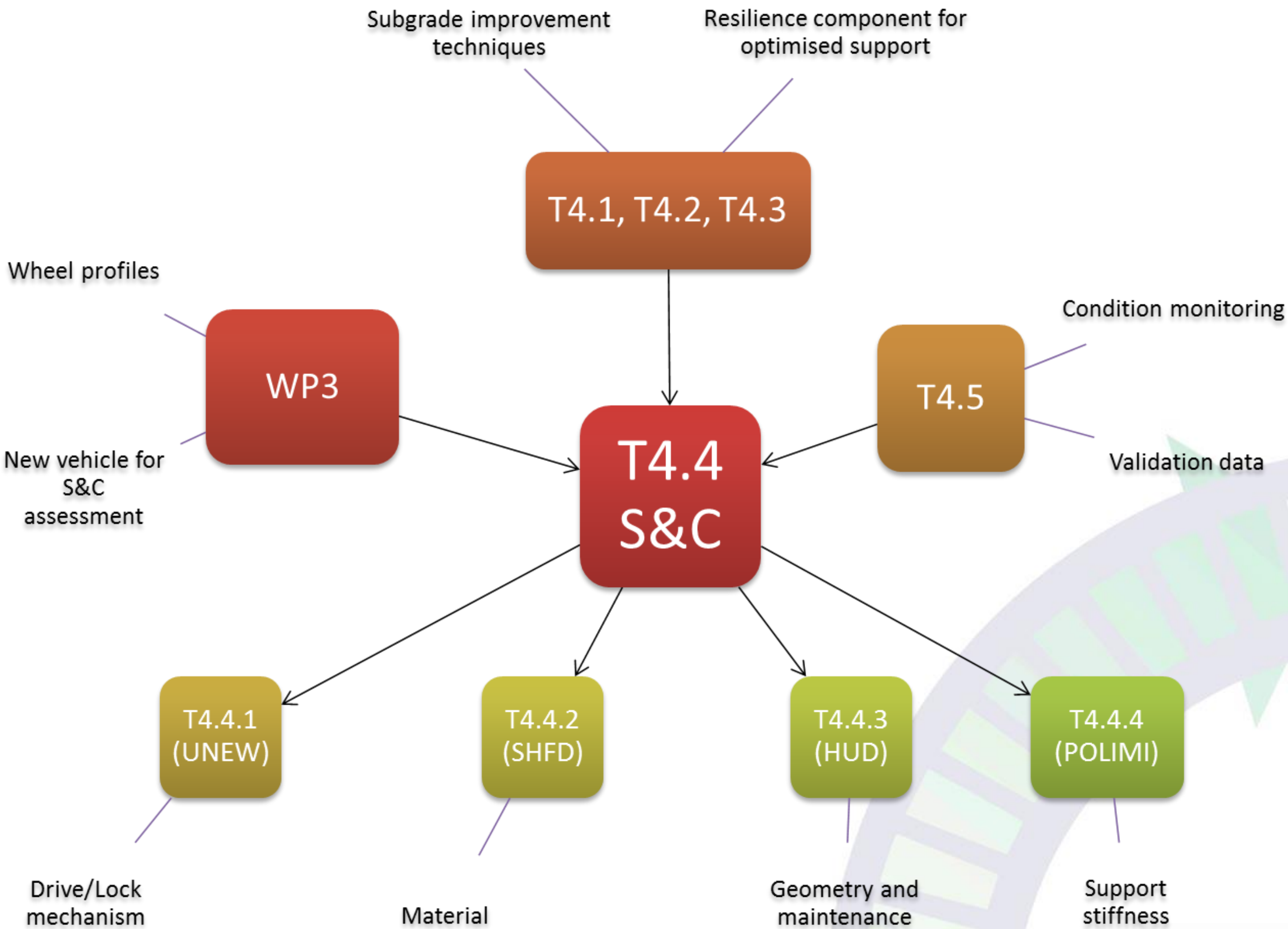
Mid Term Conference – 4th Dec 2013

T4.4 – Switches and crossings

T4.4: Switches & Crossings – integration with WP3/4



T4.4: Switches & Crossings - challenges

Switch/crossing dynamics

- reduce impact loads
- reduce the effect of geometrical discontinuities
- Use and design consistent support stiffness
- Use of premium materials

Drive & Lock Mechanism

- Increase reliability
- Plug & Play + backward compatibility
- Automatic fault detection and intelligent monitoring
- Embedded in bearers to allow mechanical maintenance

Movable interface

- increase reliability
- reduce requirement for maintenance

Areas of work identified based on preliminary review of previous research (document to be appended to D4.4).

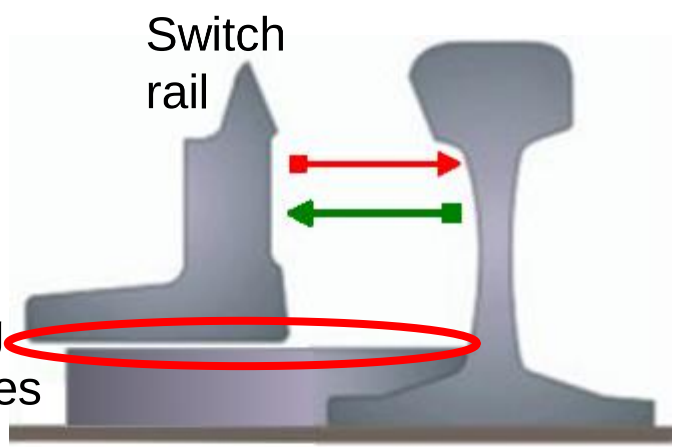
- **T4.4.1 Drive and lock mechanisms**
  - Implementation of INNOTRACK Recommendations in SUSTRAIL
- **T4.4.2 Materials and switch blades sliding surfaces**
  - Lubrication material for switch rail on heel baseplates
  - Fastening resistance of switch bars/drive under repeated loading
- **T4.4.3 Interface geometry and maintenance rules**
  - Effect of wheel/rail + track geometry on S&C dynamics
- **T4.4.4 Support stiffness through S&C**
  - Investigation of variable vs consistent support stiffness
  - Use of resilient pads (under sleeper, baseplate, ballast mat)

