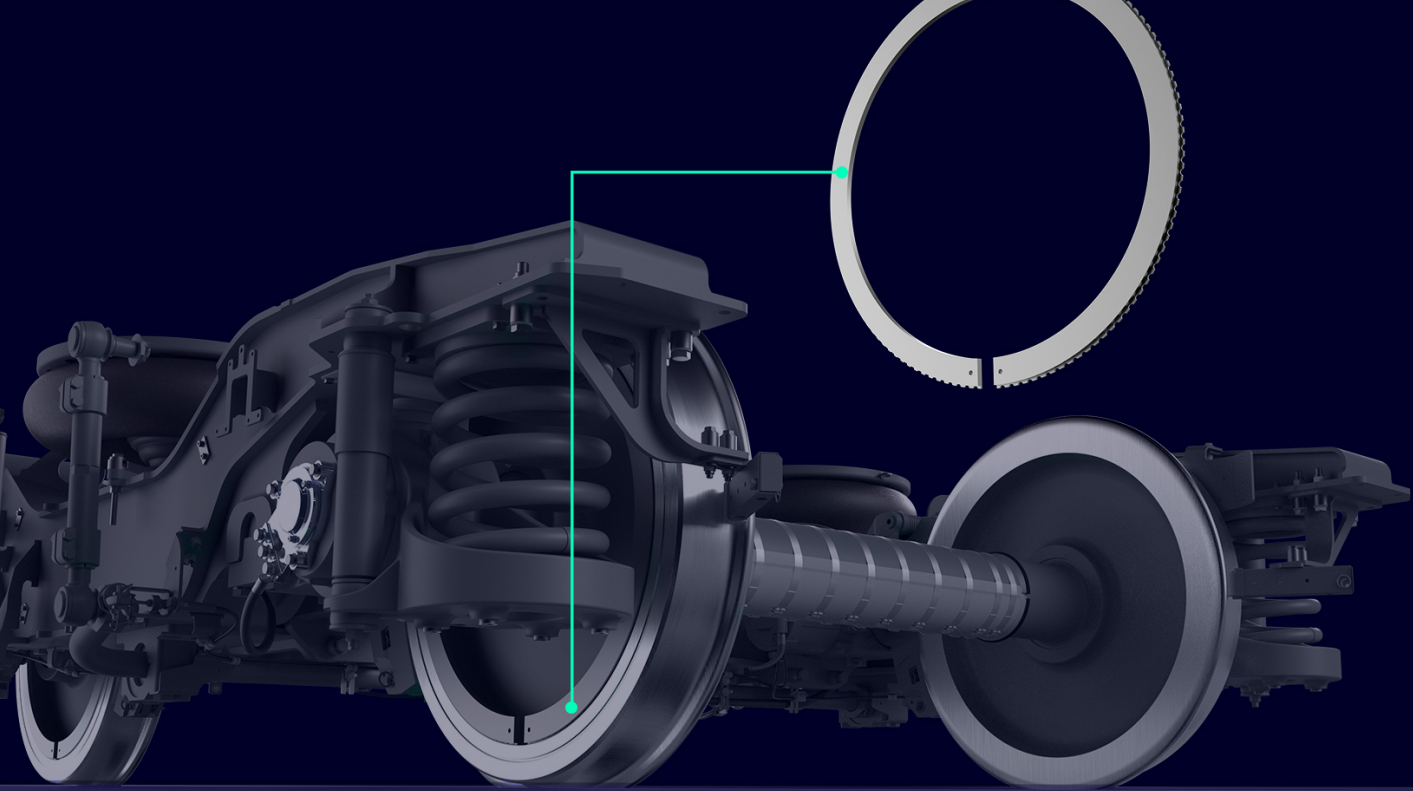




REDESIGNED WHEELSET: LESS WEIGHT, LESS NOISE, MORE PERFORMANCE

Wheelset of the Future

Dr. Johann Blaha, Dr. Laszlo Boronkai, Ing. Dschambul Huber,
Dr. Martin Rosenberger, Dr. Gerald Schleinzner,
Dipl.-Ing. Gerhard Stine, Dipl.-Ing. Helmut Trantin,
Dr. Franz-Josef Weber, Dipl.-Ing. Rüdiger Zenz, Siemens
Mobility Austria, Graz (Austria).

Abstract

The wheelset plays a significant role in the wheel-rail system due to its substantial impact on the safety, efficiency and reliability of the rail vehicle as well as its lifecycle costs. Since the 1950s, wheelsets have been designed and manufactured based on the same technologies. However, due to changing requirements, it is now time to re-think the wheelset and undergo a paradigm shift.

The future wheelset utilizes high-strength and wear-resistant steel and cast iron materials for its sub-components, such as the axle and wheel. It exploits the potential of these materials through the application of principles of structural light-weight design, under utilization of tubular structures and distributed force transmission. The Siemens Light-Weight Axle (LWA) is designed for assembly in any workshop. The wheelset of the future is equipped with a removable Siemens axle protection system called SICAP®, which provides safe protection against swirled gravel at speeds of up to 400 km/h. Its noise emissions are minimized through the application of wheel sound absorbers with an optimized interface, and the ventilation losses of the aerodynamically optimized brake discs amount only a fraction of the losses observed for standard designs.

SIEMENS

1 Introduction

State-of-the-art rail vehicles represent a central cornerstone when it comes to transporting passengers and goods. High-speed trains provide a high quality alternative to short-haul flights. Subways, commuter trains and trams represent a real alternative to road vehicles in metropolitan areas – allowing traffic congestion, CO₂ emissions and local pollutant emissions to be reduced. Freight trains enable large quantities of goods to be efficiently transported over long distances and facilitate access to all types of products. As a consequence, innovative mobility solutions play a decisive role in mastering global megatrends, such as population growth, climate change and urbanization [1]-[2]. By 2050, the world's population will have grown to even 9.7 billion. The number of megacities (with >10 million residents) will have grown from 44 today up to 67 [3]. In the EU, this development will be accompanied by a doubling of freight traffic and a tripling of high-speed rail traffic by 2050, which represents a promising perspective for the rail vehicle market.

For new projects, the clear emphasis is on ecological aspects with respect to the efficient use of existing resources and the lowest possible impact on the environment and society.

Especially when it comes to CO₂ emissions, rail vehicles offer massive advantages when compared to other transport types. When it comes to air travel, rail transport reduces CO₂ emissions by 85%, and when it comes to motor vehicles, even 91% [4]. European track access charges in rail transport represent a financial aspect. These are crucially important for all rail undertakings (RUs) as, despite a standard European legal basis, these charges are regulated differently in each country, and account for a significant percentage of the overall RU costs. Fig. 1 shows an overview of track access charges incurred per track kilometer (trkm) and type of transport (long-distance passenger rail, regional passenger rail and rail freight).

Presently, vehicle-specific properties are only taken into consideration in track access charge models in Switzerland and Great Britain. A significantly reduced weight when compared to conventional designs is especially beneficial. Depending on the operating constraints, the calculation models for track access charges can show significant savings, which in just a few years will cover the full (!) investment costs of the wheelset. This is due to the fact that the reduced wheelset weight fully impacts the unsprung vehicle mass. This reduces wear and damage to the infrastructure, regardless of whether it is taken into account in the track access charge model or not.

