



Rail

DRIVING YOUR FUTURE.
GREEN. DIGITAL.
AVAILABLE.



A Rolls-Royce
solution



CONTENTS

01 Pioneering the power that matters	04	07 Automation and peripheral systems	44
World-class power solutions and complete life-cycle support	05	One step ahead of the future.	44
		All products and benefits at a glance	46
02 PowerPacks and Engines	06	06 Power control automation	48
Putting progress on a track	07	Like a digital nervous system that doesn't miss a thing	
		08 SafeMon for MTU PowerPacks: the integrated safety center	50
Drive Solutions for Railcars	08	All-round protection.	
Improvements in performance, efficiency and trust. All on track.		powerline – Managing Your Train's Drive System	52
		Everything under control	
Drive Solutions for Multiple-Unit Trains and High-Speed Trains	11	CaPoS – Capacitor Power System for Series 4000	54
Travel at speed. Arrive on time.		Innovation right from the start.	
		CaPoS smart edition – Capacitor Power System for Series 1600, 1800 and 4000	56
Drive Solutions for Mainline and Multipurpose Locomotives	12	Innovation right from the start.	
Reliability in motion.		08 How complete lifecycle solutions help	58
		Ensure a long, reliable life.	
Drive Solutions for Shunting and Industrial Locomotives	15	Why preventive maintenance is essential	60
Versatile power. Reliable operation.		Don't let the unknown leave you unprepared.	
		Factory-certified technicians	62
Drive Solutions for Special Purpose Vehicles	17	Rely on our expertise.	
Individual drive solutions for extraordinary requirements.		ValueCare Agreements	64
		Focus on your operations.	
03 PowerPacks and Engines	19	Leave the rest to us.	
Innovative by tradition	19	Digital Solutions	66
		The future is digital.	
System Expertise and System Integration	20	Remanufactured Products	67
We develop the system to deliver your success.		Exchange and save.	
		09 Service Network	68
All engines at a glance	22	Local support. World wide.	68
04 PowerPacks for railcars	24	10 Overview of our engines	70
The MTU PowerPack	26	Series and emissions qualification.	70
Compact. Complete. Efficient.			
		11 Our engine technology	72
Hybrid PowerPack	28	Key technologies for the reduction	72
Make faster, cleaner progress.			
		12 Certified Quality	74
MTU PowerPacks for Railcars, Underfloor Installation	30	Our quality is something you can measure – and feel.	74
Series 1800			
Series 1600	32		
05 Set new standards	34		
Our engines for railcar trainsets and locomotives.			
Series 4000	36		
On tracks all over the world			
06 Repowering solutions	40		
New heart. New life.	40		
Economic alternatives to new order.	42		



Welcome to the Cutting Edge

PIONEERING THE POWER THAT MATTERS

01

Rolls-Royce provides world-class power solutions and complete life-cycle support under our product and solution brand. Through digitalization and electrification, we strive to develop drive and power generation solutions that are even cleaner and smarter and thus provide answers to the challenges posed by the rapidly growing societal demands for energy and mobility. We deliver and service comprehensive, powerful and reliable systems, based on both gas and diesel engines, as well as electrified hybrid systems. These clean and technologically-advanced solutions serve our customers in the marine and infrastructure sectors worldwide.



A solution provider

Our systems power the largest yachts, the strongest tugboats and the biggest land vehicles and provide energy for the world's most important mission-critical applications. Through advanced solutions such as microgrids, we integrate renewable energies and manage the power needs of our customers.

Our customized service offerings help you maximize uptime and performance and are supported by our digital solutions, which enable remote monitoring, predictive maintenance and a range of other benefits that keep your systems running at their best.

For over 110 years, we have provided innovative power solutions for our customers – meeting even the most demanding drive requirements. Our products and services span a wide range of applications and power needs, with both standard and customized options.

An expert in technology

As part of Rolls-Royce, we have long been known for cutting-edge innovation and technological leadership in product development. That same spirit of innovation inspires our sustainability efforts. Our focus is on developing and implementing system solutions that both maximize efficiency and reduce emissions -- which in turn work to reduce our impact on the environment.

A passionate and reliable partner

We at Rolls-Royce spend every day working together with our customers, to deliver engines, systems and complete life-cycle solutions that best fit your needs. We understand that each

application is different and has its own specific demands. Our engineers embrace the challenge of finding the perfect solution for your unique power requirements. Every step of the way – from project planning, through design, delivery and commissioning; to the lifetime care of your equipment – we are dedicated to helping you get the most from your investment.



1 Technological leader

As a supplier of high-quality, performance propulsion solutions, we stand for the highest level of technological expertise.

2 Passion

We are passionate about fulfilling the needs of its customers with the utmost professionalism and precision.

3 Partnership

We are a reliable and trend-setting partner which acts with foresight in a results-oriented manner.



PowerPacks and Engines

PUTTING PROGRESS ON TRACK.

02

Over the course of their lifetime, trains cover immeasurable distances, carry people and goods, bring support and ensure mobility. They move us and we move them. Our engines and drive systems make rail transportation powerful, reliable and safe.

Back in 1924, standard engines developed and manufactured were already being used in rail transportation and since 1950, we have supplied up to 20,000 engines as drive units and power generation units for railcars all over the world. Time and time again, over hundreds of millions of kilometers of rail, they have proven their absolute reliability, high operational availability and exceptional economic efficiency. They also incorporate the very latest in environmental technology and have the potential to meet future requirements.

These many years of experience, coupled with a unique level of expertise accumulated over decades, form the basis of our innovative strength and acknowledged systems capabilities. Locomotive and railcar manufacturers all over the world rely on us as their industrial partner.

ValueCare Agreements make it easy to optimize lifecycle costs, maximize uptime and devote more time and resources to your core business, with tailored solutions to move your business forward. Our service network is at your disposal all over the world: always and everywhere.

1 State of the art

Rail engines are reliable, powerful and eco-friendly drive units found in many of today's high-speed trains and many other rail vehicles.

2 Looking back

In 1933 our diesel engines powered the legendary "Flying Hamburger" to 160 km/h, a revolutionary speed at that time.



Drive Solutions for Railcars

IMPROVEMENTS IN PERFORMANCE,
EFFICIENCY, AND TRUST. ALL ON TRACK.

Over the course of their lifetime, trains cover immeasurable distances, carry people and goods, bring support and ensure mobility. They move us and we move them. Our engines and drive systems make rail transportation powerful, reliable and safe.

Increasing demand for local public transportation brings with it an ongoing need for modern railcars with the latest drive system technology. We – as the experienced specialist – provide the drive systems to support eco-friendly traffic designs.

The innovative Rail MTU PowerPacks meet all the requirements of this high-performance sector, which demands far more than simply a “powerful engine”. Our extremely compact, complete systems are configured to suit individual customer needs and can then be integrated into the vehicle in a quick and easy process, using Plug&Play.

The high level of reliability of our drive systems ensures that trains can run on time and that operations keep running smoothly – a key factor in economic success. In addition, low operating costs and fuel consumption figures, long maintenance intervals and a maintenance-friendly design all help keep operating costs down and further improve efficiency.



Drive Solutions for Multiple-Unit Trains and High-Speed Trains

TRAVEL AT SPEED. ARRIVE ON TIME.

Multiple-Unit trains require top-level performance over a long period, maximum operational availability and uncompromising economic efficiency. For this reason manufacturers and rail operators have depended on our Series 4000 rail drive systems for many years.

For high-speed trains in particular, which are playing an increasingly major role on national and international routes, the advantages of our engines come into their own. Extremely powerful and proven in continuous service, our drive systems demonstrate an excellent power-to-weight ratio and outstanding operational availability, enabling them to deliver the reliability, punctuality and safety expected from these high-tech trains.

A worldwide service network and on-site facilities at railway depots ensure optimum levels of support and minimum downtime.



Drive Solutions for Mainline and Multipurpose Locomotives

RELIABILITY IN MOTION.

Our drive systems for mainline and multipurpose locomotives operate in a wide variety of conditions and are always custom-made to suit their specific areas of activity.

They are in continuous use, day after day, and prove their reliability on every continent and over thousands of kilometers. They prove their worth in heavy goods operations just as much as at high speeds on long-haul passenger routes.

Long maintenance intervals, maintenance-friendly design and low specific consumption figures all contribute to keeping overall life-cycle-costs low and are thus important factors in the economically efficient running of rail vehicles.

Our worldwide service network and local railroad depots give rail operators the highest possible level of confidence: fast and competent support minimizes unproductive downtime and ensures uninterrupted operational availability of rolling stock.



Drive Solutions for Shunting and Industrial Locomotives

VERSATILE POWER. RELIABLE OPERATION.

Shunting and industrial locomotives are true workhorses. Their specialized area of operation involves frequent load changes in all part-load operations and long periods spent in low-load operations. This gives rise to very specific demands on the drive system, which our engines meet with ease thanks to their excellent part-load performance and acceleration characteristics.

Our robust and powerful engines prove their reliability – one of the key factors in all rail applications – thousands of times every day. And since the smooth running of overall railroad operations depends to a considerable extent on the reliable functioning of shunting and industrial locomotives, our drive systems clearly have an important economic role to play. Long maintenance intervals and low specific fuel consumption figures are further arguments that convince operators of the efficiency of our engines.

And wherever your fleet may be: we are not far away. Our worldwide service network will ensure that rolling stock powered by our engines is always ready to go – and to operate – under even the toughest of conditions.



Drive Solutions for Special Purpose Vehicles

INDIVIDUAL DRIVE SOLUTIONS FOR EXTRAORDINARY REQUIREMENTS.

To keep railroad operations running smoothly at all times, a range of special rail vehicles provides supporting services. For these special-purpose vehicles, we provide custom-made drive solutions.

Low exhaust emissions make our drive systems ideal for use in a range of special-purpose vehicles such as tunnel servicing and maintenance locomotives used for construction or repair work in places like subway systems. A choice of diesel-electric, diesel-mechanical and diesel-hydraulic drive versions is available.

As an industrial specialist, we offer the complete engineering package for every drive solution, from the project concept phase through to installation. Throughout the entire operating life of our engines, our service network and local rail depots will provide professional support: anytime, anywhere.

We also offer diesel-hydrostatic drive systems for construction-work and other special vehicles that operate at extremely low speed. Whichever you choose, all our engines come with the uncompromising levels of reliability, availability and economic-efficiency you need.



1



2

1 Snow plow

2 Grinding train

PowerPacks and Engines

INNOVATIVE BY TRADITION.

03

For over 90 years now, our rail engines and PowerPacks have been setting the standards by which diesel engines are measured in this demanding application.

Their uncompromisingly low downtime helps keep rail operations right on schedule, and their high efficiency plays a key part in keeping them profitable. The very latest emissions technology also makes our rail engines the cleanest power delivery systems in the world. Even so, we continue to press ahead and are developing

innovative solutions that conserve natural resources and meet upcoming emissions regulations. In this way, we remain true to our social responsibility as an engine manufacturer – and as a partner helping secure your success as we move forward.

