

„eCAS“

Electrohydraulic Controlled Axle Steering

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**LIEBHERR**

# „eCAS“ Electrohydraulic Controlled Axle Steering Content

- 1 Initial Position
- 2 Requierement
- 3 eCAS Concept and Actuator Function
- 4 Effectiveness
- 5 Option - Track Diagnostic
- 6 Status
- 7 View

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## Initial Position / Motivation

- Infrastructure Operator: Protection of Infrastructure
- Vehicle Operator: Reduction of operating costs

1995

**Council Directive 95/19/EC of 19 June 1995 on the allocation of railway infrastructure capacity and the charging of infrastructure fees**

2015

**IMPLEMENTING REGULATION (EU) 2015/909 OF THE COMMISSION of 12. June 2015**

on the procedures for calculating the costs directly attributable to train operations

## Initial Position / Motivation

- Saving potential per kilometer driven :
  - Track charge for trains depending on the track damage of the individual vehicle
    - Swiss              Track Price Modell 2017
    - Great Britain    Variable Usage Charge
    - Austria            Drive Factor
    - Other Countries should follow.....
- Potential of savings on vehicles:
  - Wear-related optimization for existing and new vehicles

# „eCAS“ Electrohydraulic Controlled Axle Steering

## Initial position of the project

- Call for proposals by RSSB (Rail Safety and Standards Board) for Infrastructure Protection Technologies 2016
- Application in a consortium with 3 partners :
  - Grand Central – Operator in UK
  - Universität Newcastle – Institut Newrail
  - Liebherr Transportation Systems – Industriepartner
- Project Award October 2017
- Project start November 2017
- Basis: MK3 Car/ BT10 Bogie



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# „eCAS“ Electrohydraulic Controlled Axle Steering Content

1 Initial Position

## 2 Requirement

3 eCAS Concept and Actuator Function

4 Effectiveness

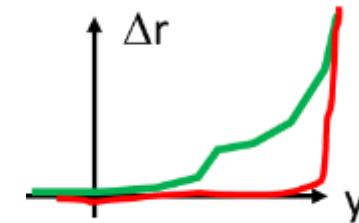
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## „Must“ Requirements

- Control independent of wheel / rail contact geometry  $\Delta r$
- Control independent of traction- and braking forces
- No vibration- and structure-borne sound transmission from the wheel to the car body
- Fail-safe design; No safety requirements higher than SIL0 in case of failure or malfunction
- No negative influences on running stability and driving dynamics
- No EMC sensitivity (electromagnetic compatibility)
- Condition monitoring and display
  
- Economics:
  - Reduced track price
  - Lower wheelset maintenance



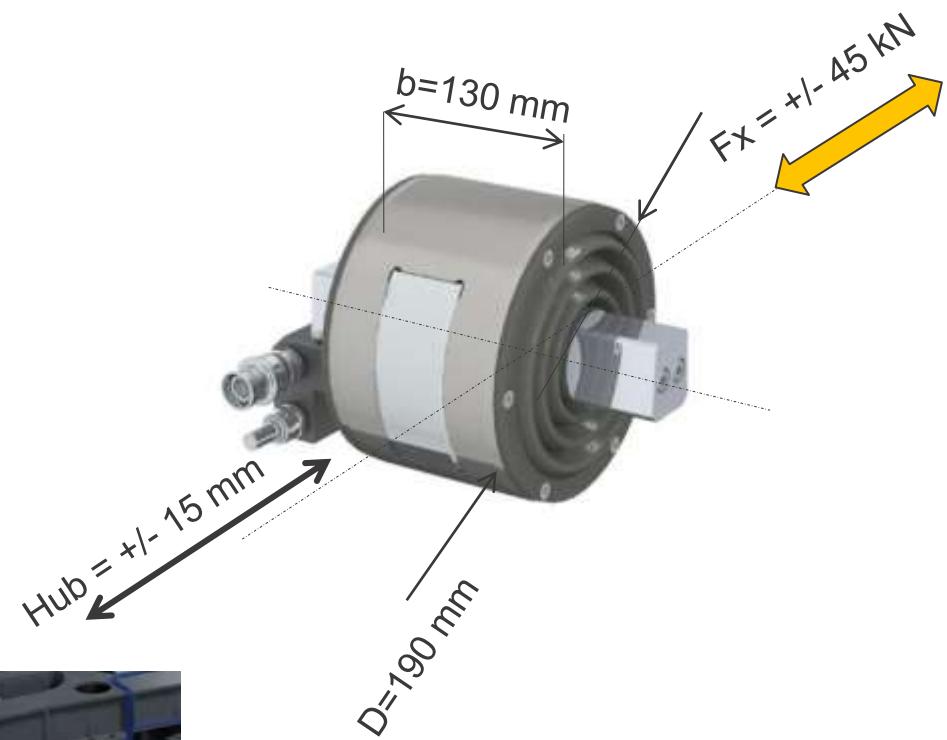
# „eCAS“ Electrohydraulic Controlled Axle Steering „Should be“ Requirements

- Control also possible in the transitional curve
- Possibility of any setting
- Lowest possible weight
- Lowest possible influence on ride comfort
- Low energy consumption of the system
- High reliability
- Reduced traction energy consumption through lower rolling resistance
- Low Life Cycle Cost (LCC)
- Potential for bogie and track condition monitoring

# „eCAS“ Electrohydraulic Controlled Axle Steering

## Requirements to the Design

- Can be installed and retrofitted in all major bogie types, without modifications to the bogie frame



