RIVAS
WP3: Conceptions of low emissive tracks in term of ground vibrations

26th October 2012

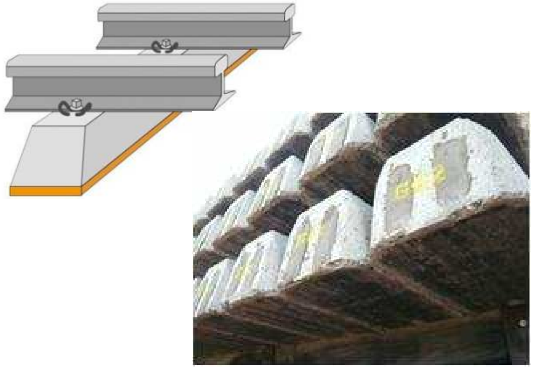
Partners: ADIF, ATSA, BAM, CEDEX, Chalmers, CSTB, DB, D2S, ER, KUL, Pandrol, RailOne, Sateba, SBB, SNCF, Vibratec

What do we know from the SoA?

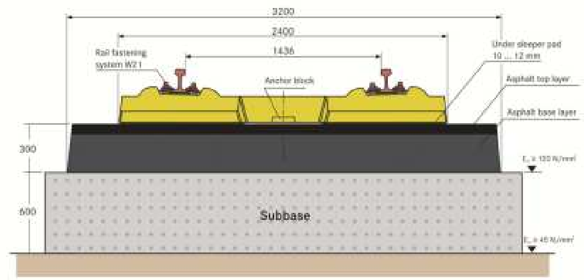
It exists various mitigation measures for Ground Vibration to be put in the track:

Very soft fastening systems

Under sleeper pad



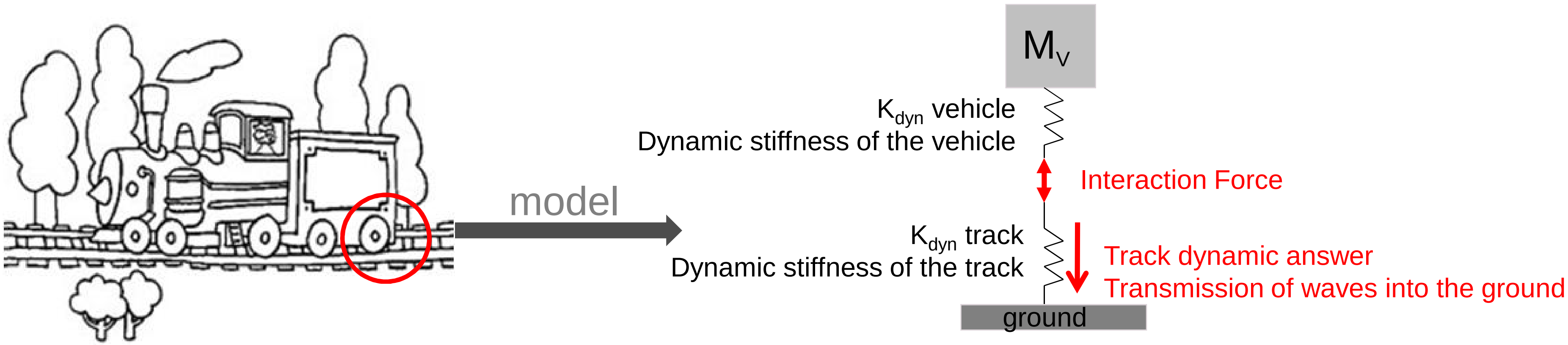
New track design



They all act on the track stiffness

What do we know from the modelization?

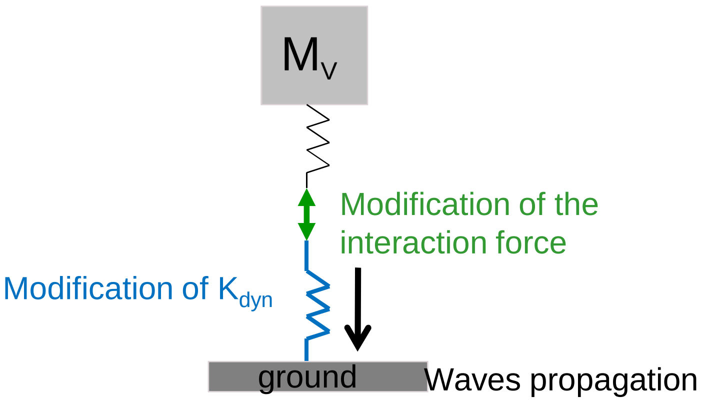
In term of vibration generation, the train/track system can be modelled as:



What do we know from the modelization?

