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Josef Gropper, Francis Carla, Nicolas Bonleux

Dear reader,

Over the past few years, the continuous growth of the aerospace industry has generated many opportunities for us.

Thanks to the confidence that our customers place in us, our investments into technologies and into operational excellence, and our highly motivated teams worldwide, we have been able to materialize these opportunities into promising paths for our future.

Many customers, aircraft manufacturers and aircraft operators have entrusted us with their renewed confidence. We are proud of their confidence which illustrates our ability to contribute to their designing and building higher performance aircraft or to their enhancing the operations of their aircraft fleets.

In parallel, we have supported our customers in developing and certifying new products, and thus opened up new markets and brought our aviation industry to new standards.

These many successes reflect both our efforts to take technology to new horizons and our commitment to supporting our customers in making sure their aircraft programs and operations meet the demanding requirements they are faced with. Going through the articles of the 2018/2019 edition of our magazine, you will get an overview of our unique range of products and technologies.

Our teams worldwide play a key role in shaping a bright future for our company and for our industry. We warmly thank them for their outstanding commitment.

Best regards,

Josef Gropper
Managing Director and
Chief Operating Officer

Francis Carla
Managing Director and
Chief Technology Officer

Nicolas Bonleux
Managing Director and
Chief Sales Officer

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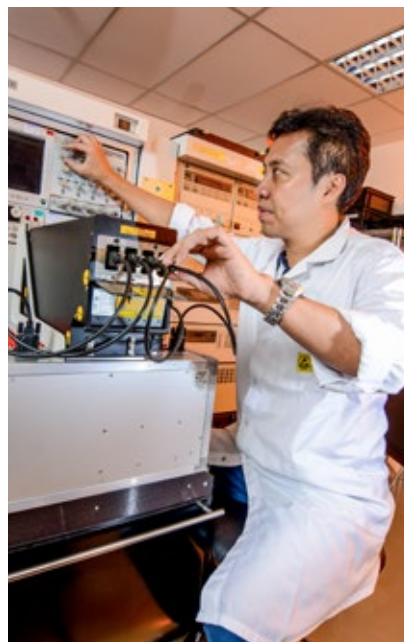
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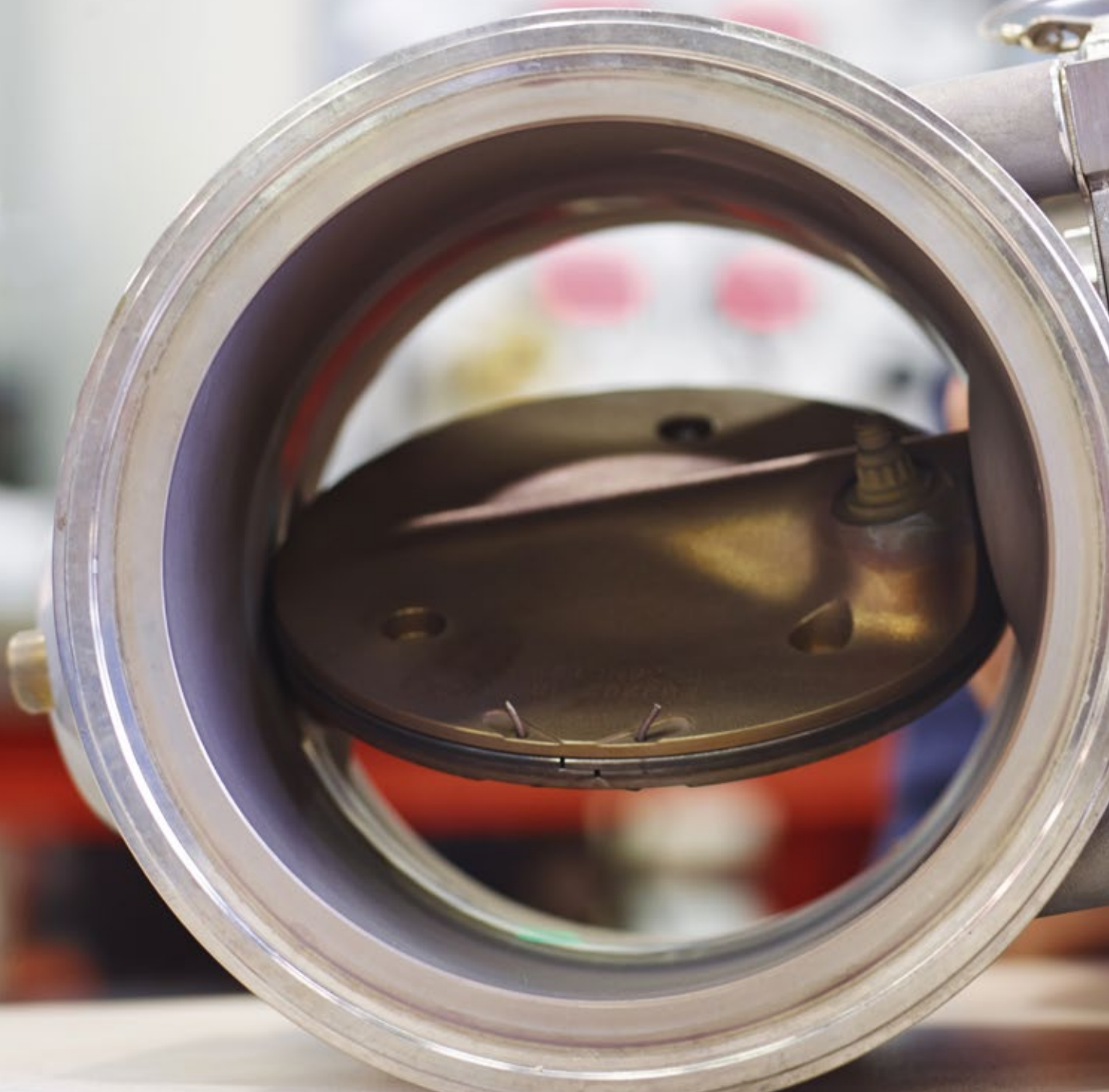
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Impressions

Know-how, sensitivity and precision are crucial for maintaining high standards of quality. With its highly skilled workers and a wide range of cutting-edge production technologies and testing methods, Liebherr-Aerospace is able to ensure that all the aviation components that it develops, manufactures and maintains function reliably and exactly as required.





The Success Factor

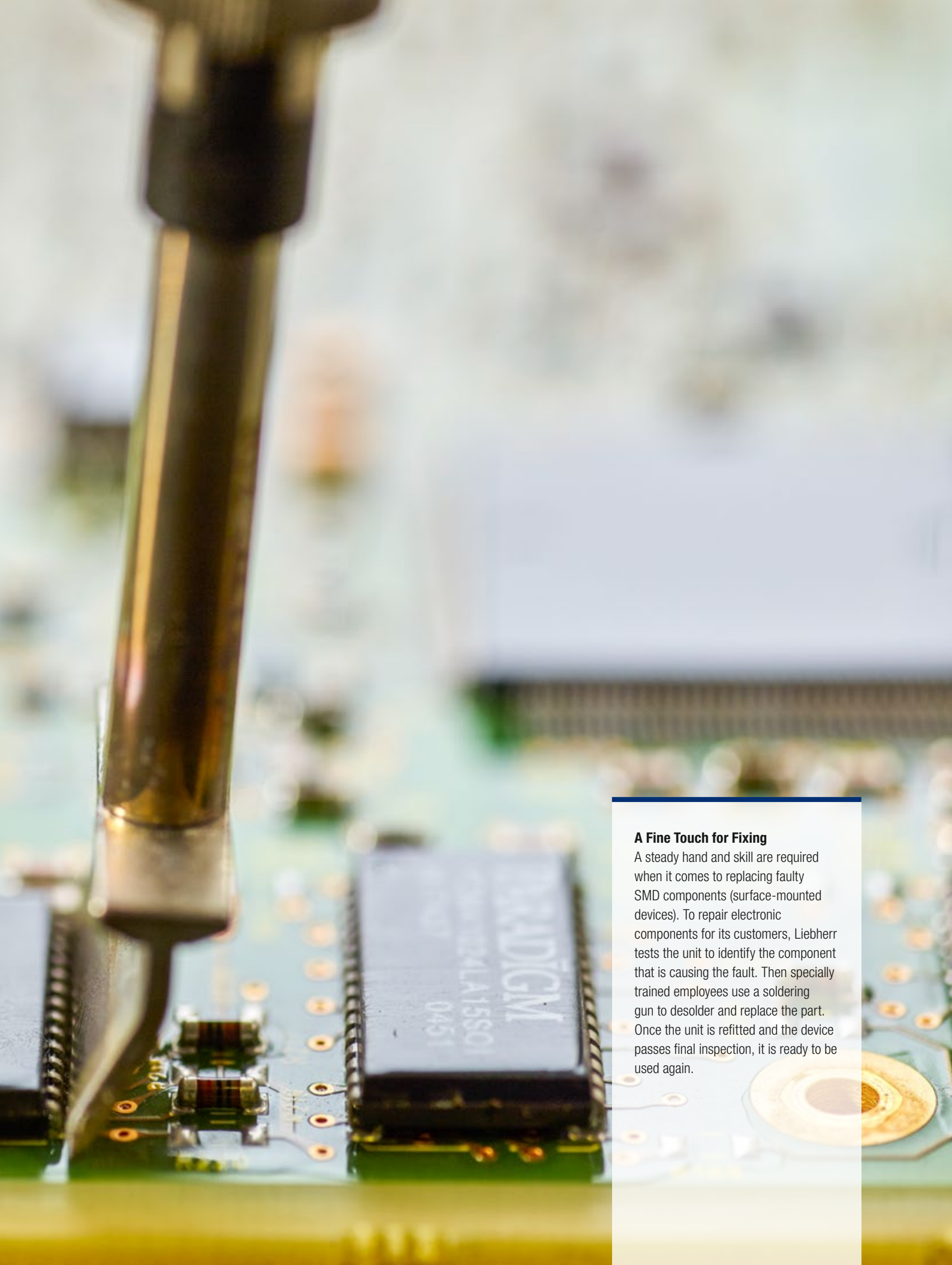
Electro-pneumatic bleed air valves from Liebherr keep working reliably at air temperatures as high as 600 °C and pressures reaching 40 bars – even under the most extreme conditions. These components are used in many aircraft programs.



MONITOR BOARD

R163
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A Fine Touch for Fixing

A steady hand and skill are required when it comes to replacing faulty SMD components (surface-mounted devices). To repair electronic components for its customers, Liebherr tests the unit to identify the component that is causing the fault. Then specially trained employees use a soldering gun to desolder and replace the part. Once the unit is refitted and the device passes final inspection, it is ready to be used again.





Next Generation Actuators

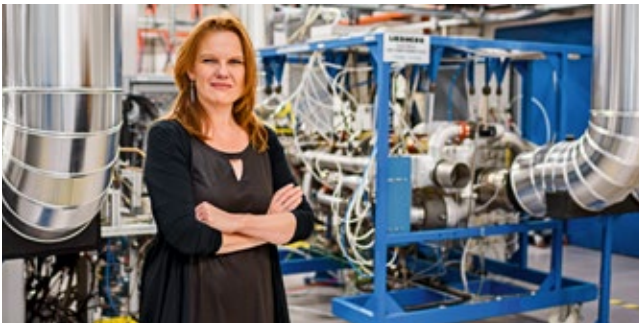
Liebherr is already working on the next generation of 3D printed hydraulic and electro-mechanic components such as a highly integrated rudder actuator. Unlike the conventionally produced version, the 3D printed component does not feature a separate valve block, neither does it have a separate cylinder housing nor an extra reservoir – all parts are built into one monolithic, compact housing.



Research & Development

Electrifying Performance

Lower fuel consumption, less weight and aircraft that are more efficient overall – these aims are the driving force behind all the research work regarding the More Electric Aircraft (MEA). Nathalie Duquesne, Director Research, Technology, Expertise, Process at Liebherr-Aerospace Toulouse (France), and Stefan Pufe, Director Research and Technology at Liebherr-Aerospace in Lindenberg (Germany), are working with their teams on new concepts for electrically powered technology for flight controls and actuation, landing gear and air management systems.



What projects is Liebherr-Aerospace pursuing in the “More Electric Aircraft”?

Nathalie Duquesne: The current projects in Toulouse relating to More Electric Aircraft cover the optimization of the electrical air conditioning system (E-ECS Electric Environmental Control System) and the electrical anti-icing system for slats (E-WIPS Electric Wing Icing Protection System). Both systems are designed to reduce weight and fuel consumption by adapting the necessary energy in every flight phase to the actual need. Right now, we are aiming to make our products ready for series production. In parallel, we are developing the connected electrical load and thermal management on board the More Electric Aircraft which take shape and are implemented on a test stand covering a surface of 200 m².

Stefan Pufe: In Lindenberg, we are currently concentrating on developing and testing electrical flight control and actuation systems. For this, we are connecting the actuators on a new research platform, which is called E-WING®. These are electro-mechanical actuators (EMA) and electro-hydraulic actuators (EHA). The EHAs, for example, had been considered as an emergency back-up. Here, we are working on making them more powerful and thus ready for use in permanent operation.

