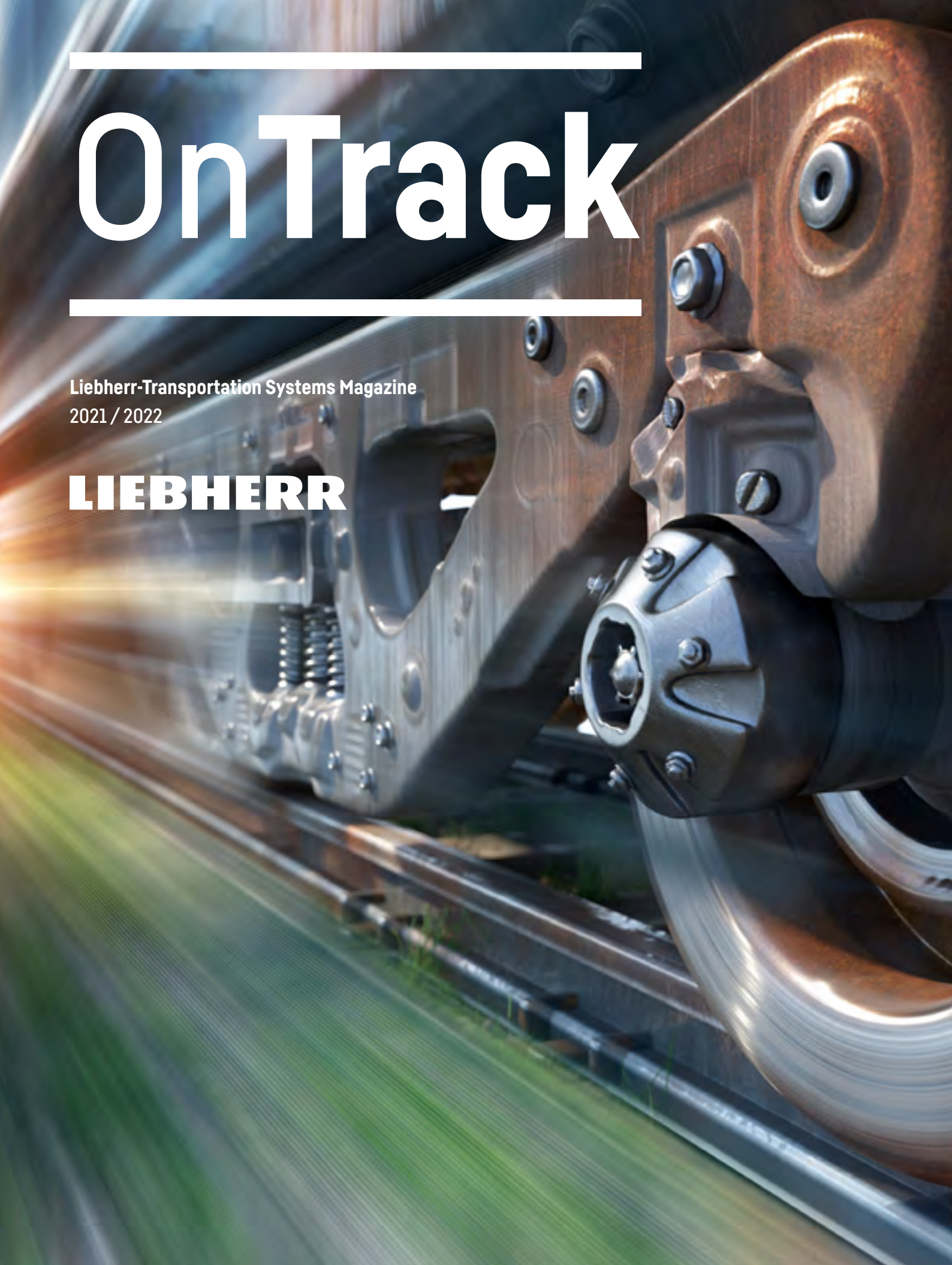
OnTrack

Liebherr-Transportation Systems Magazine
2021 / 2022

LIEBHERR



Nicolas Bonleux, Francis Carla, Alex Vlielander, Martin Wandel, François Lehmann (from left to right)

Dear Reader,

As our world progressively emerges from the pandemic, our rail transportation and aerospace industries are showing signs of recovery. While the pace of the recovery will be quite diverse depending on our planet's many countries and regions, all the signs indicate that the fundamentals of both industries are quite solid over the long term, provided we are collectively able to address the challenges we are faced with: health protection, environmental sustainability, uncompromised quality, and cost-efficiency.

We are optimistic that our company is on the right track to bring its contribution to the coming growth.

With the remarkable engagement of our team worldwide, we have been able to protect the health and safety of our employees as much as possible, while also being able to continue supporting our customers and partners throughout the past months. In order to weather the turbulences, we had to revise our plans; we are now planning the gradual return to pre-pandemic mode. We pay particular attention to our global supply chain that we support so that it is in a position to sustain the upcoming growth.

In addition, this crisis offers the opportunity to make a significant contribution to a more viable world, more sustainable rail transport, and more sustainable aviation, in particular by accelerating the deployment of highly efficient, drastically lower CO_2 emissions models and technologies.

We have always been focused on long-term success and we will continue to be a major system supplier, contributing to the future of the transportation and the aerospace industries with our technologies, our operations, and our team worldwide. The company has shown much resilience in countering this exceptional crisis, while at the same time shaping a robust future.

We wish our customers all the very best, and would like to thank our employees and our business partners for this joint achievement.

We trust you will enjoy reading this magazine, which features numerous exciting examples of the many successes we have achieved over the last months. It also provides a unique overview of the potential of our technologies.

Best regards,

Nicolas Bonleux
Chief Commercial Officer

Francis Carla
Chief Technology Officer

François Lehmann
Chief Financial Officer

Alex Vlielander
Chief Services Officer

Martin Wandel
Chief Operating Officer

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Dear Reader,
Since this magazine is reversible,
please flip it over in order to read In**Flight**,
the Liebherr-Aerospace magazine.

Also online:
On**Track** is also available at liebherr.com
for reading, viewing and downloading.

Programs & Contracts

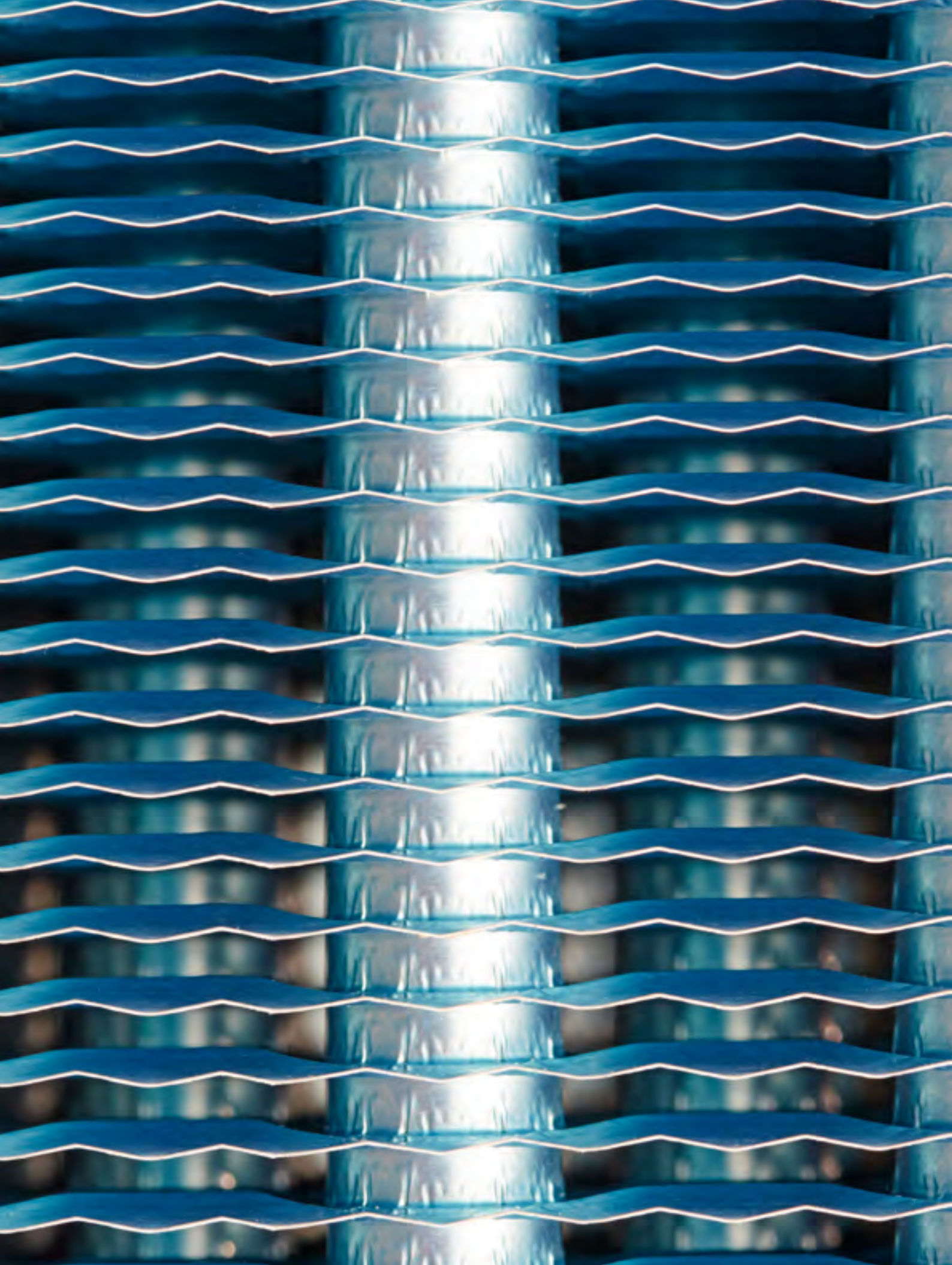
Customer Service

The World with Liebherr

Impressions

Air cooling in detail

Heat exchangers are an integral part of the efficient air-conditioning systems that Liebherr manufactures for rail vehicles. To increase their performance, the fins of the heat exchangers are ribbed and given a special coating. The task of the fins is to ensure that, as it passes through, the hot air cools down on contact with the cold air streams but does not mix with them under any circumstances.



Small but mighty

Modern air-conditioning systems consist of a large number of components. Right from the development phase, the engineers at Liebherr-Transportation Systems in Korneuburg (Austria) make sure that the individual components are robust and efficient. After all, air-conditioning systems for rail vehicles are usually designed for a service life of over 35 years! In order to meet these requirements, Liebherr uses, among others, high-performance alloys for the refrigerant piping, and applies modern brazing processes.

Comfortable in curves

A hydraulic steering damper is filled with hydraulic oil and vented through this opened connection. The hydraulic dampers developed and manufactured by Liebherr are installed in trams instead of a conventional rigid steering rod. There they serve as a link between the individual cars. They not only improve the driving behavior of the trams, but also reduce the high forces that act on the car body structure.

Industry Information

Testing of a temperature controller

100% green technology

Originally, Liebherr's air cycle technology was developed for the aerospace industry. It has been used for decades to air-condition aircraft. However, the advantages over traditional vapor cycle systems are so great that Liebherr was one of the very first companies to begin employing this technology in rail vehicle equipment. Because at the end of the day, both industries share the same objectives: efficiency and passenger comfort.

Already in 2002, Liebherr-Transportation Systems fitted an ICE 3 train from German operator Deutsche Bahn AG (DB) with air cycle air-conditioning systems for test runs. Additional fittings for the first model series and 13 eight-car trains of the second model series of the ICE 3 soon followed. In 2018, DB and Liebherr-Transportation Systems presented the results of a joint project comparing Liebherr's air cycle air-conditioning system with a traditional vapor cycle system operating with the refrigerant R134a. The UBA, Germany's Federal Environmental Agency based in Dessau-Rosslau, supported the project because of its environmental advantages compared with traditional vapor cycle systems with fluorinated refrigerants. The air cycle system uses only natural ambient air for cooling. No refrigerant is needed.