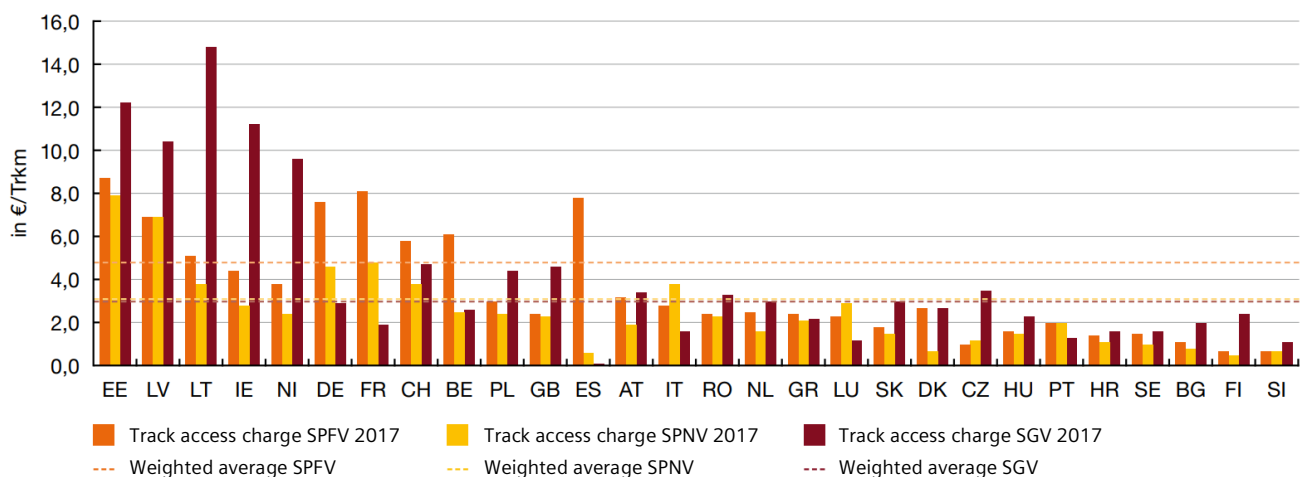


Fig. 1: Overview of European track access charges per track kilometer and transport type [5].

To sustainably address all these challenging requirements, the following objectives must be pursued when designing rail vehicles in the future:

- Lower costs (procurement, maintenance, end-of-life – LCC)
- Reduced energy consumption in operation
- Lower CO₂, noise and dust emissions
- Less damage to the rail infrastructure
- Increased service life and availability
- Autonomous digital analysis and evaluation of the vehicle state

The goal is to optimize the economic and social impact associated with the procurement and operation of state-of-the-art mobility solutions based on early-stage life cycle assessments. Making up approximately 40% of the total life cycle costs of a vehicle, an optimized bogie design makes a significant contribution when optimizing costs.

In terms of life cycle costs at the bogie level, the wheelset is a particularly important component. With its wearing parts such as the wheel, wheelset bearing and brake disk (corrective maintenance), as well as the need for regular non-destructive testing of the wheelset axle (preventive maintenance), the wheelset represents a large percentage of the overall life cycle costs. To a large extent, replacing and inspecting these components also determines preventive and condition-based maintenance intervals – and in turn, the vehicle availability.

To comply with sometimes contradictory requirements involving low costs/emissions and high vehicle availability, Siemens Mobility develops solutions to specifically address individual priorities.

In the ideal case, the focus of the requirements is already established during the tender process, allowing the development of a new vehicle and its maintenance concept to be optimized. Siemens Mobility's solutions can also be deployed after initial operational or maintenance experience has been gathered to achieve optimum results by appropriately adapting the vehicle, components or the maintenance concept.

2 Proposed solutions

In the following, several solutions for optimizing individual components as well as subsystems are presented, focusing on their operational requirements.

2.1 Siemens Light-Weight Axle (LWA)

A state-of-the-art wheelset for rail vehicles comprises a wheelset axle and wheels as main components, which are connected to each other through an interference fit. The assembly process (press-fitting the wheels onto the axle) requires a complex wheelset press. Currently, wheelset axles are either solid or hollow, manufactured out of special steel material, forged, heat-treated and machined.

Wheelset axles are extremely safety-critical railway components, which are subject to high loads over long periods of time during their service life. Only complex non-destructive testing can detect wheelset axle cracks.

When developing the Siemens LWA presented here, the objective was to reduce weight while still keeping all functional properties. The LWA structure was engineered using established structural lightweight design methods to increase the section modulus of the axle cross-section relative to conventional designs, while simultaneously reducing weight. The strength was assessed using state-of-the-art techniques for calculating fatigue strength in compliance with applicable standards. This made it possible to create a tubular axle-wheelset system that directly offers tangible benefits to railway operating companies:

- Significantly reduced unsprung mass
- Assembly and disassembly without requiring a wheelset press
- Optional wheelset structural diagnosis by internally measuring the pressure – either manually at defined intervals or automatically during operation

A first wheelset system concept was realised for field test using a freight car wheelset rated for a 25t axle load. The axle, usually forged from solid material, was replaced by a seamless steel tube with a higher section modulus. The interface to the wheel is a tubular flange. The wheel interface was also specifically adapted for use in this system. The interference fit was replaced by a screwed connection, which has the advantage that it reduces the overall weight. The wheelset axle is screwed to the wheels through the axle stub using several screws.

To validate the concept, an LWA prototype was developed, designed and realized as a freight car wheelset. The weight was able to be reduced by between 150 and 200 kg (approximately 15%, depending on the design) when compared to conventional designs. The prototype was also tested on a rotating bending fatigue test rig at Graz University of Technology (TU Graz) and validated for trial operation. In 2022, the prototype was successfully operated in series service for ore transport by Rail Cargo Austria (ÖBB) for approximately 60,000 km. The basic

function of the wheelset system in an operational environment was verified.

During trial operation, the principle of contactless internal pressure measurement was also verified. To do this, a prototype setup was realized that can contactlessly measure the internal wheelset pressure during operation and transmit the data to trackside equipment via a telecommunications link. The system would identify a pressure drop in the system if the tube was to rupture or the screw connection were to become loose. This system can identify an incipient structural failure and initiate appropriate protective responses in different ways: manually, automatically using external/trackside infrastructure or integrated in the vehicle.

Based on the results of the trial operation and the various component tests, ideas for improvement were derived and incorporated into the first version of a series design, see Fig. 2. The next planned step involves approval as a freight car wheelset according to TSI WAG.