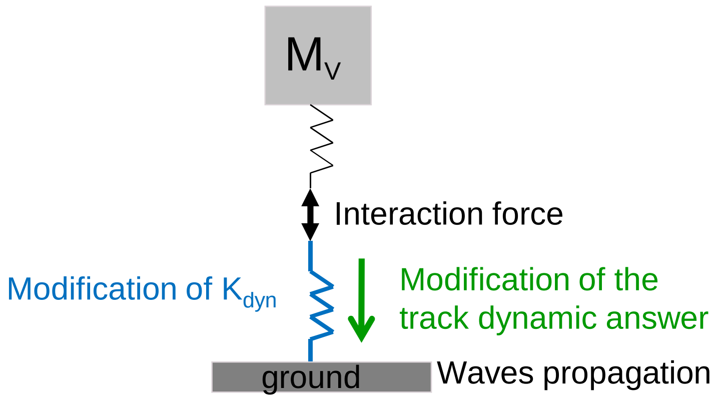
Mitigation solutions are expected to act on ground vibrations via:

Modification of the interaction force:



and/or

Modification of the track dynamic answer:



WP3 scope

OBJECTIVES:

To optimize in term of ground vibration reduction:

- the mitigation measures installed on track
- or the track components themselves

By acting on:

- The interaction force

and / or

- The track dynamic answer

WP3 scope

WAYS OF ACTION:

1. To understand the impact of such mitigation measures on the dynamic response of the track

→ To use existing models (BAM or KUL models)

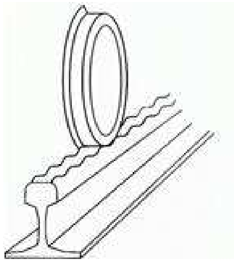
2. To understand the impact of such mitigation measures on the interaction force generation, with respect to the mechanisms of excitation

→ To make an exhaustive inventory of the mechanisms of excitation

→ To model the interaction force generation for each mechanism and to couple it with 1.models

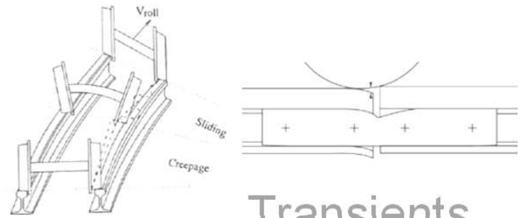
WP3 strategies

INVENTORY OF EXCITATION MECHANISMS:



Uneveness

Parametric excitation



Transients

Straight line track
(ballasted or slab)

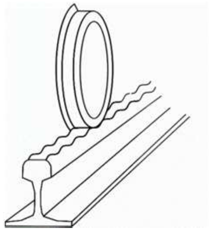
Curves and Switches

Numerical approach for the optimisation can be used (phenomena understood)

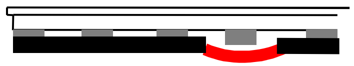
Empirical approach for the optimisation can be used (lot of phenomena at work)

WP3 strategies

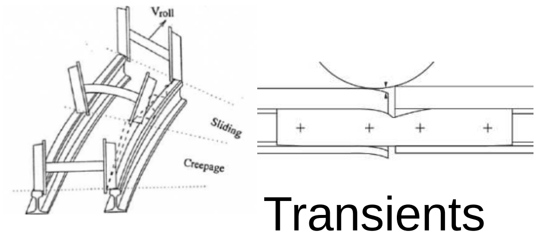
INVENTORY OF EXCITATION MECHANISMS:



Uneveness



Parametric excitation



Transients

Straight line track
(ballasted or slab)

Numerical approach for the optimisation can be used (phenomena understood)

Curves and Switches

Empirical approach for the optimisation can be used (lot of phenomena at work)

WP3 outlines

ST3: curves & switches

- USP installation in curves / track stability check
- USP installation in switches