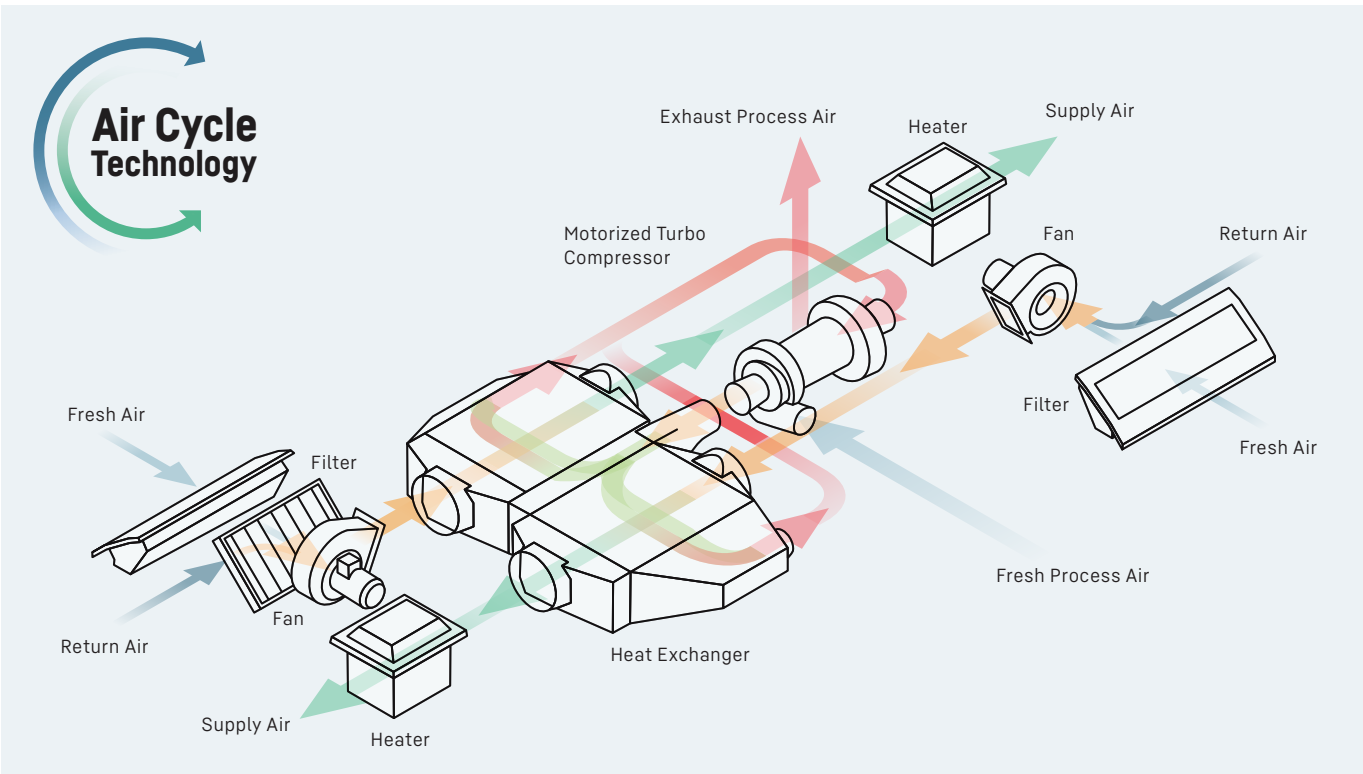
Additionally, as the system only consist of a few components, it is not only of low weight, but also simple and inexpensive to service. It is characterized by very low operating costs and low energy consumption.

The 100% green air-conditioning system by Liebherr was also tested by the Occitania Region and SNCF in France on a TER train from 2015 to 2019 and surpassed expectations in terms of passenger comfort and reduction in maintenance costs.

This next-generation air cycle technology is yet another testament of Liebherr's commitment to environmentally friendly solutions.

Advantages of the air cycle air-conditioning system

- **100% green technology**
- **Maximum passenger comfort**
- **Lower overall life cycle costs**
- **Easy to maintain**
- **No leakage**
- **Highly reliable**
- **Low noise emissions**
- **No synthetic refrigerant and storage of refrigerant necessary**



On the move – without barriers

Freedom from barriers makes life easier for us all. Electrohydraulic actuators from Liebherr elevate railway vehicles to a whole new level of comfort and safety. These technologies benefit passengers of all abilities, allowing them to easily board and exit trains, for example.

Rolling along through life
It doesn't happen too often. But this is one situation in which Patrick Berger prefers to take the lift. Taking the legendary staircase leading up to the Albertina, the famous art museum in Vienna's First District, is simply not an option. Since the age of 11, Patrick Berger has had to use a wheelchair due to the effects of myelitis. This means that large staircases with many narrow steps are of no use to him.

However, Patrick doesn't think in terms of limitations and barriers. At an early age, he topped the rankings in various sports, where he competed in both the European and World Championships. That was until the curvature of his spine caused him to give up competitive sports.

Patrick is always up for an adventure. That's why barrier-free accessibility is such an important topic for him in his everyday life. He knows that not every person with a disability is able to maneuver over obstacles. And to achieve this, barrier-free access to transportation is an absolute necessity. "It's not just about people with disabilities. It's also about making life easier for others. We're all in the same boat when it comes to accessibility," Patrick emphasizes.

High-tech, high-comfort rail travel
The team at Liebherr-Transportation Systems GmbH & Co KG in Korneuburg (Austria) are working to develop technical solutions that enable people to board and exit trains without barriers. Paul Hofbauer is an industrial engineer specializing in mechanical engineering and heads product management in the field of hydraulic systems. "Hydraulic leveling systems are an important focal point due to boarding and exiting trains without barriers," explains Paul. "Our hydraulics program ranges from complete leveling systems to passive undercarriage control systems, and all the way to electrohydraulic actuators for tilting technologies used in railway vehicles."

Leveling systems have long been in use in North America, where it is required that the height difference between a train and the platform should be no greater than 16 millimeters during boarding and exiting. "Our sensor-controlled electrohydraulics enable us to raise or lower a train at the platform by as much as 80 millimeters. Train operators in many North American regions are already using our leveling systems with excellent results," says Paul.

"We live in a mobile society. By getting rid of barriers, we make sure that everyone can take part."

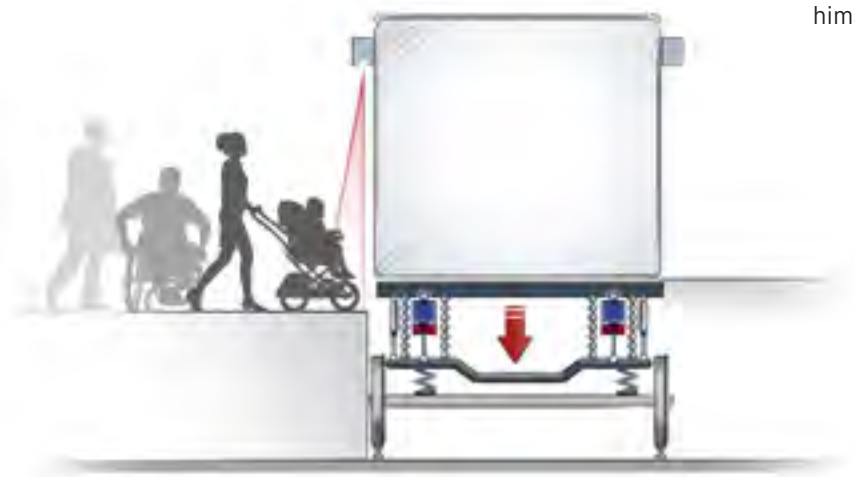
Patrick Berger
Wheelchair user and sportsman

“Hydraulic leveling systems are an important focal point due to boarding and exiting trains without barriers.”

Paul Hofbauer
Product Manager Hydraulics
Liebherr-Transportation Systems GmbH & Co KG

All aboard! Barrier-free rail travel in Europe
Successful testing has already been carried out in Hanover (Germany). “We already have the solution,” Paul continues. “But before we see large-scale investment in barrier-free railway access in Europe, we’re probably going to need new laws and regulations at EU level.” And it appears that the cornerstone has already been laid. For example, in an EU regulation it says: “Railway undertakings and station managers shall, through compliance with the technical specifications for interoperability (TSI) for persons with reduced mobility, ensure that the station, platforms, rolling stock, and other facilities are accessible to disabled persons and persons with reduced mobility.”

Insights from the aerospace field coming into play
Greater travel comfort and barrier-free mobility are just one aspect of the work being carried out by Liebherr-Transportation Systems developers in Korneuburg (Austria). They are equally concerned with travel safety and making sure the technologies are completely reliable.



That includes scenarios in which hydraulic actuators are connected with power electronics to provide active radius steering, lateral positioning, and yaw damping. The result is hydraulic leveling that is noticeably smooth and produces little noise, even at high speeds, as well as reduced wheel wear and lower risk of rail damage.

Quality comes first
To develop these comprehensive solutions, Paul and his team are working closely together with their colleagues at Liebherr-Aerospace in Lindenberg (Germany) and other Liebherr development centers. “It takes a team effort to achieve technological advances today,” says Paul.

He firmly believes that the key to success lies in the quality of technically sophisticated products. As an engineer and product manager, Paul takes some inspiration from legendary football trainer Dettmar Cramer, who once rallied his team before an international title match by telling them, “As long as better is possible, good isn’t good enough.” Patrick Berger could not have put it better himself.

Read the whole story here:
www.liebherr.com/leveling-systems

A new innovative cooling system

With the common brand Celsineo, Krone and Liebherr have entered into a partnership for the development, sales, and servicing of a new innovative cooling system. Under this agreement, Liebherr develops, manufactures, and supplies refrigeration units for temperature-controlled road transport. Krone installs these in its refrigerated semitrailers and offers them to its customers as a complete package. Krone's extensive European service network also allows it to offer expert maintenance and repair services as well as a fast supply of spare parts for all aspects of the cooling system.

Liebherr's patented system concept provides users with a modern and future-oriented solution. The entirely rethought modular design guarantees maximum availability, cost-effectiveness, as well as straightforward servicing. For Krone and Liebherr, the focus is on maximizing customer benefits, and both partners contribute to the new cooling system with their extensive experience and knowledge.

With Celsineo, Liebherr is able to apply its extensive know-how in refrigeration and air-conditioning systems for aircraft and rail vehicles to the specific requirements of road freight transport. The device's unique technology is also proof of Liebherr's innovative capabilities. The company holds several patents, which are used for the first time in Celsineo.

For the Krone Group, the cooperation with Liebherr in the area of transport refrigeration is a further step in extending its systematic focus on customer requirements and the demands of the international markets. The company's strategy of increasing service intensity across Europe is a focus in this respect, as is the implementation of new business models for its customers.

Celsineo performs cooling operations highly efficiently. Via an external 400 V power supply, the system is very fast and surpasses pull-down times in diesel mode with a currently unrivaled peak value

CELSINEO

A BRAND OF

LIEBHERR KRONE

Origin of the name Celsineo
The brand name Celsineo consists of two elements: "Celsi" is a reference to the famous Swedish astronomer, mathematician, and physicist Anders Celsius. Celsius came up with the revolutionary idea of using a universal scale to compare temperatures around the world. "Neo" comes from Greek, meaning "new," and highlights the innovative nature of the idea. The name "Celsineo" is intended to emphasize the key aspect of the product.