# „eCAS“ Electrohydraulic Controlled Axle Steering Criteria of Success

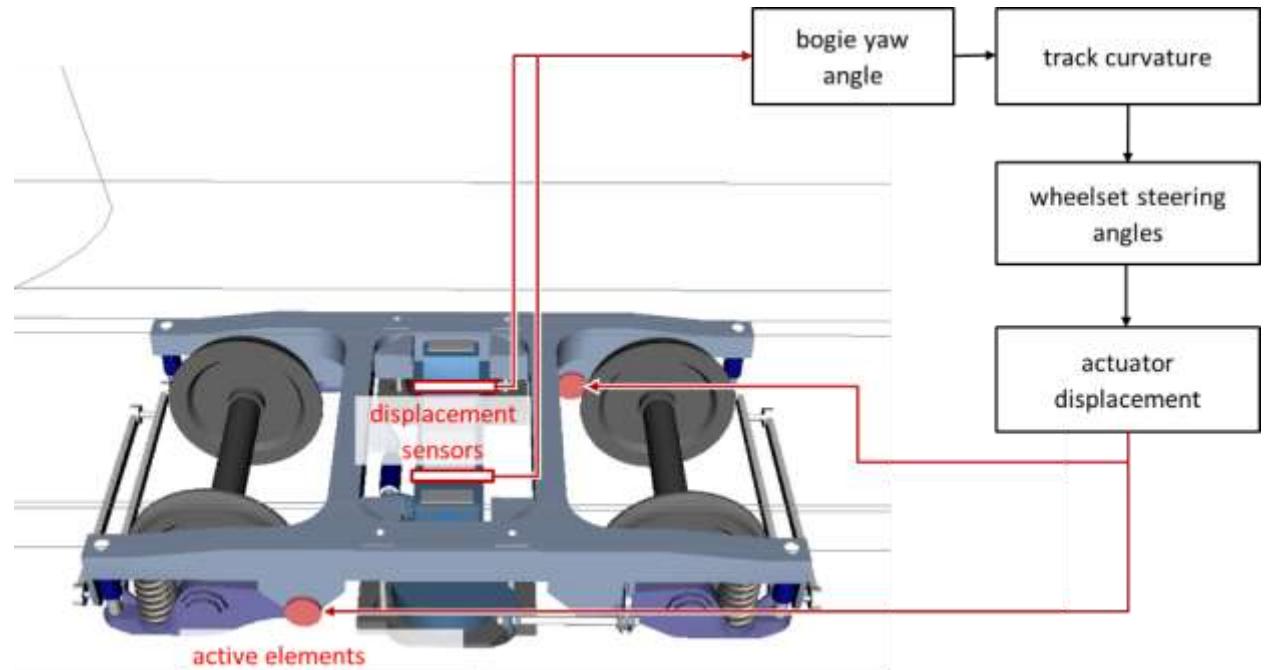
- Actuator Design
  - Compactness
  - Integration in the Bogie, Retrofitting
  - Robustness
- Control and Electronics
  - Curve Detection
  - Complexity
  - Independence of the Train Control System
- Economics

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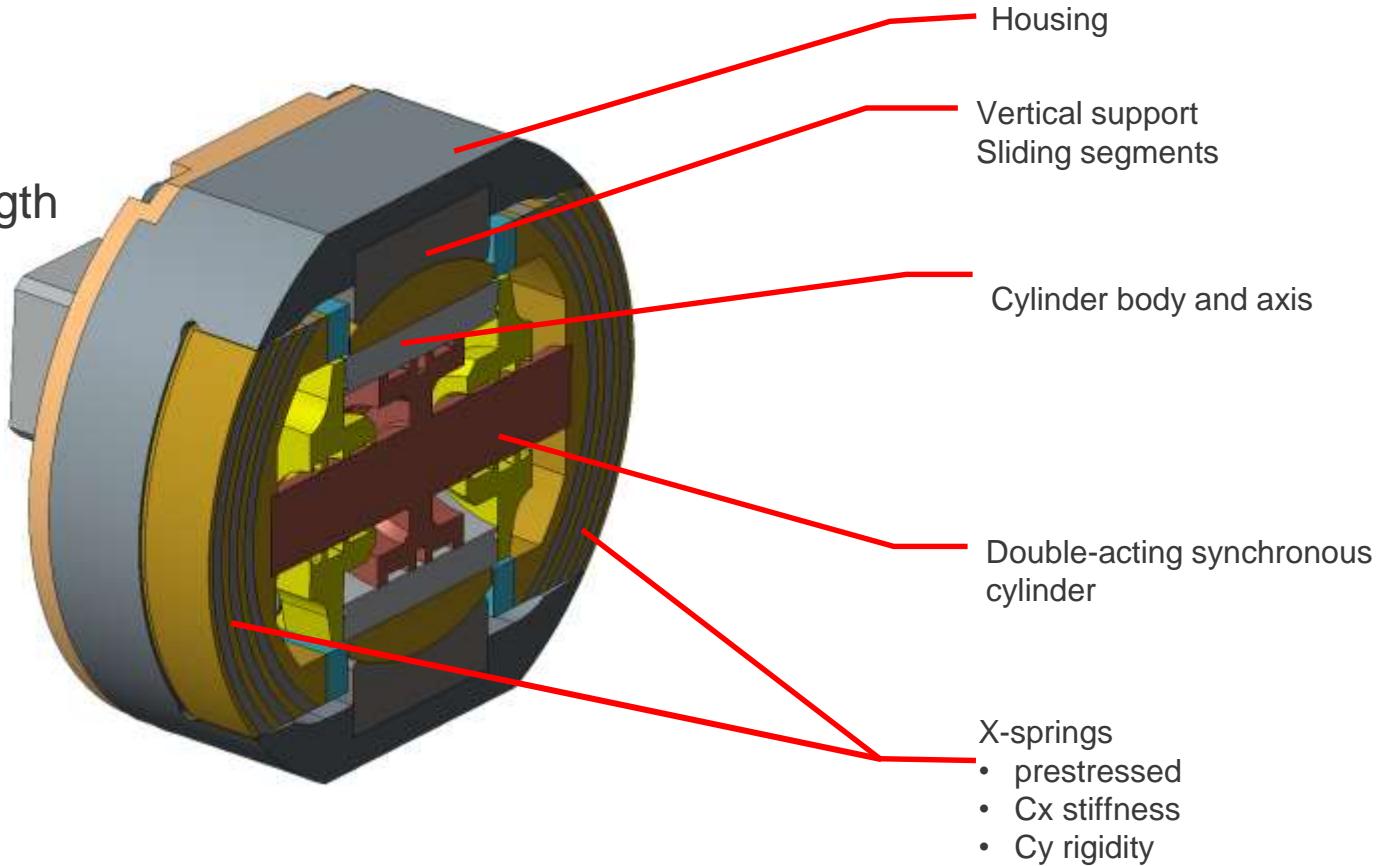
# „eCAS“ Electrohydraulic Controlled Axle Steering Concept