ST2 / ST4: track in alignement – ballasted track / slab track

- Ballasted track components optimization (USP, URP, wide sleeper + USP)
- Slab track components optimization (USP + wide sleeper)
- Field tests
  - On rig tests (USP)
  - On commercial track (URP)

WP3 ST3 - USP tests on curves

INSTALLATION:

Curve and straight line have been equipped with **under sleeper pads**

-The ground vibration reduction has been measured by comparing the levels, on the same site, with and without the mitigation measure installation

-The **track stability** of the curves equipped with USP has been characterized this summer

-The track quality is measured with SBB track measurement car (continuous deflections along the track)

WP3 ST3 - USP tests on curves

RESULTS:

- Measurement of insertion loss (IL) (reference track vs USP-equipped track):
  - In the mean IL of 30%-50% can be found with sometimes influence of traintype.
  - Geology influence on IL results along track is respectable.
- First noise measurements show noise increase for USP test track

To be done

- Analysis on frequency of mitigation effect
- Analysis on noise measurements
- Analysis on track stability data
- Analysis on track quality data
- Analysis on new laboratory measurements of USP types.

WP3 ST3 - USP tests on switches

INSTALLATION:

Location 1 (Le Landeron)

Test sites

Reference sites

Location 2 (Rubigen)

At the two locations: installations of USP under 2 switches, 2 reference switches

WP3 ST3 - USP tests on switches

RESULTS:

- Measurement of IL (reference switch vs USP-equipped switch):
  - **no consistency** of the results (Rubigen test site presents an amplification factor of 3.7 for some frequency bands).
  - question raised on the effect of USP on the different kind of excitation mechanisms (parametric excitation, unevenness, impact)
- Measurement of switches "vibration quality" in progress: track stiffness, track receptances

To be done

- To test a geometrically improved switch and look for further improvements
- Numerical models under development to better understand the phenomena at work and particularly the combination between unevenness, transient excitation and parametric excitation

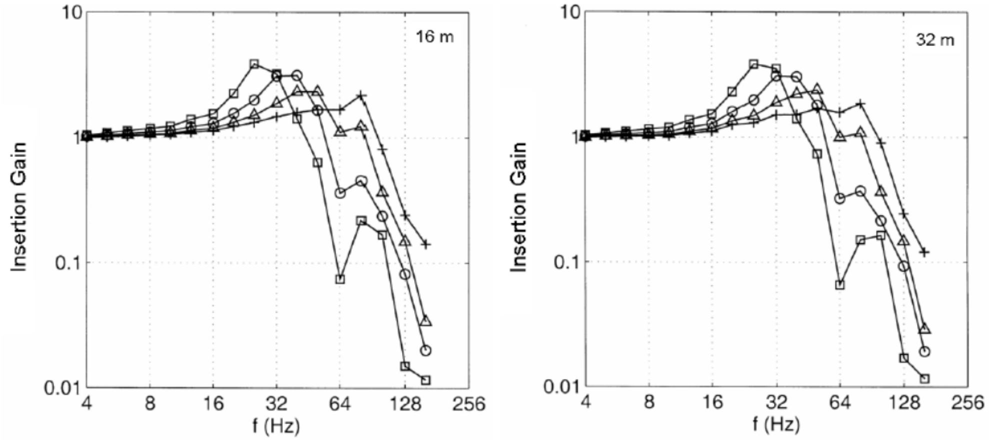
WP3 ST2 / ST4 URP and USP optimization

NUMERICAL OPTIMIZATION: PARAMETERS

- The mitigation measures that are tested here are the following:
  - the use of soft **Under Rail Pad** (URP) only for ballasted track,
  - the use of **Under Sleeper Pad** (USP),
  - the variation of the sleeper mass and dimensions

- \+ intrinsic parameters that may have an influence on the dynamic behaviour of the system, and therefore on the efficiency of the mitigation measures tested:
  - The wheelset mass,
  - The soil characteristics (stiffness, layering),
  - The ballast characteristics (stiffness, thickness) and modelling (layering)

