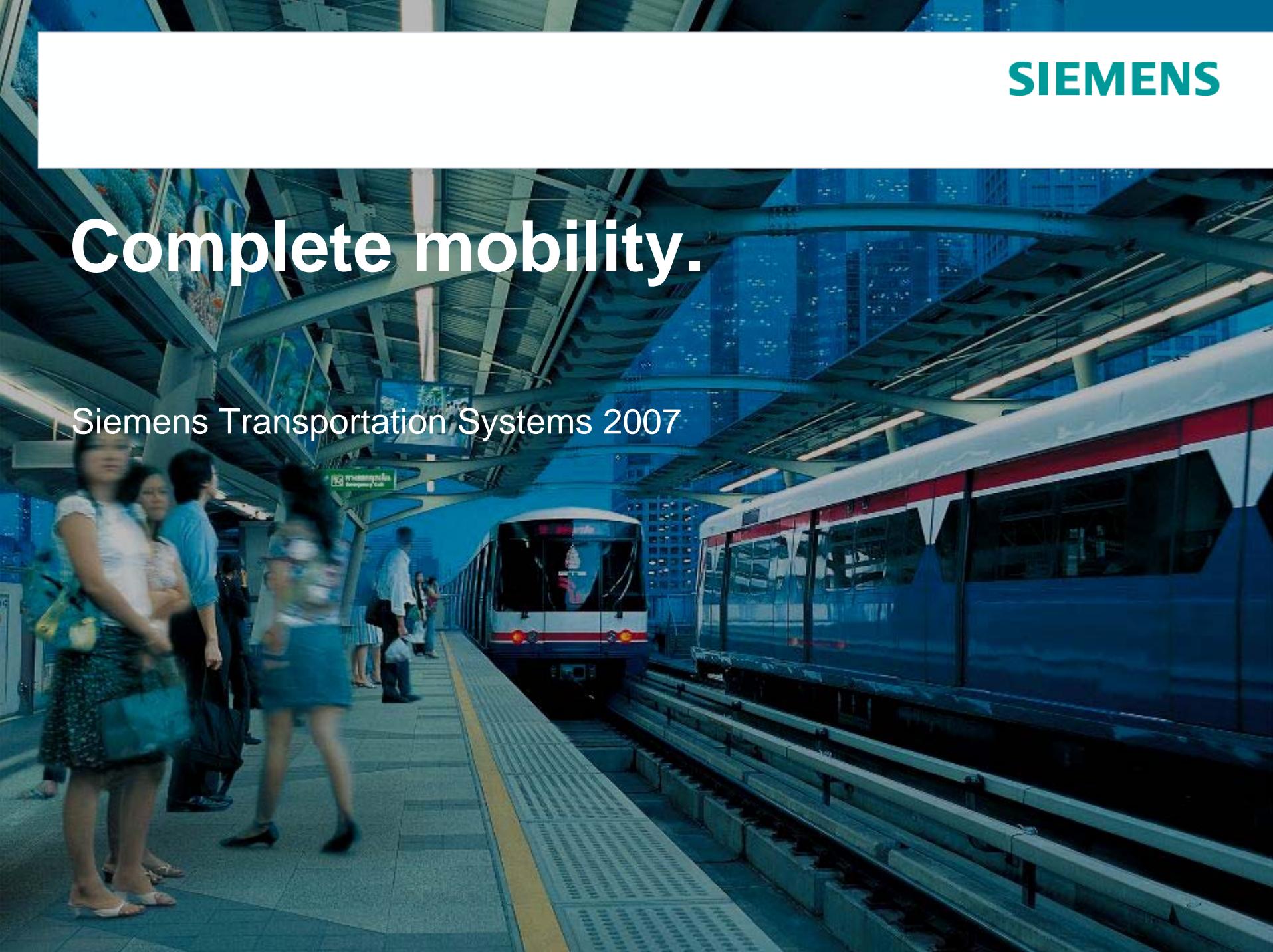
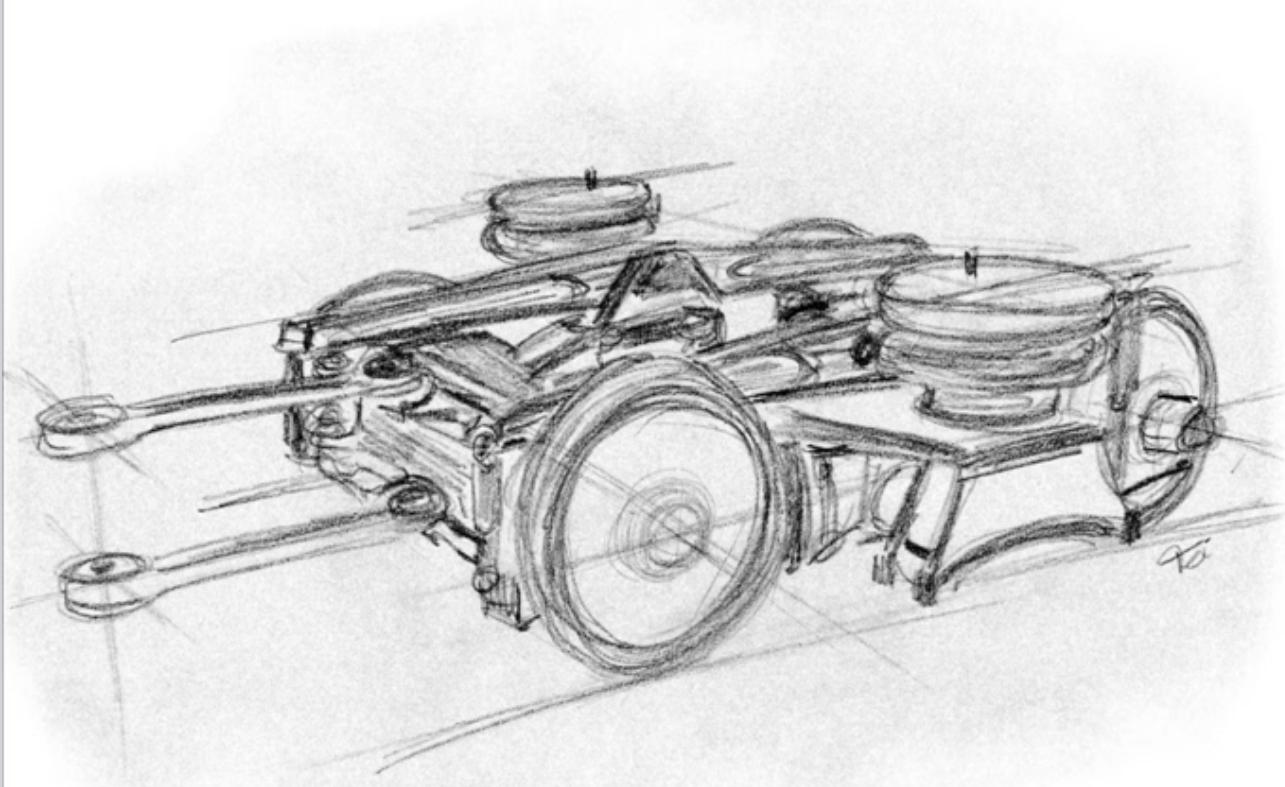


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Complete mobility.