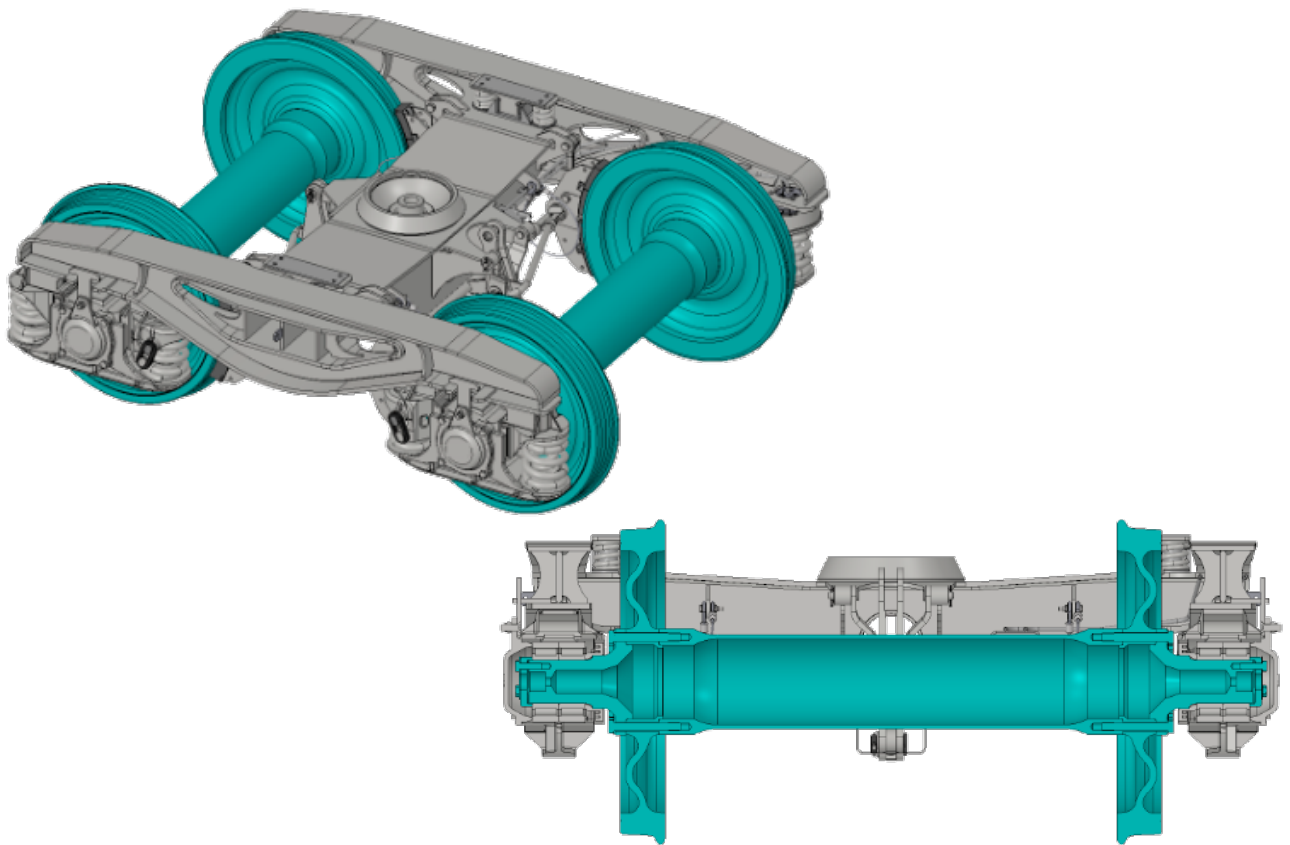


Fig. 2: The first series design of the LWA as freight car wheelset integrated in a Y25 bogie.

It is important to state, however, that Siemens LWA is just not restricted for use as freight car wheelset. In the course of the development work, concepts were drawn-up that demonstrate the significant weight reduction potential in various applications.

An integral bogie concept for a driving wheelset for metro vehicles is characterized, for example, by the fact that a fast-running brake is directly mounted on the gearbox and no longer has an interface to the wheelset itself [6]. This allows the bogie weight to be reduced by about 420 kg (approximately 10%) when compared to a reference bogie.

For example, a wheelset concept for a regional rail vehicle designed as an LWA sets itself apart as the weight is reduced by up to 200 kg when compared to the reference wheelset (approximately 16%).

Accompanying the technical development, efforts are being made to optimize industrial wheelset production to

meet the functional requirements while ensuring cost-effective production. As this involves cutting edge technology, higher investment costs are currently to be expected when compared to conventional wheelsets. Nevertheless, even at this early stage of innovation, specific business case studies show that when using a Siemens LWA wheelset system, costs can be reduced over the lifetime. For instance, as the mechanical stress on the wheelset axle is reduced in operation (lower bending stresses), non-destructive component testing (e.g. ultrasonic testing) can be reduced in the maintenance schedule. The corresponding proof of operational safety can be provided in terms of fracture mechanics. Using the example of a freight car wheelset with a 25 t axle load, a doubling of the remaining service life until crack instability can be demonstrated under comparable conditions (load spectrum, consideration of the critical axle cross-section, axle material, fracture toughness, initial crack), see Fig. 3.

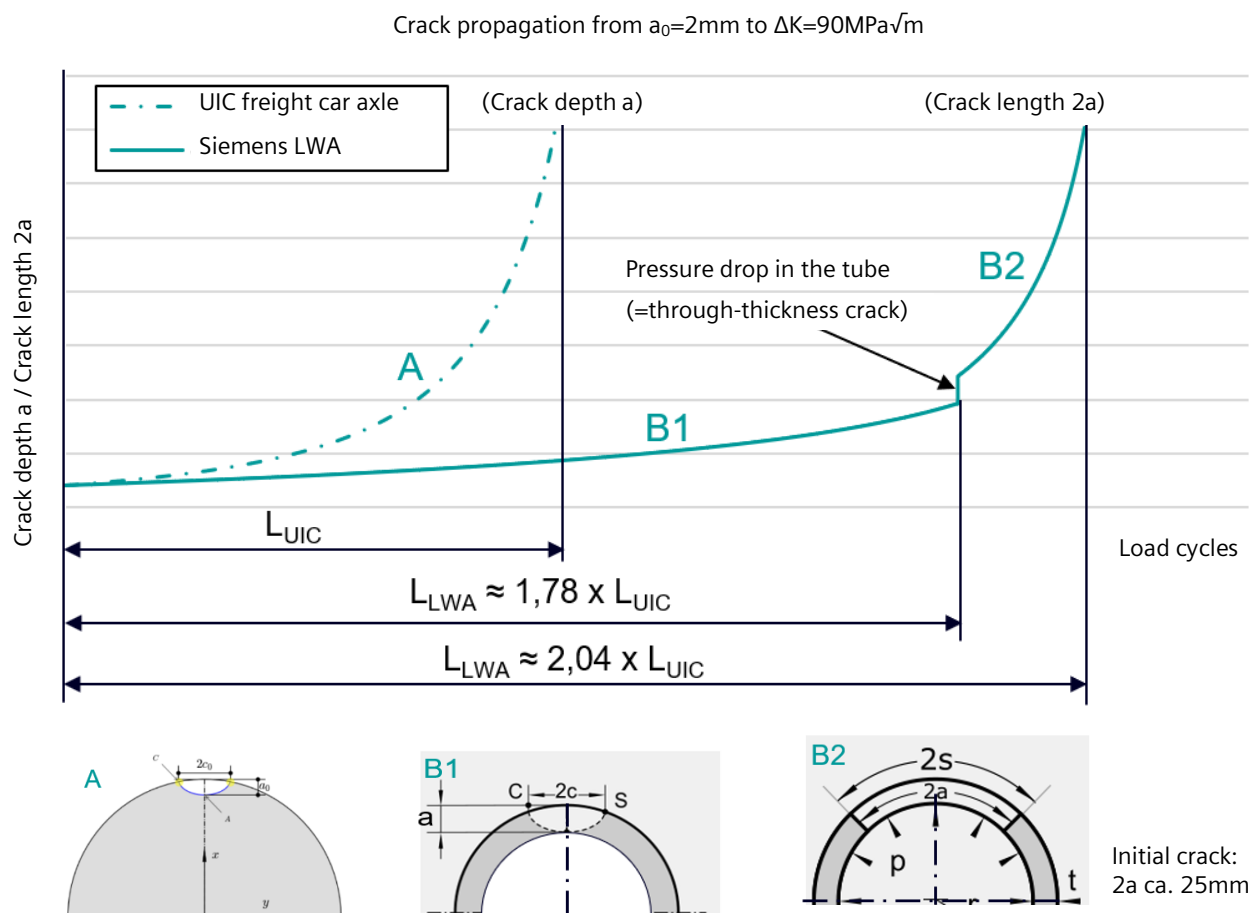


Fig. 3: Remaining service life based on fracture mechanics of the Siemens Light-Weight Axle (LWA) in a qualitative comparison to a conventional UIC freight car wheelset.

2.2 SICAP® axle protection

With the increase in operating speed and axle load, as well as the reduction in wheel diameter, the aerodynamic relationship between the vehicle and the track is becoming increasingly challenging. This becomes evident as aerodynamic forces more frequently throw up track ballast that damages underfloor components. In situations such as these, a wheelset axle is one of the most exposed components.

The SICAP® wheelset axle protection represents a further development of the SISRAP® product that has proven itself over many years. They both provide a clear separation between corrosion protection and mechanical protection functions. SICAP® is also a removable wheelset axle protection featuring a patented innovative steel-fiber composite structure. The resistance of the system against stone chipping, the effects of increased speed, stress caused by centrifugal force and acceleration, as well as the chemical effects of cleaning agents, were validated through comprehensive material analysis, laboratory tests, simulation runs and real-body trials.