© Krone

Test marathon: Celsineo in operation for more than 200,000 hours

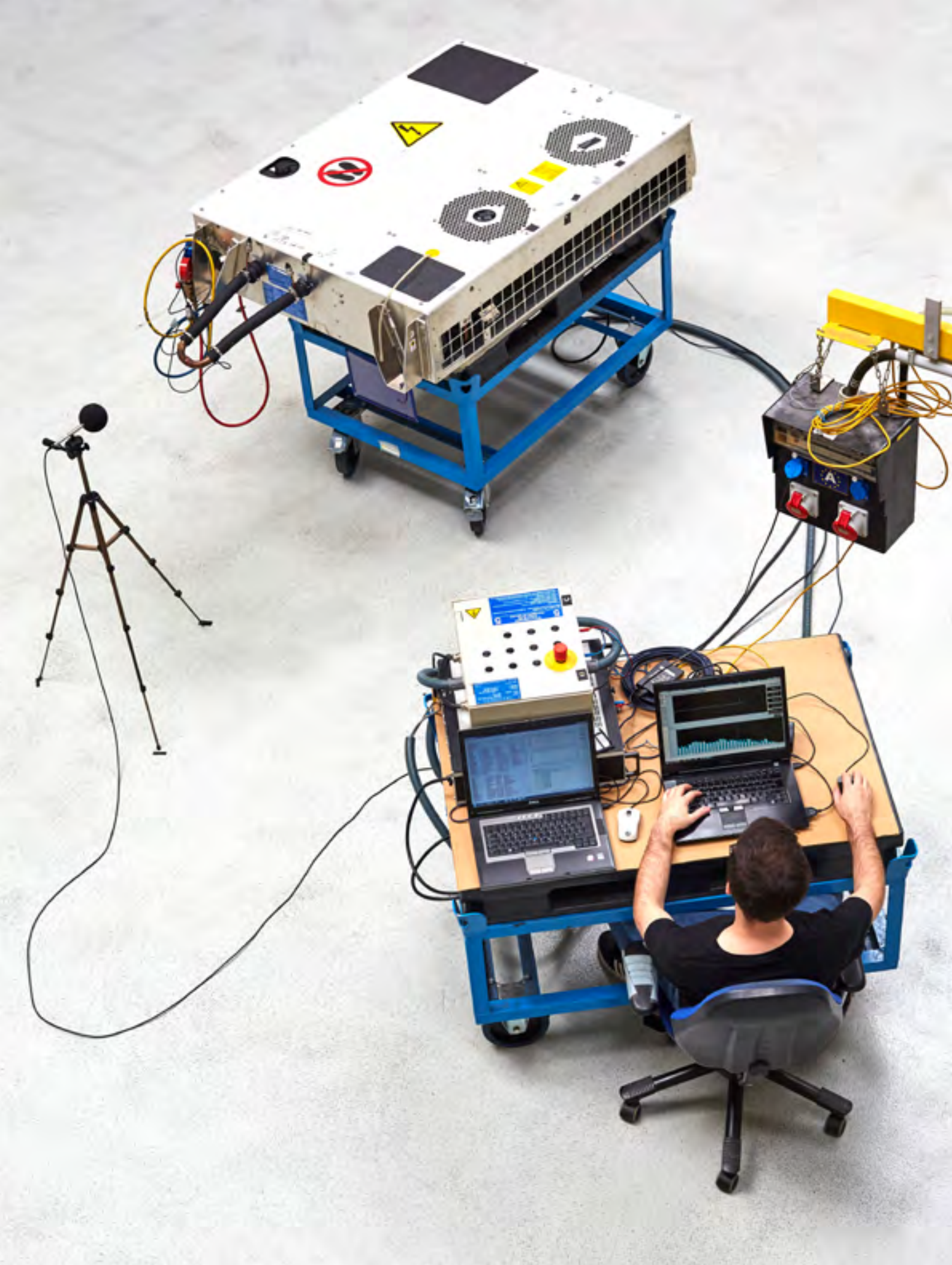
Krone Cool Liners were equipped with Celsineo refrigeration units for single-temp applications and used intensively by 20 freight forwarders in temperature-controlled transport operations. The tests have been running in various stages since 2017 over a period of three years. This not only enabled the flexibility, availability, and efficiency of the vehicles to be demonstrated, but also allowed comparisons to be made with conventional refrigeration units from other manufacturers.

The feedback from the field test customers was correspondingly positive: Freight forwarder Karlhubert Dischinger, who uses around 100 refrigerated trailers in southern Germany, was confirmed in his decision to use Celsineo: “We’ve been testing the system for six months now, and it’s running very well.”

The cooling capacity is distributed across three identically structured plug-and-play cooling modules, each of which contains a separate, hermetically sealed refrigerant circuit with only a few components. If one module fails, the other two modules can reliably maintain the set temperature in the trailer. Thus, the tour can be completed as scheduled.

Research & Development

An acoustic test of an HVAC unit is conducted at Liebherr-Transportation Systems in Korneuburg (Austria)



Contributing to Safe4RAIL-2

Within the European research project Safe4RAIL-2, Liebherr-Transportation Systems is working intensively with seven consortium partners on the development of the next-generation train control and monitoring system (TCMS). The aim is to define new train standards and pave the way for deterministic communication as well as secure interoperable connections while increasing the efficiency and safety of TCMS. Pioneering methods and tools for model-based development in the railway industry are being coordinated and implemented.

Liebherr-Transportation Systems GmbH & Co KG, based in Korneuburg (Austria), is working on the functional distribution framework (FDF) as part of the European research project Safe4RAIL-2, which aims to enable the execution of different software applications for control and monitoring systems in modern trains. A Liebherr air-conditioning system is to be implemented in this FDF and will be used to show whether subsystem suppliers, such as Liebherr, will be able to install and run their own air-conditioning control software directly in the train control system. This will make it possible to dispense with different external control units and simplify the integration of the subsystems into the next-generation of trains.

In accordance with the supplementary action project CONNECTA-2, a consortium of Alstom, Bombardier, Deutsche Bahn, CAF, Siemens, and SNCF, the Liebherr air-conditioning system is run on two different FDF implementations: One, on the basis of the AUTOSAR Adaptive Platform, is a development environment that will also be used in the automotive industry, and the other is a proprietary development environment in the same given FDF interfaces according to the predefined data protocol.

Pioneering methods for the railway industry

A further focus of Safe4RAIL-2 and its consortium partners is the coordination and implementation of pioneering methods and tools for model-based development in the railway industry. Various subsystems of a train, including, for example, the modular MACS 8.0 air-conditioning unit from Liebherr, are mapped on the computer in simulation models and virtually linked to the overall train system in a simulation environment at the car manufacturer's premises. This makes it possible to validate the correct interaction of different hardware and software systems on the computer at an early stage – even before cost-intensive hardware is built, using methodologies known as model-in-the-loop (MIL) and software-in-the-loop (SIL).

In the further course of development, the virtual model of a subsystem can be replaced by the physically built unit in the simulation environment in order to carry out

Liebherr-Transportation Systems' facility in Korneuburg (Austria)

further tests with the real hardware, a hardware-in-the-loop (HIL) strategy. However, the subsystem – in this example, the air-conditioning unit – does not have to be physically transported to the location of the car manufacturer. Instead, it can be operated directly in the test environment of the respective manufacturer in real time via the Internet, thanks to the remote access that has been developed.

As a demonstration example in the project, the car manufacturer CAF can control the MACS 8.0 air-conditioning unit from its own premises in Spain, including a test environment at the Liebherr site in Korneuburg. It can also test various operational cases in interaction with other systems on the train – some of which are still virtual while others already exist as hardware.

The advantages of this approach are obvious: time savings and the reduction of train-development costs while increasing the competitiveness of the European railway industry.

About Safe4RAIL-2
Safe4RAIL-2 (safe architecture for robust distributed application integration in rolling stock 2) is a European research-and-development project, which runs under the umbrella of the European Horizon 2020 Shift-2Rail Joint Undertaking, and is limited to 31 months. Safe4RAIL-2 is driven by a well-balanced European consortium, composed of six industrial partners (including SMEs and large companies), one research institution, and one academic partner, providing their expertise from the automotive, aerospace, and railway sector in order to create synergies with existing and emerging concepts and technologies. The members are Ikerlan S Coop (Spain), Technikon Forschungs- und Planungsgesellschaft mbH (Austria), TTTech Computertechnik AG (Austria), Moxa Europe GmbH (Germany), Westermo Teleindustrie AB (Sweden), Eurecom (France), ETAS GmbH (Germany), and Liebherr-Transportation Systems GmbH & Co KG (Austria).

France co-funds development of high-speed air compressors

Liebherr-Aerospace Toulouse SAS is developing high-speed air compressors for fuel cell propulsion for the rail transport market. The project represents an overall investment of €4.9 million. Within the "France Relance" plan, the French government will co-fund the project with €1.25 million. It involves two SME partners based in France, namely 2E WINDINGS and Danielson Engineering, as well as sub-contractor Centum Adeneo.

The compressors incorporate a unique type of technology involving the use of air bearings that helps to ensure that the air injected into the fuel cell includes no oil, which can degrade the membrane performance. These compact compressors will be used in the rail transport sector to provide compressed air to propulsion systems powered by fuel cells. The final fuel cell product itself will generate no CO_2 emissions, providing an alternative for a new generation of trains.

With the development of these compressors, Liebherr will continue its efforts to diversify its activities targeted at the rail market by offering innovative solutions based on technologies coming from the aerospace sector.

International Focus


免票兒童先行
Accompanied child in front

2021 – European Year of Rail

Rail is one of the safest, most innovative, and sustainable means of transport for Europeans. There are more than 9,100 kilometers of high-speed rail network in Europe and 75 percent of total train-kilometers are traveled by electricity-powered trains. But there is still potential that can be tapped into. OnTrack met up with Adina Ioana Vălean, European Commissioner for Transport, to discuss how the new initiative "European Year of Rail" will address this.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"Rail should play a key role at the heart of our digital, decarbonized transport system – innovative and modern solutions are making rail greener, smoother, faster, and more efficient."

Adina Ioana Vălean,
European Commissioner for Transport

Ms. Vălean, on January 1, 2021, the European Year of Rail started. What are the reasons for this initiative of the European Commission at this point in time, and what are the conclusions after the first half-year?

We dedicated 2021 to rail to highlight the crucial role it plays in our society. Rail is not only one of the most sustainable and safest transport modes we have, but it has a strong European dimension, too – connecting people and businesses across the EU.

The aim of this initiative is twofold: promoting rail and its numerous benefits, but also shedding light on the challenges we still need to overcome for rail to realize its full potential. We want to create momentum for rail that will have an effect far beyond 2021, so that more people travel by train, more businesses ship their goods via rail, and more people consider working in the rail industry.

The year 2021 was the natural choice following the launch of the European Green Deal, and then our Sustainable and Smart Mobility Strategy, in December 2020. This strategy outlines our plans to overcome the remaining challenges facing rail, with concrete milestones and measures – our aim is to triple high-speed rail traffic and double rail freight traffic across Europe by 2050, for example.

To date, various activities have taken place across the continent despite the difficult circumstances linked to the pandemic. So one of my immediate conclusions several months into the European Year of Rail is how resilient rail is. We saw this during the height of the pandemic, and we are still seeing this today – trains continue to keep us moving, and they continue to keep the goods that we rely on moving.

Although rail is one of the most sustainable means of transport for passengers and freight, it is still far from tapping its full potential. What additional measurements can be taken to convince people to travel more by train and to transport more goods by train?

Indeed, while rail already links many regions, towns and terminals across the continent, its potential is still largely untapped when it comes to long-distance and cross-border services and for many freight flows, for example. The European Year of Rail is helping us create awareness of the benefits of rail. But to ensure this momentum lasts beyond this year, I believe that the entire rail community, policymakers, and public authorities should use 2021 to match words with deeds.

It is a good sign that many new connections and services have been launched or announced this year, bringing more choice and travel options for passengers. To name just one example, a new trans-European night train now links Stockholm, Copenhagen, and Berlin.

At EU level, we are supporting increased connectivity through our Sustainable and Smart Mobility Strategy: we are working on an action plan to boost passenger rail services that I will present later this year. This plan will build on efforts by EU member states to make key connections between cities faster through better managing infrastructure capacity, coordinating timetables, and improving infrastructure to make new train services possible. In the same vein, good freight services require good infrastructure and good capacity. This will be reflected in the planned revisions of TEN-T Guidelines and the rail freight corridors.

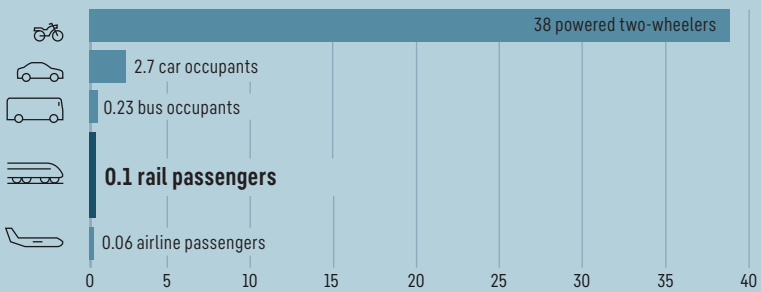
Another strategic milestone is aligning the price of using transport with its societal costs, including emissions and noise pollution, to address the current cost disadvantage of greener transport modes, such as rail. I'm optimistic that such incentives, alongside a more attractive offer and more choice, will see more passengers boarding trains.

