

BOMBARDIER

CHALMERS



Future solutions for rolling stock design

Objectives

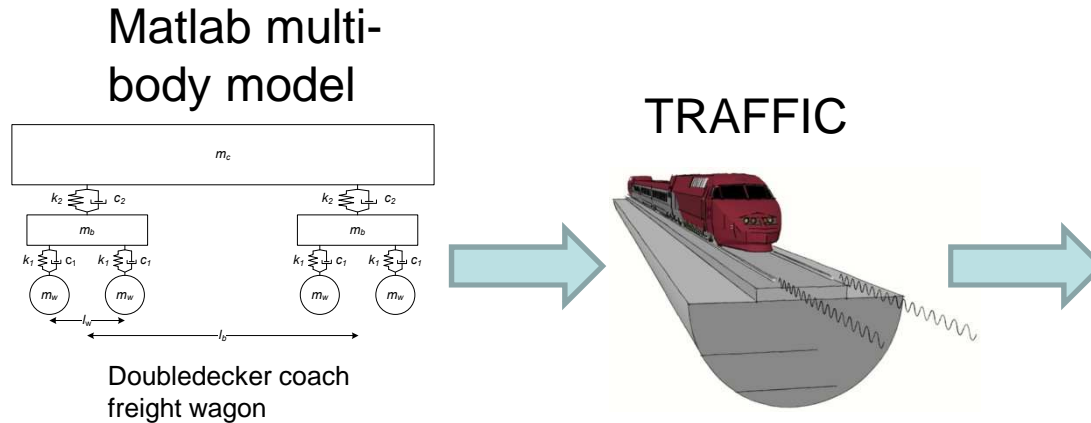


- Identify and quantify the major vehicle related parameters influencing the vibration
- Optimise measures for the vehicles to reduce vibration taking into account functional constraints and cost efficiency aspects
- Implementation and validation of the most promising mitigation measures in a full scale field test at selected test sites

Parameter studies



Calculations



- Parameter influence
- Mass
 - Suspension
 - Geometry
- For different
- Soils
 - Excitations

Measurement data

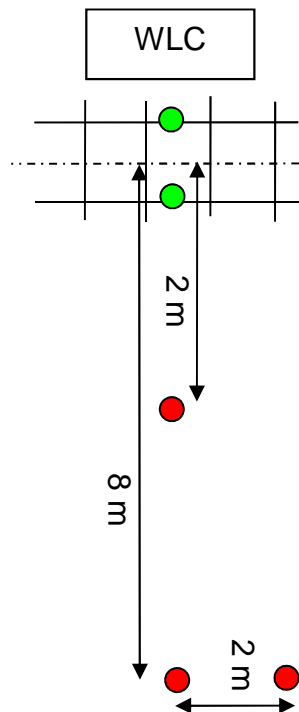
- SBB monitoring stations
- Large number trains
 - Known vehicle type and data

