InFlight

Liebherr-Aerospace Magazine
2023 / 2024

LIEBHERR

Alex Vlielander, Martin Wandel, François Lehmann and Dr. Klaus Schneider (from left to right)

Dear Reader,

This issue of our magazine focuses on the development of Liebherr's aerospace activities, which are characterized by a lot of optimism, although our industry is confronted with many challenges.

The aerospace sector finds itself in a situation that it had never experienced before. Recovery of air traffic demand picked-up after the pandemic, fueling the expectation to be back on 2019 levels by next year. Accordingly, commercial aircraft production is ramping up and new aircraft orders are coming in.

However, this positive outlook is clouded by challenges arising from geopolitical shifts and showing the fragility of our global supply chain. High inflation rates and increased energy costs are impacting financial results. Smaller suppliers are struggling to survive and need financial support. Missing material availability and the need for resourcing is slowing down supplies, leading to high levels of work in progress at OEMs and system suppliers. In addition, our industry is facing a difficult labor market, with increased competition for skilled people and young talents. Employer attractiveness and retention are therefore both in the focus of our company.

However, Liebherr-Aerospace and Transportation Systems is based on solid foundations and we are continuously preparing the future of flight by investing above industry average in innovative products, industrial capabilities and services as well as our employees. We accept the challenges on digital transformation and sustainability. Both will significantly change the way of our operations along the whole product life cycle. Against the background of all these challenges, we have rolled out a new corporate strategy, setting the path until the end of the decade and beyond, ensuring that we remain a strong and reliable partner of our customers.

transform.develop.sustain. is a strong slogan that supports our strategy, capturing its main messages: This decade will be a decade of transformation. We will develop our products and capabilities, adapting to the changing market requirements. Sustainability of our operations but also of the future transport system will drive our roadmap.

Expect to get excited by Liebherr-Aerospace and Transportation Systems as an attractive employer working on solutions for a sustainable transportation eco-system. Let's take the future into our hands and jointly re-shape our industry. Now is the right time!

Best regards,

Alex Vlielander
Chief Customer Officer

Martin Wandel
Chief Operating Officer

François Lehmann
Chief Financial Officer

Dr. Klaus Schneider
Chief Technology Officer

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The World with Liebherr

Find out more news from Liebherr in this chapter

Impressions

Flying high in a chamber

Liebherr-Aerospace has two large altitude chambers at its site in Toulouse (France) that are used to test air management systems and their components. The chambers are connected to a high-performance compressed air and vacuum circuit, which is used to simulate pressure conditions that prevail at high altitudes.

In the middle of it

Forward-looking planning leads to lasting success: employees of Liebherr-Aerospace in Lindenberg (Germany) gather at the "Shopfloor Meeting Point" and work on optimal processes to ensure delivery dates agreed with customers. And they don’t do this just anywhere, but directly and close to the equipment, as here in the assembly of primary flight control components.

© Boeing

Majestic...

Boeing has delivered the final 747 (a 747-8 Freighter), the 1,574th in total since its production started in 1967, in Seattle, WA (USA) on January 31, 2023. Liebherr-Aerospace is proud of the fact that its air-conditioning and engine bleed air system will be flying on the 747-8 for years to come. The company has been and will provide customer support regarding its equipment for all 747-8 aircraft in operation.
The 747 changed the way the world traveled and Liebherr is honored to be part of this incredible history of the “Queen of the Skies”.


LIEBHERR REF.
LIEBHERR REF.

On the move

To support internal logistics at Liebherr-Aerospace, various autonomous transport systems are currently being tested in Lindenberg (Germany), while several robots are already in use at the plant in Toulouse (France). They deliver for example equipment for repair to employees in the customer service area.

Industry Information

Helicopter pilots train to fly at night on an offshore platform.

Successfully navigating turbulent times: The path to recovery

The aviation industry faced unprecedented challenges during the COVID-19 pandemic due to a sharp plunge in air travel demand and widespread disruption to global supply chains. However, as vaccination rates increase and travel restrictions are mostly lifted, industry recovery has started and there are signs of optimism for further growth in the coming years.

One key driver of this recovery is the increasing air traffic demand, which is expected to return to pre-pandemic levels by the middle of the decade. This demand will be further fueled by aging aircraft fleets and the need for more fuel-efficient and environmentally sustainable aircraft. While the future of the original equipment manufacturers (OEMs) is closely tied to the overall health of the aviation industry, it is also subject to various additional factors and uncertainties, such as the increasingly competitive race for human talent in the industry, technological innovation, regulatory issues, as well as supply chain and continuously high inflation levels.

Liebherr-Aerospace, like many other companies, faced numerous challenges during the pandemic as well, specifically in the area of Supply Chain. However, the company was able to adapt and overcome these challenges through various measures. For example, it worked closely with its suppliers to ensure continuity of supply and maintained open communication channels to quickly address any issues that

arose. It also optimized inventory levels to ensure it had the necessary components and materials to continue production during any disruptions. Liebherr also diversified its supplier base to reduce reliance on a single supplier or region. Most notably, the company utilized digital technologies to enhance its supply chain visibility and agility, enabling it to quickly identify and respond to any issue.

Rising passenger numbers – lower cargo yield

When looking ahead, the International Air Transport Association (IATA) predicts that airlines will return to being profitable in 2023 for the first time since 2019, boosted by passenger demand, which should in turn boost the business of OEMs. However, the expected net profit margin for airlines in 2023, according to IATA, is still razor-thin, at 0.6% (US$ 4.7 billion), compared to 2019's 3.1% (US$ 26.4 billion). Nevertheless, it will also be the first time since the beginning of the pandemic that more than 4 billion people are expected to fly to their destinations, generating revenues of $522 billion. According to IATA, about 70% of travelers in 11 global markets are traveling as much or more than they did prior to the pandemic, even though the vast majority of them (85%) find the economic situation still concerning.

While IATA expects in 2023 passenger demand to reach 85% of the 2019 levels, cargo yields should fall 22.6% to US$ 149 billion. Most of the retraction is forecasted to happen in the latter part of the year, following the impact of inflation-cooling measures. Better prices for oil and jet kerosene also lead IATA to predict that the expenditure on fuel will remain consistent at 30% of the airline expenses, after some re-accommodation of the destabilization caused by the Russian invasion of Ukraine.

The outlook may, however, shift significantly, positively or negatively, depending on the largest player in the Asia-Pacific market: China. The country has maintained its strict zero COVID-19 policies and restrictions longer than anticipated, and the expectation is that there will be an easing over the second half of the year.

A look into the future

Among the key drivers for OEMs is the Advanced Air Mobility (AAM) industry. There is a strong focus on new technologies and use cases such as urban air mobility enabled by electric vertical takeoff and landing (eVTOL) aircraft, drones, and electric aviation powered by batteries or hydrogen. According to McKinsey, 6,700 orders and options were placed in 2022 for such vehicles, representing about US$ 45 billion – against a combined investment of US$ 102 billion in the five previous years. The players in this segment have a ticking clock to meet certification deadlines by the middle of this decade, so it is anticipated that 2023 should see these projects ramping up. However, many aspects of an AAM ecosystem will have still to be solved.

Another important trend to notice is the decarbonization of the skies. The consulting firm Deloitte highlights that in order to advance decarbonization of aviation, the industry will likely establish multiple partnerships consisting of technology investors, energy companies, airlines, and government agencies, as digital technologies and capabilities are increasingly becoming a competitive necessity. They also present specific challenges in the human resources area, as automation and advanced technologies demand workers with more advanced aerospace engineering, math, data science, and digital skills.

More space for future technologies

A little earlier than planned, Liebherr-Aerospace in Lindenberg (Germany) started with its expansion building already announced in September 2022. The company is continuously investing in forward-looking methods and processes including the area of surface treatment.

The groundbreaking ceremony for the building to cover already existing floor space at Liebherr-Aerospace took place in March 2023. With the approximately 1,000-m² extension, the company will create more space for state-of-the-art technology in surface treatment.

"The demands regarding components in the aviation industry are among the highest in the world. Our products have to withstand the most extreme temperature differences and high loads. With this extension, we are creating the environment for the necessary complex coating processes," explains Martin Wandel, Chief Operating Officer at Liebherr-Aerospace & Transportation SAS and Managing Director Operations at Liebherr-Aerospace Lindenberg GmbH.

The new building complex will house a center of excellence for coatings, where alternative materials for more sustainable surface treatment will also be developed. The modern coating facilities will enable new processes to replace the hard chrome used to date. Liebherr is the first aerospace company worldwide to use the sensitive coating processes within series production not only in

the treatment of outer diameters, but also in component inner diameters.

Liebherr-Aerospace is always guided by modern construction standards for the infrastructure of its sites. Heat recovery is used in the new building – a heating method that is tried and tested at the company. In addition, the heat pumps used are no longer operated with environmentally harmful refrigerants, but with gas. A photovoltaic system will be installed on the green roof to generate power.

The extension is scheduled for completion by the end of 2023, followed by commissioning in 2024.

Creation of hundreds of new jobs
Overall, Liebherr-Aerospace Lindenberg GmbH plans to create approximately 300 new jobs within the next two years in context with this and other investments.

"The aerospace industry continues to recover and our deliveries are increasing strongly. To ensure our customers receive the highest quality products expected from Liebherr-Aerospace, we are counting on our dedicated specialized staff. However, we are still looking for motivated employees to strengthen our team," explains Philipp Walter, Managing Director Commercial.

The company has vacancies particularly in the areas of surface treatment, machining and materials testing. Applications are possible via the job portal for the current vacancies:

www.liebherr.com/en/deu/career/job-vacancies/job-vacancies.html

With the help of a Liebherr crane, construction site activities are progressing quickly.

Eric Ballerstedt, Mayor of Lindenberg (2nd from right), and the Managing Directors of Liebherr-Aerospace Lindenberg GmbH, Gerd Heinzelmann (3rd from right), Dr. Klaus Schneider (2nd from left), Philipp Walter (3rd from left) and Martin Wandel (right) as well as Werner Gebauer, Member of the Works Council of Liebherr-Aerospace Lindenberg GmbH (left), had a look at the construction site.

More sustainable air transport: An emblematic project in Toulouse

Developing the More Electrical Aircraft of the future is a priority shared throughout the aviation industry. Among the solutions being considered, Liebherr-Aerospace Toulouse is working on systems and equipment to reduce fuel consumption and to contribute to more sustainable air transport.

An emblematic project consists of using a hydrogen fuel cell power source to generate sufficient electrical power, in the range of 400 kW, to feed all the non-propulsion systems of next-generation aircraft. Liebherr-Aerospace Toulouse is developing this power generation system as part of the France Relance (France Relaunch) plan with the support of the French Civil Aviation Authority (Direction Générale de l'Aviation Civile).

In order to test and assess this solution in a representative environment, Liebherr, supported by the Région Occitanie, installed a hydrogen test bench in its test center at its Toulouse site.

This new investment in test facilities will enable Liebherr-Aerospace Toulouse to demonstrate the ability to generate electrical power, using fuel cells, to supply the major non-propulsive electrical systems of a new generation single-aisle aircraft, while ensuring the thermal management of the whole (fuel cells and electrical systems).

In addition to these substantial investments in hydrogen, Liebherr-Aerospace Toulouse is also developing new systems and equipment with lower emissions, particularly of CO_2, and is working with the wider aeronautical industry and other academic institutions to step up development of the systems and equipment needed for the next generation of low emission aircraft.

Hydrogen bench in Liebherr-Aerospace's test center in Toulouse

Good results in first CDP and EcoVadis ratings

A solid C from CDP and the Silver Medal from EcoVadis are the good overall results for Liebherr-Aerospace & Transportation SAS. The company participated for the first time in the ratings.

Sustainability is on everyone's mind, as it is very prominently in the focus of customers and the political authorities in Europe. Even more reason for Liebherr-Aerospace & Transportation SAS to be proud of its very good and noteworthy CDP and EcoVadis ranking results.

In 2022, the product segment Liebherr-Aerospace and Transportation Systems of the Liebherr Group participated in the Carbon Disclosure Project (CDP) for the first time and received the score of C, representing a company that is taking various steps to manage its environmental impacts and understands the risks and opportunities presented by climate change.

While CDP has a narrower focus on carbon and climate-related data, EcoVadis takes a broader approach and considers four main topics: environment, labor and human rights, ethics, and sustainable sourcing. Liebherr-Aerospace & Transportation SAS received from EcoVadis the Silver Medal, a very good result considering the fact that the company participated in this rating for the first time as well. This score places Liebherr-Aerospace & Transportation SAS in the 70th percentile, meaning that its score is higher than or equal to the score of 70% of all companies assessed by EcoVadis.