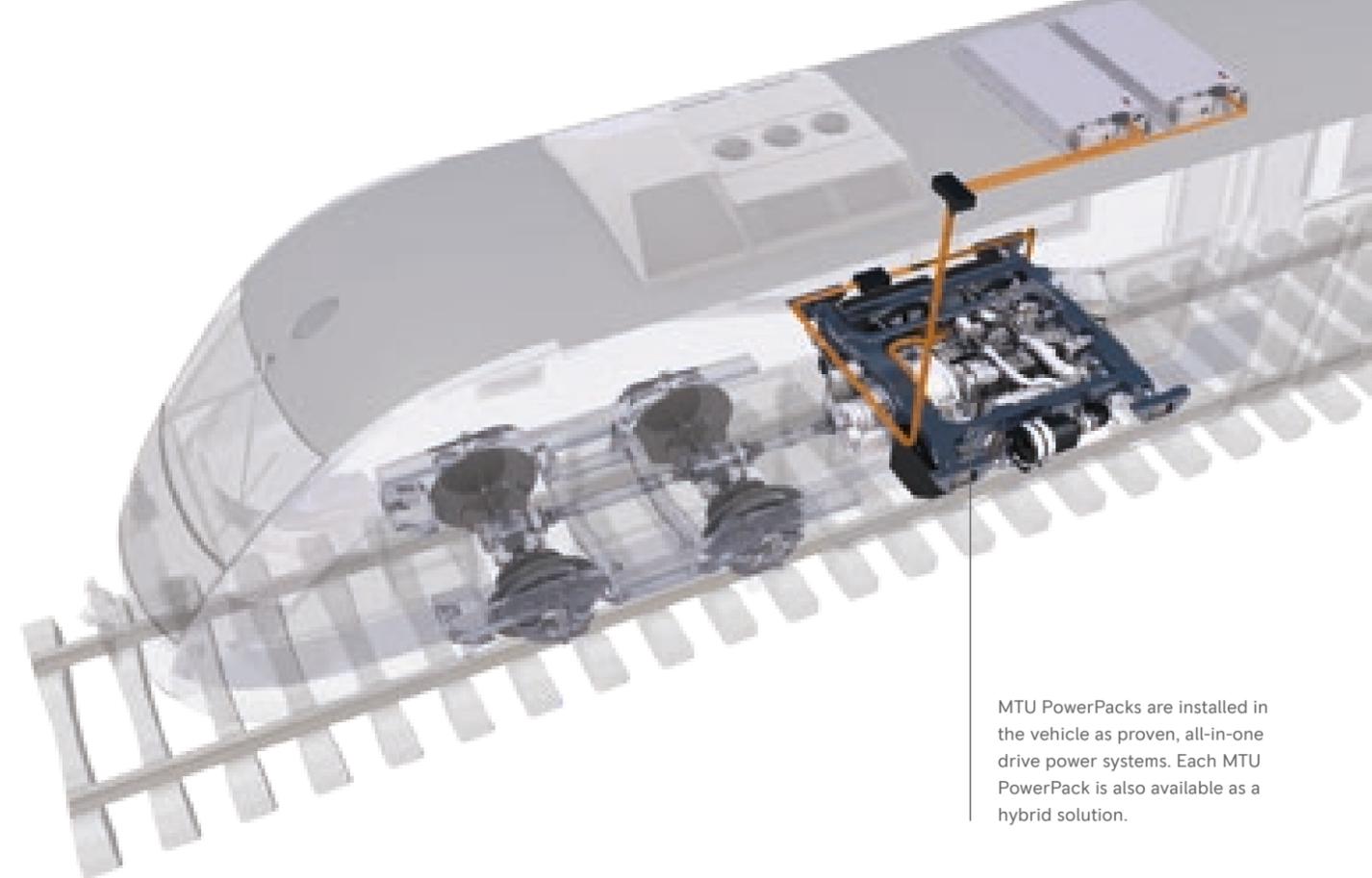
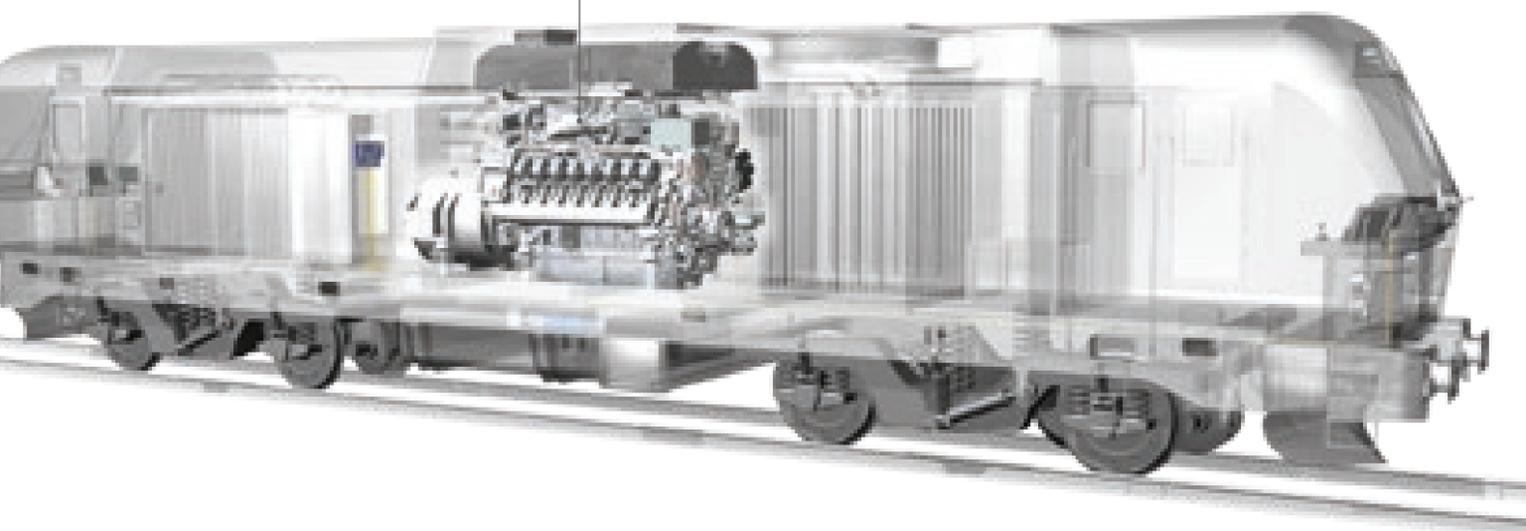


System Expertise and System Integration

WE DEVELOP THE SYSTEM
TO DELIVER YOUR SUCCESS.

A conventional drive system made up of individual components or an PowerPack: As an experienced system supplier we design and deliver individualized complete solutions, tailor-made to suit a specific application, a broad range of needs, and all associated conditions and requirements.

Conventional railroad drive systems
Comprising a series of individual
components. The foundation of
each is our Series 4000 engines. In
each case we design and supply an
individual system solution.



MTU PowerPacks are installed in the vehicle as proven, all-in-one drive power systems. Each MTU PowerPack is also available as a hybrid solution.

At the heart of what we do is always the engine. A choice of underfloor or engine room installation, low weight and compact installation dimensions make our diesel engines the best solution for drive systems in railroad vehicles.

The high flexibility of the system configuration makes the engines suitable for use in diesel-electric, diesel-mechanical or diesel-hydraulic drive units. This means that complete drive systems can be individually fitted.

A wide range of accessories is also available, to suit your requirements and all of these meet the same high quality standards as the engine itself. Such items ensure simple integration at all interface points as well as the functionality of required special features.

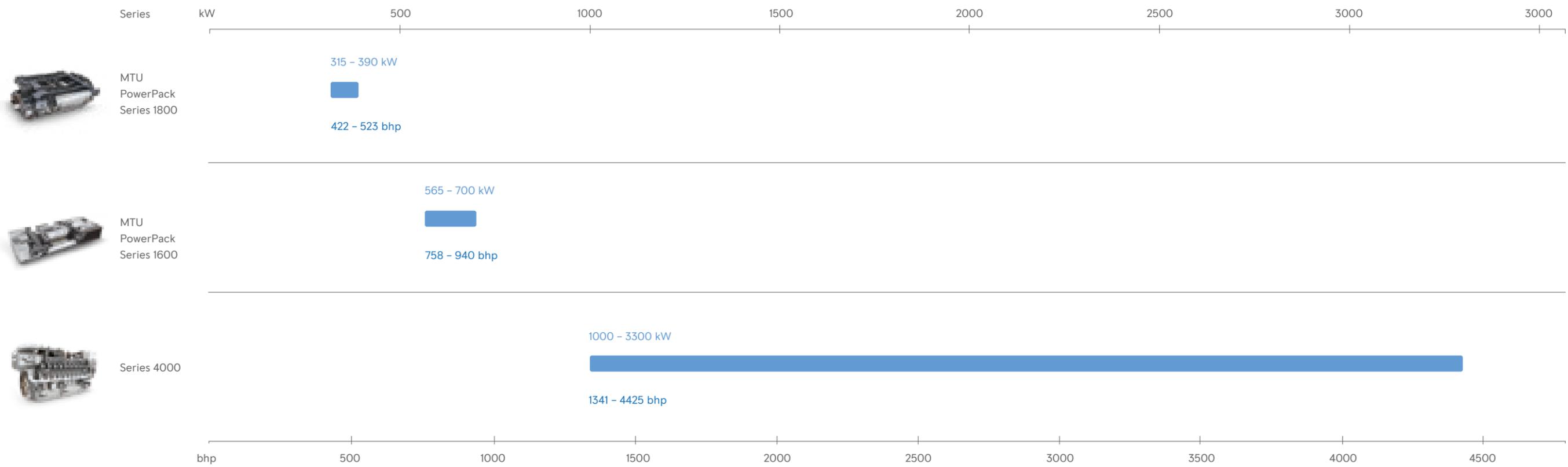
The high standard of our comprehensive engineering expertise is just as convincing. During the design phase of individual drive solutions, our Competence Center Rail, as we call it, will provide you with a level of expertise that is unique, anywhere in the world.

On the basis of our long-standing experience and solid references, we can understand your requirements - no matter how difficult they may be. And no company has been able to consistently offer the complete package of capabilities that is necessary for the development of complete customer-specific solutions from one source.

Take advantage of our expertise.

PowerPacks and Engines

ALL ENGINES AT A GLANCE.



Efficient and powerful:

MTU POWERPACKS
FOR RAILCARS.

04



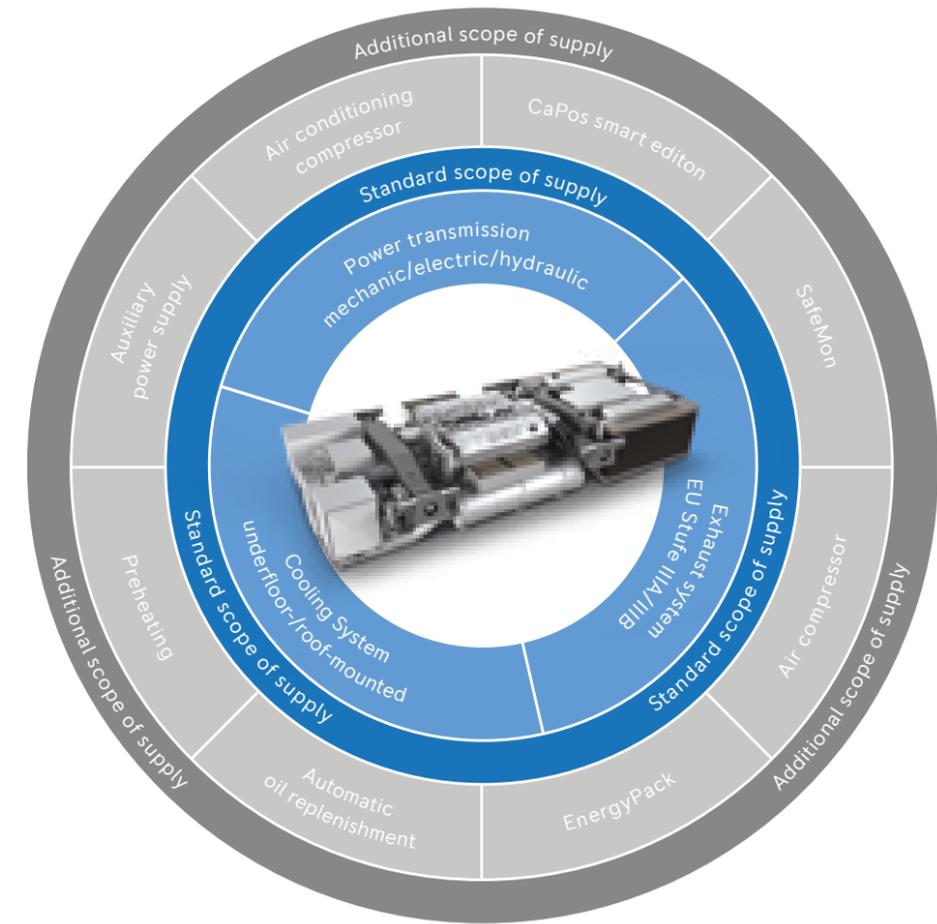
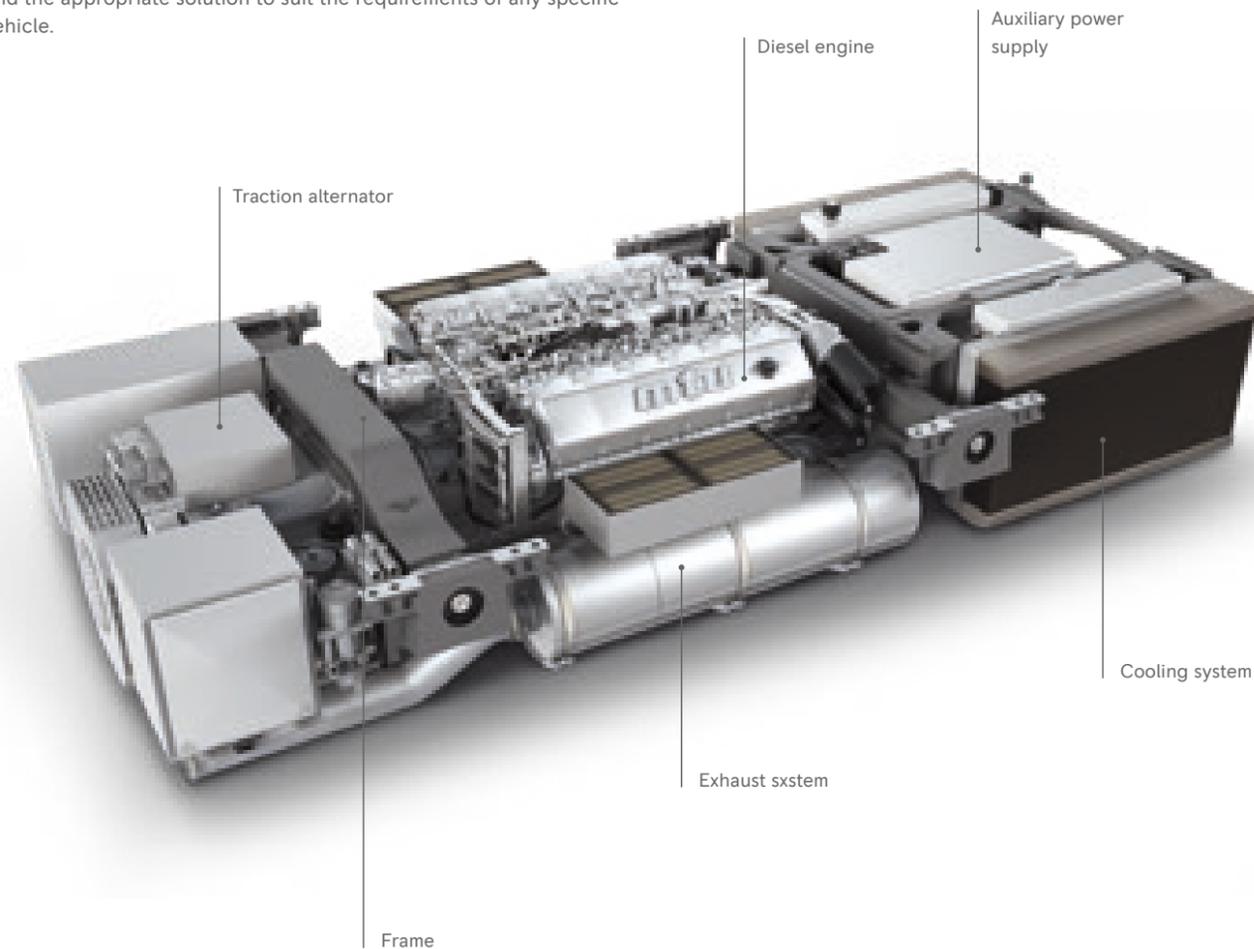
The PowerPack:

COMPACT. COMPLETE. EFFICIENT.