Siemens Transportation Systems 2007





Dr.-Ing. Andreas Jöckel

Dr.-Ing. Lars Löwenstein

Ing. Martin Teichmann

**Syntegra® – a new technology combines low risk
and extensive benefits**

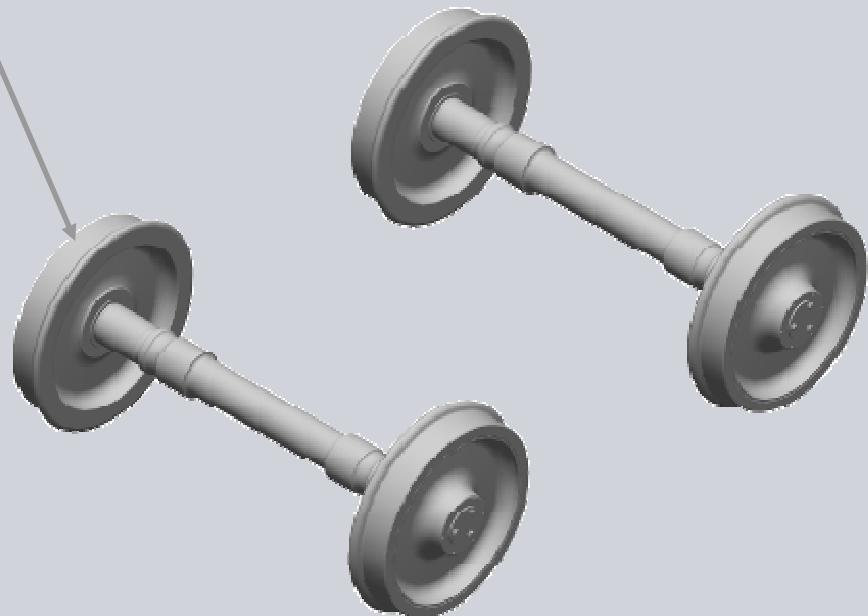
SIEMENS

- Technology



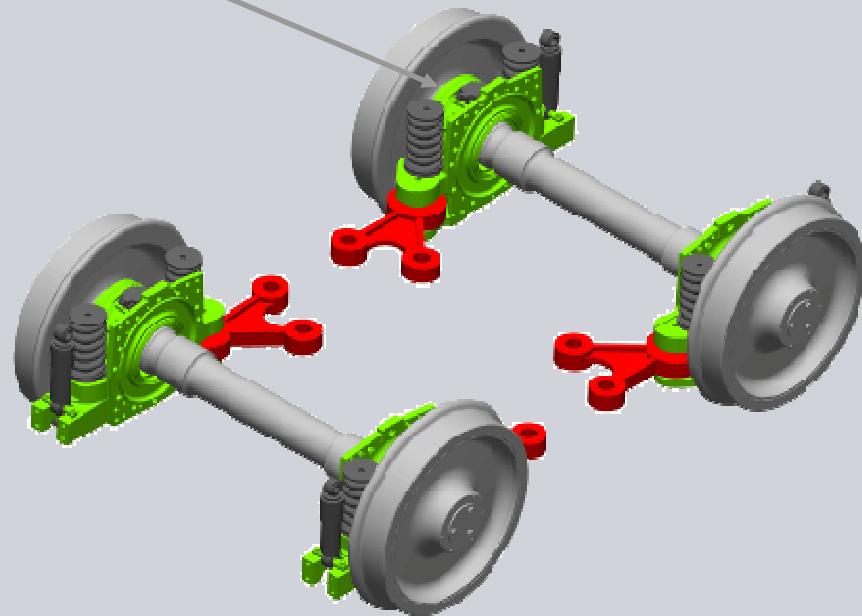
Syntegra® uses small wheels

- Small wheel diameter
- Shorter wheelbase



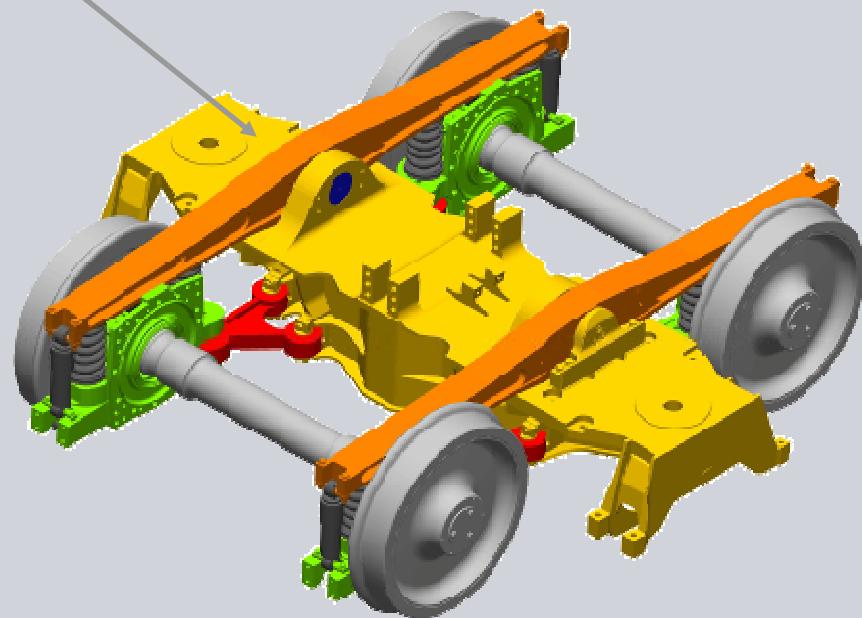
Syntegra® uses inside bearings

- Inside bearings
- Integrated wheelset guidance
- Adherence to small clearance envelopes
- Possibility of aeroacoustic cladding



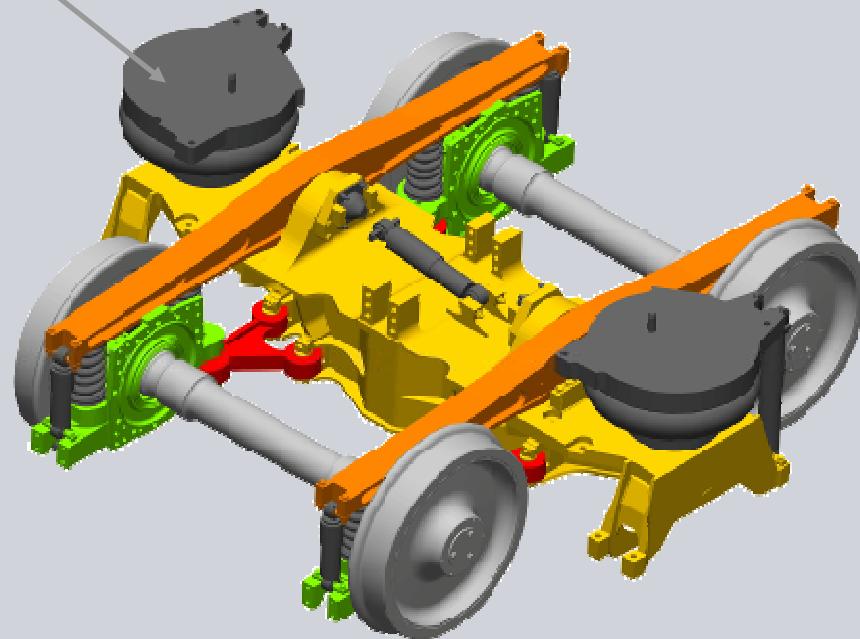
The frame structure is torsionally flexible

- Torsionally flexible frame
- Hinged longitudinal beams
- Resolution of design conflict in the primary stage
(derailment/load increase/comfort)
- Increased payload



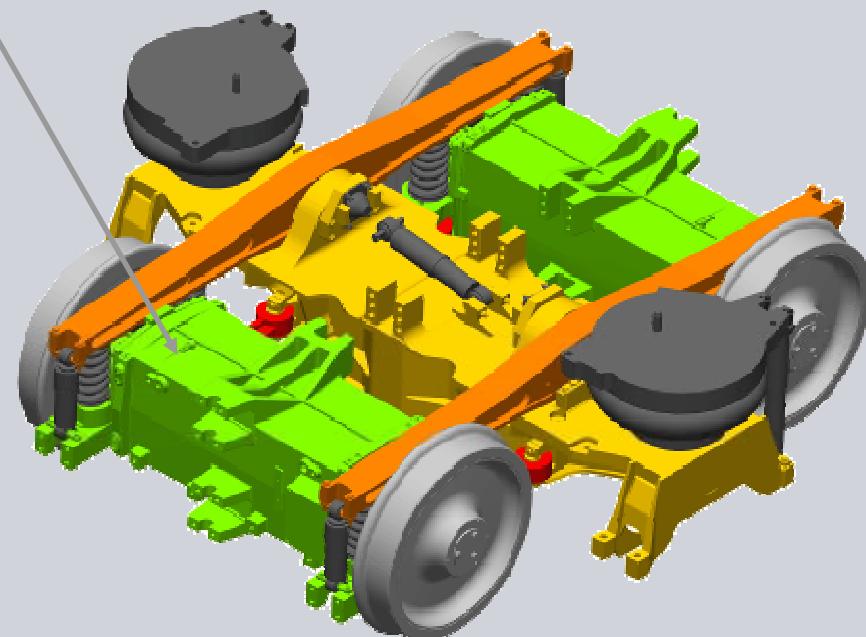
Syntegra® offers optimum interfaces to the car body

- Top of air springs at lower level
- Optimum interface to car body
- Lower floor height possible
- Integrated additional volume in the bogie cross beam



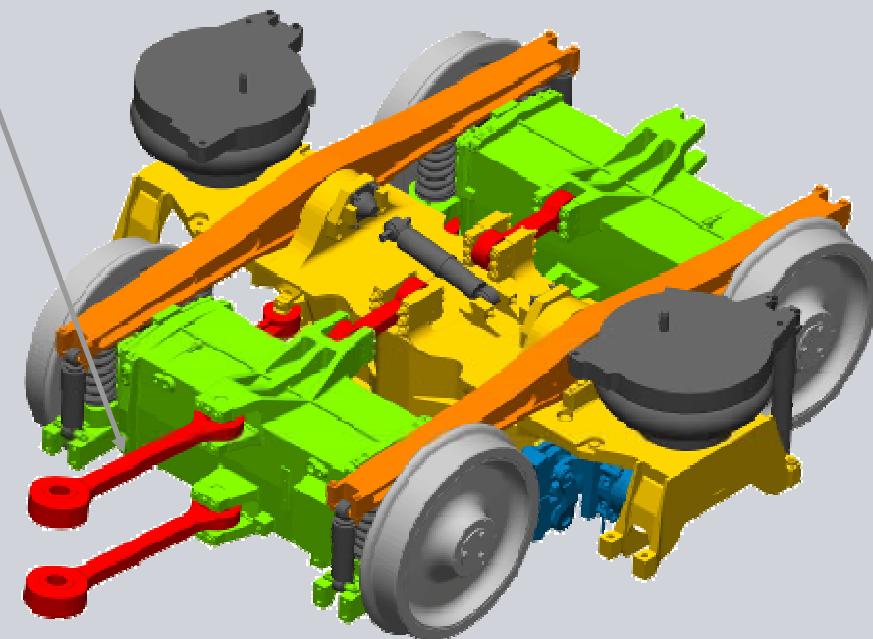
The direct drive is completely integrated

