RIVAS 1st workshop

WP3: Mitigation measures on track

14th september 2011

WP3: overview

Partners: ADIF, ATSA, BAM, CEDEX, Chalmers, CSTB, DB, D2S, ER, KUL, Pandrol, RailOne, Sateba, SBB, SNCF, Vibratec

The scope of this WP is to tackle ground vibrations at source by developing and optimising mitigation measures on the track itself. Activities comprise ballasted in-line track, curves, switches and slab track.

The expected reduction of ground vibration for different configurations of tracks and soils, the installation features, the consequences onto the track maintenance, the costs will be provided for each mitigation measure.

WP3: overview

- Task 1: state-of-the-art
- Task 2: mitigation measures for ballasted track
- Task 3: mitigation measures for ballasted curves and switches
- Task 4: mitigation measures for in-line slab track

WP3: task 1

Task 1: State-of-the-art

The compiled document gathers the different mitigation measures on track. It proposes technology assessments of existing vibration mitigation measures and definition of priorities for further work

Classification: (benefit = positive insertion loss)
Class A: benefit < 5 dB
Class B: benefit 5 – 10 dB
Class C: benefit 10 – 20 dB
Class D: benefit > 20 dB

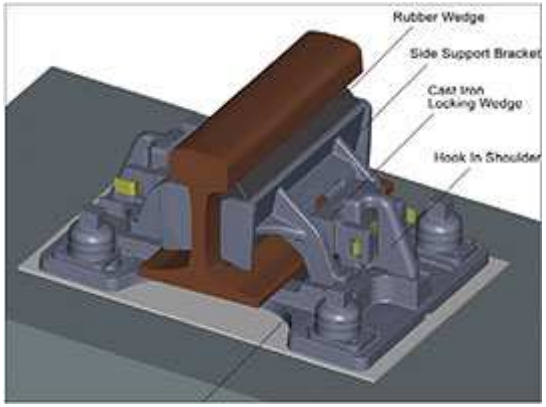
T1: State-of-the-art

Modification of the super structure:

- Resilient rail fastening system
- Under-sleeper pads (ballasted track)
- Booted sleeper (slab track)

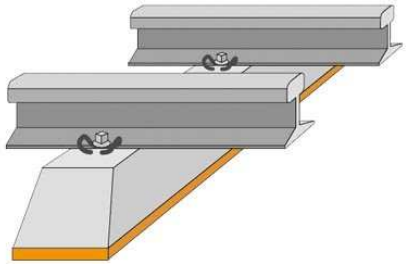
T1-SoA: resilient fastening system

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
Slab track with VANGUARD baseplates (dynamic vertical stiffness of the order of 10 kN/mm)	Tung Chung line, Hong Kong; Measurement points: close to track	Passenger train, 10 – 13 tonne axle load, 60 km/h	300 EUR/m (baseplates without installation)	31,5 Hz 1/3 octave band and above; **benefit: class B**
Slab track ZÜBLIN with **resilient BWG fastening system**	Mainline, Germany; Measurement points: 8 m beside the middle of the track	ICE, 160 km/h	No information	31,5 Hz 1/3 octave band and above; **benefit: class C**
Soft under baseplate pads	**Test bench** in France, 4 baseplate pads with different stiffness	2 static loads (90 kN/ 120 kN), dynamic excitation: 8 Hz – 400 Hz	No information	63 Hz/ 80 Hz 1/3 octave band and above, resonance of the system around 40 Hz; **benefit: class B/C**



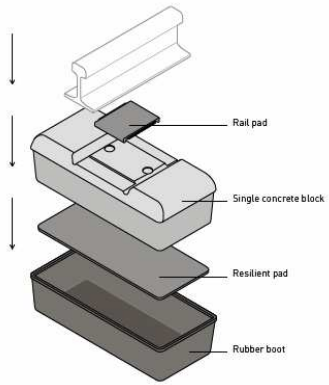
T1-SoA: under sleeper pads (BT)

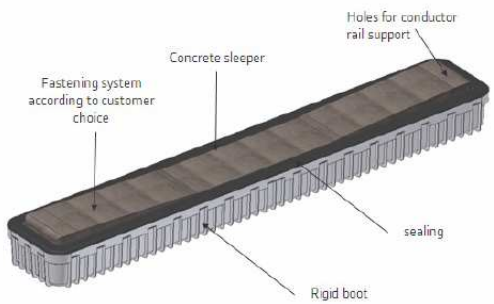
Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
Ballasted track with B70 concrete sleeper + sleeper pads	Mainline, Germany; Measurement points: 8 m beside the middle of the track	ICE, 160 km/h	90 EUR/m for new lines, 250 EUR/m for upgraded lines (costs for sleeper-dismantling included)	31,5 Hz 1/3 octave band and above; **benefit: class B**
Ballasted track + sleeper pads	Different sites in Switzerland	No information	No information	31,5 Hz 1/3 octave band and above); **benefit: class B/C**
Under sleeper pads	**Test bench** in France, 2 different types of sleeper pads	2 static loads (90 kN/ 120 kN), dynamic excitation: 8 Hz – 400 Hz	No information	63 Hz/ 80 Hz 1/3 octave band and above, resonance around 40 Hz; **benefit: class B/C**



T1-SoA: booted sleepers (ST)