Fig. 4 shows the impact of standard railway gravel on a SICAP®-protected wheelset axle at a speed of approximately 400 km/h, which corresponds to an impact energy of about 1300 J.

SICAP® consists of two U-shaped steel half-shells, which are designed according to the axle geometry: the axle diameter as well as the transition geometry of the axle are taken into consideration. The half shells are placed on the surface of the wheelset axle coated with a corrosion protection agent and fastened using circumferential fastening straps. The half shells are removed during maintenance by cutting the fastening straps. As a result of the easy assembly and disassembly as well as reusability, SICAP® offers cost-effective and sustainable maintenance when compared to conventional protection and coating systems.

A low-profile version is available if installation space is limited (e.g. short distance between drive and axle). With this version, the fastening straps are directly integrated into the U-shaped shells, see Fig. 5.

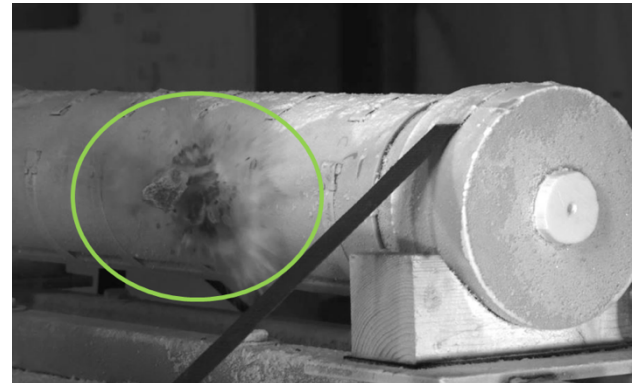


Fig. 4: Ballistic test on a frozen axle with track ballast at an impact angle of 90° and a projectile velocity of V=400 km/h.

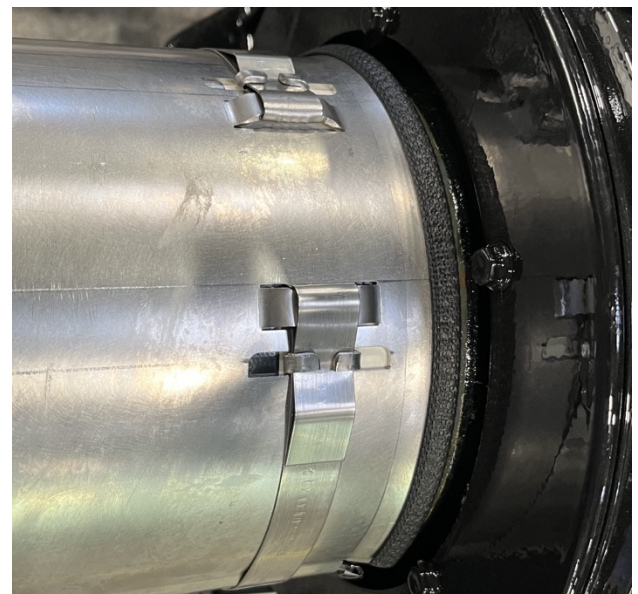


Fig. 5: SICAP® with integrated fastening.

Table : Comparison of thick-film coating-SISRAP®-SICAP®.

	Thick film coating	SISRAP®	SICAP®
Usage temperature (°C)	-35 / +50	-50 / +50	-50 / +50
Validated impact energy, mean value (J)	90	600	1300
Max. validated operating speed (km/h)	320	250	400
Operational experience	-/+	+	being tested
Fire protection	-/+	+	+
Maintenance costs	-	+	+
LCC	-	+	+

+ ... better / - ... worse

2.3 ADI spoke wheel

Wheels, as a key element of conventional rail vehicles, account for a significant percentage of the costs over the lifetime of a vehicle. The wheel weight represents the main cost driver as this must be continuously accelerated and braked. As the wheel weight represents an unsprung mass, the forces acting between the wheel and the rail are strongly dependent on the weight of the wheel.

Almost more important is the wear between wheel and rail, which, in addition to the dynamic behavior of the vehicle, is strongly influenced by the wheel material and the wheel surface quality. The wheels are also responsible for a significant percentage of noise generated by rail vehicles.

Cast iron in the form of spheroidal graphite cast iron is frequently used in general mechanical engineering, automotive engineering and energy technology; however, to date, it has not yet been utilized for wheels. The main reasons for this are the high demands placed on the wheel at the wheel contact point. For solid wheels, a material is demanded that has both high strength and a low wear tendency at the wheel contact point, high ductility and fatigue strength in the wheel web. ADI stands for “austempered ductile iron” and refers to a heat-treated

ductile cast iron with a significantly higher strength compared to conventional spheroidal graphite cast iron with the same elongation at fracture.

By using a cast iron material the wheel web can be freely designed. In the present work, this approach is being used as an alternative to the conventional axis-symmetric wheel web, which is typically manufactured by forging and rolling due to process constraints. A wheel web with numerous openings was created [7].

For the final design, the spokes are distributed in two largely parallel rows on the outside and inside of the wheel, see Fig. 6. This ensures optimal use of space in terms of structural strength. If a spoke fails, the wheel forces can still be transmitted by redistributing the force flow from one spoke to another. This means that the structural functionality of the wheel is not compromised even if a spoke fractures.

The advantages of this new wheel type include:

- Lower weight
- Lower noise emission
- Less wheel wear
- Lower tendency to polygonal wear

In Fig. 6 the ADI spoke wheel is compared to a standard forged wheel.

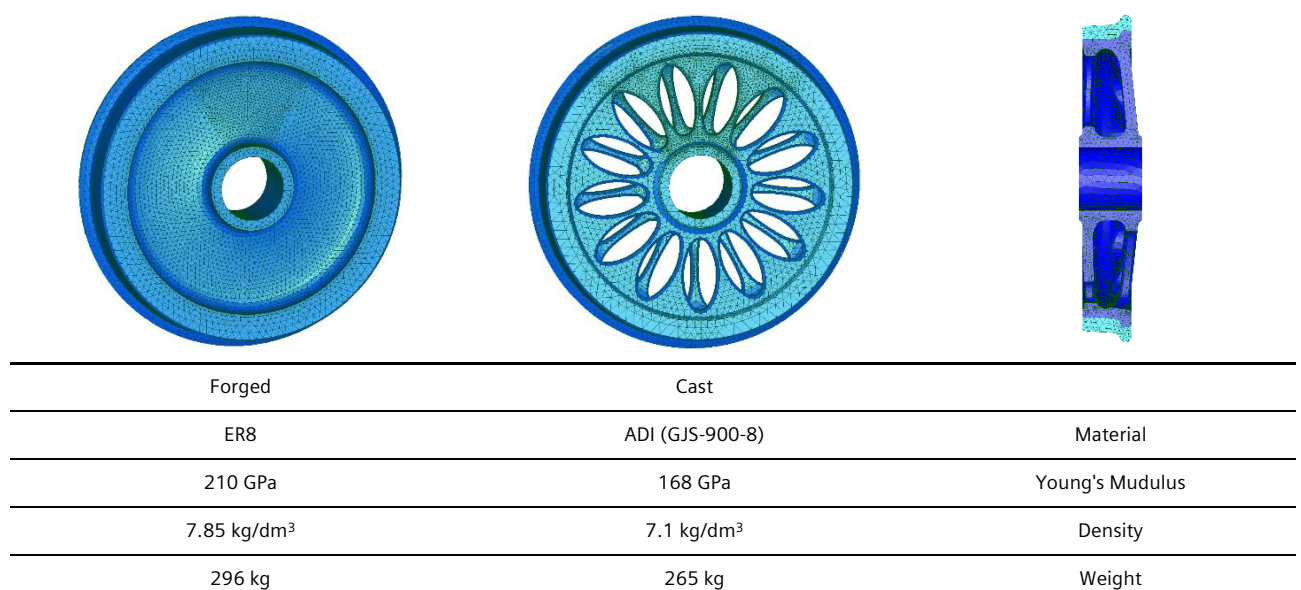


Fig. 6: ADI spoke wheel compared to a standard forged wheel for a metro vehicle.