Optimal S&C Drive and Locking Mechanism Configuration

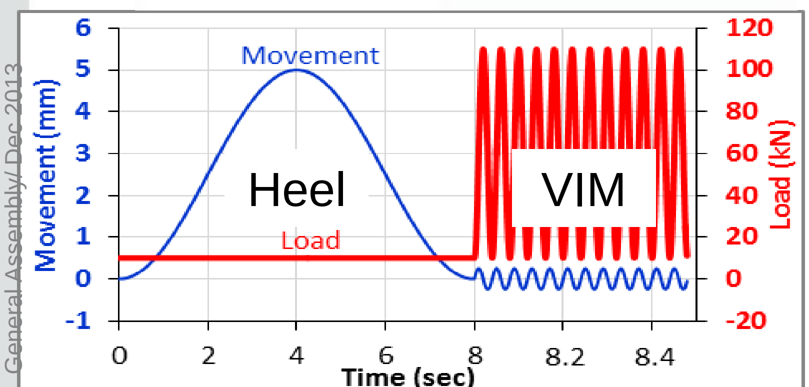
- **Drive, locking and detection mechanism integrated into hollow bearer arrangement is most beneficial:**
  - Allows tamping access to maintain uniform support stiffness
  - Proven to be technologically feasible
- **Standardised bearers, mounting, S&C design, interlocking interface would allow economies of scale and increase applicability of innovations.**
- **Computer based interlocking interface would enable access to condition monitoring of DLM and S&C unit**
- **Potential to reduce maintenance and delay costs with condition monitoring, move to condition-based maintenance**