- Bogie Autonomous Conception
- Curve Detection via angle of rotation to the car body
- One Actuator Concept per Wheel Set
- High Development Potential



# „eCAS“ Electrohydraulic Controlled Axle Steering Actuator Function

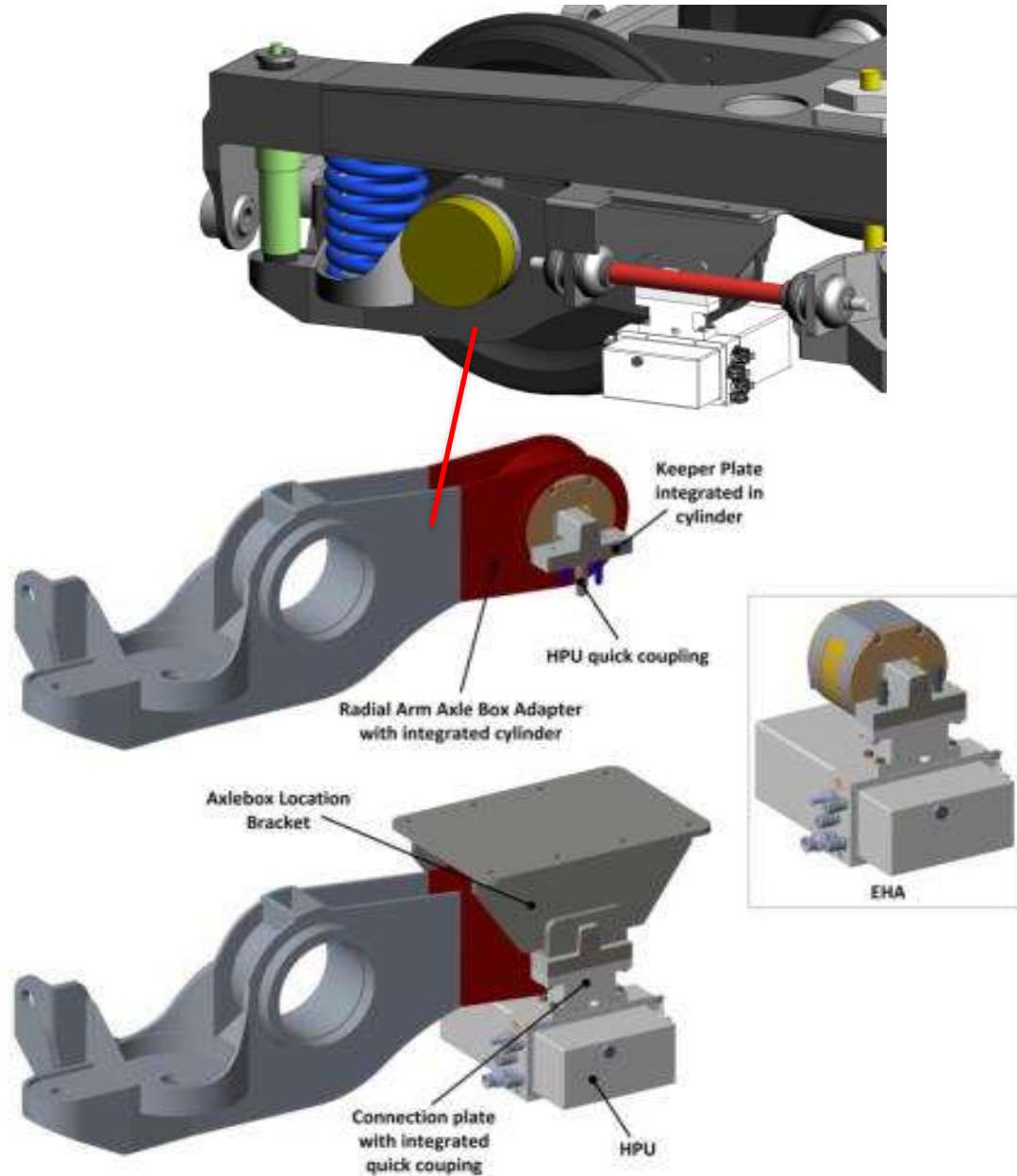
- Compact Design
  - Largest possible stroke for a given length
  - No longitudinal parasitic stiffness