How would you describe E-WING in concrete terms?

Stefan Pufe: E-WING is a sequence of currently five test stands. In Lindenberg, 300 m² is available as a test area on which we will connect the individual concepts with each other as demonstrators and simulate their actual operation. We have designed a complete, special computer architecture with its own bus system for this, with central and local computer units. In addition, we are using an unusual power supply for the tests: In an airplane today, the equipment is controlled normally with 115 V 400 Hz AC. The technology of the future tends to use DC, and a much higher voltage of 540 V. We are testing this directly in the test center to see whether our components also function as expected in these conditions. One of the models for this platform was the GETI (Gestion dynamique de l'énergie électrique et thermique) platform developed by our colleagues in Toulouse who test their air conditioning components on it.

What is the current status of the E-ECS?

Nathalie Duquesne: The series of flight tests that was carried out in 2016 with both the ATR72 and A320 test aircraft was very successful and showed that a competitive solution for aircraft is available. Our interdivisional team captured, evaluated and analyzed the flight test data. The results showed an excellent correlation with the forecasts and the tests carried out on our test stands in Toulouse. These include cabin pressure control in high altitudes and the interaction with the electrical HVDC network. The greatest challenges for E-ECS were offering aircraft manufacturers additional advantages compared with traditional air conditioning systems and at the same time keeping the expected reliability and maturity at the same level at least.

The control principle of the E-ECS was also a critical point, as it was extremely important to ensure perfect system operation in all flight phases. Both internal trials and flight tests completely confirmed its robustness and stability. These tests also enabled us to validate all our models. We are currently working on integrating all the results from the flight tests into our system architecture. The aim is to further optimize E-ECS for our customers. We are currently preparing the design freeze of our recently improved E-ECS architecture for use in single-aisle aircraft with an even higher level of maturity of the architecture and the key technological components.

And how are things looking as regards E-WING?

Stefan Pufe: We are building the test rigs, adjusting the controller systems and creating the technical environment for the upcoming tests. Within this frame, we will be testing the actuators in real conditions – instead of an aerodynamic load, for example, they are moving a hydraulic one – and recording and evaluating the results for the bus system. And of course, we want to see how the actuators work under the higher voltage of 540 V DC.

What makes such a large test environment unusual?

Stefan Pufe: We want to use the E-WING to gain a better understanding of the overall architecture with its various components. To qualify the individual actuators, we would not need an integration test on this platform. But with the E-WING, we have the unique opportunity to test our components – present and also future – in a context. One of the aims is – after the modeling – to scale the entire wing system. Because the aircraft in which our actuators are used range from business jets to the huge A380. With this simulation, we will be able to adapt the entire architecture accordingly.

What is the advantage for aircraft manufacturers?

Stefan Pufe: Not only do we have a better overall understanding of the technology, we are also able to work actively on improving the system because we are familiar with the higher level, the E-WING. This takes component research to a completely different level. In addition, not every aircraft manufacturer has the opportunity to research an entire architecture sufficiently for itself. We can take this on immediately.



How do the MEA experts from Lindenberg and Toulouse exchange ideas?

Nathalie Duquesne: Both locations are deeply involved in the Clean Sky 2 initiative which helps develop a common understanding of aircraft manufacturers' expectations and predict future challenges better. When it comes to the overall vision of the More Electric Aircraft, we work very closely together and make use of the synergies and the experiences we exchange. This close collaboration also happens with Liebherr-Elektronik GmbH in Lindau (Germany) which is at the cutting edge in the field of power electronics, a major component of the More Electric Aircraft. These common approaches help us not only to coordinate our requirements with each other and to bundle our strengths and our knowledge but also to keep on challenging ourselves. Cooperation makes us stronger so that we can prepare the aircraft concepts of the future in the interests of our customers.

3D Printing Technology Made by Liebherr: The Next Milestones

In March 2017, an Airbus A380 test aircraft flew for the first time with a spoiler-actuator valve block made by Liebherr-Aerospace using a 3D printer. Since then, a lot has happened in additive manufacturing at Liebherr-Aerospace – and development is advancing at a fast pace.



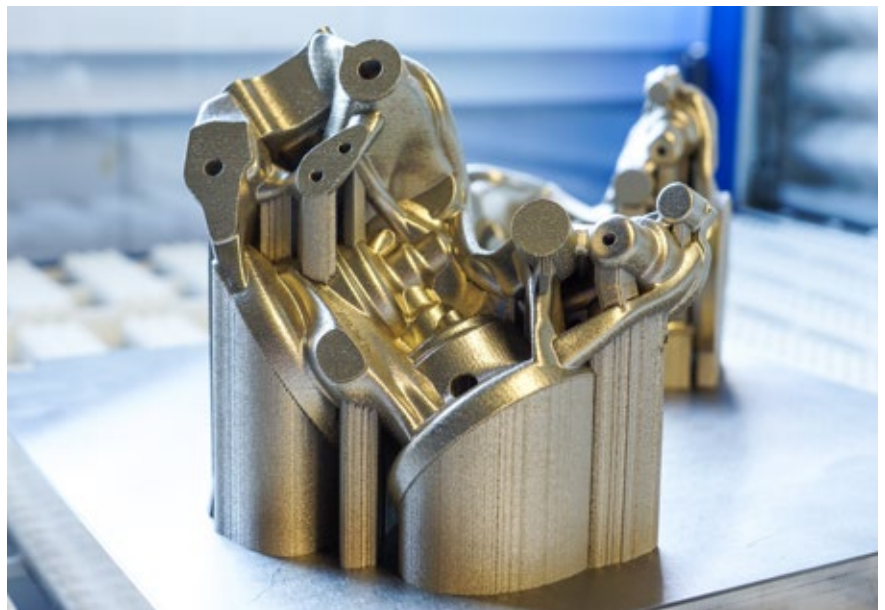
To remove powder residues from the components reliably, they are cleaned in an electro-chemical bath in Lindenberg after manufacture.

While long-term experience with the technology is gained during the flight test on the A380, Liebherr-Aerospace in Lindenberg has been working mainly on optimizing and documenting the individual process steps. In the fall of 2017, the team reached a key milestone: Liebherr-Aerospace Lindenberg GmbH is one of just three companies in Germany to be authorized by the German Federal Aviation Office (Luftfahrtbundesamt, LBA) to produce flight components using the additive manufacturing technique. This great success means that Liebherr is a recognized pioneer and trusted partner in the aircraft world. Specific plans are already underway for the industrial launch of non-safety-critical mountings for landing gear sensors and flight control systems. In the medium

term, more complex and also safety-critical components will be produced,

which fully utilize the potential of additive manufacturing. Partly for this reason, the Lindenberg site recently acquired a second 3D printer. There are also plans for the company's own product designers to be trained by colleagues in additive manufacturing, to establish a shared understanding of the technology.

Liebherr-Aerospace Toulouse SAS, in Toulouse (France), is driving development forward with nickel alloy 718: a serial part from the 3D printer is currently undergoing qualification in an engine bleed air valve on an ATR 42/72. The first deliveries of the equipment are scheduled for the end of 2018. In 2017, the team in Toulouse also made parts from an aluminum alloy using the 3D printing process, with the result that Liebherr-Aerospace in Toulouse now has a wider available selection of 3D materials

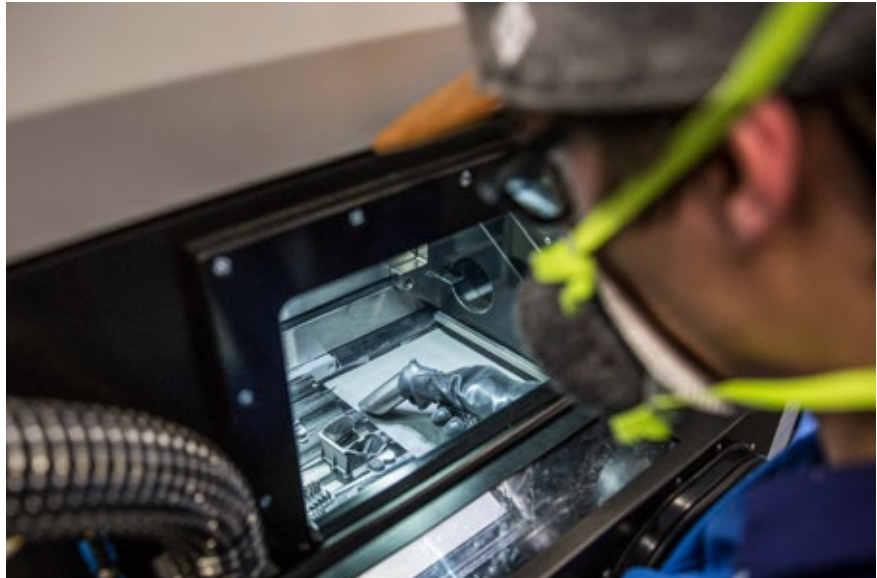


Semi-finished valve bodies from Toulouse with production stands that are removed in a later processing step.

that are suited to its requirements. Furthermore, the company is working in partnership with a number of aircraft manufacturers on more complex and more critical high-value air system components, which could be offered for their future platforms.

Two sites – one common strategy

Both Aerospace sites are pursuing a common strategy across all their activities. Constant communication is therefore an important part of their work, to gain from synergy effects. This applies for example to the creation of necessary technical documentation so that some of their own components can go into series production. At the same time, experts in Lindenberg and Toulouse are identifying a shortlist of components that could similarly benefit from additive manufacturing in terms of weight savings or multifunctionality. Both teams are working in close consultation with aircraft manufacturers – not only to enhance or develop new components, but also to streamline and optimize processes. This



Looking into the production chamber of the 3D printer in Lindenberg

too is a top priority since it is a key factor in cost-efficient production. The experts in Toulouse have their sights firmly set on the future milestones: additive manufactured nickel alloy components need to be ready to put into service in aircraft, and they are also working on

producing more complex and flight-critical components, as well as external supplier qualification. With a fast-growing number of providers of new processing machines and powder manufacturers, this is a highly dynamic field.

Award for 3D Printing

In March 2017, Liebherr made aviation history: a 3D printed spoiler actuator valve block flew on a flight test A380 for the first time. This is the first 3D printed primary flight control hydraulic component ever flown on an Airbus aircraft. Liebherr-Aerospace developed the hydraulic component in close cooperation with Airbus and Chemnitz University of Technology. The project was partly funded by the German Federal Ministry of Economic Affairs and Energy. For this development achievement, the aircraft manufacturer presented its Tier 1 supplier with the prestigious Airbus System Supplier Award, the “Golden Concept Plane”.



Alexander Altmann (center) from Liebherr-Aerospace accepts the Airbus “Golden Concept Plane” award.



Engineering & Production

Safe Take-Offs and Landings – An Airplane Life Long

Landing gear systems are among the core skill areas of Liebherr-Aerospace Lindenberg GmbH. The development teams work continuously on new, efficient system solutions. Once a system is ready for series production, the In-Service Engineering Team for Landing Gear is brought in to take over system engineering responsibility. Internally, the department is the interface between all the specialist disciplines involved; externally, it is the main point of contact for aircraft manufacturers for any technical questions.

Landing gears are among the safety-relevant systems on an airplane. Take-offs, landings, taxiing along the runway – if there are problems here, then nothing else works. To prevent this from happening, Liebherr-Aerospace in Lindenberg is constantly working on innovative, efficient landing gear systems on which around a million passengers a day across the globe can rely. And the loads here are massive: An average regional jet, for example, has a take-off weight of around 22 metric tons; a medium-sized long-haul airplane can weigh as much as 300 metric tons. For the specialists at Liebherr-Aerospace, the product lifecycle does not come to an end after the first design sketch, prototype production, certification and series delivery. In fact, the company also offers comprehensive servicing for the landing gear systems, which remain in service for up to 30 years, the life time of an aircraft. Alongside maintenance and repairs, Liebherr-Aerospace attaches particular importance to the continued further development and optimization of series products – in close coordination with the aircraft manufacturers. In order to realize this concept as effectively as possible, an In-Service Engineering Team was set up in Lindenberg. Around 30 specialists work on an interdisciplinary, cross-divisional basis with all the departments involved in the product manufacture and further development. At the same



The In-Service Engineering Project Coordination Team

time, the team is the first point of contact for customers for all technical matters relating to the landing gear systems.

“We are probably one of the departments with the most interfaces to other sections within the company”, comments Thorsten Ferentschik, Team Leader Project Coordination, In-Service and Lifecycle Management Landing Gear Systems at Liebherr-Aerospace Lindenberg GmbH. “We work with the teams in Series Production and New Development, plus the After-Sales and Repair department.” This diversity is

matched by the range of tasks undertaken by the Team, which is subdivided into Technical Project Coordination and Product Management plus an In-Service Design Team of its own. The In-Service Engineering Team thus also supports quality assurance by evaluating components during production.