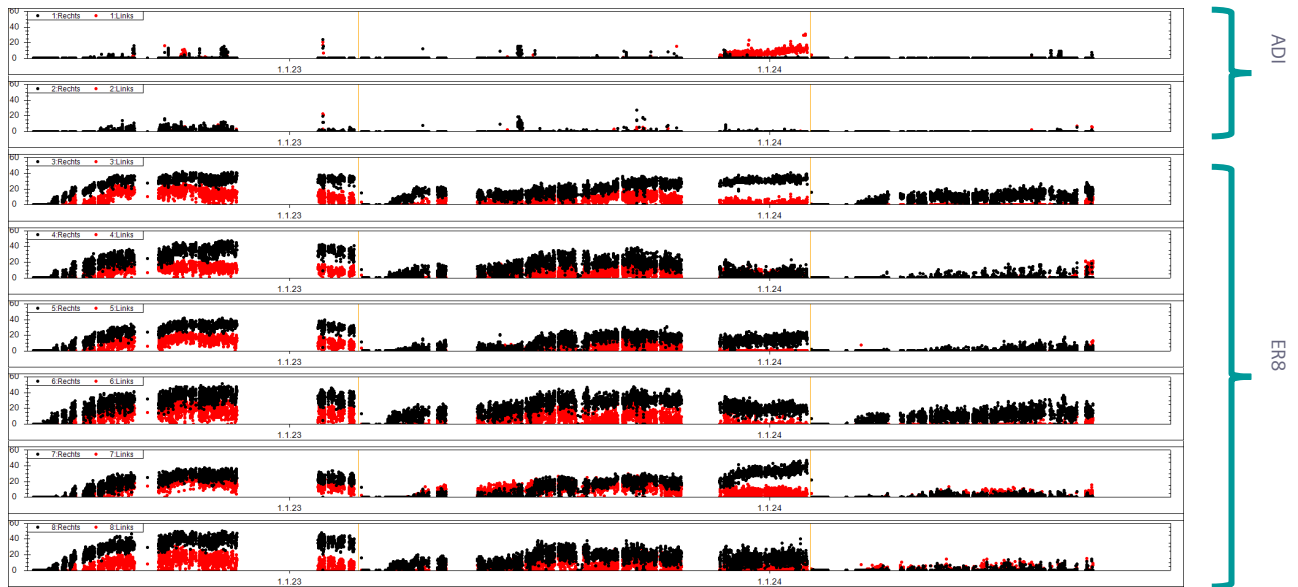


Fig. 7: Acceleration measurement during operation in a metro application.

One advantage of the spoked design is its lower sound radiation; the well-known bell effect of the wheel web as noise emitting membrane does not occur with a spoke wheel.

After development followed by an intensive testing phase, to validate operational behavior, prototypes were manufactured, homologated and have now been used in metro operation since December 2018. In operational service, any wheel out-of-roundness is determined at a fixed trackside acceleration measurement point. Over a period of more than 2 years and a mileage of > 150,000 km, there was a significantly lower tendency for out-of-roundness to occur, see Fig. 7. While the ER8 wheels had to undergo multiple reprofiling due to out-of-roundness, the ADI spoke wheels generally only required diameter adjustments to comply with the allowable diameter variation limits in the vehicle.

2.4 Siemens sound absorber

Noise and vibration (N&V) are one of the main obstacles to public acceptance when introducing new vehicles, building new lines or increasing traffic volumes on existing lines. The ecological transformation of the transport sector is another objective of the EU, closely aligned with initiatives aimed at noise reduction. Important aspects of vehicle noise are rolling noise and curve squeal. Both can be reduced by using wheel sound absorbers or wheel dampers. Different variants are available on the market.

To make this technology attractive, in addition to effectiveness, a compelling price, easy installation and minimum effect on the wheel geometry for the interface are key issues. Any imbalance should be low and it should be able to be used for wheels equipped with tread brakes. These goals were achieved with the Siemens sound absorber, see Fig. 8 to Fig. 9.



Fig. 8: Sound absorber variant for metro applications (tread brake).

A metal and elastomer sandwich design is used with optimized geometry to achieve maximum wheel damping. The interface to the wheel is a simple 2 mm deep groove, which means in principle that existing wheels can also be retrofitted. The sound absorber was tested on vehicles at speeds up to 320 km/h, and on a test bench up to 400 km/h. Fig. 8 shows a variant for metro applications with a tread brake. The thermal energy introduced into the absorber is reduced by the tothing on the ring that sits in the groove.

Fig. 9 shows the sound absorber installed on a high-speed vehicle. A locking element provides additional protection against loss and ensures good wheel balancing.

Fig. 10 shows the effect of an optimized wheel design and an additional sound absorber. Optimizing the wheel geometry reduces the sound radiated by the wheel by 3 dB – and by additionally attaching the sound absorber, a further reduction of 3 dB can be achieved.

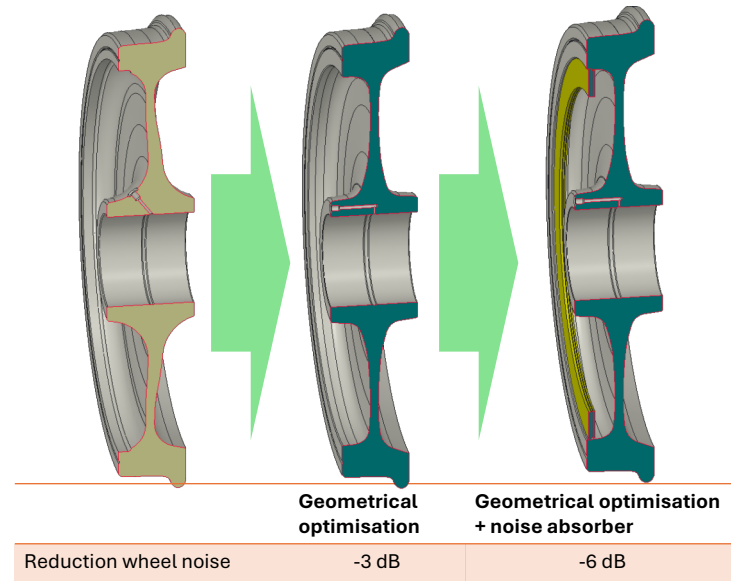


Fig. 10: Reduction of rolling noise with optimized wheel geometry and sound absorber.



Fig. 9: Testing the sound absorber in high-speed operation (Velaro Novo) to reduce rolling noise.

2.5 Ventilation-optimized brake disks

Rail vehicle brakes are absolutely essential for safety and control of trains. They are used to reduce speed, reliably and safely bring the train to standstill and keep the speed constant on downhill track sections. They are subject to high thermal and mechanical stresses and, in the case of wheel and axle brake disks, also contribute to the unsprung masses that significantly influence wheel and rail damage.

Geometrically adapting the design of the cooling ducts reduces weight and energy consumption (accelerated masses and ventilation losses). As soon as a wheel turns, ventilation losses always occur and must be compensated by a higher drive power. Variants of the ventilation-optimized brake disk are shown in Fig. 11. Flake-graphite cast iron was selected as friction ring material to achieve the most uniform temperature distribution possible with low associated thermal stress.

The development was supported by FEM calculations of the assembly comprising wheel, friction ring and fastening elements, followed by extensive test bench trials.