NUMERICAL OPTIMIZATION: RESULTS FOR **USP** ON BALLASTED TRACK



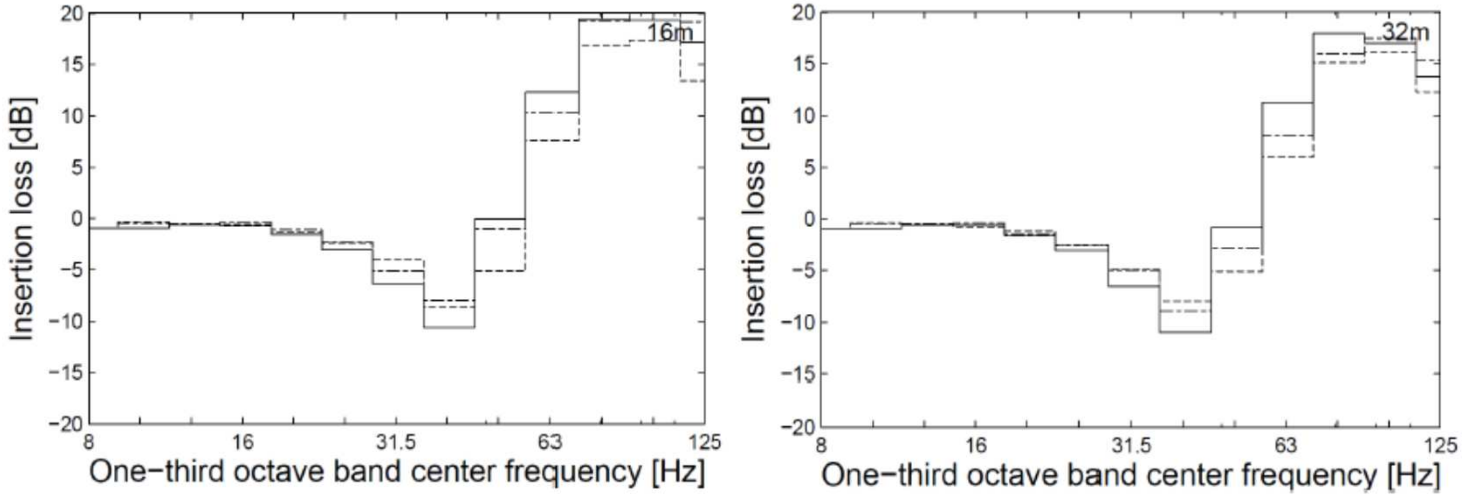
Insertion gain of the vehicle/track mobility for under sleeper pads with stiffness of 25MN/m (□)*,* 50MN/m (○)*,* 100MN/m (Δ)*,* 200MN/m (+)*. Left:* 16m *to the track. Right:* 32m *to the track.*

- negative IL before *fv/t* up to −10 dB,
- **positive IL above fv/t of 10 − 20 dB in the 60 − 125 Hz range** at 16m and 32m from the track
- When USP are used in addition with standard URP, the effects quite similar to those observed for very soft URP

⇒Use of wider sleepers:
- the same USP material will lead to less deflection under the same static load,
- or that a softer material will lead to a better insertion loss with the same static deflection.

WP3 ST2 / ST4 URP and USP optimization

NUMERICAL OPTIMIZATION: RESULTS FOR **SOFT URP** ON BALLASTED TRACK

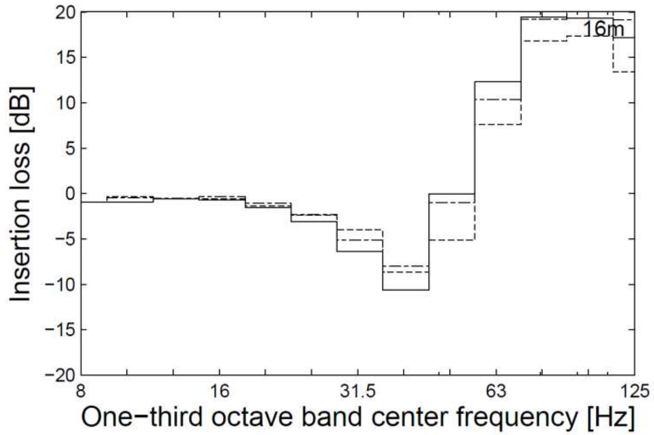


Insertion loss of the free field velocity due to an AGC pass-by for a rail pad stiffness of 25MN/m *relative to the case of* 150MN/m *on different soils: stiff half-space (solid line), 2 mid-stiff layers on stiff half-space (dashed line) and 2 soft layers on mid-stiff half-space (dashdotted line). Left:* 16m *to the track. Right:* 32m *to the track*