Our PowerPack is an innovative drive system that combines all the individual system elements into a single functional unit mounted on a supporting frame. This system is specially designed for underfloor installation and is characterized by its particularly flat design. We supply all three types of power transfer: diesel-electric, diesel-mechanical and diesel-hydraulic. Every PowerPack can be individually configured.

The MTU PowerPack – the highly compact, highly integrated solution. Representation of a diesel-electric PowerPack 12V 1600 with SCR technology (EU Stage IIIB)

We have developed a series of individualized solutions involving a range of different frames and will use our extensive experience to find the appropriate solution to suit the requirements of any specific vehicle.



- Responsibility for the design and performance of the drive system PowerPack as a whole stays in one place. A single supplier is responsible for all elements of the system – from the project initiation phase through to the final handover inspection.
- Interfaces are reduced to the most extreme system limits of the MTU PowerPack. This means that the complete system has been coordinated and tested well before it is installed in the vehicle.
- The Plug&Play configuration makes installation and removal of the unit quick and easy – also for maintenance purposes. Your trains are sure to run on time.
- The installation of the MTU PowerPack makes standardization possible and reduces complexity. This leads to better cost-effectiveness than through the use of individual components.
- The compact arrangement of the components reduces the total weight of the MTU PowerPack.
- An electronic control system monitors, controls and regulates all functions.

– For test purposes, it is possible to run the full drive system outside of the vehicle – even under load.

– The technology for eco-friendly drive systems:

We take responsibility for technology – also in the interests of protecting the environment: Our PowerPacks meet all current legislative requirements, while we also already have the solutions to enable us to meet the next level of emissions standards. We meet EU Stage IIIA compliant and EU Stage V, with proven technologies, e.g. through an optimized combustion process and SCR technology.

Selective Catalytic Reduction technology (SCR) involves the targeted aftertreatment of the exhaust gas to convert nitrogen oxides (NOx) to harmless, naturally occurring air components.

Further features of the MTU PowerPacks are their low particulate emissions and reduced levels of noise and vibration.

Hybrid PowerPack

MAKE FASTER, CLEANER PROGRESS.

Saving fuel through braking energy recovery

With hybrid drives, braking energy is converted into electrical energy and stored in the battery. This energy can then be reused later as a boost on gradients or to accelerate. As a result, up to 25 percent of the diesel fuel can be saved. Hybrid technology is especially efficient for use on local lines where braking and acceleration in stop-go mode is frequent, and much of the braking energy can be recovered. In this case, the hybrid drive is amortised after just a few years.

Significantly reduced emissions through load point optimization

If during periods of low load factors the diesel engine is operated at a more favorable energetic operating point or switched off entirely, emissions can be reduced substantially: per kilometer, up to 230 grams less CO₂ and up to 0.92 grams less NO_x compared with conventional systems.

Optimizing travel times with the Boost Mode

With a combined diesel and electric drive, the train accelerates even better. When it comes to keeping tightly calculated schedules or catching up on delays, the electric motor provides additional torque. This means that the railcar can travel uphill faster or reach the target speed quicker. For example, the time for a 72-kilometer-long route can be shortened by more than five minutes.

Significant noise reduction

The electric motor can be used as the main drive when rail vehicles need to be operated as quietly as possible: For example, during travel through residential areas and tunnels or while stopped at a railway station. The noise level when stationary can be reduced by up to 21 decibels.

Flexible vehicle deployment and simple retrofitting

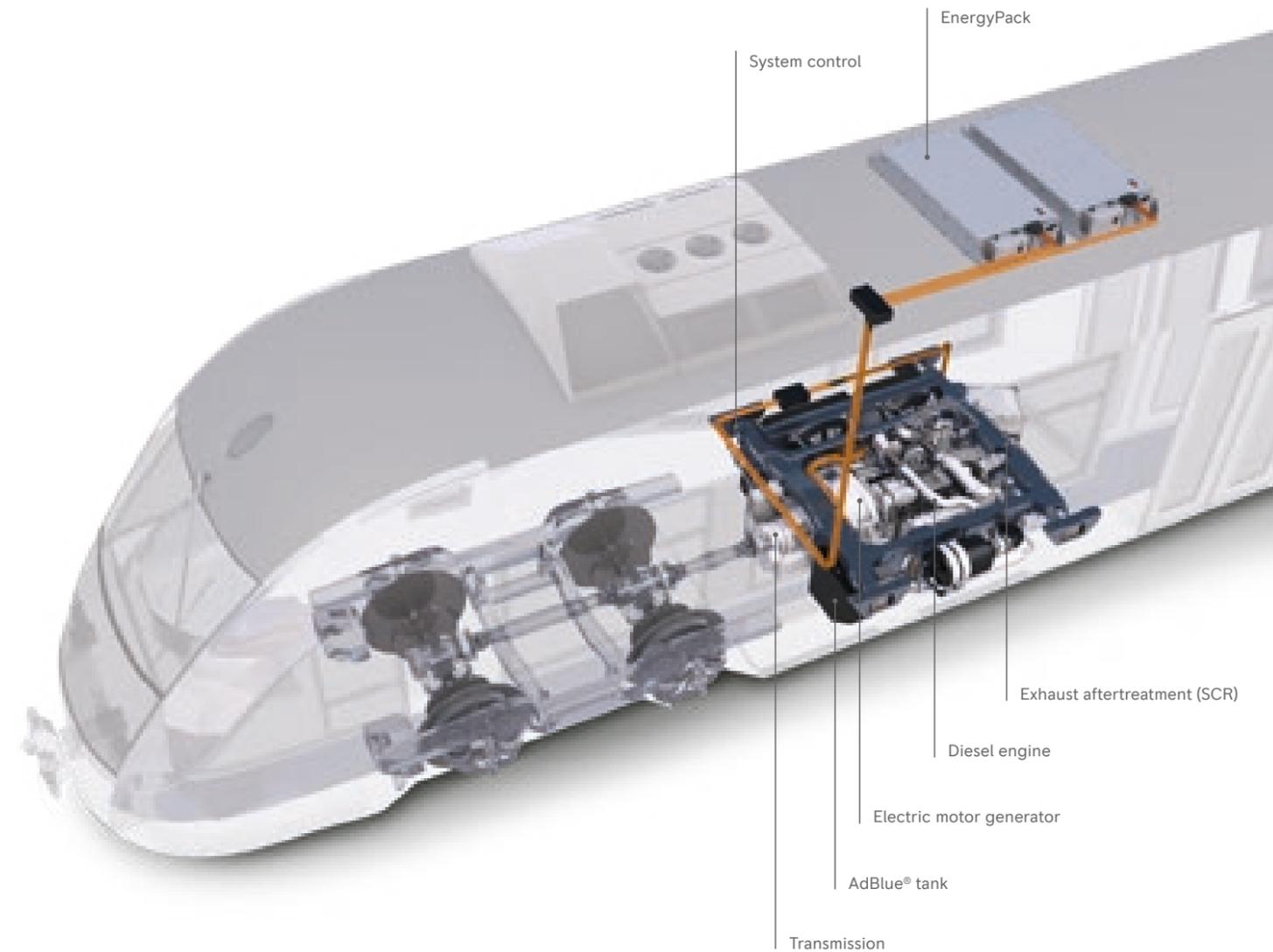
Naturally, rail vehicles with hybrid drive can also be powered exclusively by the diesel engine. This also means great flexibility for the operator: The trains can be deployed on both electrified and non-electrified rail routes. In addition, upgrading to a trimodal* power system – with an additional pantograph – is easy because the system is already equipped with an electric motor. This gives the operator considerable freedom with regard to deployment of the vehicles – it's a big plus when they can respond flexibly in the future to every route requirement or tender invitation.

* diesel + battery + catenary

Marketable technology – tailored solutions

Extensive test runs in a Siemens Desiro Classic Railcar (DB Series 642) have proven the reliability of our Hybrid PowerPack.

The projections of the simulation have also been confirmed. As a result, we can make reliable statements to customers with regard to efficiency as well as the reduction of noise pollution and exhaust emissions, and offer them tailored hybrid solutions that in every case will generate the greatest possible benefits for the application.

**The new generation of PowerPacks**

The Hybrid PowerPack was developed from the successful underfloor drives: Tried and tested MTU PowerPacks were modified and equipped with additional components and functionalities in order to integrate the hybrid technology. Our hybrid concept consists of a modular kit with a variety of drive elements. It satisfies all existing railway standards and can be arranged according to customer specifications.

Thanks to its compact design and the use of power-dense electrical machines, the Hybrid PowerPack can be easily integrated in the existing installation space under the floor, both in new rail vehicles and in repowering of an existing vehicle. Our EnergyPacks – the energy storage – can be positioned at various places in the vehicle: in the roof or in the space under the floor of the railcar. The modular design creates great flexibility for operators who are planning new vehicles or want to convert existing vehicles.

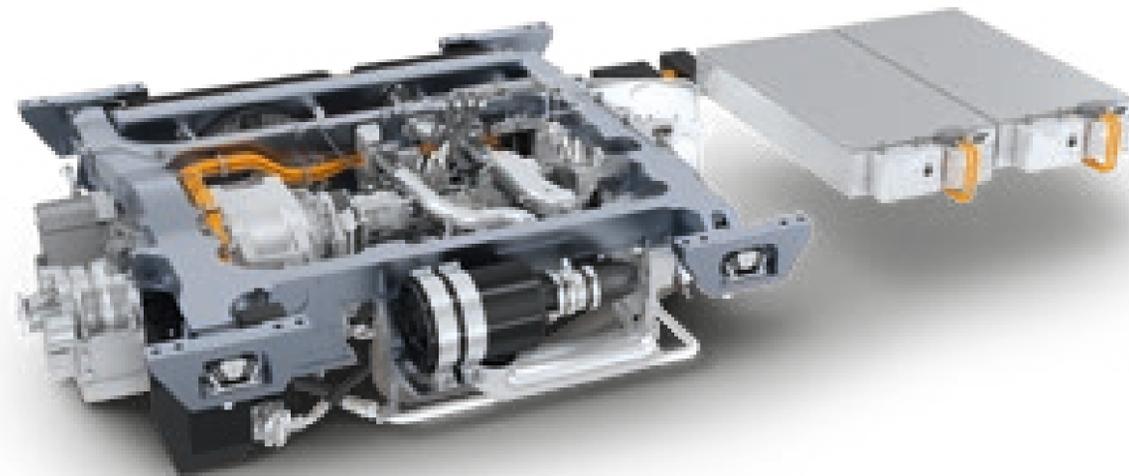
Based on specifications for the vehicle and the profile of the planned routes, we can simulate the lifecycle costs (capital, maintenance and operating costs) of specific projects. This means that a variety of drive options can be defined even before the design stage. Together with the customer, we then determine an optimal needs-based concept.

PowerPacks for Railcars, Underfloor and Roof Installation

SERIES 1800

The benefits to you:

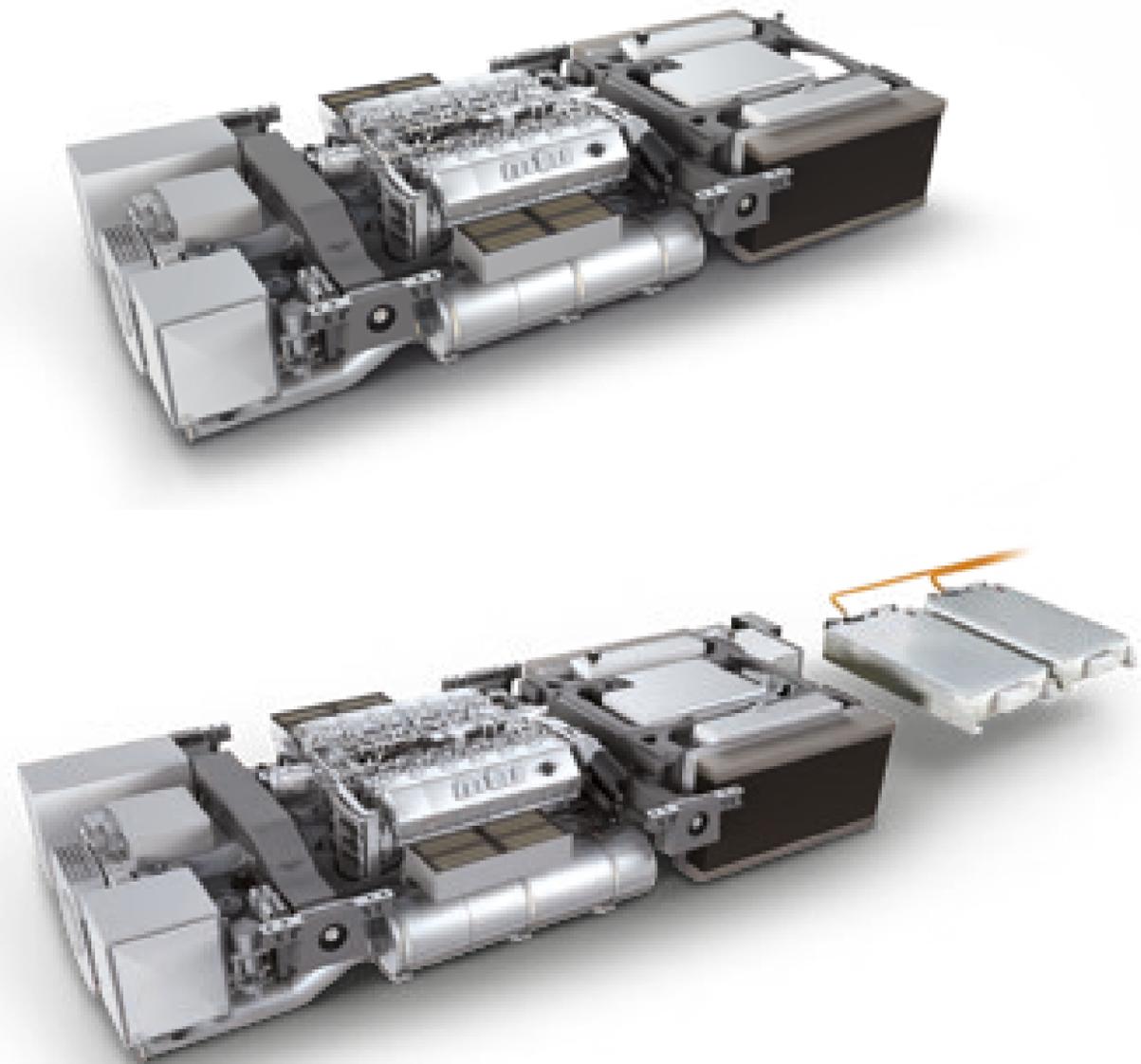
- Constant design improvements with the same footprint (module strategy)
- Can operate with zero emissions on chosen stretches: with the Hybrid PowerPack
- Over 20 years of systems capability
- Ready to repower: extend the life of your investment