## „eCAS“ Electrohydraulic Controlled Axle Steering

# Integration in the Bogie

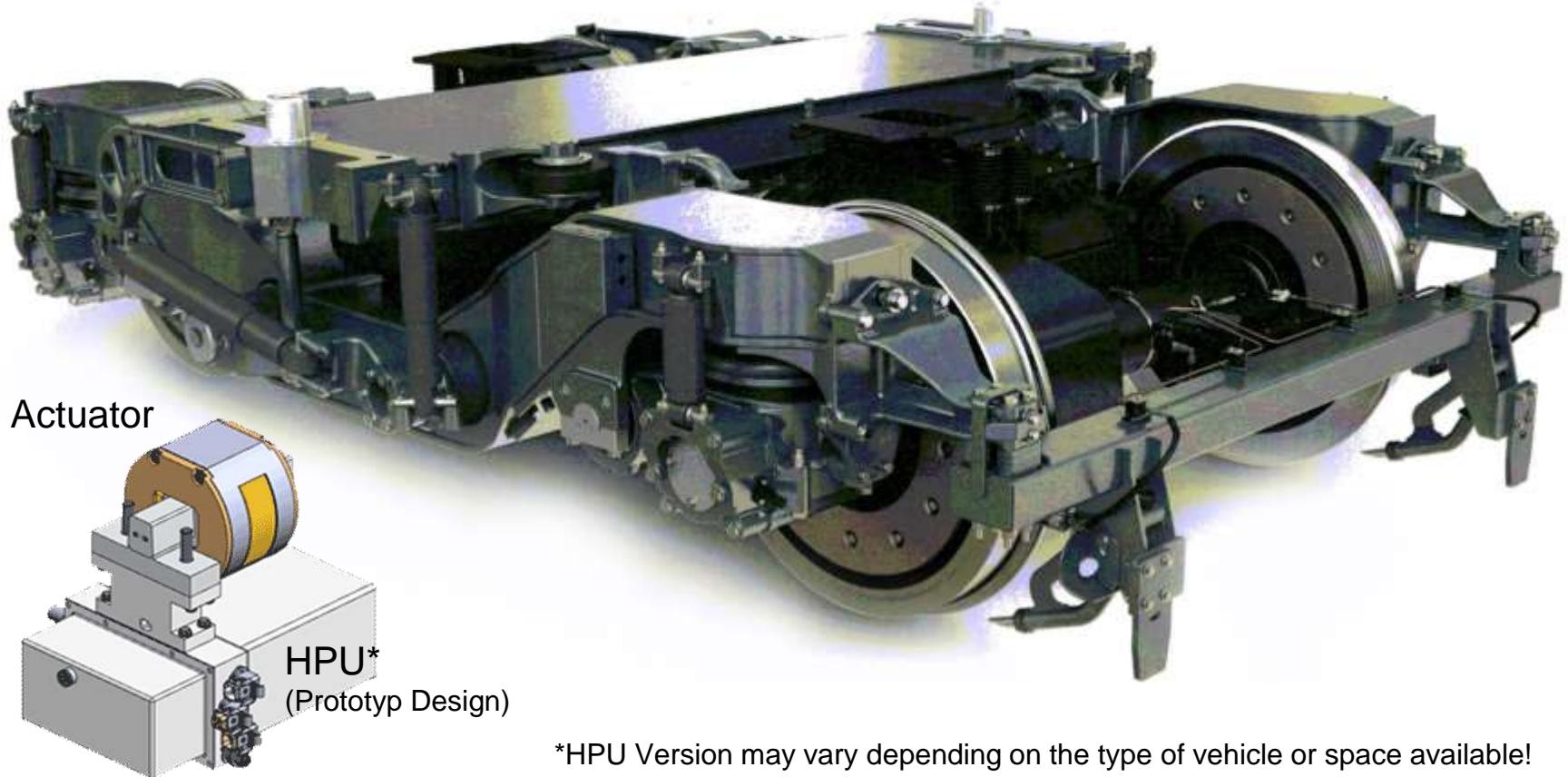
- Cylinder is pressed directly into existing swing arm
- After installation in the chassis, calibration of the displacement sensors would be required
- Actuator is commissioned in the factory
- After installation in the chassis, calibration of the displacement sensors would be required



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# Integration in the Bogie

- Example: **STADLER** - Bogie



\*HPU Version may vary depending on the type of vehicle or space available!

# Performance Data

- Standard version for the widest possible field of application

Eigenschaft	Wert	Einheit
Wheelload	19	t
Stroke - Cylinder - 100% Radial adjustment for 2.7m wheelbase to radius of radius	+/- 15 300	Mm m
Actuator Force «Fx»	45	kN
Position Speed	7	mm/s
Energy Consumption in average	250	W
Energy Consumption “peak”	1	kW
Diameter Actuator «D»	190	mm
Width Actuator «b»	130	Mm
Parasitic Stiffness - Actuator - Primary Suspension	0 (200 – 500)	N/mm N/mm
Transverse Stiffness of the Actuator Cy	2.0 – 7.0	kN/mm
Longitudinal Stiffness of the Actuator Cx (x-springs serially to oil stiffness)	>= ~25	kN/mm

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## Effectiveness based on Simulation