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
LVT HA	EIFFAGE-RAIL, Germany; Measurement points: 0 m, 8 m, 16 m	Unbalanced mass generator “Dynaq”, 10 Hz – 100 Hz	Only available for test section	40 Hz and above; **benefit: class A, partly B**
HAS	Metro (16 t axle load); Measurement points: 4 m beside the track, both sides	Metro, 30 km/h and 60 km/h	No information	Above 100 Hz compared with a ballasted track as reference; **benefit: class A to B**





T1: State-of-the-Art

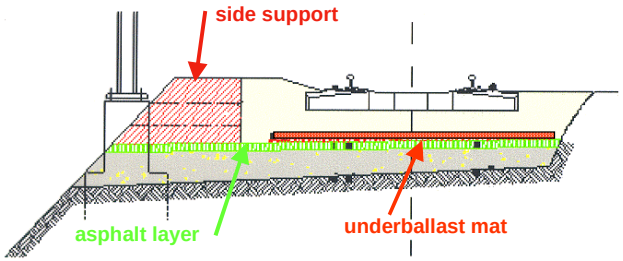
Ballasted track: **modifications of the infrastructure**

- Under ballast mats,
- ballasted trough with under ballast mat,
- concrete slab in the ground+soft under ballast mat

T1-SoA: under ballast mat

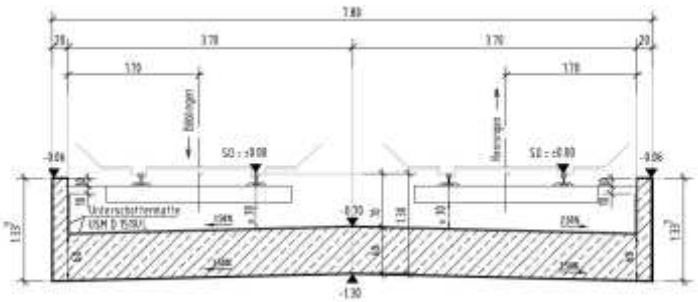
Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
Ballasted track with under sleeper mat	Mainlines in Switzerland, Germany and other European countries	Trains (no further information)	25 EUR/m^2 – 90 EUR/m^2 (Germany)	40 Hz 1/3 octave band and above, **benefit: class B/C**

Underballast mats for surface track



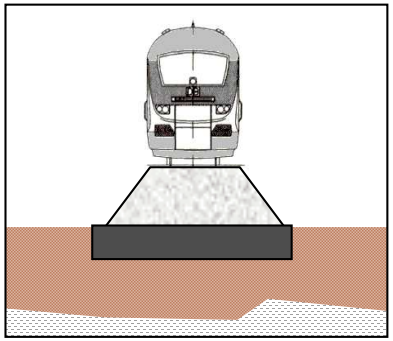
T1-SoA: ballasted trough

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
Ballasted trough with under sleeper mat for ballast protection	Mainline, Germany; Measurement points: 4 m and 12 m beside the middle of the track	Suburban trains (ET 420), 60 km/h and 120 km/h	1.200 EUR/m (higher for short troughs or poor ground conditions)	16 – 31,5 Hz and above 63 Hz 1/3 octave band, no negative insertion loss even at about 40 Hz 1/3 octave; **benefit: class B**



T1-SoA: slab in the ground

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
Concrete slab in the ground (without/ with under ballast mat)	Mainline, Germany; Measurement points: 8 m beside the middle of the track	Suburban and freight trains, 40 km/h	Not available	Without under ballast mat: close to 0, with soft under ballast mat: 8 Hz 1/3 octave band and above with resonances at 16 Hz and 31,5 Hz; **benefit: class B, partly C**



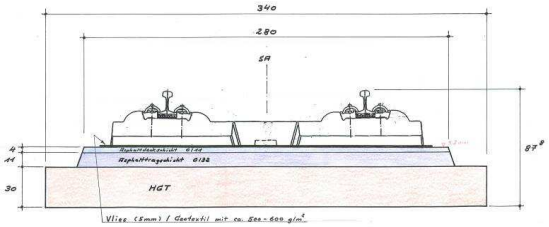
T1: State-of-the-Art

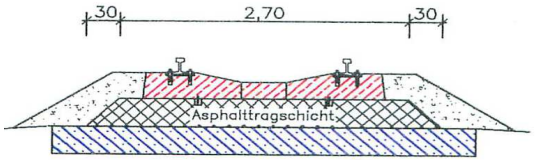
Slab track: modification of the infrastructure

- Asphalt layer
- Continuously supported track
- "Lawn-track" with longitudinal sleepers

T1-SoA: Asphalt layer

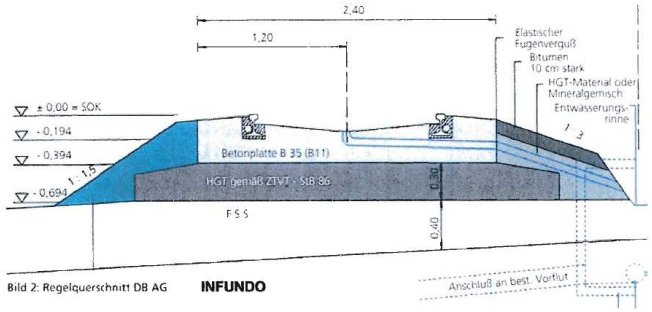
Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
GETRAC	Test-field EIFFAGE-RAIL, Germany Measurement points: 0 m, 8 m, 16 m	Unbalanced mass generator “Dynaq”, 10 Hz – 100 Hz	Only available for test section	40/50 Hz and above (results depending on the load and the distance of the measurement points from the track, for some measurements **negative insertion loss at about 100 Hz**); **benefit: class A, partly B**
SATO	Mainline, Germany Measurement points: 8 m beside the middle of the track	ICE, 160 km/h	No information	Mostly positive effect from 40 Hz to 160 Hz 1/3 octave band (**benefit: class A to B**); **negative insertion loss below 40 Hz and from 160 Hz to 315 Hz**