Series	1800				
Engine model	6H 1800 R				
Cylinders	6/in-line				
Power output	kW	315	335	360	390
	bhp	422	449	483	523
Drive systems ¹⁾	DM/DH/DE/Hybrid				
Speed	rpm	1800			
Emissions certification	EU Stage IIIA compl./EU Stage IIIB				

1) Drive systems:
DM = diesel-mechanical
DH = diesel-hydraulic
DE = diesel-electric

Battery System	EnergyPack				
Type	151M1P	151M2P	151M3P	151M4P	
Energy Content	kWh	30.6	61.2	91.8	122.4



PowerPacks for Railcars, Underfloor Installation

SERIES 1600

The benefits to you:

- Constant design improvements with the same footprint (module strategy)
- Can operate with zero emissions on chosen stretches: with the Hybrid PowerPack
- Over 20 years of systems capability
- Ready to repower: extend the life of your investment

Series	1600				
Engine model	12V 1600 R				
Cylinders	12V				
Power output	kW	565	625	660	700
	bhp	758	838	885	939
Drive systems ¹⁾	DM/DH/DE/Hybrid	DM/DH/DE/Hybrid	DE/Hybrid	DE/Hybrid	
Speed	rpm	2100	2100	1900	1900
Emissions certification	EU Stage IIIB	EU Stage IIIB	EU Stage IIIB	EU Stage IIIB	

1) Drive systems:
DM = diesel-mechanical
DH = diesel-hydraulic
DE = diesel-electric

Battery System	EnergyPack				
Type	151M1P	151M2P	151M3P	151M4P	
Energy Content	kWh	30.6	61.2	91.8	122.4

Set new Standards:

OUR ENGINES FOR RAILCAR
TRAINSETS AND LOCOMOTIVES.

05



Series 4000

ON TRACKS ALL OVER THE WORLD.

Through Siberian ice deserts. Through sandstorms. In the blistering Australian Outback. Over extreme gradients. Throughout the world, Series 4000 diesel engines drive heavy trains through difficult terrain. In heavy freight train operation as well as at high speeds in passenger train service. Without tiring. The numbers speak for themselves: of the total of 37,000 Series 4000 engines sold since 1996, the rail application accounts for altogether more than 3,000 engines. These alone have already reliably completed 65 million hours of operation for 240 customers in over 70 countries.

For over 20 years, our Series 4000 engines have been the preferred drive systems for modern locomotives. Over hundreds of millions of kilometers, these engines have set the benchmark for what a high-performance rail drive system needs to deliver in this day and age. Absolute reliability. Maximum operational availability. Uncompromising economic efficiency.

Fewer emissions with less fuel consumption and improved overall economy at the same time – oriented to the very real requirements of the rail operation. The Series 4000 embodies our competences in all essential key technologies, reducing emissions and consumption. It manifests our claim of offering you the optimal system solution in each case. And it provides you – just as you would expect from our drive solutions – with much more than just sophisticated and constantly improved technology: all the prerequisites for more success in your application. Now and in the future.

The Series 4000 in overview:

- Cylinder variants 8V, 12V, 16V, 20V
- Lower emissions and consumption thanks to the common rail injection system
- 20 years ago, as the first and only Off-Highway engine manufacturer, we introduced the common rail injection system.
- Now in the fourth generation, the tried and tested and continuously further developed key technology ensures that engines will continue to set the standards in economy and low emissions.
- Optimum charging due to our exhaust gas turbocharger
 - High charge pressures lead to increased power yield and reduced particulate emissions
 - High efficiency for low fuel consumption
- Optimized combustion process
 - Reduction of NOx due to Miller cycle at optimal fuel consumption
- ADEC electronics (engine control system)
 - Robust electronics, perfectly matched to the engines

Advanced technology for environmental friendliness – the new generation: Series 4000 R04

The new Series 4000 engines with our emissions technology represent the next generation of an engine series that has been proven thousands of times over. They fulfill the current emissions legislation EU Stage IIIB as well as US EPA Tier 3 – and are thereby very compact, powerful and extremely economical.

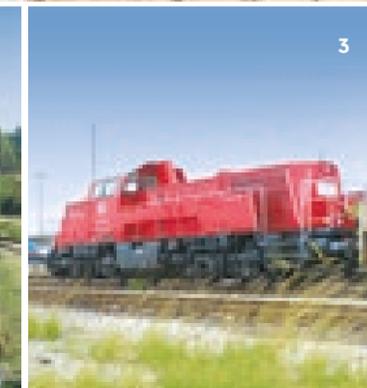
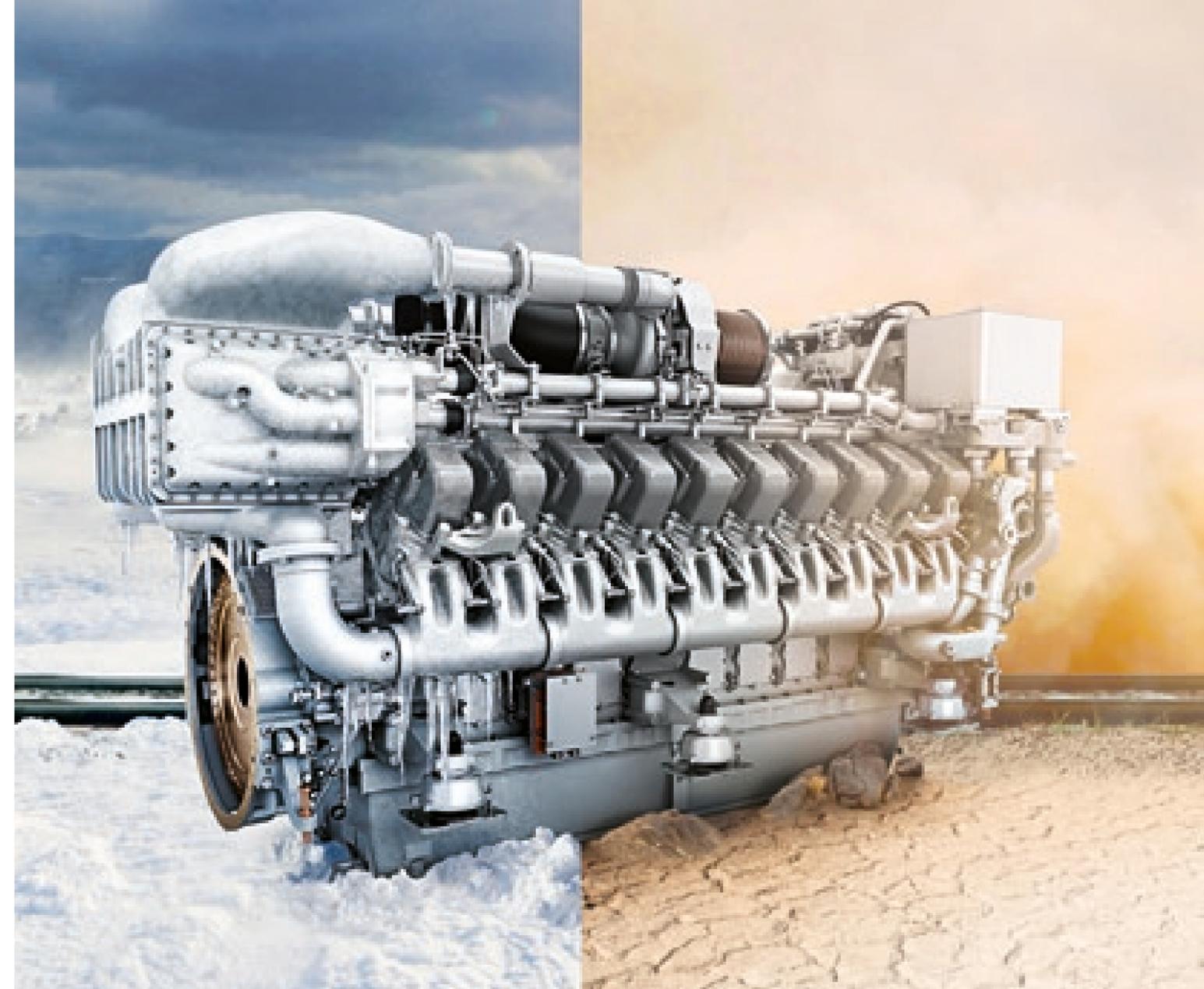
Our innovative emissions technology meeting EU Stage IIIB is based on both in-engine and aftertreatment solutions.

In-engine technologies minimize the generation of pollutants during combustion:

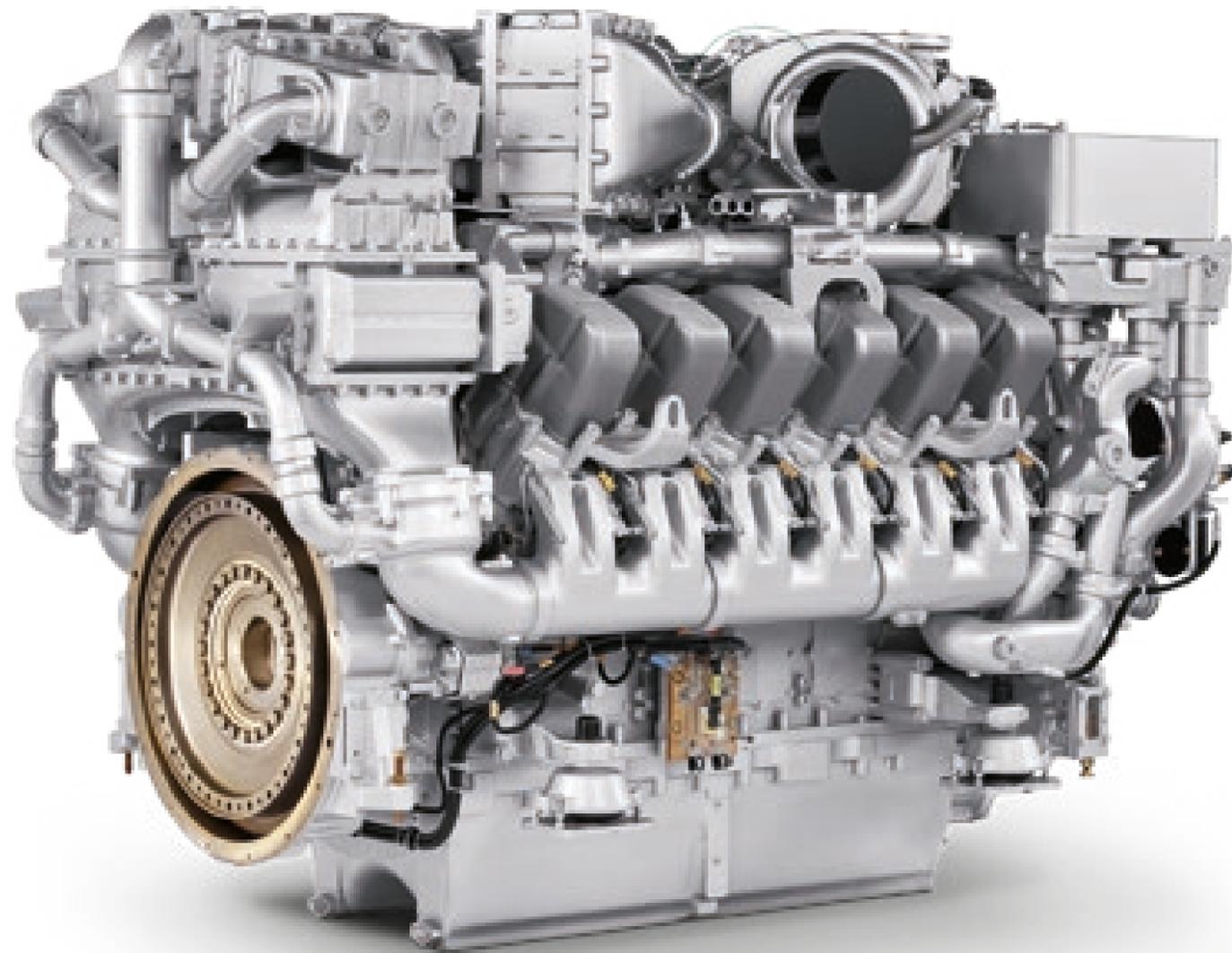
- Cooled exhaust gas recirculation
- LEAD 2 injection system up to 2200 bar
- 2-stage regulated charging, 3 turbochargers, intercooling
- NOx-optimized valve control (Miller cycle)
- New low-NOx, low-soot combustion process
- Max. cylinder pressure 220+10 bar
- Advanced Diesel Engine Control system (ADEC) with emissions regulation

The aftertreatment technology eliminates over 90% of particulate emissions through use of a diesel particle filter with passive regeneration.