Rail has grown from a series of national monopolies, each with their own standards. We've been working on eliminating these for many years, but to realize the full potential of the Single European Rail Area, we need another big push to get rid of the remaining obstacles. This will make it much easier to establish new pan-European services, cut costs, and bring new innovations into the network. Just as cars, lorries and planes can go everywhere in Europe, we need trains able to do the same.

Lastly, research and funding are key to realizing rail's full potential. It is very fitting that this year will also see the launch of Europe's Rail, a research partnership that will continue the important work begun by the Shift2Rail Joint Undertaking, pooling and coordinating research and innovation efforts at EU level – boosting rail through innovation. At the same time, a very significant support package is being put in place, with rail investments foreseen by several EU sources, including the Cohesion Policy, the Recovery and Resilience Facility (RRF), and the Connecting Europe Facility (CEF), for example.

Rail is a safe means of transport

Fatalities per billion passengers/km (2011–2025)



Source: https://europa.eu/year-of-rail/why-rail_en

How could the railway equipment industry with companies like Liebherr contribute to make train journeys even more attractive?

When it comes to creating more attractive rail services, I believe that the railway equipment industry plays a crucial role. Rail should play a key role at the heart of our digital, decarbonized transport system – innovative and modern solutions are making rail greener, smoother, faster, more efficient, and contributing to a better customer experience, both for passengers and freight. New digital systems in particular should make rail more efficient and reliable – we are working on new generations of ERTMS, including automatic train operation and satellite positioning, with digital automatic coupling to transform freight. Continued work on power systems, HVAC, and all other components is needed to further enhance rail's already strong environmental performance, but also to cut maintenance costs and boost reliability.

Where do you see the European railway industry compared to the UK, China, Russia, and the Americas?

Europe's rail network is the world's densest – which is key for mobility around the continent, and a great asset in meeting our climate targets. Great new investments are planned from EU member states using the Recovery and Resilience Facility. But we need to do much more to make freight more attractive, where other parts of the world are certainly ahead.

The EU rail supply industry has historically been one of the world's strongest, with world-beating products such as the TGV and ERTMS. But like many other industries it now faces very strong competition from around the world – particularly East Asia. To compete, it's vital that it continues to innovate, and that it has a strong European home market. That's why we work with it in Europe's Rail Joint Undertaking, in addressing its skills needs with the Staffer Project under the European Blueprint for Skills, and in getting market access through free trade agreements. And it why we continue to address issues of fair international competition in our Rail Supply Industry Expert Group.

One of the key trends is "Digitalization" – what are the expectations or visions of the EU regarding the railway industry?

Digitalization and innovation play a key role in improving the efficiency of the transport system, as well as its sustainability, safety, security, reliability, and comfort. I am therefore a huge supporter of digitalizing rail. Fully rolling out the European Rail Traffic Management System (ERTMS) is a priority as the EU-wide signaling and speed control system will ensure interoperability between different EU countries. Digital automatic couplers and automatic train operation also have huge potential to increase efficiency. Digitalization also gives us the means to ensure the EU remains among the leaders in transport equipment manufacturing and services, and improves its global industrial competitiveness through efficient and resilient logistics chains. This is reflected in the Sustainable and Smart Mobility Strategy, which includes two flagships on digitalization: making connected and automated multimodal mobility a reality and boosting innovation and the use of data and artificial intelligence.

For passengers, planning and buying tickets for trips combining different modes of transport is still much too difficult in the EU. Making this easier would certainly benefit rail, and this is one of the reasons why we are supporting the development of multimodal digital mobility services for passengers, including by revising the Delegated Regulation on multimodal travel information services.

The EU is also supporting rail's digitalization through the various funding instruments that I mentioned – rail is the primary recipient of EU funding under the Connecting Europe Facility, and Member States are making good use of the RRF to fund rail projects.

Lastly, rail research and innovation are among the key enablers of the digital transition and I look forward to seeing more innovations come to life, for example in the Europe's Rail partnership, helping rail play a key role in delivering decarbonization of transport.

New company in Pinghu

Liebherr opened a new production site in Pinghu, eastern China, in August 2020. The newly founded Liebherr-Transportation Systems (China) Co., Ltd. develops, produces, and services components and systems for rail transport in China and worldwide. The new company strengthens the presence of Liebherr-Transportation Systems on the Chinese market while, at the same time, further enhancing reaction time and service performance for customers.

An opening ceremony on August 18, 2020 in Pinghu, marked the official launch of business activities for Liebherr-Transportation Systems (China) Co., Ltd. The new site marks an important step in Liebherr's goal of growing its abilities to develop, test, and manufacture state-of-the-art railway equipment in China. It will serve both the Chinese domestic market and Asia.

Engineering competencies and support

Liebherr-Aerospace & Transportation SAS decided to invest in an additional China-based production site in Pinghu in 2019, with the aim of generating additional value for the local-based railway industry as well as for the international railway market. With a production and engineering facility covering approximately 11,700 m², Liebherr-Transportation Systems (China) Co., Ltd. will intensify its existing activities in the country by offering its customers best-quality and cost-efficient railway products for faster, safer, more environmentally friendly, and more comfortable railway travel.

German Consul Dr. Christine Althauser (4th from left) and high-ranking officials visited the opening ceremony

Andreas Walter, Executive Director, Liebherr-Transportation Systems (China) Co., Ltd. stated, "Our new factory represents an important base for our air-conditioning technology and hydraulic actuation systems for all types of rail vehicles developed and manufactured in China for the domestic and international railway market."

Besides the reinforcement of engineering competencies and seamless product delivery in China, Liebherr has also intensified comprehensive service performance for its customers in the country. Liebherr-Transportation Systems (China) Co., Ltd. strives to support its customers along the entire life cycle of the products – with on-site service based on interconnected train components. Tracking and observing all relevant components of the train enables efficient diagnostics so that components in need of maintenance, service, or overhaul can be easily identified and taken care of by Liebherr on-site.

Best quality for high-volume transport

Liebherr provides products out of Pinghu in line with the highest standards and compliance with current and future technical regulations in China and everywhere else in the world. Liebherr-Transportation Systems will not only facilitate high-volume railway transport in Asian megacities but will also contribute to the development of the international, cross-border transport sector, thus strengthening the Chinese Belt and Road Initiative.

Successful IRIS certification

Liebherr-Transportation Systems (China) Co., Ltd. has been officially certified in accordance with the International Railway Industry Standard (IRIS). The company obtained the certification for design, manufacturing, production, and maintenance related to its product range of heating, ventilation, and air-conditioning systems as well as hydraulic actuation technology for the Chinese and international railway market.

This certification enables Liebherr-Transportation Systems (China) Co., Ltd. to expand its existing presence in the railway sector in China and Asia through partnerships with train manufacturers as well as operators. It further underlines its ability to support its customers. This milestone is not a final achievement, but supports Liebherr to continue its journey to provide environmentally friendly solutions for the railway industry.

Liebherr-Transportation Systems (China) in Pinghu

Liebherr elected as a special institute council member

The secretary and members of the Shanghai Air-Conditioning and Refrigeration Institute (SARI) visited the new Liebherr-Transportation Systems (China) Co., Ltd. facility in Pinghu, and were impressed by the state-of-the-art equipment implemented for the design, engineering, assembly, and maintenance of heating, ventilation, and air-conditioning (HVAC) systems for railway vehicles. In addition to the setup for a highly efficient production flow, Liebherr presented its comprehensive maintenance, repair, and overhaul capabilities for future customer projects. The company is eager to support its customers throughout the HVAC systems' and components' life cycle – for example, by providing the health data of components – which will further enable efficient service.

"As an elected special council member of the Air-Conditioning and Refrigeration Institute in Shanghai, we are able to contribute even more to the development of environmentally friendly cooling technologies, the related aftermarket, thereby strengthening our presence in the country," explained Andreas Walter, Executive Director, Liebherr-Transportation Systems (China) Co., Ltd. "We will be an active market player in the industry under the guidance of the association. It is a good opportunity to further enhance the strengths and market competitiveness as well as to promote the technical and innovative development of the cooling industry in the Yangtze River Delta."

SARI was founded in 1985. The association consists of refrigeration and air-conditioning equipment manufacturing enterprises, design institutes, universities, and other cooling function-related organizations in China. Currently, more than 600 cross-regional companies hold memberships in SARI. It is the biggest regional refrigeration industry-related production and engineering cluster.

Honored to receive the SARI certificates: Deputy General Manager Roland Friedrich (right) and Operations Director Yongkang Yu (left) of Liebherr-Transportation Systems (China) Co., Ltd.

"We are able to contribute even more to the development of environmentally friendly cooling technologies."

Andreas Walter,
Executive Director, Liebherr-Transportation Systems (China) Co., Ltd.

Ready to serve the rail transport market in Brazil

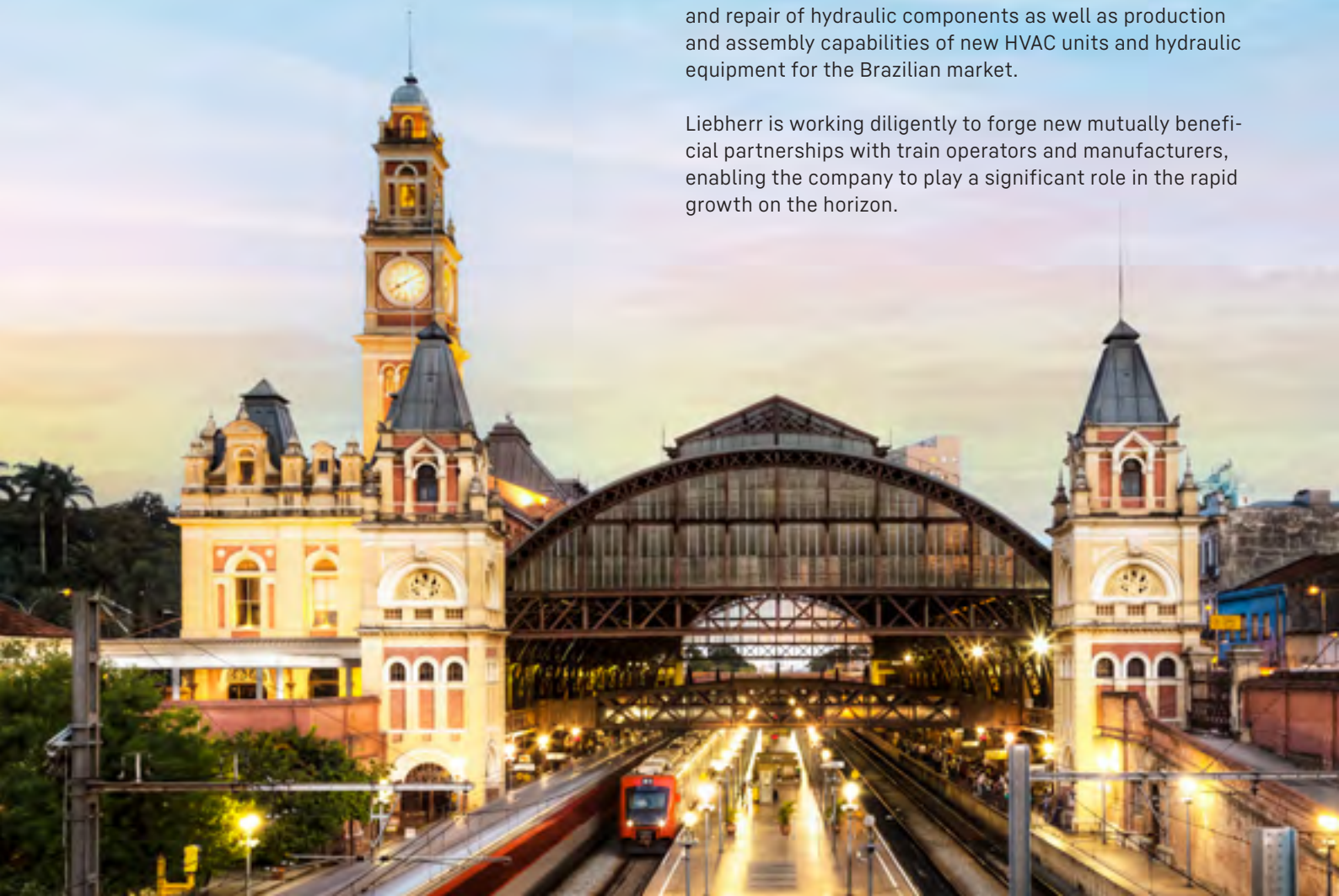
Liebherr is expanding its operations in Brazil beyond aviation into the rail transport market, which is expected to grow quickly in the next few years. Recent announcements of infrastructure development in several major cities and regions have been made by local governments. As a result, Liebherr sees an opportunity to be part of this positive development.