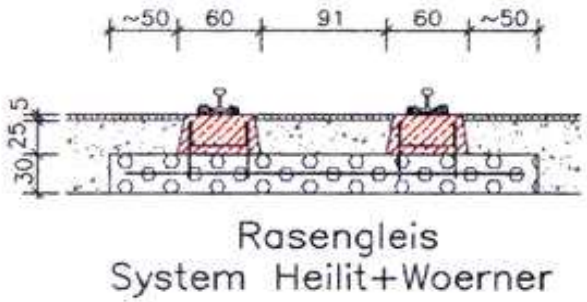
T1-SoA: Continously supported track

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
INFUNDO	Mainline, Germany; Measurement points: 8 m beside the middle of the track	Suburban trains, 120 km/h	Not available	63 Hz to 250 Hz 1/3 octave band **(benefit: class B to C)** and some positive effects from 8 Hz to 16 Hz 1/3 octave band (**benefit: class A/B**);



T1-SoA: "Lawn-track" with longitudinal sleepers

Mitigation measure	Test site	Excitation	Costs	Positive insertion loss
“Lawn-track”	Mainline, Germany; Measurement points: 8 m beside the track	ICE, 160 km/h	Not available	20 Hz to 100 Hz and above 160 Hz 1/3 octave band ; **benefit: mostly class A**



T1: State-of-the-Art

- Mitigation measures presented below have been tested by at least one of the WP3 partners, most of them need further investigations

- Many others are in the scope of the WP3 and could be investigated such as:
  - Wide-sleeper track + under sleeper pad
  - Combination of slab in the ground + under sleeper pads
  - Combination of asphalt layer + booted sleepers

- for example, but also new designed track such as the BBest from Balfour Beaty and the Corus Two Layers Steel Slab Track (presented below within the task 3)

WP3: task 2 & Task 4

Task 2: in-line ballasted track

Development of vibration **mitigation measures** based on optimization of rail fastening systems and sleeper / ballast interaction

Steps:

– Parametric study

– Optimization of the components characteristics tha depends on in-site parameters via a numerical approach

– In site installation of mitigation measures

– Guidelines

Task 4: slab track

Classification of existing slab track systems with respect to emission of ground vibrations and development of mitigation measures with focus on the sleeper/slab interface

Steps:

-Classification of slab track

-Parametric study

-Numerical optimization of a mitigation measure

-In-site installation of mitigation measures

-Guidelines

T2 & T4 / upstream phase

- Characterisation of test site dynamic behaviour

  Parameters identification for parametric study and numerical optimisation process

-> Track stiffness concept

  – How to measure it?

  – Parameter identification for numerical study: is track stiffness a good input to identify them?

T2 & T4 / track stiffness

Measurement tools used and compared within Innotrack

Geophysical methods

> **Seismic methods:** observation of seismic waves propagation (bulk density & modulus of elasticity of the soil)

> **Resistivity / tomography:** measurement of electric resistivity of the rocks (water content & soil grain size)

> **Geological Radar (GPR):** electro magnetic waves transmitted and reflected from geological boundaries

> **Gravimetry (+ levelling):** observation of changes in soil gravity

Track stiffness measurement methods

> **RSMV:** track loading vehicle made of a freight wagon, equipped with hydraulics and vibrating masses. The vertical track stiffness is calculated continuously from measured axle box forces and accelerations.

> **Penetrometer Panda coupled with endoscope:** investigates Granular material resistance and material behaviour variability of the track structure. It consists in driving calibrated cone through the soil and recording the data which represent the cone resistance with the depth.

Sampling methods

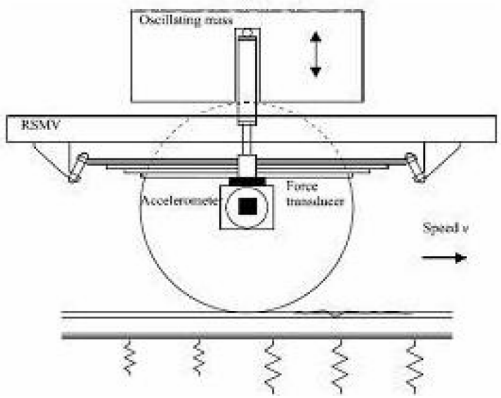
> **Resonant Column tests** and **large scale triaxial tests:** From soil sampling and in-situ density estimation, a lab characterization of the soil is done

T2 & T4 / track stiffness

Stiffness assessment: Rolling Stiffness Measurement Vehicle (RSMV)

> The RSMV: TLV (Track Loading Vehicle) made of a rebuilt two axle freight wagon, equipped with hydraulics and two vibrating masses.