- Direct drive encloses axle concentrically
- Common wheelset and traction motor bearings
- Exploitation of synergies due to system integration

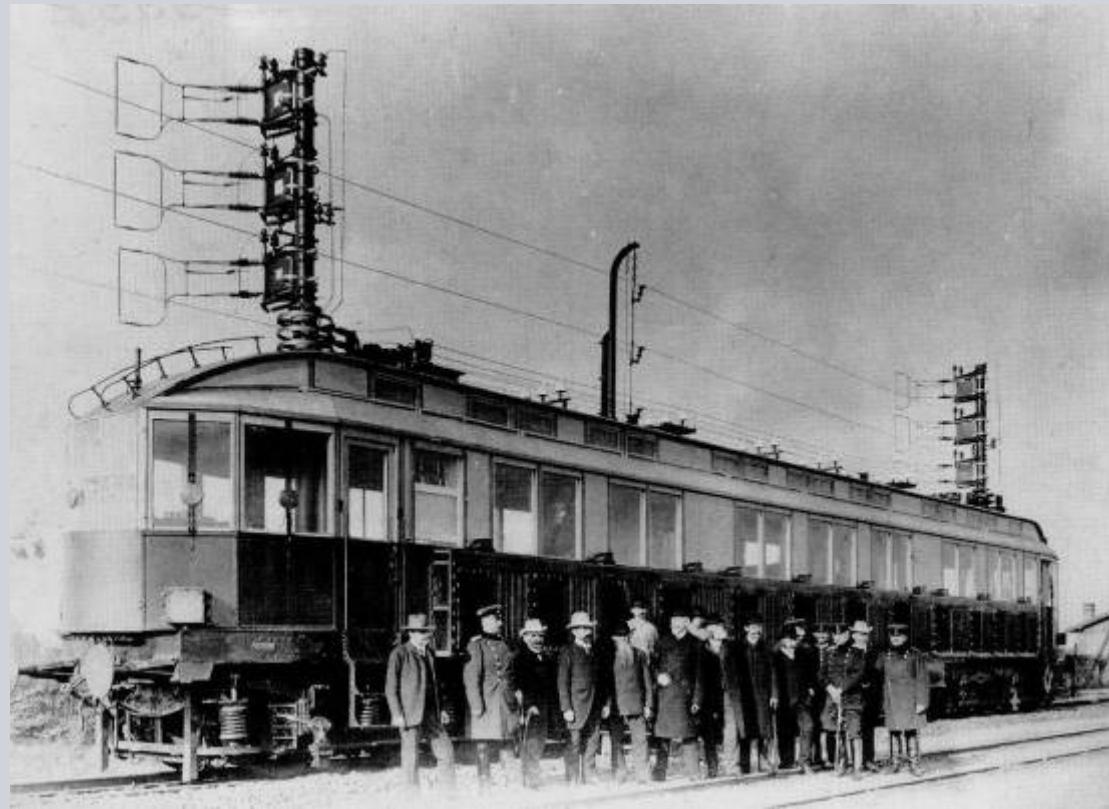


The car body is directly connected

- Direct connection to the car body
- No transfer of traction forces via the bogie frame
- No axle relief due to traction forces



Direct drives – a new idea ?



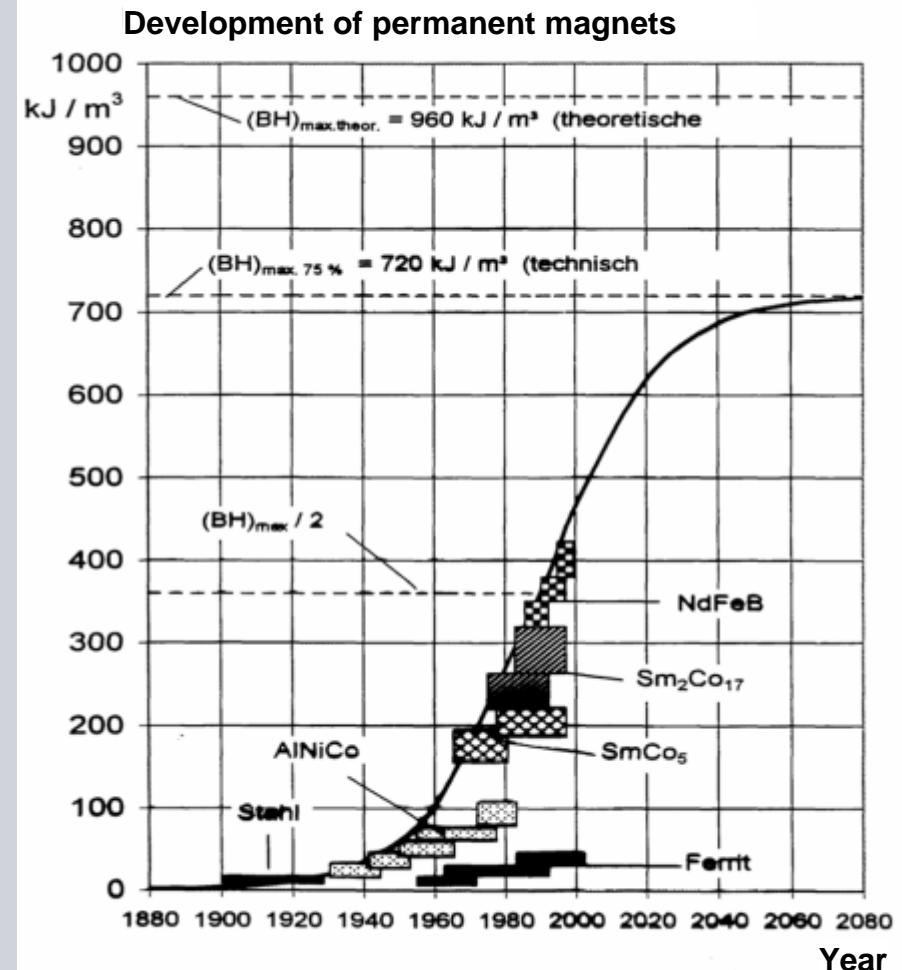
100 years ago.....

The first train using direct drives based on an induction machine developed by AEG and Siemens operates at Marienfelde - Zossen