Statistical evaluation



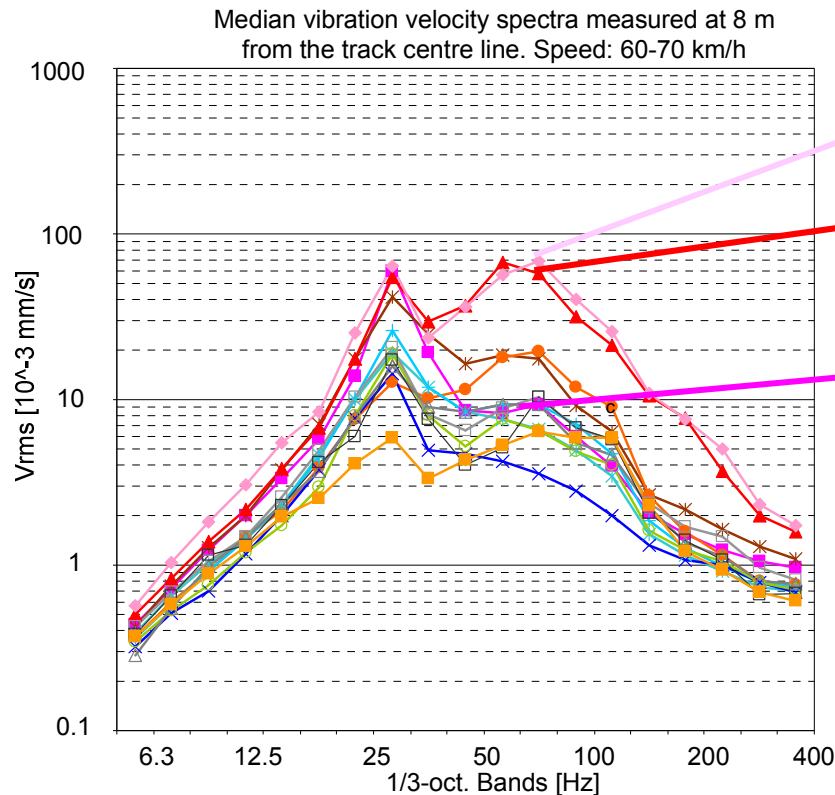
- Identified influence
- Vehicle type
 - Speed
 - Vehicle parameters

Measurements



- Accelerometers on ground
- Strain gauges on rail

Measurement result



Locomotives	Regional & IC	Freight wagons
Re 460	NINA	l_w 1.8 m
Re 482/484	IC 2000	l_w 2.0 m
Re 420	EW IV	2 axle bogie
Re 620	EW II	RoLa bogie
	RIC Bpm	