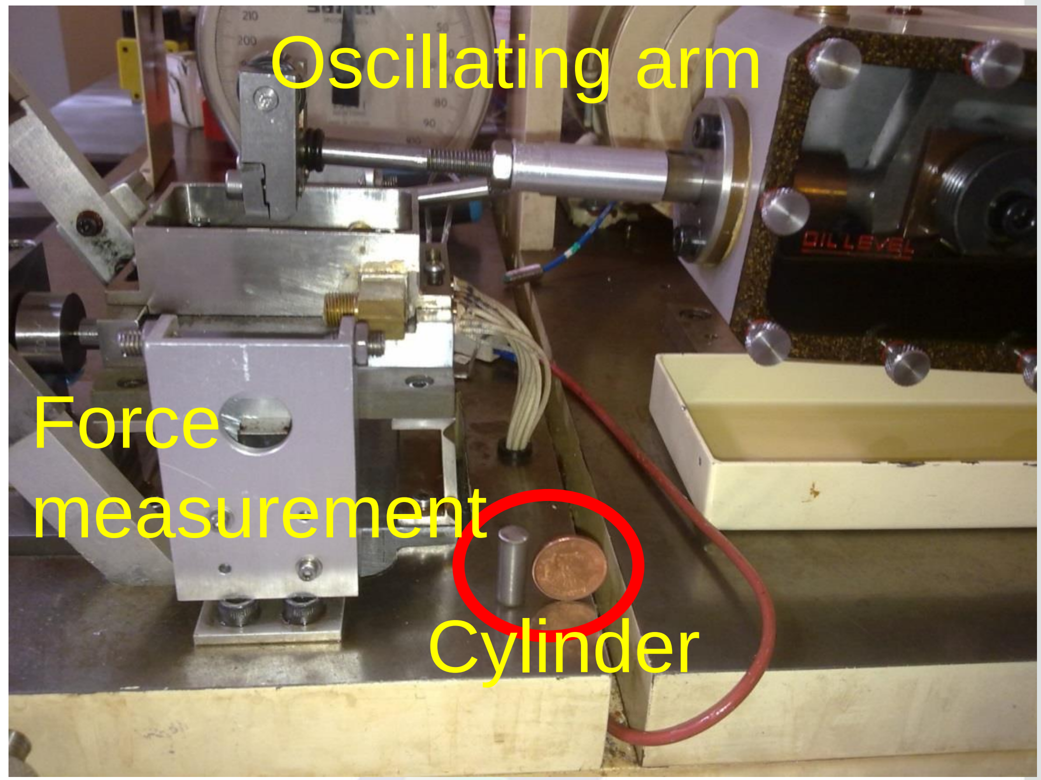
Testing Switch Slide-plate Lubrication

- First phase of small-scale testing completed



- Two load environments

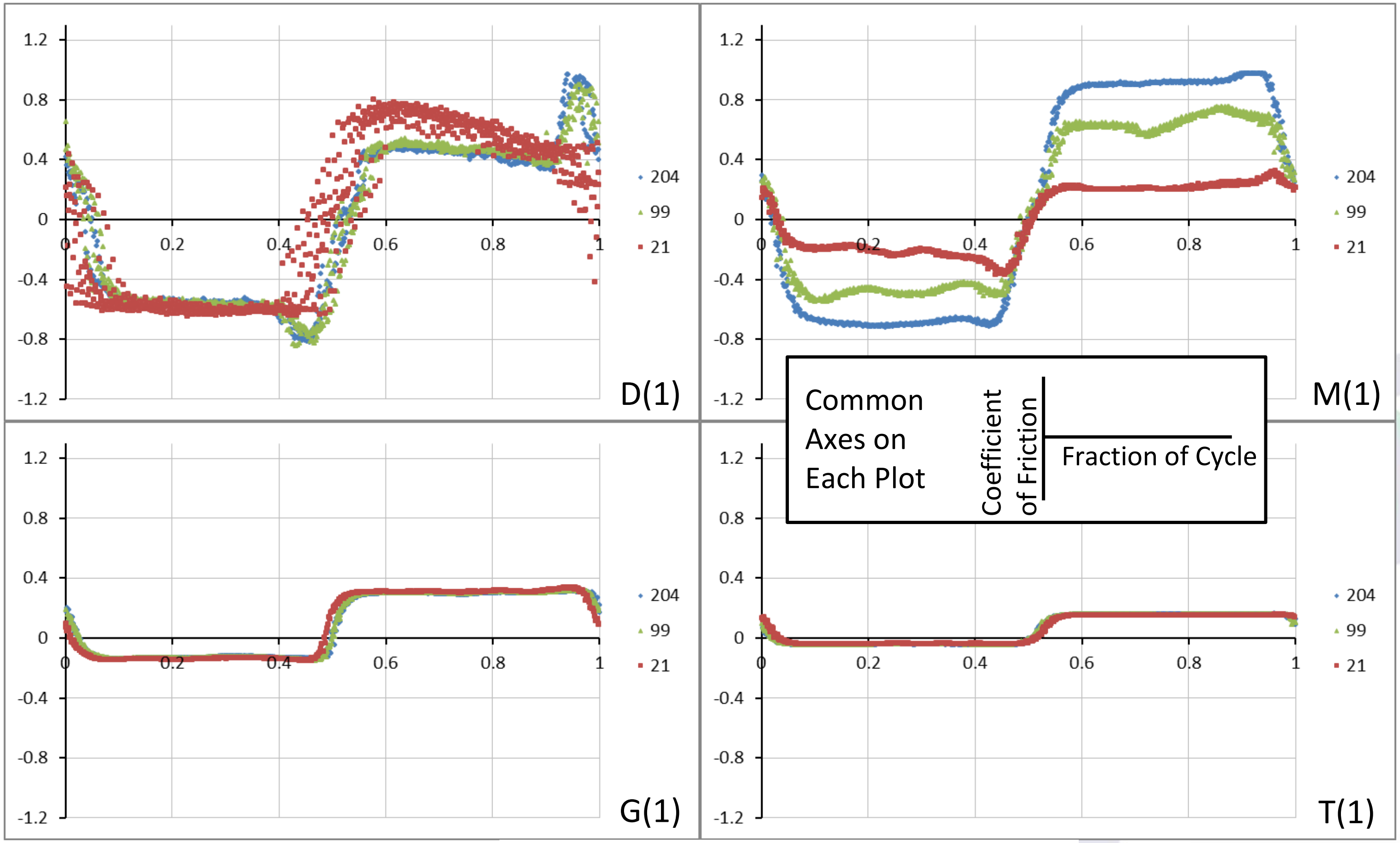




VIM: Vehicle Induced Motion

VIM loading

- D: Dry, M: MoS_2, G: Grease, T: Teflon

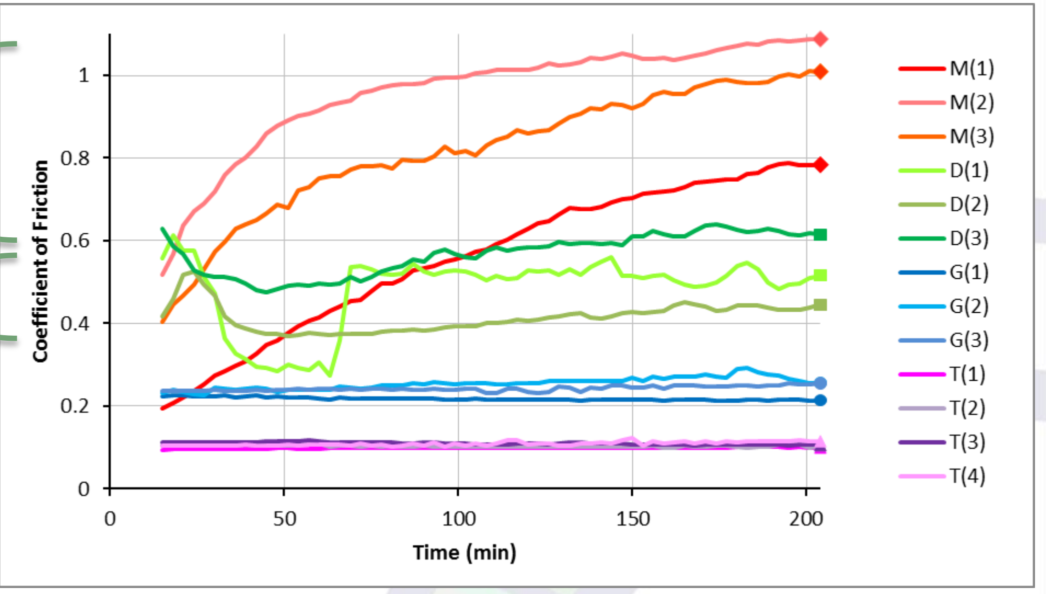


Beginning, Middle, End of Test

Task 4.4.2 – Materials: Preliminary Findings

Small-scale testing

- **Grease and Teflon both exhibit consistent low-friction performance under both heel and VIM loading and (in clean laboratory conditions) maintained this for two months of simulated life**
- **MoS_2 coating rapidly wears away under VIM loading**
- **Unlubricated (dry) surface is associated with highest friction under heel loading**

