MITIGATION MEASURES IN TRACK

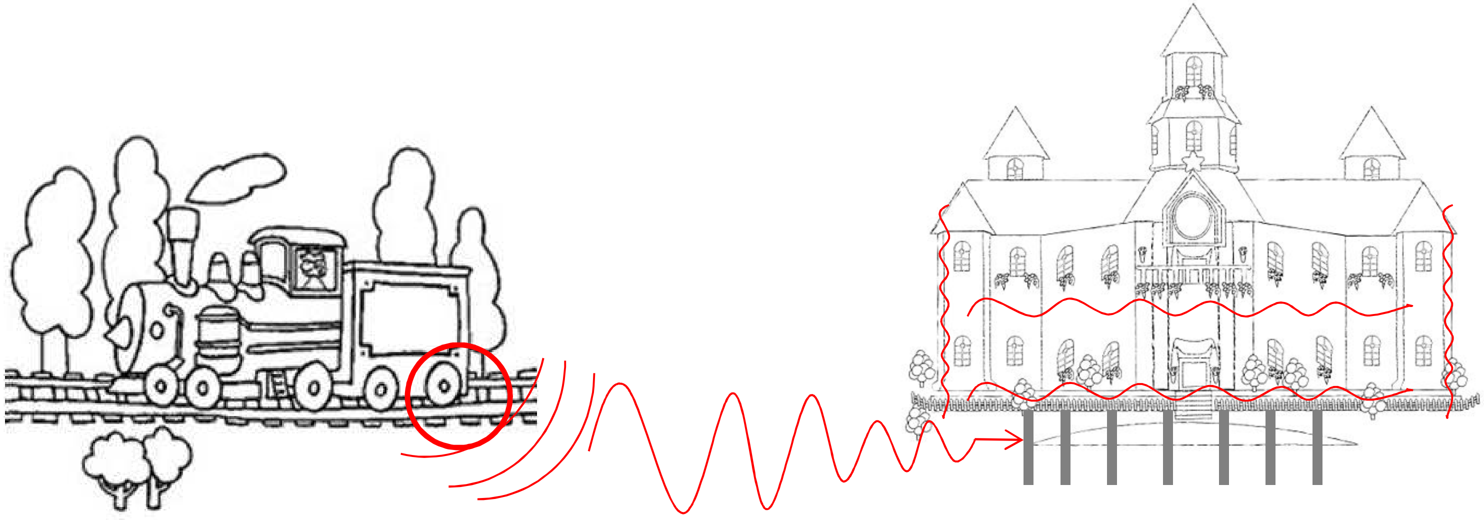
OUTCOMES
APPLICATION TO SPECIFIC TRACK SECTIONS

FINAL CONFERENCE, 21st November 2013

Track vibration: impact

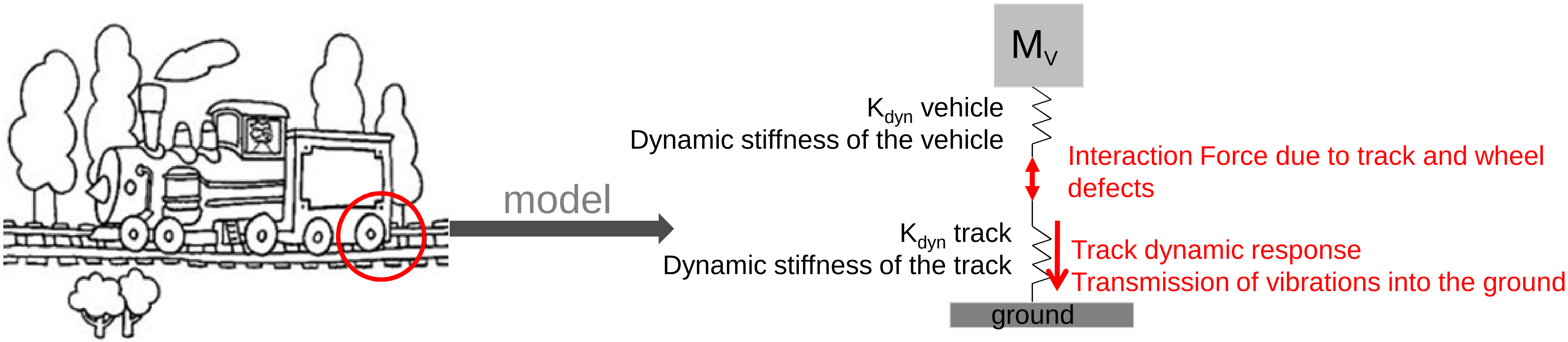
Excitation at the wheel-rail contact, induces vibrations in the track

