The track-friendly high-speed bogie developed within Gröna Tåget

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Outline

- Introduction
- Investigated concepts
- Radial self-steering (*RSS*)
- Active secondary suspension (*ALS* and *AVS*)
- Conclusions

Gröna Tåget

- Research and development programme initiated in 2005 by Banverket (today: Trafikverket) – closed by the end of 2012
- Develop a concept for the next generation of high-speed trains for Nordic conditions
- Increase vehicle speed from today's 200 km/h up to 250–320 km/h
- Focus: vehicle dynamics, energy consumption, passenger issues, infrastructure, market needs, capacity, economics…

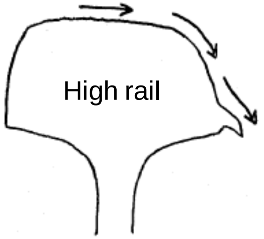
Track-friendly high-speed bogie

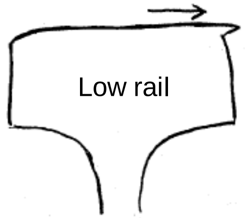
- Challenge: contradiction between stability on straight track at high speed and reasonable wheel/rail wear in small- and medium-radius curves
- Developing and optimizing a track-friendly high-speed bogie by simulations, verifying the design by on-track tests and service use

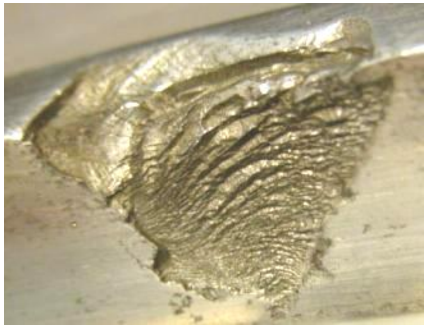
Track friendliness

- Low wheel/rail forces on the track to avoid track wear and fatigue
- Minimize track deterioration, causing maintenance and renewal (high costs, traffic interruptions)
- Costs for track deterioration to be included in the track access charges

$\rightarrow$ Increased need for track-friendly vehicles



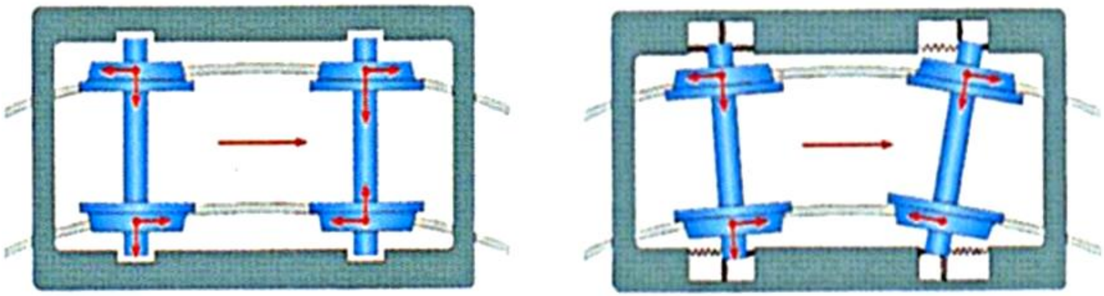




Radial steering running gear

- Stiff connection prevents the wheelset to take up radial position

  $\rightarrow$ Increased friction energy and wear in curves
- The longitudinal stiffness of the wheelset guidance is an important issue to allow radial self-steering



Running stability

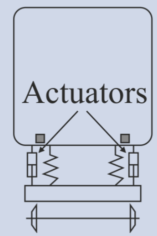
- A certain amount of wheelset guiding stiffness is necessary to avoid bogie hunting
- Lower guiding stiffness can often be compensated by a higher amount of yaw damping
- A thorough optimization of other important parameters is also necessary

Strategy

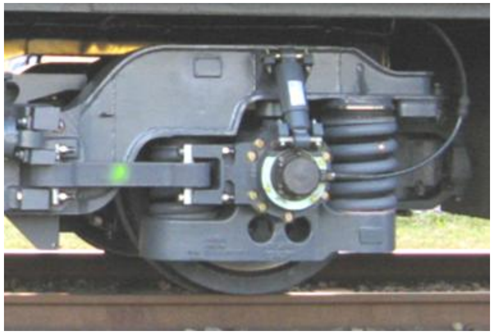
- Running stability is just one of several targets
- Track friendliness and good ride quality are other important issues