“For the final assembly of the systems into the aircraft, we support manufacturers with our expertise by drawing up technical instructions, for example”, says Thorsten Ferentschik. The situation is similar for repairs: “We supply our repair shops and our customers across the globe with detailed repair instructions for maintaining and overhauling the systems.” These instructions are integrated into the maintenance manuals if necessary in order to enhance the repair capabilities and possibilities of the components. To get an idea of the reliability of the products in operation, the staff from the In-Service Engineering Team also work closely, for example, with their colleagues in Repairs. The aim of all the measures is to maintain the airworthiness of the systems and to maximize their endurance. This includes making technical improvements to the components which are integrated into the existing landing gear systems over the years as a result of the development competence of Liebherr-Aerospace. As the direct point of contact for aircraft manufacturers, however, the team also provides answers to technical queries about the products supplied, takes up feedback and processes it.



Interdisciplinary teamwork with various departments is a top priority.

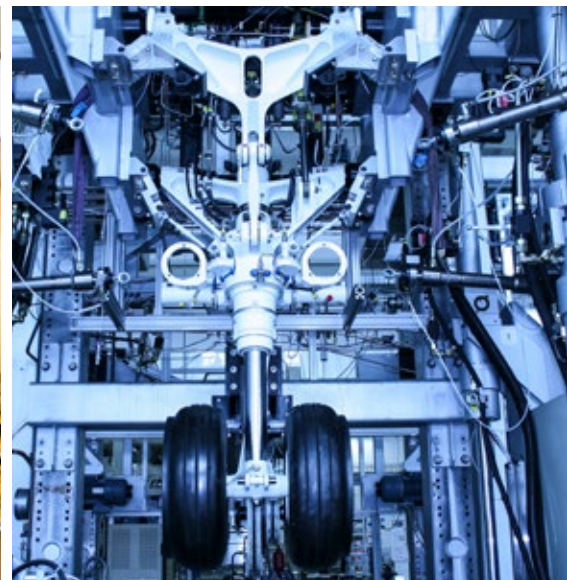
The In-Service Engineering Team for Landing Gear Systems is thus a further step in improving the collaboration between Liebherr-Aerospace and aircraft manufacturers even further. For customers, the advantage is that they have just one technical contact partner for all their queries. “This makes coordination processes particularly simple and communication routes are short”, explains Thorsten Ferentschik. Depending on the query received, the internal groups get together and tackle the problem from completely different viewpoints, respond flexibly to customer wishes and work together to develop the best solution. There is no limit to the diversity of the projects – the landing gear team works on civil and military helicopters and fixed-wing aircraft.



Embraer 190 Main Landing Gear



Airbus A350 XWB Nose Landing Gear



ARJ21 Nose Landing Gear in a test rig

Zinc-Nickel Corrosion Protection for Aircraft Components

Customers and the environment are the big winners following an investment made by Liebherr-Aerospace Lindenberg GmbH as part of its “Factory 2020” project. We’re talking about the new zinc-nickel coating plant, which has been operating since September 2017. “This plant is a major element in the ‘Factory 2020’ project”, states Claus Glocker, Treatment Department Manager at Liebherr-Aerospace in Lindenberg. The plant, which is the first of its type in Europe, is now also providing a more environmentally safe corrosion protection process for the aviation industry, which is already well established in the mechanical engineering and automobile sector. “Until now, our aircraft components have been given a cadmium surface coating, a process which is only still permitted for the aviation sector”, says Claus Glocker. The aim is to stop using the toxic heavy metal in the future – without any loss of quality.

Zinc-nickel surface treatment is one of the electrolytic processes which work with an actively connected power source and a conductive medium, the sodium hydroxide base. “This produces stable, pore-free, bubble-free surfaces which can then be painted as required and as the customer wishes”, says Claus Glocker: “At the end of production, the unit – combined with the paint – has become an also visually advanced component with a very high-quality corrosion protection.”

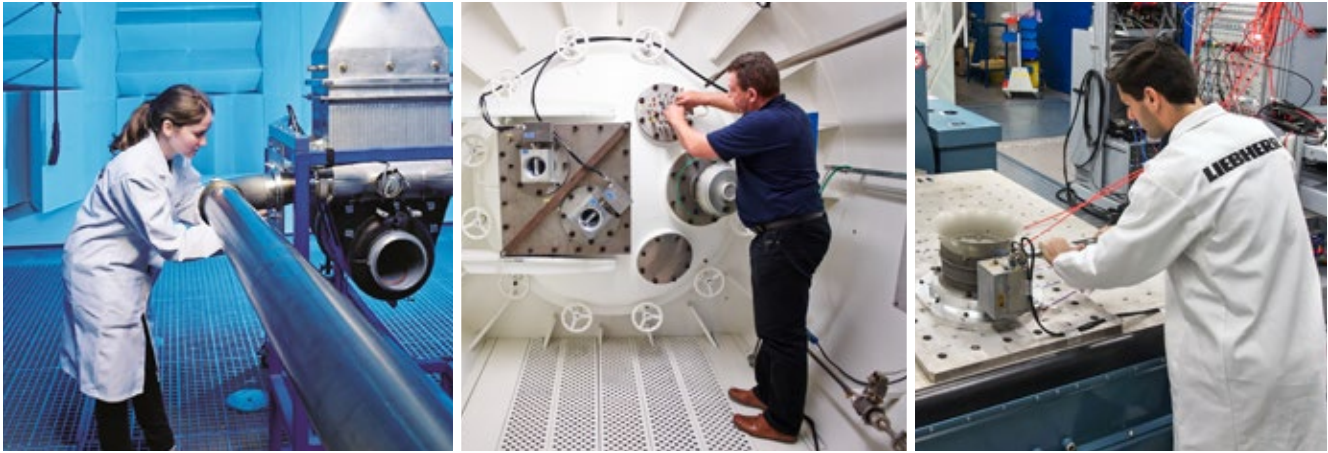
The new coating plant at the Lindenberg site is made up of three independent individual plants: a manual plant for decoating components, a further manual plant for small parts and an automatic plant for the coating of large parts. The individual plants are constructed on two levels. The plant operation is housed on the ground floor. Maintenance and tub care are taking place in the basement. In total, the complex is approx. 25 m long, around 10 m wide and some 12 m high. The basins are designed for components up to 2,900 mm in height and weighing max. 1,500 kg. Until now, Liebherr-Aerospace had to outsource large, “1 m plus” components, as it only had a manual unit for components less than 30 cm large in-house. “The new plant shortens the delivery chain massively – which benefits our customers, as it saves on time and transport costs”, explains Claus Glocker.

At the same time, the optimally coordinated air intake and extraction system produces a clean atmosphere in the hall. The integrated heat recovery system also saves energy and costs. The automated sliding covers on the process tubs improve the air extraction system even more.

Presently, the new coating plant is going through the approval process. The plan is to have developed a production process that is ready for series use by the end of 2018.



With the new zinc-nickel coating plant, Liebherr-Aerospace is now also able to coat large components itself.



In the acoustics chamber, in one of the two altitude chambers or on the vibration test stand (left to right):
In Toulouse, components are thoroughly tested.

Extreme Tests on 9,000 m²

The test center in Toulouse plays an important part in research and development activities for air management systems at Liebherr-Aerospace. Since 2011, systems as well as components have been tested on 28 test rigs in a soundproof chamber, subjected to immense pressures, and shaken – all according to the highest requirements of aviation. At the test center, it is made clear that only units which can withstand these extreme tests will make their way onto aircraft.

They put the systems through their paces: experts use the 9,000 m² test center – a unique facility in Europe – to test new developments at Liebherr-Aerospace. With state-of-the-art equipment, around 40 employees test the maturity and reliability of bleed air, cabin pressure control and air conditioning systems as well as individual components. In terms of materials and construction, the developers go to the limits of resilience and beyond. Anything that fails here has no chance of being used later on. In this way, the Liebherr team ensures that products aboard airplanes and helicopters guarantee the absolute safety of passengers and crew.

Tests in the two pressure chambers, for example, with a total volume of up to 190 m³, are particularly demanding. Here, via the air pressure, components are taken to a simulated altitude of 18,000 m, and exposed to temperatures between minus 55 °C and plus 250 °C. It is a combination that demands everything from the systems. And it allows the Liebherr team to gather valuable data about how the equipment reacts to absolute extreme situations – and still functions.

One of the test center's latest investments is a vibration test stand. On this machine, 4 m long and weighing 23 metric tons, Liebherr-Aerospace not only tests air management systems,

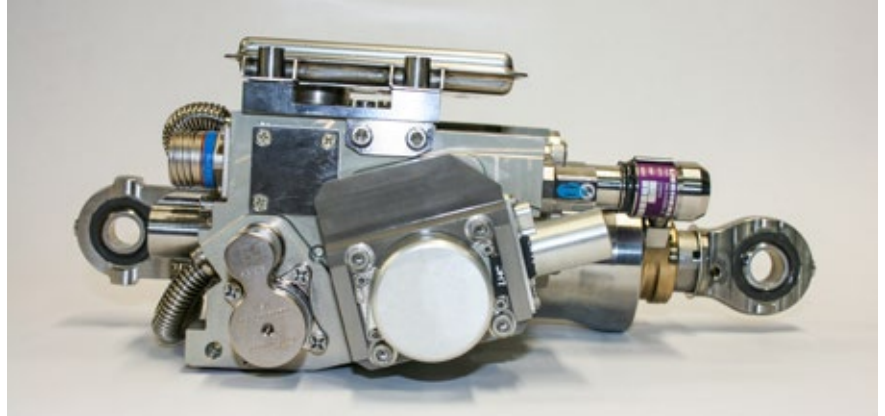
but also carries out its own certification in accordance with standards. In two test phases, the components are shaken and jolted in all directions for a duration of four to five days. And not gently, either, but at up to 2,500 oscillations per minute. That is the same striking speed as a jackhammer. Every year, more than 50 systems are put through this vibration testing.

By contrast, things are dead quiet in the 7.5 x 7.5 x 8.0 m anechoic chamber. This is where Liebherr-Aerospace tests whether systems meet aircraft manufacturers' specified noise emission values. Inside the cabin, for example, the sound level should be between 65 dB – comparable to watching television at normal room volume – and a maximum of 75 dB, which is approximately equivalent to the background noise in an open-plan office. The air conditioning system is switched on with an ambient temperature as low as minus 55 °C at an altitude of 10,000 m. Numerous microphones in the room then pick up the sound and reliably measure whether the systems at least meet the required values.

Liebherr-Aerospace will continue to invest in its test and research facilities, to develop technological solutions for the aircraft of tomorrow.

An Extremely Versatile Control Unit

Less weight, faster final assembly, more flexibility: The ingenious concept of the Remote Electronic Unit developed by Liebherr-Aerospace offers plenty of advantages, thanks to digitization. The electronic control unit is mainly used to evaluate sensor data and to control systems locally, with the measured data being digitized locally and forwarded to a main computer. To fulfill various tasks, the Remote Electronic Unit can easily be adapted to the relevant requirements using the software. Until now, this had only been possible with correspondingly varying hardware. Thanks to its small size, the control unit can even be mounted directly in aircraft wings or on actuators, which means that the cabling required previously is no longer necessary. This in turn not only shortens the wing production time considerably, but also reduces the total weight of the aircraft by as much as 500 kg in comparison with



Servo-Control Actuator with integrated Remote Electronic Unit

traditional construction methods with completely cabled actuators. Because of its modular design, the Remote Electronic Unit can be used flexibly in the aerospace and space industry. With its laser-welded capsule it can also withstand harsh maritime conditions.



Meeting about the integration of the Remote Electronic Unit into a system test rig

Robot Assistance: More Efficiency

They are quiet, precise, fast and happy to take over even the most tiring tasks: Four robots that are used in the Liebherr-Aerospace factory in Toulouse in complex phases of the heat exchanger manufacturing process. Three of them work in a cabin in a very confined space and are responsible for applying the precisely measured solder onto separator and cover plates in an extremely short time. The first robot, responsible for handling, takes the plates one by one for processing. The other two robots apply a cement which makes sure that the sprayed brazing powder sticks to it. The following heat treatment fixates the brazing powder before the robots turn the plate and carry out the same procedure on the back side. Once this process is finished, the first robot forwards the prepared plates for further production stages.

High speed, maximum precision

The entire process takes no more than two minutes – far less than the manual process would need. “Overall, the time saved allows us to increase our production capacities. In the face of rising demand from aircraft manufacturers, this is very important for us in meeting our delivery schedules”, says Guillaume Deltombe, Head of Manufacturing at Liebherr-Aerospace in Toulouse. To keep pace with these faster cycle times in the welding section, a robot fixes the components of a heat exchanger – the housing, matrix, etc. – with a continuous weld seam by taking the burner accurately around these pre-positioned elements. Automation makes the process five times faster while guaranteeing consistent quality.

Apart from the time gained, the special robots used to apply solder guarantee maximum precision. Not only must the powder be applied evenly across the plate in question; the quantity of solder applied must be the same on each plate. “This level of precision cannot be achieved in a manual process, and certainly not at this speed”, Guillaume Deltombe says with certainty. Heat exchangers are an integral component of complex air conditioning systems which Liebherr develops and produces for its customers in the aviation industry.