Once these vibrations are induced at the track-ground interface, they propagate through the surrounding ground to the buildings foundations



Track vibration: phenomenology

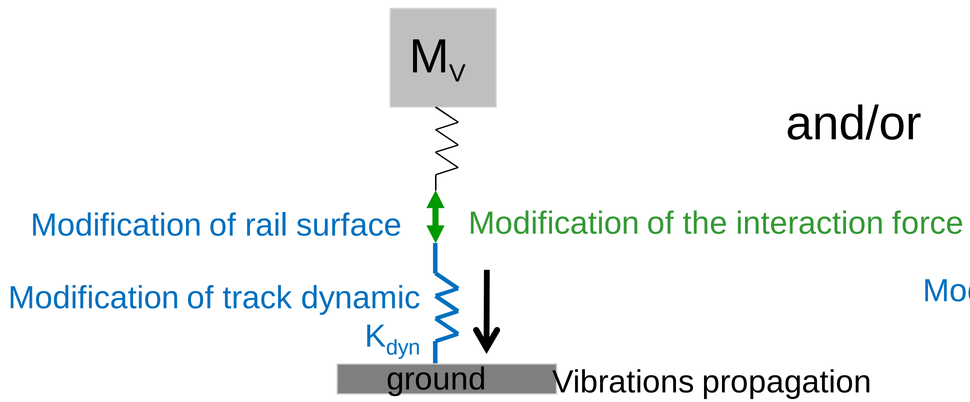
In terms of vibration generation, the train/track system can be modelled as:



Track mitigation measures: phenomenology

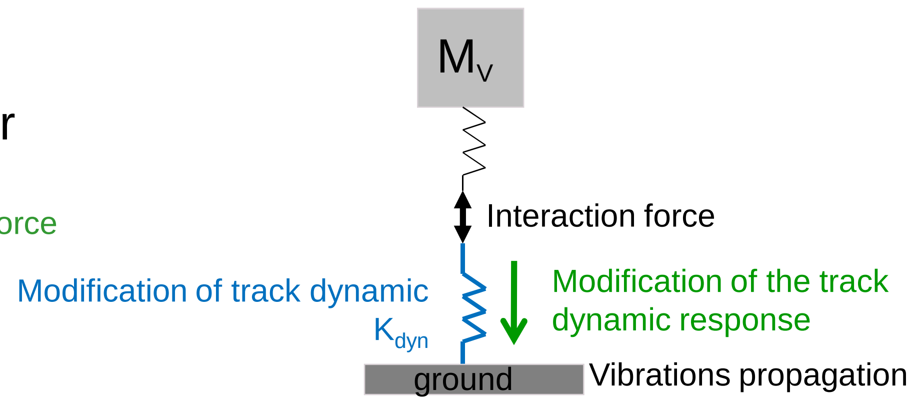
Mitigation solutions on track are expected to have an impact on ground vibrations via:

Modification of the interaction force:



and/or

Modification of the track dynamic response:



How to design a track mitigation measure?

General principles

Inventory of excitation mechanisms

To make an exhaustive inventory of the excitation mechanisms

Model of vehicle track interaction

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

Coupled with

Model of track dynamic response

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

Assessment of MM impact on the excitation and on the track dynamic response

Optimization of the MM

In track installation

Straight track mitigation measures: design

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In track installation

RIVAS implementation for straight lines (ballasted and slab track)

Inventory of defects on track (in collaboration with WP2)

Models implemented in numerical tools

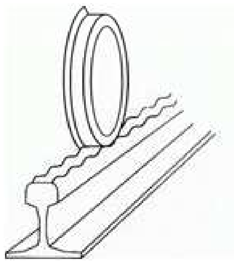
Assessment of Insertion Loss for the different MM
depending on ground conditions and vehicle types

Selection of best mitigation measures

TESTS !