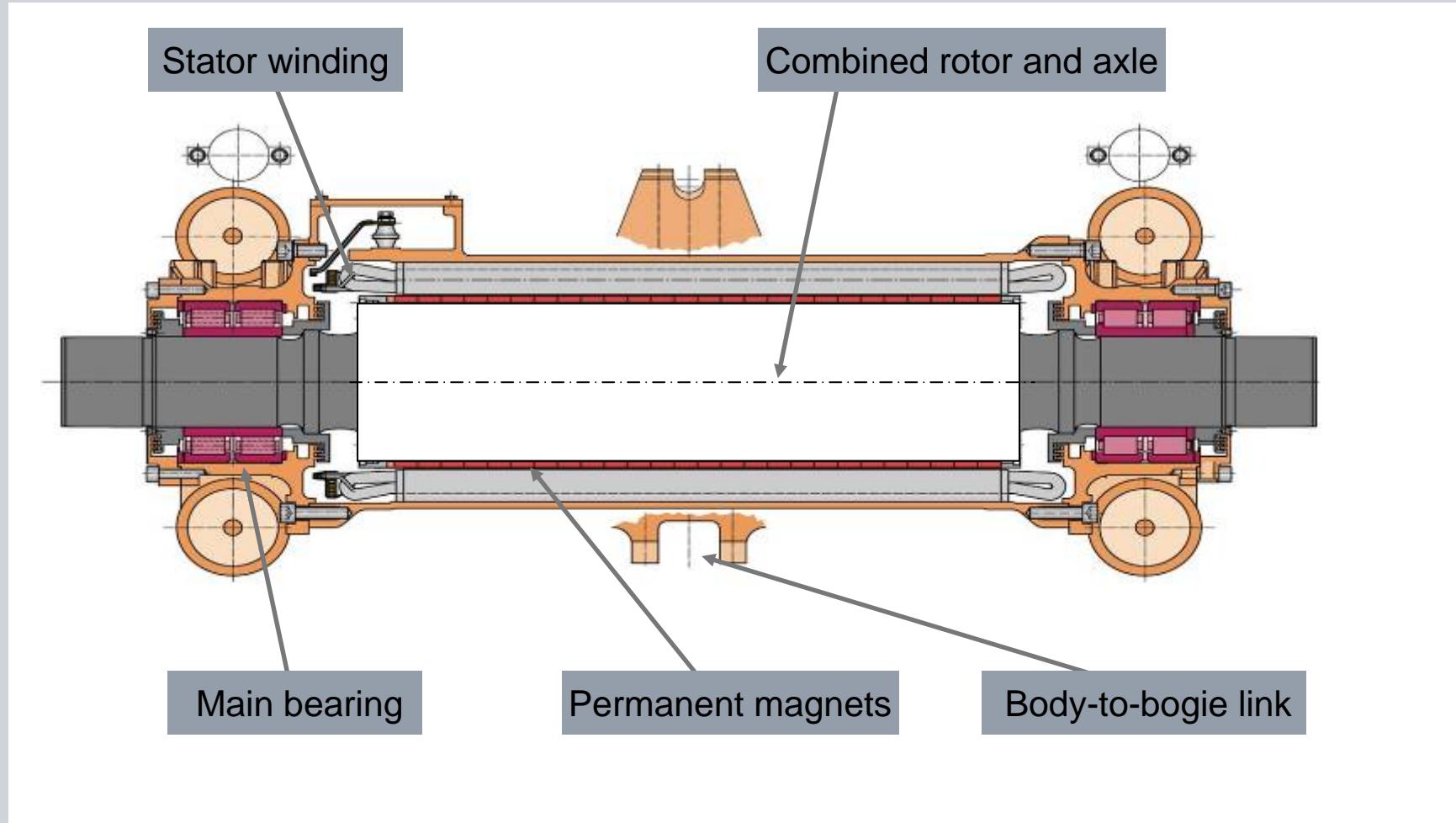
High-Power Permanent magnets: Today's Materials enable new drive-systems

SIEMENS

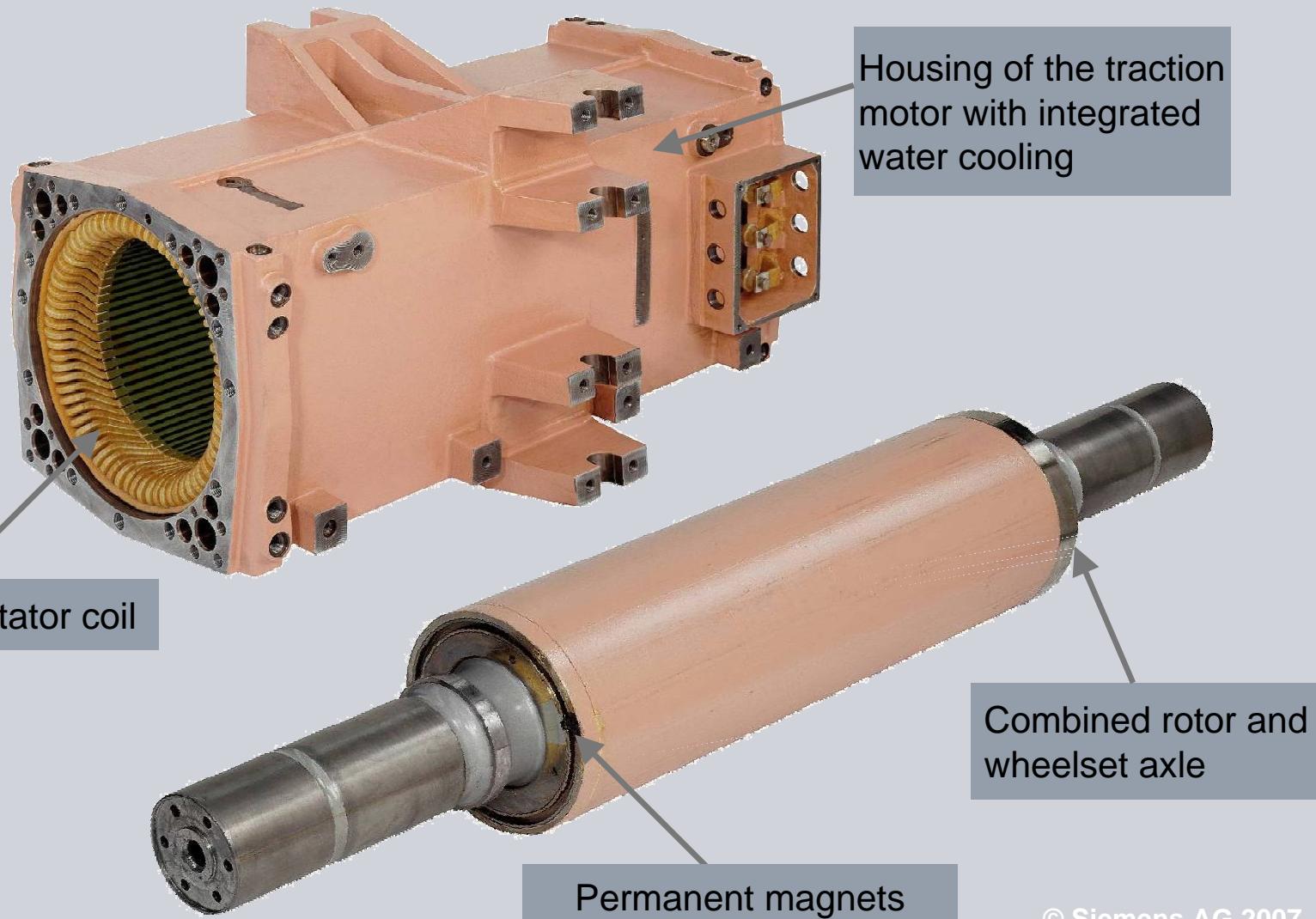
- Energy density of NdFeB today surpasses other materials and meets the requirements for traction drives
- Cost of PM Materials are today at a reasonable level
- PM-Machines are ideal for high-torque-applications
- Cooling the machine is simple due to very low rotor losses



Cross-section through the gearless drive



Robust and well designed motor structure

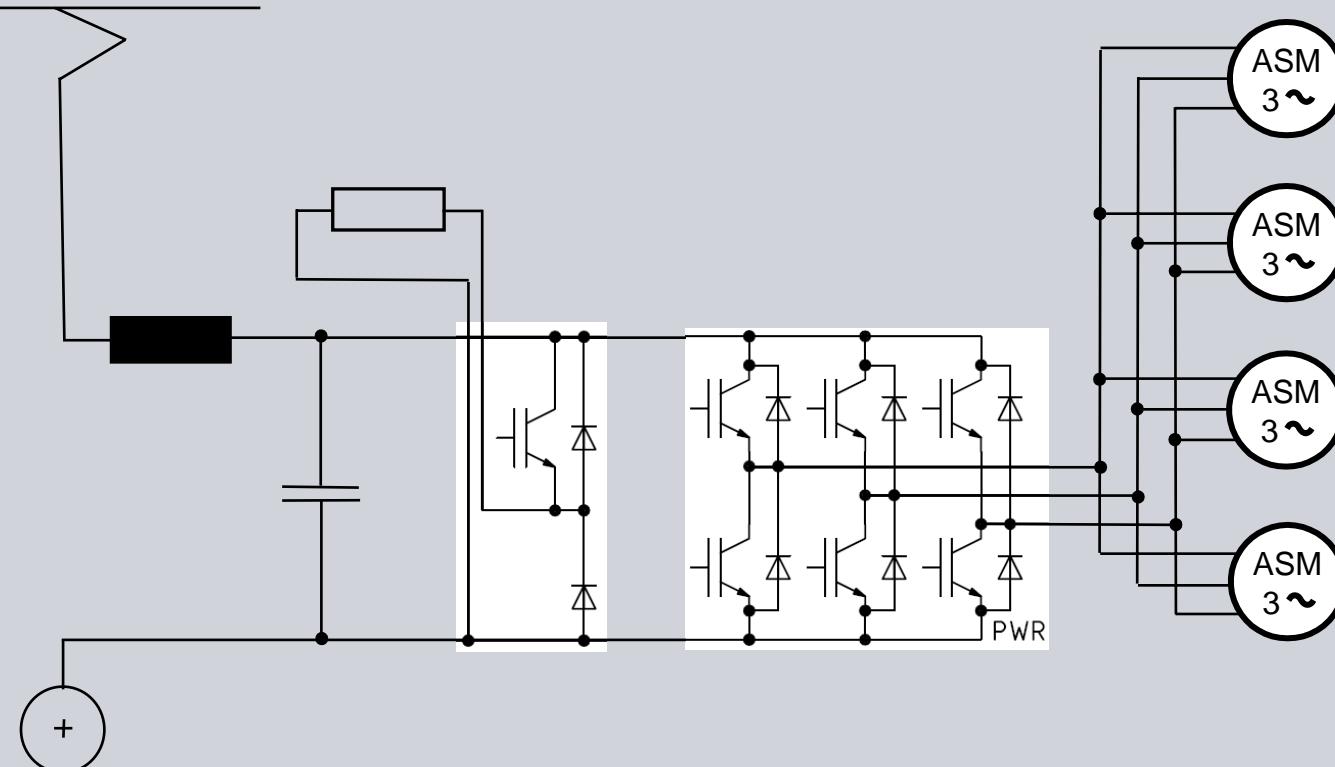


The traction motor is driven by a conventional IGBT power converter

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Today's requirements for the pulse-controlled inverter:

- 3-phase System
- Fundamental frequency up to 150Hz
- Frequency of the pulses 500...1000Hz
- Sensorless traction control based on SITRAC®

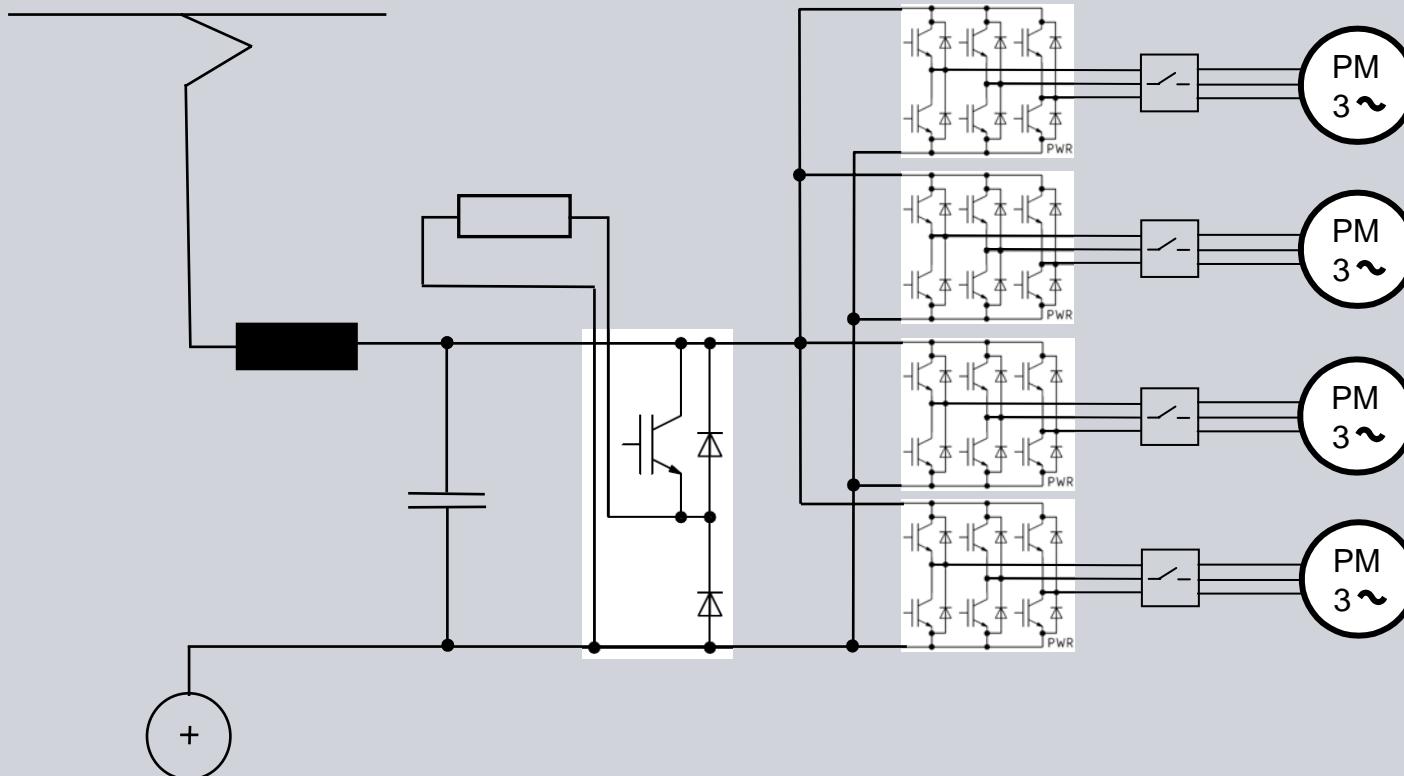


The traction motor is driven by a conventional IGBT power converter

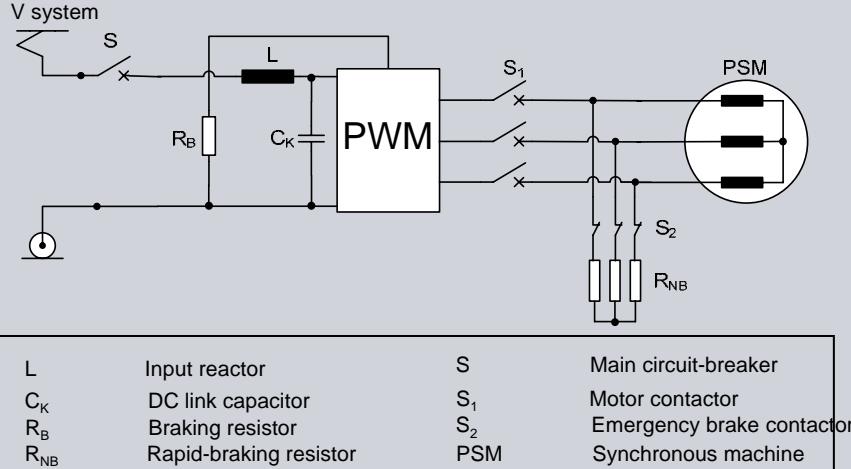
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New structure of the power converter:

- Common DC voltage link
- Separate pulse-controlled inverters (independent axles)
- Adaptation of the traction control only by software