So far, Liebherr Aerospace Brasil Ltda. in Guaratinguetá (Brazil) has been mostly focused on precision machining, surface treatment, and the assembly of high-tech components for air management systems, flight controls, and actuation systems for its aerospace sister companies in France and Germany as well as long-time customer Embraer.

In 2020, Liebherr saw enormous potential for the development of the metropolitan train market. “Thus, we seized the opportunity to expand operations in order to fulfill the needs of manufacturers and operators of the national rail transport market,” explains Matthias Flach, Manager Liaison Office Brazil of Liebherr-Aerospace & Transportation SAS. “We have built up at Liebherr Aerospace Brasil know-how regarding HVAC maintenance and repair, including overhaul procedures, customized testing equipment, identification of national suppliers for spare parts, transport logistics, and the associated regulatory and legal conditions. We have also begun conceptualizing a new workshop layout to support our growth.”

As the first step, part of the expansion includes maintenance and repair capabilities for air-conditioning systems, including the servicing of units produced by other equipment manufacturers. Liebherr can look back on a long history of expertise in manufacturing and servicing air management systems. This legacy will now be extended to the new rail transport clients in the growing Brazilian rail transport market. The second step will be maintenance and repair of hydraulic components as well as production and assembly capabilities of new HVAC units and hydraulic equipment for the Brazilian market.

Liebherr is working diligently to forge new mutually beneficial partnerships with train operators and manufacturers, enabling the company to play a significant role in the rapid growth on the horizon.



Programs & Contracts

Testing under extreme conditions
in the Rail Tec Arsenal in Vienna (Austria)

Successful tests for the new Vienna metro

A new heating, ventilation, and air-conditioning (HVAC) system, which was developed and manufactured by Liebherr-Transportation Systems on behalf of Siemens Mobility for the so-called “X cars” successfully completed numerous tests in the Rail Tec Arsenal (RTA), the climatic wind tunnel in Vienna (Austria).

The Liebherr HVAC system was assessed in a test vehicle under extreme climatic conditions. For example, outside temperatures ranging from –25°C to +45°C and strong wind conditions were simulated. In addition, the tests served to optimize the settings of the air distribution system in order to create the best-possible comfort conditions for passengers.

The tests in the RTA are part of the approval process for the new generation of metro trains that Siemens delivered to Wiener Linien. They complement the temperature and function tests that Liebherr-Transportation Systems carried out in advance in its own test facilities in Korneuburg (Austria).

Ultralight air-conditioning units on board new maglev train in China

Liebherr-Transportation Systems supplied German-based construction company Max Bögl with ultralight MACS 8.0 air-conditioning units. They were installed in Max Bögl's new maglev urban transportation system TSB. The first serial vehicle was delivered to Chengdu Xinzhu Road & Bridge Machinery Co., Ltd. based in China at the beginning of June 2020. The train operates at up to 160 km/h and demonstrates the many advantages of TSB urban maglev technology to the Chinese market.

MACS stands for the modular air-conditioning system that has been developed and produced by Liebherr. It enables flexible integration by arranging the modules according to the individual car design and the required cooling-power demand. MACS 8.0 was designed to respond to the most challenging market requirements of the modern railway industry.

In addition to the contract with German-based construction company Max Bögl, Liebherr China officially signed its own agreement with Chengdu Xinzhu Road & Bridge Machinery Co., Ltd. in April 2021. This time, the agreement was to provide ultralightweight air-conditioning systems named MACS 10.0, which is based on MACS 8.0.

Each passenger compartment will be equipped with three ultralightweight MACS 10.0. The new and improved product design offers advantages because of its high degree of flexibility, integration, and modularization while also maintaining a low height. There is no need for a specific duct system anymore. The air-conditioning system meets the customer's needs regarding passenger transport according to Chinese requirements.

The innovative MACS units will be brought to serial-production readiness after ambitious development and testing, and will be engineered and produced at Liebherr-Transportation Systems newest production and engineering site in Pinghu, Zhejiang Province (China).

Liebherr is very honored to be a key supplier of the flourishing domestic maglev train industry that plays a role in China's 14th Five-Year Plan objectives – a national plan that outlines the direction of China's economic development and approach to tackle issues related to climate change, alternative energy, and biodiversity.

Maglev train project by Chengdu Xinzhu Road & Bridge Machinery Co., Ltd.

Air-conditioning units for the Rhein-Main and Stuttgart suburban railway

Liebherr-Transportation Systems will supply Alstom (formerly Bombardier in Hennigsdorf (Germany)) with further air-conditioning equipment for seven ET 430 series Rhein-Main suburban railway trains and for 58 suburban railway trains operated in Stuttgart. The first Liebherr air-conditioning systems for the ET 430 series were delivered to the rail vehicle manufacturer in 2010.

Four air-conditioning units for the passenger compartments and two for the driver's cabin will be installed in each Rhein-Main train set. Alstom has ordered 28 roof-mounted air-conditioning units for the passenger areas and 14 units for the driver's cabs of the vehicles operated by DB Regio AG, Hesse Region (Germany). The delivery will be made in two parts: In the second quarter of 2021, units for three train sets were delivered to Hennigsdorf, and then, in the first half of 2022, units for four train sets will be delivered to the Alstom plant in Bautzen (Germany).

Since the end of 2014, the modern and environmentally friendly suburban railway trains have been in service on the Rhein-Main rail network on the S1, S7, S8, and S9 lines. They can also be used as replacement vehicles on other routes.

Alstom has also ordered a total of 232 roof-mounted air-conditioning units for the passenger compartments and 116 units for the driver's cabs of the vehicles operated by DB Regio AG, Stuttgart (Germany). Four units per train set will be installed for the passenger compartments and two for the driver's cabin. Deliveries are scheduled to take place by March 2022.

The air-conditioning units in the passenger compartment are designed to be particularly energy-efficient, as they use the thermal discharge from traction to heat the passenger areas. Heating using electrical energy can therefore largely be avoided.

The Liebherr air-conditioning units are mounted on the ET 430 suburban railway train

The ET 430 series is the evolution of the ET 422 fleet. It is a four-part, electric, multiple-unit train and is operated by Deutsche Bahn on the suburban networks in various metropolitan areas. Since 1999, more than 700 trains of the ET 422, 423, and 430 series have been fitted with air-conditioning systems from Liebherr.

Air-conditioning units for low-floor trams in Down Under

In January 2021, Liebherr-Transportation Systems was commissioned by Yarra Trams/KDR Victoria Pty Ltd., Melbourne (Australia) to supply rooftop air-conditioning units for installation in Combino low-floor trams.

The scope of delivery includes two replacement air-conditioning units for the passenger compartment and three replacement units for the driver's compartment. These replacement units can be swapped for the units installed in the vehicles, which were also supplied by Liebherr, within a very short time during maintenance work. In this way, the maintenance-related downtimes of the fleet can be significantly reduced. Delivery is scheduled for the beginning of December 2021.

The Combino low-floor trams were developed and manufactured by Siemens AG. They have been in operation in Melbourne for inner-city public transport since 2002.

© Keolis

Customer Service

HVAC units in stock at the Liebherr-Transportation Systems facility at Gatwick (UK)

A hub for support and maintenance in the UK

Liebherr-Transportation Systems has a dedicated service and support facility in the UK. The facility is equipped with an experienced and skilled team of technicians carrying out a broad set of tasks that contribute to the success of customers' operations in the railway market.

Located in Crawley, near Gatwick, the facility's capabilities include diagnosing, repairing, overhauling, and maintaining various heating, ventilation, and air-conditioning (HVAC) modules and system components. This strategic location gives Liebherr-Transportation Systems access to direct interface with train owners, vehicle MRO companies, and passenger service operators; thus, it has become a hub in the UK.

Opened in 2014, the facility is responsible for managing major support and maintenance functions for products supplied by Liebherr-Transportation Systems. Since its opening, the company has refurbished, repaired, and overhauled almost 6,000 HVAC units and related devices. Due to the growth of the UK railway market and the Liebherr network expansion, the facility has grown significantly. The site is engaged in continuous improvement, not just process-wise, but also physically. The team is committed to ensure alignment between customer objectives and requirements as well as capabilities. This continued growth has resulted in an increase in skilled and experienced resources and tools within the engineering and administration functions.

"Liebherr-Transportation Systems is showing its commitment to support its customers in the UK by having a specific facility and dedicated presence here. The facility ensures excellence in operations and support. Our goal is to increase products and services by working with customers to understand their objectives and ultimately deliver as much value to them as possible," says Rob Wheeler, Director of Sales and Customer Services for the UK.

Maintenance of an HVAC system

"In a world that has been challenged by a pandemic and a country that is now dealing with change due to Brexit, we are exploring how we can increase our efforts to provide safe support for our customers. We need to deliver value-added benefits while further understanding how our customers and their customers have been affected by these events," he explains.

Continuous growth of customer services business in France

Since opening its doors in France, just north of Paris, in 2004, the customer services and liaison office of Liebherr-Transportation Systems has grown continuously. It offers after-sales support and third-party maintenance activities to customers in the region.

The service technicians on-site are qualified for all types of rail and bus interventions. The facility stores spare parts of all brands and is able to perform maintenance, repair, and overhaul of HVAC units, plus leak detection and duct cleaning among other capabilities.

In July 2020, Liebherr-Transportation Systems was selected by the RATP Group to overhaul and repair 284 heating, ventilation, and air-conditioning (HVAC) systems for Paris trams. RATP is the state-owned company that operates one of the largest urban and suburban networks in the world in the Greater Paris region. The review and maintenance work will be carried out in the repair shop through December 2021.

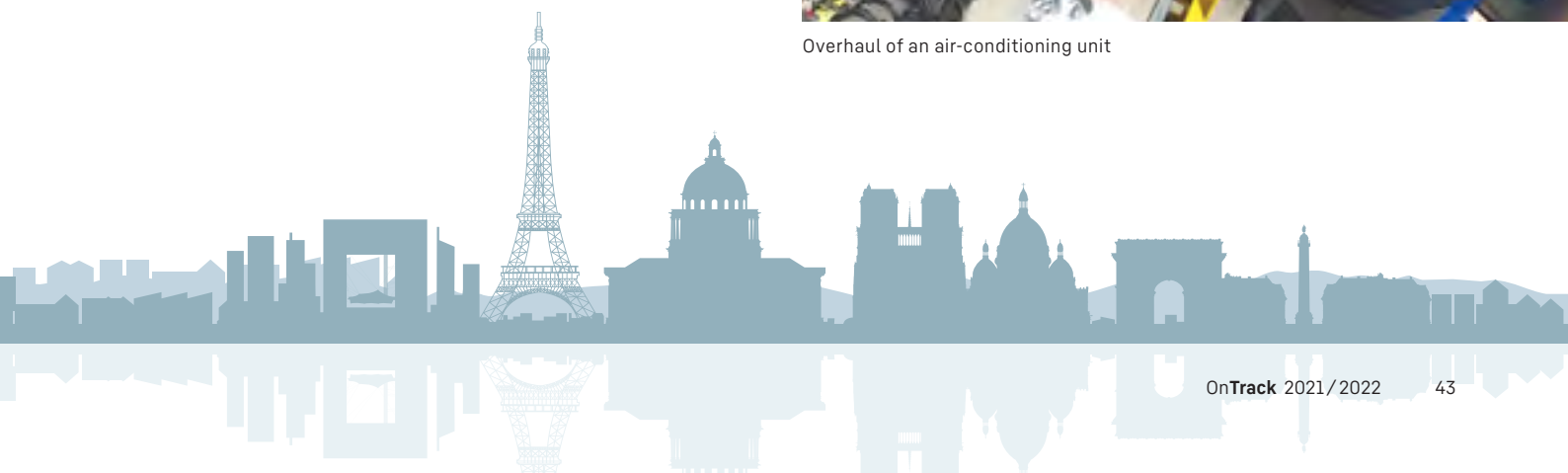
The contract covers preventive maintenance and associated spare parts for 118 saloon and 166 driver's cab HVAC units. The third-party design systems onboard Parisian trams run with vapor-cycle technology and use the refrigerant R134a.