Straight track case (ballasted and slab track)

INVENTORY OF EXCITATION MECHANISMS:



Uneveness

Parametric excitation

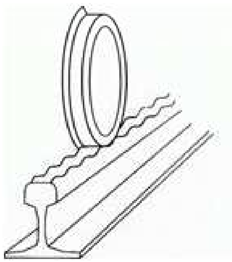
Straight line track
(ballasted or slab)

⇩

Vibrations generation

Straight track case (ballasted and slab track)

EXCITATION MECHANISMS MODELED FOR NUMERICAL APPROACH:



Uneveness

Parametric excitation

Straight line track
(ballasted or slab)

⇩

Numerical assessment of vibrations generation and propagation

Parametric excitation is today not taken into account whereas it has a contribution in the low frequency range

Straight track case (ballasted and slab track)

MODELIZATION OF TRACK DYNAMIC RESPONSE:

Numerical tools FEM/BEM + KCM for some parts of the track

Input of this numerical simulations to be given according to the track components characteristics.

Important parameters:

- -Railpad stiffness and damping
- -Under sleeper pads stiffness and damping
- -Ballast stiffness and damping
- -Plateform dynamic response

Straight track case (ballasted and slab track)

MODEL OF TRACK DYNAMIC RESPONSE: INPUT CHARACTERIZATION

Some lab tests could be necessary to characterize the track components, particularly the resilient components

specimen, concrete block with USP

Test rig for small components (KPM), static and low frequency bedding modulus

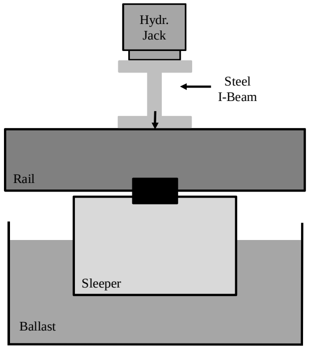
Straight track case (ballasted and slab track)

MODEL OF TRACK DYNAMIC RESPONSE: INPUT CHARACTERIZATION

Some lab tests could be necessary to characterize the track components, particularly the resilient components

Some lab tests procedures should be adapted to characterize the resilient components to take into account their non-linear behaviour:

- Major parameter for this test: the pre-load application, when assessing the dynamic stiffness
- ! Beware that this pre-load depends on the resilient element stiffness



Experimental setup and photo, high amplitude tests

Straight track case (ballasted and slab track)

MODEL OF TRACK DYNAMIC RESPONSE: INPUT CHARACTERIZATION

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- ! Beware that this pre-load depends on the resilient element stiffness

We are aware that:
- For USP, the contact area between {sleeper+USP} and ballast is modified depending on the USP stiffness
- Some other parameters such as ballast stiffness remain difficult to be assessed

Ballast imprints on a USP sample

Straight track case (ballasted and slab track)

SELECTION OF MITIGATION MEASURES / OPTIMIZATION AND TESTS

Refer to the 2 previous presentations:

- Numerical approach for selecting the best options/combinations
- Lab tests for in field implementation
- Testing

Straight track case (ballasted and slab track)

SELECTION OF MITIGATION MEASURES / OPTIMIZATION AND TESTS

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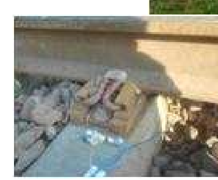


Straight track case (ballasted and slab track)

MAIN OUTCOMES: MM PERFORMANCES

Although some parameters are not fully mastered…

➔ Results in accordance with the expectations (most of them)

- Soft undersleeper pads imply an IL up to 15 dB for frequencies above 40Hz
- Coupling USP with wide sleepers has a noticeable positive effect
- Soft USP installation in slab track such as GETRAC system imply an IL up to 15 dB for frequencies above 40Hz
- Very soft railpads, with dedicated fastening systems imply an IL up to 12 dB for frequencies above 50 Hz