$m_w - 3480 \text{ kg}$
 $k_s - 2.5 \text{ MN/m}$

$m_w - 3200 \text{ kg}$
 $k_s - 2.5 \text{ MN/m}$

$m_w - 1900 \text{ kg}$
 $k_s - 3.6 \text{ MN/m}$

Un-sprung mass

+

Suspension stiffness

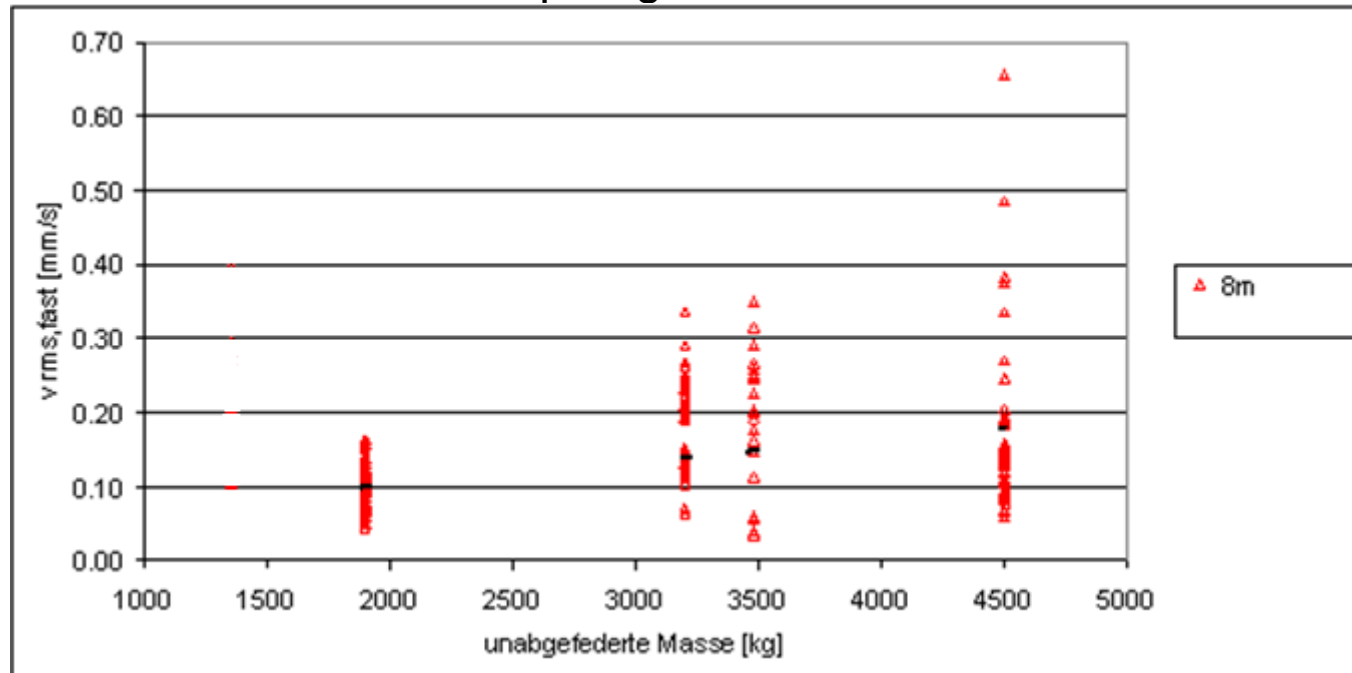
+

?

Measurement result



Un-sprung mass



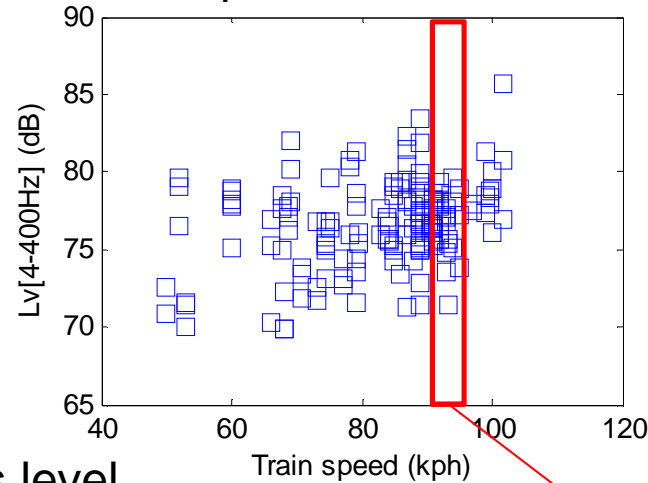
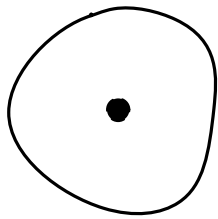
**Locomotives Re460, Re420, Re620 and TRAXX F140
(from left to right).
@ Thun, speed: 60-70 km/h.**

Wheel condition & vibration

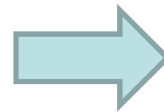
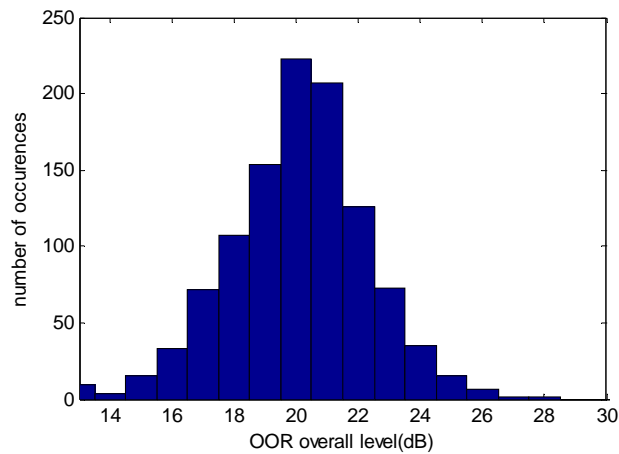