Both very good scores encourage Liebherr-Aerospace and Transportation Systems to strive for the next levels of sustainability performance.

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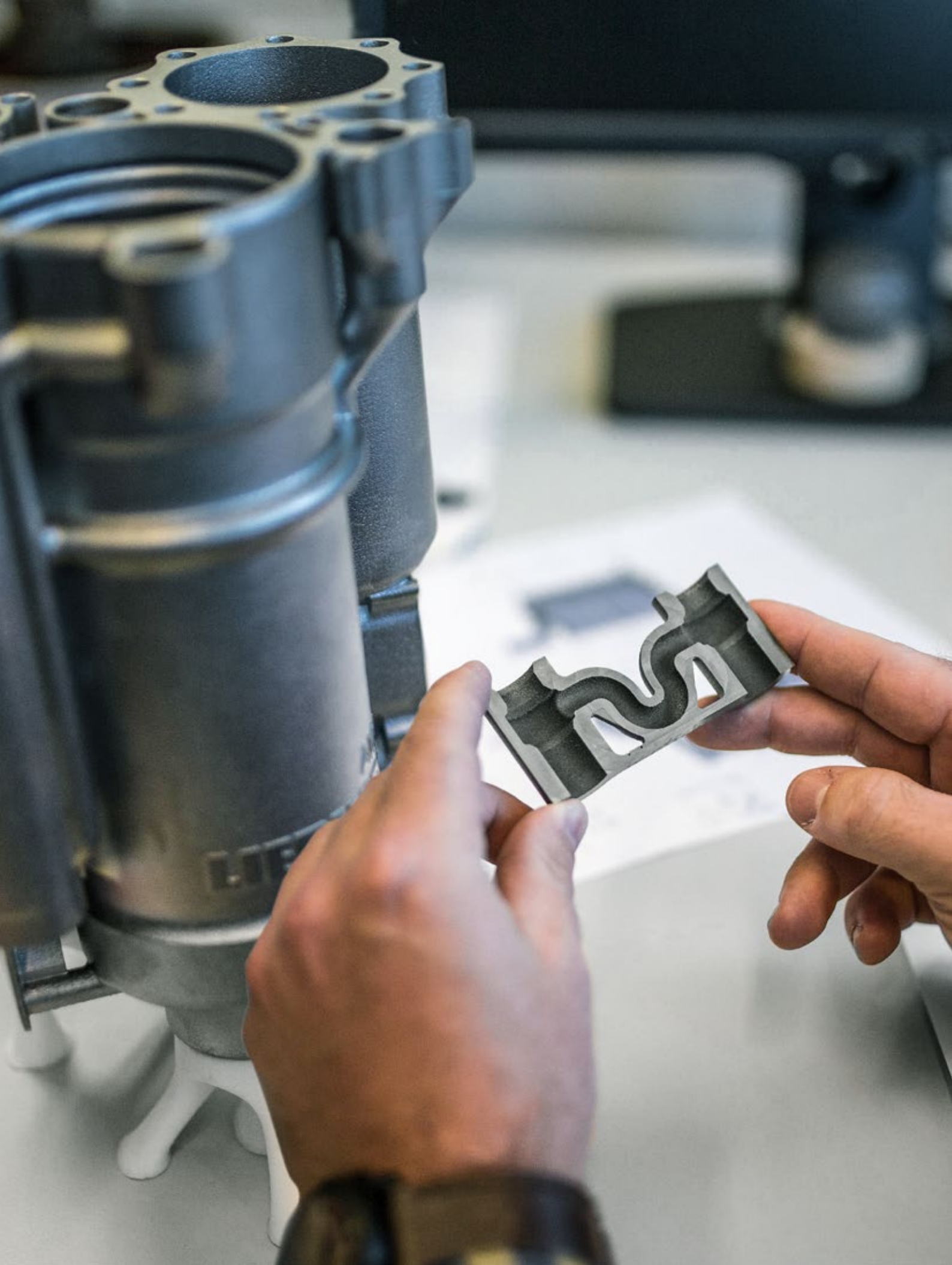
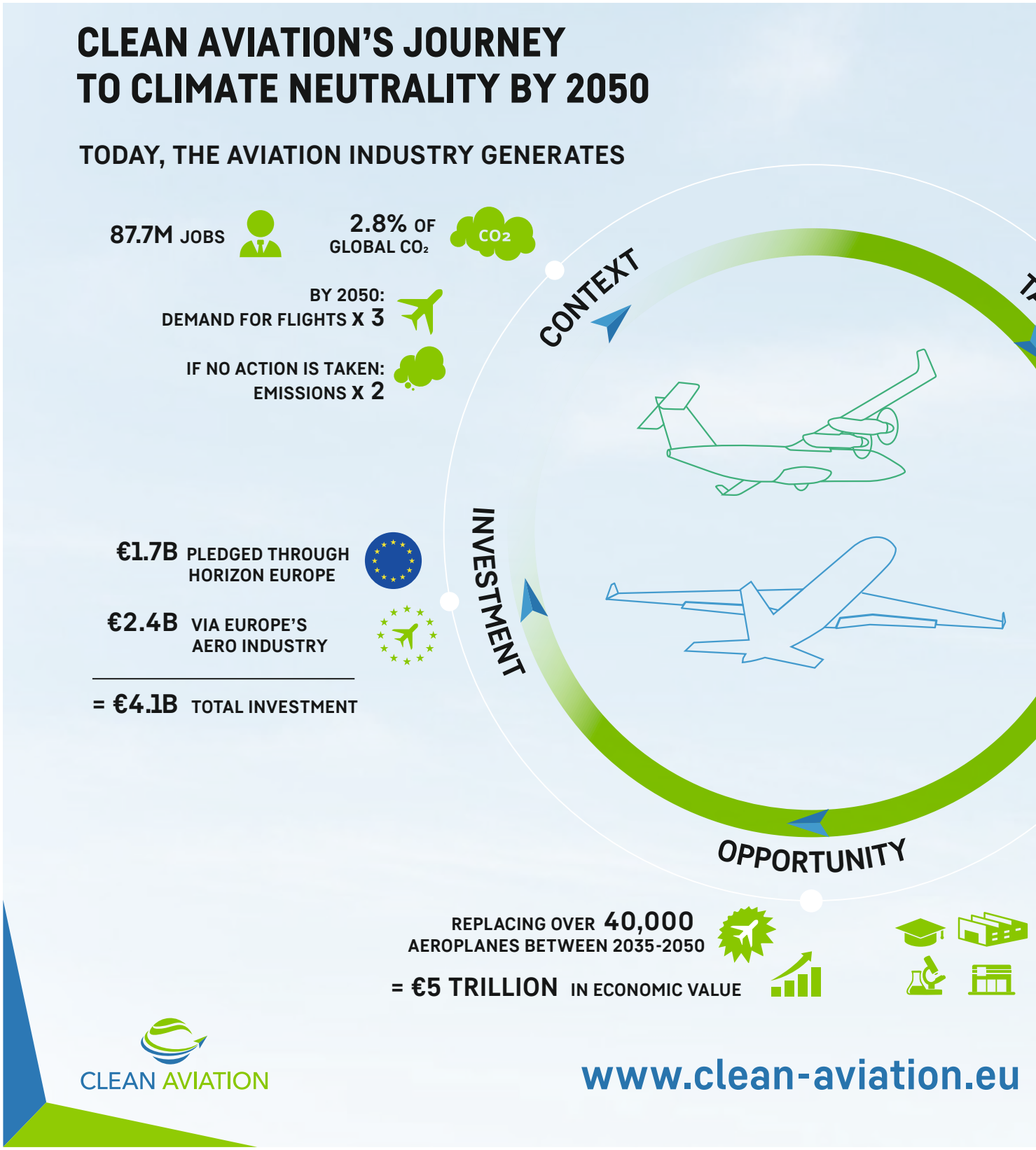
As the world takes steps toward a climate-resilient, deforestation-free, water secure future, ambitious corporate action is more important than ever.

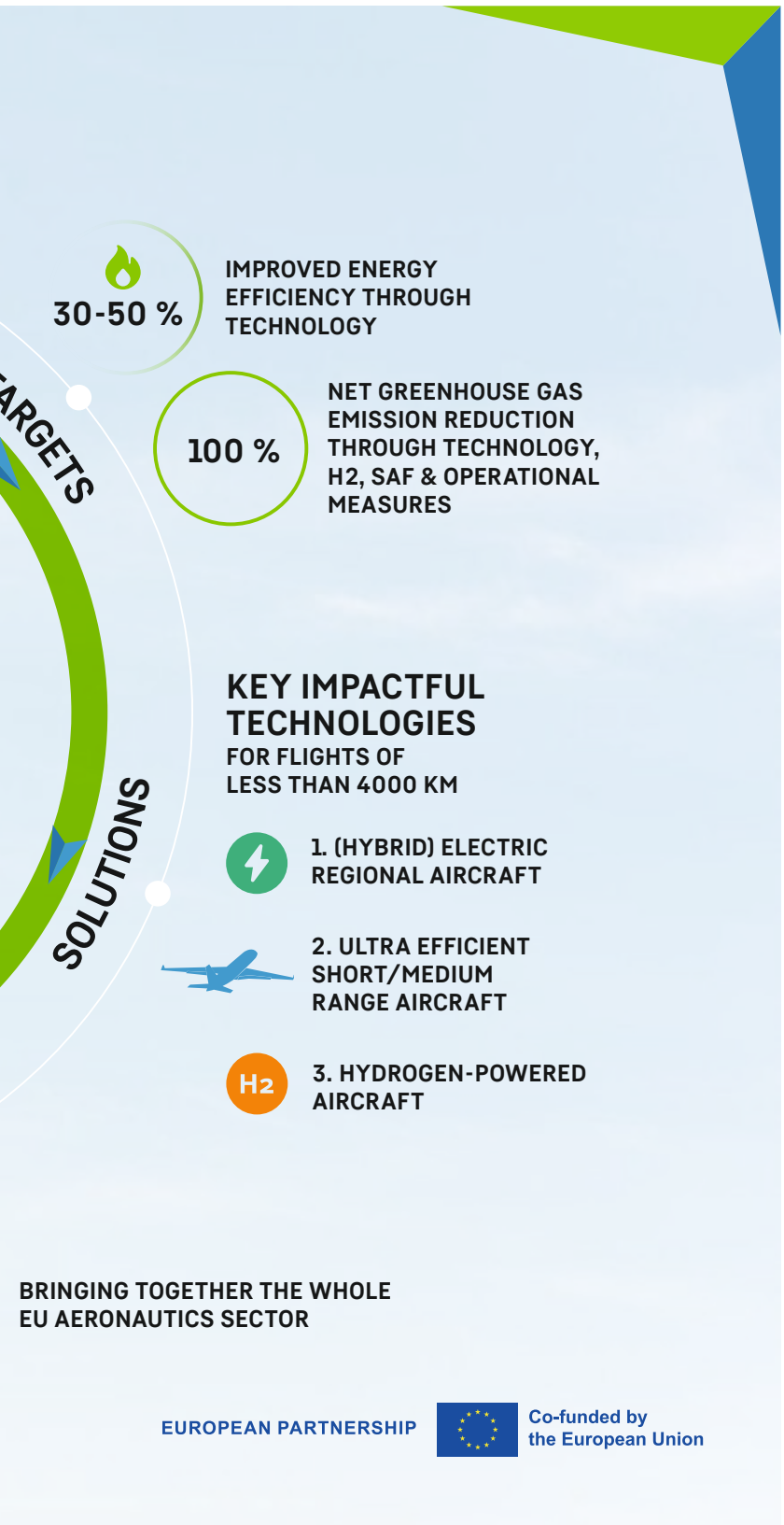
Research & Development

Constant investment into research and development play a key role in Liebherr-Aerospace's long-term vision and strategy. This allows the company to develop technologies that are employed in next generation aircraft.



New aircraft concepts





Clean Aviation aims to develop, integrate and demonstrate disruptive technological innovations into new aircraft concepts by 2030. This will decrease aircraft greenhouse gas emissions by no less than 30%, compared to 2020 state-of-the-art technology, and pave the way towards climate-neutral aviation by 2050, in line with the European Green Deal's vision.

The European Union within the Horizon Europe Research & Innovation Programme collaborates with the European aeronautics sector to reach these climate ambitions.