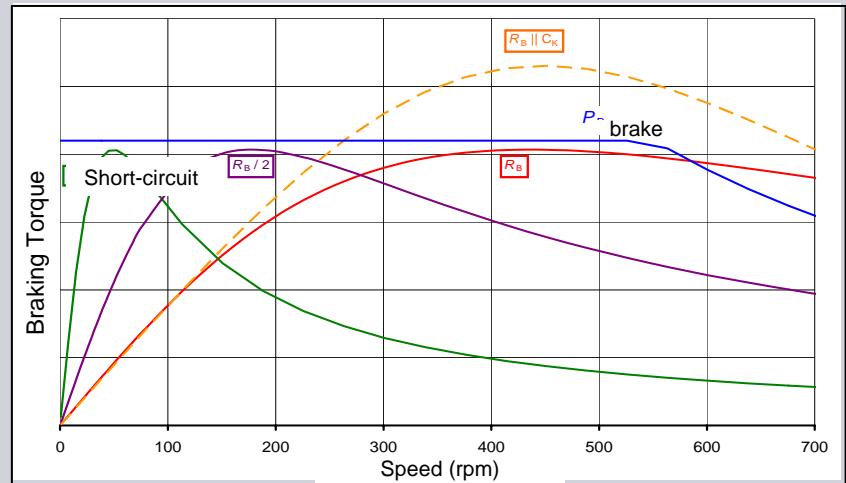


The fail-safe electric brake

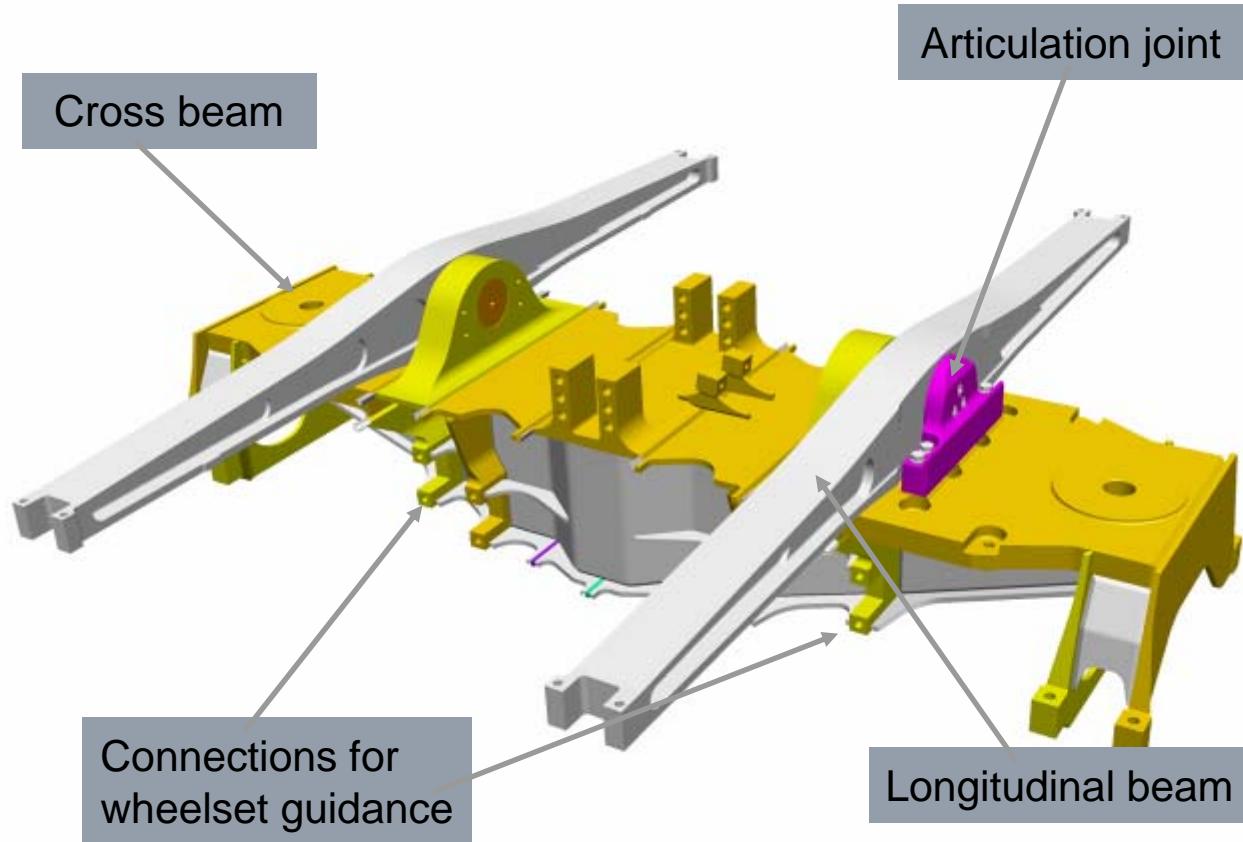


- Permanently magnetic synchronous machine generates an inherent braking torque in the case of resistor circuit connection
- Fail-safe electric brake uses minimum number of components
- Emergency braking contactor in fail-safe design

- Speed-dependent braking torque
- Maximum value is stipulated in advance by machine parameters
- Displacement of the maximum along the speed axis is possible by changing the circuit resistance, increase through parallel connection of capacitors possible

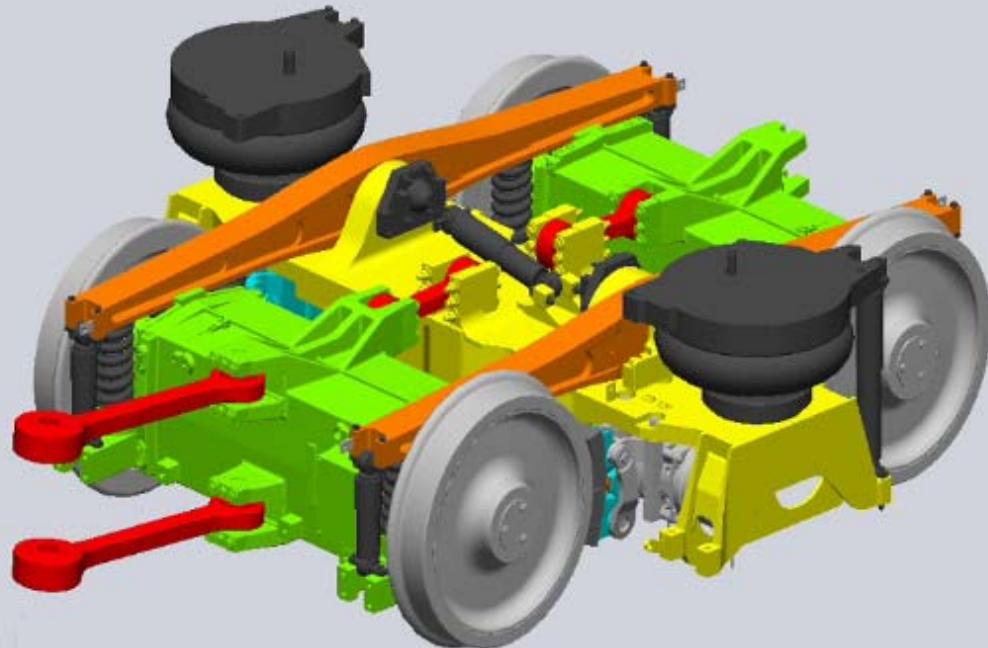


Syntegra® is a torsionally flexible bogie



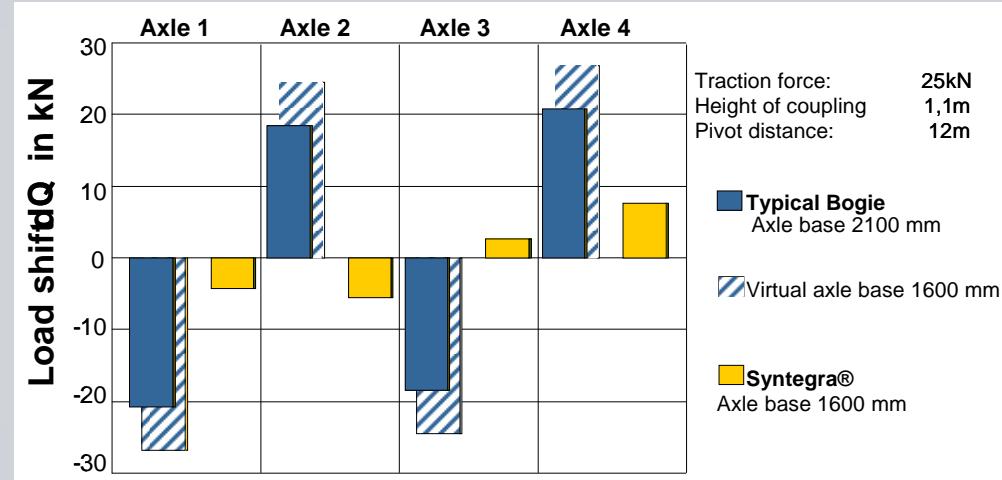
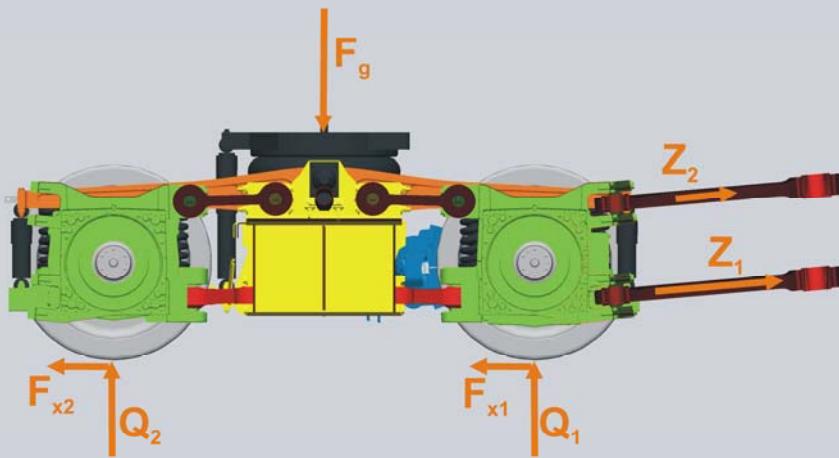
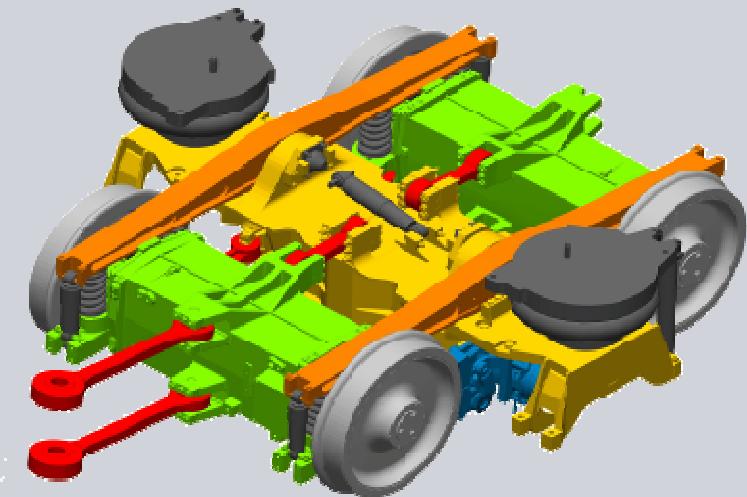
Bogie frame is flexible

- Longitudinal beam and cross beam coupled by joints
- Best protection against derailment
- Higher payload
- Use of pivot possible
- Unpowered bogie uses same technology