Therefore: design for *sufficient* running stability while optimizing the total performance

Investigated concepts

Concept	**Radial self-steering (*RSS*)**	**Active radial steering (*ARS*)**	**Active lateral secondary suspension (*ALS*)**	**Active vertical secondary suspension (*AVS*)**
What?				
Theoretical study	2005–06	2006–07	2006–07	2010–11
On-track tests	2006–07	2007–08	2007–08	2013?
Service experience	2009 →	–	2009 →	–
First firm order	–	–	2010	–

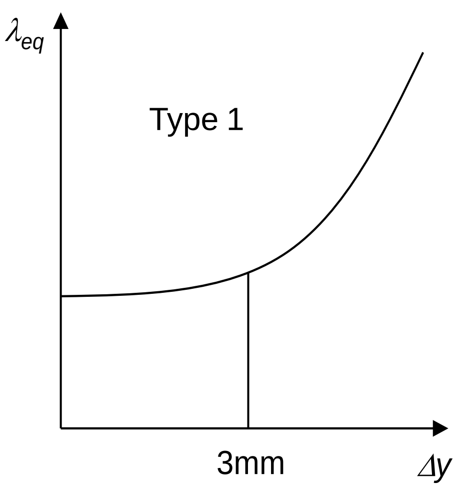
Radial self-steering (*RSS*)

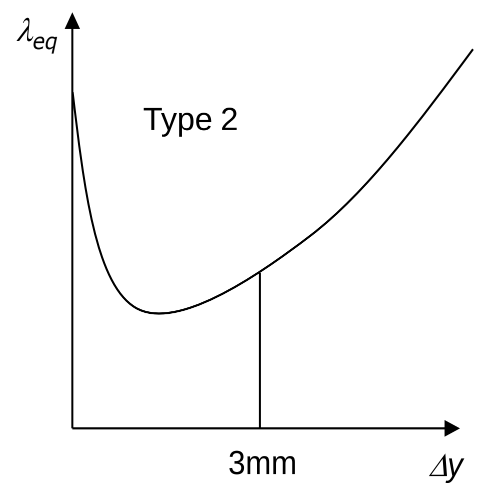


Simulation conditions

- SIMPACK model of a Swedish *REGINA* car
- Ten wheel/rail combinations

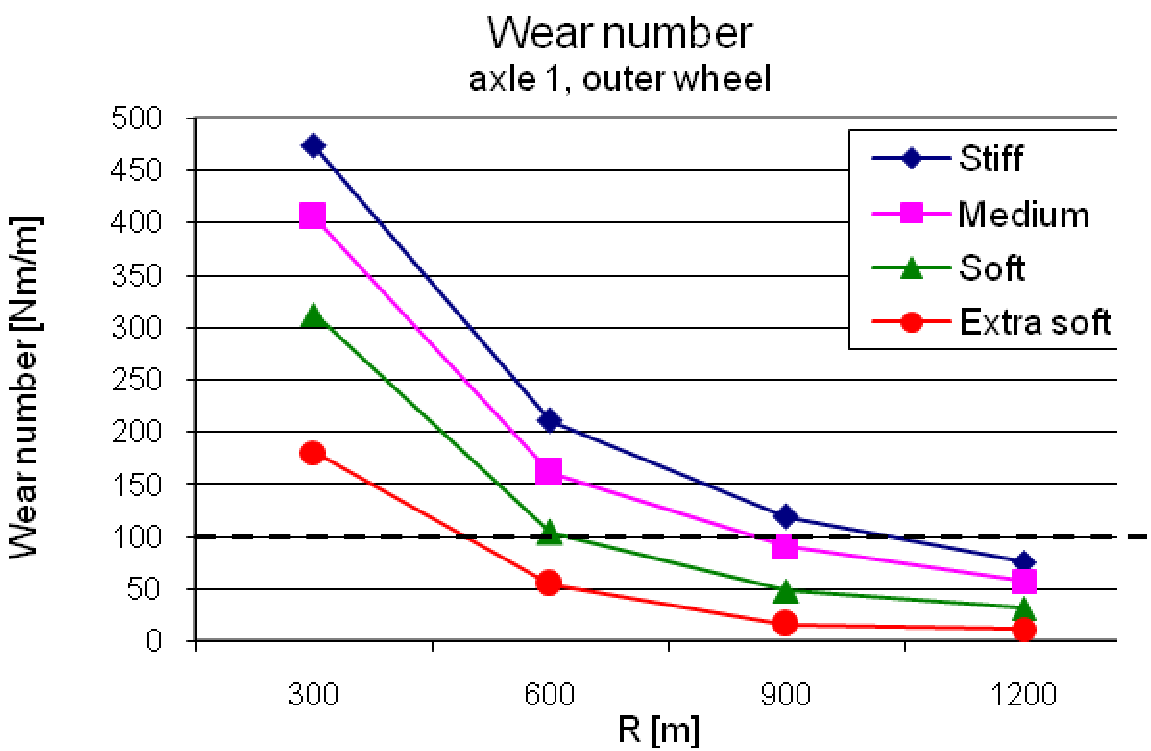
  $\rightarrow$ equivalent conicity: 0.01-0.4 (Type 1 and 2)