Liebherr-Aerospace is one of the many partners in Clean Aviation and contributes its expertise and know-how to this joint undertaking.

Investing in the future of flight
To be ready for the aircraft that will enter service in the future, Liebherr-Aerospace consistently invests above industry-average ratios into the R&D activities in its fields of expertise: landing gears, flight controls, actuation, gears, gearboxes, and air management systems.

Liebherr works on such topics as next generations of electric actuators, electric wing, electric environmental control system, auxiliary power generation systems, hydraulic power supply, and thermal and power management on-board the aircraft.

The future of aviation has begun – and Liebherr is a part of it.

Unlocking the power of Augmented Reality and Digital Twin Technologies

Liebherr-Aerospace is constantly seeking ways to improve processes and procedures. Through the use of Augmented Reality (AR) and Digital Twin (DT) technologies, the company can considerably enhance visualization and accuracy of inspections for example on nose landing gears. That is why the Liebherr team in Lindenberg (Germany) has developed a 3D design model since 2018 in an AR environment for the Airbus A350 nose landing gear.

The advantages are many – the AR model of the nose landing gear can provide technicians with on-demand access to relevant information and instructions during inspections, and it can improve accuracy and efficiency of maintenance processes. With AR, the team is able to quickly identify problem areas and access relevant repair and maintenance procedures on the spot. The use of AR technology can also lead to more accurate and efficient inspections, reducing the risk of errors and improving safety.

Moreover, through the future development of DT technology, the virtual replica of the physical nose landing gear will use real-time data and physics-based simulations to provide a complete and accurate virtual representation of the landing gear at serial number level. It will allow for real-time monitoring and optimization of the landing gear performance, enabling predictive maintenance and reducing downtime. It will also support product and process innovation and the Liebherr designers and engineers can experiment with new materials, designs, and performance parameters.

The use of AR technologies has revolutionized Liebherr-Aerospace's maintenance and inspection processes for nose landing gears and the teams in Toulouse (France) and Lindenberg (Germany) work diligently and closely to further develop AR and DT use cases. The goal is to monitor the performance of systems and component in real-time, identify potential problems before they occur, and to optimize maintenance and repair processes for maximum efficiency and safety. Liebherr-Aerospace remains committed to investing time and resources to grow its team and expand on the digital transformation journey of the entire organization.

Augmented reality (AR) is a technology that overlays digital information or images onto the user's real-world environment, enhancing their perception of reality. AR has the potential to revolutionize the way companies design, build, and service their products. AR models are instrumental in troubleshooting and identifying issues before they even occur.

A Digital Twin (DT) takes it to the next level with a virtual replica of a physical object, system, or process that can be used for analysis, optimization, predictions and monitoring purposes.

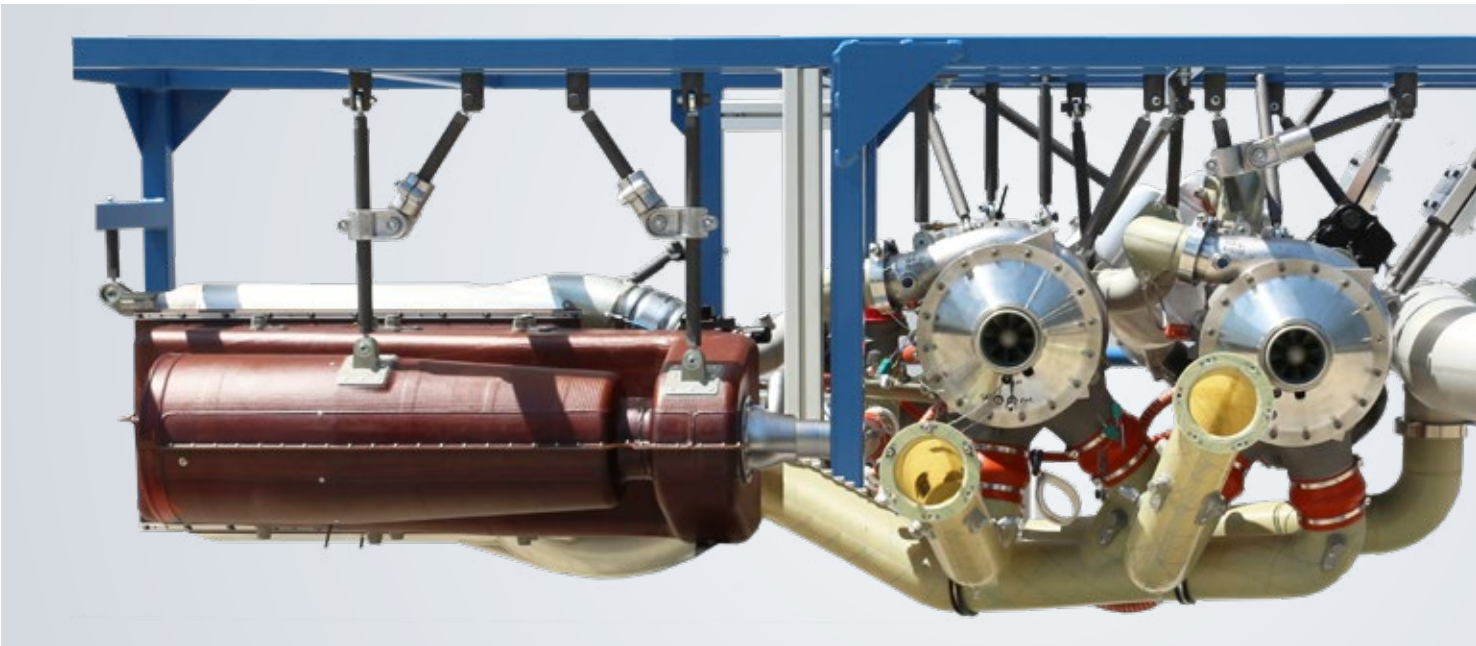
The advancement of AR modules and the road to full DT applications for various components started at Liebherr with the A350 nose landing gear and it continues. Accelerating growth in this area is an extremely important piece of an enterprise-wide Digital Transformation journey.

Towards a greener future in aviation

Fuel cell systems are a promising technology in the aviation industry because they reduce carbon emissions and increase energy efficiency. In recent years, there has been significant research and development in fuel cell systems, including advancements in fuel cell materials, stack design, and system integration. Liebherr-Aerospace is at the forefront of this research, developing innovative technologies to address the challenges of climate change and reduce dependence on fossil fuels.

The company is exploring new materials and manufacturing processes to reduce the cost of fuel cell systems and increase their scalability. Additionally, by collaborating with various partners, including universities, research institutions, and industry partners it has been able to advance the research and development of fuel cell systems, not only in aviation but also in rail and automotive industries. These collaborations enable Liebherr-Aerospace to share knowledge, expertise, and resources to accelerate the adoption of fuel cell technology in various applications.

A fuel cell system is an energy conversion technology that produces electricity through an electrochemical reaction between hydrogen and oxygen, without combustion. One of the main advantages of fuel cell systems is their high efficiency, which can convert up to 60% of the energy in the fuel into electricity, much higher than conventional combustion-based technologies. Additionally, fuel cell systems have low emissions and produce only water as a byproduct, making them environmentally friendly. They are also versatile, as they can be powered by hydrogen, natural gas, or methanol, which can be produced from renewable sources.



Liebherr's more energy efficient Electrical Environmental Control System (eECS)

While there are still technical and economic challenges to overcome in the development of fuel cell systems, Liebherr is actively working to improve the efficiency, durability, and performance of these systems. Liebherr-Aerospace began researching fuel cell systems over 20 years ago for automotive applications with a turbocharger. Recently, there has been growing interest in the aviation industry for this technology.

In early 2020, Liebherr started research activities for aerospace applications, culminating in the development of a hydrogen-powered test bench to evaluate fuel cell systems performance. This test bench was inaugurated in Toulouse in 2022. Now, Liebherr aims to connect a fuel cell system to the air conditioning system of aircraft and utilize this technology as the primary power source for the AC system in the next generation of aircraft expected to enter the market around 2035. This would be a major step towards the development of a decarbonized aviation industry, as the air conditioning system accounts for a significant portion of the aircraft's energy consumption.

Creation of a more energy efficient Electrical Environmental Control System (eECS)

Air conditioning systems are one of the main energy consumers on board an aircraft, because they take or bleed off air from the engines, which reduces their thrust output by ca. 5-8%.*

A good reason for Liebherr-Aerospace Toulouse and Airbus to work on a Clean Sky 2 initiative to design a more energy efficient eECS for more electrical aircraft that will need less fuel and emit less CO_2 and NOx.

Instead of bleeding the air from the engines, the eECS will use only ambient air from outside the aircraft. This means that the engines will have more thrust available – especially during take-off and the climbing phase until the aircraft has reached its cruising height. The ambient air is then pressurized and conditioned to a temperature that is comfortable for passengers and the crews.

Liebherr and Airbus built a high-level demonstrator with the support of several partners. Within the frame of Clean Sky 2, the OEM and aircraft manufacturer joined forces with 12 consortia from 5 European countries, including academics as well as small and middle class enterprises (SMEs).

The key technologies of the eECS have been successfully tested in dedicated benches. These results coupled with virtual demonstration and based on representative models of the eECS, will enable the system to reach Technical Readiness Level (TRL) 6 level most likely at the end of 2023.

TRL 6 means: "technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)" according to "Horizon 2020 – Work Programme 2014-2015 – General Annexes", Annex G – Extract from Part 19 – Commission Decision C(2014)4995.

* "A breath of fresh air with Clean Sky's Environmental Control System" 2021 Clean Sky 2 JU – www.cleansky.eu

Clean Sky 2
EUROPEAN PARTNERSHIP
Co-funded by the European Union

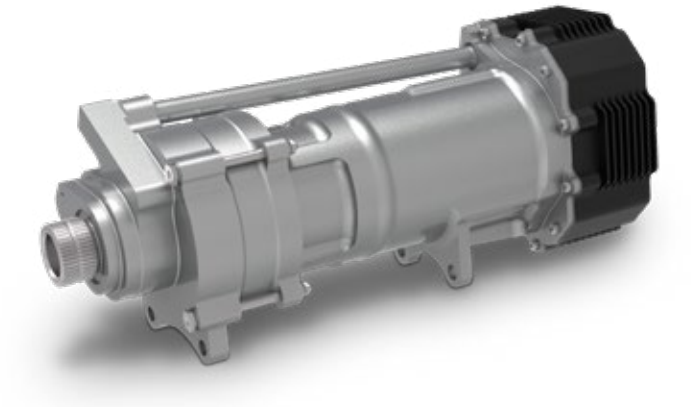
The all-rounder

Liebherr-Aerospace has always been on the forefront in terms of R&D activities of electro-mechanical actuation technology (EMA) for medium to large commercial aircraft applications (EASA CS-25).

Now, the company is taking this experience into the future: Liebherr is expanding its portfolio to smaller sized actuators. The new concept allows the transition from customized design to customized assembly of standardized modules. It specifically targets the rising AAM (Advanced Air Mobility) sector expanding also into smaller (EASA CS-23) aircraft, business jets and helicopters.

The family concept takes advantage of millions of in-service flight hours of geared actuators and related electronics collected during the last decades in numerous aircraft programs.

From commercial to defense, from fixed wing to rotary wing, from flight controls to utility actuation – the small electro-mechanical actuators serve many needs. The design approach offers scalability for small installation envelopes, beneficial power-to-weight ratio and high reliability.



EASA CS-25 stands for European Aviation Safety Agency Certification Specifications for Large Aeroplanes, i.e. aircraft powered by turbines. They prescribe airworthiness standards for the issuance of type certificates and changes to those certificates.

EASA CS-23 refers to Certification Specifications for Normal-Category Aeroplanes, i.e. aircraft with a passenger seating configuration of 19 or less and a maximum certified take-off mass of 8,618 kg (19,000 pounds) or less.

A perfect match

Liebherr-Aerospace also successfully entered the marked with a remote electronic unit (REU). Its design concept offers great versatility for system and position control, data concentration, monitoring and conversion as well as high reliability – an ideal solution for different kinds of applications. Various aerospace customers rely already on the REU for their programs.

The remote electronic unit is a perfect match with the small EMA family and Liebherr's proven system integration capability is taking credit from decades of flight control system development for all major aircraft manufacturers. All relevant actuation system architectures can be realized with these elements.

New technologies for hydrogen-powered aircraft

Liebherr-Aerospace is supporting Airbus in its ambition to develop the world's first hydrogen-powered commercial aircraft by 2035. Liebherr develops an air supply system for the fuel cell dedicated to the propulsion of Airbus demonstrator aircraft.