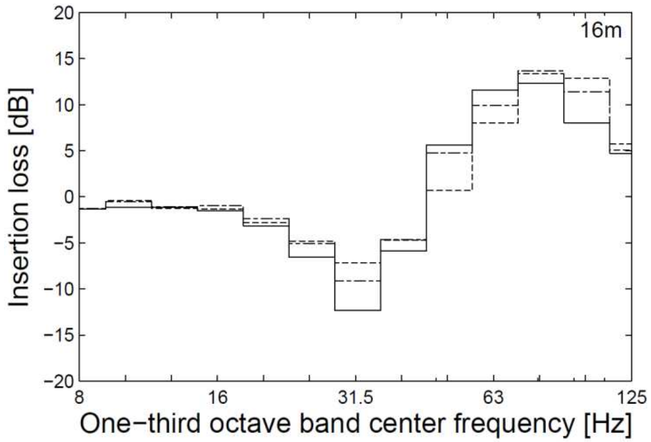
- ! Insertion loss given in dB
- Depending on the soil characteristics insertion loss between 15 and 20 dB can be reached after the unsprung mass on track resonance frequency (between the 40 Hz and 50 Hz 1/3 octave bands).
- Negative IL before this frequency, up to 10 dB

WP3 ST2 / ST4 URP and USP optimization

NUMERICAL OPTIMIZATION: **VERY SOFT URP VS. SOFT USP** ON BT



Very soft railpad (25MN/m relative to the case of 150MN/m)

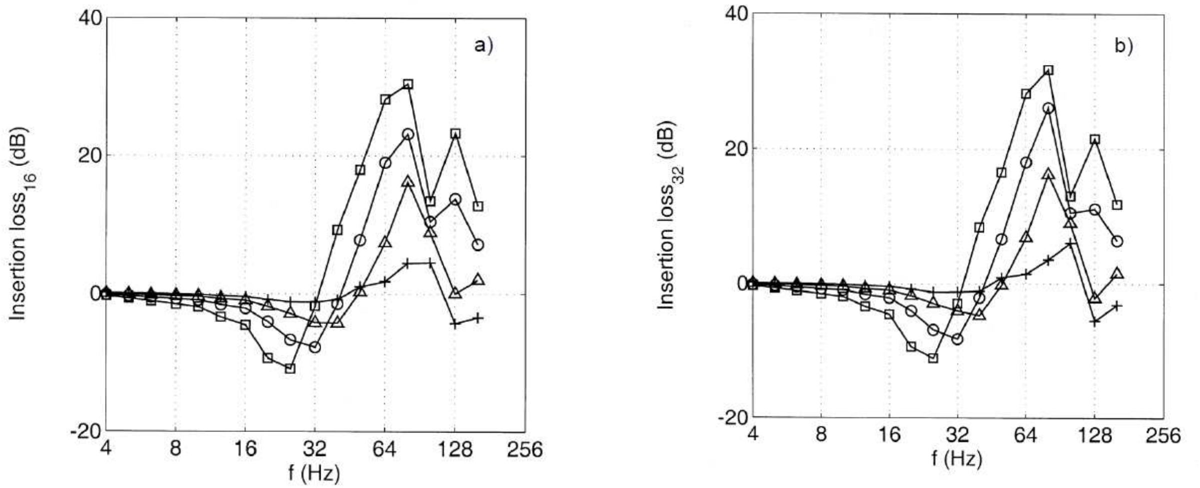


Under sleeper pad of 50MN/m relative to no USP (both cases with railpad of 150MN/m)

- The transition frequencies lower in the case of USP. Positive IL reached for lower frequencies for USP than for soft URP, and over a broader frequency range (although frequencies above 125 Hz not considered here)
- Soft URP leads to slightly higher positive IL for high frequencies and to less negative IL at $f_{v/t}$.
- Mitigation effect with USP installation can be increased by combining it with wide sleepers installation: they allow lower USP stiffness to be used with reasonable track deflexion