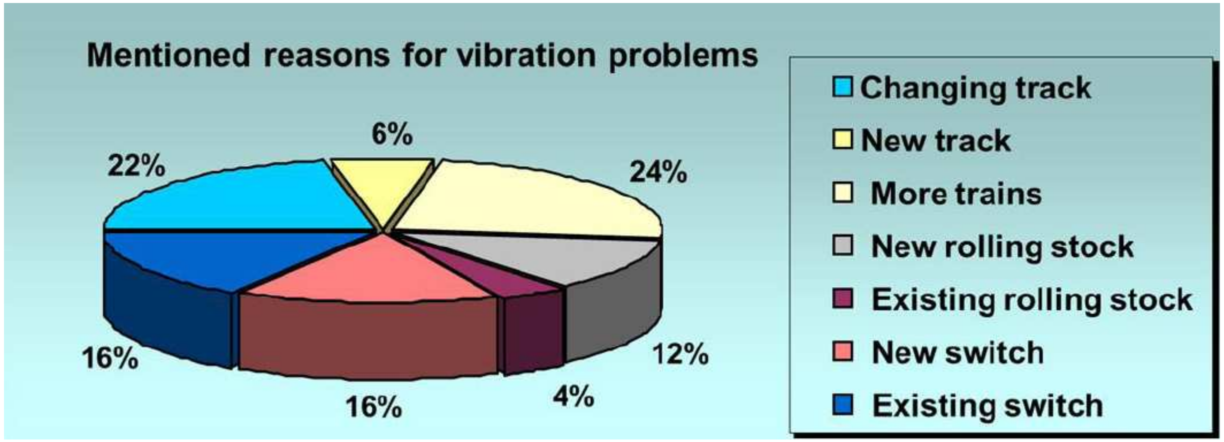
➔ Some phenomena have still to be looked at carefully:

- Non-linear stiffness / performances of the resilient elements with the pre-load
- Effect of mitigation measures on the parametric excitation
- Effect of the mitigation measures on track in time and maintenance (reduction of w/r contact force)

Specific track sections

TURNOUTS

Major issue in terms of ground vibrations because it causes a high increase of wheel-rail interaction force, by many different ways of action



Survey on the Swiss network (SBB ®)

Turnout mitigation measures: design

General principles

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To make an exhaustive inventory of the excitation mechanisms

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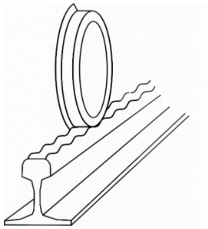
To understand the impact of such mitigation measures on the dynamic response of the track

Could we still apply these general principles for the design of mitigation measures in turnout?

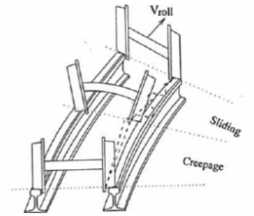
Specific track sections: turnouts

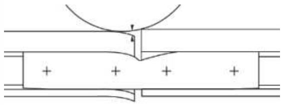
INVENTORY OF EXCITATION MECHANISMS:



Uneveness

Parametric excitation





Transients

Curves and Switches

⇓

Coupling of empirical approach and numerical approach
(lot of phenomena at work)

Specific track sections: turnouts

EMPIRICAL APPROACH: TESTS of PROVEN MM (in case of straight track)

Tests of soft USP installation in several turnouts

2 turnouts couples (with and without USP) on 2 different sites → 4 turnout couples

Main conclusions:

1- Each turnout (without MM) is a special case

Le Landeron

Track Nr.	Turnout without USP MP 3		Regular track MP 4		Factor: Turnout-amplification	
	KBFt	v_{Leq}	KBFt	v_{Leq}	KBFt	v_{Leq}
1 (MP 3c / MP 4c)	0.224	0.102	0.208	0.091	**1.08**	**1.12**
2 (MP 3b / MP 4c)	0.148	0.073	0.153	0.073	**0.97**	**1.00**