Influence of speed, Re 620 locomotive

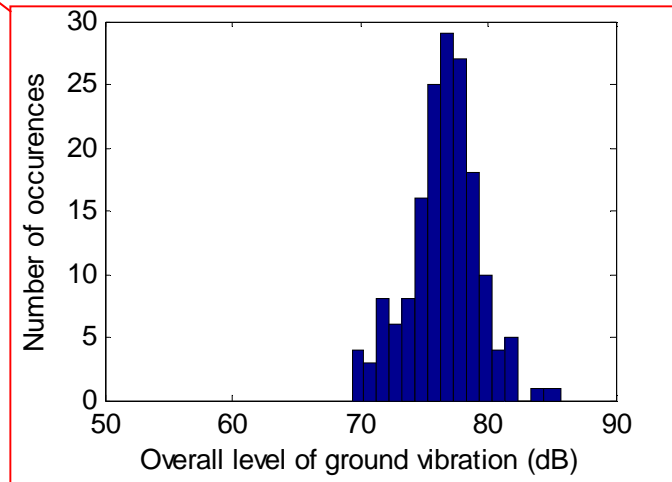
Out-of-round wheel



Out-of-roundness level



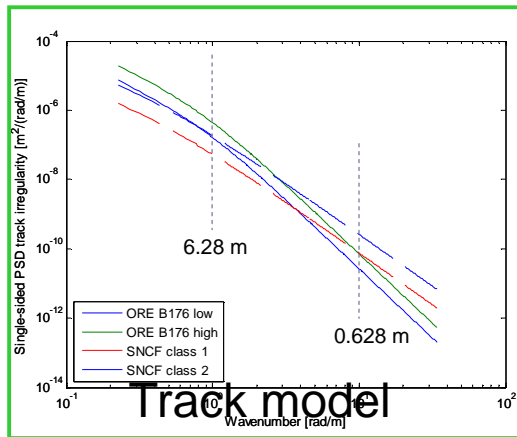
Constant speed



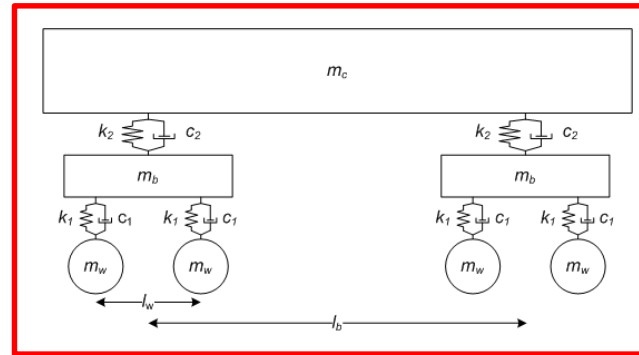
Simulations



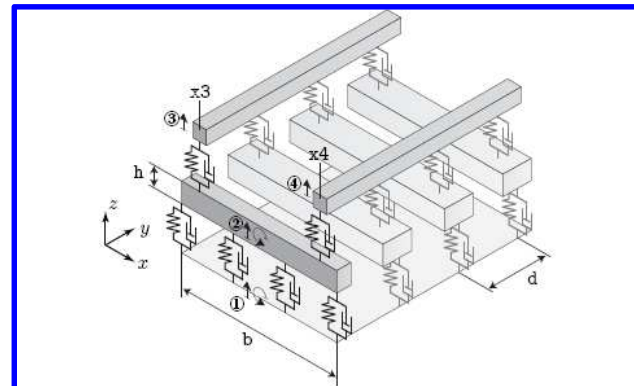
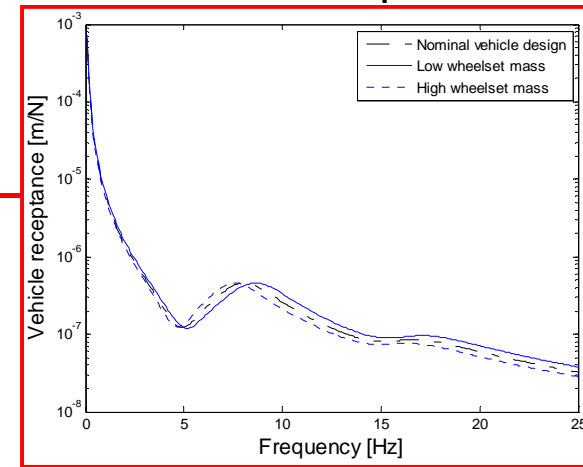
Excitation from rail irregularities