Four robots in total are used at Liebherr-Aerospace in Toulouse in the heat exchanger manufacturing process. The robot responsible for handling takes the individual separator plates for processing.

Humans give the orders, machines follow ...

Constantly repeating difficult work processes – that can really put a strain on people. In addition, sometimes uncomfortable protective equipment is required to prevent any risk to health. On the other hand, monotony and high stress levels in difficult environments are not a problem for robots, and this is precisely where the advantage of using robots for applying solder becomes clear. Humans, with their expertise, are definitely still essential: for equipping, monitoring, checking or carrying out complex manufacturing tasks. And wherever robots are used, humans are always on hand to control them and guarantee the final result.



International Focus

Just-in-Time: Landing Gear Assembly in Canada

At Liebherr's Laval site in Canada, final assembly and inspection of landing gear system components for the Bombardier C Series started on schedule in August 2017. As Liebherr-Canada Ltd. expands, the Laval site is developing new offerings in addition to service and assembly. Customers in the rail vehicle sector are also being serviced here.

Following the official opening of a new assembly hall in Laval, near Montreal, in October 2017, the Aerospace and Transportation Systems division at Liebherr-Canada is now able to handle just-in-time deliveries directly to Bombardier Aerospace's aircraft assembly line. Liebherr invested around €2.9 million in the new building, which offers 1,400 m² of space for seven final assembly cells as well as test equipment for the Bombardier C Series landing gear system. Bombardier Aerospace fits the landing gear to the aircraft at their Mirabel site, about 35 km away. Liebherr-Aerospace is responsible for the extended logistics as well as final assembly and testing of the landing gear and air management system.



The Liebherr-Aerospace team in Laval

Certified quality and environmental standards

The quality management system applicable to the Aerospace and Transportation Systems Division at Liebherr-Canada Ltd. was recently recertified to the latest AS9120 Rev B and ISO 9001:2015 standards. A stringent audit preceded the recertification. The Aerospace and Transportation Systems team spent several months updating documentation for internal processes and procedures to meet the high certification requirements. This work was rewarded with a confirmation that the quality management system meets all current requirements for the distribution of products for the aerospace and defense industries. Liebherr-Canada's Aerospace and Transportation Systems team also updated the documented information as

was necessary for the recertification of their environmental management system to ISO 14001:2015, which is expected shortly.

Shorter routes and faster response times

With a population of almost 423,000, Laval is the third-largest city in the Canadian province of Quebec. It enjoys a favorable strategic location close to Bombardier Aerospace's sites in Montreal and Mirabel, for which Liebherr-Canada offers technical and logistical support. The new assembly hall cuts the response time for customer inquiries, and further optimizes material flow. In the hall, components of the C Series landing gear system from Liebherr-Aerospace in Lindenberg, Germany, as well as parts from suppliers in Canada and the U.S. are

brought together, assembled and inspected. Then they are shipped to Bombardier Aerospace. Mid March 2018, the final assembly and inspection of the 50th landing gear system component was completed in Laval.

"Expanding into an assembly site brings us still more opportunities," says Stéphane Rioux, General Manager for the Aerospace and Transportation Systems Division at Liebherr-Canada. "We are already using part of the new building for maintenance and repair work for our customers in the rail vehicle sector and we want to continue expanding our offerings in this field as well."

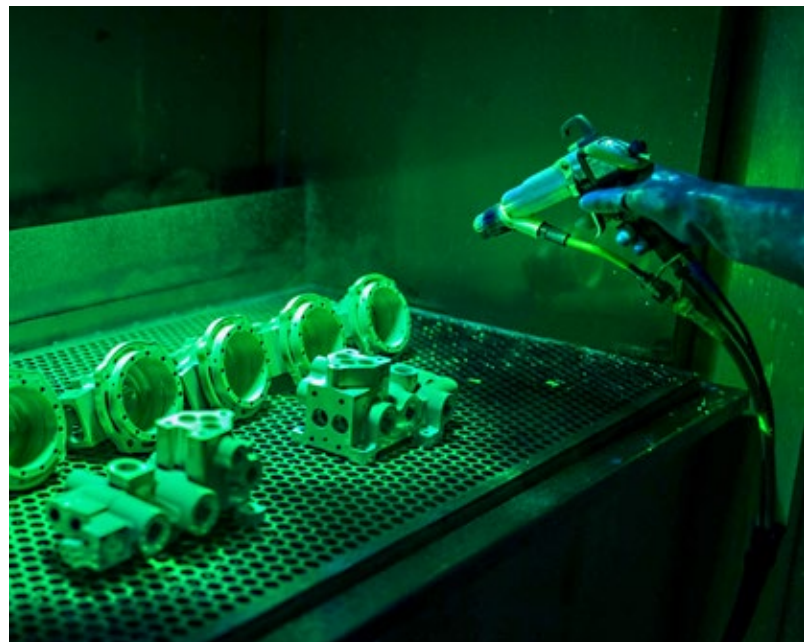
Nadcap Certifies Liebherr Aerospace Brasil Ltda.

Liebherr Aerospace Brasil Ltda. has received two certifications at once from the Nadcap Management Council*: for non-destructive testing and chemical processing. The successfully completed audits are a confirmation of the far-reaching investments made by Liebherr-Aerospace at its Brazilian site in Guaratinguetá. In the plant, established in 2005, facilities for non-destructive testing and a state-of-the-art infrastructure for surface treatment have recently been installed which enable the company to meet its customers' strict standards and specifications.

Liebherr Aerospace Brasil Ltda. specializes in the precision production, surface treatment and assembly of high-tech components for landing gear, flight control and air management systems for a wide range of commercial aircraft programs. The company employs around 300 people. "Our non-destructive testing and chemical processes certified by Nadcap represent the highest standards of quality and reflect the high level of standardization that Liebherr-Aerospace has reached in Brazil. We are thus demonstrating our stable working processes, our measures for continuous improvement and our competitiveness – all advantages that benefit our customers", says Plant Manager Mario Coelho.

Alongside the certifications for non-destructive testing and chemical processing, Liebherr Aerospace Brasil Ltda. is also certified under AS9100-Rev. C (NBR 15100:2010) and ISO 14001:2015.

*Nadcap is a world-wide cooperation program established by various aerospace companies. Its intention is to administer a cost-efficient consensus on special processes and products and to achieve continuous improvements in the aerospace industry. Nadcap is managed by the Performance Review Institute, a non-profit business association founded in 1990, the employees of which also organize the audits.



Non-destructive testing: With the help of fluorescent liquid and UV light, trained technicians detect the faulty areas on the surfaces of valve blocks and housings.

Customer Service Center in Shanghai Expands Range of Services

To ensure the availability of spare parts and rapid repair for all customers in China, Liebherr-Aerospace is continuously further expanding its portfolio in the Liaison and Customer Service Center in Shanghai. The site has also recently acquired a new test stand so that it can test, maintain and repair bleed valves of air management systems. The Chinese aviation authority has officially certified the test rig, which means that Liebherr is

authorized and able to offer its customers an additional service in the area of repair and maintenance. In addition, Liebherr-Aerospace is planning to complete a test stand for air cycle machines later this year, so that the “heart” of the air conditioning systems can be also maintained directly in China.

With the aim of supporting aircraft operators even more efficiently and

reliably at local level, Liebherr-Aerospace is also using a new software specially developed for repair work. Shorter communication routes and an extensive range of services are the standards that the company sets for itself too.



Specially trained skilled workers ensure reliable customer service.

“It Never Gets Boring”

Kal Wai Leong works as Assistant Manager Product Support for the Aerospace division at Liebherr-Singapore Pte Ltd. The qualified mechatronics engineer took his first steps in aviation in the Republic of Singapore Air Force (RSAF) before his career path took him to Liebherr-Aerospace. In this interview, he tells us what makes his work here so special.



You originally joined Liebherr from the world of military aviation. Did the changeover to the civil aviation industry require a major adjustment?

Not very much, actually. After my arrival at Liebherr-Aerospace, my manager immediately took me on a tour of the workshop to introduce me to the team. That gave me a feeling of familiarity straight away – especially as I also came across a few faces I knew from my time with the RSAF. And naturally, I was also delighted to have the opportunity to work on aircraft components in the civil aviation industry.

In 2011, you moved from the workshop out into the field – why?

After I had worked for six years in the workshop, the position of Field Service Representative became available and I applied for it. In the Field Service, I was responsible for providing customers with technical support and acted as a communication channel between the customer and the company, and consequently I regularly visited my customers within the Asia-Pacific region which is precisely what attracted me to this position: having the fantastic opportunity to experience other cultures and making new contacts. I still find it exciting today.

You now work as Assistant Manager Product Support, which must be very different from your previous positions ...

Yes, it is very different from the jobs I've had to date, because I have management responsibilities in this post. In addition, the work I do here has a multitude of facets, which I really

like. On the one hand, I am the point of contact for our technical support team, assisting and guiding them during the resolution of questions or problems. On the other hand, I am equally responsible for customer relationships. As part of this, I am involved in the preparation, implementation and review of customer requests and contracts so that we can fulfil individual customer requirements and exceptions to standard processes. In addition to this, I am responsible for the development, implementation and analysis of reporting tools and methods. And last but not least, I report regularly to the Divisional Management about current themes, trends and the status of our work.

You have now been working at Liebherr-Aerospace for twelve years. What makes your employer special?

Throughout my career at Liebherr-Aerospace, I have always met colleagues and teams providing a sympathetic ear, as well as enjoying constant management support and supportive line managers allowing me the scope of work responsibility that I need to keep on re-inventing myself and developing further. This enabled me to pursue my career path from a workshop engineer via Field Service to my current position as Team Leader. Liebherr offers frequent professional development opportunities which help me move forward in my daily work and master day-to-day challenges. In addition, the management values my commitment and the efforts I make within the frame of my work. This is my motivation each day.

What would you advise other people who are interested in a career with Liebherr?

Basically, my advice to anyone who wants to enter the aviation industry would be: Work hard and be realistic! For Liebherr-Aerospace specifically, it is an advantage to be interested in the company's products and services and to gain experience at entry level. You have to understand what part every individual system plays in an airplane. It is also important to be aware of your responsibilities as you work in a team. If you have questions, more experienced colleagues are always ready to help and advise. The exciting thing is that there is always something new to learn in our industry and that it never gets boring. The technology is developing all the time – and the teams and every individual employee need to do so, too. Liebherr has understood this.

On Course for Growth

It all started in 1988 with a small spare parts warehouse and two storekeepers. Today, there's no question of "small" when we talk about Liebherr-Aerospace in Singapore. In the mid-1990s, operations were expanded by the addition of a workshop with a handful of technical employees. "A very wise decision", says Ekkehard Pracht, General Manager Aerospace of Liebherr-Singapore Pte Ltd. Because based on huge customer demand, nearly 90 people are now employed at the site, which is currently being expanded as part of the "Project 2025" corporate strategy, with further improvements made to infrastructure and equipment. In August 2017, for example, the new compressor building became operational. This plays an important part in the supply of compressed air for the state-of-the-art test rigs used to test the function of various components of aircraft air conditioning systems.

The reason for Liebherr-Aerospace's activities: "Everywhere the Asia-Pacific region is showing signs of growth", explains Ekkehard Pracht. "The standard of living is increasing, and one of the

ways in which this is reflected is that the aspiring middle classes are traveling more – preferably by plane." The natural consequence of this is a real boom in flying, which means that new airports are being built and existing ones enlarged, aircraft fleets are being expanded and modernized and so the demand for maintenance and repair is increasing. "We have been operating in Singapore for nearly 30 years and feel committed to the location and to our customers in the region. This is why we want to offer them a customized service in the shortest possible time so that we can support them just as they need in operating and maintaining their growing aircraft fleets. To do this, we are constantly expanding our capacities and technical capabilities." For example, in servicing, spare parts delivery and technical support. "Because for us, customer service doesn't mean an anonymous call center in a completely different time zone – it means being close to customers and having a local presence", says Pracht. "In particular, it also includes our service engineers being able to get to customers quickly – people and parts don't need to travel too

far." Singapore is the ideal location for this: geographically in the center of the Asia-Pacific region, and with one of the world's best airports on hand.

The next challenge that Ekkehard Pracht foresees for Singapore as a location is the need to service old and new technologies at the same time. "Slowly but surely, a new generation of aircraft technology is pushing through, which works increasingly with "smart" technologies and integrated electronics. However, until this has completely replaced its mechanical predecessors, we need to be able to offer the expertise and materials for both options". Alongside the additional space required, this will also be a question of having well-trained staff on hand: "The training and continuing professional development of our own specialist staff and close collaboration with the local educational establishments are the main cornerstones of our HR strategy so that we can continue to thrive in this competitive world", says Pracht.



Always Open to Innovative Change

Nicolas Canouet is a “Data Scientist” and has been working at Liebherr-Aerospace Toulouse SAS in Toulouse (France) for five years. The 42-year-old is currently building a company-wide, interdivisional data lab there. In this interview, he explains how it all came about and why trust and creativity belong together.

It was your idea to develop a data lab in Toulouse. What made you think of it?