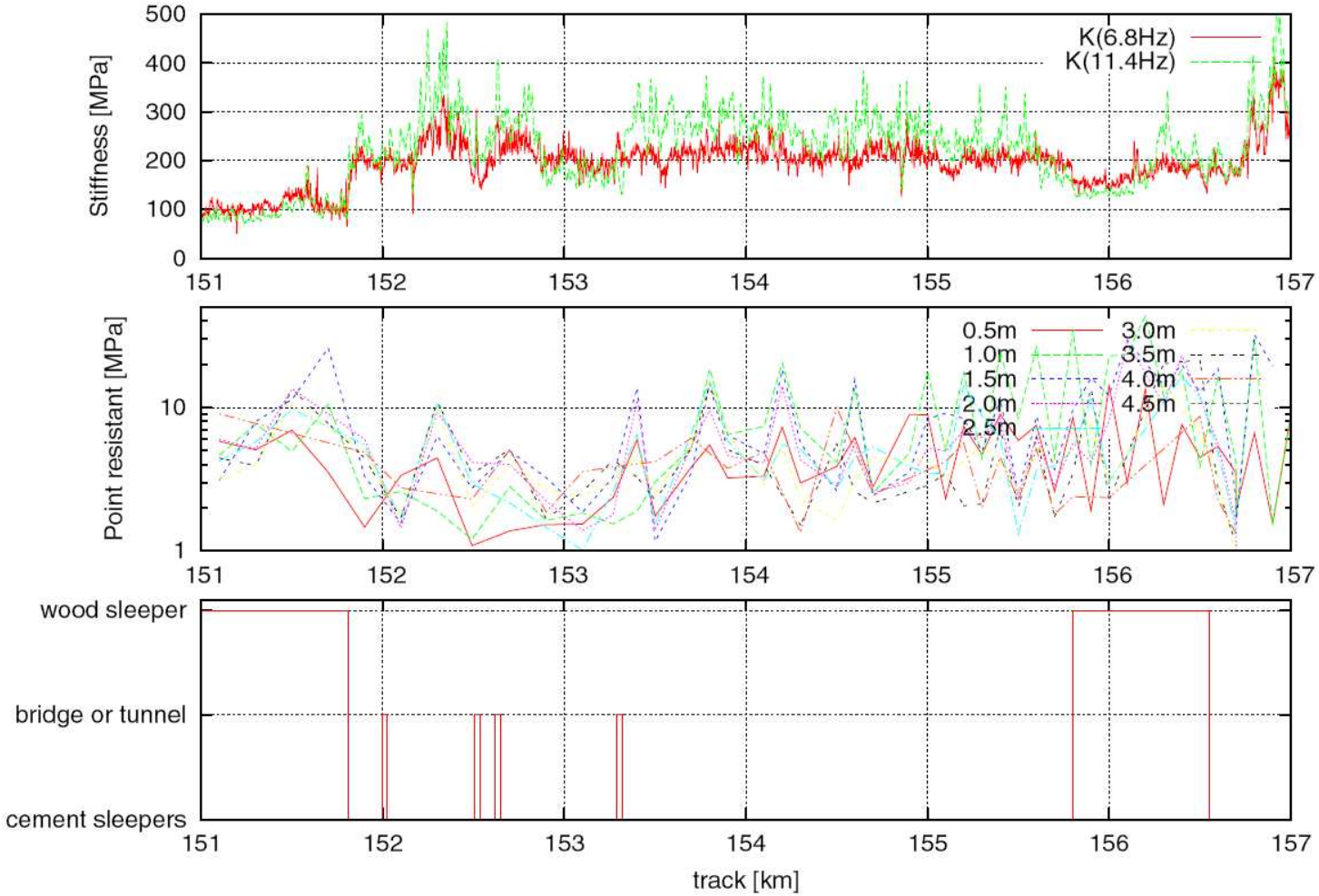
> With the concept of exciting discrete sinusoidal frequencies, the vertical track stiffness is calculated continuously from measured axle box forces and accelerations.



T2 & T4 / track stiffness

Is track stiffness a good input to identify track dynamic parameters?