Simulation results

Wheel/rail wear

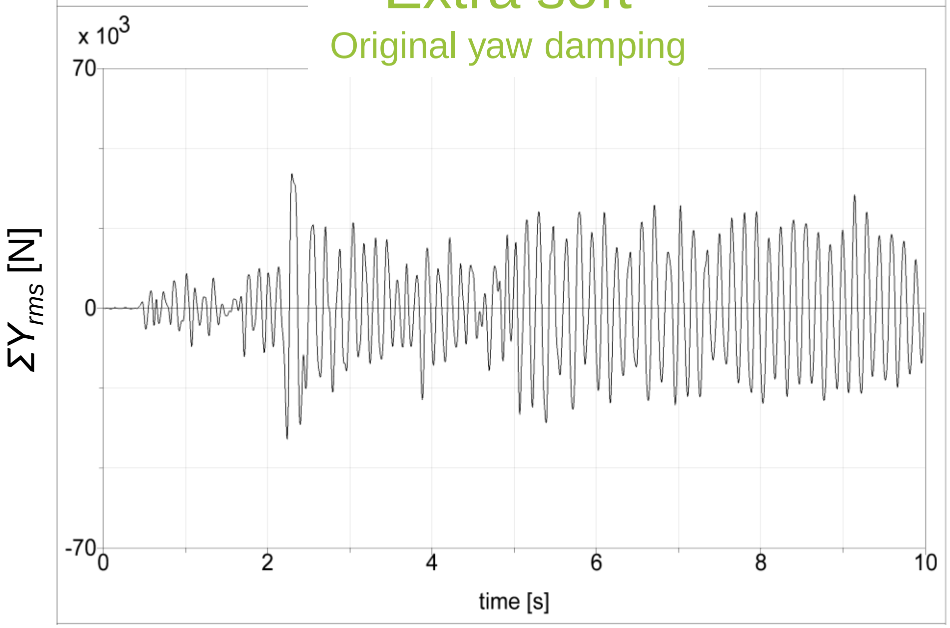


Simulation results

Running stability

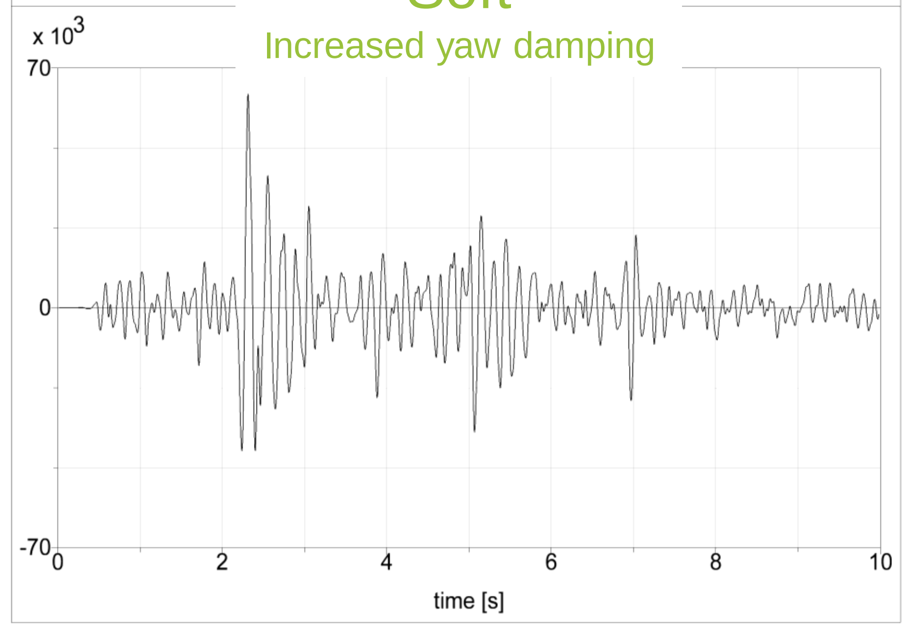
Extra soft

Original yaw damping



Soft

Increased yaw damping



Straight track
Eq. conicity = 0.3
v = 275 km/h

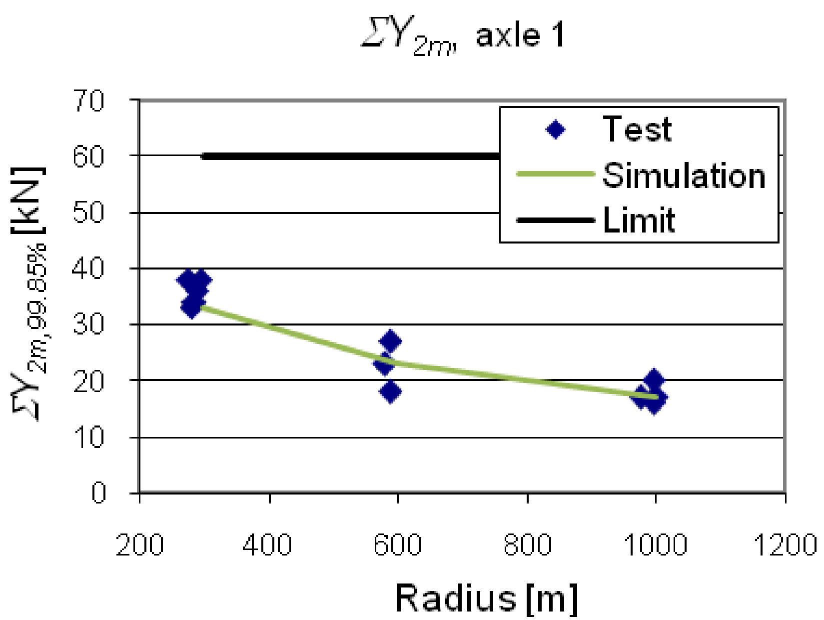
On-track tests