After the first study phase, Liebherr-Aerospace has already designed and delivered a functional air supply system demonstrator with a power of 1 MW, which is presently installed in Airbus' testing facilities.

During the second study phase, currently in progress, Liebherr aims to design and qualify a safety-of-flight air supply demonstrator, which is able to withstand the integration constraints in an operational environment close to the propulsion system. This demonstrator will support a flight test campaign to demonstrate the performance of a fuel cell propulsion system under operational conditions by the middle of the decade.

"We are very pleased to support Airbus in this ambitious project. As Liebherr's center of excellence for air management systems, we are continuously investing in Research and Development to offer innovative technological breakthrough solutions to our customers. Our systems and components are on board the Airbus aircraft family and we are proud to say that we will also participate in this emblematic program that will contribute to transform aviation towards a sustainable future," commented Dr. Nathalie Duquesne, Managing Director at Liebherr-Aerospace Toulouse SAS.

Unfolding efficiency!

Improved aerodynamics need longer wing spans and longer wings need to fold their wing tips to match with the airport gates. Liebherr is able to provide reliable folding mechanisms for future more efficient aircraft platforms.

A very prominent example is the new Boeing 777X, the world's largest and most efficient twin-jet engine jet. With the new breakthroughs in aerodynamics and engines, the airplane will – according to the US airplane manufacturer – deliver 10% lower fuel use and emissions and 10% lower operating costs than the competition.

The aerodynamics of the wing combined with the new energy-savings engines will considerably reduce kerosene consumption and will help airlines not only to save fuel but also to reduce other costs such as airport charges. The folding wing tips reduce the wingspan from 71.8 m to 64.8 m on each side, allowing the 777X to use standard gates at the airports, like all other airplanes, without any additional costs for the airline. Before the airplane takes off, the wing tips are once again folded out into the horizontal position. It is the first time in history that a commercial airliner features a folding wing tip.

Liebherr-Aerospace supplies the components for the 777X folding wing tip actuation system. Boeing Commercial Airplanes selected the company to supply the fold subsystem, the latch pin actuator and the secondary lock actuator.

For the secondary lock actuator, Liebherr has developed a 3D printed housing. During the stress analysis, the 3D printed part was analyzed successfully with the same methods and templates as the conventionally manufactured part.

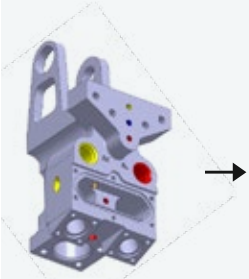
Supported by:

Federal Ministry for Economic Affairs and Climate Action

on the basis of a decision by the German Bundestag

Design development of the secondary lock actuator

Conventional design



Weight: 1.5 kg
15-5PH

Additive manufacturing design

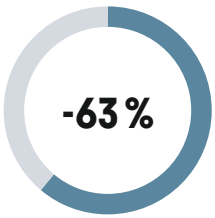
Weight: 0.56 kg
Ti6Al4V
Part count: -6 plugs

Process Chain

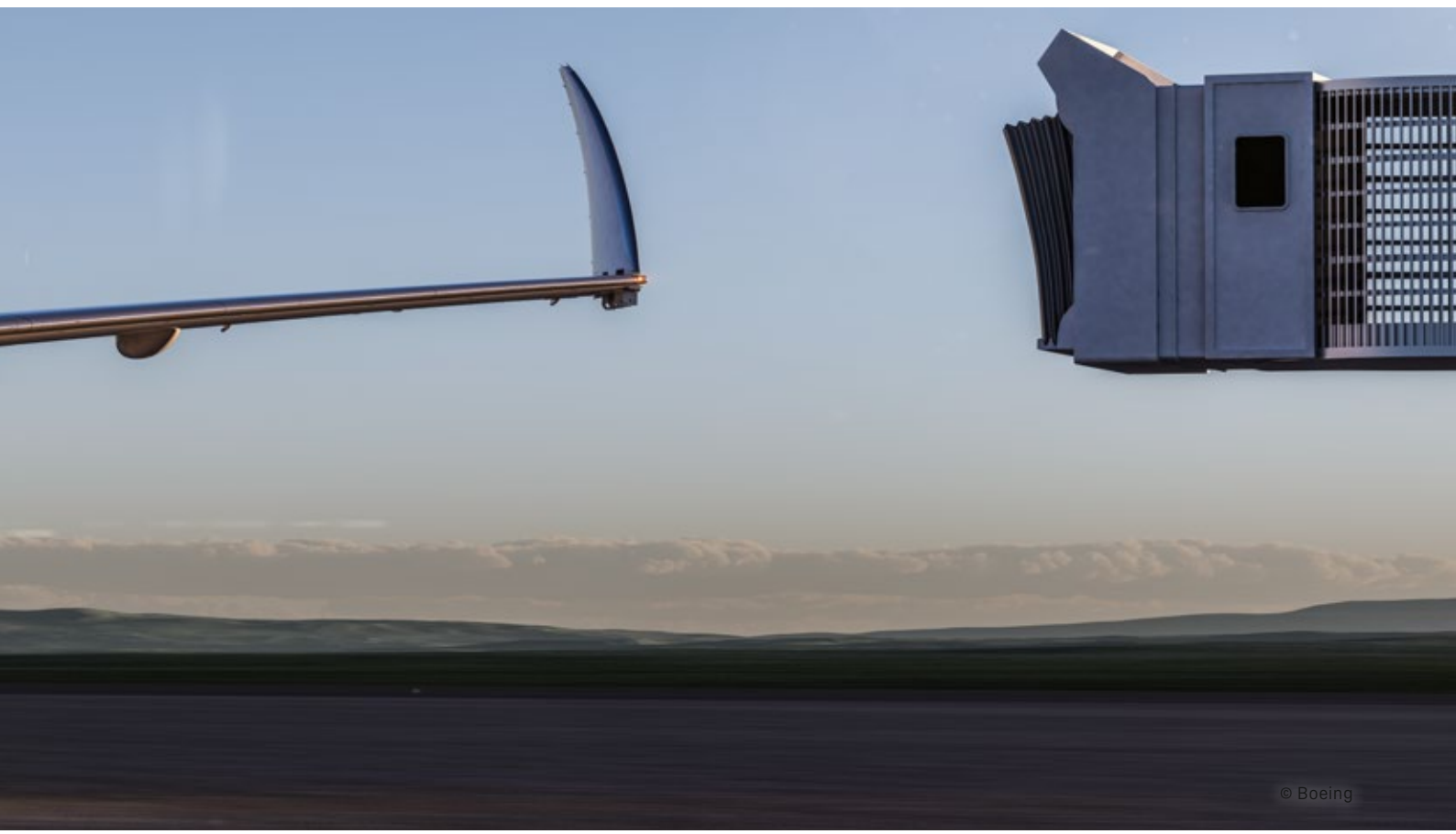
Hydraulic actuator with integrated valve block

- Stress analysis: Part analyzed with the same methods/templates as the conventional part
- Same performance
- Same interfaces
- Same assembly parts
- Highly improved buy to fly ratio

Weight redution:



Performance:



Programs & Contracts

Liebherr-Aerospace develops continuously long-standing partnerships worldwide.

© Airbus

Additive manufacturing takes flight: The growing role of 3D printing in aviation

Liebherr-Aerospace is collaborating intensively with Airbus in the development of additive layer manufactured components.

At the beginning of 2019, Liebherr-Aerospace started the serial production of 3D printed parts. The company had successfully certified and delivered a printed proximity sensor bracket for the A350 nose landing gear. This bracket was the first-ever introduced Airbus system part to be qualified for titanium additive layer manufacturing. Recently, Liebherr has reached a new important milestone: Airbus has selected the OEM to supply a more complex 3D printed component – the valve of the lower cargo door actuator system – for the same aircraft.

Liebherr-Aerospace is on board of all Airbus commercial aircraft programs, and this contract is another demonstration of the trust between the two companies and their mutual commitment to introduce cutting edge innovation.

Additive manufacturing (AM) allows producing components that are lighter compared to conventional ones. AM has the potential to revolutionize aircraft design, production, and maintenance. The advantages are numerous, including rapid prototyping, reduced development time and costs, weight and performance improvement, as well as versatility – all critical factors for success in the ever-evolving aviation industry.

Innovative technologies for Eurodrone

Liebherr-Aerospace and Airbus Defence and Space have strengthened their relationship by signing a contract for the development and manufacturing of the entire landing gear and hydraulic system of the Eurodrone MALE RPAS (European medium-altitude, long-endurance remotely piloted air system). For Liebherr-Aerospace, this cooperation marks the next step into the market of unmanned aerial systems.

Liebherr-Aerospace Lindenberg has been selected by Airbus Defence and Space to deliver the Eurodrone landing gear and hydraulic system. Liebherr takes responsibility for development and manufacturing of the main and nose landing gear including actuation, steering and electronic control, as well as the electric-motor driven pump (EMP).

The Eurodrone's hydraulic power supply is purely electrical-driven. Liebherr's EMP is core of this new power supply. The EMP belongs to a range of innovative and scalable solutions offered by Liebherr for de-centralized electro-hydraulic power supply. The EMP can be installed much closer to the single consumers than conventional engine-driven pumps. The benefits are more efficiency, less weight and less noise emission.

These characteristics are essential for the Eurodrone MALE RPAS of Airbus Defence and Space. As a four-nation-project (France, Germany, Italy and Spain), the program is intended for flights in non-segregated airspace and will give Europe its own capabilities in the growing sphere of unmanned aerial systems.

First delivery of the Eurodrone is scheduled for the end of this decade.

The Eurodrone contract strengthens Liebherr's long-term cooperation with Airbus Defence and Space.

Elevating a long-standing partnership to new heights

Liebherr-Aerospace Lindenberg earned a spot in Boeing's Premier Bidder Program, an exclusive initiative that recognizes and rewards high-performing suppliers that meet and exceed the aircraft manufacturer's high standards in the areas of safety, quality, integrity, on-time delivery, and performance.

The program gives access to specialized training, technical support and other resources that will ensure that Liebherr continues to meet and exceed Boeing's expectations. Most notably, the program provides Premier Bidder members with an opportunity to increase their business with Boeing, including visibility of upcoming bids and an invitation to program conferences with key Supply Chain leadership.

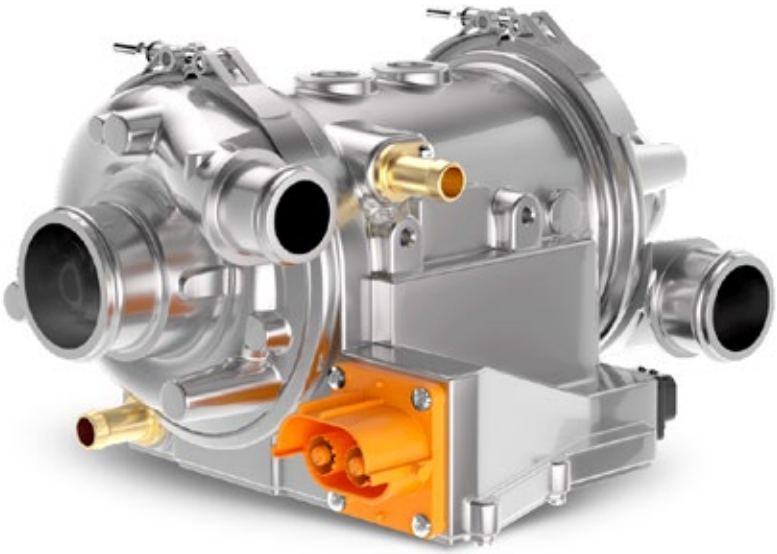
Liebherr-Aerospace Lindenberg manufactures the main gear steering system for the Boeing 777 and Boeing 777X, the folding wing tip actuation, high-lift actuators, the power drive unit and the hydraulic motor for the leading edge actuation system for the 777X as well as the nose wheel steering remote electronic unit for the Boeing 787 Dreamliner.

The company joins approximately 140 suppliers that have met and sustained the high quality, delivery and performance criteria required for inclusion in the Premier Bidder Program.

© Boeing

Liebherr and ZF jointly develop high-speed compressors

Liebherr has entered a strategic as well as historic collaboration with ZF to develop new high-speed compressors for medium size, heavy duty as well as long haul hydrogen fuel cell powered vehicles. Customers will benefit from the huge know-how of the two system designers with ZF being one of the major players in the automotive and with Liebherr being one of the leading Original Equipment Manufacturers in the aerospace branch.