->crossed data analysis



T2 & T4 / upstream phase

- Identification of problematic sites

-> Innotrack Database

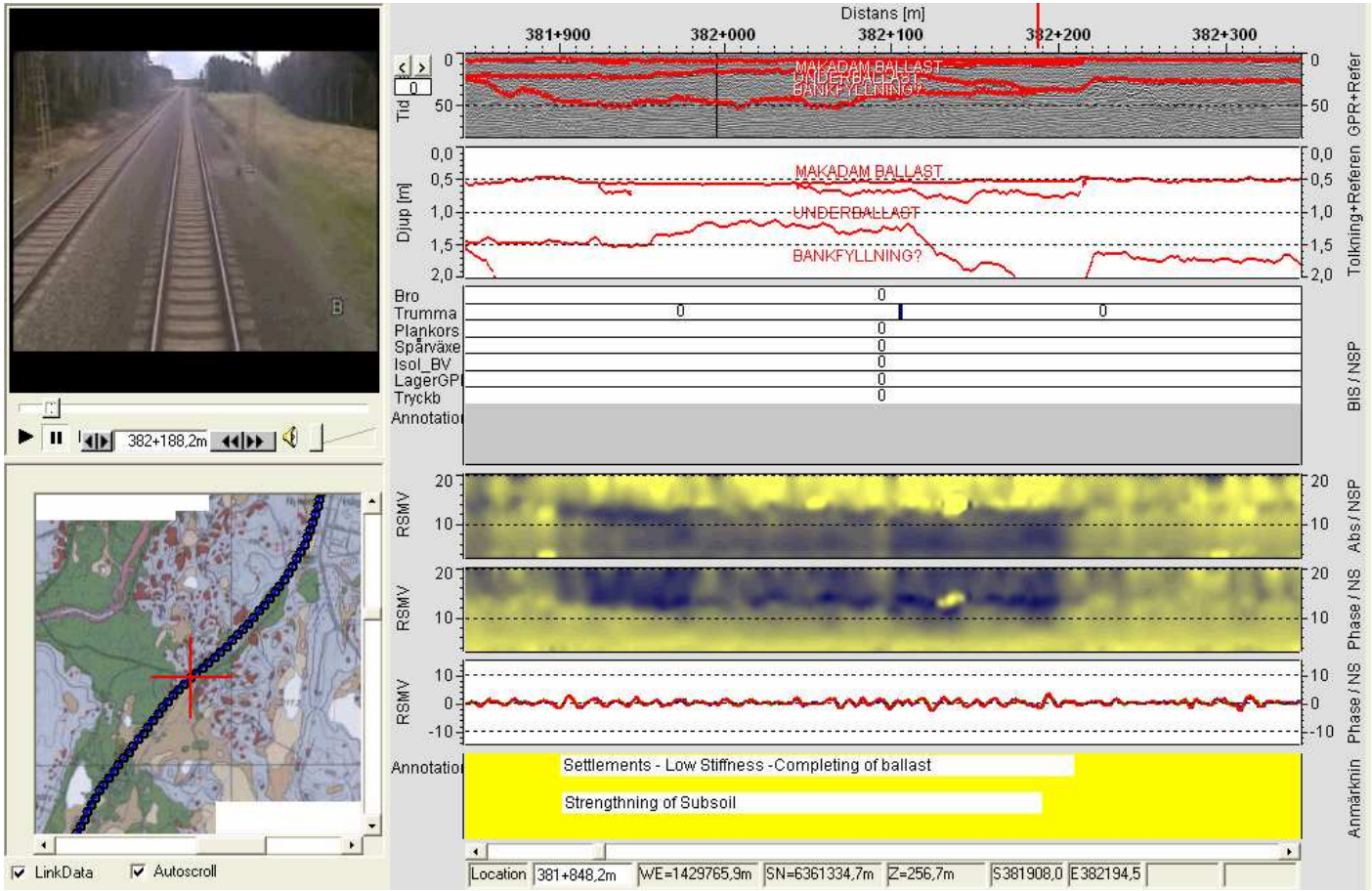
– Is track stiffness a relevant global indicator for the track propensity to propagate vibration?

– How to efficiently use Innotrack results /database?

T2 & T4 / upstream phase

Is track stiffness a relevant global indicator for the track propensity to propagate vibration?

Q. to Alexander Smekal, from TV

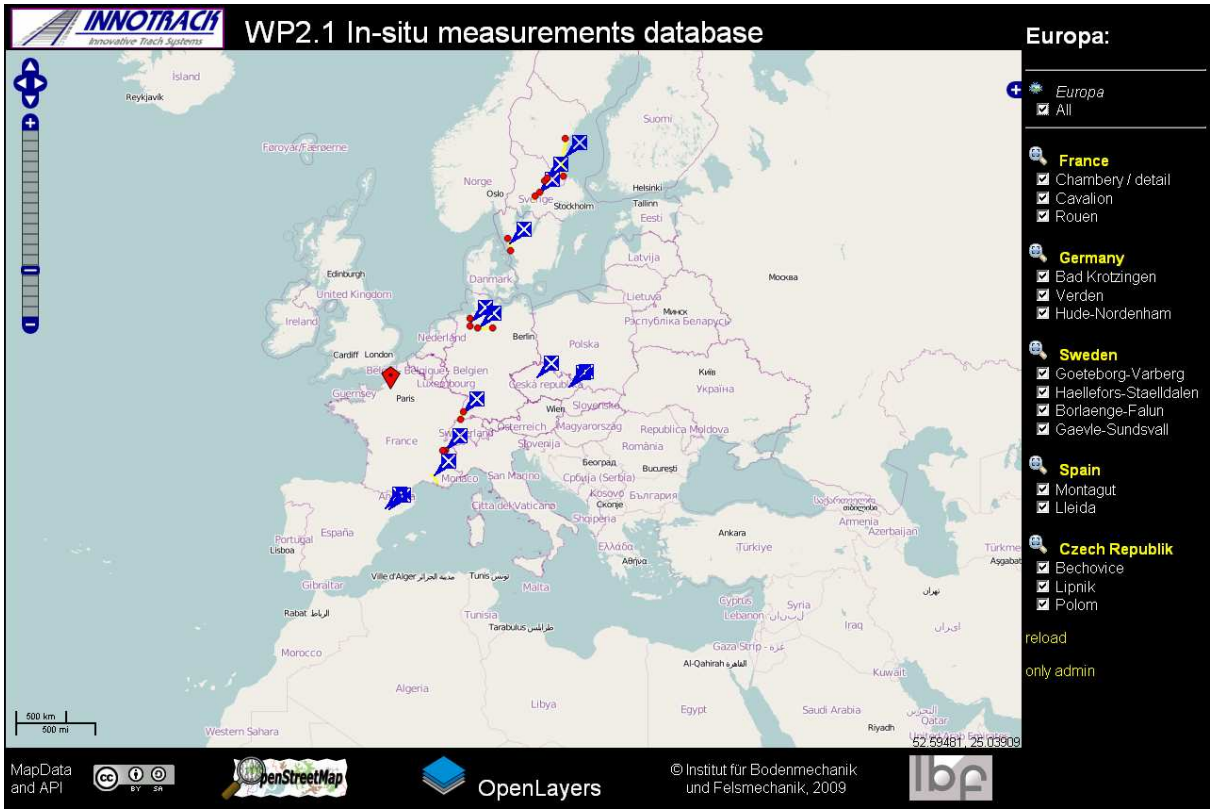


T2 & T4 / Innotrack Database

identifying the relevant parameters and techniques, and building a multi-parameters assessment method.