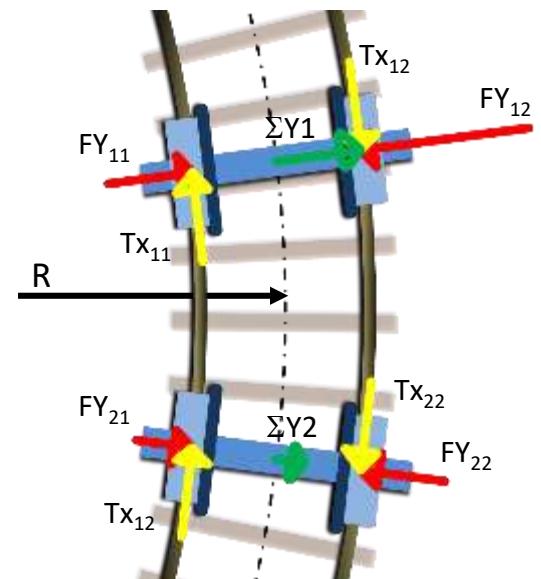
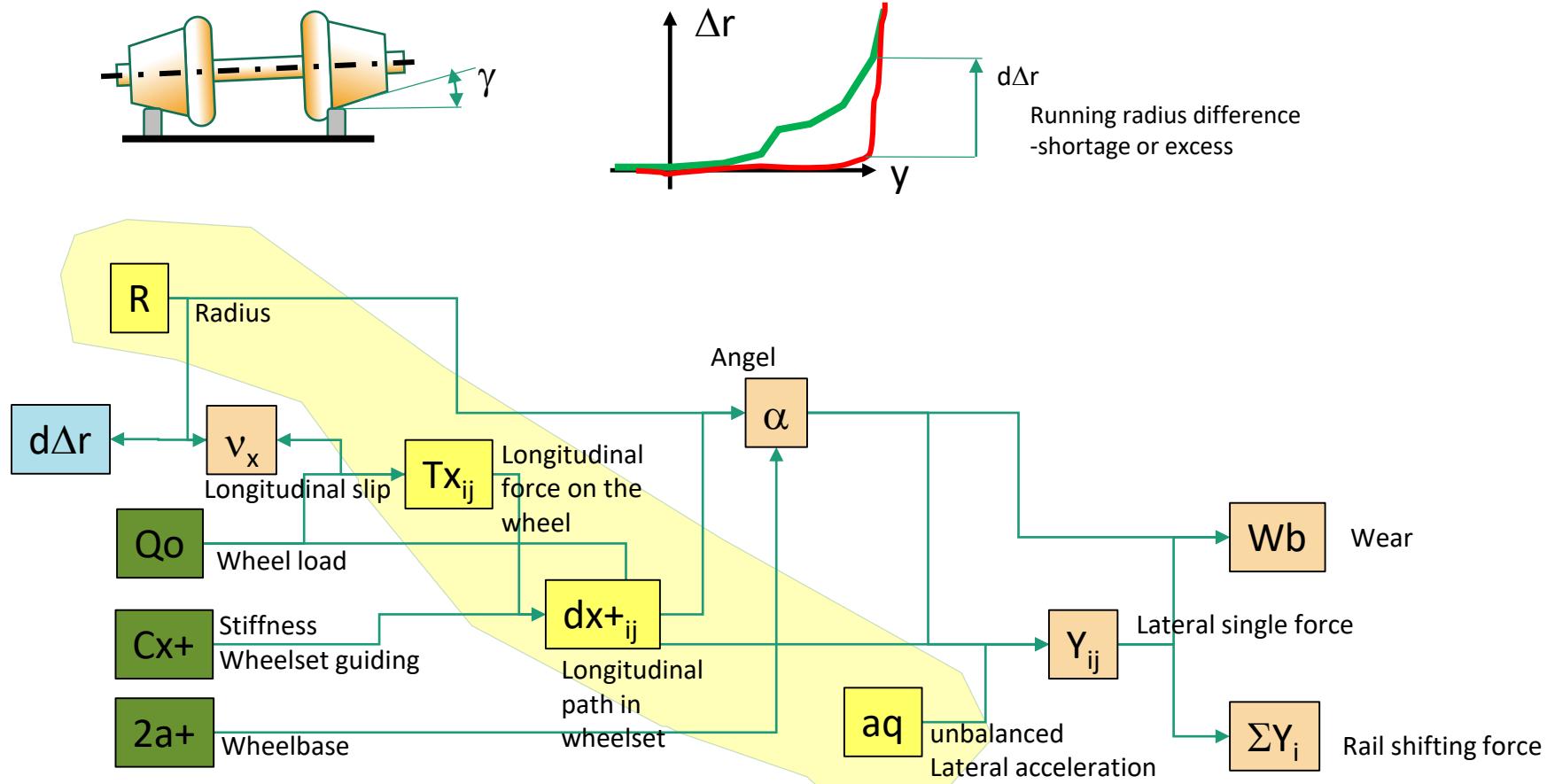
- Ideal radial steering provides lowest track displacement forces SY down to 50% to the standard bush
- eCAS provides the best possible distribution of the track displacement force  $\Sigma Y$  on both wheelsets
- Rolling Resistance
  - 76 - 91% Reduction of rolling resistance in the range of 200m to 1000m radius
  - Energy saving according to the curve frequency (per vehicle)
    - eCAS ~ - 5 MWh/year
- Wheel wear
  - ~33% reduction of operation costs
- Savings of track fee

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# Option Diagnostic

- With little additional effort, track diagnosis via indirect wheel- / rail forces measurement feasible



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# „eCAS“ Electrohydraulic Controlled Axle Steering Status RSSB - Project

- 3 Main Project Phases:

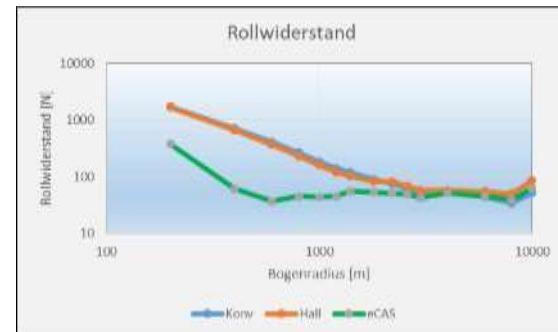
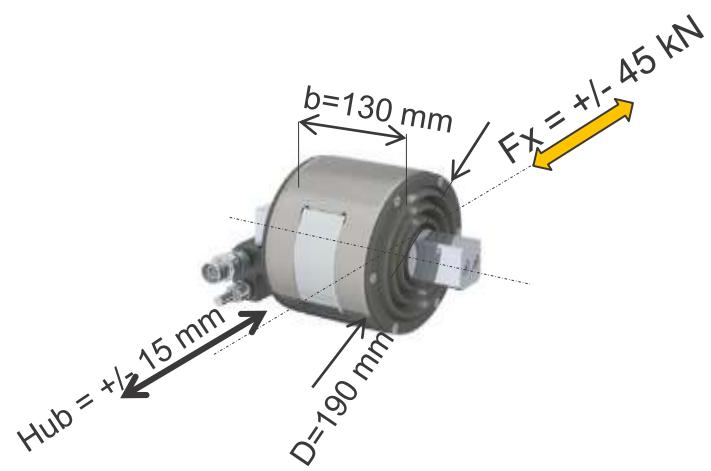
Start 11 - 2017