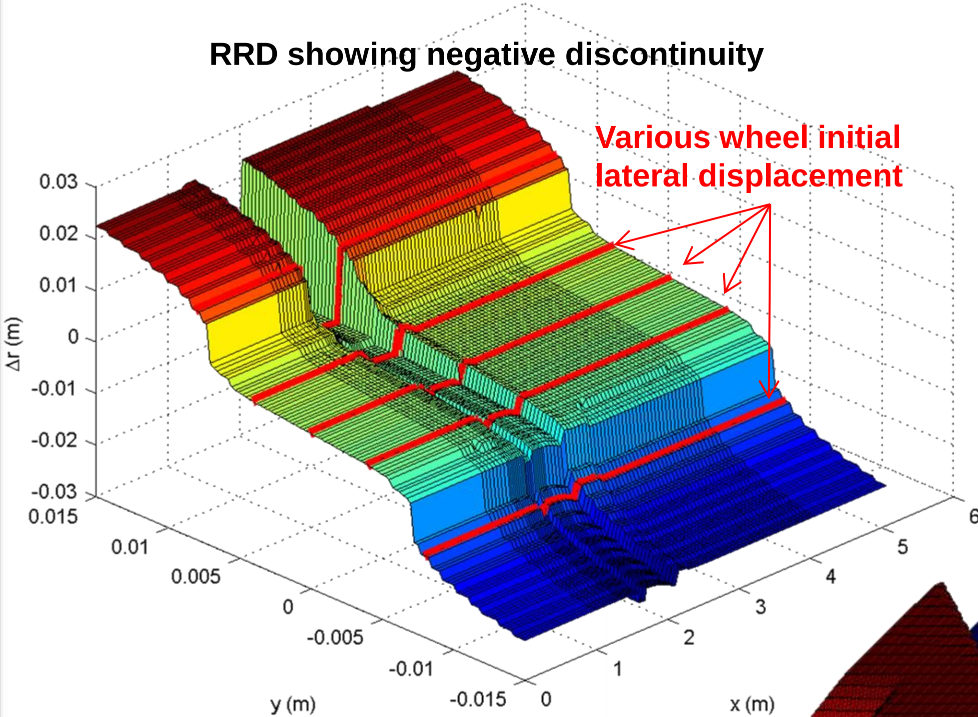


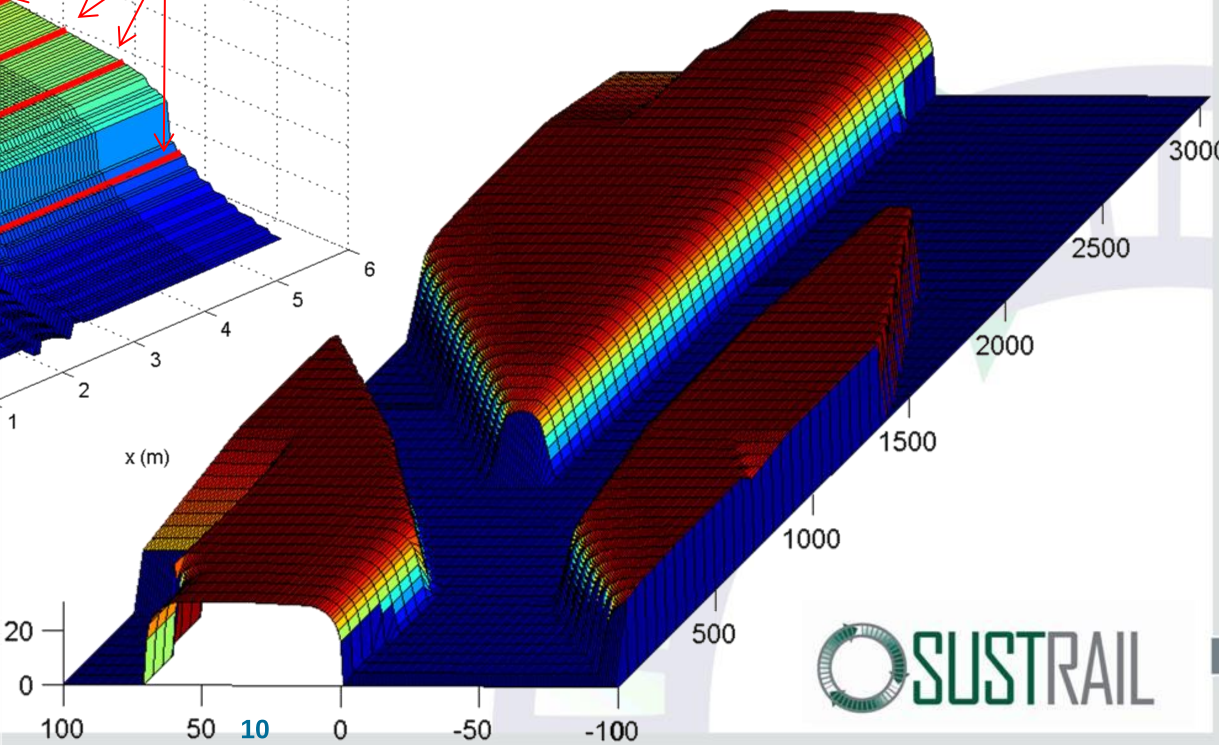
Investigation on crossing dynamics

- **Most relevant issues (NR source 2013)**
  - Squat on casting
  - Crossing nose wear / lipping /
  - Shelling of running surface of casting
  - Transverse cracking of casting (crossing vee/wing rail/foot)
  - Transverse defect from RCF
  - False Flange damage
  - Etc...
- **All above derived from wheel transfer impact load**
  - Implication of crossing maintenance (grinding/welding/wear)?
  - Implication of vehicle suspensions/wheel conditions?
  - Implication on ballast degradation, voiding, and general support conditions?

Modelling the dynamic interaction at crossings

- Kinematic motion of wheels (z,y) predicted from W+R geometries – derived Rolling Radius Difference

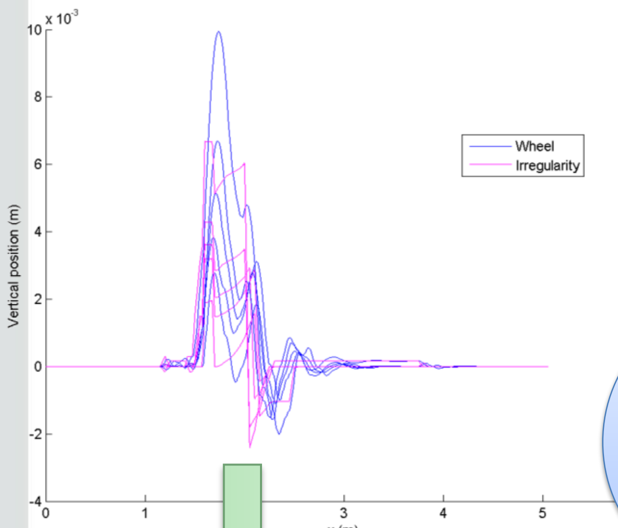




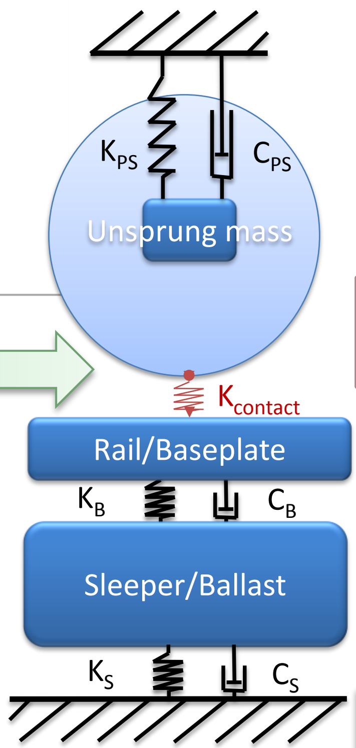
SUSTRAIL

Modelling the dynamic interaction at crossings

- Multibody system model to predict vertical dynamic interaction forces

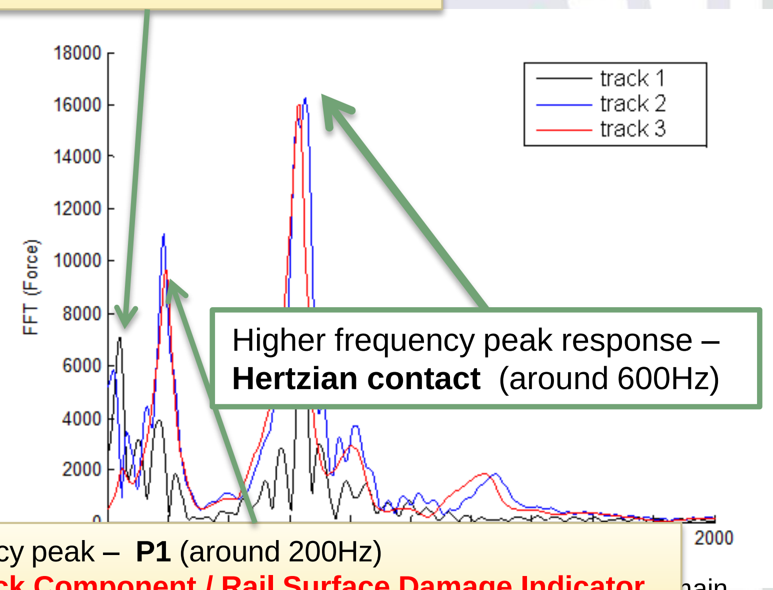


Vertical motion of wheel through crossing as input irregularity



Predicted output force (time and frequency domain)