© ZF

Liebherr and ZF joined forces to develop and produce new high-speed compressors in different power classes for the application in various sized vehicles powered with fuel cell technology. ZF is planning to offer the compressor platform concept to the automotive market.

The two partners will jointly develop the design of the compact and reliable compressors with dedicated power electronics; ZF will take care of the necessary steps for industrialization and series production.

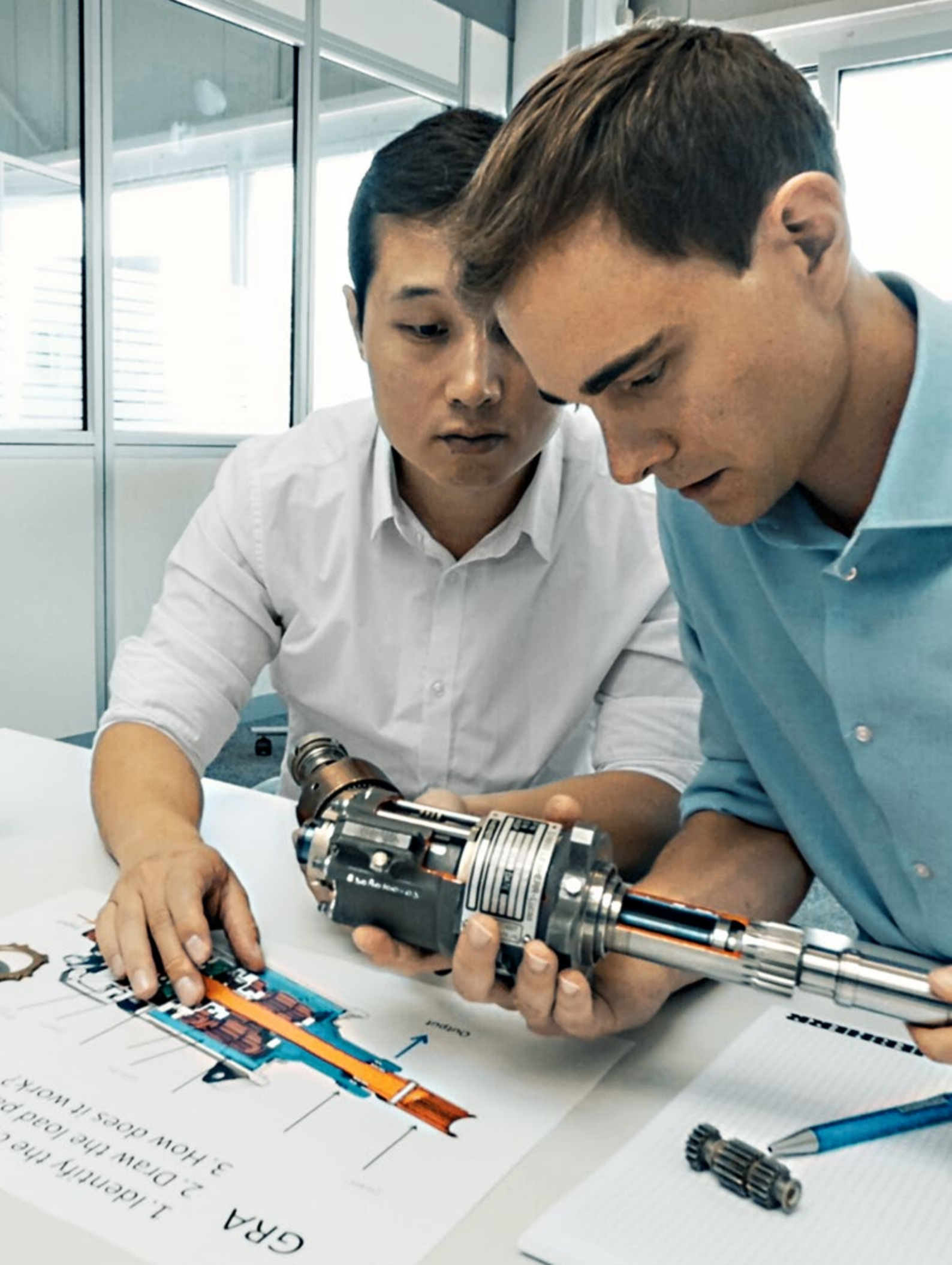
Liebherr's technology is eco-friendly: Its high-speed compressors are driven by an electrical motor and feature air bearings, which means that they do not require any lubrication. Thus, the compressors supply clean, compressed air to the fuel cell stack, not adding any pollution to the membrane. Such technology is an enabler for the deployment of fuel cell propulsion systems with only emissions of water and heat, which aids in the movement for more environmentally friendly transportation.

"Liebherr-Aerospace can look back at more than 40 years of experience in the development and production of air cycle air conditioning systems, where the air cycle machine, that is the compressor, constitutes the core of the system without any use of refrigerants. These systems based on air bearing technology are on board many commercial aircraft and business jet platforms around the globe and perform also very successfully in the railway market. Since the early 2000's, such compressor technology was transferred to the automotive market for application in fuel cell propulsion systems. In this regard, we have been working with major carmakers worldwide. With ZF, we have now the right collaboration partner. They will receive our high speed compressor know-how as an enabler to offer critical equipment for fuel cell propulsion systems in the automotive market", said Dr. Klaus Schneider, Chief Technology Officer, Liebherr-Aerospace & Transportation SAS. "Liebherr will of course continue to develop and offer high speed compressors to the aerospace and railway sector", he explained.

"Thanks to the new partnership with Liebherr and the integration of its know-how and expertise into our solutions, ZF can significantly shorten the time to market for fuel cell compressors for commercial vehicles," adds Claus Umnus, Head of the Chassis Technology Product Line in ZF's Commercial Vehicle Solutions Division.

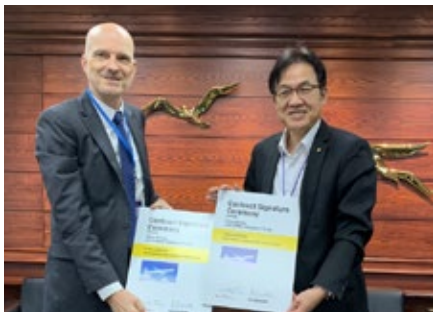
Customer Service

Regional Technical Workshops are part of Liebherr-Aerospace's vast customer services offer.



A long-term partnership

Liebherr and China Airlines have entered into a long term agreement, under which the OEM Liebherr-Aerospace will provide repair support services for a wide range of air conditioning and bleed system components installed on China Airlines' fleet of 25 Airbus A321neo. All material support and component maintenance services will be provided by Liebherr Singapore, Liebherr-Aerospace's dedicated service center for the Asia-Pacific region.



Jason Tsai, Vice President Engineering at China Airlines (right) and Ekkehard Pracht, General Manager Aerospace, at Liebherr Singapore at the contract signature ceremony.

The contract underlines the close relationship that China Airlines has built up with Liebherr-Aerospace since many years. "We really appreciate Liebherr's service and place our trust and confidence in the company. We want to continue our long term partnership and thus decided to choose Liebherr as our service provider for the component support on our new Airbus A321neo fleet", commented Jason Tsai, Vice President Engineering at China Airlines.

"This is a great success for Liebherr-Aerospace in the Asia-Pacific region. We are honored and proud to further extend our partnership with China Airlines and continue supporting their success. China Airlines has been our customer for many years and this selection re-affirms their continuous confidence in the quality and efficiency of our team and services provided," said Ekkehard Pracht, General Manager Aerospace at Liebherr Singapore.

China Airlines is the largest airline in Taiwan, headquartered in Taoyuan International Airport. It operates short, medium, and long haul services to international and intercontinental destinations across Asia, Europe, North America, and Oceania. Further subsidiaries of the China Airlines group of airlines include Tigerair Taiwan as well as Mandarin Airlines.

Re-coring for efficient operation

Liebherr Aerospace Saline, Michigan (USA) has reached a milestone with the delivery of the first re-cored ram heat exchanger, which is part of the air-conditioning system on board the Boeing 747-8.

The maintenance procedures for heat exchangers like re-coring has been developed considering Original Equipment Manufacturer (OEM) design know-how and enables Liebherr to restore the heat exchanger to the status of "new condition". This ensures most efficient operation for customers.

Proud members of the Liebherr Aerospace Saline team with the re-cored heat exchanger

Liebherr-Aerospace is one of the leading specialists to maintain, repair and overhaul heat transfer equipment, i.e. heat exchangers, expanding consequently its service network: Already in 2016, the company built an extra facility in Saline, integrating the best solutions in the industry for each process, and in September 2022, the latest heat exchanger repair center in Singapore was inaugurated, dedicated to serve Liebherr-Aerospace's Asian Pacific customers.

Liebherr works per OEM Component Maintenance Manuals (CMMs), has developed design engineering solutions and uses only original parts in case of replacement. Furthermore, Liebherr-Aerospace has an authorized heat exchanger test and clean network operated by selected partners.

Expansion of landing gear service network in Asia-Pacific Region

Liebherr-Aerospace and REVIMA Landing Gear Services Asia Pacific team up for offering maintenance, repair, and overhaul (MRO) services for the Airbus A350's nose landing gear to airlines operating in the Asia-Pacific region. This new cooperation aims to expand the Liebherr landing gear service network by integrating REVIMA Landing Gear Services Asia Pacific as a prime MRO supplier, offering top-class services to all Liebherr landing gear customers.

Liebherr-Aerospace is the Original Equipment Manufacturer of the A350 nose landing gear for all Airbus A350 variants. Since its entry into service in 2016, this aircraft has become a highly popular aircraft program among Asian-Pacific operators.

REVIMA is a leading independent MRO provider with over 60 years of landing gear expertise and has facilities located in Rives-en-Seine (France) and Chonburi (Thailand).

This agreement will accelerate the ramp-up of nose landing overhaul capabilities in the Asia Pacific region, while the partnership between Liebherr-Aerospace and REVIMA will ensure a reliable build-up and sustainable provision of services.

"Our customers in the APAC region, A350 operators and MROs alike, will benefit from this collaboration, as it brings together the expertise of two of the leading names in the aerospace industry. Both Liebherr-Aerospace and REVIMA are committed to providing high-quality services to their customers and this cooperation will undoubtedly enhance the region's availability of state-of-the-art MRO capabilities," said Alex Vlielander, Chief Customer Officer, Liebherr-Aerospace & Transportation SAS.

"We are delighted to partner with Liebherr-Aerospace, and have our new, state-of-the-art landing gear facility in Thailand, serve the requirements of the Asia Pacific region for the many years to come. We are highly impressed by the legacy of Liebherr-Aerospace and look forward to a very successful program", said Olivier Legrand, REVIMA Group President & CEO.

All smiles at the Memorandum of Understanding signature ceremony of Revima and Liebherr-Aerospace at MRO Americas 2023

Double award from COMAC

The Chinese civil aircraft manufacturer COMAC has honored Liebherr-Aerospace twice. At the annual supplier conference in Shanghai in March 2023, Liebherr was presented with the "2022 Excellent On-Site Support Award" for the landing gear system on board the single-aisle C919 aircraft. Suppliers that have won this award have performed outstandingly in terms of Final Assembly Line Support, Flight Tests Support and On-Site Engineering Support.

“It is a great honor and we are very grateful to have our performance recognized by our customer. We have developed a strong local footprint in Shanghai in order to support our customers. We are proud to contribute to the bright future of COMAC and we are looking forward to further deepen our fruitful cooperation,” commented Julien Moll, General Manager – Aerospace Division of Liebherr (China) Co., Ltd.

Proud members of the Liebherr team at COMAC's Supplier Conference in Shanghai

Marc Zhang, Final Assembly Line and Flight Test Support Supervisor at Liebherr (China) Co. Ltd. (2nd from left), received the award at COMAC's Global Supplier Conference 2022.

The second award came at the end of 2022, when Liebherr-Aerospace received the "2021 Supplier of the Year – Performance Excellence Silver Award" for its air management system for the C919 and ARJ21 aircraft programs at the annual supplier conference in Wuxi (Zhejiang Province). COMAC thus recognized Liebherr’s outstanding performance as well as continuous quality improvements.

Liebherr has been in China since 1978, with Liebherr (China) Co., Ltd. as the Regional Headquarter based in Shanghai. The company has developed a local footprint for its aerospace activities with a liaison office and MRO facility in Shanghai and a joint venture with AVIC LAMC in Changsha: Liebherr LAMC Aviation (Changsha) Co., Ltd.