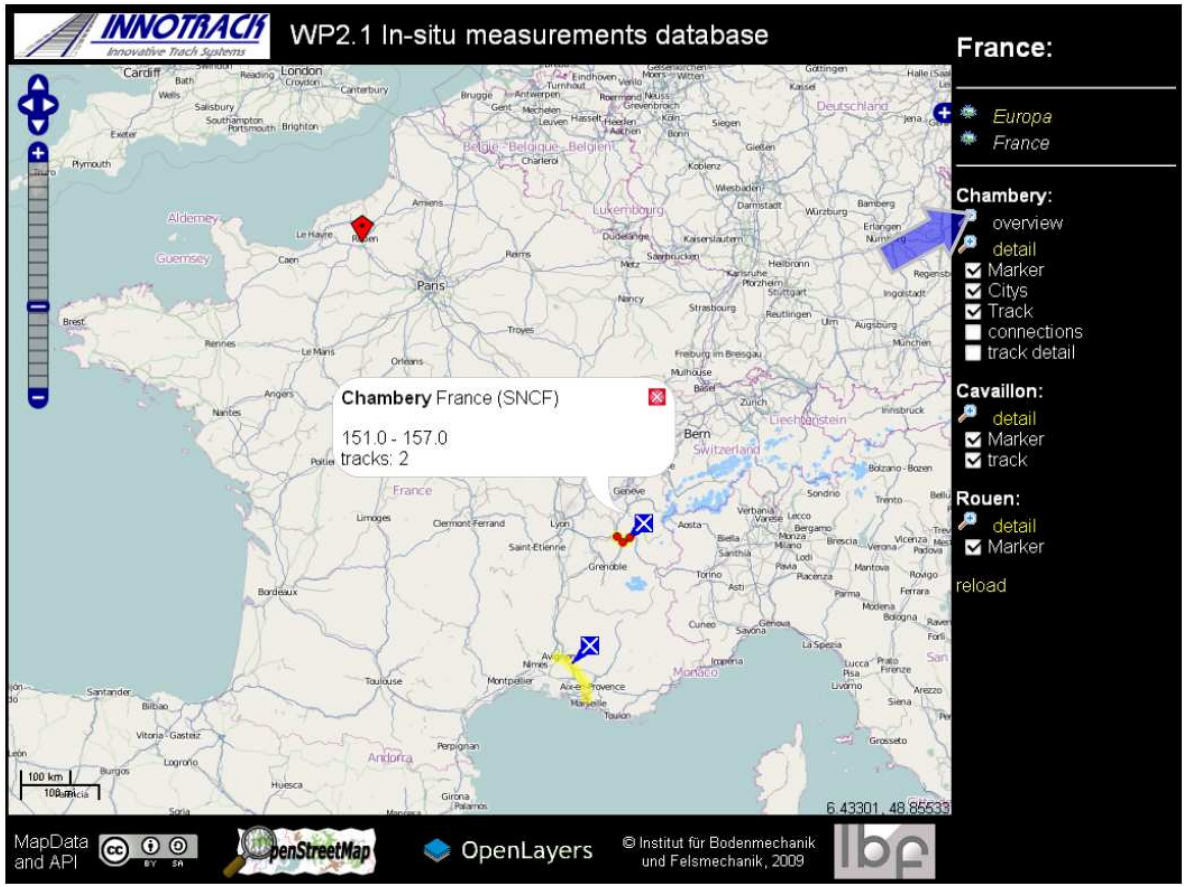
> 15 investigated sites in 5 European countries

> 5 existing and developed measurement techniques have been used for investigations