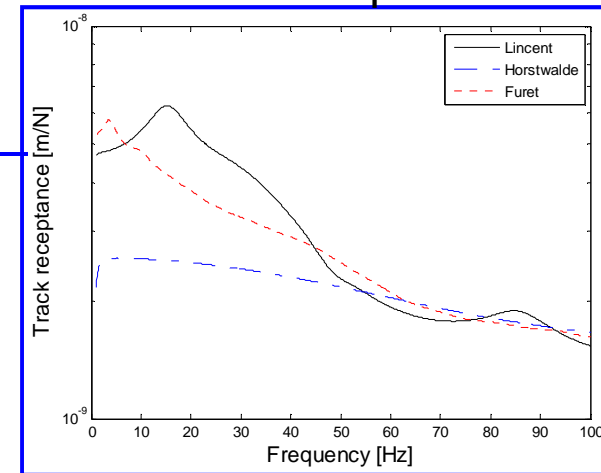
Track model



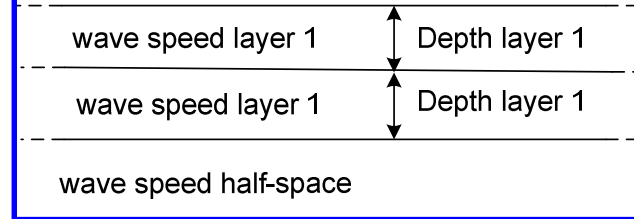
Vehicle receptance



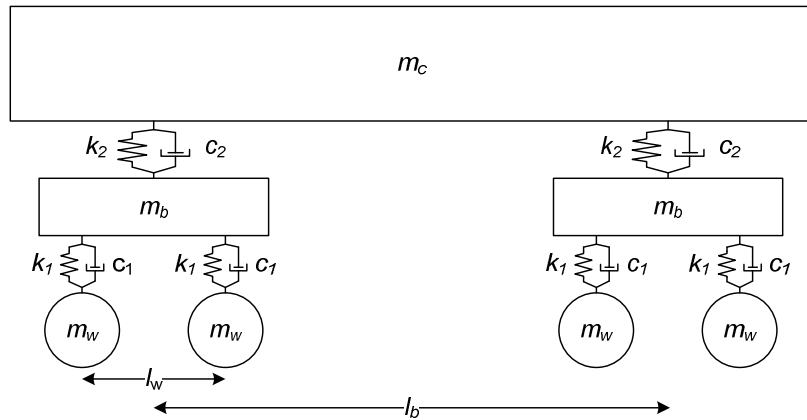
Track receptance



Ground model



Fractional factorial design study



Parameter	variable	Unit	Low level	High level
Axle spacing	l_w	[m]	1.6	2.0
Bogie spacing	l_b	[m]	8	9.7
Un-sprung mass	m_w	[kg]	1250	1600
Primary suspension damping	c_1	[kNs/m]	40	160
Primary suspension stiffness	k_1	[MN/m]	4	7
Bogie frame mass	m_b	[kg]	1572	2572

- 6 design variables for the freight model
- 9 design variables for the passenger vehicle model
- Resolves single parameter effects and interaction effects