My career at Liebherr-Aerospace started in Customer Service, where I was responsible for Reliability for four years. During this time, we developed methods for analyzing the repair data from our components. Using these methods and tools, we were able to improve the quality of our work, speed up the process of analysis and give our customers recommendations on working methods in maintenance that were customized to their needs. These activities took me naturally, as it were, to Big Data, i.e. the collection and evaluation of massive quantities of data. The subject of Big Data is a highly topical one. This is why I suggested setting up a central data lab that would take over these tasks.

... And people were open to the idea?

Yes. Because the subject of digital transformation is also important at Liebherr-Aerospace, of course. The timing was just right. However, implementing innovations like this naturally requires the right environment. The management was immediately convinced that a data lab could make a major contribution to our viability for the future. I had plenty of scope to develop my idea and was given the support I needed.

What are your current tasks?

The data lab supports the various departments at the Toulouse site in evaluating and utilizing the data available to them. We carry out studies, provide consolidated data and develop tools which can be used to improve our



processes and develop new services. It is my job to establish the data lab as an efficient platform for services such as predictive maintenance. Currently, we are in the process of building up a team.

It sounds like a lot of responsibility. What personal characteristics does this job call for?

It is important to build up relationships with all the departments and to be in constant contact. I try to match the requirements of the various teams up with the technological opportunities available and to answer my colleagues' questions. This all calls for an analytical mind, curiosity and also a touch of creativity when it comes to finding digital solutions for innovative ideas.

It doesn't seem as if you could learn this from a training course.

No, in fact lots of things here follow the trial-and-error method. I am very

pleased that Liebherr-Aerospace offers the creative scope to try something out in order to find new approaches. That requires a great deal of trust, because it is not a given that we will always achieve a successful result. But this alone is a type of permanent training course, because we learn something important from every mistake.

What would you say to young newcomers who are applying to Liebherr?

Commitment is called for – and is rewarded. Liebherr is open to change and makes decisions quickly if they are useful for the company. I was positively impressed in my job interview firstly by the stability that the company radiates and secondly by its innovation capabilities. And: Anyone who wants to develop further can do it.

New Factory Building at the Campsas Site

Liebherr-Aerospace recently expanded its factory in Campsas in the Département Tarn-et-Garonne (France) by an additional building. The site, with 170 employees, specializes in the manufacturing of mechanical precision parts for air management systems. Equipped with the latest generation of production machines, including equipment for additive manufacturing, the extension of the site, which is about 33 km to the northwest of Toulouse, is intended to help increase production capacities by up to 30 percent over the next few years. In this way, Liebherr is pursuing its policy of investing continuously in its own sites and developing pioneering industrial solutions internally so that it can offer its customers an innovative, high-quality product portfolio. “The expansion will enable to fulfil the forecast increased demand in aviation at the same high level”, says Mathieu Tournier, Director of the Site in Campsas.

In the new 3,300 m² extension precision parts such as rotors for turbines and compressors and high-temperature valve bodies will be produced. They are used in on-board air conditioning systems or engine bleed air systems which are part of the range of products which Liebherr supplies to aircraft manufacturers all over the world.

The building itself has been designed according to the latest cutting-edge standard for industrial buildings and, alongside robot-controlled CNC machines, additive layer manufacturing technologies are also used. “The factory meets all the demands of our Factory 4.0 Strategy”, explains Tournier and adds: “The digitization of processes and the juxtaposition of tried and tested manufacturing methods and additive layer manufacturing will further increase our efficiency.”



The expansion of the Campsas site will help to increase production capacities by up to 30 percent in the years to come.

Keyword “Synergy”

Even the experts never stop learning. Quite the opposite: exchanges of ideas and collaborative learning are key drivers of innovation at Liebherr-Aerospace, as was seen at a recent international expert meeting in Toulouse. Around forty specialists from all Liebherr-Aerospace sites

across Europe met to learn from each other, and during the workshop they looked in more detail at possibilities and suggestions for improving collaboration and increasing synergies within the division. In this way, all parts of the company benefit from the special expertise of each individual site. Francis Carla, Managing Director & CTO at Liebherr-Aerospace & Transportation

SAS, underlined the key role that experts play in the company: “The ability to innovate and develop new products and services base on the outstanding expertise of our employees.”

Challenged and Supported



Three steps up the career ladder in less than five years – this is a remarkable career development. It has been achieved by Christian Franz, Director Customer Service at Liebherr-Aerospace Lindenberg GmbH, on the basis of his sound technical knowledge of aerospace technology and his management skills. However, he also benefited from the Talent Management Program at the Lindenberg site, which specifically promotes young talents.

Getting out of his own office and into the workshops and assembly halls: Christian Franz joins his staff on site as often as possible. Even during his training, he learned that you have to visit the troops if you want to know where there are problems. “This advice, which was given to me by my former superior, a captain in the German Army, can be easily transferred to working together in a company”, says Christian Franz, as an explanation of his policy.

Director Customer Service is Christian Franz’s third post at Liebherr-Aerospace in Lindenberg, and it is his most challenging task to date. The department covers a wide spectrum of products and services. 300 employees spread across seven sections pursue the common goal of keeping customers extremely satisfied

when it comes to spare parts, repairs and servicing. This also includes optimizing internal structures. “Our clients’ expectations of repairs are increasing all the time. They want to have their aircraft operating again faster and more cheaply than ever. We have to reinvent ourselves here”, reports Christian Franz. In looking for potential for improvement, he is supported by his expertise as an aerospace engineer and his many years of experience in the Technical Service of the German Air Force. But specialist knowledge is not enough to motivate a team so that everyone pulls together in the face of change. “As a manager, you need to be open to the input of other people, combine it with your own experiences, record and assess everything in a structured way and then implement it consistently”, says Christian

Franz. Characteristics like this are what make people interesting for Liebherr-Aerospace’s Talent Management Program. The selected candidates go through an eighteen-month support program, with workshops where they can enhance their management techniques, give each other feedback and network as a group of potential managers.

The course is not a guarantee of a later managerial position. But it offers talented employees the chance to train further and demonstrate their skills. It worked for Christian Franz. After starting as a project manager in landing gear development for the A350-1000 nose landing gear, he was promoted, after completing the first major development milestone, to Department Head, Electronic Systems Development, and then after a further two and a half years to Director Customer Service. Christian Franz is convinced that career leaps like this are possible in the Liebherr Group because the employees’ performance and commitment are recognized and rewarded.



Customer Service Manager Christian Franz often joins his staff in the workshops and assembly halls.

“Totally Cool!”



Building bridges: San Francisco and the Golden Gate Bridge were also on the program for Niklas Werner and Eric Stenzel.

“Anyone who gets this opportunity should definitely make use of it!” Niklas Werner and Eric Stenzel agree: “The exchange is totally cool and very enriching – not just personally, but also in terms of our day-to-day work.” The two young men are just about to complete their apprenticeship with Liebherr-Aerospace Lindenberg GmbH and in 2017 were the first of the company’s trainees to visit and work in the Liebherr-Aerospace facility in Saline, Michigan (USA), for four weeks. “Everything went pretty fast”, recalls Niklas Werner: “At the beginning of May, we had a meeting together with our training manager, Ralf Büttinghaus, who made us the offer – and less than two months later we were on a plane heading to the USA.”

and its culture. Niklas Werner and Eric Stenzel were initially “completely stunned when we heard that we had actually been awarded the places”, says Eric Stenzel. Then everything began to move quickly for the two young men: Their English language skills needed to be freshened up – after all, school was a while ago; work clothing and an international driving license needed to be organized, and all sorts of other things. Liebherr took care of the flights, transfer and accommodation.

At the beginning of August, the two exchange trainees were at Liebherr-Aerospace Saline, Inc.. “We were greeted via a welcome message on a giant screen right at the entrance”, reports Niklas Werner. “And things continued to be just as friendly and open over the



Niklas Werner (left) and Eric Stenzel outside the gates of the Liebherr branch in Saline

Liebherr-Aerospace adds an international aspect to its training portfolio and thus increases the incentive for young people to join the company. In future, the two best – in terms of commitment, grades and personal maturity – of the relevant batch of trainees will be selected for this special apprenticeship project each year. They will spend a few weeks getting to know their US colleagues, their working methods and, of course, the country

next four weeks.” Their new colleagues integrated them into their everyday working pattern, allowed them to help and even to “work fairly independently”, as they found to their amazement. As production employees, they were given the opportunity in the repair shop for landing gear and actuation systems to build-up their knowledge and gather experience. Generally, at 3.45 pm they called it a day – and the young Europeans

were introduced to the “typical American culture” and way of life. There were discussions about politics and attempts to explain Germany’s successful dual training system. “It was great fun!” recalls Eric Stenzel, who is still in contact with some of his colleagues in Saline via social media. “The exchange project is a real step forward professionally and privately.” His traveling companion Niklas Werner confirms: “We have become more independent, gained a lot in terms

of our English language skills – and also learned a lot when it comes to work, for example, that there are lots of different ways to reach one’s goal.”



Fun after work: the Liebherr-Aerospace Saline soccer team

Customer Proximity is Key

Liebherr-Aerospace in Hamburg is even closer to its customer Airbus in Hamburg-Finkenwerder since the Liaison Team operating in the Hanseatic city moved into the Center of Applied Aeronautical Research (ZAL) in November 2017. This is an excellent basis for further intensifying the close

collaboration between the engineering and R&D teams of both companies. “Our close cooperation with the engineering teams at Airbus will help foster new ideas, enable their immediate realization and implement such technologies quickly into the market”, says Peter Eusemann, Liaison Manager for Airbus

at Liebherr-Aerospace, confidently. “The fast, efficient development of new technologies will be a key contributor to the success of the aircraft of tomorrow.” The specialists at Liebherr-Aerospace will carry out both engineering activities as well as tests and will support fast track development work on site.



At the opening ceremony: From left to right: Roland Gerhards, Managing Director / CEO, ZAL GmbH, Peter Eusemann, Liaison Manager, Hamburg Office, Liebherr-Aerospace & Transportation SAS and Francis Carla, Managing Director & CTO, Liebherr-Aerospace & Transportation SAS



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Programs & Contracts

A Sound Basis and Development in China

The Chinese aviation industry is developing rapidly, and so are the activities of Liebherr-Aerospace locally in the People's Republic. In line with the Liebherr philosophy of promoting organic growth, the company is committed to a long-term, reliable cooperation with its customers and partners in China.

The first landing gear to be assembled in China for the ARJ21 was supplied by Liebherr LAMC Aviation (Changsha)

Co., Ltd. last fall, and the joint venture is now creating the structural basis for the transition to series manufacture. This is partly founded on a series of test flights by the ARJ21 which have been successfully completed.

Liebherr LAMC Aviation (Changsha) Co., Ltd. will also be assembling the landing gear for the C919 commercial aircraft, which completed its maiden flight in May of last year, and delivering

it from Changsha to COMAC for the first time in fall 2018. In this phase, Liebherr-Aerospace is also preparing for maintenance activities in order to be able to offer COMAC and the operators of the C919 comprehensive servicing across the entire life cycle of the aircraft. In addition to the landing gear system, Liebherr-Aerospace is also providing the complete integrated air management system for the aircraft program. Furthermore, Liebherr LAMC Aviation



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The ARJ21 flies with Liebherr's air management and landing gear system.

(Changsha) Co., Ltd. sees a possibility for contributing to the development of the Chinese-Russian C929 long-haul aircraft as a follow-on project.

With these important milestones, Liebherr-Aerospace is further expanding the cooperation between Liebherr-Aerospace Lindenberg GmbH and the Chinese

company LAMC (AVIC Landing Gear Advanced Manufacturing Corp.), which started in 2012. The number of Chinese suppliers is also to be gradually increased so that the company can continue to remain internationally competitive with an increasingly independent location.



The team of Liebherr LAMC Aviation (Changsha) Co., Ltd.

Team of Excellence-Award



Liebherr-Aerospace has received the "Team of Excellence"-Award for the successful maiden flight of the regional jet C919. The award was presented by Wu Yue, Assistant to the President of the Chinese aircraft manufacturer COMAC, during the suppliers' conference held in Shanghai in November 2017 to Arndt Schoenemann, Managing Director, Liebherr-Aerospace Lindenberg GmbH. Liebherr-Aerospace has developed, produces and supplies the integrated air management system as well as the complete nose and main landing gear system for the C919.

Three at One Go: Type Certification in Record Time

For aircraft manufacturer Embraer, there were plenty of reasons to celebrate in February 2018: Three aviation authorities – the Brazilian Agência Nacional de Aviação Civil (ANAC), the Federal Aviation Administration (FAA) and the European Aviation Safety Agency (EASA) – gave their approval of the new E-Jet E190-E2 at the same time. Only 56 months passed between the start of the program and certification. Paulo Cesar de Souza e Silva, Embraer’s President & CEO, expressed his gratitude to everyone involved: “Having had the pleasure of launching the E-Jet’s E2 family back in 2013, it is very emotional for me to see the E190-E2 reach Type Certification today, on schedule and on budget. Our development teams have once again excelled in their creativity, dedication and competence!” With the completion absolutely on schedule of all the tests and documentation, the teams from Liebherr-Aerospace in

Lindenberg and Toulouse had laid the necessary foundations for the successful certifications. Liebherr-Aerospace Toulouse SAS supplies the integrated air management system for the Embraer E190-E2, while Liebherr-Aerospace Lindenberg GmbH is responsible for the new E-Jet’s high lift system.