Further our key technologies for the reduction of emissions and consumption can be found in the Overview on page 72/73.



- 1 Swiss | 4x 12V 4000 R43L
Schalker Eisenhütte GmbH
- 2 Germany | 400x 8V 4000 R41
DB Cargo
- 3 Germany | 177x 8V und 12V
4000 R43(L)
Voith Gravita
- 4 Thailand | 50x 16V 4000 R41
State Railway Thailand
- 5 South Africa | 232x 20V 4000
R63
CNR Dalian
- 6 Latvia | 28x 16V 4000 R43
2M62 CZ-Loco



Engines for Push-Pull Trains, Shunting Multi-Purpose and Mainline Locomotives, Engine Room Installation

SERIES 4000

The benefits to you:

- Reliable performance - in all conditions
- Clean power - pure profitability
- The preferred drive power system for locomotives and push-pull trains for over 20 years now
- Ready to repower: extend the life of your investment

Series	4000			
Engine model	4000 R43			
Cylinders	8V	12V	16V	20V
Power output kW	1000 - 1200	1500 - 1800	2000 - 2400	2700 - 3000
bhp	1341 - 1609	2012 - 2414	2682 - 3218	3621 - 4023
Speed rpm	1800			
Emissions certification	EU Stage IIIA compliant ¹⁾ /UIC IIIA			

Series	4000	
Engine model	4000 R63	
Cylinders	20V	
Power output kW	2700 - 3300	
bhp	3621 - 4425	
Speed rpm	1800	
Emissions certification	EU Stage IIIA compliant/UIC IIIA	

Series	4000							
Engine model	4000 R64		4000 R74		4000 R84		4000 R54	
Cylinders	12V	16V	16V	12V	16V	12V	16V	
Power output kW	1500	2000	2200	1800	2400	1800	2400	
bhp	2012	2682	2950	2414	3218	2414	3218	
Speed rpm	1800						1800	
Emissions certification	EU Stage IIIB						EPA Tier 3	

¹⁾ EU IIIA type approved. Under special preconditions certification available on request.

Repowering Solutions

NEW HEART.
NEW LIFE.

06



Repowering Solutions

ECONOMIC ALTERNATIVES TO NEW ORDER.

After reconditioning and repowering, tried and tested locomotives and railcars can be a genuinely economical alternative to placing a new order with four positive effects:

- The use of a modern diesel engine reduces operating and maintenance costs, maximizing the economic benefits to the operator.
- All legally stipulated exhaust gas emission standards are met. Noise emissions are also significantly reduced.
- The availability and reliability of the vehicles are brought up to the level of a new vehicle.
- The cost of investment is considerably lower than if a new vehicle was purchased.

Following the conversion, the reduced operating costs bring the following potential savings for the operator:

- Reduction in fuel costs.
- Long maintenance intervals and minimal maintenance costs thanks to new maintenance concept.
- Legal requirements are met with well-proven combustion technology; low fuel and oil consumption lead to low pollutant emissions and thus high regard for the environment.
- Lower investment costs through reducing reserve locomotive stock.
- Limited downtime thanks to high availability and high reliability.

Our expertise as your industrial partner means that we will not only provide the engines to be repowered but will also deliver a comprehensive package of support services:

- Design phase through implementation of the drive system; active support and professional engineering through all stages of the repowering project.
- Supply of the very latest, extensively proven engines and MTU PowerPacks with the compact dimensions that make them simple to mount in the available space, and with an excellent power-to-weight ratio that makes the installation of higher outputs possible without permissible axle loads being exceeded.



1



2



3



4

1 Repowering is an economical alternative for a broad variety of rail applications.

2 We care for a smooth repowering process: with excellent support and quality.

3 Ease of integration thanks to the compact design and small footprint of our engines.

4 Trains repowered with our engines run worldwide – safe and reliable.

Automation and peripheral systems

ONE STEP AHEAD OF THE FUTURE.

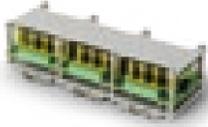
If you want to achieve new goals, you have to break new ground. The development path leading to our automation systems shows clearly how today's innovative drive can become tomorrow's innovative drive solution: they have a modular design, are easy to integrate, and enable the customer to realize the very highest levels of efficiency and available performance. Like a digital brain, they control, regulate and monitor system functions. An an important integral part of our drive systems, and used in connection with our digital products, they deliver the ultimate in efficiency, reliability and environmental compatibility, not to mention all the benefits of simplified vehicle and fleet management.

07



Automation and Peripheral Systems

ALL PRODUCTS AND BENEFITS AT A GLANCE.

Automations system	PowerControl	SafeMon (Safety Monitor)	Powerline	CaPoS (Capacitor Power System)	CaPoS smart edition
					
Scope of supply	<ul style="list-style-type: none"> – PowerPack Automation 	<ul style="list-style-type: none"> – SIL (Safety Integrity Level) certified monitoring unit – Safety- and approval-related documentation 	<ul style="list-style-type: none"> – Motorregler – PAU Engine (Power Automaton Unit) – POM (Power Output Module) 	<ul style="list-style-type: none"> – Ultracap – DC/DC voltage transformer – Connection cable 	<ul style="list-style-type: none"> – Ultracap
Advantages at a glance	<ul style="list-style-type: none"> – Automation for complete system – Powerful and scalable – For new rolling stock and repowering projects – An intelligent system for the entire PowerPack line-up 	<ul style="list-style-type: none"> – Monitors safety-relevant functions and ensures safe operation – Documentation simplifies the approval process 	<ul style="list-style-type: none"> – Special rail automation system – Central interface for complete system – For new-production and repowering projects – Certified for rail applications 	<ul style="list-style-type: none"> – Electrical system voltage 16V DC - 154V DC – CAN interface – Maintenance-free 	<ul style="list-style-type: none"> – Integral charger – Stand alone component – Enclosure rating IP66 – Maintenance-free
MTU PowerPacks for Railcars					
Series 1800	■	■			■
Series 1600	■	■			■
MTU Engines for Railcar Trainsets, Push-Pull Trains and Locomotives					
Series 4000			■	■	■ only available for 8V 4000 engines
Page	48	50	52	54	56

PowerControl Automation

LIKE A DIGITAL NERVOUS SYSTEM THAT DOESN'T MISS A THING.

Visionary, and packed full of benefits: The PowerControl Automation system is innovative high-end technology for rolling stock, i.e. railcars. PowerControl Automation optimizes the control, regulation and monitoring of the entire drive system. The modular system ensures that the drive system can be adapted to the complex operating conditions that occur in railway applications.

PowerControl Automation enables:

- Simple integration with new or - in the case of conversions - existing vehicle control systems
- Flexible adjustment capability to suit the vehicle, its components and project-specific requirements
- Automatic power adjustment or, if required, engine shutdown by the integrated safety system as well as all other required monitoring and safety functions
- The built-in automatic power management system ensures that maximum available drive power is always to hand
- Maximum uptime in the tough operating conditions that confront rail operators, including extremes of heat, cold, airborne dust and water spray

The new PowerPack generation therefore offers you:

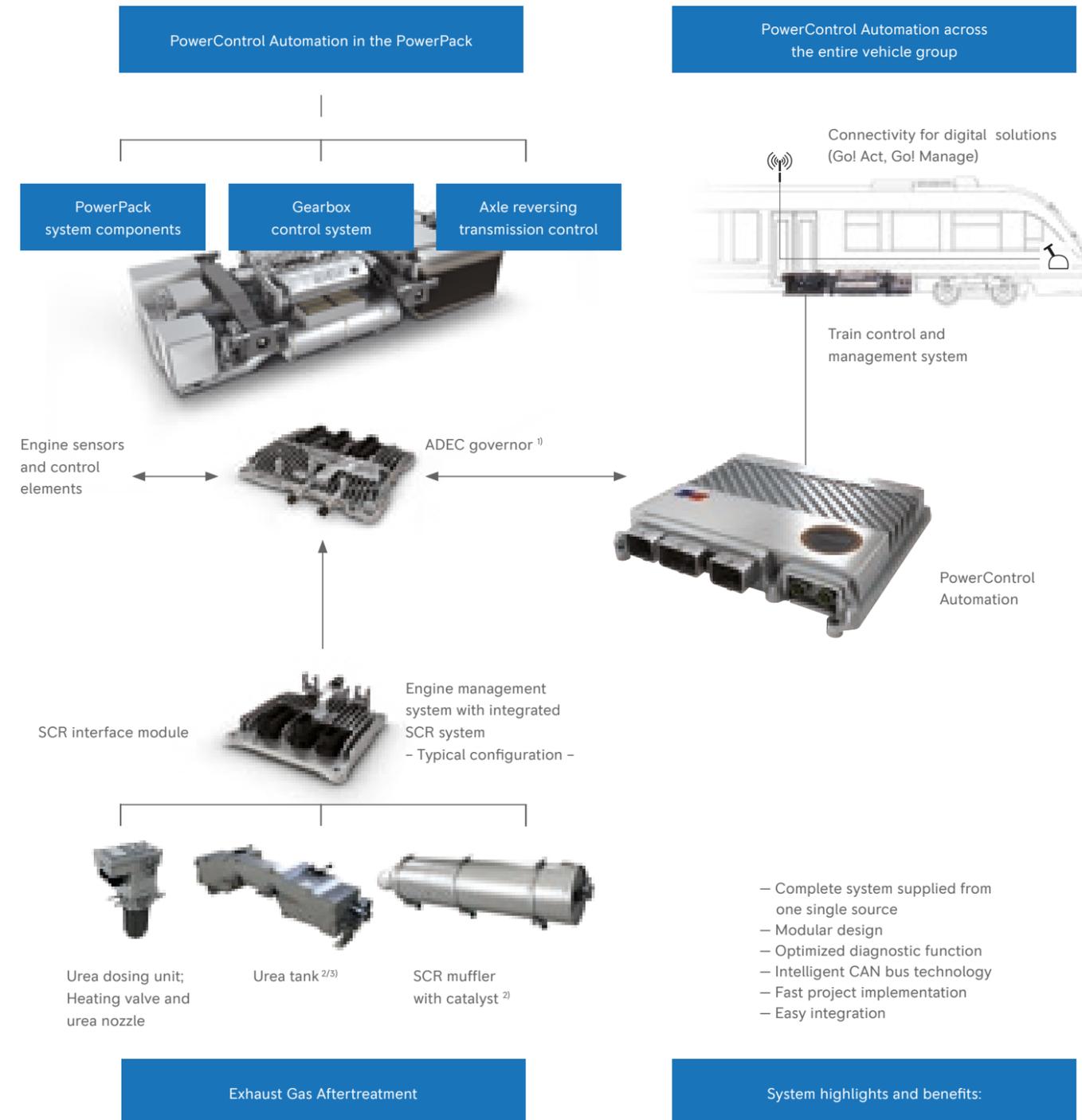
- High power efficiency
- Minimum fuel consumption
- Minimum exhaust emissions that are significantly below statutory requirements (e.g. valid EU Stage IIIA and EU Stage IIIB)
- Flexible, standardized interface solutions

An optimum environment for diagnosis and maintenance:

- Provision of operating and diagnostic data for maximum drive system uptime
- Unlocking the full potential of our systems using our digital solutions MTU Go! Act and MTU Go! Manage, for example via
 - proactive failure prevention
 - fast service support through efficient communication tools
 - intelligent troubleshooting
 - optimized maintenance planning



PowerControl Automation



PowerControl Automation is a modern interface module with a leading-edge design and high connectivity.
Available interfaces to the vehicle control system:

- CAN-Bus interface with CANopen or SAE J1939 protocols
- 10BASE-T / 100BASE-TX Ethernet
- 24V DC binary inputs and outputs
- 0-5V DC / 0-10V DC / 4-20mA analog inputs and outputs

1) Engine mounted 2) PowerPack mounted 3) Vehicle mounted

SafeMon for PowerPacks: the integrated safety center

ALL-ROUND PROTECTION.

For vehicle manufacturers and railway operators, the safety of their passengers has top priority. With the SafeMon (Safety Monitor) we help you to reduce operational risks – and to achieve the set safety objectives even faster and easier.

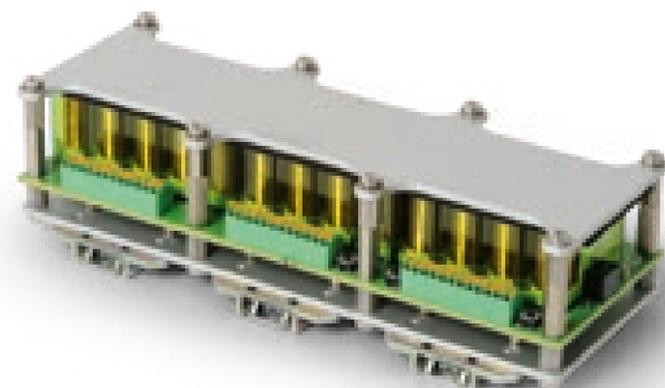
SafeMon consists of a certified monitoring unit for safety-relevant functions as well as the associated safety- and approval-related documentation. The functions that control these signals fulfill the level of safety specified by the operator, rated according to Safety Integrity Level (SIL). This specifies, that in the event of faulty or defective components, safety-relevant procedures, such as braking, coupling or uncoupling, are guaranteed just as before. As a result, consequential damage due to unwanted traction or overspeed is prevented.