The first C919 was delivered to China Eastern Airlines on December 9, 2022.

On December 18, 2022, COMAC delivered an ARJ21 aircraft to the Indonesian operator Transnusa Airlines. It is the first oversea customer delivery of the Advanced Regional Jet.

One of the best suppliers

During the Embraer Suppliers Conference held on April 18th, 2023, Liebherr-Aerospace received again an Embraer Best Supplier Award. This time, the Brazilian aircraft manufacturer had selected Liebherr for the category "Outstanding collaboration – best turn around/recovery" for the year 2022.

Roberto Chaves, Senior VP Global Procurement (left) and Luis Marinho, Executive VP Operations (right) of Embraer presented the award to Mathieu Tournier, Managing Director, Liebherr-Aerospace Toulouse (2nd from right) and Gerd Heinzelmann, Managing Director, Liebherr-Aerospace Lindenberg (2nd from left).

"We feel very honoured and thank Embraer for receiving this outstanding award. 2022 was a particularly tough year, during which we had to ensure the post-COVID ramp-up despite tremendous challenges in our supply chain. This award underlines the quality and strength of our partnership with Embraer and the ability of our teams to maintain operational performance even under severe conditions", commented Gerd Heinzelmann, Managing Director of Liebherr-Aerospace Lindenberg GmbH.

Liebherr-Aerospace develops, manufactures and provides customer services for various components and systems such as landing gears, flight controls and air management to several Embraer programs, incl. the E-Jet E1 and E2 families, the C-390 Millennium, the Super Tucano, and the Praetor 600.

The Embraer E190 E2 regional jet was certified in 2018.

People & Community

Aviation trade shows, such as ILA Berlin, always attract many visitors.

© ILA Berlin

Liebherr apprentices support aircraft maintenance at Dornier Museum Friedrichshafen

An experienced team of former aircraft mechanics maintains and repairs aircraft exhibits at the Dornier Museum Friedrichshafen (Germany). Now they are receiving support from apprentices of the Liebherr-Aerospace plant in Friedrichshafen.

The Dornier Museum presents more than a dozen fixed wing aircraft and a helicopter in the museum building and on its outdoor grounds. In order to keep the exhibits, most of which accessible, in as original a condition as possible, regular care and maintenance is a prerequisite. The Dornier Museum is supported by an experienced group of helpers. Recently, this group has also included apprentices from Liebherr-Aerospace at the Friedrichshafen site. As junior mechanics, they help with the maintenance and repair of the exhibits and will take over these tasks in the future.

The annual maintenance cycle takes around a week in spring and fall. The aircraft are closely inspected and any damage is repaired. The team solders, seals, primes, fills and repaints; it tightens screws and sometimes grinds them off. "The existing experienced team knows the Dornier aircraft in detail. The enthusiasm for aviation with which they have maintained the aircraft for decades has impressed me immensely," says Carlo Job, a second-year apprentice at Liebherr-Aerospace's Friedrichshafen plant.

The accessible aircraft model on the outdoor grounds of the Dornier Museum has been overhauled.

Goal achieved: the maintenance team in fall 2022

The trainees benefit from the enormous knowledge and wealth of experience of the group of older helpers. "Our apprentices take away an incredible amount of input from this project. They are learning skills outside their everyday tasks from absolute professionals. This knowledge enables our trainees to work independently on the exhibits in the future. Leaving their familiar surroundings at our training center is a great and special experience," explains Andreas Christ, Liebherr trainer at the Friedrichshafen site. The training team there also includes Birgit Hahn and Heiko Engels. Together, they take care of a smooth organization in order to involve as many trainees as possible in the maintenance project. This also includes appropriate documentation to ensure that knowledge is passed on to the next generation of apprentices.

Liebherr-Aerospace has already gained experience in working with the Dornier Museum: in 2019, the company provided significant support and funding for the flight simulator now on display in the museum.

An excellent project

In spring 2023, Liebherr-Aerospace Toulouse received an honorary award of "Toulouse + Verte", an initiative created by the City Council to highlight renaturation projects in Toulouse.

Liebherr's "Centrale Parc" project was created after the demolition of an old building. It is a green space combining employee well-being and biodiversity. It is an area that can accommodate employees for example for their meetings during the summer months in a natural setting. The project has been rewarded precisely for this reason.

In total, nine renaturation projects, such as tree planting and actions in favor of biodiversity, were recognized through this initiative.

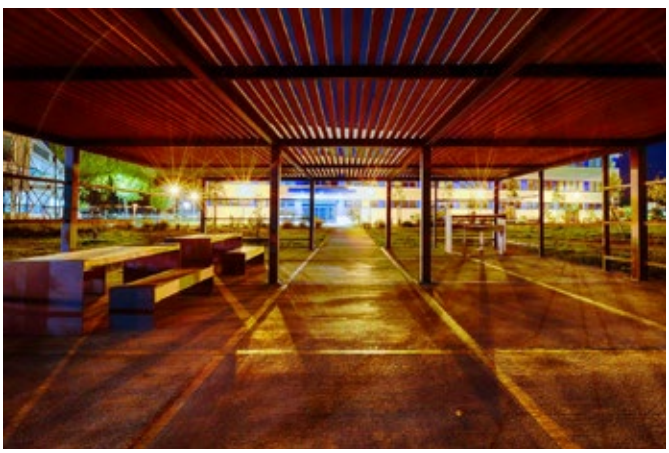
"Toulouse + Verte"
→ https://toulouseplusverte.makesense.org/

The park is surrounded by greenery with more plants to come.

The winners of the "Toulouse + Verte" Initiative were welcomed in the « Salle des Illustres » at Toulouse City Hall.

The park has been generously landscaped and the plants can grow now.

« Centrale Parc » can accommodate up to 12 employees for business meetings.



The space allows you to enjoy the beautiful weather while being protected from too much exposure to the sun.

Participation in programs

Fixed Wing Aircraft

Airbus

Airbus A220
- Integrated Air Management System
- Landing Gear System

Airbus A300-600
- Cabin Pressure Control System
- High-Lift System
- Krüger Actuator
- Latching Actuator
- Landing Gear Door Actuators
- Nose Landing Gear
- Upper Cargo Door Actuator

Airbus A310
- Cabin Pressure Control System
- High-Lift System
- Krüger Actuator
- Nose Landing Gear

Airbus Single Aisle Family ceo / neo
- Air Chillers
- Air-Conditioning System
- Avionics Cooling System
- Cargo Heating System
- Cockpit Static Inverter
- Engine Bleed Air System
- eRudder Actuator
- Fuel Tank Inerting System – CSAS (except A319CJ)
- High-Lift System
- High Pressure / Power Transfer Unit Manifolds
- Integrated Flight Control Computers
- Rudder Servo Control
- Safety Valve

Airbus Long-Range Family ceo / neo
- Air Chillers
- Air-Conditioning System
- Auxiliary Power Unit Gearbox
- Avionics Cooling System
- Engine Bleed Air System
- Cargo Heating System
- Cockpit Static Inverter (A330)
- Cargo Door Actuator
- Crew Rest Humidification System
- Fuel Tank Inerting System – CSAS
- High-Lift System
- Landing Gear Door Actuation
- Rudder Servo Control (Airbus A340 Enhanced)
- Spoiler Actuation
- Spring Strut

Airbus A350 XWB
- Flap Active Differential Gearbox
- Load Sensing Drive Strut
- Lower Deck Cargo Door Actuator
- Moving Damper
- Nose Landing Gear
- Slat Actuation

Airbus A380
- Air / Hydraulics Cooling System
- Cargo Heating System
- Engine Bleed Air System
- High-Lift System
- Pneumatic Distribution System
- Reservoir Air Supply Cooler
- Spoiler Actuation
- Supplemental Cooling System

Airbus BelugaXL
- Air-Conditioning System
- Conditioned Air Supply System (a subsystem of the fuel tank inerting system)
- Engine Bleed Air System Components
- High-Lift System
- Landing Gear Door Actuation
- Spoiler Actuation

Airbus

A330 MRTT
- ARBS Ruddervator Control System

A400M
- Aileron, Elevator, Rudder Servo Control
- Air-Conditioning System
- Cabin Pressure Control System
- Door Ramp Actuation System
- Engine Bleed Air System
- Fuel Tank Inerting System – CSAS Components
- Nacelle Anti-Ice System
- Power Control Unit
- Spoiler Servo Control
- Ventilation Control System
- Wing Anti-Ice Valves
- Wing Tip Brake

Eurodrone
- Landing Gear System
- Hydraulic System

Eurofighter / Typhoon
- Airbrake Actuator Servo Control
- AMAD Gearbox
- Engine-Driven Hydraulic Pump
- Filter Package Units
- Nose Landing Gear
- Nose Landing Gear Retraction Actuator
- Main Landing Gear Side Stays
- Primary Flight Control Actuators – Fly-by-Wire Technology

ATR

ATR 42 / 72
- Integrated Air Management System

AVIC

MA700
- Valve Actuator

Boeing

747-8
- Air-Conditioning System
- Engine Bleed Air System

777-200LR
- Fuel Tank Pressure Regulating Valves

777 / 777X
- Main Gear Steering System

777X
- Folding Wing Tip Actuation
- High-Lift Actuators
- Power Drive Unit and Hydraulic Motor for Leading Edge Actuation System

787
- Nose Wheel Steering Remote Electronic Unit

KC-46
- Fuel Pressure Regulating Valves
- Refueling Hose Drum Drive System

MQ-25
- Tailhook Actuator

Participation in programs

Fixed Wing Aircraft

Bombardier Aerospace

Challenger 300 / 350
- Flap System
- High- and Low-Pressure Ducting
- Integrated Air Management System

Global Express / G5000 / G5500
- Cabin Air Humidification System
- Integrated Air Management System
- Nose Landing Gear Shock Strut

G6000 / G6500 / G7500 / G8000
- Integrated Air Management System

COMAC

ARJ21
- Integrated Air Management System
- Landing Gear System incl. Braking System, Wheels, and Tires
- High- and Low-Pressure Ducting

C919
- Integrated Air Management System
- Landing Gear System
- High- and Low-Pressure Ducting

Daher-Socata

TBM850 / 900
- Air-Conditioning System
- Cabin Pressure Control System
- Engine Bleed Air System

Dassault Aviation

Falcon 50EX / 900 / 2000 / 2000EX
- Air-Conditioning System
- Cabin Pressure Control System
- Engine Bleed Air System

Falcon 6X
- Integrated Air Management System
- Cabin Air Humidification System

Falcon 7X / 8X
- Cabin Air Humidification System
- Engine Bleed Air System

Falcon 10X
- Integrated Air Management System
- Landing Gear Actuation and Steering Components

Mirage 2000
- Air-Conditioning System
- Cabin Pressure Control System
- Engine Bleed Air System

Rafale
- Air-Conditioning Components
- Cabin Pressure Control System
- Engine Bleed Air System

De Havilland

Q400
- Cabin Pressure Control System

Deutsche Aircraft

D328eco
- Air Management System
- Flap and Spoiler Actuation System

Embraer

AMX
- Cabin Pressure Control System

C-390 Millennium
- Air-Conditioning System
- Cabin Pressure Control System
- Engine Bleed Air Valves
- Refueling Hose Drum Drive System
- Wing Anti-Ice Valves

E-Jet E1
- Landing Gear System incl. Braking System, Wheels, and Tires

E-Jet E2
- Nose Wheel Steering Control Module
- High-Lift System
- Integrated Air Management System
- Machining of Main Landing Gear (E175 E2)

Embraer 135 / 145 / Legacy 650
- Cabin Pressure Control System
- Flap System
- Nose Landing Gear

Legacy L500ER
- Fuel Tank Pressurization System

Lineage
- Landing Gear System incl. Braking System, Wheels, and Tires

Praetor 600
- Fuel Tank Pressurization Valve

Super Tucano
- Air System Components

Tucano
- Air System Components

FAdeA

IA-63 Pampa III
- Air-Conditioning, Heating, and Ventilation Components
- High-Lift Actuation Components
- Primary Flight Control Components
- Landing Gear Components

General Atomics AeroTec Systems

Dornier 228 New Generation
- Flap System
- Landing Gear Actuators
- Nose Wheel Steering System

HAL

Dornier 228
- Flap System
- Landing Gear Actuators
- Nose Wheel Steering System

HJT 36
- Cabin Pressure Control System

Jaguar
- Cabin Pressure Control System

LUH
- Heating and Ventilation System

Tejas
- Cabin Pressure Control System

IAI

G200
- Cabin Pressure Control System Components
- High-Lift System

Leonardo (Aircraft)