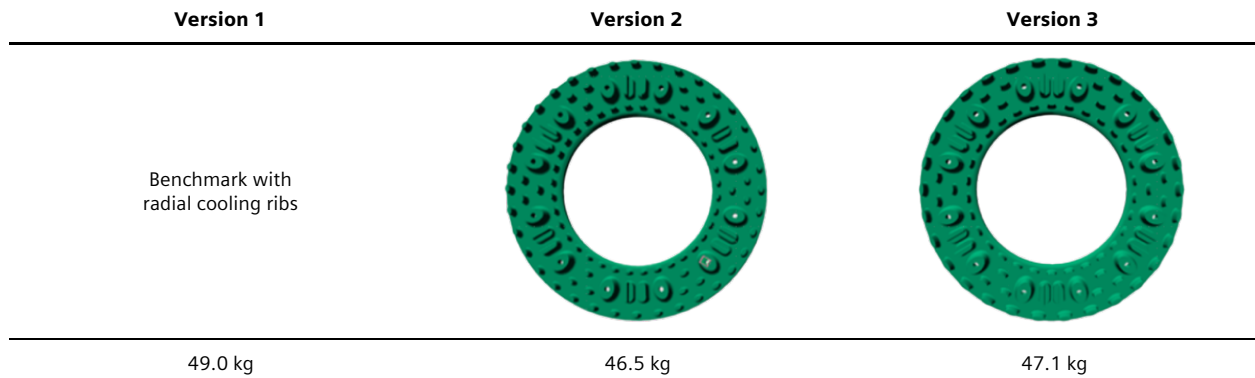


Fig. 11: Brake disk variants for multiple units with optimized cooling rib design.

Ventilation losses are significantly reduced by optimizing the cooling ribs, see Fig. 12. Wheel brake disks with optimized ventilation losses manifest only minimal differences in cooling behavior when braking to a stop, see Fig. 13. When braking continuously, the temperature increases slightly but remains in the non-critical range.

Furthermore, the geometrical design of the connection to the wheel – including connecting and centering elements – ensures low screw connection loads, which leads to a reduction in screw forces, especially when warm. This was confirmed by measuring the temperature and forces at the screws as part of the test stand trials.

For further optimization of the weight the wear reserve can be adapted according to specific vehicle requirements.

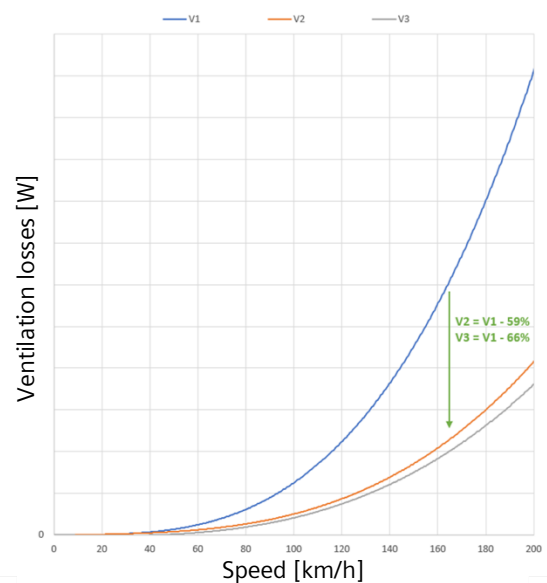


Fig. 12: Ventilation losses of different cooling rib variants.

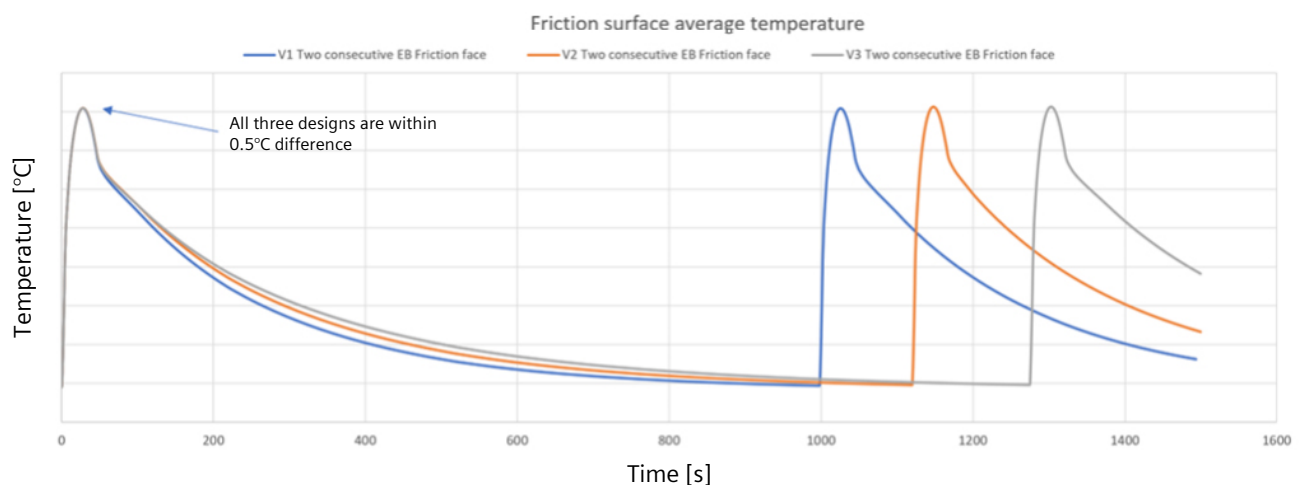


Fig. 13: Temperature characteristic when braking to a stop: Speed of 200 km/h when starting to brake, deceleration 1.18 m/s^2 , $P_{\text{max}} 651 \text{ kW}$.

2.6 Digitizing the wheelset – wheelset diagnostics

To reduce the maintenance costs of the wheelsets over their life cycle, to increase availability and predictability and also to maintain or even further increase the level of safety, Siemens has developed an intelligent bogie diagnostic system. This system not only allows the wheelsets to be continuously monitored, but also the driving behavior of the vehicle as a whole and important maintenance-relevant components of the bogie. The bogie diagnostic system provides the maintenance depot with the following information and data:

- Health states – what is the state of the wheelset and/or the vehicle.
- Remaining useful lifetime – how long can the vehicle be operated until maintenance work is required.
- Workshop notifications – for a deviation from a normal health state, what specific maintenance work must be carried out in the depot.

Sensors, which are installed at wheelset bearings, bogie frames and in the railcar body form the basis of this

innovative bogie diagnostics system. These sensors are predominantly acceleration sensors, which allow the dynamic behavior of the vehicle to be acquired, i.e. its response to the specific track section, the ambient conditions and the operational cycle. In a diagnostics computer, the data captured are combined with information such as the vehicle load state, travel direction, GPS position and speed. Intelligent algorithms, ranging from classical signal processing methods through physics-based approaches up to state-of-the-art machine learning and artificial intelligence methods, process the data to capture diagnostic bogie information. This provides insights on wheelset bearings, wheel flats, wheel diameters, wheel out-of-roundness, rolling contact fatigue on the wheel (RCF) and brake disks, etc., see Fig. 14.

With bogie diagnostics as a modular and scalable system, damage is detected and assessed at an early stage – and by being completely integrated in maintenance systems, a transition is made from corrective to preventive maintenance, see Fig. 15. Non-scheduled downtimes are therefore avoided and the necessary lead time to plan maintenance activities is created. For instance, this can reduce costs associated with the failure of wheelset bearings. Customers simultaneously benefit from higher degree of vehicle availability.