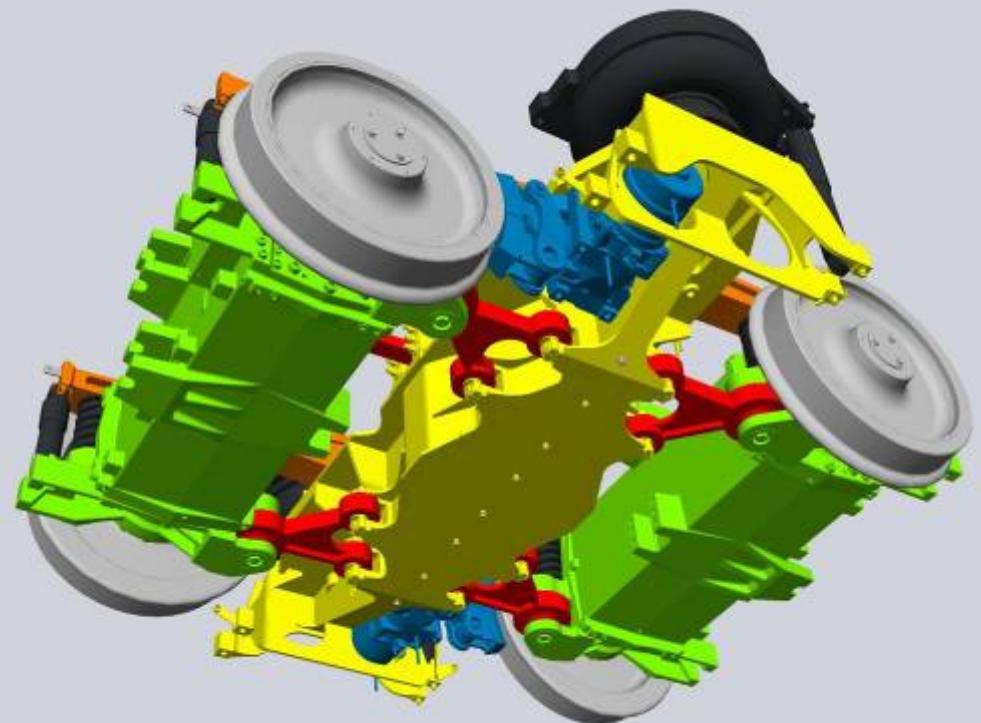
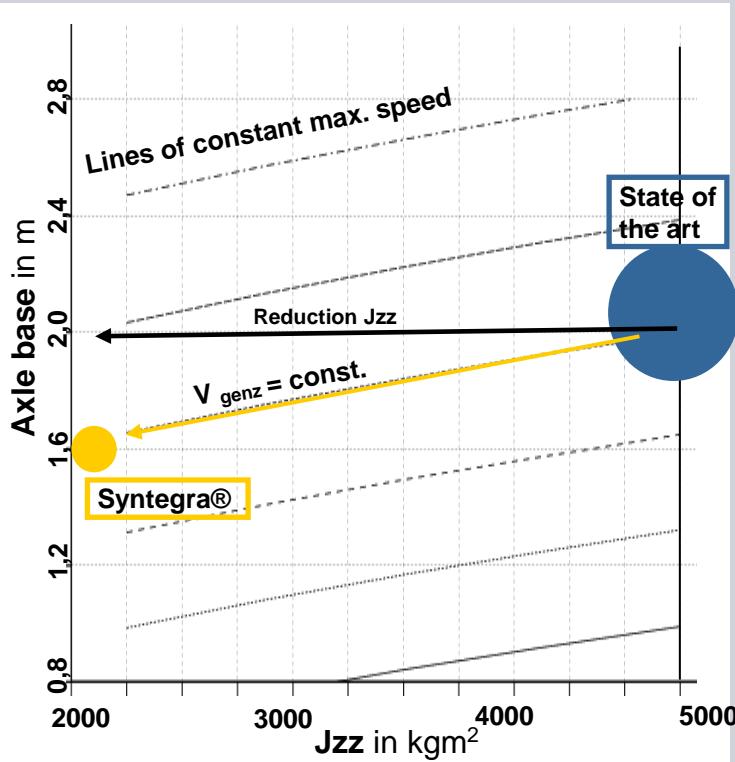
Direct connection of traction motor and carbody

- No traction forces to be led through the bogie frame
- Lowest load shift achieved



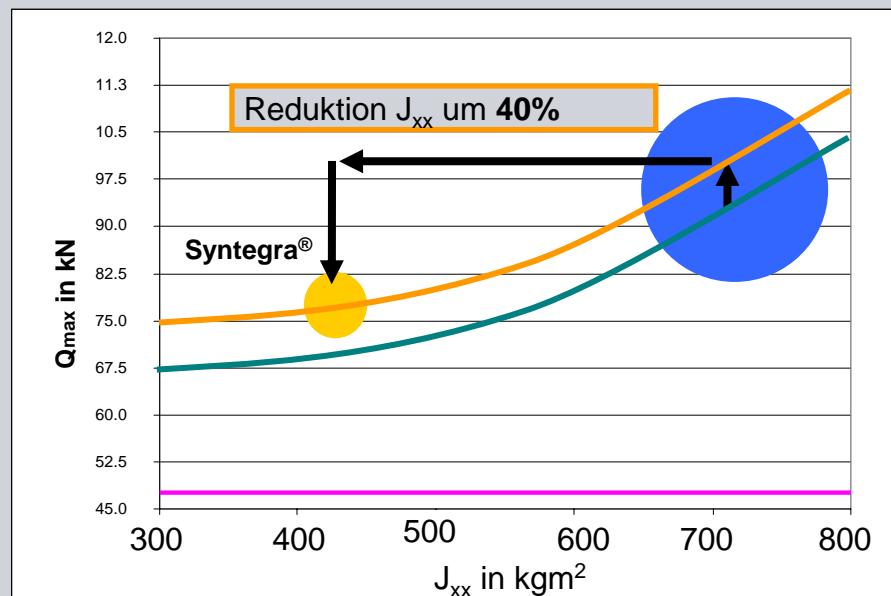
Guidance uses conventional wheelsets

Even with a smaller axle base the maximum speed is not reduced due to lower moment of mass inertia around the vertical axis.



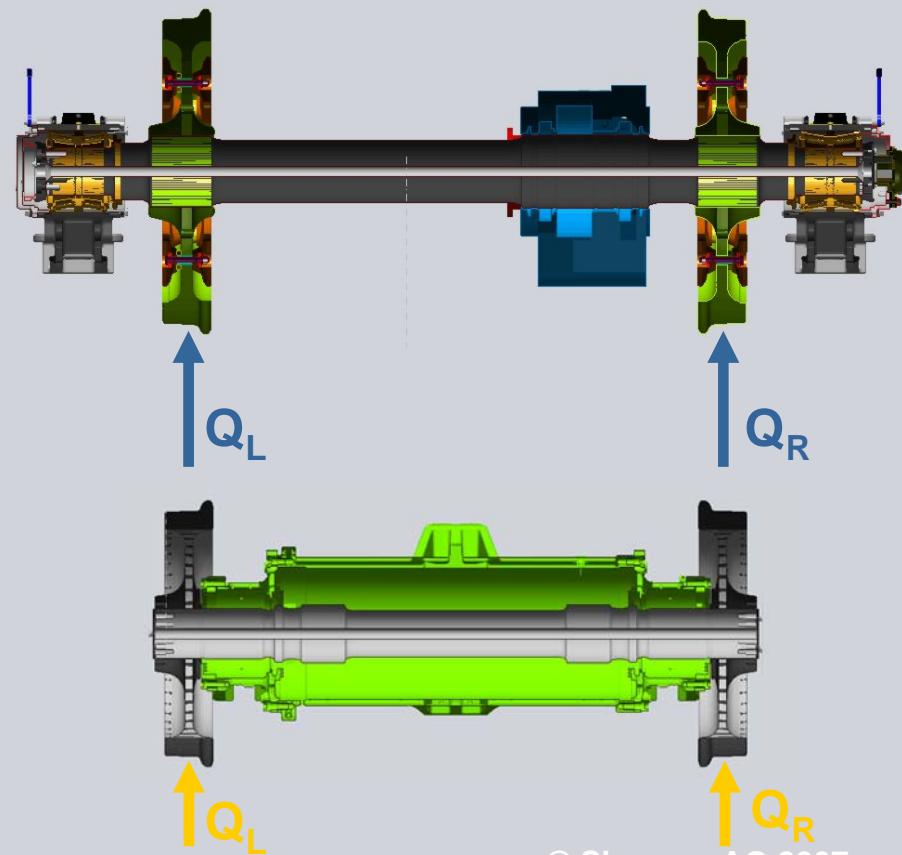
Low track-forces due to mass and geometry

Low dynamic wheelset loads Q_{dyn} due to low moment of mass inertia around the center line of the bogie