WP3 ST2 / ST4 URP and USP optimization

NUMERICAL OPTIMIZATION: RESULTS FOR **GETRAC SYSTEM** OPTIMIZATION SLAB TRACK



Insertion ***loss*** *of the vehicle/track mobility for under sleeper pads with stiffness of* 25MN/m (□)*,* 50MN/m (○)*,* 100MN/m (Δ)*,* 200MN/m (+)*. Left:* 16m *to the track. Right:* 32m *to the track.*

- Optimisation of the system with USP insertion and modification of the sleepers
- Optimal system for the ground vibration reduction: wide sleepers with soft USP and stiffer railpads (no clear specification of the stiffness that have to be used for the USP and the railpad)

WP3 T2: installation of optimized USP

COMPLEMENTARY LAB TESTS:

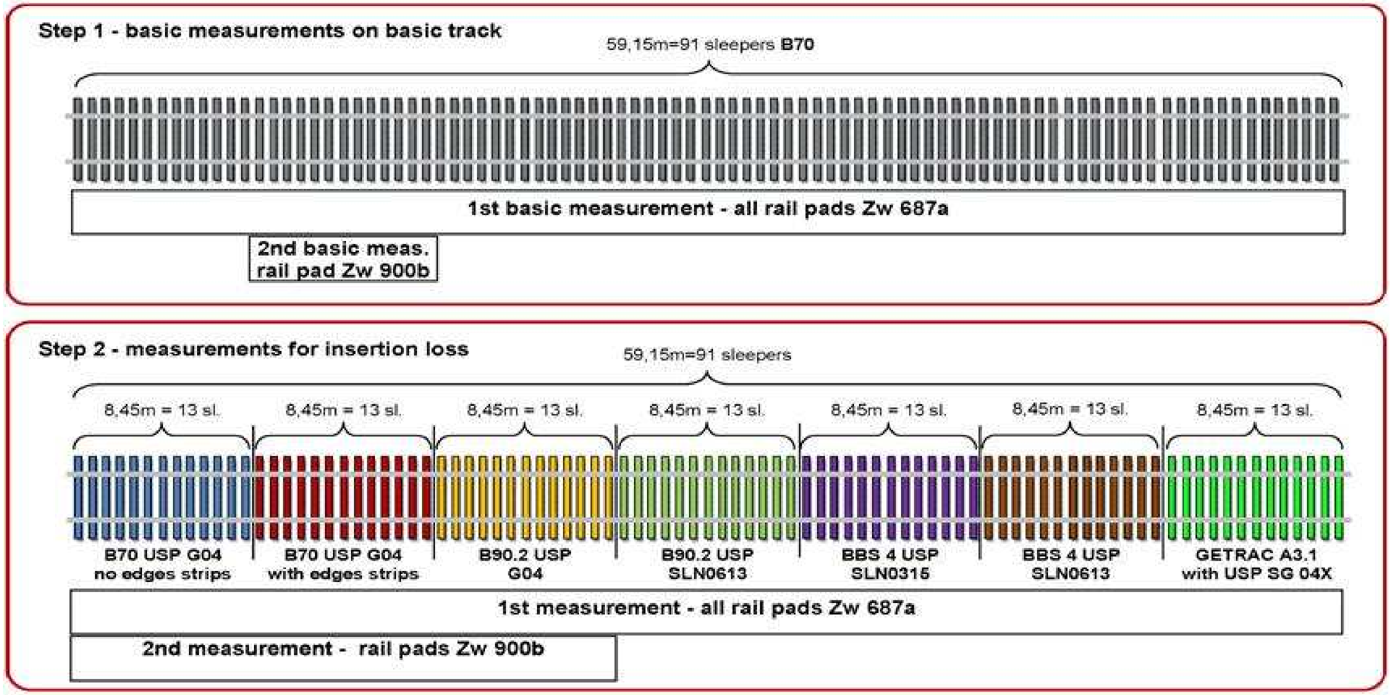
Of these heavy sleepers coupled with various USP on:

- BAM test bench (dynamic stiffness, static stiffness, fatigue…) for 6 sets {sleepers+USP} and 3 different kind of sleepers (standard, wide and heavy sleeper)
- Cedex track box measurements: to assess the performances over time of 1 of these sets (to be chosen according to serviceability tests by BAM) *To be done*

WP3 T2/T4: installation of optimized USP

TEST ZONE DESIGN:

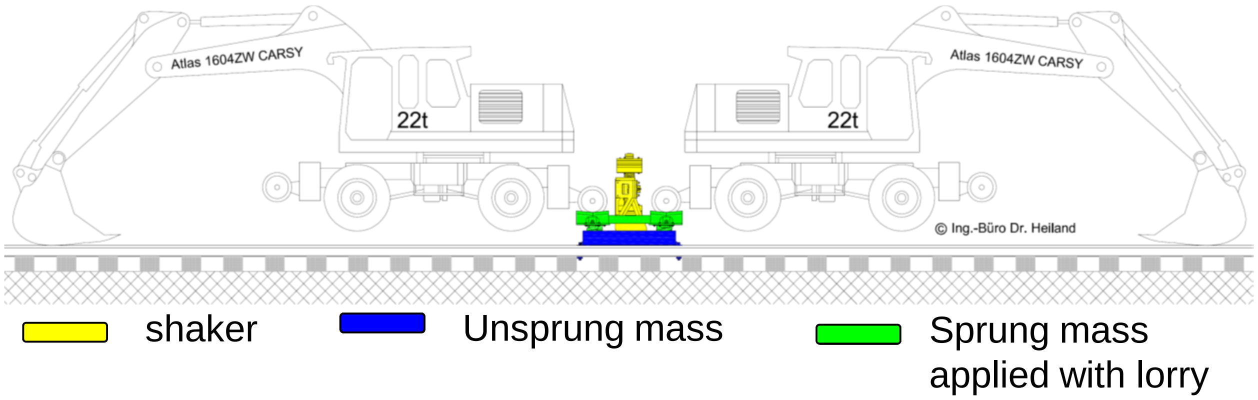
- Ballasted track: 6 different {USP+heavy sleepers} systems will be installed on a test rig
- Slab track: 1optimized GETRAC system will be installed on a test rig



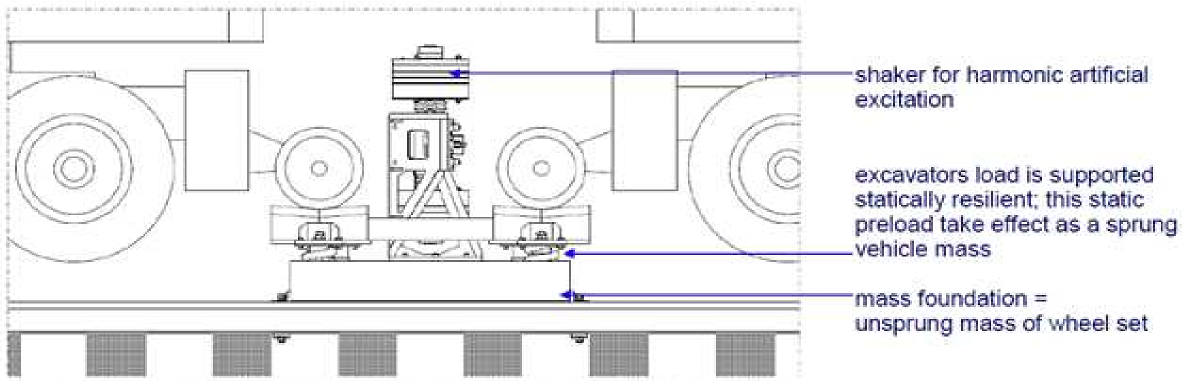
WP3 T2/T4 : tests of optimized USP

TESTS TO BE PERFORMED:

- Test rig track loaded with a couple of lorry to get the appropriate sprung mass



- Dynamic excitation with a shaker, transmitted through a fitted sprung mass

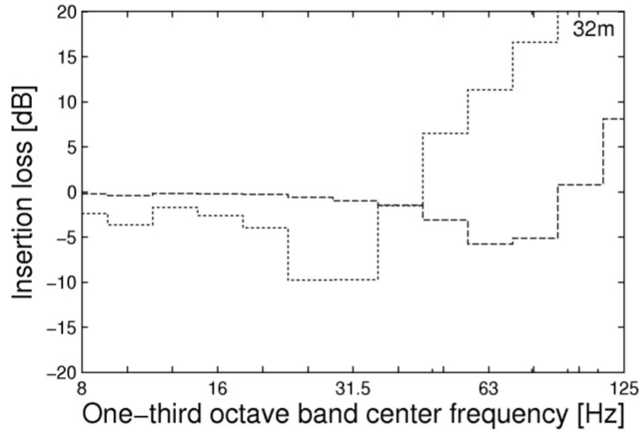


WP3 T2: installation of optimized URP

COMPLEMENTARY LAB TESTS:

Characterization of the **dynamic stiffness** of the different fastening systems

Numerical simulations to assess the mitigation effect on the test site of these systems: an IL up to 20dB can be reached with VANGUARD installation



Insertion loss of the free field velocity at 32m for the DFC system (dashed line) and the VANGUARD system (dotted line) when compared to the standard SNCF pads

Test bench

Dynamic stiffness estimation
Under realistic load

WP3 T2: installation of optimized URP

TEST ZONE DESIGN:

For the DFC:

Section	Standard track	Transition 1	Transition 2	Transition 3	Test section
Length	∞	26,4 m	26,4 m	26,4 m	100,8 m
Fastening	FC @ 120 kN/mm	FC @ 120 kN/mm	FC @ 120 kN/mm	DFC @ 120 kN/mm	DFC @ 120 kN/mm
Sleeper type	M450	M450	M450	M260-DFC	M260-DFC
Ballast height	25 cm	25 cm	25 cm	27 cm	27 cm

For the VANGUARD:

Section	Standard track	Transition 1	Transition 2	Transition 3	Test section
Length	∞	26,4 m	26,4 m	26,4 m	100,8 m
Fastening	FC @ 120 kN/mm	FC @ 80 kN/mm	FC @ 37 kN/mm	DFC @ 21 kN/mm	DFC @ 21 kN/mm
Sleeper type	M450	M450	M450	M260-DFC	M260-DFC
Ballast height	25 cm	25 cm	25 cm	27 cm	27 cm

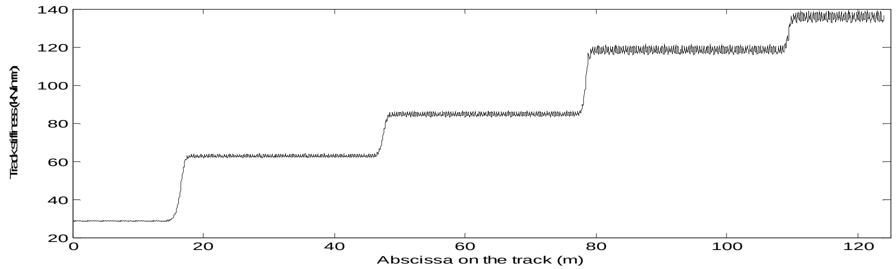
Test site in the East of France, on a Freight corridor (Thionville – Longuyon)

Certification process of the DFC + new dedicated sleepers in progress (VANGUARD only checked for short term installation)

WP3 T2: installation of optimized URP

TEST ZONE DESIGN: TRANSITION ZONES

- Estimation of the **track stiffness evolution**



- Estimation of the **rail-wheel interaction force** at these transitions, to be compared with the interaction force experienced along a track with non-critical vertical defects

Wheel-Rail interaction force on:
- perfect track with transition zones for the track stiffness (left)
- same track with usual geometrical defects (right)

➔ No emergence on the interaction force due to the transition zones

WP3 T2: installation of optimized URP

TESTS TO BE PERFORMED:

- Commercial Freight and regional trains traffic

- Measurements on a reference site and the test site:
  - Of ground dynamic properties via SASW characterization
  - Of rail accelerations during pass-by
  - Of ground vibrations during pass-by @ 8m, 16m and perhaps 32m
  - Track deflexion to check track stability

Mid-term outcomes

Optimization of the mitigation measures, depending on the configurations:

- → Empirical approach for curves and switches
- → Numerical approach for straight line (ballasted and slab track)

- ➔ Curves and Switches equipped with soft USP
- ➔ Optimization for the implementation of soft USP / very soft ralpaids / Getrac system with via numerical simulations
- ➔ In-field tests of these optimized mitigation measures to be carried out

New challenges raised (to be studied in collaboration with WP2):

- → To assess the contribution of the different excitation mechanisms: uneveness -done-, parametric excitation –under development- and transient –under development-
- → To predict the effects of mitigation measures depending on the combination of these mechanisms of excitation

Thank you for your attention.

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