Eléonor Borrallo-Gautier, Head of the French site of Liebherr-Transportation Systems, commented upon being awarded the contract: "The adaptability of our service organization in Paris was one of the determining factors for this new agreement. We will carry out the repairs and maintenance in our workshop in the north of Paris, which we established especially for this purpose."

"With this new partnership, we have been able to combine the expertise of RATP and the experience of Liebherr. This contract will allow us to guarantee an optimum level of quality of service for travelers," said Gaël Teixeira Cardoso, head of rolling stock at RATP's Ateliers de Championnet in Paris.

This and many other contracts are proof of the high-level performance and vast experience of Liebherr-Transportation Systems' service center and liaison office in Paris. Eléonor Borrallo-Gautier is confident: "Competition in the after-sales market is fierce, but with our skilled team, our expertise, customized service solutions and with us being here on-site, close to our customers, we are in a very good position to grow our business."

Overhaul of an air-conditioning unit



Customer services for ETR 700 high-speed trains

Liebherr-Transportation Systems overhauls, repairs, and maintains cab cooling and saloon air-conditioning systems, which are installed in ETR 700 high-speed trains operated by Trenitalia on the route Milan – Bologna – Ancona – Lecce.

Liebherr was commissioned by AnsaldoBreda S.p.A., Naples (Italy) to provide customer services for 39 cab-cooling and 157 saloon air-conditioning systems onboard 19 ETR 700 high-speed trains. Each ETR 700 train consists of eight cars and two driver's cabs, and eight saloon HVAC units are installed in each car.

The air-conditioning systems have been designed and manufactured by Liebherr. In addition to mandatory examinations, the certified service technicians from Liebherr-Transportation Systems will also perform on-site repairs for the refrigerant circuits of the air-conditioning systems. These measures will further enhance the safety, availability, and reliability of the HVAC units and, consequently, the travel comfort for both passengers and drivers.

The contract is complemented by the provision of a stock of spare parts, which will permit the service team to perform the corrective maintenance directly on-site at Trenitalia S.p.A.

Liebherr HVAC technology on board the Trenitalia ETR 700 high-speed trains enhances the traveling comfort

Preventive maintenance and checks for Graz trams

On behalf of Holding Graz – Kommunale Dienstleistungen GmbH (Austria), Liebherr-Transportation Systems maintains 45 driver's cabs and 90 compartment air-conditioning systems. The five-part, low-floor sets of the Variobahn type from Stadler Rail have been operated by Holding Graz since the end of 2007.

The trams undergo preventive maintenance and technical checks by the qualified Liebherr service technicians every year. The tailor-made customer service for the air-conditioning systems enables both the highest possible availability of the vehicles and a high level of comfort for the passengers.

The maintenance order underlines the competence of Liebherr-Transportation Systems to provide suitable service solutions for modern air-conditioning systems.

The World with Liebherr

Liebherr tower cranes at work in Tel Aviv (Israel)

Highlights of the year 2020

January

A new business complex for Israel
For two years now, it has been almost impossible to imagine the skyline of Tel Aviv (Israel) without them: seven Liebherr tower cranes. On a construction site in the Bnei Brak industrial zone, they are involved in the construction of the three-tower LYFE business complex, steadily growing into the sky with it. Upon completion in 2021, the buildings will tower over the city on the Mediterranean Sea at 160, 173, and 230 meters.

May

Around the world and back
Day after day, the S-Bahn trains in Munich (Germany) cover a distance equivalent to a journey around the globe and back. On the Marienhof construction site in the heart of the city, six Liebherr machines play a major role in the construction of one of the central access structures to the second main line. In addition to two cable excavators with slurry wall cutters and grabs, the LB 24 and LB 44 drilling rigs are being used in the extension of the S-Bahn. An LR 1250 crawler crane lifts the reinforcement cages, which weigh up to 55 tonnes and are 55 meters high, into position.

June

To the airport with hydrogen
Success for Liebherr's developers: Liebherr technology is now on board the hydrogen-powered shuttle buses manufactured by Shanghai Automobile Group Co., Ltd, which shuttle between Hongqiao and Pudong airports in Shanghai. The integrated electric compressor is a crucial component of the PROME P390 fuel cell system on board the buses. The system received the mandatory Chinese certification (CCC) at the beginning of 2020.

September

Groundbreaking at Erzberg
In cooperation with VA Erzberg GmbH, Liebherr developed a trolley assist system for the diesel-electric T 236 Mining Truck. Successful tests on a 500-meter route are followed by the ground-breaking for a trolley line five kilometers long in the world's largest siderite ore mine in Eisenerz (Austria). By moving to electric energy for the six T 236s, three million liters of diesel will be saved per year.

October

"Digital Hub" in a prime location
One year after construction started, Liebherr-Hausgeräte GmbH moves into its new premises in Science Park III in Ulm (Germany). In addition to sales and services, the new building also houses the digitalization department. This is the ideal prerequisite for future-oriented digital work. The proximity of the innovation center to Ulm University makes Liebherr an attractive employer for students and junior staff.

December

The world's first battery-powered crawler crane
Ending the year on a high note: with the LR 1250.1 unplugged, Liebherr presents the world's first battery-powered crawler crane in a brand new design. Model number one goes to Kynningsrud Nordic Crane AS in Norway, which uses the crane in Oslo. An investment for the future, considering the Norwegian capital's goal to be independent from fossil energy by 2030.

“We will emerge stronger from this phase, too”

A conversation with **Dr. h.c. Isolde Liebherr**, Vice President of the Administrative Board of Liebherr-International AG, **Dr. h.c. Willi Liebherr**, President of the Administrative Board of Liebherr AG, and **Sophie Albrecht** and **Patricia Rüf**, members of the Administrative Board of Liebherr-International AG which was first published as part of the 2020 annual report at the beginning of this year.

The coronavirus started to change the world in ways we could never have imagined. Can you describe what it was like for you at the beginning of the pandemic?

Willi Liebherr: We received reports that a virus was spreading around China from staff based at Liebherr's Chinese subsidiaries. And this was subsequently confirmed by the media. At the beginning of February, we had to shut down our Chinese manufacturing companies, and our employees working in China switched to remote working. We only really realized the global extent of the virus at the beginning of March when the situation in Europe started to look more serious.

Sophie Albrecht: I can remember it really well. I was visiting Conexpo, the construction machinery trade fair in Las Vegas. The atmosphere was very different – you could sense a general feeling of uncertainty. We had been looking forward to meeting our customers from Asia, but they were unable to travel. On some stands, machinery was on display but there were no personnel. And people had also stopped shaking hands when they greeted each other. Whilst I was at the trade fair, the situation in Europe changed dramatically. The borders were closed shortly after I returned and we had to partially or completely shut down production at many of our sites. It was really surreal and difficult for us all to comprehend at first. But it soon became clear that we needed to learn how to adapt to the situation as quickly as possible.

How did the outbreak of the pandemic affect you personally?

Isolde Liebherr: It affected us the same way as it did many other families. Our lives were suddenly very different. We had to practice social distancing and were continually worried about contracting the virus or passing it on to others. We also kept contact with our children and grandchildren to a minimum. It is difficult not seeing them very often.

Patricia Rüf: Having to suddenly adjust to living every day within the much narrower confines of our homes and having to dramatically reduce our contact with others is a big change. Face-to-face contact with our customers and employees as well as regular contacts to customers and our companies and offices all around the world are an important part of our jobs. This all disappeared overnight. Fortunately, we were able to keep the communication lines open thanks to digital technology. However, I can't wait to meet people in person again and speak to them face-to-face.

What were the biggest challenges from a business perspective during this time?

Willi Liebherr: This unprecedented situation has unquestionably had an impact on the entire Liebherr Group. We had to strike a balance between protecting every Liebherr employee and ensuring that our factories and company offices continued operating. As a family-owned business, the health and well-being of our employees is our top priority. We responded quickly to facilitate remote working wherever possible. We modified shift patterns, converted canteens, implemented the "Hands. Face. Space" rule and provided face masks and disinfectants. And we also listened. We appreciated every suggestion for improvement that we received from members of staff.

Isolde Liebherr: At the beginning, the economic uncertainty, global lockdowns and supply chain disruptions thankfully only resulted in a few cancelled orders and our companies only had to be closed on a temporary basis. Looking back, it's fair to say that we quickly got the situation under control. The Group's decentralized structure has once again worked to our advantage. We were able to manage the Group at a central level, whilst allowing our companies to respond as they saw fit and take into account requirements based on the country, region, and specific legal situation.

What conclusions do you draw from this?

Patricia Rüf: The pandemic and its effect on conditions in general must not stop us from looking positively into the future. We've learned that unforeseeable circumstances can quickly turn everything on its head. But we've also learned that we are capable of dealing with these kinds of situations. We are a strong, financially independent company. Our job is to make sure this continues to be the case. And it became apparent once again that we are flexible. We are able to react quickly to changing circumstances. To put it briefly, we have proven that we are an adaptable company. We have been able to progress during the pandemic. We have digitalized numerous processes and found new ways to collaborate with our customers and partners. We are working on new development projects

and processes and will continue to do so. All of this allows us to look forward to a bright future. We will emerge stronger from this phase, too.

Nearly 48,000 people work for Liebherr all around the world. What measures are you currently taking to safeguard jobs?

Patricia Rüf: Anyone who experienced the financial crisis whilst working at Liebherr back in 2008 and 2009 will remember that the Group introduced every possible type of measure to safeguard jobs. The same applies to the current situation. We are very happy that we could keep our headcount stable throughout 2020. We've introduced some measures to cushion the impact of the pandemic on our employees. For example, we have introduced short-time working, temporarily reduced working hours, and have ensured that we continue to pay wages at all times. We've also boosted certification programs and enabled employees to transfer to other departments. In addition, we've temporarily redeployed staff at different sites in order to balance out capacity fluctuations between our manufacturing facilities.

Let's turn to some of the Group's key figures. Liebherr achieved a turnover of €10,341 million. What does this mean to you?

Isolde Liebherr: We already knew during the spring of 2020 that we would not meet our sales forecast for the year and we soon realized that we would have to factor in a substantial drop in sales. However, as the year went on, we were able to make up for the lost months in some of our product segments. We are very satisfied with the results, considering the circumstances.

Sophie Albrecht: We are pleased that we were able to achieve a small positive operating result. Despite difficulties in the currency markets and tax accounting challenges, we were able to report a moderately positive result after tax.

What were the key milestones and highlights of 2020 for you?

Isolde Liebherr: I think an overwhelming feeling of togetherness is what will stay with me the most. We have all had to deal with an extremely challenging year on a personal level. And despite this, our employees have quickly adapted to new ways of working and shown an amazing amount of commitment, creativity, and loyalty. We would not have gotten through the year without them.

The performance of our Refrigeration and Freezing product segment has also been a particular highlight for me. For the first time in our company's history, we posted a net turnover of €1 billion for this segment.

I was also delighted when I found out that some of our chefs had received prestigious awards from Gault&Millau Austria. Our head patissier at the Interalpen-Hotel Tyrol was awarded "Patissier of the Year," and our head chef at the Löwen Hotel in Montafon won his third Gault&Millau toque. These are truly remarkable achievements.

Willi Liebherr: I was particularly pleased that despite a fall in sales, the order book for Earthmoving was much healthier by the end of the year compared to its starting position in January. We were also able to continue developing new technologies such as electric drive concepts in our Materials Handling Technology segment. I think we can draw very positive conclusions from this which apply across the entire Group.

2020 also marked an important anniversary – our 50th year in the USA. We celebrated this special event at Conexpo in Las Vegas with the slogan "50 Years United by Successs." It was great to celebrate this event with some great machinery on show.