Flap/slat control system tested in EMT laboratory

“To verify the interference resistance of our flap/slat system, we designed and built a special test setup covering an area of over 25 m², which we tested in the Electromagnetic Test Laboratory”, explains Stefan Männl, Head of Department Electrical Drives & Components, at Liebherr-Aerospace Lindenberg GmbH. The engineers tested the robustness of the system and the control computers when exposed to electromagnetic interference. This is caused, for example, by other electrical equipment, lightning



In order to ensure interference resistance to electromagnetic fields, all components of the flap/slat control system in the new E-Jet E190-E2 were tested in the EMT laboratory for three months.

strikes, mobile phones, radio or radar radiation. The test setup therefore covered all electrically relevant components of the flap/slat system including two kilometers of original aircraft cabling and was compliance-tested and approved by Embraer and the aviation authority. The design of the test was quite a challenge because of its dimensions, and the setup also needed to be transportable for later testing in the Electromagnetic Test Laboratory (EMT Laboratory). Commissioning was carried out at Liebherr in Lindenberg, where all the components were calibrated and tests were carried out to ensure that the system also worked perfectly with other computers to simulate a realistic environment. After it was moved to the EMT Laboratory, various antennae and radiation sources exposed the equipment and

its electrical connections to powerful electromagnetic fields at varying frequencies. All the key data were recorded and evaluated automatically because of the massive volumes of data involved.

Within just three months, all the possibilities and eventualities were thus successfully tested in countless measurements and trial runs in the presence of representatives of the authorities. The auditors particularly praised Liebherr-Aerospace's ingenious modular set-up concept, which allows the tests to be reproduced later at any time. The test setup will now be stored by Liebherr for the years to come.

New Air Management System for the ATR 42/72 Aircraft Family

Liebherr-Aerospace has been awarded the contract by ATR for the development, manufacture and supply of a new generation air management system for the ATR 42 and ATR 72 aircraft programs.

The system will be developed and produced by Liebherr-Aerospace Toulouse SAS, Toulouse (France), Liebherr's center of excellence for air management systems. The system supplier is also responsible for maintenance. The air management system includes the bleed air, air conditioning and cabin pressure control subsystems and is characterized by high reliability and low weight – which also, not least, reduces operating costs. In addition, it is adapted to the aircraft's particular operating conditions. The air management system provides maximum comfort for passengers and crews both in flight and on the ground. An optional system also cools the air as long as the aircraft is on the ground. "We need to make sure passengers are always comfortable,

from the moment they step into the aircraft right up until they step out at their destination. Our new air conditioning management system will strongly contribute to further enhancing the passenger experience, while substantially minimizing maintenance costs and needs", David Brigante, ATR's SVP Procurement, declared.

To develop the system, Liebherr-Aerospace made use of its comprehensive experience in air management systems for turboprop and regional aircraft. The new contract is proof of the trust that Liebherr has built up through decades of collaboration with ATR since the early years of the ATR 42/72 family.



Comfortable temperatures in the aircraft cabin as passengers board – Liebherr Technology makes it possible.

Power Gearbox in the Rolls-Royce UltraFan® Engine Sets New Record

70,000 horsepower – this was the record-breaking level of power achieved last year by what is the world’s most powerful aerospace gearbox. It is a key component of the new Rolls-Royce UltraFan® engine, which is expected to be ready for service from 2025. Compared with the first-generation Trent engine, it will use at least 25 per cent less fuel and emissions will be correspondingly lower.

In order to develop manufacturing capability and capacity for manufacturing the new power gearbox, Rolls-Royce is working with Liebherr-Aerospace through the “Aerospace Transmission Technologies” joint venture, based in Friedrichshafen, Germany.

The power gearbox is a key component of the future UltraFan® engine. It allows the fan (which is massive and easily visible on the front of the engine) to operate in a low speed range which is ideal aerodynamically and acoustically.

The gearbox is being developed primarily at Rolls-Royce in Dahlewitz, where tests are taking place on a new test rig. It is being designed to run at up to 100,000 horsepower, which makes it the world’s most powerful aerospace gearbox.

Paul Stein, Chief Technology Officer at Rolls-Royce, commented on reaching 70,000 horsepower in the tests as follows: “Setting this record is a great achievement for the team and I’m proud we’ve managed to get there so quickly. Our power gearbox

technology is central to the success of the next generation of Rolls-Royce engines and I’m pleased to see us setting new standards with our work.” It is easier to imagine the massive forces involved if the horsepower figure is converted: The power gearbox in the new system needs to be capable of managing the equivalent power of around 500 family cars. When running at maximum power, each pair of teeth on the gearbox will transmit more power than an entire grid of Formula 1 cars between them, with the complete gearbox with all five planets thus handling roughly as much power as 100 Formula 1 cars. “Reaching this milestone and impressive performance is proof of the great cooperation of all parties involved and especially of the expertise that accumulates in our joint venture with Rolls-Royce,” commented Arndt Schoenemann, Managing Director, Liebherr-Aerospace Lindenberg GmbH, confidently.



At the Rolls-Royce test center in Dahlewitz



A new test rig for the extensive tests

Comfortable Temperatures Inside the Helicopter

The team at Liebherr-Aerospace Toulouse has been selected by Airbus Helicopters for the development, production and qualification of heating valves for the H160 helicopter program and for servicing them.

The system manufacturer supplies two valves for the helicopter's heating system which regulate the supply of warm air into the cabin. The warm air ensures, on the one hand, that the temperature on board is comfortable for the passengers and crew. On the other hand, it demists the window panes of the helicopter.

In the development of the highly reliable heating valves, Liebherr-Aerospace incorporated its latest innovations from the field of high-precision electro-mechanical controls. The valves are made from light-weight aluminum and contribute to the optimization of the helicopter's operating costs.

The contract to supply heating valves is actually the second order that Liebherr-Aerospace has received for the H160 helicopter program. Back in September 2012, the company had been chosen to supply the main rotor actuator for the medium twin engine aircraft designed to be the successor to the Dauphin helicopter.

Liebherr-Aerospace supplies flight control, landing gear and air management systems or components for almost all of Airbus Helicopters' programs.



Labeled with "Best Innovator Overall" by Airbus

Airbus Defence and Space has chosen Liebherr-Aerospace from its over 10,000 suppliers worldwide as the winner of its "Best Innovator Overall". The award was presented at the 4th Supplier Annual Conference in Munich in November 2017. The manufacturer paid

tribute to the system supplier for its strong, reliable technology-driven achievement in offering innovative solutions and aligning technology roadmaps – especially for its next generation of air management and cooling systems and future-oriented flight control and actuation systems.



Customer Service

Practical Training Courses for Optimized Operations

Being able to identify faults quickly is the essence of effective maintenance and repair – but it is not an easy task given the vast number of different components in an airplane or helicopter. Liebherr-Aerospace therefore provides interactive seminars and training courses to support airlines and manufacturers specifically to improve their effectiveness.



Landing gear training on the actual product in Lindenberg (Germany)

The source of a malfunction is often determined quickly – but then the big question arises: Is the component really faulty? Does it have to be removed and replaced or can the cause actually be rectified in just a few simple steps? Paloma De La Infiesta, Technical Trainer at Liebherr-Aerospace in Lindenberg (Germany) knows that these are the most crucial points for the participants in the technical training courses run by Liebherr-Aerospace. “Technicians, engineers and maintenance staff all need to be able to decide quickly and, most importantly, reliably whether a component really needs to be replaced or not. Finding faults efficiently is therefore a top priority.” Liebherr-Aerospace regularly runs training seminars at its locations in Toulouse (France) and Lindenberg (Germany), on the various product groups such as air management systems, landing gear and flight control systems and all aircraft and helicopter programs in which Liebherr-

Aerospace products are installed, such as Airbus, Boeing, Bombardier, COMAC and Embraer, for example. “However, we also provide training direct to customers on site”, adds Jean-Yves Bourbeau, Technical Trainer at Liebherr-Aerospace in Toulouse. “Our range of services is aimed at all operators of aircraft and helicopters and helps them to analyze and solve their in-service issues.”

Practice and dialog

The seminars are offered in different levels, ranging from a general overview of the systems, their location and function in the aircraft, through to detailed technical maintenance courses for individual components. “The training courses familiarize the participants with

the systems and how they work. This supports people in daily operations and is done on a very practical basis using the model of a component”, explains Paloma De La Infesta. The trainers are technical experts with many years of experience in customer service, and they consider interaction to be very important. Alongside the theoretical principles, the focus is therefore on direct discussions and practical work with the systems. “We work in small groups of a maximum of ten people, so a direct dialog is always possible. We share our detailed knowledge of components and provide helpful advice, but at the same time everyone also benefits from the experience of colleagues.” The participants’ questions, but also, most

importantly, having components to touch, train on and try out are important for Jean-Yves Bourbeau. “We also go through our manufacturing facilities and show how the systems are made. That too promotes understanding of how to handle them.” At the end, the customers’ operating teams are more effective in detecting and excluding faults, which leads to shorter maintenance and down times and, of course, to lower maintenance costs.

The Seminar Calendar on the Liebherr-Aerospace website www.liebherr.com provides an overview of all the current dates.

Maintenance Services for Embraer

Brazilian aircraft manufacturer Embraer and Liebherr-Aerospace have signed an agreement covering maintenance services. The agreement covers for example the delivery of spare parts for the Embraer aircraft programs ERJ135 and ERJ145. In addition, the overhaul of the nose landing gears of the aircraft has also been included along with the overhaul of the nose landing gears of the Legacy 600 business jet. The aircraft are all part of the ERJ145 family, the most produced regional aircraft in the world.

Support is provided by the Liebherr-Aerospace OEM and service centers in Lindenberg and Toulouse. The German location contributes its expertise in landing gear and flight control systems, the French site provides expert support regarding air management systems.

The contract was formally signed in Embraer’s Dutch office in Amsterdam. Rodrigo Maeda, Director Repair Management at Embraer Services & Support, stated: “Liebherr is a reliable partner for our air management and flight control components and as well as nose landing gear maintenance activities. They have a proven level of flexibility, performance and quality. This contract will make our services even more competitive for our operators in terms of service level and operational costs.” In return, Thierry Gourmannel, Head of Sales & Marketing EUMA, Customer Services at Liebherr-Aerospace & Transportation SAS, welcomed the intensification of collaboration between

the companies: “This is the achievement of a long historical relationship between our two companies. Liebherr-Aerospace offers tailored solutions, adapted to our customers’ fleet sizes and business requirements.”



Eduardo Marchese Ribeiro (on the right), Contract Administration Manager, Embraer Netherlands BV, and Thierry Gourmannel, Head of Sales & Marketing EUMA, Customer Services, Liebherr-Aerospace & Transportation SAS, at the contract signing

Worldwide Network for Heat Exchanger Cleaning

In 2016, Liebherr-Aerospace started its new repair center for the cleaning, repair and re-core of heat exchangers with the opening of a new facility in Saline, Michigan (USA). In 2018, the next step is being taken: The development of a worldwide network for cleaning and servicing heat exchangers in association with local licensed partners. The plans are already well advanced, as Joël Cadaux, Director Business & Services – Customer Support & Services, Liebherr-Aerospace & Transportation SAS, explains. “Operations started very successfully in Saline, and there was in the meantime, an increasing interest from the customers in an offer for high quality local services. This includes cleaning the heat exchangers close to the aircraft operators’ maintenance centers in order to shorten the service times, and optimize spares inventory.”

Liebherr-Aerospace is currently setting up a worldwide network for this in association with a dozen selected partners, under a license agreement. The partners will meet “the Liebherr-Aerospace technical qualification criteria and are positioned at geographical key locations, for example, in the Middle East, India and Brazil. In the UK, Liebherr-Aerospace is working with its long-standing cooperation partner, Avia Technique,

a member of the SK AeroSafety Group. The company has already been cleaning and testing heat exchangers for three years, for customers including EasyJet. “We are looking forward to working more closely with Liebherr-Aerospace in this field as a qualified partner in the Heat Exchanger Cleaning Network”, emphasized Robert Sims, SK AeroSafety Operations Director.

Faster service and expertise worldwide

Every four years, or approx. every 12,000 flying hours, a heat exchanger, which is part of the air management system, must be inspected, cleaned and maintained. Depending on the ambient conditions and the frequency of use of the aircraft, the intervals must be reduced to avoid pollution clogging. Generally, a thorough cleaning of the components using high-pressure, ultra-sonic and immersion bath cleaning processes is enough. This is followed by a leakage and pressure test and minor repairs done locally. After this, the heat exchanger is ready for re-use. If the inspection reveals major cracks or irreversible clogging, the heat exchanger is completely overhauled by

the specialists at Liebherr-Aerospace in Saline. In this way, all the partners and aircraft operators benefit from the experience of the Liebherr experts. “The Heat Exchanger Cleaning Network means that we can roll out our servicing operation from Saline into the whole world, so that we will be able to offer our customers even faster and efficient support in the maintenance of their aircraft”, says Joël Cadaux confidently.