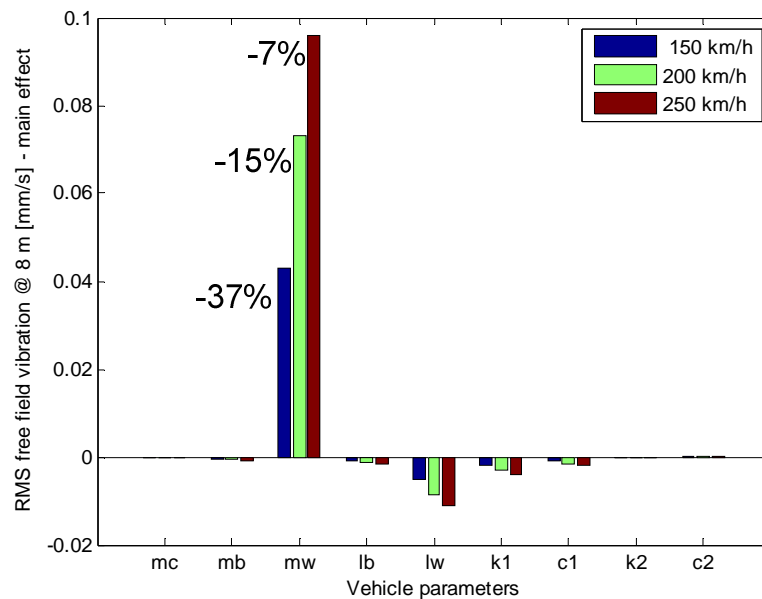
Simulation results

- Main effects

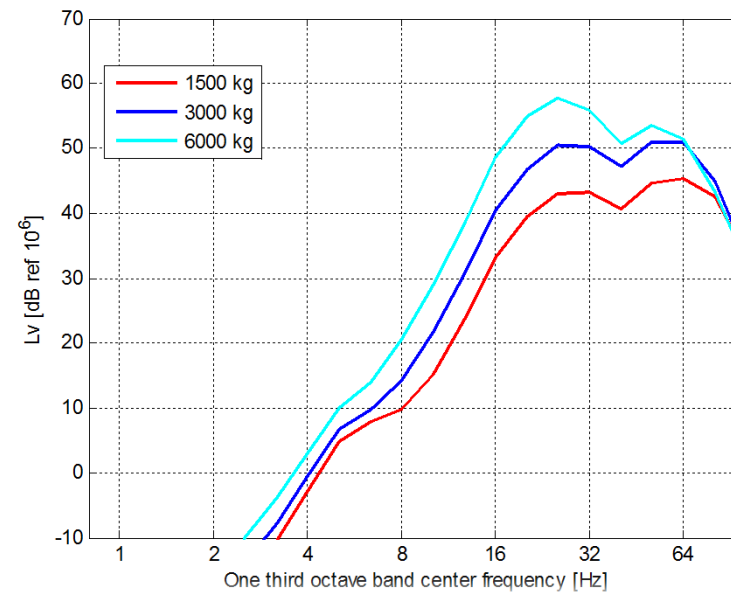


Double deck model

Influence of 9 parameters



Influence of un-sprung mass
Vehicle speed 200 km/h



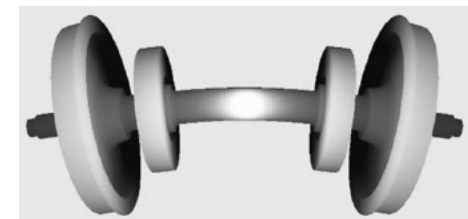
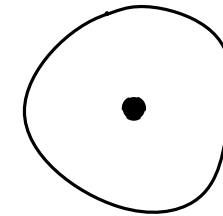
Influence from varying one parameter at a time.

Interaction effects are negligible.

Conclusions and next steps



- Measurements have shown significant influence from wheel out-of-roundness on ground vibration
- Simulations have shown significant influence from the un-sprung mass on ground vibration
- Measure wheel out-of-roundness on different vehicles
- Measurement with dedicated test trains
- Simulation model with flexible wheelset
- Technology and cost assessment of mitigation measures



Thank you!

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