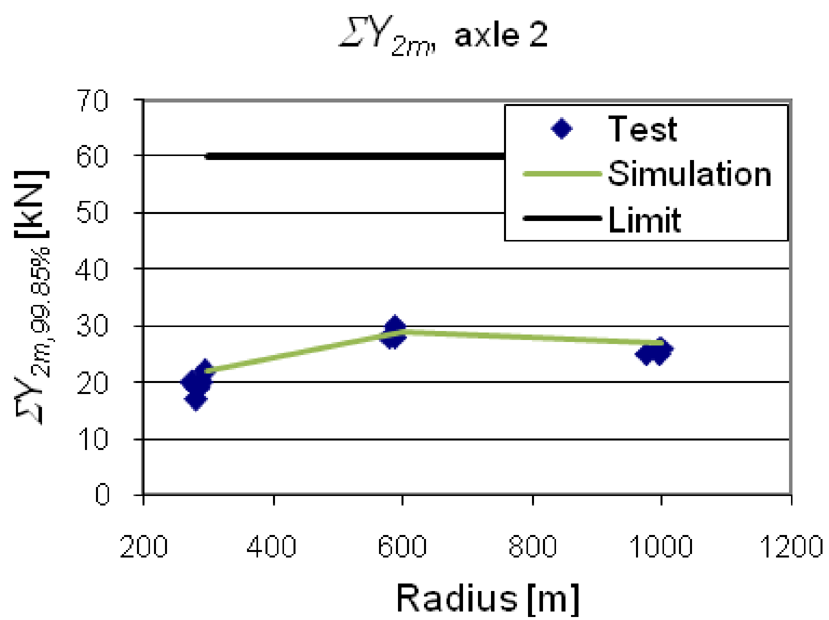
- Different Swedish tracks (straight track, curves)
- Stability tests on straight track, equivalent conicity 0.1–0.8
  Measurement results: Stability (ΣY_{100rms}) = 30 % of limit value
- High cant deficiency curving at curve radius 300 m
  Measurement results: Wear (Y_{qst}) = 60–75 % of limit value