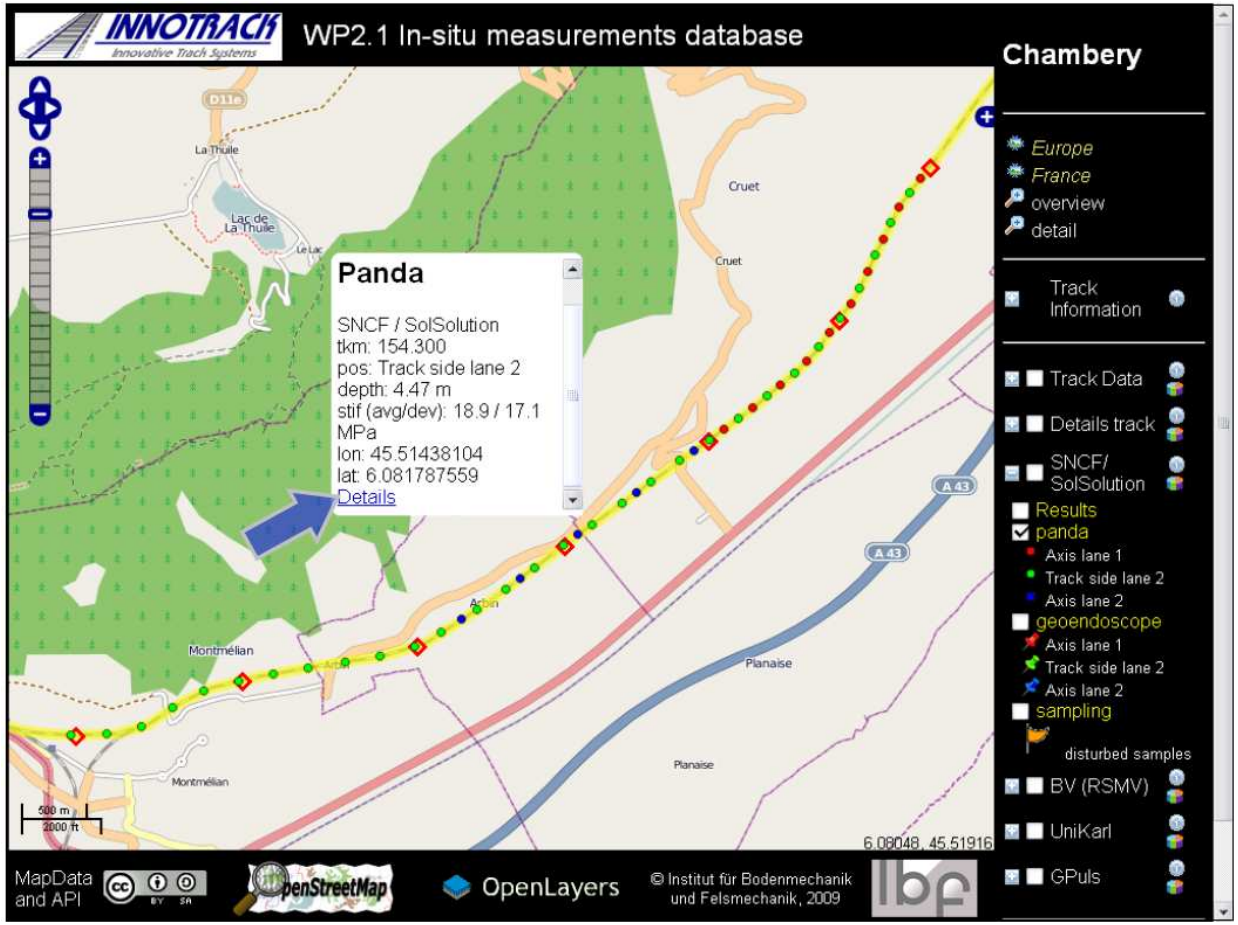
T2 & T4 / Innotrack Database

Example from the database (crossed data analysis)