Low frequency peak response –
P2 (around 50Hz)
Mainly Track Ballast Damage Indicator



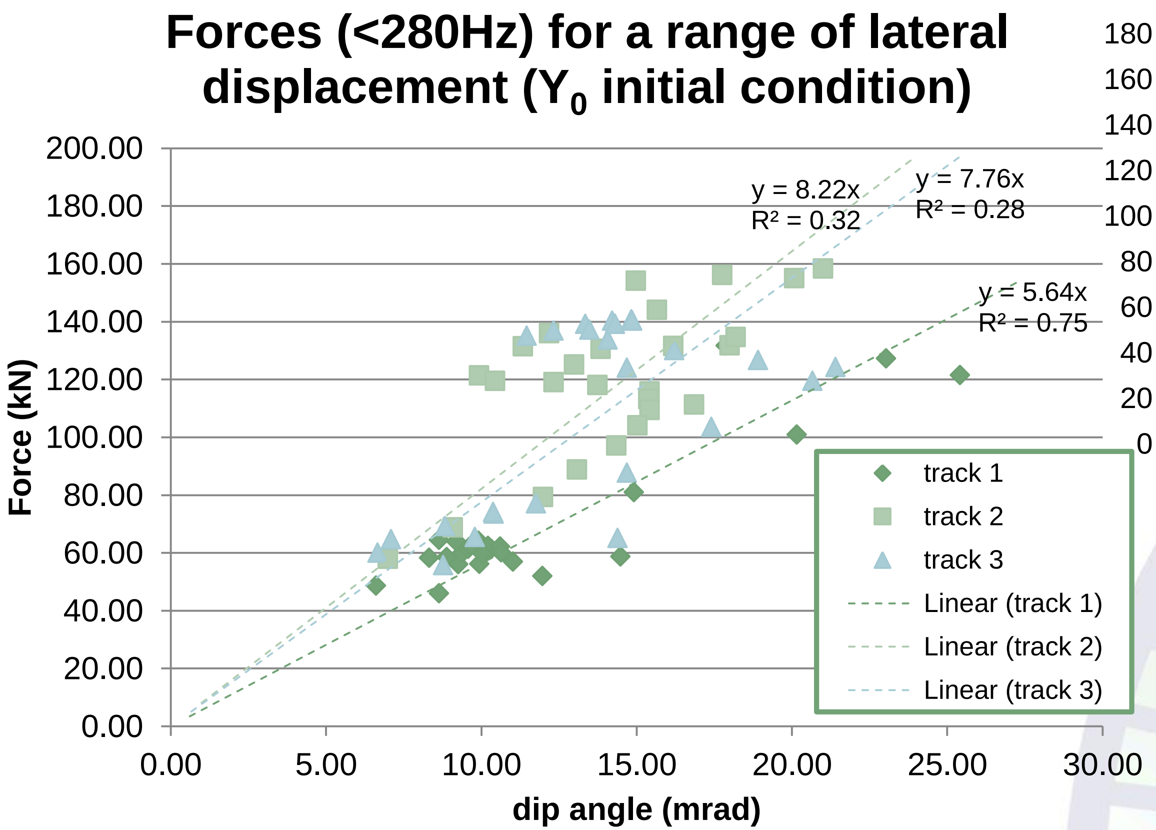
Higher frequency peak response –
Hertzian contact (around 600Hz)

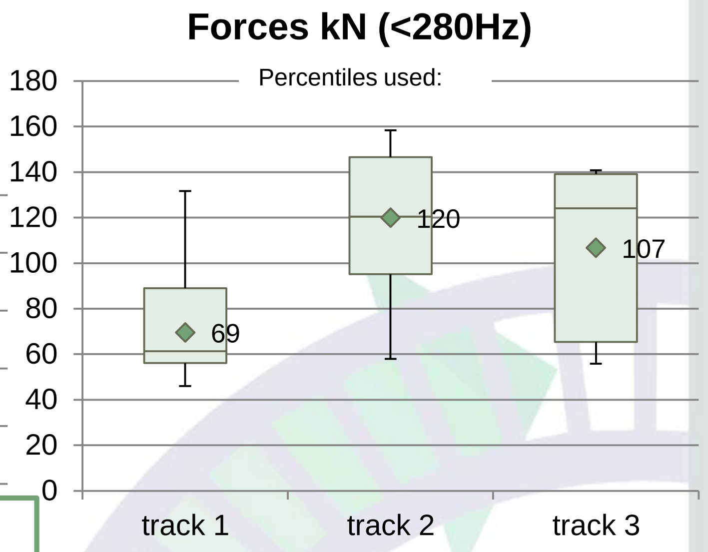
2nd frequency peak – **P1** (around 200Hz)
Mainly Track Component / Rail Surface Damage Indicator