Our Concrete Technology segment also reached an important milestone in 2020 when it delivered its 100,000th truck mixer manufactured since 1967.

Liebherr Aerospace was also awarded the "Best Supplier Award" by Comac and Embraer. We were very pleased to be honored with such an accolade, which demonstrates that we are able to provide our customers with high-quality products and services, even during difficult times.

Patricia Rüf: I was pleased to see the strides we are continuing to make in digitalization across the Group. This was particularly evident in the first-ever remote assembly of a mobile harbor crane. Our team of technicians based in Germany assisted with the construction of the crane in Argentina using our digital service app.

We are also very excited to be one of the founding members of the "Center Construction Robotics," project. The project is being run by a consortium of companies from Europe and an interdisciplinary team of researchers at RWTH Aachen University who are working together to develop "the construction site of the future."

Another highlight was that we were able to maintain our position as the global market leader of duty cycle crawler cranes within our Deep Foundation Machines segment.

A number of innovations were also premiered by our Gear Technology and Automation Systems segment, including the LGG 500 gear grinding machine, the LK 280 DC gear skiving machine, and an innovative automated assembly concept for battery packs.

Sophie Albrecht: I was very pleased that despite the conditions last year we were able to present several products to the world in the digital space. This included the LR1250.1, which is the world's first battery-powered crawler crane, the TA 230 Litronic articulated dump truck and a new addition to our mobile crane fleet, the LTM 1150-5.3. We are also very pleased that sales remained high for our Mobile and Crawler Cranes segment, and that we could efficiently resume crane deliveries following the difficult period in March and April.

Our Mining segment also achieved great things in the customer service arena. The team pulled out all the stops to provide each customer with the best possible solutions. The 1,000th mining excavator also rolled off the production line – an achievement we are particularly proud of.

We also learned that Asia continues to be an important market for the Components division, particularly the wind energy sector. This is why we are investing in new facilities in China and India.

You have already touched on the fact that Liebherr is working on a wide range of digital technologies. But a lot is also happening in the area of product stewardship. Could you outline what is happening on this front?

Sophie Albrecht: Product stewardship means ensuring that our products are safe, efficient, and environmentally friendly. Workplace safety and emissions reduction are therefore key components of our development work. You only need look at the many innovations that are mentioned in the 2020 Annual Report. These include the electrification of the T 236 mining truck and the fully-electric and hybrid construction machines, such as the LR 1250.1 unplugged crawler crane and the ETM 1005, our fully electric truck mixer. We are also working on fuel cell systems for mobile equipment in Aerospace and Transportation Systems.

And we are promoting new ways of working through our new digital technologies. Our condition monitoring solution allows our customers to monitor the life cycle of their machinery and components at any time. Our augmented reality tools and Remote Service App enable us to provide excellent customer service and maintenance solutions which help to avoid multiple visits. Our digital services, such as the Crane Planner and MyJobsite, also help our customers to carefully plan on-site activities before they even use any construction machinery.

Finally, can you give us your outlook for the current financial year?

Willi Liebherr: We are certain that this year is going to be better, and our sales forecasts are looking promising. We also have good reason to feel more optimistic due to changes in the geopolitical situation, now that there no longer appears to be a major trade war on the horizon and renewable energy solutions are becoming increasingly relevant. This opens up many opportunities in the future, and we are certainly in a good position to offer plenty of excellent solutions.

We strongly believe that the technical projects we have already initiated have put us on the right track for the future. And this is why investing in the future is and will remain so important to us. We believe that investment is a critical factor for healthy growth and for the future of our company. This also applies to the current financial year.

The year 2020 in numbers

The Liebherr Annual Report

10,341
Turnover in € m

605
Investments in € m

47,925
Employees*

* as at year-end; worldwide

Turnover by product segment

	€ m	%*
Earthmoving	2,008	-10.4
Material Handling Technology	477	-24.2
Deep Foundation Machines	258	-17.0
Mining	964	-9.8
Mobile and Crawler Cranes	2,504	-4.8
Tower Cranes	444	-18.5
Concrete Technology	193	-10.2
Maritime Cranes	795	-10.4
Aerospace and Transportation Systems	1,024	-31.3
Gear Technology and Automation Systems	213	-12.3
Refrigeration and Freezing	1,007	2.4
Components	403	-6.3
Others	51	-33.8

* Changes compared to the previous year in percent

>140
companies

>40
production sites

Present in over **50**
countries on all continents

International presence

You can find the Annual Report online:
www.liebherr.com/annual-report

More than just a logo

What's behind Liebherr's new brand identity

You've probably already noticed that something has changed when you first opened this magazine or visited our website: Liebherr has a new brand identity – and it's not just about the logo.

Strengthening the brand
Strong brands don't come about overnight. They have a history, and they are the result of years of effort and systematic work. They emerge when what a company promises its customers and the public is actually delivered and people have certain positive associations with a brand. And this needs to be consistent over many years.

Which is exactly what Liebherr does. A recent study on Liebherr's brand image has confirmed that Liebherr is a strong brand. But we aren't just going to sit back and be content with what we've achieved so far. The Liebherr brand has the potential to become even stronger. To this end, the Group has decided to update its brand identity. However, a professional brand presence is not a product of chance or something that just happens. There is a structured process behind it, from analyzing the previous brand image and developing a sound strategy to elaborating and implementing essential elements of the new brand image. And we have gone through this process to a large extent here at Liebherr.

Our new brand identity covers a wide range of aspects, from our logo, typeface, and colors to what the design looks like overall, and how we present ourselves at trade fairs. We also created a new communication basis that reflects the content of Liebherr's brand experience and presents our key corporate messages. There will also be changes in our language: we plan to round off our brand experience with a fixed set of terms and guidelines on tone and style. All those changes together will determine how people will experience the Liebherr brand from now on.

Bringing the brand experience to life step by step
The first results of this development have been evident since April. We gave our website a facelift, for example, and premiered new elements of our revamped corporate design – just a few clicks is all it took! As part of our new brand identity, our website now also features Liebherr's new look and feel.

This issue of our magazine also sports the new design for the first time, with many new basic graphic elements. Immediately obvious are the technically optimized Liebherr logo and our new corporate typeface. The latter, in particular, creates a characteristic and unique effect. Finally, the updated color scheme is intended to give the magazine a modern and inviting touch.

Of course, that's not all that has changed and will change. So keep an eye out for innovations – they are just around the corner!

Memorable
The high recognition value of the new Liebherr design

The most important visual changes

There were many changes. They are based on a modular system of basic elements and layout principles. How does this work? Like building blocks, the individual elements can be combined to create different designs and layouts. The three key elements are:

Optimized logo
The existing logo is strong and characteristic of our brand, so we have made only minimal changes. The shapes of the letters have been optimized, and the spacing between the individual letters has been increased. This makes the logo easier to read and ideal for small sizes and digital applications.

New Liebherr typeface
Liebherr now has its own unique typeface with a high recognition factor. This allows us to communicate independently and autonomously.

Whether in headlines, continuous text, or product labels – the new typeface is easy to read in every setting.

Liebherr Head Black
Liebherr Head Regular

Liebherr Text Bold
Liebherr Text Medium
Liebherr Text Regular

Liebherr Text Bold Italic
Liebherr Text Medium Italic
Liebherr Text Regular Italic

Liebherr Text Condensed Bold
Liebherr Text Condensed Regular

LIEBHERR PRODUCT

Distinctive color scheme
In the future, both the Group as a whole and the individual product segments will communicate in yellow. Only the Refrigeration and Freezing product segment will keep the color blue. Our color scheme continues to be white, black, and yellow. An additional secondary color palette rounds off the new color design.

Liebherr Yellow
Liebherr White
Liebherr Black

Liebherr Arctic Blue

Steel
Slate
Terra
Clay
Leaf
Ruby

Chasing for cold

Already been to the refrigerator today? Fresh food, ice cubes in the drink, air-conditioned rooms – nowadays, cold is omnipresent and taken for granted. However, getting there was a long, sometimes exhausting, journey that demanded a great deal of ingenuity.

Refrigeration technology is everywhere:
in the home, in supermarkets, in the office, in manufacturing, in museums, or in operating theatres. It provides the latest in precision control; from ambient comfort and fresh food through to cold storage and super-freezing for sensitive, life-saving medical products and vaccines. And day after day, it helps fulfill one of humanity's most long-held dreams.

Blowing hot and cold
"For Heat and Cold are Nature's two hands, whereby she chiefly worketh; and Heat we have in readiness, in respect of the Fire. But for Cold, we must stay till it cometh, or seek it in deep Caves, or high Mountains; and when all is done, we cannot obtain it in any great degree." English philosopher and statesman Sir Francis Bacon (1561–1629) summed up the dilemma of the pre-industrial age: cold is simply impossible to grasp. Perhaps because it doesn't actually exist? In physical terms, cold is in fact heat – or rather the absence of heat or, to put it more simply, a state that is lower than the ambient temperature.

Even the early hunter-gatherers knew that lowering the temperature could make life a lot easier and more agreeable. They began preserving perishable food not only by drying and curing it, but also by keeping it in cool caves or holes in the ground, thus paving the way for their transition to a settled lifestyle.

The cold rush
In those places where ice was within reach, people often went to great lengths to transport it to cold storage rooms. Once the basic concept had been grasped, a broad variety of culinary delights and an overall better quality of life were only a few steps away. The infamous Emperor Nero (37–68 AD) sent teams of runners up into the Alps to carry ice back to Rome in special backpacks so he could cool his (presumably alcoholic) drinks.

Ice was a hot commodity in classical antiquity and the Middle Ages. People who could afford it dug deep into their pockets to store natural ice carved from glaciers and lakes in deep pits and cellars during the winter, so that it could be used bit by bit during the summer months.

Food storage, as well as certain fermentation and ripening processes, was highly sensitive to temperature. This made people inventive, giving rise to underground storage rooms, where clay pots and heavy wooden barrels and chests were used to keep the temperature as stable as possible.

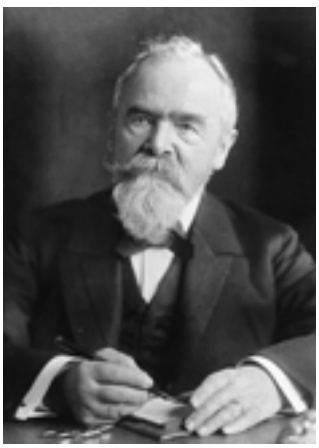
While the growing demand for refrigeration resulted in increasingly sophisticated logistical solutions, and natural winter ice began to be carved out of Arctic seas, glaciers, frozen lakes, and rivers and transported to far-flung markets, it remained by its very nature an ephemeral commodity that usually did not survive the summer, even behind the thickest of walls or with the use of chemicals such as saltpeter and water.

Refrigeration played a particularly important role in the production and storage of beer and wine. “A wise brewer always keeps his cellar full of ice,” advises a brewers’ and maltsters’ calendar as late as 1880. Each year, the 17 breweries in Munich (Germany) alone stockpiled 56,000 tonnes of block ice to achieve the low temperatures required for the production of especially flavorsome bottom-fermented beer.

At the same time, the desire to produce cold and ice artificially fired the imagination of many a clever inventor and technician in the early years. In 1756, Scottish physician and chemist William Cullen was the first to produce small amounts of artificial ice at the University of Glasgow by evaporating diethyl ether. It took almost another 100 years until the chemical refrigerator was developed in 1834. This appliance, however, was not suitable for private households, and so the only option available to most people was to place blocks of ice inside boxes specially lined with wood and insulating materials to create the popular “icebox.”

A breakthrough for compressor technology

German engineer and inventor Carl Paul Gottfried Linde (1842–1934), or Ritter von Linde as he was known after he was knighted in 1897, was the first to break new ground in 1873 with his calculations on the efficiency of compressor technology as compared to absorption technology, which was then the prevailing method used in refrigeration and air-conditioning. Professor Linde promptly founded his own company and very quickly attracted the interest of other inventors and entrepreneurs. The first to benefit were the brewers. By the 1930s, refrigerators had become a standard feature of private households in the USA.