C27-J
- Cabin Pressure Control System

M-346
- Main Landing Gear System
- Nose Landing Gear System
- Nose Wheel Steering System

Longview / De Havilland Canada

MELTEM III-MMI
- Anti-ice system
- Auxiliary Cooling System
- Cabin Pressure Control System

Mitsubishi Heavy Industries

CRJ700 / 900
- Integrated Air Management System
- Low-Pressure Ducting

CRJ1000
- Command-by-Wire Rudder Control System
- Integrated Air Management System
- Low-Pressure Ducting

Textron Beechcraft

750 / 850XP / 900XP
- Cabin Pressure Control System

Participation in programs

Actuation – Advanced Air Mobility – Engines – Pods – Rotor Wing Aircraft – Space Applications

Airbus (Helicopters)

AS350 / 355 Ecureuil
- Environmental Control System Components
- Gears for Main Gearbox

BK117
- Gears for Power Transmission Gearboxes
- Hydraulic Power Supply
- Main and Tail Rotor Servo Controls

H120
- Environmental Control System Components

H130
- Air-Conditioning System

H135 / H135M
- Gears for Power Transmission Gearboxes
- Hydraulic Power Supply
- Main and Tail Rotor Servo Controls

H145
- Gears for Power Transmission Gearboxes
- Hydraulic Power Supply
- Main and Tail Rotor Servo Controls
- Tail Gearbox

H155
- Environmental Control System

H160
- Environmental Control System Components
- Heating Valve
- Main Rotor Servo Controls
- Tail Rotor Gearbox

H175
- Environmental Control System Components

H225 / H225M
- Environmental Control System Components
- Heating System

NH90
- Actuation Control Computer
- Auxiliary Power Unit Gearbox
- Environmental Control System Components
- Fly-by-Wire Main and Tail Rotor Servo Controls

Tiger
- Gears for Tail Gearbox
- Air-Conditioning System
- Main and Tail Rotor Servo Controls
- Tail Landing Gear

UH-72A Lakota LUH
- Gears for Power Transmission Gearboxes
- Hydraulic Valve Block / Reservoir
- Main and Tail Rotor Servo Controls

AVIC HAIG

AC 312
- Air-Conditioning System

Boeing

MH-139
- Environmental Control System
- Landing Gear System

Cobham

Cobham Mission Equipment POD
- Hose Drum Drive System

HAL

ALH
- Heating and Ventilation Systems

IAI

Elta
- Environmental Control Unit for POD

Korean Aerospace Industries

KHP
- Environmental Control System Components

KT-1
- Cabin Pressure Control System
- Engine Bleed Air System
- Ventilation Control System

Leonardo (Helicopters)

AW109
- Environmental Control System

AW139
- Heating and Ventilation
- Landing Gear System

AW149 / AW189
- Environmental Control System
- Fly-by-Wire Main and Tail Rotor Actuators
- Landing Gear System

AW169
- Environmental Control System

T129
- Environmental Control System

Northrop Grumman

Litening
- Environmental Control Unit for POD

Rafael

Litening
- Environmental Control Unit for POD

Rolls-Royce

Pearl 700
- Pneumatic Component Package

Trent 7000
- High-Pressure Non-Return Valve

UltraFan®
- Power Gearbox*
- Temperature Control Valve

*In cooperation with Aerospace Transmission Technologies GmbH – a joint company of Liebherr-Aerospace and Rolls-Royce

Spirit AeroSystems

- Thrust Reverser Actuation System for Rolls-Royce Pearl® 10X Engine

Thales

Damocles
- Environmental Control Unit for POD

RECO NG
- Environmental Control Unit for POD

MELTEM II
- Environmental Control Unit

Thales Alenia Space

Space Inspire
- Thermal Management Components

Turkish Aerospace

Turkish Light Utility Helicopters (TLUH)
- Air-Conditioning System
- Oil Cooling System

Volocopter

VoloCity
- Pilot-/Interface Control Computer

Liebherr-Transportation Systems

Liebherr-Transportation Systems is one of the leading manufacturers of systems and components for the rail industry. Backed by many years of experience, Liebherr stands for competitive technological solutions in air conditioning and actuation systems as well as electronic components for all kinds of rail vehicles.

Groundbreaking technologies at InnoTrans 2022

The COVID-19 pandemic had a profound impact on conferences and trade shows worldwide, leading to the cancellation or postponement of several major events and exhibitions that serve as crucial platforms for networking and showcasing the latest technologies and innovations. InnoTrans, the world's leading trade fair for transport technology and mobility, was no exception, and the event was postponed in 2020 due to safety concerns related to the pandemic. However, with the rollout of vaccines and the implementation of safety measures, the industry had been eagerly looking forward to the return of in-person events. The recent resurgence of InnoTrans in Berlin from September 20 to 23, 2022, served as a clear signal that networking at large-scale events is poised for a comeback, with new products, technologies, and innovations taking center stage.

The event came back in full force bringing together more than 2,800 exhibitors from over 50 countries, providing an excellent opportunity for companies like Liebherr to showcase their latest products to a global audience of industry experts and potential customers. Sustainability was a central theme at the event, with a strong focus on alternative fuel systems, battery-electric and fuel cell-powered buses and trains, as well as other eco-friendly technologies.

Air-free brake actuator with "brake-by-wire" ready for series production

Liebherr-Transportation Systems impressed attendees with cutting-edge technologies. As a highlight exhibit, the company presented an air-free brake actuator for the first time at InnoTrans. The actuator is part of Siemens Mobility's air-free brake system. Liebherr and Siemens Mobility jointly developed the electro-hydraulic brake actuator that provides the brake force for the brake system.

In contrast to a conventional pneumatic brake, the brake control in the new air-free brake system from Siemens is completely electrical. This system, also known as "brake-by-wire," therefore eliminates the need for all piping and all pneumatic components for controlling the brake. Siemens Mobility is using the new brake technology for the first time in the "X-Wagen" metro project in Vienna (Austria). There it went into passenger service at the end of 2022. In operation, the new system leads to lower costs in several areas: in maintenance, for example, and it also reduces the time required for train commissioning as well as cycle time.

The Liebherr booth attracted many visitors at InnoTrans.

Component of LiCAS

Less wear on rails: LiCAS
Liebherr's Controlled Axle Steering "LiCAS" system was also a standout innovation at InnoTrans. This system significantly reduces wear and tear on the rails and wheels, while providing stability and control. It also helps to improve safety and passenger comfort by reducing vibrations and noise levels and contributes to the longevity of rail infrastructure and the conservation of resources. The system was developed by Liebherr-Transportation Systems and successfully subjected to an initial field test in cooperation with the British railroad company Grand Central (part of the Arriva Group) and NewRail (the center for rail transport research at Newcastle University).

Air-conditioning system with natural refrigerant propane
Another highlight at Liebherr's booth was the demonstrator of propane-based air-conditioning system – an innovative technology designed to provide efficient and eco-friendly cooling for railway vehicles. The corresponding technical concept, which takes into account all relevant safety requirements, was developed in cooperation with TÜV Süd. The system uses propane, a natural refrigerant, which reduces the reliance on traditional refrigerants that are harmful to the environment. The system operates with high efficiency, ensuring maximum cooling power while minimizing energy consumption. This makes it an ideal choice for railway vehicles, where energy consumption is a crucial factor. In addition, the system is designed to be easy to maintain and service, ensuring minimum downtime and reliability for railway operators. As environmental concerns continue to grow, Liebherr's propane-based system is set to play a crucial role in the future of railway vehicle air conditioning, offering a sustainable and efficient solution for vehicle manufacturers and operators.

Cooperation with Sung Shin RST
Aside from the impressive showcase of products and innovations, Liebherr also made a significant announcement that further signals its commitment to the rail industry. The company signed a memorandum of understanding with Sung Shin Rolling Stock Technology, a renowned manufacturer and supplier of passenger train sets, diesel locomotives, and other special-purpose vehicles based in South Korea. The partnership is set to collaborate in market and work on air-conditioning technology of railway vehicles, combining Liebherr's expertise in technology with Sung Shin Rolling Stock Technology's vast market reach and experience.

The air-conditioning system is based on R290 refrigerant. A first series production-ready version will be available for the market from mid-2023.

The signature ceremony with Sung Shin RST took place at the Liebherr booth during InnoTrans 2022.

Impulses for the future

Road freight transport is facing increasingly complex challenges – especially when it comes to alternative fuels and digitalization. This is where the strength of both CELSINEO manufacturers especially come into play.

Krone is a well-known and respected manufacturer of commercial vehicles in Europe, offering a wide range of trailers and semi-trailers for various applications. All of Krone's commercial vehicles are designed with a focus on safety, efficiency, and durability, and the company's commitment to quality is reflected in the high standards of its manufacturing processes and materials. With a reputation for excellence and innovation, Krone is a trusted and reliable choice for commercial vehicle needs in Europe and beyond.

Liebherr is known as a technology-driver in the area of thermal management and generations of engineers have developed expertise in cooling and refrigeration. After aviation and rail, the next step was into road transport: The Liebherr team developed with CELSINEO a highly advanced refrigeration system for use in trailers that transport temperature-sensitive goods, such as food and pharmaceuticals. The system provides precise temperature control and high levels of efficiency, while also being easy to use and maintain. It consists of three separate cooling units, each with its own compressor, evaporator, and condenser. The three units work together in a coordinated manner to provide optimum cooling performance, while also allowing for redundancy in case one unit fails or requires maintenance.

CELSINEO is highly energy-efficient, with advanced control algorithms that optimize the cooling process and reduce energy consumption. In addition, it is user-friendly, with a simple interface that allows for easy monitoring and adjustment of temperature settings. It can be integrated with telematics solutions to provide real-time data on temperature and other parameters, allowing for remote monitoring and management of the refrigeration system.

Electrification, telematics and over-the-air-upgrades are the next steps and actual product developments running at full speed towards their release. The transport sector needs new options for Europe's roads in order to make journeys as easy as possible.

Continuously creating new impulses for resource conservation, economic efficiency and comfort – this is the joint mission of Liebherr and Krone.

The triple pack

When it comes to creating a brand, many companies focus on the visual elements such as logos, color schemes, and typography. While these elements are undoubtedly important, there is another crucial factor that is often overlooked: emotion. When Krone and Liebherr joined hands to create a new marketing strategy for CELSINEO, they worked diligently to ensure that all details of the brand would really speak to customers.

CELSINEO's marketing campaign is very emotionally resonant – the sight of three huskies running ferociously through the glittering white snow represents the power of the three modules of the cooling system developed by Liebherr.

The huskies' captivating and mesmerizing gaze is a sight to behold. A large and endearing image of one of the husky's face has been utilized as a key visual across various marketing platforms such as brochures, videos, trailer labeling, and at the CELSINEO stand during trade fairs. People are irresistibly drawn to gaze into the bicolor eyes, generating a powerful emotional connection to the CELSINEO brand. The blue and brown eye represent the two distinct yet perfectly complementary powerful companies Liebherr and Krone.

One thing is unequivocally true – the sight of these three-pack huskies running powerfully through the snow will stay etched in the memory of their customers.

The mastery of the brand development: CELSINEO cleverly represents a combination of the word "Celsi", inspired by Anders Celsius, who introduced the concept of a universal temperature scale, and "Neo", which means "new" in Greek. The three bars in the logo for both letters E are also a gentle and succinct reminder of the modular cooling system.

The World with Liebherr

At Bauma, Liebherr was the largest exhibitor with numerous innovations and forward-looking developments from many of its product segments.


LIEBHERR

Our highlights

What special things the year 2022 had in store for Liebherr

From technology package to turnkey robotic cell
Liebherr is making its expertise in industrial robot vision applications accessible to a wide range of users through its LHRobotics.Vision technology packages. As a manufacturer of bin-picking robotic cells, Liebherr is familiar with the challenges of this application and has used artificial intelligence to simplify the software so that it can be used intuitively by anyone.

Anniversary crane travelling to the Czech Republic
Liebherr-Werk Biberach has shipped its 1,000th mobile construction crane. The MK 140 Plus is going to Hanyš - Jeřábnické práce, s.r.o., the largest provider of crane operations in the Czech Republic. In fact, it is the first mobile construction crane of this type to be supplied to the Czech Republic. The MK 140 is characterised by great flexibility, a compact footprint and a high level of operator comfort.