T4.4.3 – Geometrical interface performance

Performance of different crossing geometries

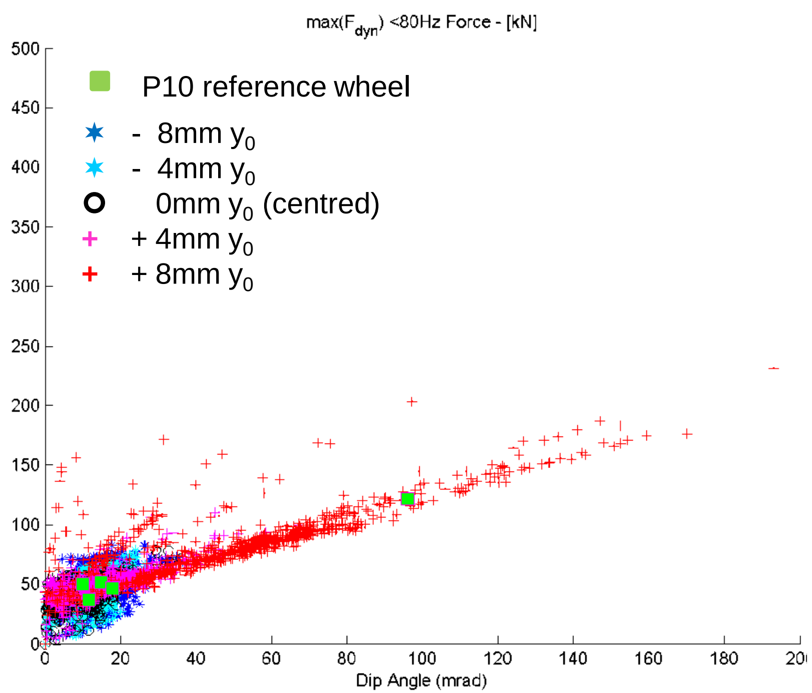
- Strong correlation between F_{max} and equivalent dip angle
- Variability of wheel path taken into account

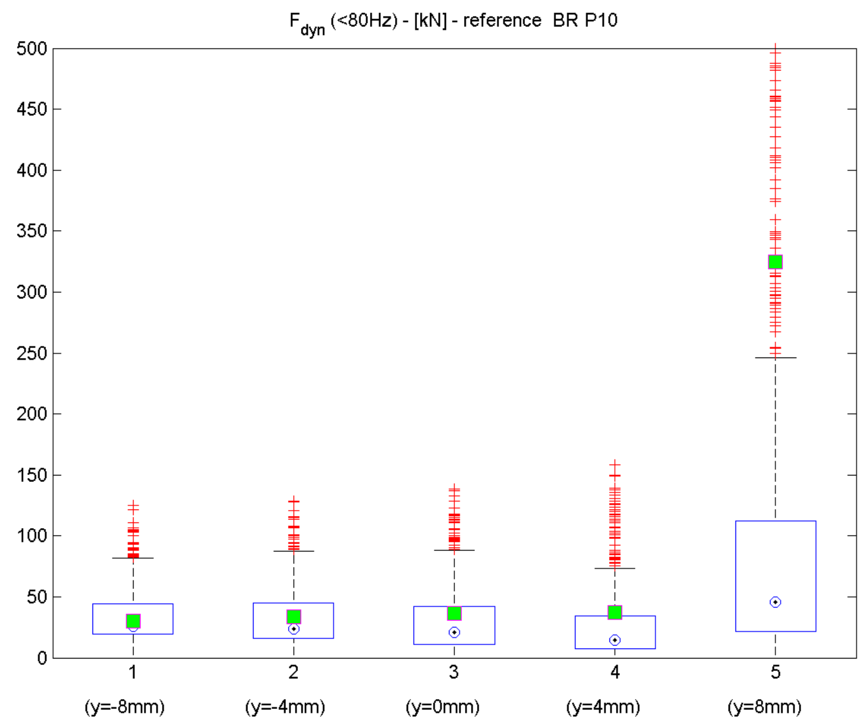




Performance of based on different wheel shapes

- Highest Forces for wheel towards flange contact on Xg
- Worn wheels (831 pairs) highlight statistical spread of results



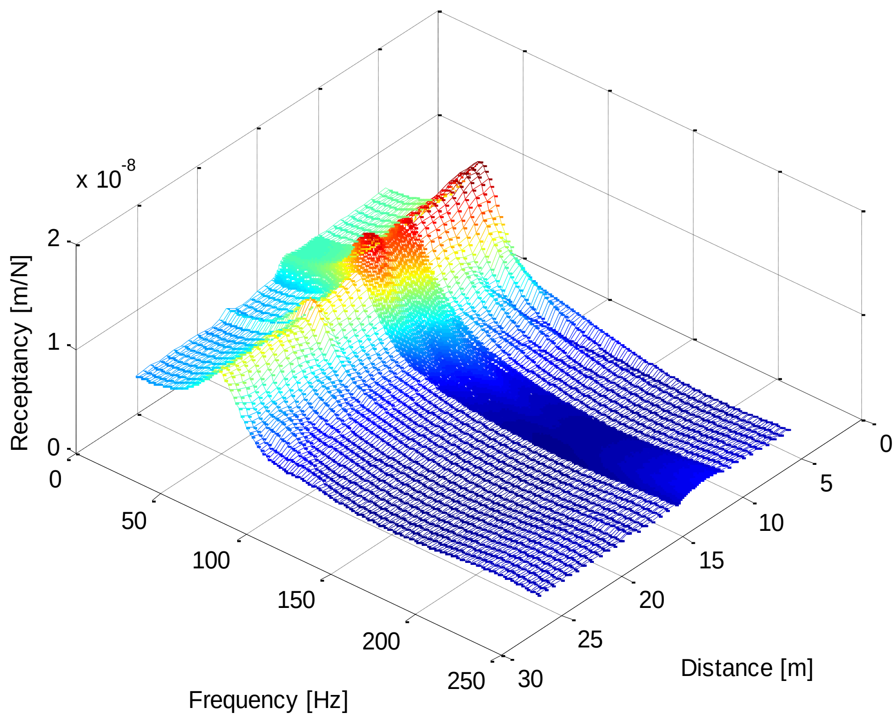


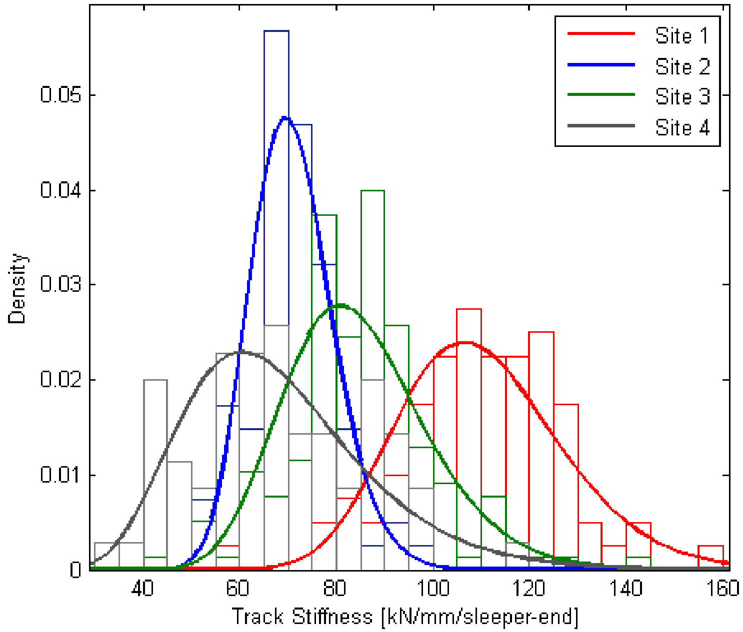
Large dip angles and forces seen for flange contact conditions (y=+8mm)