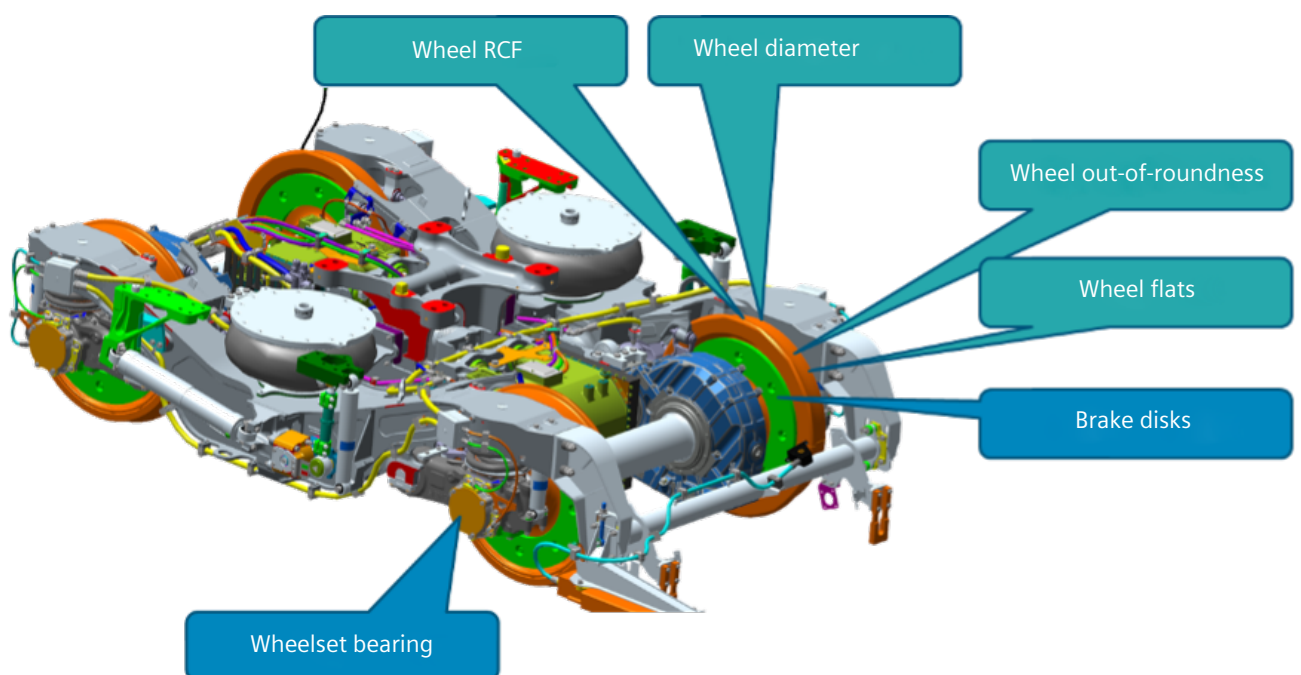


Fig. 14: Wheelset-related bogie diagnostic functions.

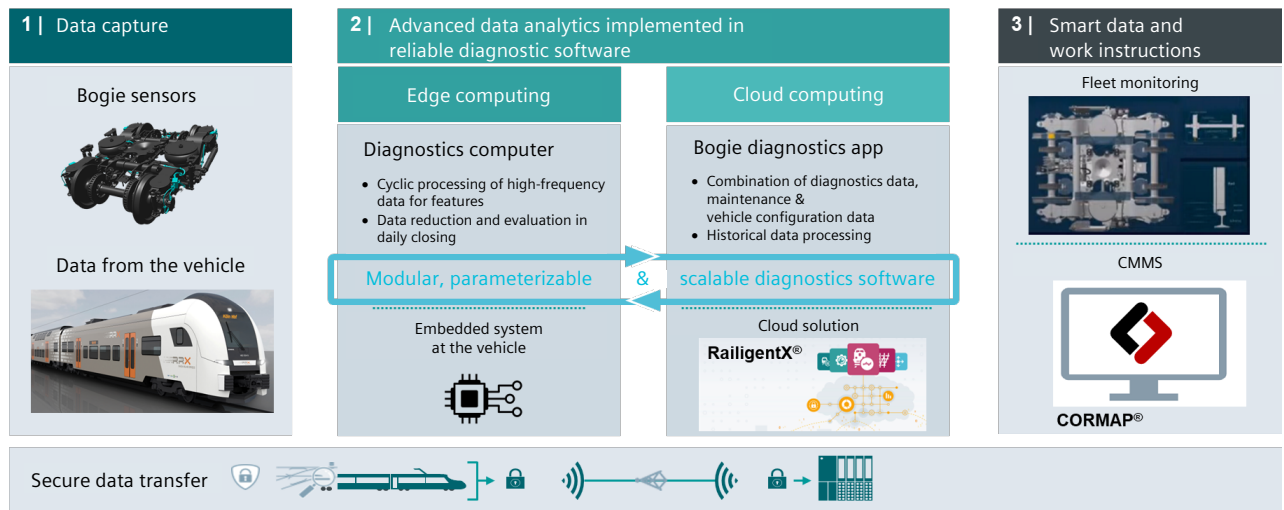


Fig. 15: Bogie diagnostics architecture.

By continuously monitoring the bogie and its components, visual inspection intervals can be extended, which also leads to lower maintenance costs and higher vehicle availability. In addition, vehicle maintenance work can be better planned in the depot, and vehicle scheduling and spare parts logistics can be organized more efficiently. Through regular and preventive analysis of the remaining service life of, for example, the wheelset component, reprofiling is only carried out as needed, which can lead to a lower number of wheelset changes over the life cycle.

Using sensors deployed at the axle bearing and bogie level, bogie diagnostics can also be complemented with algorithms to evaluate the condition of the track. This allows infrastructure managers to continuously monitor the track condition. Faults that develop between measuring vehicle runs can be detected at an early stage. This increases the planning reliability of track maintenance work and route availability. The intervals between measuring vehicle runs can also be extended, which would reduce costs even further.

3 Summary

Sustainably evaluating technical solutions in rail vehicles must be based on a life cycle assessment. In other words, higher development or procurement costs can have a positive impact on the overall costs. Generally, separately optimizing individual components or functions does not result in an optimized vehicle.

The solutions presented here offer the following benefits:

In addition to reduced weight and simplified maintenance without requiring a wheelset press, the Siemens Light-Weight Axle (LWA) allows inspection intervals to be extended – and in conjunction with pressure monitoring – condition-based maintenance to be implemented.

By separating functions that protect against corrosion and against mechanical damage, the SICAP® axle protection system provides a highly efficient solution for reducing the costs of corrective maintenance and increasing the availability of vehicles traveling at speeds of up to 400 km/h.

The unique combination of a wear-resistant cast material with a rigid spoke design reduces wear and tendency for wheels to become out-of-round, but also weight and noise radiation.

An easy-to-install and cost-effective sound absorber reduces curve squeal and rolling noise, therefore representing an important contribution to the environmental friendliness and acceptance of new rail vehicles.

Geometrically adapting the design of the cooling ducts, the weight and energy consumption (accelerated masses and ventilation losses) of brake disks can be significantly reduced. Wheel brake disks with optimized ventilation losses show only minimal differences in cooling behavior when braking to a stop and only slightly higher temperature increases in a non-critical range when continuously braking.

The digitization of the wheelset using bogie diagnostic systems allows the wheelset component service life to be optimally adapted, e.g. wheels and axle bearings, and increases the predictability of maintenance work. Apparent ad-hoc failures and damage can be reduced by continuously monitoring and evaluating component states. As a consequence, life cycle costs can be reduced and vehicle availability increased. This leads to a further improvement in the ecological footprint of the rail system as a whole and enhanced customer acceptance.