Very small amplification and even decrease of GV at turnout (depending on the position of measurement in the turnout)

Rubigen

Track Nr.	Turnout without USP MP3		Regular track MP4		Factor: Turnout-amplification	
	KBFt	v_{Leq}	KBFt	v_{Leq}	KBFt	v_{Leq}
1 (MP 3b / MP 4a,b,c)	0.576	0.237	0.199	0.098	**2.89**	**2.42**
2 (MP 3c / MP 4a,b,c)	0.563	0.245	0.321	0.130	**1.75**	**1.89**

Very high amplification whatever is the position of measurement in the turnout

Specific track sections: turnouts

EMPIRICAL APPROACH: TESTS of PROVEN MM (in case of straight track)

Main conclusions:

2- Impact of USP highly dependent of the the turnout

Regular straight track

Track Nr.	Regular track MP 2		Regular track MP 4		Factor (track/subsoil effects)	
	KBFt	v_{Leq}	KBFt	v_{Leq}	KBFt	v_{Leq}
1 (MP 2c / MP 4c)	0.138	0.054	0.208	0.091	0.66	0.59
2 (MP 2c / MP 4c)	0.094	0.042	0.153	0.073	0.61	0.58

Decrease of vibrations with USP installation in the straight neighbouring track

Le Landeron

Track Nr.	Turnout with USP MP 1		Turnout without USP MP 3		Factor (USP mitigation effect, if smaller 1)	
	KBFt	v_{Leq}	KBFt	v_{Leq}	KBFt	v_{Leq}
1 (MP 1c / MP 3c)	0.405	0.175	0.224	0.102	1.81	1.72
2 (MP 1b / MP 3b)	0.349	0.150	0.148	0.073	2.36	2.06

INCREASE of vibration with soft USP installation

Rubigen

Track Nr.	Turnout with USP MP 1		Turnout without USP MP 3		Factor	
	KBFt	v_{Leq}	KBFt	v_{Leq}	KBFt	v_{Leq}
1 (MP 1b / MP 3b)	0.858	0.363	0.576	0.237	1.49	1.53
2 (MP 1c / MP 3c)	0.685	0.273	0.563	0.245	1.22	1.11

INCREASE of vibration with soft USP installation

USP installation increases the GV in turnout, but with various ratio of increase…

Specific track sections: turnouts

EMPIRICAL APPROACH: TESTS of PROVEN MM (in case of straight track)

Main conclusions:

2- Impact of USP highly dependent of the the turnout

RESULTS TOO INCONSISTENT TO CONCLUDE ON THE IMPACT OF USP ON GROUND VIBRATION GENERATED BY TURNOUTS

SOLUTION:

➔ CONSIDER EACH TURNOUT AS A SPECIAL CASE

-IDENTIFY THE SOURCES OF GV

-DESIGN DEDICATED MITGATION MEASURES HELPED WITH NUMERICAL APPROACH

Track Nr	Regular track MP 3		Regular track MP 4		Factor (track/subsoil	
1 (MP 1b / MP 3b)	0.858	0.363	0.576	0.237	1.49	1.53
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Decrease of vibrations with