Swedish high-speed record in September 2008:
303 km/h

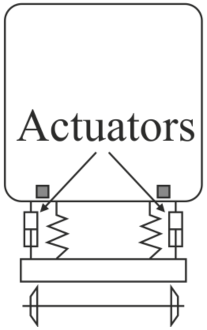
Model validation

Lateral track shift forces



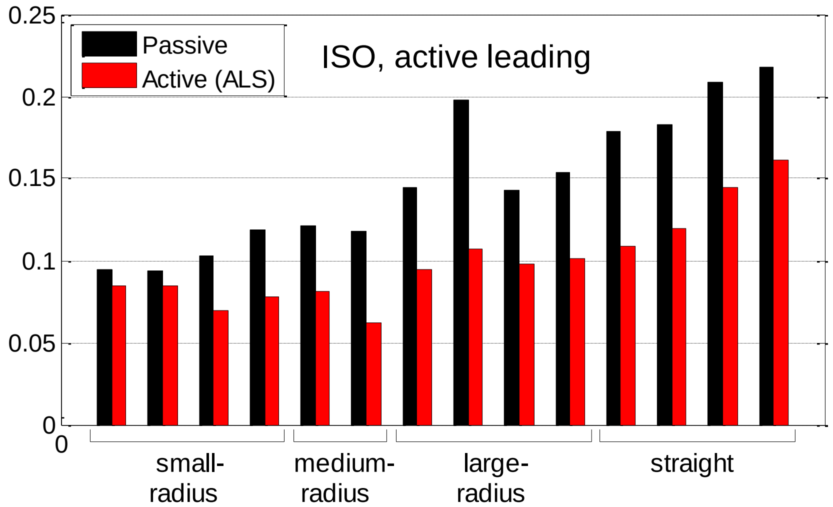


Active secondary suspension (*ALS* and *AVS*)