We develop the safety technology in-house - and it is therefore perfectly oriented to the MTU PowerPack. SafeMon is integrated directly in the power system via a simple hardware interface, existing vehicles can also be readily upgraded. Manufacturers of rail vehicles receive a complete package that has already been subjected to all hazard- and risk assessments and certified for the safety level that they require; we prepare the corresponding documentation.

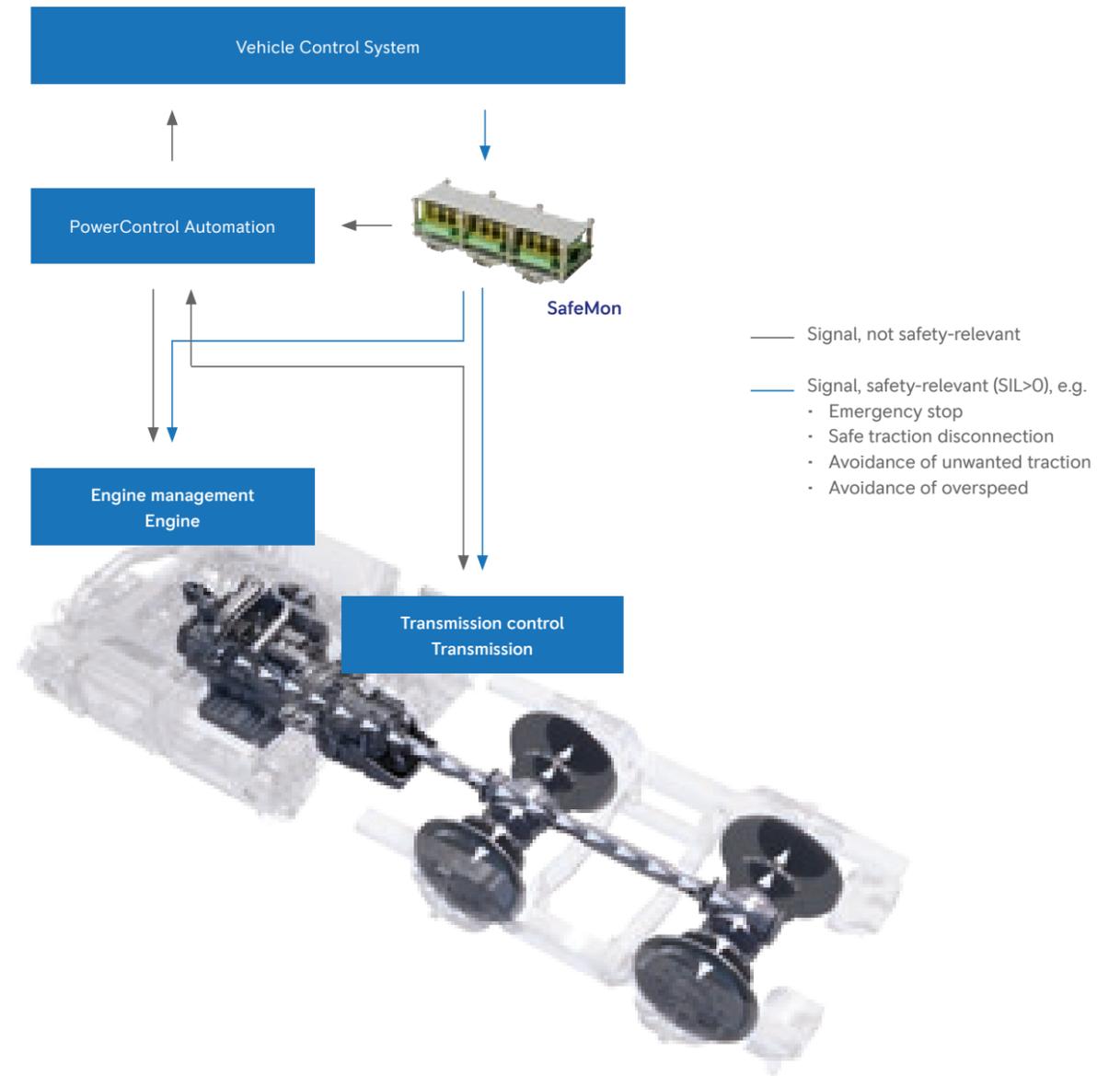
The separate safety certificate can be included directly in the report for the independent assessment body. This considerably simplifies the approval process for the complete vehicle.

With SafeMon you are safely en route at all times:

- Complete safety concept for the entire power train
- Control of all safety functions according to the required safety level
 - completely documented and already examined by external bodies
- Complete power system from a single source, certified according to the European Standard for Proof of Safety (EN 50129)
- We supply the associated documentation and thereby simplifies the approval process



SafeMon - monitoring unit



Implemented safety functions		
SIL 1	SIL 2	SIL 3
<ul style="list-style-type: none"> – Avoidance of unwanted traction – Protection against overspeeds 	<ul style="list-style-type: none"> – Safe shutdown of the PowerPack, if required (Emergency Stop) – Safe uncoupling 	<ul style="list-style-type: none"> – Safe disconnection of the propulsion power (traction)

Optional: Monitoring pressure and temperature for other safety functions

The Safety Integrity Levels have been determined in accordance with the CSM Regulation (Common Safety Methods) and confirmed by independent experts.

powerline – Managing Your Train’s Drive System

EVERYTHING UNDER CONTROL.

powerline – automation system for train drive units – represents a step into a whole new future of technology for rail vehicles. Even with only the basic components ADEC, POM and PAU, the powerline automation system makes the integration of the engine into the locomotive a simple process.

POM, like ADEC, is an electronic module mounted permanently to the engine. Control, regulation and monitoring are all part of the package that we deliver. With the help of optimized interface technology, the engine is quick and easy to install.

powerline for new locomotives or repowering with Series 4000

PAU Engine (Power Automation Unit)

Module for the monitoring, control and system integration of peripheral engine components, with the following features:

- Stand-alone component with (redundant) CAN-open interface to vehicle control system
- Transfer of all engine-related operational data including diagnostics to the vehicle control system
- Additional monitoring and control of peripheral engine systems
 - Coolant level monitoring
 - Fuel pump actuation
 - Air filter monitoring
 - Integrated safety functions
 - Data output for fuel consumption indicator
 - Ethernet diagnosis interface (e.g. service laptop)
 - Fault ring buffer
 - Cooling fan regulation
 - Preheating control

ADEC engine control system

The engine control system ADEC (Advanced Diesel Engine Control) for Series 1600, 4000 R03/R04 is a system that has been developed and produced by us specifically for use with the very latest high-performance diesel engine technology – designed not only for full control of the Common Rail technology in the Series 4000, but above all for the management of frequent extreme loads and sudden load changes, which can be overcome effortlessly and smoothly using this system.

The most important features at a glance:

- Component mounted on and wired into the engine
- Integrated control and monitoring system
- Fuel-optimized output regulation
- Integrated safety and self-test system
 - Data bus interface

POM (Power Output Module) for Series 4000 R03/R04

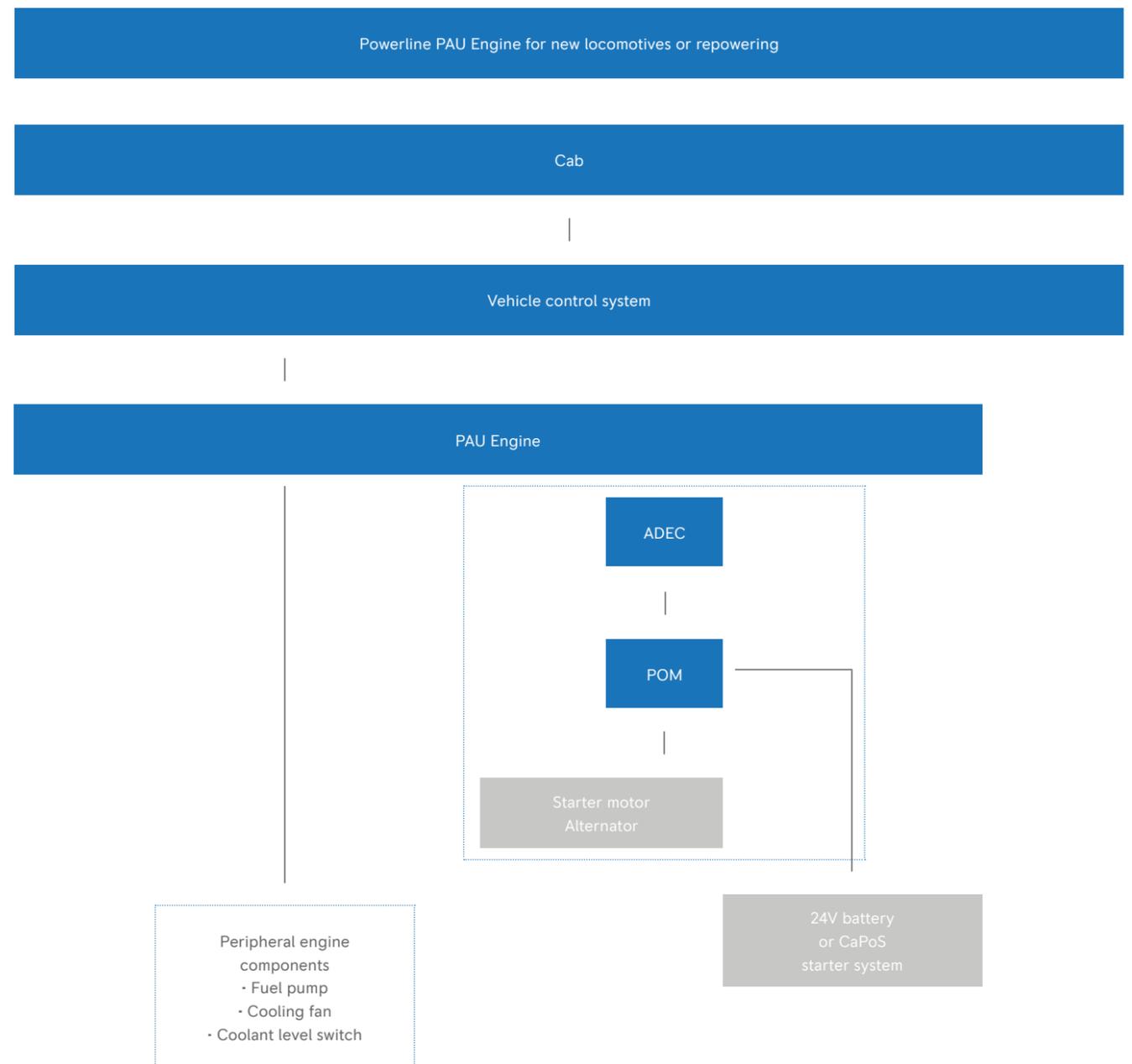
Module with actuating function for the starter motor and alternator, with the following features:

- Component mounted on the engine
- Starter relay and other conventional power routing not required
- Optimization of start-up process; starter motor monitoring with engaging function
- Alternator function monitoring
 - Line break and short circuit monitoring
 - Battery voltage monitoring with start-up intervention plus status indication and error report function
 - ADEC and POM linked via CAN data bus
 - Fully automated start-up control with ADEC



ADEC = Advanced Diesel Engine Control
PAU = Power Automation Unit
POM = Power Output Module

for Series 4000 R03/R04





CaPoS with powerline -
Sample for the 12V 4000

CaPoS – Capacitor Power System for Series 4000

INNOVATION RIGHT FROM THE START.

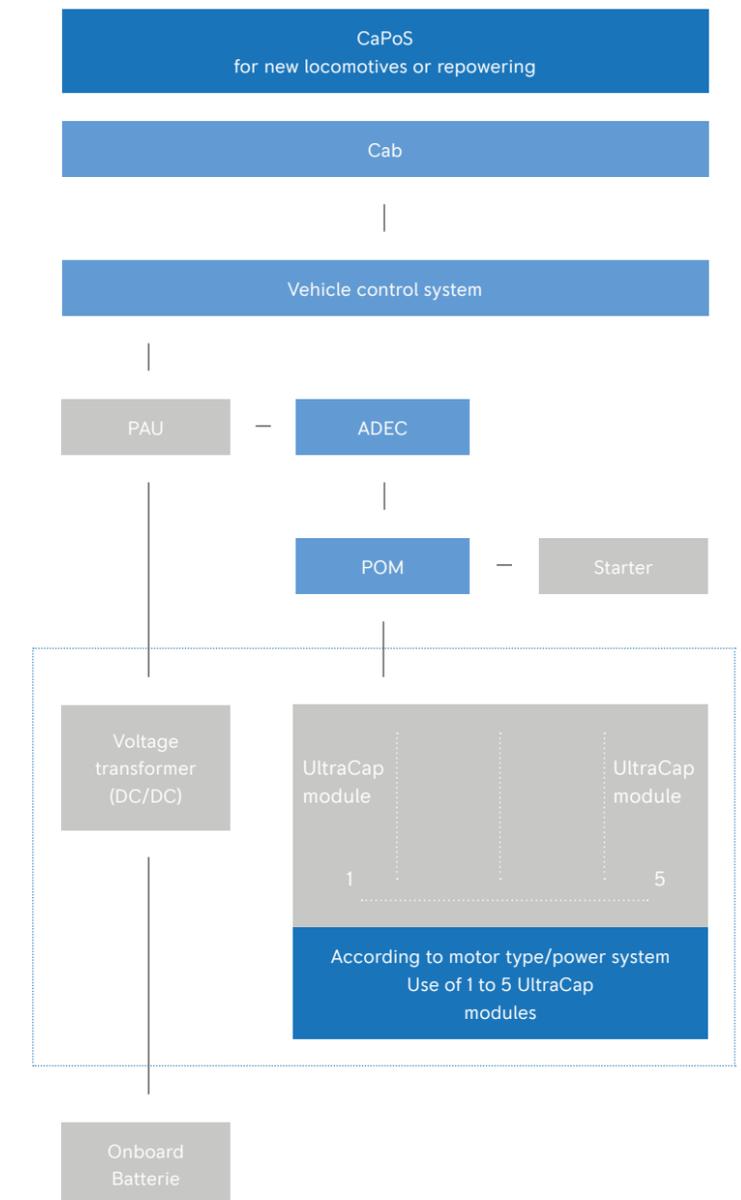
CaPoS is an innovative UltraCap voltage supply system which obviates the need for conventional starter batteries in railroad applications.