09 - 2019



Theoretical phase / prototype development



03-2020 End

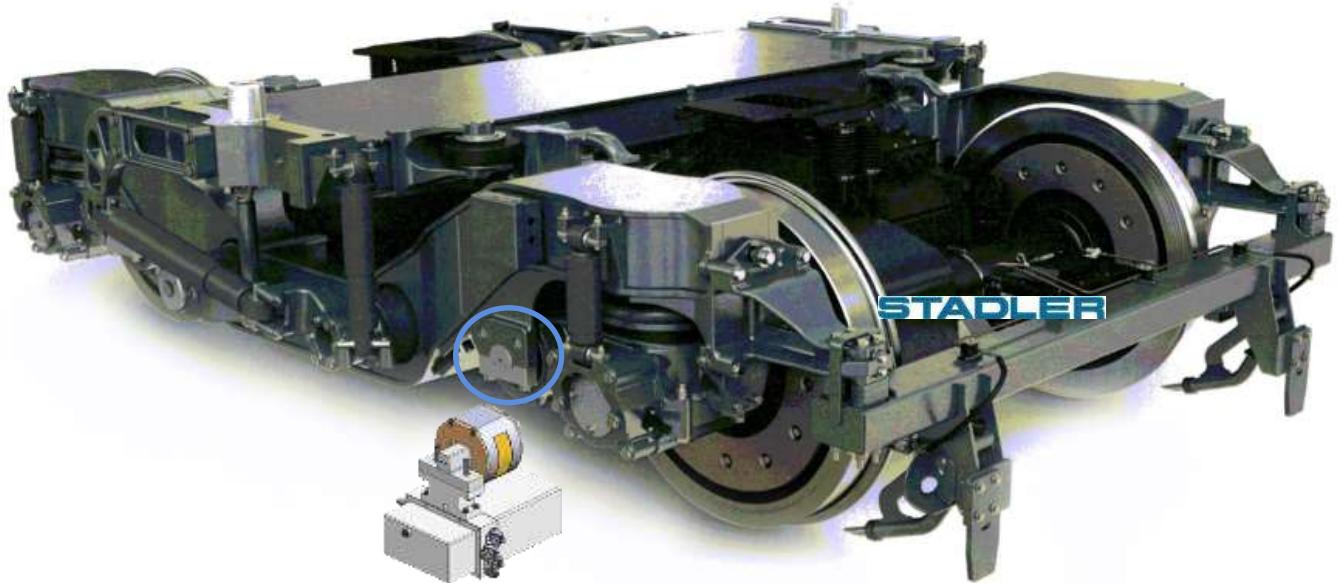
Validation Phase - Demonstrator on bogie

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# „eCAS“ Electrohydraulic Controlled Axle Steering View

- Serial implementation parallel to the validation phase from mid-2019
- Aim:
  - Retrofit solution for existing vehicles
  - ROI: 2-5 years
- Optimized variant for new build vehicles
- ROI: 2-4 years