Q_{max} (EN 14363)
Variation of J_{xx}

Unsprung mass Partly sprung
 Sprung mass Sprung mass
 Q_0 Q₀



Syntegra® – a new technology combining low risk and extensive benefits

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■ Proven Design



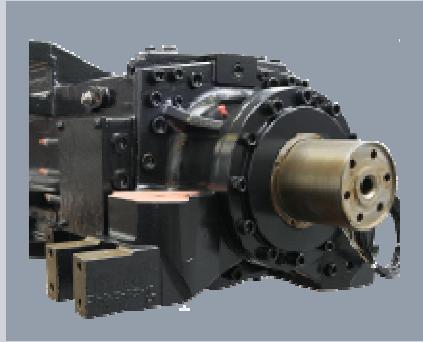
Lowest Risk due to chosen Parts and technologies



Conventional spring and guidance Parts, state of the art air spring and metal-rubber parts



Parts of the frame:
Welded or forged steel



Parts of the housing:
Modular graphite casting

The roll-out of the technology is qualified by intense testing

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Static and dynamic tests of the bogie frame in Graz Plant



Test of the whole drive system in Nuremberg Plant



Static test of the safe electric brake in Dresden

The roll-out of the technology is qualified by intense testing

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Static and dynamic tests of the prototype metro car at the Siemens Testcenter Wildenrath



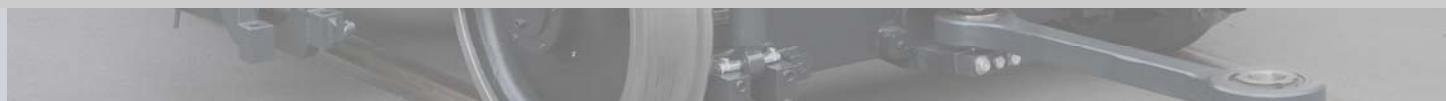
Setting into operation of the metro and optimization of the system



Dynamic tests on running conditions, braking performance and security aspects

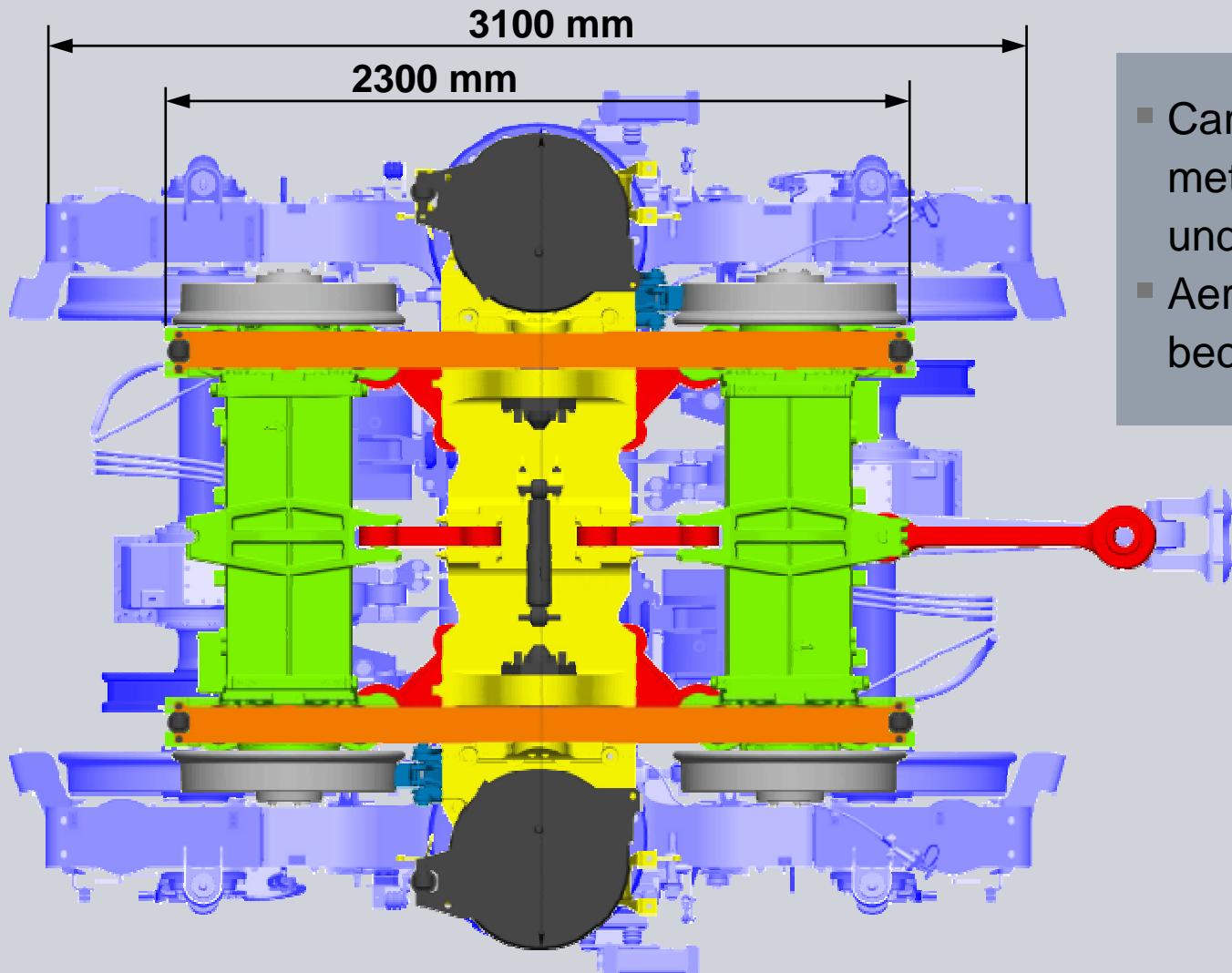
Syntegra® – a new technology combining low risk and extensive benefits

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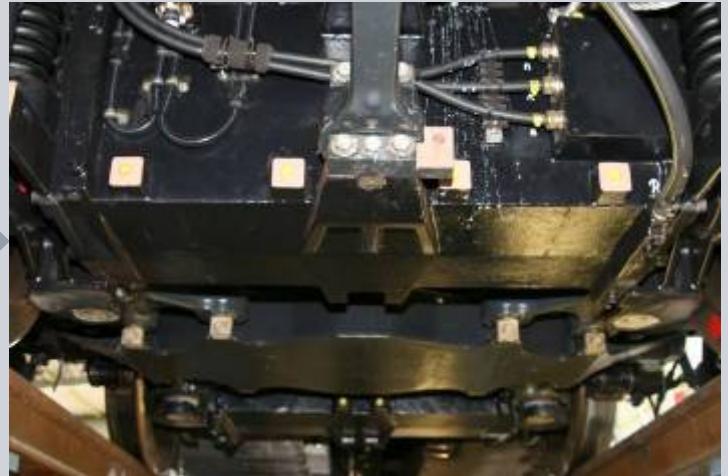
■ Benefits

Syntegra® is small



- Car offers up to 1 meter more useable under floor length
- Aero-acoustic shielding becomes possible

Syntegra® offers an environmentally compatible solution



- Lighter vehicles
- Energy savings
- Elimination/reduction of pollutants (e.g. oil and brake abrasion particles)
- Solid lubricant for wheel flanges
- Emission reduction: quiet drive
- Improved efficiency

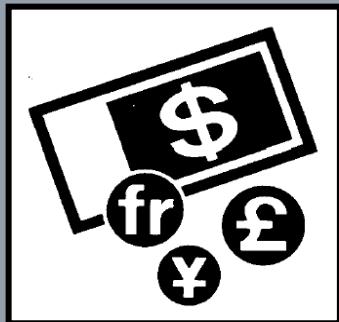
Syntegra® offers a conceptual weight advantage up to 4 tons per car

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Up to 4 tons of more equipment, e.g. air condition
No need of expensive lightweight construction

or



Reduced Cost of operation due to less weight,
less energy consumption and lower track access
charges / track maintenance costs

or



Up to 4 tons more payload per car, equal to 50
more passenger at 200 passenger-cars

Reducing energy consumption and CO₂ emissions



Regarding metro vehicle in a typical network

- 4 cars, 100% powered bogies
- DC750V, 40% recuperation



Reduced kinetic mass by app. 13%

Reduced rotating mass by app. 75%

Reduced energy consumption by app. 20%



Each 4 car train saves up to 340MWh each year

- equal 27.000€ at 8ct/kWh
- equal energy consumption of 113 private homes
- equal 235.000kg of CO₂

Syntegra® – The new generation of powered bogies

- Lower life cycle costs due to:
 - improved efficiency of the powertrain (approx. + 2-3%)
 - greater mileage due to less wear and tear
 - greater availability due to higher drive redundancy
 - lower costs for maintenance of bogie and tracks due to oil-free direct drive concept
- Reduced weight, increased payload
- No gear unit
- Mechanical brake eliminated
- Lower installed height and less installation space
- Greater safety and better running characteristics due to torsionally flexible bogie
- Noise reduction of drive by over 50%



Thank you for your attention !