Standard value used for fatigue calculation = 20mrad

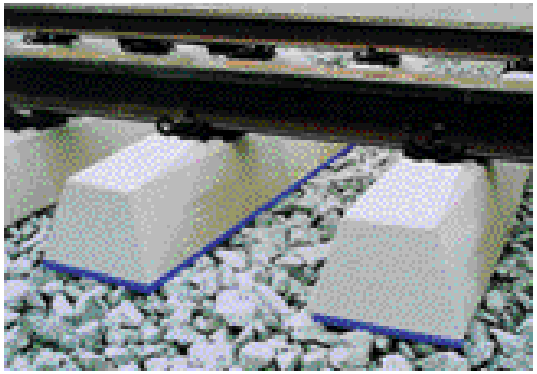
Consideration for track stiffness properties at S&C

- High degree of variation of ballast stiffness (site to site, sleeper to sleeper)
- Local discontinuities (rail section change, rail support change, sleeper length variation, discrete support, voids, etc)





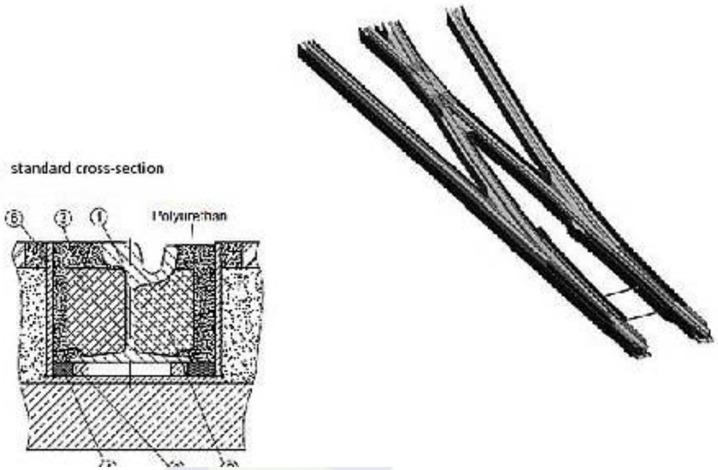
Examples of existing practical implementations



Sylomer® UnderSleeper Pads

ERL - Elastic Ribbed Plate Support

USP by Getzner



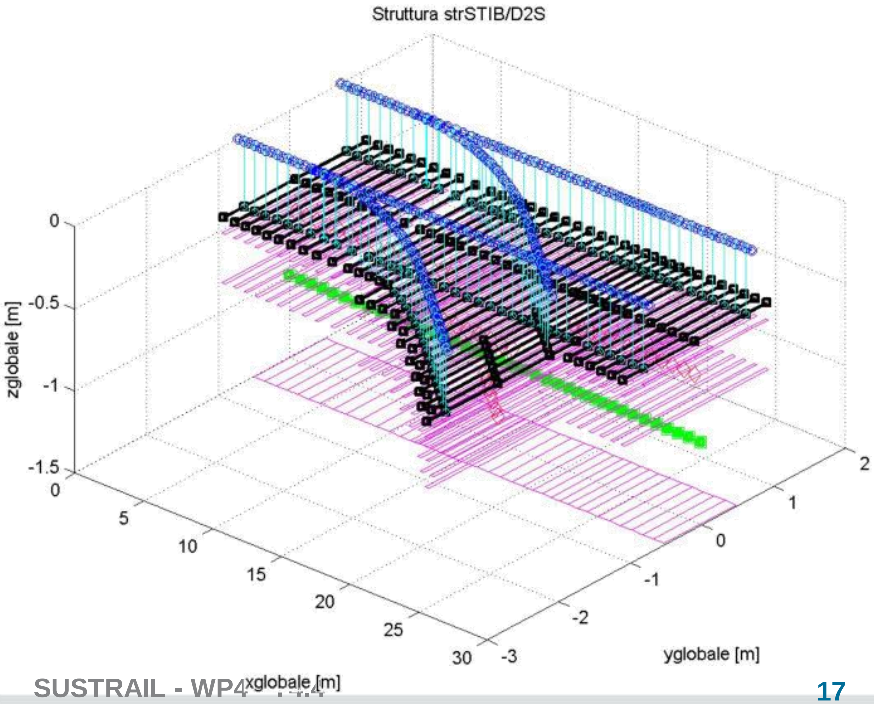
Elastic grooved rail turnout by Thyssen-Krupp

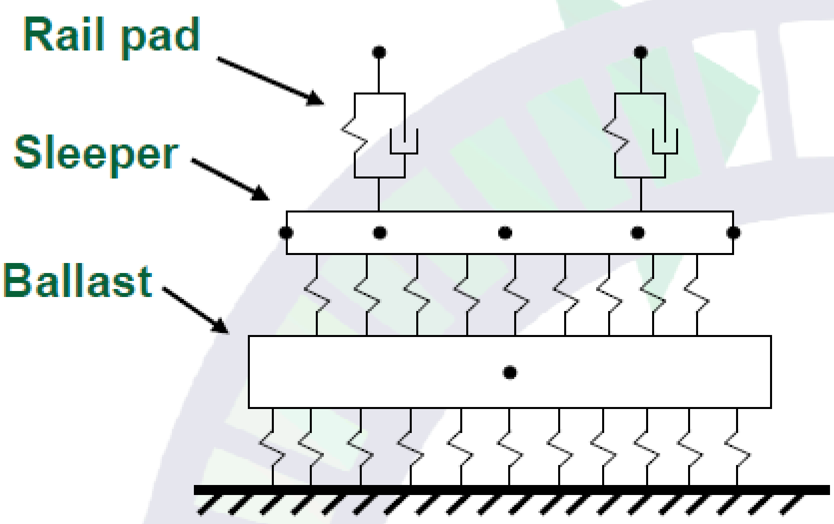
FE model of the track

- Complex turnout rail geometry fully considered
- Reproduce track flexibility variation along the turnout

FE model of the track

- Rails and sleepers schematization through beam elements
- Rail fasteners schematization through lumped parameter spring/damper elements
- Ballast representation through a lumped mass and two layers of viscoelastic elements