After cleaning, the heat exchanger is tested.

“Health Manager” App – Screening the Need for Maintenance

Reliable, safe performance and optimum availability of their fleets – these are the most important things for airline operators. After all, nothing disrupts smooth operation more than unforeseen repairs and thus unplanned aircraft downtimes, which can last just a short time or longer. In order to prevent this even more decisively, Liebherr-Aerospace is developing its Predictive Maintenance further and integrating aircraft operators digitally.

One example is the “A380 CRU Health Manager” app developed by Liebherr, where CRU stands for Central Refrigeration Unit. This is the central cooling unit of the supplement cooling system, which is used to keep food stocks on board constantly cool for the entire length of the flight. The app, which is designed for PCs and mobile devices such as smart phones, helps operators of Airbus A380 aircraft to maintain this additional cooling system easily and reliably. It shows, for example, how many flying hours are left before the next cleaning of the CRU heat exchanger is due, whether the cleaning was carried out optimally and – as an extra add-on – whether the system has enough refrigerant left.

The supplement cooling system works like a refrigerator, but is much more complex. The technology used here is called “vapor cycle”. The central refrigeration unit is an important component within this system. The condenser of the central refrigerator unit is a heat exchanger that cools down the refrigerant that is used to keep the food on board at the right temperature. For the cooling process, the condenser uses

outside air (also on ground) and naturally draws in everything else contained in the air: which means water, hail, sand, dust and salt, to name just a few. Depending on the region in which the airplanes are operated, these dirt and water particles build up on the systems to different extents. The result is always the same, however: The more thickly the dirt builds up on the heat exchanger, the less efficient it becomes. In the worst case, the unit is clogged completely and the system fails.

The Health Manager app literally has this development on its screen, which means that aircraft operators can take action in good time and clean the condensers regularly. To make sure that this is done in accordance with Liebherr’s standards, the company trains the airlines.

The app is the result of the 18-month cooperation between Liebherr-Aerospace and aviation and data management partners. For this, the system supplier bundled together all sorts of skills, including those offered by designers, data scientists and specialists from its Technical Customer Service, in

one core team. The team’s focus is to analyze the causes of interruptions in operation. Using predictive calculations, the specialists optimize the use of the different systems in order to clearly reduce wear and the number of key components to be replaced. The basis for this is the comprehensive specialist knowledge of Liebherr-Aerospace in the field of cabin air management systems and components. And, not least, the ability of the system supplier to be able to filter out and further process relevant data from the flow of information.

Digital solutions such as the “Health Manager” app represent a new direction in the operation and maintenance of aircraft fleets. They also open up new perspectives for other product areas. It will be possible in the future to optimize rotating parts, for example, in terms of quantity and storage location and to streamline repair processes – especially in terms of material requirements – because system deficiencies and indications will be easier to calculate.



Practical, handy and always up to date:
The “A380 CRU Health Manager” app

Participation in Programs

Airbus

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
- Engine Bleed Air System
- Fuel Tank Inerting System – CSAS (except A319CJ)
- High-Lift System
- High Pressure/Power Transfer Unit Manifolds
- Rudder Servo Control
- Safety Valve

Airbus Long Range Family ceo/neo

- Air Chillers
- Air Conditioning System
- Auxiliary Power Unit Gearbox (Long Range)
- Avionics Cooling System
- Engine Bleed Air System
- Cargo Heating System
- 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
- 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 Defence and Space

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

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

MRTT ARBS

- Ruddervator Control System

Cobham

Cobham Mission Equipment

Pod

- Hose Drum Drive System

Airbus Helicopters

AS350/355 Ecureuil

- Environmental Control System Components
- Gears for Main Gearbox

AS365

- Environmental Control System

BK117

- Gears for Power Transmission Gearboxes (ZFL)
- 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 (ZFL)
- Hydraulic Power Supply
- Main- and Tail Rotor Servo Controls

H145

- Gears for Power Transmission Gearboxes (ZFL)
- Hydraulic Power Supply
- Main and Tail Rotor Servo Controls
- Tail Gearbox

H160

- Environmental Control System Components
- Main- and Tail Rotor Servo Controls
- Tail Rotor Gearbox

H175

- Environmental Control System Components

H225 / H225M

- Environmental Control System Components
- Heating System

NH90

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

Tiger

- Gears for Tail Gearbox (ZFL)
- Air Conditioning System
- Main- and Tail Rotor Servo Controls
- Tail Landing Gear

UH-72A Lakota LUH

- Gears for Power Transmission Gearboxes (ZFL)
- Hydraulic Valveblock/Reservoir
- Main- and Tail Rotor Servo Controls

Antonov

AN-74/AN-140

- Cabin Pressure Control System

AN-132/AN-148/AN-158/AN-178-Prototype

- Integrated Air Management System

ATR

ATR 42/72

- Integrated Air Management System

AVIC HAIG

AC 312

- Air Conditioning System

Boeing

B747-8

- Air Conditioning System
- Engine Bleed Air System

B767 Tanker

- Fuel Tank Inerting Valves
- Refueling Hose Drum Drive System

B777-200LR

- Auxiliary Tank Pressurization System

B777X

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

Bombardier Aerospace

Challenger 300/350

- Flap System
- High and Low Pressure Ducting
- Integrated Air Management System

CRJ700/900

- Integrated Air Management System
- Low Pressure Ducting

CRJ1000

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

C Series

- Integrated Air Management System
- Landing Gear System

Dash8-400

- Cabin Pressure Control System

Global Express

- Cabin Air Humidification System
- Integrated Air Management System
- Nose Landing Gear Shock Strut

G5000

- Cabin Air Humidification System
- Integrated Air Management System
- Nose Landing Gear Shock Strut

G6000 / G7000 / 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

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

Embraer

ALX

- Cabin Pressure Control System

E-Jets E1

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

E-Jets 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

KC-390

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

FAdeA

IA-63 Pampa III

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

HAL

ALH

- Heating and Ventilation Systems

Dornier 228

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

HJT 36

- Cabin Pressure Control System

Jaguar

- Cabin Pressure Control System

Tejas

- Cabin Pressure Control System

IAI

Elta

- Environmental Control Unit

G200

- Cabin Pressure Control System Components
- High-Lift System

Kamov

KA-226T

- Air Conditioning System

Korean Aerospace Industries

KHP

- Cabin Pressure Control System Components

KT-1

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

Leonardo Aircraft

C27-J

- MELTEM III-MMI Auxiliary Cooling System
- MELTEM III-MMI Environmental Control Unit

M-346

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

Leonardo Helicopters

AW109

- Environmental Control System

AW139

- Environmental Control System
- 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

Trent 7000

- High-Pressure Non-Return Valve

RUAG Aerospace

Dornier 228 New Generation

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

Sukhoi Civil Aircraft Company

SuperJet 100

- Fly-by-Wire Flight Control System
- Fuel Tank Inerting System – CSAS
- Integrated Air Management System

Textron Beechcraft

750/850XP/900XP

- Cabin Pressure Control System

Thales

Damocles

- Environmental Control Unit for POD

RECO NG

- Environmental Control Unit for POD

MELTEM II

- Environmental Control Unit

TRJet

328 Series

- Air Management System
- Flap and Spoiler Actuation Subsystem

Turkish Aerospace Industries

Turkish Light Utility Helicopters (TLUH)

- Air Conditioning System
- Oil Cooling System



Liebherr-Transportation Systems

Environmentally Friendly Air Conditioning Systems Successful in Project with Federal Environmental Agency and Deutsche Bahn

What advantages are offered by air conditioning systems with natural refrigerants in comparison with traditional vapor cycle air conditioning systems operating with the refrigerant R134a, and how can the former sustainably cool and heat public transport vehicles? Liebherr-Transportation Systems successfully completed the project to examine and answer these questions as part of the Environmental Research Plan of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, Dessau-Roßlau (Germany). At the beginning of the year, the company, along with Deutsche Bahn (DB) and the Federal Ministry, presented the results of the project.



For the project, the air cycle air conditioning system developed by Liebherr-Transportation Systems was tested, measured and evaluated in Deutsche Bahn cars over a period of two years. The Liebherr technology is considered to be particularly environmentally friendly as it works without any traditional refrigerants at all. Instead, natural ambient air is used for cooling.

The “test vehicle” was a train from the ICE-3 fleet, series 403, the first model series in which individual cars were equipped with the air cycle air

conditioning systems in the DB facility in Nuremberg. The train prepared for the trial phase started daily passenger operation at the end of June 2015. The Liebherr-Transportation Systems team had installed additional sensors and measuring systems for a long-term test in order to collect extensive operating data and thus allow a detailed analysis of the systems. The aim was to calculate the system’s energy consumption over its entire life cycle using data collected in real operating conditions and through all seasons. The focus was largely on the energy

efficiency of the Liebherr systems in daily passenger service operation. The test train was kept under careful observation, particularly during the hot summer months of July and August. Together with the Federal Environmental Agency



and DB, the Liebherr team thoroughly analyzed and assessed the data which was collected.

Reduced energy requirement and lower operating costs

Overall, when it came to annual energy consumption in realistic operating conditions, air cycle technology showed a clear advantage. Reduced energy consumption had an immediate effect in lowering the environmental impact of energy provision (depending on the power mix).

Another of the project's goals was to carry out a realistic total costs analysis in comparison with conventional systems operating with the refrigerant R134a. Here too, the air cycle technology came out in front: The lower energy requirement not only cuts environmental pollution, but also clearly reduces operating costs. In this context, the comparatively lower maintenance costs are a particular competitive advantage. As the entire air cycle air conditioning system comprises only a few components, it is very easy to maintain. And last but not least: While

employees working in air conditioning system production and on rail operation need training in handling refrigerants, no special training is required for handling air.

Pioneering technology for environmental protection

With its innovative technology for air cycle air conditioning systems, Liebherr-Transport Systems is making an important contribution to sustainable passenger transport. At the presentation in Berlin, representatives from the Federal Environmental Agency were therefore very positive about the results of the joint project. Particularly as regards the EU's Fluorinated Greenhouse Gases Regulation no. 517/2014, which calls for a phase down of the volumes of partly fluorinated hydrocarbons (HFC) available on the market by the year 2030, the Liebherr technology represents an anticipatory alternative. It not only avoids greenhouse gases, but also remains available if the refrigerants are reduced to the required 21 percent, which could considerably limit the operation and maintenance of traditional systems in future.

Over 100 Liebherr-Transportation Systems air cycle air conditioning systems are already in use in Deutsche Bahn trains and have proved extremely successful in daily passenger service operation. For Liebherr, the encouraging results of the field data analysis are not just a confirmation but also driving factor to continue working on the further development of the environmentally friendly air conditioning of rail vehicles in a broader range of applications. With over ten years of operating experience, air cycle technology, which originally comes from aviation and has been developed for the rail industry by Liebherr, represents a reliable, environmentally friendly alternative.

Within the scope of the project, Liebherr-Transportation Systems was able to obtain useful information and insights that will enable it to meet its customers' needs and requirements even better in the future.



© DB AG

Liebherr air cycle air conditioning systems have proved reliable in everyday operation.

All Indicators are Pointing to Growth

“We want to support China in expanding its infrastructure – using environmentally friendly technology.” Andreas Walter is working at Liebherr-Transportation Systems since November 2016 and, as Executive Director of Liebherr Machinery Service (Shanghai) Co. Ltd., is responsible for the further development of the Transportation China branch. “Transport and infrastructure represent a big market in China”, explains Walter, who has been living in the People’s Republic for ten years. “The state is investing hugely in these areas in order to keep the high volume of commuters moving. For this, the suburban districts wish to be, and must be, connected to the major cities – not to mention the fact that various cities of a million people need a metro network.”

Liebherr-Transportation Systems is supporting this boom in local public transport by providing innovative solutions: “We are focusing on new technologies, such as environmentally friendly air cycle air conditioning systems. It is not only the rail vehicle manufacturers who are interested in this. The state is also keen to find out about low-maintenance and climate-protecting technologies so that it can tackle the issue of air pollution”, says Andreas Walter. In parallel, Liebherr-Transportation Systems is continuing to work hard on qualifying its factories in China. “We want to offer local customers in a dynamic market environment added value, both as a first tier supplier and in the areas of after-market and maintenance, in the form of advanced technology which is produced locally according to the high Liebherr standards. For this, we are developing in-house skills further and implementing new technologies in the fast-growing Chinese market in cooperation with local science and industry.”



Andreas Walter, Executive Director, Transportation China – Liebherr-Transportation Systems

The Liebherr Group has been supplying Chinese rail vehicle manufacturers with heating, ventilation and air conditioning systems and their components via the joint venture Zhejiang Liebherr Zhongche Transportation System Co., Ltd., Zhuji, since 2007.