More space, less weight
Liebherr is a partner of the new air-free brake system from Siemens. The two companies have jointly developed an electrohydraulic brake actuator that converts the brake force for the brake system. Unlike a conventional pneumatic brake, the system – also known as 'brake-by-wire' – is controlled entirely by electrical means.

Revolutionising refrigeration and freezing technology
Liebherr is the only manufacturer worldwide to use a vacuum and finely ground lava rock – the raw material perlite – to insulate its appliances. Due to its crystalline microstructure, this lava rock has very low thermal conductivity. When coupled with a vacuum, this offers the best possible insulation in terms of energy.

A game-changer for tomorrow's energy
The market requirements for large crawler cranes are growing. Driven by the energy transition, unit weights are increasing, especially for machinery intended to handle offshore wind turbines. Liebherr has risen to the challenge with the new LR 12500-1.0 crawler crane. Boasting immense load-bearing capacity and a unique transport concept, it is also designed as a cost-effective crawler crane for projects all over the world.

Your dream machine – just a few clicks away
The new product configurator for earthmoving and material handling machines gives prospective buyers the opportunity to configure their dream custom Liebherr machine from anywhere and at any time. Step by step, the intuitive application guides the user through the machine design and the available versions of the equipment.

The future of flying
At ILA 2022 in Berlin (Germany), Liebherr presented innovations for more environmentally friendly flying in the future. This includes solutions for the More Electric Aircraft concept, research into new energy sources such as hydrogen, and strategies for reducing the weight of components through 3D printing.

Zero emission mining
Liebherr and Fortescue have signed an agreement to develop and supply mining trucks with zero-emission drive systems. Through such efforts, the companies are jointly tackling the challenge of reducing CO_2 emissions from heavy mining equipment.

Zero local emissions
Construction sites are becoming increasingly electrified, so they have a rapidly growing need for environmentally friendly energy. Liebherr's new Liduro Power Port (LPO) enables emission-free on-site operation and charging of construction machinery.

On site all year round
Concrete mixing plants, truck mixers and concrete pumps will be on display for customers, partners and dealers all year round at the new Liebherr-Mischtechnik GmbH exhibition area. The in-house display allows visitors to inspect the various systems throughout the year and obtain professional advice on site in Bad Schussenried (Germany).

Digitalisation in deep foundation engineering
Processes on construction sites are becoming increasingly complex and more and more data is being recorded. Processing and evaluating such data immediately is crucial in order to optimise work steps and ultimately save time and money. Digitalisation is now finding its way into deep foundation engineering with the MyJobsite digital solution. This enables the relevant process, machine, construction site and position data to be recorded, managed, analysed and evaluated.

Ready for future climate demands
Liebherr is expanding its heavy-duty ship crane portfolio with a new 800 tonne crane to establish itself in the growth market of ever-larger components for the wind power industry. The highlight of the LS 800 E is its fully electric drive concept.

On your site
Liebherr is the largest exhibitor at the Bauma construction industry exhibition in Munich (Germany). Across more than 15,000 m² of exhibition space, the Group presents the latest developments in the fields of construction machinery, cranes, material handling, mining, and components with over 100 exhibits.

Expansion of the Löwen Hotel Montafon
New architecture, stylish interior design, culinary indulgence, and the return of a legend: extensive construction work at the Löwen Hotel Montafon in Schruns (Austria) is set to continue until early 2023.

Interview with the family shareholders

A conversation with Dr. h.c. Isolde Liebherr, vice president of the administrative board of Liebherr-International AG until 31 March 2023, Dr. h.c. Willi Liebherr, president of the administrative board of Liebherr-International AG until 31 March 2023, Patricia Rüf, member of the administrative board of Liebherr-International AG, and Jan Liebherr, incoming president of the administrative board of Liebherr-International AG from 1 April 2023.

Isolde and Willi Liebherr, you have resigned from your positions as vice president and president of the administrative board of Liebherr-International AG, effective end of March 2023. Does this mean that you're now leaving the Liebherr Group and entering retirement?

Willi Liebherr: My sister and I will continue to be members of the administrative board, so we won't be leaving the company. Nevertheless, with the replacement of my son Jan and my niece Stéfanie in the presiding committee, we have taken another step towards a generational change in the company's management.

Isolde Liebherr: As long-standing members of the administrative board, all representatives of the third generation have a great deal of experience in managing our Group. We transferred shares in Liebherr-International AG to them back in 2012. Since then, they have managed various areas of the Group alongside us. The presiding committee of the administrative board is elected every three years. We thought that this year's election was the right time to make a new appointment to the presiding committee.

Mr Liebherr, what does this change mean for the Liebherr Group and for its customers and partners?

Jan Liebherr: We've simply taken another step towards the gradual transfer of responsibility from the second to the third generation of this family-run company. This process has been underway for several years. With my cousin and me as the presiding committee of the administrative board as well as the other representatives of the third generation, we guarantee continuity in the management of the company. We will continue to manage our Group as an independent family-run company based on long-standing values. Long-term orientation, responsible conduct, sound management, pronounced customer focus and immense technological expertise continue to be key factors in our success, and that's not going to change in the future.

Let's take a look back at 2022. How did the 2022 business year measure up?

Willi Liebherr: We've come through a very eventful year, shaped both by the effects of the coronavirus pandemic and the war in Ukraine. We remain

deeply saddened by the situation there. Unfortunately, our initial hopes for an immediate end to the hostilities and Russia withdrawing from Ukraine were dashed. Our deepest sympathy goes out to the people of Ukraine and the many refugees who had to leave their homes. This crisis has not only claimed countless lives and created the need for massive humanitarian aid, but has also left a deep mark on the global economy. The existing bottlenecks and uncertainties surrounding global supply chains and the procurement of materials were exacerbated by the war. Added to this were sharp increases in raw material and energy prices, high inflation rates and further increases in material and transport costs.

Patricia Rüf: Nevertheless, looking back, we can also report on some positive developments. We experienced very high demand for our products, and turnover reached a new record level by the end of the year. Following the many restrictions due to the pandemic, we were finally able to travel and hold face-to-face meetings with our customers again. In 2022, we made tremendous progress with our technologies and solutions, and invested heavily in them once again.

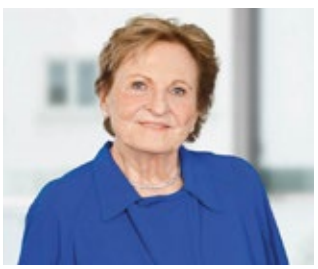
Can you tell us some of your personal highlights from the past year?

Jan Liebherr: The major highlight was, of course, the Bauma exhibition going ahead and proving to be a massive success. We were the largest exhibitor there, with a great many innovations and future-oriented developments, so we were able to make a big statement. Once again, we were able to demonstrate our technological leadership in many different areas.

Patricia Rüf: It was a very special experience, with an atmosphere of noticeably positive energy from day one. And, of course, it was nice to meet up with so many employees and customers in person again after such a long time.

Willi Liebherr: A special highlight for me was our new crawler excavator R 9XX H2, which is equipped with a prototype hydrogen combustion engine and which won the Bauma Innovation Award in the climate protection category. Or the presentation of our T 274 mining truck with trolley system, which saves fuel and also CO_2.

Jan Liebherr: To remain with the topic of mining, in the middle of the year we entered into a partnership with Fortescue Metals Group Ltd for the development and supply of mining trucks with zero-emission drive systems. These enable our customers to take one more step towards decarbonisation. That was also a special milestone for me.



Isolde Liebherr: For me, one of the top highlights was a world premiere for our refrigerators and freezers. Our new BluRoX technology makes us the only manufacturer to use an insulation vacuum in conjunction with perlite, a finely ground lava rock with very low thermal conductivity.

Let's take a look at the current business year. What are your predictions for 2023?

Jan Liebherr: The general conditions that we mentioned are still causing uncertainty and putting a strain on the global economy. It's difficult to make accurate predictions at this point in time, as things very much depend on global political development over the course of the year. Nevertheless, we began 2023 with a high order backlog and expect further growth in turnover.

Patricia Rüf: Generally speaking, there are plenty of opportunities for us this year. Just think of the energy transition and all the new opportunities and areas of business it is generating. This business year, we're once again engaging with this topic through our ongoing research into alternative drive systems and the advancement of existing technologies. We've taken the right path for the sake of future generations, and we're already making good progress. We're sure that we'll reach many more milestones this year. We're feeling optimistic about the rest of the year and are already looking forward to the Group's upcoming anniversary in 2024.

This text is an excerpt of the interview. The full interview can be found in our online annual report:

→ www.liebherr.com/annual-report-2022

The best of all worlds

They say that all roads lead to Rome. And the same applies to sustainable development and climate-friendly technology. An openness to technology of all kinds is a must in order to address the diverse requirements of commercial vehicle transport, on construction sites, mines or off-road. This is where the future lies.

No shortcuts to climate action

Climate protection at the touch of a button would be great. Unfortunately, however, an instant feel-good shift from fossil combustion engines to sustainable carbon-free or at least carbon-neutral drives is still a long way off, especially for certain types of construction machinery. “A compact wheel loader for horticultural use will have different requirements than a 100-ton crawler excavator used in mining sites at altitudes of 5,000 m in the Andes. In other words, developing drive concepts calls for a great many and different skills,” says Jürgen Appel, Head of Technology Coordination at Liebherr-International AG.

Seeing the big picture

What does the carbon footprint of construction machines include? To find out, Liebherr carried out a comprehensive life-cycle analysis of the greenhouse gas emissions of standard construction machines in cooperation with business consultancy Frontier Economics. Exactly the same machine model was equipped with different drive solutions and examined. It became apparent that there is no superlative, catch-all solution for climate-neutral drive systems for construction machines.

"We can only achieve the CO_2 reductions that we want and need by looking at the entire life-cycle of a machine holistically. And we can't do if we're closing our eyes to certain technologies from the outset. Instead, we have to concentrate on ensuring that innovative, future-proof and climate-relevant technology is presented in such a way that customers can work with it, too," says Jürgen Appel.

Future to the power of three

Liebherr is pursuing a three-part approach to its technology:
1. increasing the efficiency of existing drive systems
2. electrification
3. alternative fuels for combustion engines

Liebherr technologies with bright prospects

The Frontier Economics study has shown that holistic, life cycle-based analysis of construction machines and heavy equipment is necessary in order to achieve the climate goals laid down in the Paris Agreement. Liebherr brings together a wide range of experience and engineering skills in its central operations Corporate Technology and its own competence centers, such as our facility dedicated to batteries in Biberach and the Liebherr Digital Development Centre in Ulm.

"Liebherr isn't just a manufacturer of machines and components, it also combines entire system competence in one place. This enables us to make advances in efficiency in all types of drives," says Jürgen Appel. "This is invaluable for the timely and practical transition of technology." It is always about taking a holistic perspective that encompasses both the environment and the available infrastructure: "It doesn't make sense to develop alternatives based on renewable energies without considering their availability. Openness to technology means that our machines actually work for our customers, not least in terms of progressive climate action."

Liebherr's path to the energy transition

Liebherr equipment and components are playing an important role in the global transition to a decarbonised economy. The Group's contributions include ship and mobile cranes for the construction of offshore and onshore wind farms, construction machines for smart city and rail network expansion, or with material handling technology for recycling valuable materials.
It must be said that many of the Liebherr machines that will play a key role advancing energy transition are designed for high power requirements and continuous operation, and are therefore based on a powertrain using fossil fuels. As this makes them major emitters of CO_2, Liebherr has accelerated the development of low-emission and zero-emission technologies across its wide range of products, making significant progress along the way.
"In the interests of future generations, we are continuing to invest heavily in innovations that are good for our customers and the environment alike," explains Jürgen Appel. "In doing so, we are focusing on a comprehensive increase in efficiency."

Green electricity bottleneck

The key to lowering greenhouse gas emissions lies in the electricity generated from renewable forms of energy. It is the basis for climate-neutral electric drive systems and the production of e-fuels and "green" hydrogen. In its annual survey of energy professionals, the global classification society Det Norske Veritas (DNV) recently found that few figures in the industry (17%) believe that the energy transition over the next decade will deliver safe, clean and affordable energy for all parts of the energy system in their country.

However, the energy industry expects higher investments in clean energy sources by as early as 2023, mainly in low-carbon hydrogen / ammonia (52%). Wind power (49%) and solar energy (46%) will see a similar share in investment.

Renewables are still on the rise in Europe and the USA. In Germany, for example, they accounted for already 48.3% of consumption in 2022 (2021: 42.7%).

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