T4.4 – Validation and supporting data

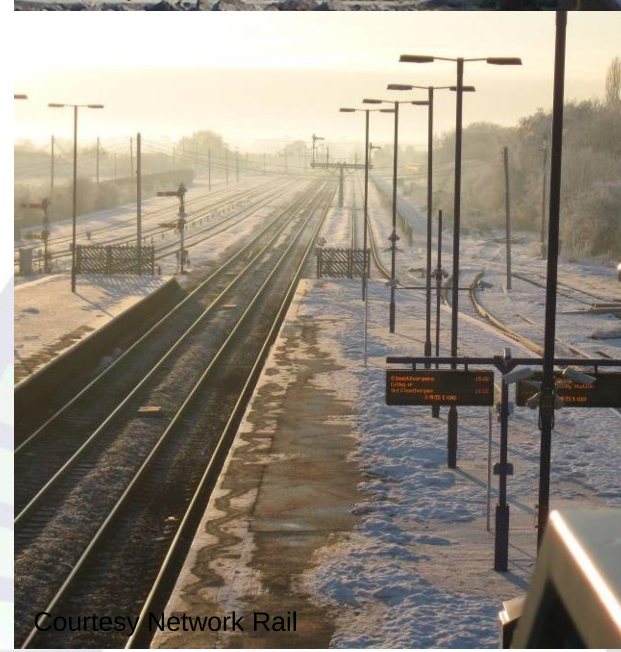
UK test site on crossing - Wrawby

- Crossing geometry (full cant, half cant)
- Explosive Depth Hardening
- Under sleeper pads

UK test site for full S&C

- East Coast Main Line
- 2 S&C on same line (same traffic)
  - One standard installation
  - One with under sleeper pads
- Geometrical survey
  - Track geometry
  - MiniProf measurement
  - Accelerations
  - receptances

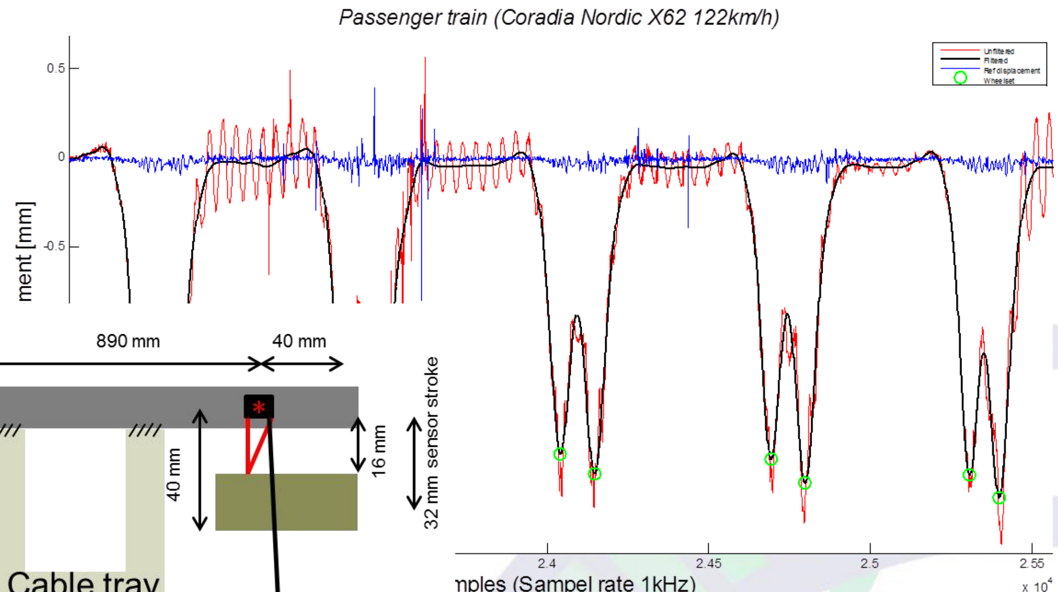
Courtesy Network Rail

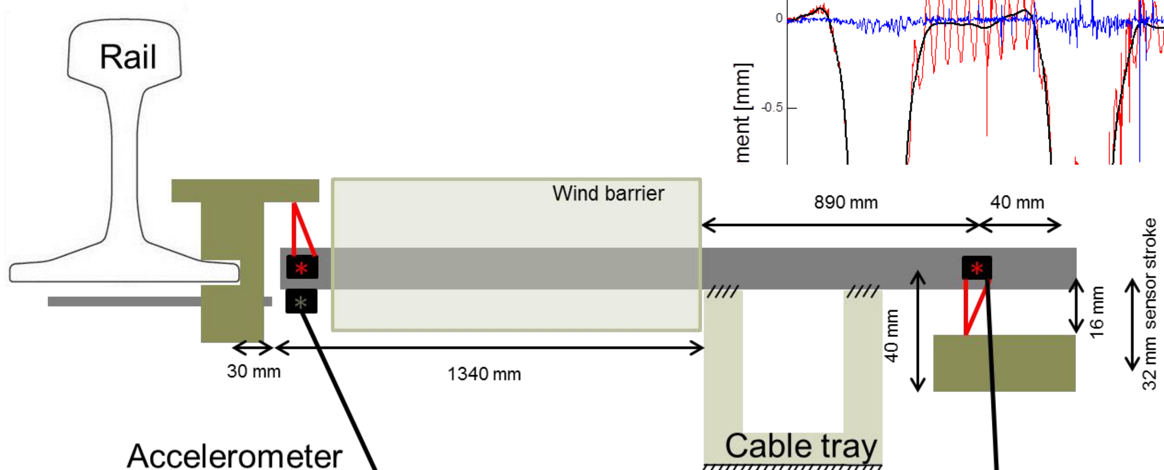


Courtesy Network Rail

Validation data from Swedish site (LTU) measuring

- Track deflection under known service loads used to derive stiffness at S&C





Measurement performed between two sleepers

Achieved so far

- Comparative assessment of various lubricants vs dry for switch blades sliding surface performance
- Suit of dynamics simulations tools (vertical MBS and full FE) developed and used to
  - assess various crossing geometries, their interface with worn wheels and varying support stiffness

Next steps

- Application of INNOTRACK recommendation to SUSTRAIL routes for LCC
- Premium material for switch and crossing parts
- Recommendation for vehicle/crossing geometrical interface performance
- Full assessment of the dynamics performance of S&C using lower resilience support stiffness components