vibration with soft USP installation

Rubigen

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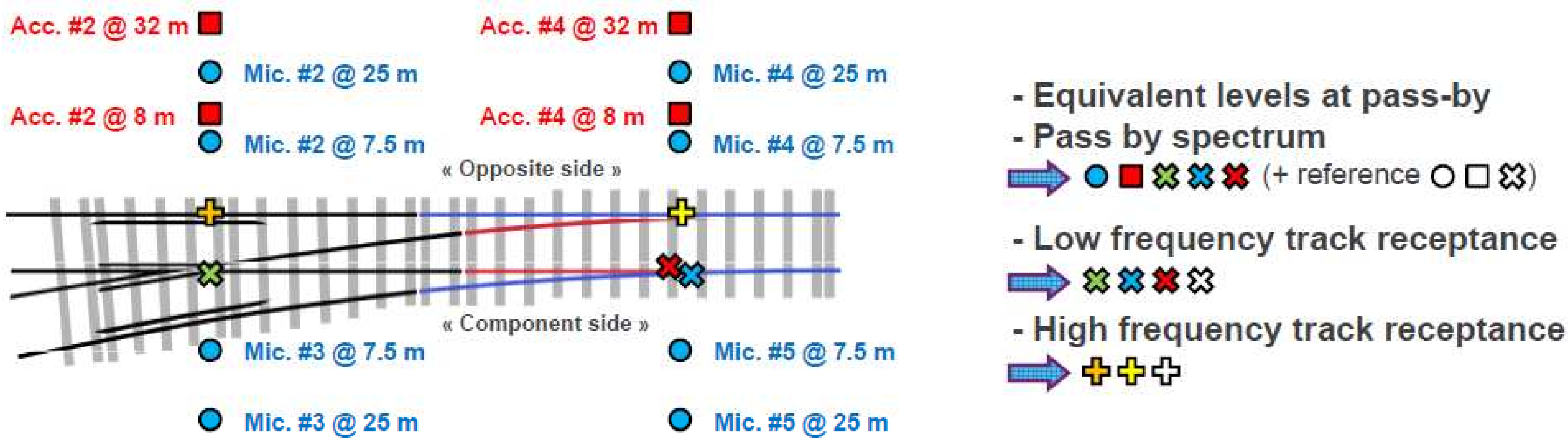
Specific track sections: turnouts

TURNOUT CLASSIFICATION: IDENTIFICATION OF GV GENERATION MECHANISMS

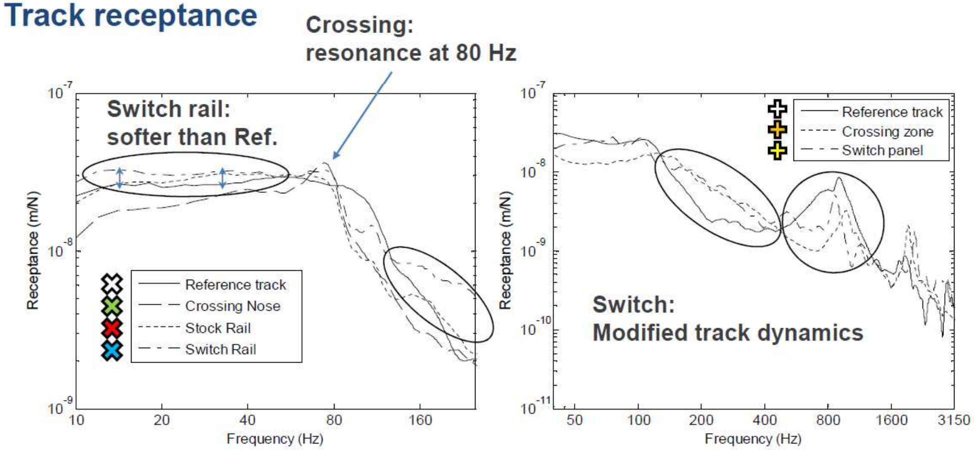
Measurement methodology to understand a turnout in terms of GV generation



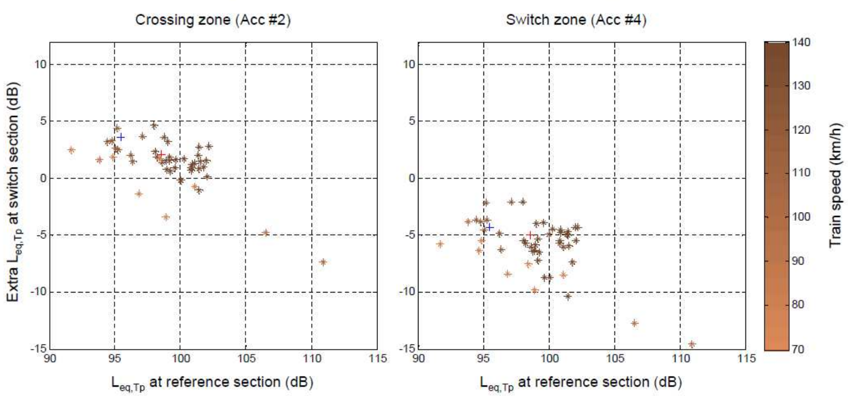
Specific track sections: turnouts

TURNOUT CLASSIFICATION: IDENTIFICATION OF GV GENERATION MECHANISMS

Track receptance



Extra vibration (soil accelerometers at 8 m)