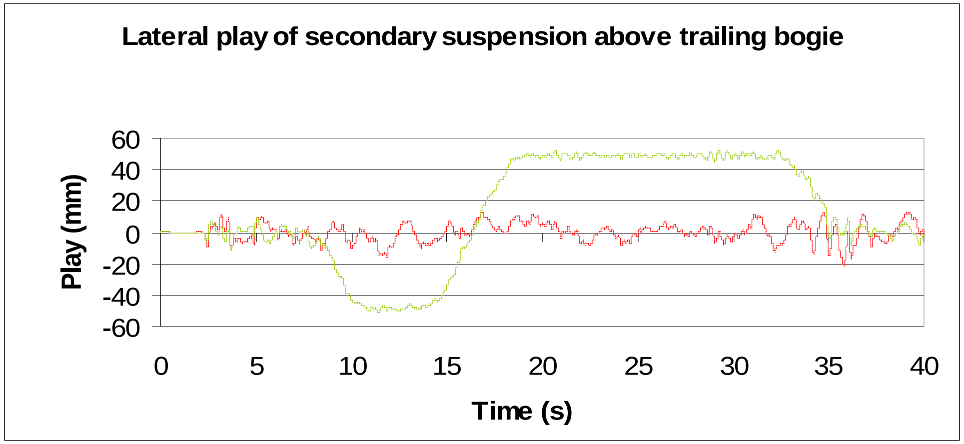


Active lateral suspension
Measurement results

Ride comfort improvements



Reduced secondary lateral play



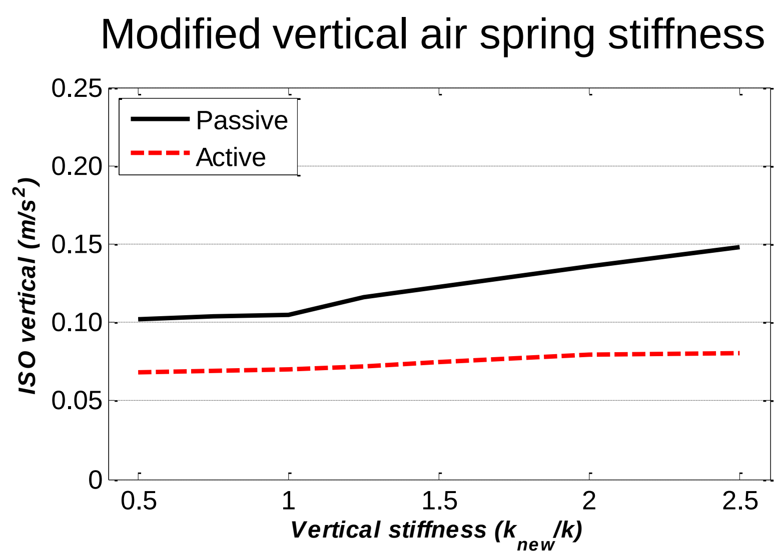
…resulting in:

- possible speed increase for the same level of ride comfort
- maintained ride comfort although track conditions are unfavourable
- increased carbody width

Active vertical suspension

Simulation results

- Generally improved vertical ride comfort
- Less sensitivity for suspension stiffness
- Less sensitivity for carbody bending frequency



Active vertical suspension

Simulation results

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- Less sensitivity for suspension stiffness
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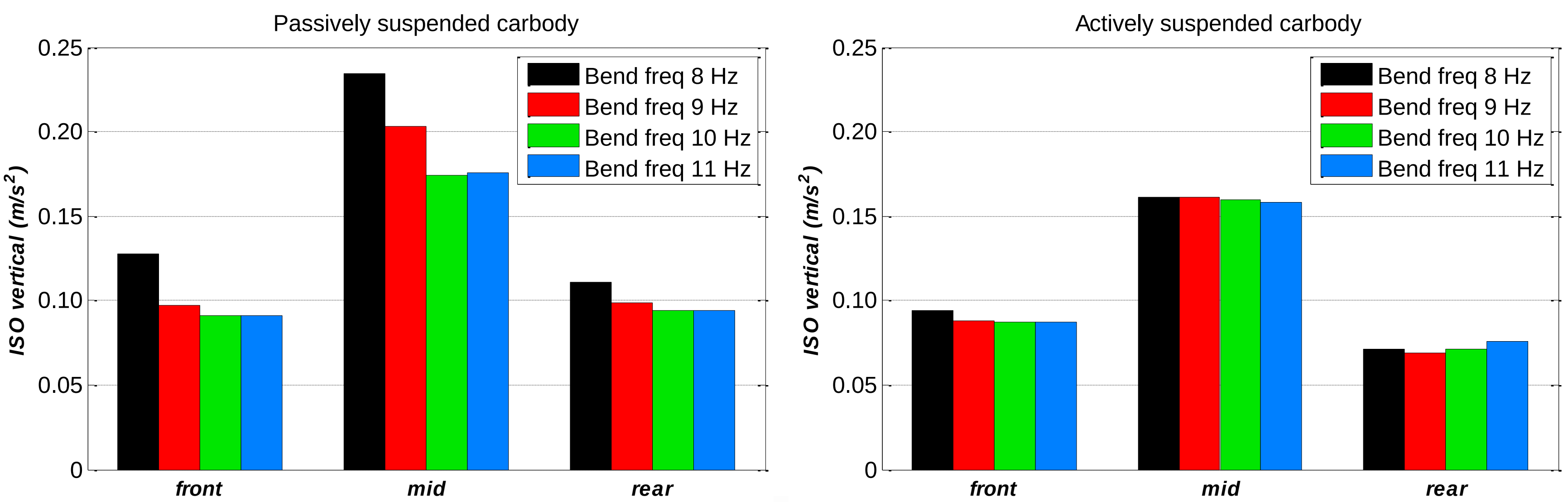
Modified carbody bending frequency



Intro
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Conclusions

- Developing a bogie with relatively soft wheelset guidance to allow passive radial self-steering
- Appropriate yaw damping applied to ensure stability on straight track at higher speeds
- The design verified by simulations and on-track tests
- Active suspension (*ALS* and *AVS*) mainly to improve ride comfort

More than 600.000 km in service operation without reports of poor running behaviour or wheel reprofiling due to wear

Thank you for your attention!

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