# Backup **First Simulation Results**

# „eCAS“ Electrohydraulic Controlled Axle Steering Effectiveness based on Simulation

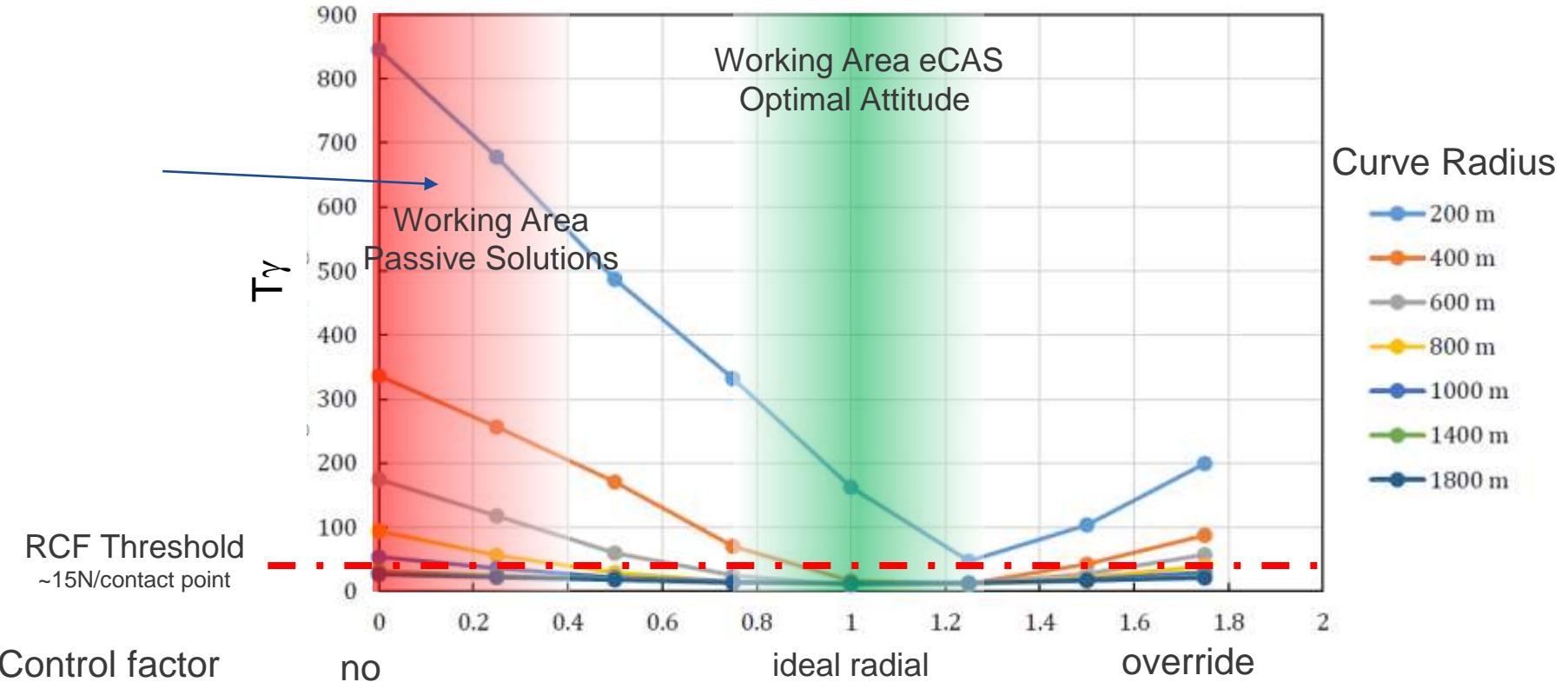
- Boundary Conditions

- Operator: GRAND CENTRAL
- Train/Bogie: Mark 3 / BT-10
- Load of Wheelset: 11.4 t
- Friction Value: 0.4
- Cant Deficiency: 40 mm
- Wheel Profile: P8
- Rail: UIC 60
- Rail Inclination: 1/20



# „eCAS“ Electrohydraulic Controlled Axle Steering Effectiveness based on Simulation

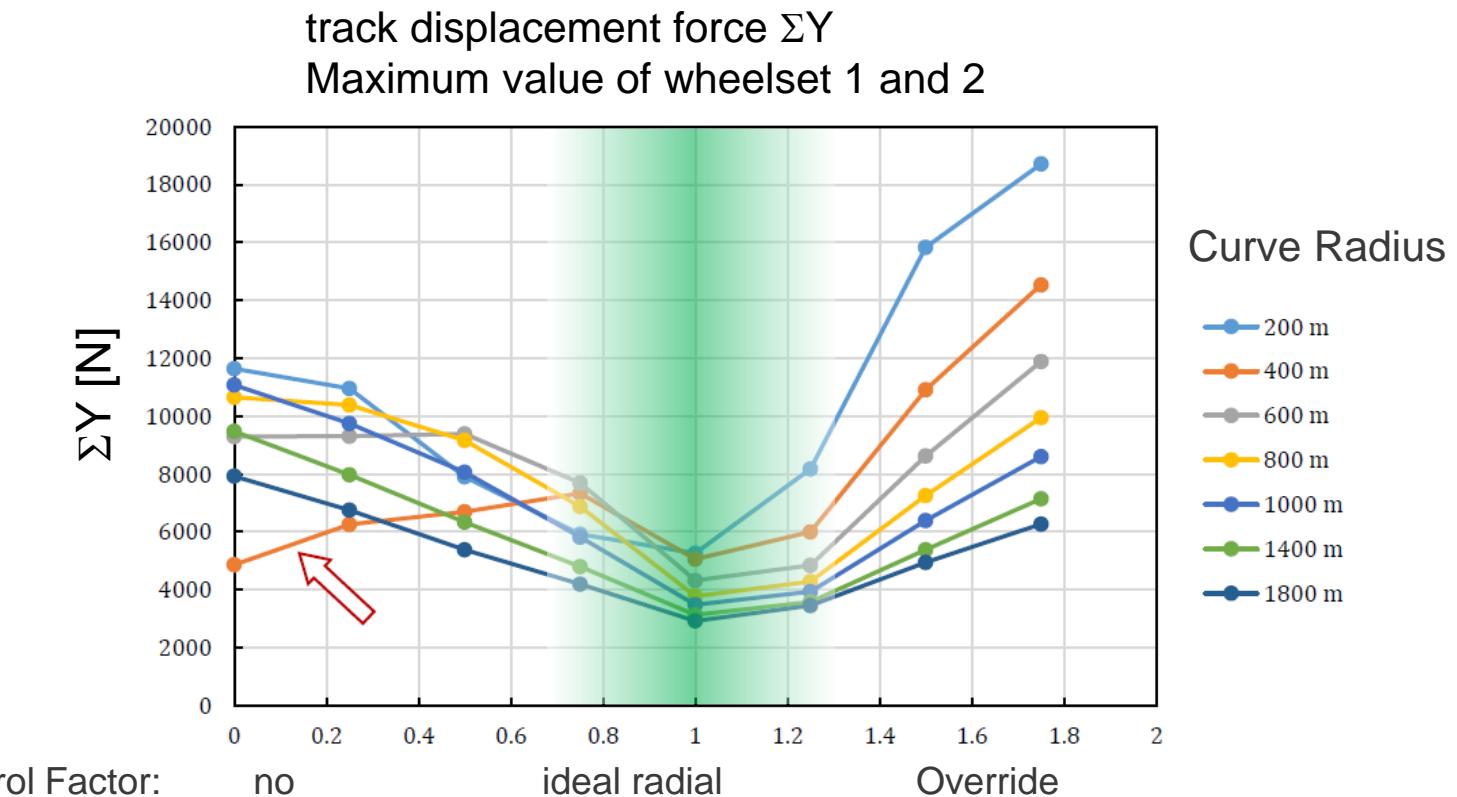
- Wear indicator  $T_y$ , in addition to axle load and unsprung mass, an important factor in track price models