Carl Paul Gottfried Linde (1925)

In other parts of the world, however, refrigerators were still viewed as luxury items and symbols of prosperity and progress, and it took quite some time for the new technology to become commonplace. Refrigerators were expensive, bulky, and didn’t work without a reliable power supply. In countries like Germany, community cold stores for storing fruit, vegetables, and other provisions continued to hold the advantage. It wasn’t until the 1950s that the Wirtschaftswunder (the post-war economic boom in Germany) heralded the introduction of the refrigerator into private life – daily shopping trips became a thing of the past and home cooking became increasingly varied, setting the tone for a new era of prosperity and social, economic, and technological progress.

Hans Liebherr discovers the market gap – and creates a global brand

Liebherr entered the market for designing and manufacturing refrigerators in 1954. Right from the outset, company founder Hans Liebherr focused on quality products – from the first floor-mounted appliances through to integrated refrigerators and combined fridge-freezers. As early as 1978, the specialist manufacturer began to develop refrigeration batteries, which create an additional cold reserve to maintain temperature in the event of a power failure. From innovations such as NoFrost and BioFresh (a patented technology for improved freshness) to the use of natural coolants combined with more efficient refrigeration circuits and new insulating materials, Liebherr has set, and continues to set, benchmarks in the industry.

The company offers a wide range of models worldwide – all with top energy efficiency ratings. Energy labeling of all refrigerators and freezers in Europe has been revised as of March 1, 2021. The previous labeling system offered consumers very little help when choosing what to buy, because all the products were concentrated at the top of the scale. With the new labeling system, devices will be rated on an efficiency scale from A to G so they are more spread out, giving a clearer overview. Classifications like A+++ will no longer be used. Refrigeration technology is not just used for keeping food products cool, though. In medicine it is indispensable for laboratories, research institutions, and ultralow temperature freezers, as seen recently in the storage of new types of mRNA vaccines.

Liebherr also develops energy-efficient, ecological equipment for climate control on trains, metro systems, and aircraft, and for reliable transportation of goods in a temperature-controlled environment in refrigerated semi-trailers. In addition, the company is developing completely new specialist applications, such as those increasingly used in electromobility to cool live high-voltage cables or batteries. Liebherr is also involved in space technology. The company and its partners are developing key components for the technology payload and platform cooling system to actively control electronic heat dissipation on board next-generation telecommunications satellites. As the evaporators and condensers will be spending at least 15 years in space without maintenance, they must be extremely reliable.

High-precision refrigeration technology is also essential for controlling air-conditioning in operating theatres, intensive care units, and radiology measuring systems. The field of refrigeration and cooling technology is constantly expanding. Global sales in the non-commercial business segment alone are in the order of more than €100 billion, with a strong upward trend. This will lead to a corresponding intensification in the pressure to innovate. Climate change and political demands for more sustainable technologies mean that experienced and innovative developers are more in demand than ever before – people who can think outside the box in their own field and who know how to forge new links between different subjects and disciplines. The search for cold continues – Sir Francis Bacon would probably be delighted to see how many new prospects are associated with the field today.

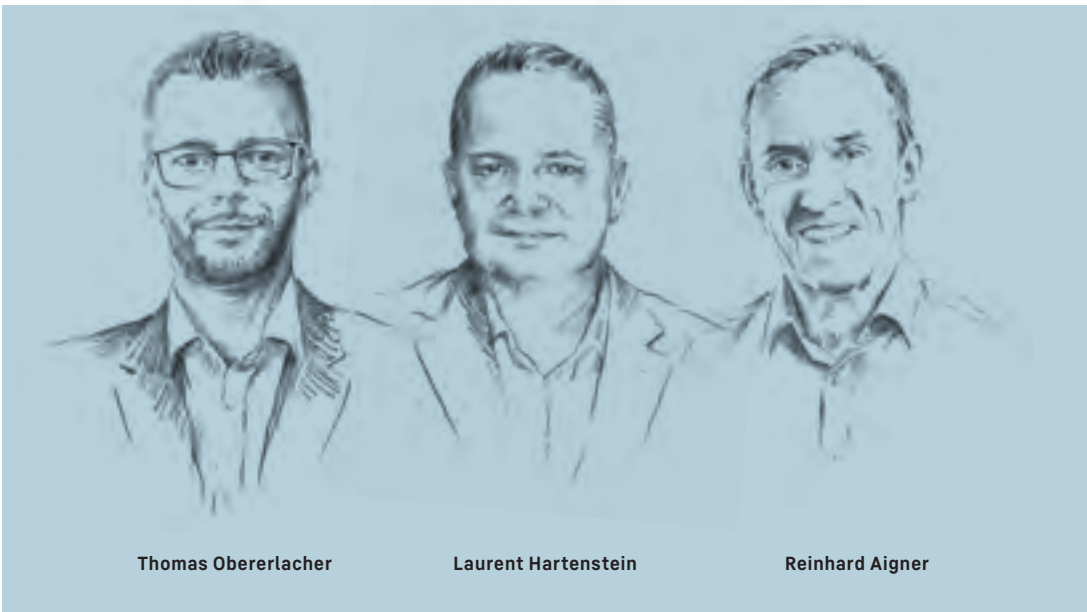
1954 Liebherr enters the refrigerator design and manufacturing business

One topic, three industries: the present and future of cooling

What does a freezer, an aircraft cabin, and a charging cable of an electric car have in common? None of them would function without cooling. Cooling and air-conditioning are hot topics at Liebherr. Demand for reliable air-conditioning is growing worldwide – whether for comfort or as a technical requirement. Cooling systems is a large market. So we decided to sit down with three experts from different areas within our Group to learn more about it: Thomas Obererlacher from the refrigeration and freezing appliances segment, Laurent Hartenstein from aerospace, and Reinhard Aigner from transportation systems.

Where are we now and where will we be tomorrow?

Are there over-arching trends and challenges?



Thomas Obererlacher | Laurent Hartenstein | Reinhard Aigner

Let's get started straight away with transportation systems. Mr. Aigner – whether it is trains, trams, or the metro. What are the current cooling solutions?

Reinhard Aigner: Cooling is based on the principle of a vapor-compression refrigeration system. Synthetic refrigerants are still the most frequently used option. However, depending on the area of application we also work with CO_2 or air as the refrigerant.

Our customers in the transportation industry are, with a few exceptions, rather traditional in the refrigerants they use. Technologies only become established if there is sufficient demand for them. The pressure to change comes particularly from institutions, for example the F-gas Regulation of the European Union. Air-conditioning units with air circulation on the ICE 3 of the Deutsche Bahn were introduced.

The general trend in air-conditioning is clearly heading towards the use of CO_2, air, or other natural gases with minimal global warming potential. For instance, the refrigeration and freezing segment uses propane and butane in their cooling circuits. However, these substances have a significant disadvantage when used in the quantities required for the transportation industry: they are highly combustible.

Refrigeration and freezing are a good segue into the next topic. Mr. Obererlacher, what is different with refrigerators – especially in terms of technology?

Thomas Obererlacher: Compared to other industries, our cooling technology is already quite green as we use electricity for cooling and the energy consumption has been greatly reduced over the last few years. We are intensively working on making cooling technology even more efficient and therefore more sustainable. People have been talking about "new cooling technologies" for some time now. However, it remains to be seen whether these technologies will become established in the long term.

What do you understand by "new cooling technologies"?

Thomas Obererlacher: Examples of new technologies include the so-called calorific processes. These cooling systems do not require a compressor or refrigerant. In these processes, a suitable calorically sensitive material is subjected to a cyclically changing field – this can be magnetic, electrical, or mechanical – which causes a temperature change that can be used for cooling. We are keeping a close eye on these technologies. However, its use only makes sense if significant advantages arise in terms of energy consumption and sustainability. In the Liebherr refrigeration and freezing appliance segment, we already recognized many other innovations as being more attractive in a timely manner.

For example, we are focusing on the ideal storage conditions for every food. We are continuously working on new solutions, such as our BioFresh technology, for storing food at optimal conditions to extend its shelf life and play a part in reducing food waste.

Another important focal point is the use of intelligent new materials and components to produce sustainable products, as well as digitalization. One thing is clear – smart technology is the way of the future!

You mentioned efficiency, which leads us on to the aerospace industry: Mr. Hartenstein, what role does efficient cooling play in the aerospace industry?

Laurent Hartenstein: If we look at modern air transportation, efficiency does not only lie in cooling performance. Energy-efficient systems shall cater for air-conditioning, air quality, and comfortable cabin pressure functions as well.

The aerospace industry has always been an energy-intensive business. Technologies in the aerospace industry are continuously evolving, driven by economic and environmental factors. To make "greener" aircraft, sustainable solutions are now a must. Reducing the footprint of the aerospace industry on the environment – by reducing fuel consumptions or enabling "greener" fuel solutions – has become a great priority.

And which specific technologies are used at Liebherr-Aerospace?

Laurent Hartenstein: The air-conditioning system is one of the largest energy consumers on board a passenger aircraft, where 2–3 percent of the engine power is used to air-condition the aircraft cabin. This is equal to around one kilowatt for every passenger. Making this function more efficient is therefore a key differentiator that needs to be pursued to offer best-in-class products.

Our challenge is to maintain technological advances in the wide range of products we offer to support the needs of our market. This requires innovative technology measures in many fields: from vapor compression cycles to turbomachinery. Vapor compression cycles, also used in the refrigeration and freezing appliances segment, represent 10 percent of the market for "small" carriers. Whereas turbomachinery – which uses air itself as the cooling media – accounts for 90 percent of the market for systems. Nothing is greener than air when it comes to the greenhouse effect!

One of the main technological changes that can be noted in this quest for efficiency is the change in air systems. Conventional systems use air extracted from high pressure compression stages of the engines and process it to meet adequate comfort in the cabin. This entails a significant waste of energy in the process. That's why we are introducing an innovative system using ambient air. This system takes "just" the necessary energy to bring it to the cabin. It has the advantage of drastically reducing the power consumption for the function and is always ensuring the highest possible quality of air supply for the passengers.

What potential do you see in fuel cells and electric drives?

Laurent Hartenstein: These technologies are a major step beyond the conventional aircraft and require new aircraft and possibly propulsion systems concepts. They represent full or partial alternatives to the use of fossil fuel. That's why they are thoroughly investigated in order to drastically reduce the environmental footprint of aviation.

Fuel cells are already in use in stationary and automotive applications. Mastering fuel cell cooling is clearly a catalyst for this technology to be fully adapted in aerospace applications. This is an advantage for us.

Preparations for these future activities have already begun: at system level through our knowledge of integrated airborne cooling systems and key core products used, such as motorized turbomachines and heat exchangers.

Mr. Aigner, the situation in traffic engineering is different. Electric mobility and fuel cells are no longer a futuristic vision. How is Liebherr getting involved?

Reinhard Aigner: We are already playing a part when it comes to cooling in the context of electric mobility – with rapid charging stations for electric cars or battery cooling of battery-powered bus or railway vehicles. Faster charging of electric cars will be possible using higher voltage and current. With thermal conditioning units, the cables and plugs used for charging on these rapid charging stations are cooled with a fluid to significantly reduce the charging time.

The charge capacity must also be further increased in the future as electric mobility becomes more widespread. In parallel to this, charging should also be made more convenient, for example through an inductive charging process – in other words, wireless charging. The inductive charging station may need a cooling unit for an efficient and rapid charging process and our cooling systems could play an important role here, too.

As you can see, cooling and air-conditioning are and will remain a very diverse and extensive field for Liebherr. Is there any way you could summarize the parallels amongst these individual fields?

Laurent Hartenstein: I see the cooling technologies first and foremost as "something that empowers people." The development of cooling technologies is driving major changes in the way people behave. This applies to all areas where Liebherr is involved in cooling.

The invention of the refrigerator and the technology behind it introduced a complete change in the way people live and interact with food – what products they consume and have access to, how they consume it, and so on.

The situation in the aerospace industry is similar: Until the 1940s, the only way to have a cabin environment – meaning pressure and temperature – compatible with passengers, was to fly at low altitude. A flight from Munich to New York required over 20 hours and several stops and could only carry 30 passengers! The invention of a conditioned, pressurized cabin and the technology behind it, has drastically changed the travel capabilities and costs of aviation. This makes long haul flights accessible to many more people across different time zones.

What drives us all at Liebherr is the ambition to push technological progress. We continuously make investments to further develop our products so that we can offer solutions for the challenges of our times.

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