4 References

- [1] Kammler M.; Küter C.: Mireo – Die neue S-Bahn und Regionalbahn von Siemens – Innovative Transportlösungen für Megacities am Beispiel von Fahrzeug- und Subsystemkonzepten, Vortragsreihe Innovationen in der Fahrzeugtechnik, Graz, A, (2018).
- [2] IEA, The Future of Rail, IEA, Paris, <https://www.iea.org/reports/the-future-of-rail>.
- [3] Rise of new megacities will drive global urban growth | Oxford Economics
- [4] Bobsien S.: Disruptive Trends in der Schienenfahrzeugindustrie – Emissionsfreie Antriebe & Digitalisierung, 20. Internationale Schienenfahrzeugtagung Dresden, D, (2024).
- [5] Arnold H.; Henrich-Köhler C.: Studie zur Gestaltung und Entwicklung der Eisenbahninfrastrukturpreise in Europa, PricewaterhouseCoopers GmbH für Deutsche Bahn AG, www.pwc.de (2018).
- [6] Körner, O.; Weber F.-J.; Ebert, F.; Pahlke, H.; Rieger M.; Stine G.; Strommer K.; Trantin H.: Schnelllaufende Antriebe mit integrierter Bremse und Leichtbauradsatz, ZEVrail 146, Tagungsband SFT Graz (2022).
- [7] Strommer K.; Weber F.-J.: The ADI spoke wheel – new developments to meet new requirements, XIX International Wheelset Congress, Venice, I (2019).

5 List of diagrams

- Figure 1: Überblick über die Trassenpreise in Europa je Trassenkilometer und Verkehrsart [5]. – Page 2
- Figure 2: Erste Serienkonstruktion der LWA als Güterwagenradsatz integriert in ein Y25 Drehgestell. – Page 4
- Figure 3: Bruchmechanische Restlaufleistung der Siemens Light-Weight Axle (LWA) im qualitativen Vergleich zu einem herkömmlichen UIC-Güterwagenradsatz. – Page 5
- Figure 4: Beschusstest einer tiefgekühlten Radsatzwelle mit Oberbauschotter unter 90° Auftreffwinkel und einer Geschwindigkeit von $V=400$ km/h. – Page 6
- Figure 5: SICAP® Integrierte Befestigung. – Page 6
- Figure 6: ADI-Speichenrad im Vergleich zu einem geschmiedeten Standardrad für einen Metro-Einsatz. – Page 7
- Figure 7: Beschleunigungsmessung im Betrieb bei einem Metro-Einsatz. – Page 8
- Figure 8: Schallabsorbervariante für den Metro-Einsatz (Klotzbremse). – Page 8
- Figure 9: Schallabsorber-Erprobung im Hochgeschwindigkeits-Einsatz (Velaro Novo) zur Reduktion des Rollgeräuschs. – Page 9
- Figure 10: Reduktion Rollgeräusch mit optimierter Radgeometrie und Schallabsorber. – Page 9
- Figure 11: Brems Scheibenvarianten für Triebzüge mit optimiertem Kühlrippendesign. – Page 10
- Figure 12: Ventilationsverluste unterschiedlicher Kühlrippenvarianten. – Page 10
- Figure 13: Temperaturverlauf bei einer Stoppbremsung: Bremsausgangsgeschwindigkeit 200 km/h, Verzögerung $1,18 \text{ m/s}^2$, $P_{\text{max}} 651 \text{ kW}$. – Page 10
- Figure 14: Fahrwerksdiagnosefunktionen rund um den Radsatz. – Page 11
- Figure 15: Architektur Fahrwerksdiagnose. – Page 12

6 CV

Dr. Johann Blaha (52). Studied materials science at the Montan University Leoben, doctorate at Technical University of Munich (TUM) in the Faculty of Mechanical Engineering. Since 2013, he has been working for Siemens Mobility Austria GmbH in the bogie development department as Head of Wheelset Development.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN SDE WS, Eggenberger Str. 31, 8020 Graz, Austria.

Email: johann.blaha@siemens.com

Dr. László Boronkai (50). Studied mechanical engineering and received a PhD in rail vehicles at the Budapest University of Technology and Economics (BME), Department of Rail Vehicles; studied industrial engineering, specializing in transport, at the Budapest Technical University. 1998-2004 Design Engineer, Manager Technology Ganz-David Brown GmbH, Budapest. Component Manager at Siemens Mobility Austria GmbH since 2004. Current activity: Principal Key Expert, Wheelset Development, Member of the European Standardization Body CEN TC256 SC2 WG11.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN SDE WS, Eggenberger Strasse 31, 8020 Graz, Austria.

Email: laszlo.boronkai@siemens.com

Ing. Dschambul Huber (32). Higher Federal Technical Institute for Mechanical Engineering. Since 2015, at Siemens Mobility Austria GmbH in the bogie development department, first as module designer and subsequently as component manager in the wheelset department.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN SDE WS, Eggenberger Str. 31, 8020, Austria.

E-Mail: dschambul.huber@siemens.com

Dr. Martin Rosenberger (48). Studied and obtained a doctorate in mechanical engineering and mechatronics at Graz University of Technology (TU Graz). Since 2016, he has been working for Siemens Mobility Austria GmbH in the Bogie Development Division, Head of the Vehicle Dynamics, Acoustics & Analytics Department and Area Manager Innovation Area Digitalization in Products.

Head of the Rail Vehicle Working Group at the Österr. Verkehrswissenschaftlichen Gesellschaft (ÖVG)

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN VDA, Eggenberger Str. 31, 8020 Graz, Austria.

Email: martin.rosenberger@siemens.com

Dr. Gerald Schleinzer (55). Studied physics at the Graz University of Technology and materials science at the Montanuniversität Leoben. Since 2000, responsible for bogie acoustics in the bogie development department at Siemens Mobility Austria GmbH. Member of the TSI Noise Working Group (ERA) and member of the European Standardization Body CEN TC256 WG03.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN VDA AC, Eggenberger Str. 31, 8020 Graz, Austria.

Email: gerald.schleinzer@siemens.com

Dipl.-Ing. Gerhard Stine (48). Studied mechanical engineering and transport engineering at Graz University of Technology (TU Graz). Since 2010, he has been working for Siemens Mobility Austria GmbH in the bogie development department as component manager in the wheel-set department. Key Expert Wheelset Development, Member of the European Standardization Body CEN TC256 SC2 WG11.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN SDE WS, Eggenberger Str. 31, 8020 Graz, Austria.

Email: gerhard.stine@siemens.com

Dipl.-Ing. Helmut Trantin (56). Studied Industrial Engineering – Mechanical Engineering at Graz University of Technology (TU Graz). Head of the Bogie Brake Systems Group since 2014.

Address: Siemens Mobility Austria GmbH, SMO RS CP B BEN, Eggenberger Str. 31, 8020 Graz, Austria.

Email: helmut.trantin@siemens.com

Dr. Franz-Josef Weber (58). Studied mechanical engineering at RWTH Aachen, doctorate at Budapest University of Technology and Economics (BME). Since 1997 at Siemens Mobility Austria GmbH in the Bogie Development Department, since 2012 as Head of Systems Development, since 2021 additionally Innovation Area Manager Components & Alternative Materials.

Address: Siemens Mobility Austria GmbH, SMO RS CP BG&P EN SDE, Eggenberger Str. 31, 8020 Graz, Austria.

Email: franz-josef.weber@siemens.com

Dipl.-Ing. Rüdiger Zenz (62). Studied Industrial Engineering – Mechanical Engineering at Graz University of Technology (TU Graz). Senior Engineer for bogie braking systems.

Address: Siemens Mobility Austria GmbH, SMO RS CP B BEN, Eggenberger Str. 31, 8020 Graz, Austria.

Email: ruediger.zenz@siemens.com

This is an English translation of the original article published in the proceedings of the Schienenfahrzeugtagung Graz 2025. The original article was written in German and published under the title „Radsatz der Zukunft“ by Johann Blaha. This translation has been prepared by Siemens Mobility GmbH for informational purposes only. In case of discrepancies, the original German version shall prevail.

**Published by
Siemens Mobility Austria GmbH**

SMO RS CP BG&P
Eggenberger Straße 31
A-8020 Graz
Austria

© Siemens Mobility GmbH 04/2025

[siemens.com/mobility](https://www.siemens.com/mobility)

Subject to changes and errors.
The information given in this document only contains general descriptions and/or performance features which may not always specifically reflect those described, or which may undergo modification in the course of further development of the products. The requested performance features are binding only when they are expressly agreed upon in the concluded contract.

SIEMENS