How can active suspension reduce cost in rail vehicles?

Rickard Persson, KTH Rail vehicles

Examples of active suspensions today

Vehicle	Application	Business case
 Shinkansen (Japan)	Active secondary lateral suspension to reduce aerodynamically induced vibrations.	The active suspension makes it possible to run at enhanced speed, which may attract more passengers and makes use of vehicle and crew more efficient.
 X2000 (Sweden)	Active tilting to reduce lateral quasi-static acceleration	
 ETR1000 (Italy)	Active secondary lateral suspension to reduce vibrations at high speed curving	

RUN2Rail in short

Budget: **2,732,463€**

Partners: **15**

Duration: **24 months**

RUN2Rail in short

WP1 - Innovative sensors & condition monitoring

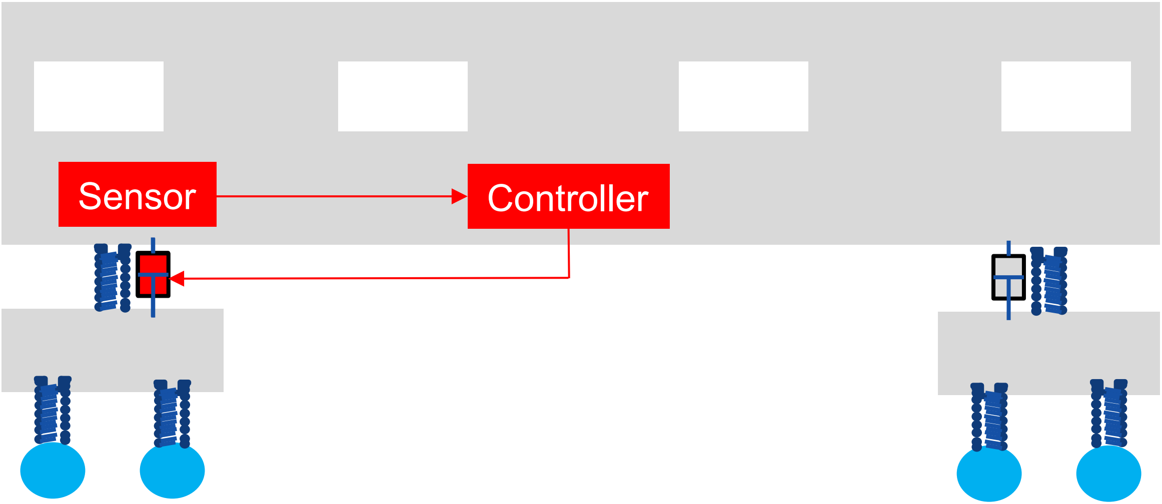
WP2 - Optimised Materials and Manufacturing Technologies

WP3 - Active Suspension & Control Strategy

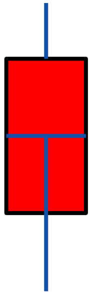
WP4 - Noise and Vibration

WP5 - Dissemination, Exploitation/Impact Management and Cooperation with Shift2Rail

What is active suspension?



The actuator



There are may types of actuators, the most common type is similar to a conventional hydraulic damper.

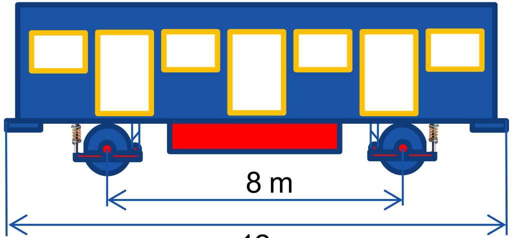
1. If we make the damper controllable we get a semi-active actuator
2. If we want to have a fully active actuator we must add a power source, a pump driven by an electrical motor

RUN2Rail WP3
The new business case

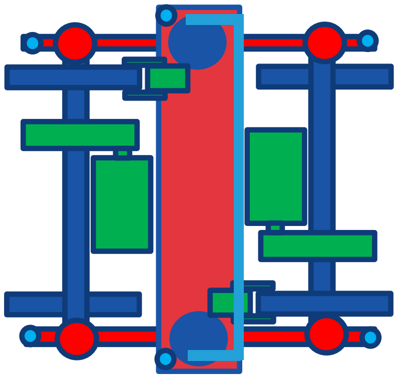
Vehicle	Application	Business case
 Single axle running gear for passenger vehicles	Active suspension to achieve an acceptable vibration~~al~~ comfort	Reduced vehicle weight Reduced vehicle cost Reduced maintenance cost
	Active wheelset steering to reduce wear on wheel and rail	

RUN2Rail WP3
Target vehicle properties

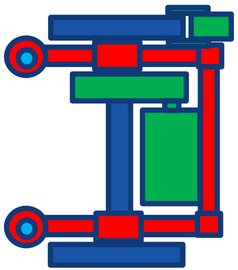
Key property	Metro Madrid class 8000	Innovative
Max speed	120 km/h	120 km/h
Number of cars	3	3
Train length	55.049 m	36.000 m
Pay load per m	1.000 kg/m	1.000 kg/m
Tare weight per m	1.900 kg/m	1.500 kg/m
Pay load to tare weight ratio	53%	67%
Max axle load at pay load	14.350 kg	15.000 kg