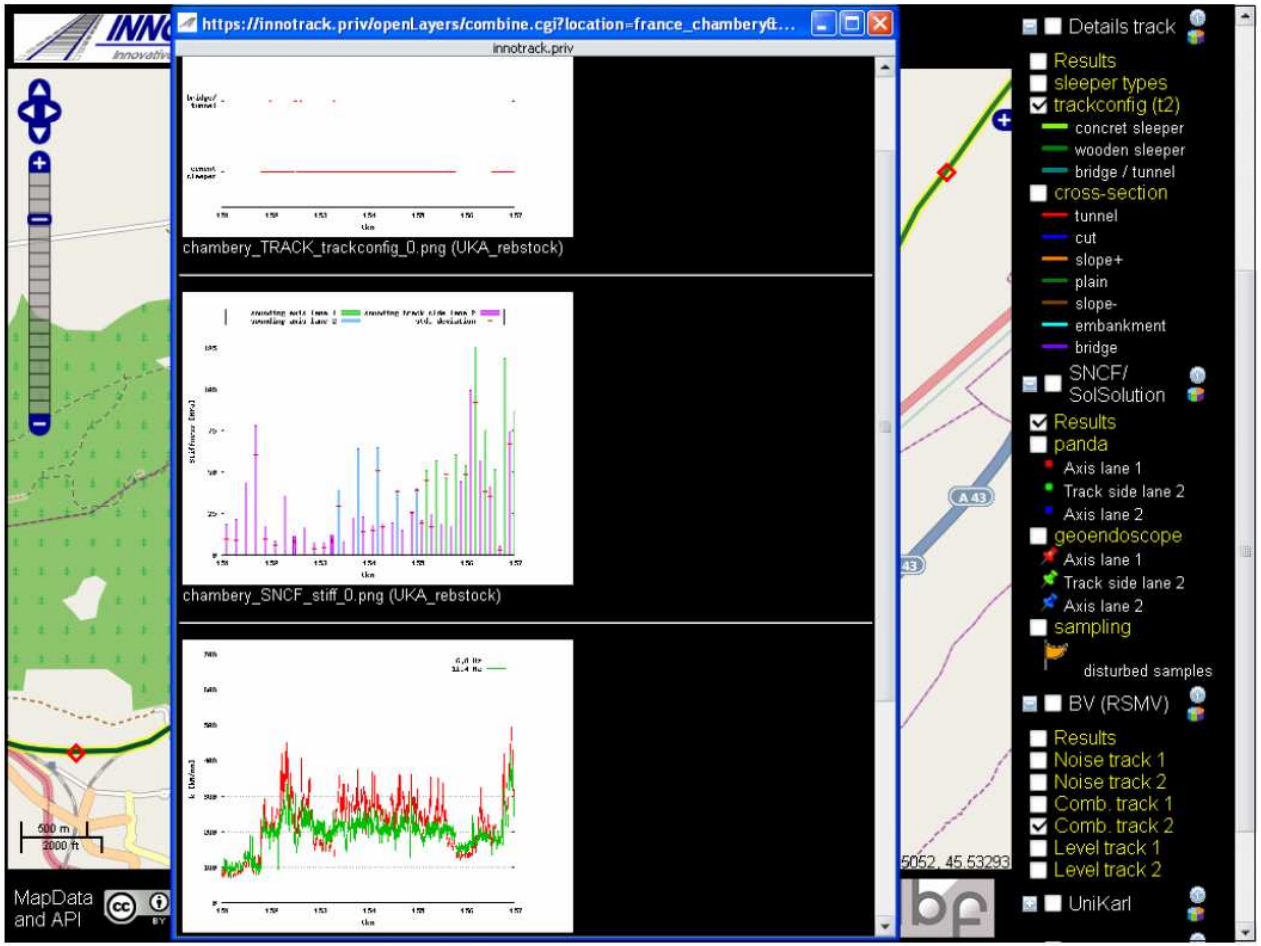
T2 & T4 / Innotrack Database

Example from the database (crossed data analysis)



T2 & T4 / Innotrack Database

Example from the database (crossed data analysis)



T2 & T4 / downstream phase

- Measurement of the impact of mitigation measures on ground vibration -> WP1.2 protocol
- Impact of mitigation measures on maintenance?
  - How to quantify this impact?
  - What is the most damageable with the insertion of:
    - a new designed URP
    - a USP
    - a ballast mat

WP3: task 3

Task 3: curve and switch

Assessment of the potential of **under sleeper pads** as vibration mitigation measure for **curves**

Better understanding of the phenomena causing ground vibrations by **switches** and subsequent design of efficient mitigation measures

WP3: task 3

- Curves:

-> USP as mitigation measures for curves

  – Impact on track static behaviour?
  – Impact on rolling stock behaviour?
  -> to be measured within RIVAS (SBB)

  – Impact on maintenance?

WP3: task 3

- Switches
  - To characterize in-site the ground vibrations induced by switches
  - To combine the numerical approach developed in Chalmers that allows to estimate the wheel/rail interaction force when RS runs over a switch to a software that simulates GV propagation in free-field
  - To propose mitigation measures for switches configuration

  - Are new designed track such as Balfour beaty (BBest) and Corus a good option? How to handle, in such installation, the transition zone issue?

WP3: New designed track opportunities

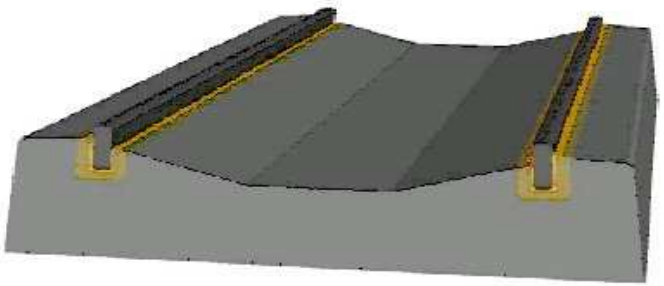
Balfour Beaty Slab Track: BBEST

> **Low maintenance** slab track

> **Continuous support of the rail**

> Modified rail section

> Accommodation of both soft subgrades and high axle loads

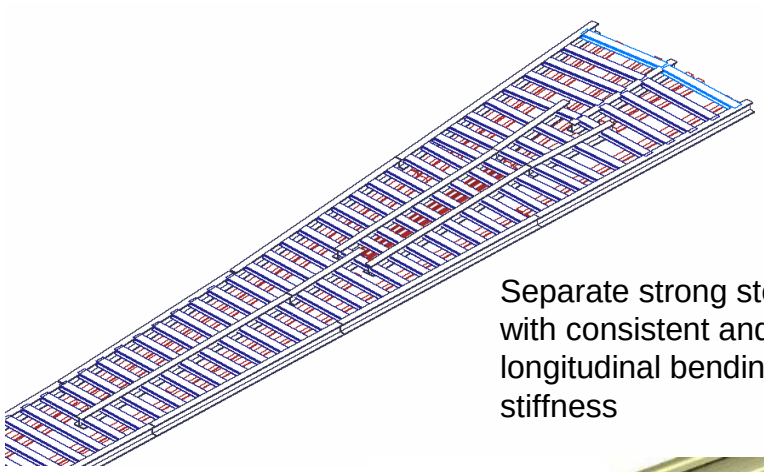


A test track has been installed in Germany

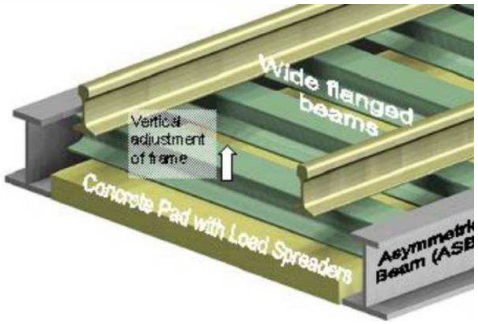
WP3: New designed track opportunities

Corus Two Layers Steel Slab Track

> **Low maintenance track** support system
> Low construction time (≈ ballasted track)
> Continuous rail support
> Potential recycling of old ballast as infill material
> High initial cost implies no installation in plain line, but for critical track segments:
=> Improvement of poor formation/instability.
=> Critical track locations: S&C example
- Logistic advantages
- Significant reduction in future maintenance needs



Separate strong steel frame with consistent and high longitudinal bending stiffness



A test track has been installed in Scunthorpe (UK)

Thank you for your attention!