- Only active wheelset controls deliver sustainable reduction of track damage

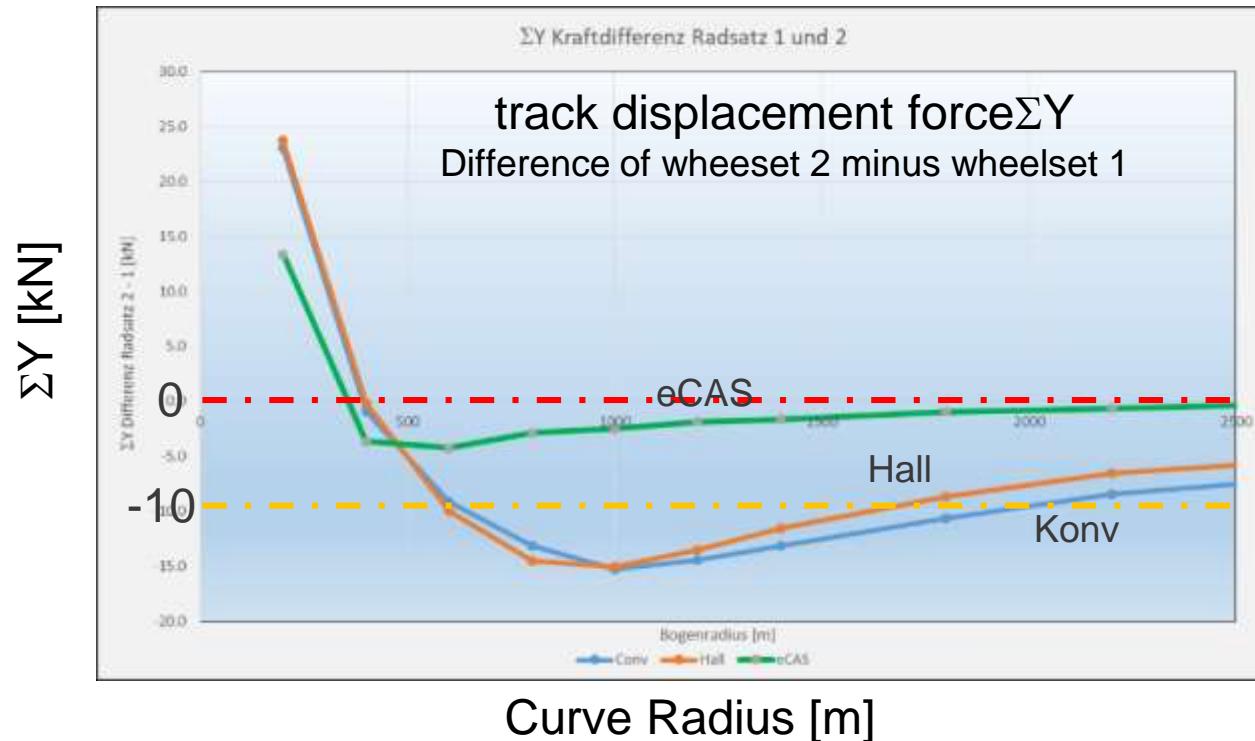
# „eCAS“ Electrohydraulic Controlled Axle Steering Effectiveness based on Simulation

- Ideal radial steering provides lowest track displacement forces  $\Sigma Y$



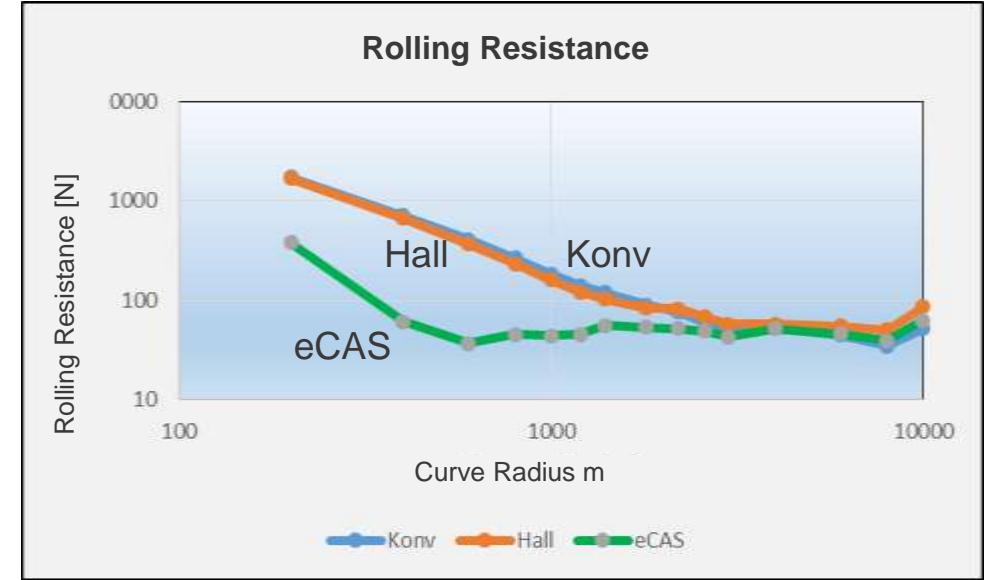
# „eCAS“ Electrohydraulic Controlled Axle Steering Effectiveness based on Simulation

- eCAS provides the best possible distribution of the track displacement force  $\Sigma Y$  on bot wheelsets
- HALL provides virtually the same behavior as conventional suspension



# „eCAS“ Electrohydraulic Controlled Axle Steering Effectiveness based on Simulation

- Rolling Resistance
  - 76 - 91% Reduction of rolling resistance in the range of 200m to 1000m radius
  - Energy saving according to the curve frequency (per vehicle)
    - eCAS ~ - 5 MWh/Jahr
    - Hall +/- 0 MWh/Jahr
- (entsprechend niedrigere Werte bei niedrigeren Reibwerten )



- Wheel wear
  - ~33% reduction of operation costs
- Savings of track fee



Experience the Progress.

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