CaPoS uses capacitor technology to optimize startup behavior. The number of UltraCap modules used is dependent on the motor type/power system and its breakaway torque. CaPoS may be used autonomously or in conjunction with the powerline automation system.

The most important features at a glance:

- Autonomous and modular construction
- Maintenance-free system
- Significant reductions in weight and volume compared with conventional starter batteries
- Optimized cold-starting properties
- Low life-cycle-costs
- No voltage dip in the onboard network during the start procedure
- Onboard voltage of 16V – 154V possible
- Wired-up complete system
- CAN interface with powerline

for Series 4000 R03/R04





CaPoS with powerline -
Sample for the 12V 4000

CaPoS smart edition – Capacitor Power System for Series 1600, 1800 and 4000

INNOVATION RIGHT FROM THE START.

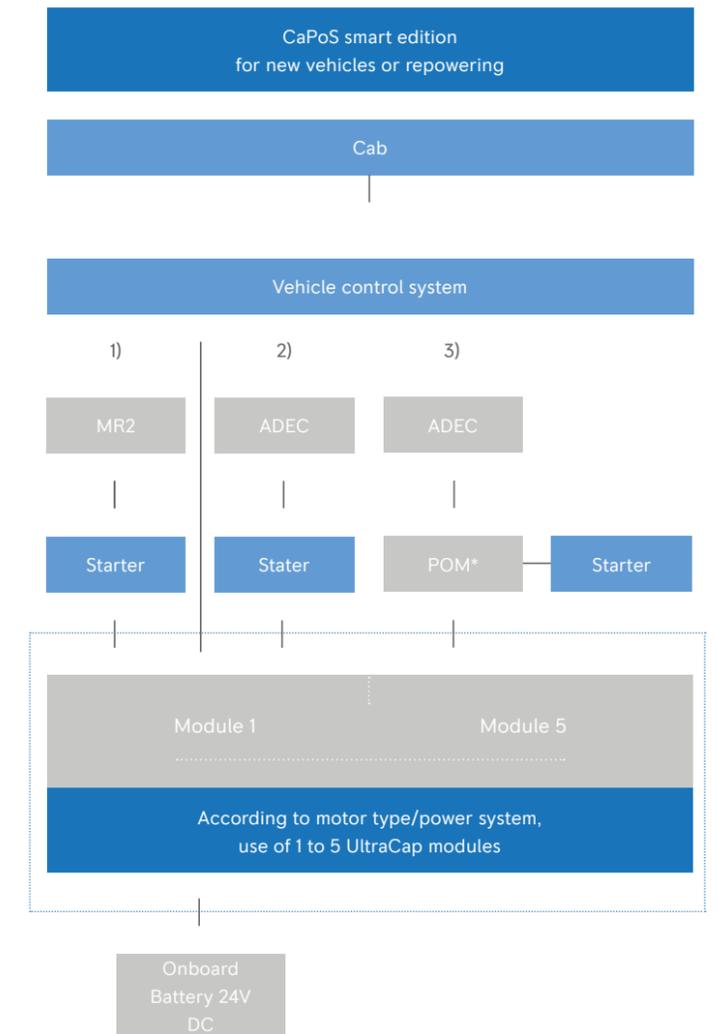
CaPoS smart edition was especially developed for heavy and duty applications and provides the high energy required by the 24V DC starters during the starting sequence.

CaPoS smart edition uses capacitor technology to optimize start-up behavior. The number of modules used is dependent on the motor type/power system and its breakaway torque.

The most important features at a glance:

- Autonomous and modular construction
- Maintenance-free system
- Significant reductions in weight and volume compared with conventional starter batteries
- Optimized cold-starting capabilities
- Low life-cycle-costs
- No voltage dip in the onboard network during the start procedure
- Onboard voltage of 24V DC
- Integrated self-monitoring system with interface to vehicle control system
- Integrated DC-/DC converter for automatical recharging
- IP66 protection

1) for Series 1800
2) for Series 8V 4000
3) for Series 1600, Series 8V 4000
* Optional for Series 1600



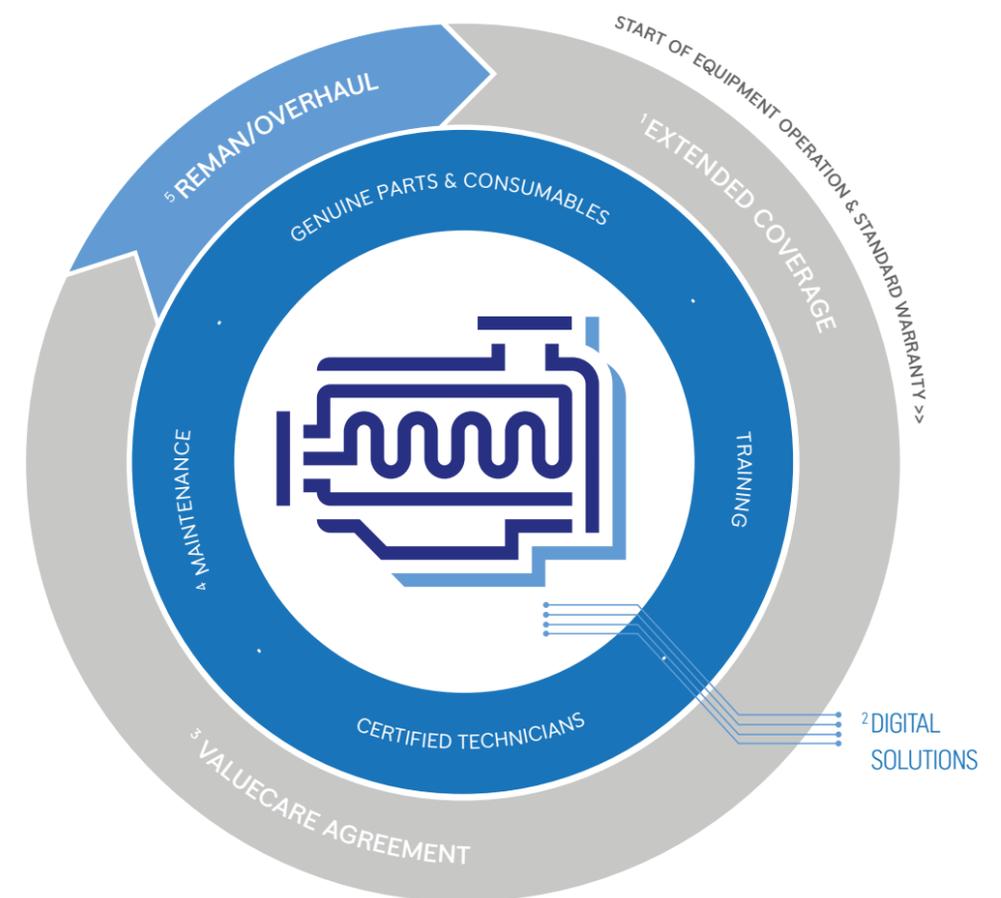


How complete lifecycle solutions help

ENSURE A LONG, RELIABLE LIFE.

08

As your equipment ages, its needs—and yours—change. Our full portfolio of service solutions wrap around your investment, providing 360 degrees of customized support, for optimal value at every stage of life.



- 1 Avoid the unexpected with added protection beyond the standard warranty.
- 2 Make better decisions faster with digitally-enhanced tools.
- 3 Maximize availability and optimize lifecycle costs with a ValueCare Agreement.
- 4 Improve system performance and extend equipment life with on-demand support.
- 5 Keep a good thing going with factory reman/overhaul solutions.

Why preventive maintenance is essential

DON'T LET THE UNKNOWN LEAVE YOU UNPREPARED.

With large investments, lifecycle costs can be significant. It's often the unforeseen costs lurking below the surface—things like fuel consumption, unplanned downtime and repairs—that have the greatest potential to impact your business. That's why it pays to invest in our superior power systems and plan ahead with preventive maintenance. There's no better way to optimize fuel economy, maximize uptime and avoid the unexpected.

Optimize fuel economy.

Fuel consumption accounts for up to 90 percent of total lifecycle costs depending on the application—by far one of the most significant costs associated with your equipment. Well-maintained engines deliver industry-leading fuel efficiency, helping you keep fuel costs down over the long term.

Maximize uptime.

Preventive maintenance services can be planned around your schedule, so your equipment is available when you need it most.

Avoid the unexpected.

Planned maintenance helps solve problems before they start, helping you avoid unexpected downtime and resolve problems early before they escalate.

Work with one source.

We keep maintenance simple, safe and efficient. Our factory-approved methods and expert technicians ensure everything is done correctly according to our proprietary preventive maintenance schedules, optimizing the availability of your equipment, reducing lifecycle costs and helping you avoid unforeseen problems.

The Importance of Preventive Maintenance

When preventive maintenance is a high priority.

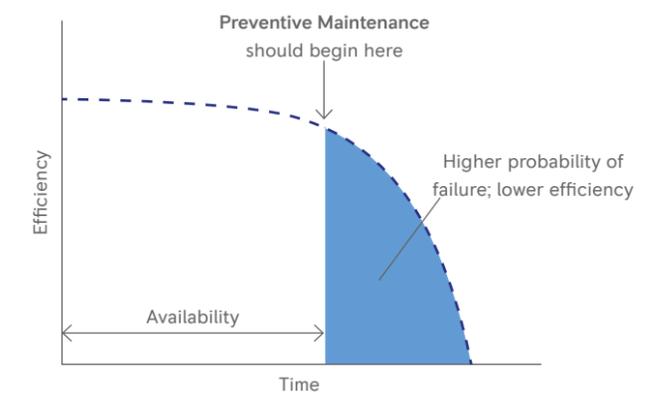


1. Scheduled stops
2. Improved performance
3. Better control over operation

When preventive maintenance is a low priority.



1. Nonscheduled stops
2. Inability to plan
3. Lower performance



We focus on preventive maintenance to reduce the downtime and added costs of corrective maintenance.

Delaying maintenance increases unexpected failures and decreases performance and fuel economy.

Factory-certified technicians

RELY ON OUR EXPERTISE.

To give your equipment a long and productive life, choose a partner you can trust. Only factory-certified technicians know how to get the job done right using proven service methods, factory-specified maintenance schedules and genuine OEM parts.

From preventive maintenance to complete overhaul, we are your true lifecycle partner. Whatever level of support you need, our global network of factory-trained professionals knows all about your equipment and is ready to help you maximize performance and minimize lifecycle costs.

Never compromise.

Our engines and systems are built to last with legendary high standards. When it's time for service, don't settle for anything less. Protect the life of your equipment with professional factory-certified service technicians and genuine OEM parts and consumables—the only options that live up to our standards for craftsmanship, quality and performance. To get the most from your equipment, there are no shortcuts. You can trust for maximum reliability, performance and uptime.

If you need us a little:

On-Demand Support—including professional inspections and preventive maintenance recommendations from us—helps you identify and address problems early, save on repairs or unexpected downtime, and optimize your equipment's performance and longevity. Inspections include visual assessment, test run and leak check, on-site oil and coolant analysis, diagnostic evaluation and reporting.

If you need us a lot:

ValueCare Agreements make it easy to keep your business running smoothly and reduce total cost of ownership by maximizing uptime, optimizing lifecycle costs and helping you avoid equipment-related business disruptions through preventive maintenance. Learn more about ValueCare Agreements on page 26.



ValueCare Agreements

FOCUS ON YOUR OPERATIONS. LEAVE THE REST TO US.

You've got a tough job. With us as your partner, you'll you get the power, performance and peace of mind to get it done right. Our digitally connected power systems, wrapped in ValueCare Agreements, make it easy to keep your business running smoothly and reduce total cost of ownership by maximizing uptime, optimizing lifecycle costs and helping you avoid equipment-related business disruptions through preventive maintenance.

Service solutions designed around your priorities

ValueCare Agreements make it easy to optimize lifecycle costs, maximize uptime and devote more time and resources to your core business, with tailored solutions to move your business forward.