The source for the weight savings



7530 kg

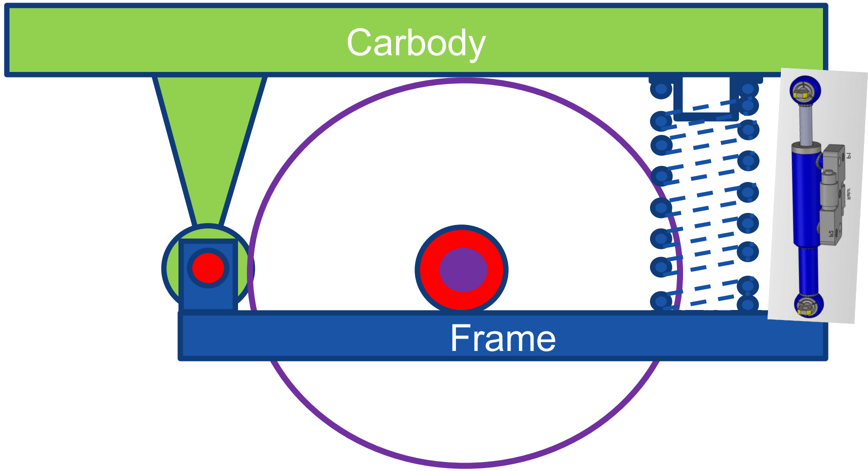


3000 kg

The axle boxes moved to inside the wheels => Shorter and lighter axle
=> More compact and lighter frame
One suspension step eliminated => Less weight
No need for air suspension => Cheaper + Air free train???
Anti roll bar part of frame => Less weight
The weight savings on the running gear will lead to other weight savings (100 kg/m)

In total 400 kg/m weight savings

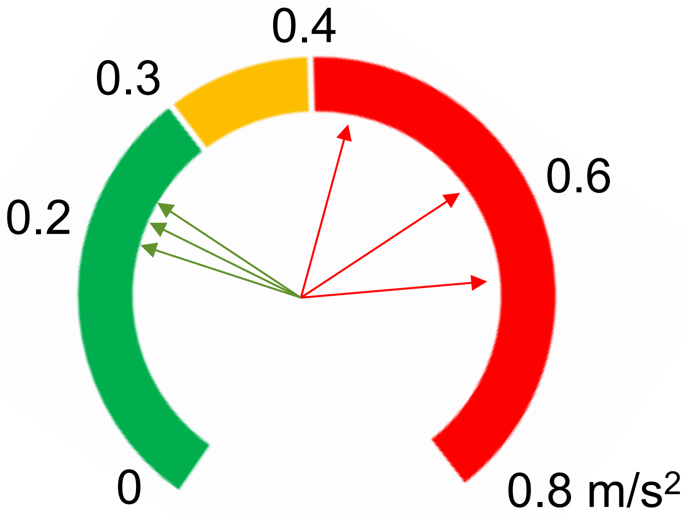
RUN2Rail WP3
Vibrational comfort



A bogie has two suspension steps, one from wheelset to frame and one from frame to carbody. The single axle running gear has only one suspension step.

A suspensions step works like a filter, attenuating vibrations. As the vibrations initiate from the rail there is a risk that the vibration attenuation from rail to carbody might be poor.

RUN2Rail WP3
Ride comfort



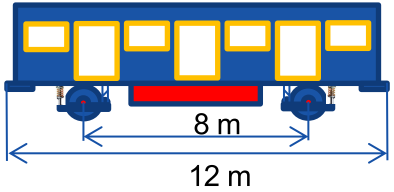
Simulated vertical ride comfort on tracks with different qualities

The simulations confirm that the ride comfort with passive suspension will be unacceptable.

With active suspension the ride comfort will be acceptable.

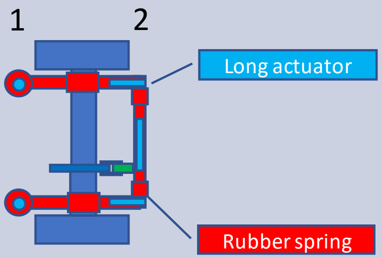
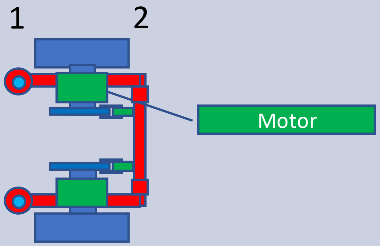
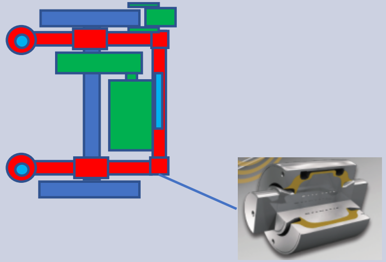
RUN2Rail WP3
Wheelset steering

Wikipedia: Excessive flange squeal on tight curves has been a problem on class 142 caused by the long wheelbase and lack of bogies.



Simulations for the innovative vehicle with passive axle guidance confirm~~s~~ that the wheel (and rail) wear will be worse than for the reference bogie vehicle.

RUN2Rail WP3
Wheelset steering

Force wheelset to radial position	Motorized independently rotating wheels	Frequency dependent axle guidance
		
Two longitudinal actuators force the wheelset to take a radial position	The motors on the independently rotating wheels are controlled to make the wheelset to take a radial position	The frequency dependent axle guidance will allow the wheelset to passively take an approximately radial position

RUN2Rail WP3
Wheelset steering

Vehicle	Passive bogie vehicle (reference vehicle)	Passive single axle running gear	Force wheelset to radial position	Motorized independently rotating wheels	Frequency dependent axle guidance
Wear on wheel and rail relative reference vehicle	0%	+45%	-71%	-94%	Not studied yet

Metro Madrid Line 10 as example for wear calculations

The calculation is made per axle

Conclusion

The single axle running gear will reduce the tare weight per meter train with 400 kg/m (40 tons for a 100 m long train)

40 tons less to manufacture

40 tons less to propel

With active suspension installed this vehicle will bring acceptable ride comfort and reduced wheel and rail wear