Modified track properties:

- Softer track under the switch panel
- Stiffer track under the crossing (rigid component)
- Resonance of the crossing on the ballast stiffness at 80 Hz

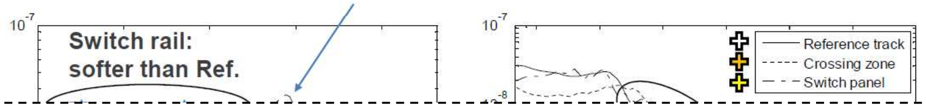
Impacts on ground vibration:

- More vibration in front of the Crossing:
  - Resonance of the excitation at 80 Hz (rail)
  - Band pass for the track/soil path
  - High sleeper excitation
- Less vibration in front of the switch:
  - Low frequency vibration isolation

Specific track sections: turnouts

TURNOUT CLASSIFICATION: IDENTIFICATION OF GV GENERATION MECHANISMS

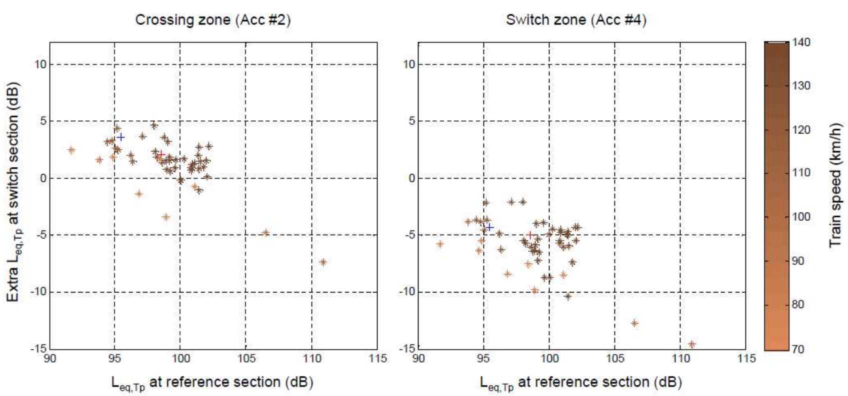
Track receptance



Modified track properties:

For this specific turnout, the design of mitigation measure should be focused on the crossing panel optimization, to reduce impact load

This classification /source identification should be done for each turnout under study



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Specific track sections: turnouts

NUMERICAL APPROACH: SOLUTIONS FOR THE REDUCTION OF W/R INTERACTION FORCE AT CROSSING PANEL

Numerical approach developed by Chalmers to predict w/r interaction force when running in a turnout, depending on:

- -Turnout geometry parameters (crossing panel designs, switch design…)
- -Turnout equivalent global stiffness
- -Wheel design (several wheel designs and wear rates are considered)

Main conclusions:

→ optimization of turnout geometry is too much constraint by safety limits to be effective for interaction force reduction

→ The best option to reduce impact load at the crossing panel should be the installation of very soft railpads

Outcomes of track mitigation measures

- Mitigation measures in track present positive IL (up to 15dB) above 50Hz… but this is without considering effects on parametric excitation and on defect growth. This 2 last points should be further investigated

- Special care should be taken to determine the characteristics of the track (dynamic behaviour, defects), surrounding ground and vehicles running on it before choosing mitigation measures

- Collateral effects of MM implementation should be taken into account:
  - Impact on noise: could be assessed with numerical approach
  - Impact on track lifecycle and maintenance operations: could only be determined with feedback from experience

➔ Outcomes summed-up in the on-coming guidelines

Thank you for your attention.

Visit our website wwww.rivas-project.eu

Thanks to all the WP3 partners!

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