		
<p>Bronze</p> <p>Ensure parts availability and price stability</p> <ul style="list-style-type: none"> - Digital connectivity (Go! Connect) and platform access (Go! Manage) - Automated delivery of parts (preventive) at a predefined rate based on operating hours - Preventive maintenance labor options to fit your business needs - Our dedicated support for technical issues - Quarterly reporting of completed and upcoming maintenance and costs - Annual on-site engine health check by our technician 	<p>Silver</p> <p>Eliminate unexpected maintenance costs</p> <ul style="list-style-type: none"> - Proactive maintenance planning, troubleshooting and remote engine health monitoring - Fixed pricing per operating hour for maintenance and repairs - Key corrective maintenance components always in-stock at our main warehouses - 24/7 standby service with remote technical support - Quarterly reports, including reliability analysis (mean time between failure) <p><i>Silver also includes all benefits of Bronze level</i></p>	<p>Gold</p> <p>Maximize operational uptime</p> <ul style="list-style-type: none"> - Operational uptime commitment to meet or exceed your availability targets - Regular supervision by local service partner (e.g. monitoring of parts stock, improvements) - 24/7 emergency assistance with on-site support - Monthly reports, including availability and average repair times - Asset health monitoring - Annual performance meetings and trend analysis with us to address technical updates, engine fleet data, operational optimization and more <p><i>Gold also includes all benefits of Silver & Bronze levels</i></p>

« Delivering a best-in-class travel experience requires an uncompromising commitment to quality. And that's exactly what we get from MTU—reliable power systems with complete lifecycle support. »

Andy Clarke
Head of Commercial (Engineering), Great Western Railway



ValueCare Agreements help you:



Increase operational uptime



Guarantee parts availability and service quality



Predict equipment-related costs



Optimize maintenance planning



Connect to us, 24/7

Digital Solutions

THE FUTURE IS DIGITAL.

For over 100 years, we've been known for technological innovation and leadership—driving efficiency and reliability to new heights. Today, we're applying that same spirit of innovation to digitalization. Fueled by your system's data—and supplemented with our exclusive expertise, smart analytics and extensive database—digital solutions magnify the power of your investment.

From proactive failure prevention and intelligent troubleshooting to instant failure support and smart maintenance planning, digital solutions unlock the full potential of your system.

 **Go! Act**
1. Service in your pocket

Designed to support on-site operators of our powered equipment, Go! Act:

- Receives push notification of failure codes from connected assets
- Provides crew members with vital information about failure codes
- Supports event reporting with convenient photo capture functionality
- Enables direct communication with fleet managers or the our Customer Assistance Center


 **Go! Manage**
2. Monitor your fleet

Built for fleet managers with our powered equipment, Go! Manage:

- Provides a live overview of fleet, asset and engine conditions
- Displays active and closed alarms
- Enables interaction and communication with on-site staff via Go! Act
- Shows maintenance schedule, with completed tasks clearly marked
- Supports remote troubleshooting via multigraph



Remanufactured Products

EXCHANGE AND SAVE.

Factory remanufactured products deliver the same high standards of performance, service life and quality as new products, along with identical warranty coverage – at a fraction of the cost. And with design and model-related updates, they also feature similar technological advancements. Developed by R&D engineers, the remanufacturing process saves you time and money, while benefiting the environment through the reuse of materials. To help you work efficiently, a wide range of remanufactured parts, engines and systems are available worldwide.

Reduce lifecycle costs.

As you evaluate your long-term power needs, you must consider a variety of factors. Factory remanufactured products are a smart solution, helping you reduce the total lifecycle cost of your equipment.

Save time.

Factory remanufactured products put your equipment back to work faster than an overhaul, which reduces downtime, service time and indirect costs such as storage.

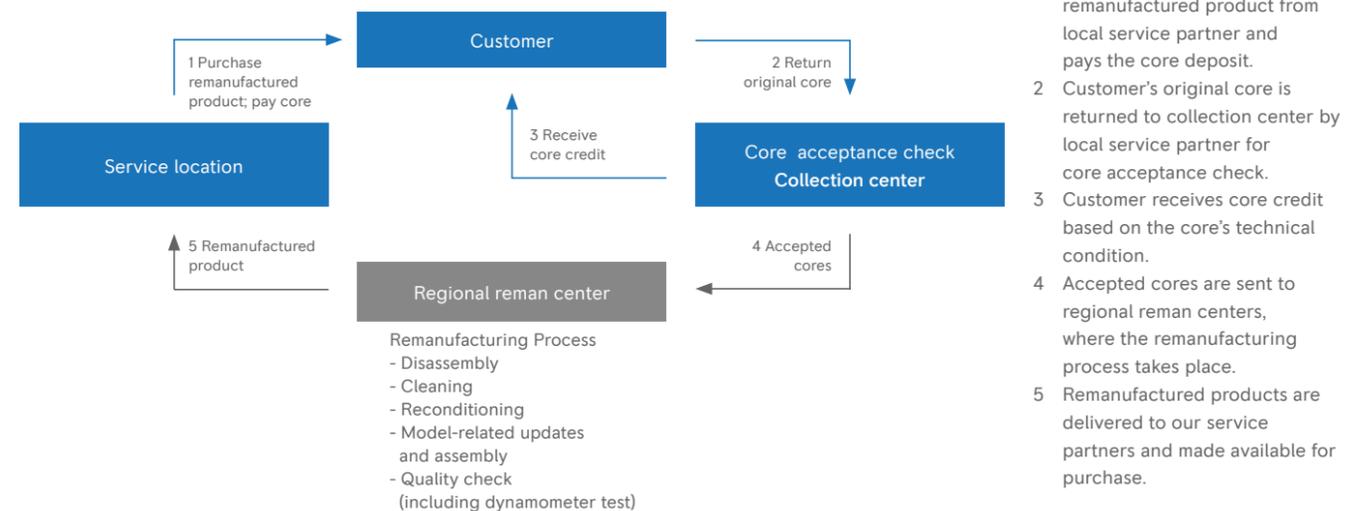
Our maintain standards.

All products are remanufactured to strict to our standards by certified technicians at our regional reman centers can remanufacture our parts, engines or systems to original factory specifications.

Protect the environment.

Since remanufacturing is an efficient use of resources and energy, factory remanufactured products benefit the environment as well.

Exchange Process



Service Network

LOCAL SUPPORT. WORLDWIDE.

09

Whenever and wherever you need expert support, our specialists are available. Our global service network of more than 1,200 locations – backed by our cutting-edge Parts Logistics Centers – provides you this assurance. To find your local distributor, visit www.mtu-solutions.com.

Local support. Worldwide.

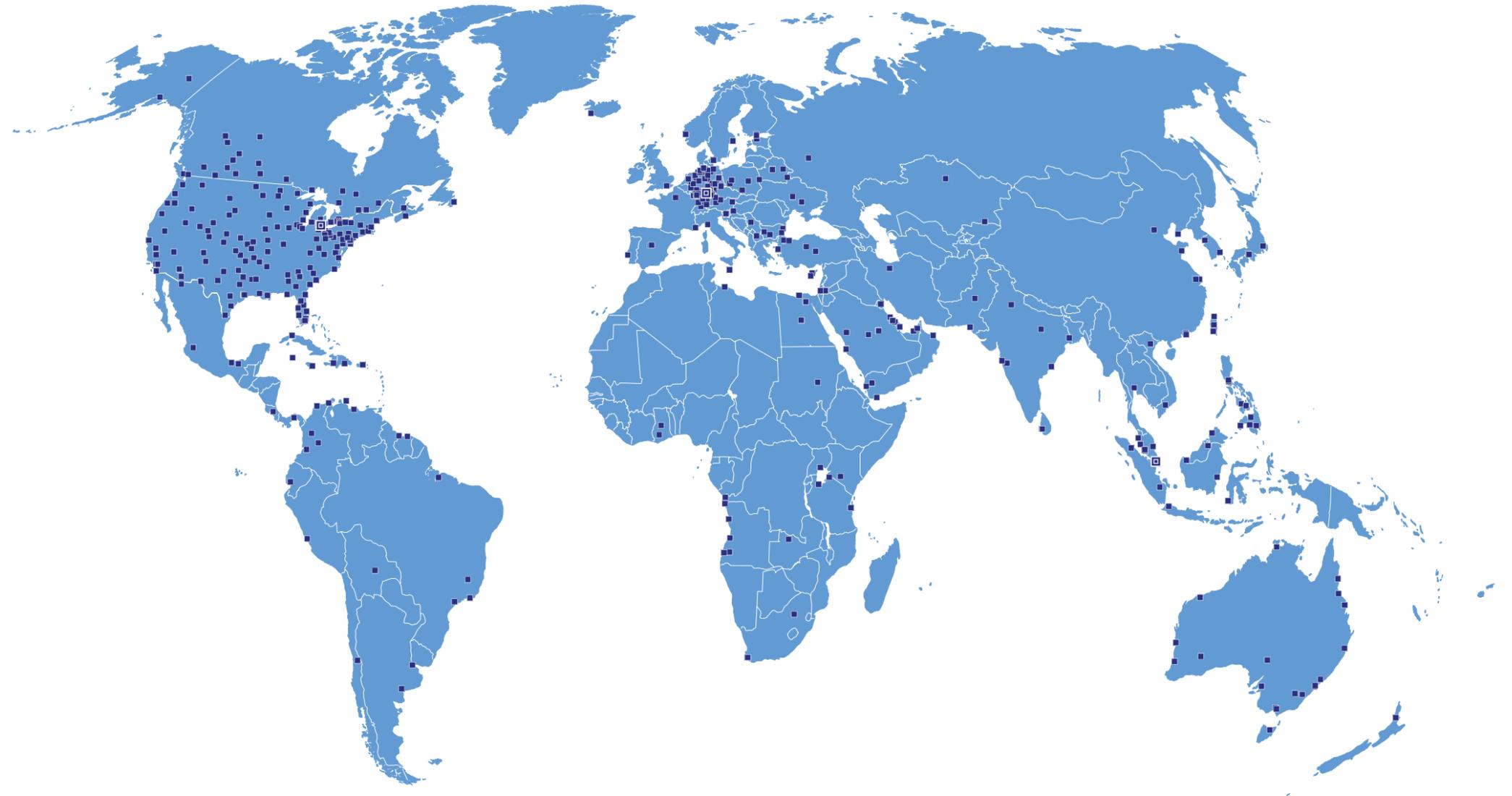
We ensure that you receive individualized support from our global network of more than 1,200 service centers—anywhere, anytime. Local support. Worldwide. We ensure that you receive individualized support from our global network of more than 1,200 service centers – anywhere, anytime.

Always on call, 24/7

Whether it's connecting you with a local service partner or assigning an urgent problem to a dedicated team of our experts, we're ready to assist you—wherever you are, whatever you need.

Europe, Middle East, Africa +49 7541 90-77777
Asia/Pacific +65 6860 9669
North and Latin America +1 248 560 8888

info@ps.rolls-royce.com



SERIES AND EMISSIONS QUALIFICATION.

	PowerControl	UIC IIIA	EU Stage IIIA compliant	EU Stage IIIB certified	US EPA Tier 3
	MTU PowerPacks for Railcars				
Series 1800 	Series 1800		■	■	■
Series 1600 	Series 1600			■	
	Engines for Railcar Trainsets, Push-Pull Trains and Locomotives				
Series 4000 	Series 4000				
	8V/12V/16V/20V 4000 R43 ¹⁾	■	■		
	20V 4000 R63	■	■		
	12V/16V 4000 R54				■
	12V/16V 4000 R64/74/84			■	

1) EU IIIA type approved. Under special preconditions certification available on request.

Our engine technology

KEY TECHNOLOGIES FOR THE REDUCTION OF EMISSION AND CONSUMPTION.

Perfectly tuned key technologies enable us to comply with current and future emissions standards and reduce fuel consumption at the same time. As a systems supplier, we also ensure that all system components interact perfectly for smooth operation.

Engine model	Exhaust Gas Aftertreatment		
	1 SCR	2 DPF	3 DOC
Railcar			
Series 1800	■		
Series 1600	■		
Locomotive			
Series 4000		■	■

Internal Emission Technology		
4 EGR	5 Two-Stage Turbocharging	6 Advanced CR Fuel Injection
		■
■	■	■



1 Selective Catalytic Reduction (SCR)

The SCR system can remove as much as 90 percent of nitrates from exhaust gas. In SCR development, we have primarily focused on low fuel consumption and a low space requirement for SCR components.



2 Diesel Particulate Filter (DPF)/



3 Diesel Oxidation Catalyst (DOC)

Our Diesel Particulate Filters and Diesel Oxidation Catalysts are capable of lowering soot emissions to levels that in some cases are well below the statutory limits. Statutory limits form part of the emissions concept.



4 Exhaust Gas Recirculation (EGR)

Exhaust Gas Recirculation can reduce nitrogen oxide generation within the cylinder by 40 percent and more. We have designed a solution for compact integration of all EGR components so that virtually no additional space is required. This enables customers to upgrade their rail vehicles for compliance with the new emissions standards at no great expenditure.



5 Two-Stage Turbocharging

Turbocharging enables our engines to achieve low fuel consumption and high power output across a wide speed range. Turbochargers are finely adjusted to suit the demands on the engine in terms of cost-effectiveness, performance, dynamic response and service life. Space-saving integration of turbochargers into the engine brings the customer the added benefits of compact design.



6 Enhanced common rail injection

We have been using common rail systems successfully for over 20 years now. Our systems capability means we're able to exploit potential during the combustion process to help make engines especially clean and economical.



Certified Quality

OUR QUALITY IS SOMETHING YOU CAN MEASURE – AND FEEL.

12

We have set the standard by successfully retaining our ISO 9001 certification for many years now, and have so proven time and time over how our capabilities can benefit our customers.

Yet what we have already achieved is not enough for us – it is just a basis and gives us the momentum for our further development and continuous improvement.

Other credentials – UIC-certification of Series 4000 engines, the environmental management certificate ISO 14001, and “Q1 supplier” classification by Deutsche Bahn – speak for themselves and for the high level of quality and customer satisfaction that we offer.



1 Leading in quality and certification
Certification awarded by further renowned certification bodies demonstrates clearly the uncompromising way in which we apply our quality philosophy across all products and processes.