Zhejiang Liebherr Zhongche Transportation Systems Co., Ltd. in Zhuji

Double Saving Effect by Reducing Wheel and Track Wear

In many countries, rising passenger figures and increasing levels of goods transport are causing rail networks to suffer wear more quickly. To combat wear on the UK infrastructure, the Rail Safety and Standards Board (RSSB) invited applications for a subsidy which a consortium of Liebherr-Transportation Systems and New Rail, led by Grand Central Rail won on the basis of its idea: the development of an Active Radial Suspension System. This reduces wear on the wheels and tracks and enables the operators of rail vehicles to save on track fees and maintenance costs.

Liebherr-Transportation Systems, in association with its consortium partners, the UK rail company Grand Central Rail (part of Arriva Group) and NewRail (Center for Railway Research at Newcastle University), was awarded a grant from the RSSB – along with a funding from the UK Department of Transport – to develop an Active Radial Suspension System (ARSS) which can be retrofitted to an existing bogie. The aim of this technology is to reduce wear on both the infrastructure and the vehicles. The ARSS uses electro-hydraulic actuators to actively steer wheels on rail vehicle bogies, thus reducing wheel and track wear.

In the UK, the reduction of track wear is of particular significance, as track wear is a notable contributor to the Variable Usage Charge (VUC) train operators pay to operate trains on the UK rail infrastructure. The ARSS solution is expected to considerably reduce track wear, and the project aims to validate this, and its potential reduction of VUC.

The electrohydraulic actuators set the wheels with millimeter precision, depending on the curve radius. “In comparison to the passive control systems already available today, the active system is much more effective, since it can be optimally adapted to the track-wheel geometry and the different regional conditions of the tracks”, explains Paul Hofbauer, Product Manager Hydraulics at Liebherr-Transportation Systems.

Liebherr-Aerospace developed the technology of electrohydraulic actuators around 30 years ago for aerospace application. They are a good example of how Liebherr transfers technologies between its Aerospace and Transportation division. In 2007, the actuators were adapted for use in rail transport, and they have been used as standard in various applications since 2011, for example, for roll compensation or for active lateral suspension, which can allow higher train speeds with improved traveling comfort.

During the project, the consortium will first model the effects of retrofitting the Liebherr ARSS to an existing UK bogie design. Should the modelling demonstrate the expected benefits, the system will be installed on a trial vehicle and tested.

The project is expected to be completed by late 2019, which if successful could then be made available for commercial use by Liebherr, both in the UK and other world markets.

Seen economically, the installation of an ARSS for rail vehicle operators is doubly interesting. Firstly, driving in a way that reduces track wear will lower VUC. Secondly, the reduction in friction resulting from optimum curve running will also reduce wear on the wheels of rail vehicles. This will extend maintenance intervals, which means, for example, that expensive vehicle wheel replacement can be done much later than usual.





The Liebherr Group

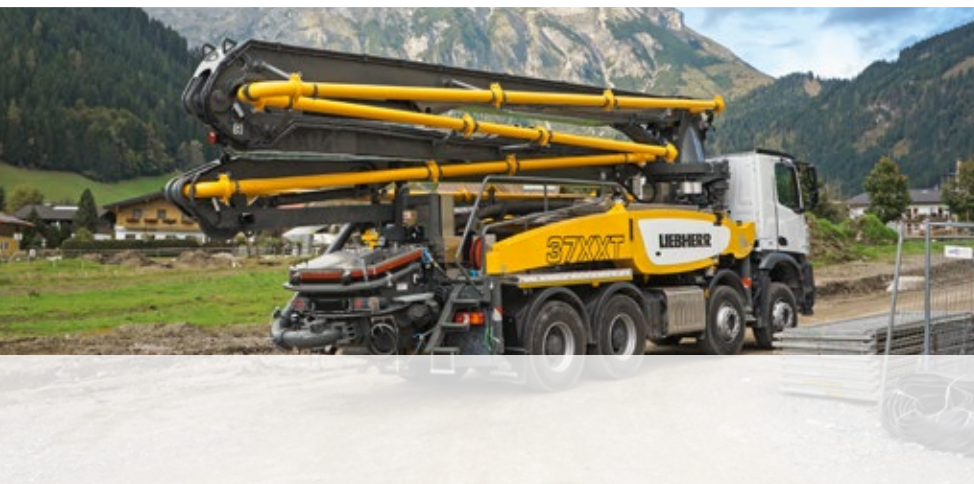
In 2017, Liebherr achieved the highest turnover in the Group's history, of €9,845 million.

There were marked differences in sales performance between the various regions. In Western Europe, Liebherr's most important sales region, turnover increased significantly. This was due in part to renewed growth in Germany, Liebherr's largest market, as well as to upward trends in France. In the UK, turnover remained at the previous year's level.

Sales performance in Eastern Europe, particularly in Russia, was encouraging. In Poland, by contrast, a decline in turnover

was recorded. In the Far East/Australia and America, revenues were also above the previous year's level. The Near and Middle East and Africa, however, recorded a fall.

2017 saw a further increase in the workforce. The Liebherr Group had 43,869 employees worldwide. This represents an increase on the previous year of 1,561 or 3.7%. The number of people employed by Liebherr companies will again rise slightly in 2018.



The Group has traditionally emphasized the importance of making regular investments in its production facilities and its global distribution and service networks. Last year, the Group invested €749 million, a slight decrease of 0.3%. Offset against this was depreciation of €485 million. The Liebherr Group will also continue to invest substantially in its international production facilities and in its distribution and service network.

According to current forecasts, the global economy will grow even more strongly this year than it did last year. Growth, in the

newly industrialized and developing countries in particular, will increase, while economic growth in the industrialized countries will remain at the previous year's level. The Group expects a further increase in turnover for 2018. Liebherr anticipates growth in the construction machinery and mining segment, as well as in the other product areas. Appreciable gains are forecast in the Mining, Concrete Technology, Machine Tools, Automation Systems and Earthmoving divisions.

 **Discover more:**
www.liebherr.com

Gear Technology

Skiving Machine – Tool – Process



Liebherr makes skiving a more reliable process with the new LK 300 and LK 500 gear-skiving machines. The principle of gear skiving was invented over a century ago. Yet in practice the highly dynamic kinematics involved in this method frequently caused major problems. Up to now, the process was very unfavorable for the tools. The skiving tools are very complex and an incorrectly designed tool has a negative impact on tool life and machining quality.

In the LK 300 and 500 gear skiving machines, process, tools and machine come from a single source, including tool changer and automation system. In Skiving³, the delivery of an integrated solution for the customer is of primary interest. Skiving³ is especially suited for internal gears of medium size and quantity, as it is much faster than shaping and more economical than broaching. The machine can be operated using the touch-based control system LH Geartec that intuitively leads the machine operators through the menus.

Domestic Appliances

Energy-efficient, Quiet and with Great Usable Volume



BluPerformance, Liebherr's most innovative appliance series, has some new additions. In the 70 cm width, the refrigeration and freezer appliances offer even more space for food storage. The integration of the refrigeration technology

in the appliance plinth has created an additional 20 percent more usable volume. In combination with specially mounted compressors this innovation creates a further advantage: the appliances are particularly quiet in operation. And they consume even less energy. All BluPerformance appliances are available in the highest energy efficiency class A+++ and some are even 20 percent more economical. Nevertheless they also offer the latest refrigeration technology such as innovative BioFresh climate zones to keep food fresh for longer. High-quality materials, perfect workmanship down to the last detail, user-friendly and precise Touch electronics define the range. Within its new digitization strategy framework, Liebherr is presenting digital solutions to simplify food management. All refrigerators in the BluPerformance series can be equipped with the new generation SmartDeviceBox, a convenient solution for networking refrigeration and freezer appliances. It allows consumers to digitally interact with their Liebherr refrigerator and in the process opens up new dimensions in food and groceries management.

Maritime Cranes

The Largest Crane Ever Developed

With the HLC 295000, Liebherr has developed a heavy-lift crane with a load capacity of 5,000 metric tons at 35 meters and a maximum lifting height of up to 170 meters above deck. It is the largest crane ever developed by Liebherr. The first of its kind will be supplied for the Orion, a new wind farm installation and platform decommissioning vessel ordered by DEME from COSCO (QiDong) Offshore, a subsidiary of COSCO Shipping Heavy Industry. The crane will be delivered in spring 2019. "The diversification of our offshore crane portfolio in general purpose, subsea and heavy lift cranes opens the door to new markets," says Daniel Poll, Sales Director Liebherr Ship and Offshore Cranes. "Winning this order is proof we are heading in the right direction. It will be another important step to provide access to new growth potential," adds Leopold Berthold, Managing Director Maritime Cranes. The Group's maritime hub

in Rostock is perfectly suited for the manufacturing of such huge offshore machines. Steel construction, assembly, installation/loadout and testing will be fully processed in the facility on the Baltic Sea.

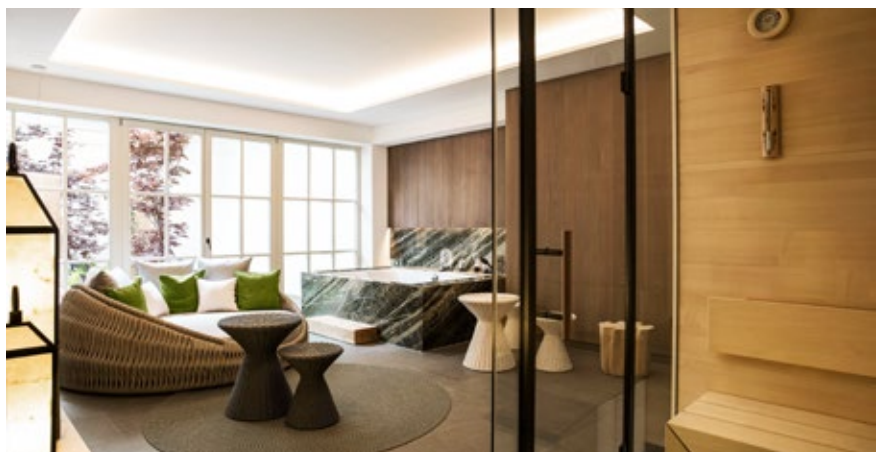


Hotels

Award-Winning Relaxation

The Liebherr Group owns six hotels: three in Ireland, two in Austria and one in Germany. It is their high quality standards that unites them. This can be seen in the award-winning 5,300 square meters spa of the Interlpen-Hotel Tyrol in Austria. The hotel offers a private spa after the redesign of the beauty and massage rooms. A massage in the luxurious spa suite, relaxing in the private sauna or in the well-being bath – privacy is a priority here.

Since June 2017, the 5-star superior hotel near Seefeld has offered a fully equipped Tyrolean alpine hut for exclusive events in an alpine atmosphere in addition to its eleven conference rooms. Whether a Tyrolean hut evening for a conference finale, a private party



with live music or a cozy fondue evening: the charming alpine hut can accommodate up to 150 people and combines a relaxed atmosphere with a high-quality ambience and best service.

Largest Duty Cycle Crawler Crane in the Port of Piombino

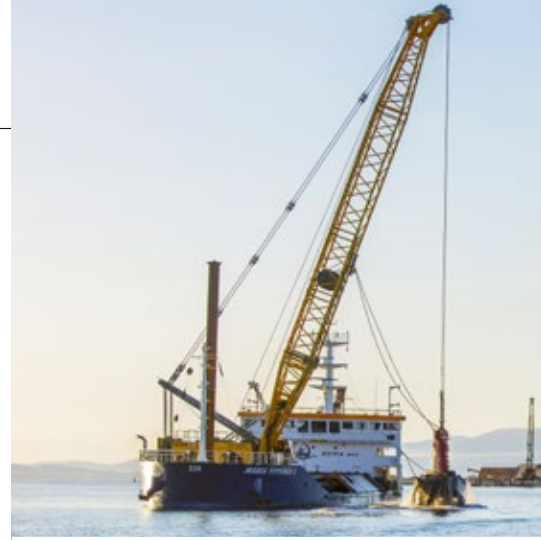
Currently the largest duty cycle crawler crane of Liebherr, the HS 8300 HD, has recently carried out dredging work in Piombino. The aim of the project was to remove deposited sediment from the mouth of the port and also to increase the depth of the water. For this purpose, the hybrid duty cycle crawler crane was equipped with a hydraulic clamshell grab with a filling capacity of 22 m³.

With its capacity of 300 metric tons the HS 8300 HD is one of the largest duty cycle crawler cranes worldwide and the powerhouse has recently carried out dredging work in the Port of Piombino. Over the years, the depth of the water at the mouth of the port was reduced to as little as 8 meters through sediment. The work not only involved the removal of the sediment. The depth of the water was also increased to 14 meters in order to allow for larger vessels to run into the port. The importance of trouble-free shipping traffic is underlined by the fact that more than three million passengers pass through the port on their way to the Tuscan Archipelago, Sardinia or Corsica. The work in Piombino was carried out in a six-month project by the Italian dredging specialist Zeta S.r.l.

Material amounting to a total of 600,000 m³ had to be removed from the entrance to the port. With the duty cycle crawler crane type HS 8300 HD, the contractor Zeta S.r.l. found a real powerhouse. On the one hand, the challenge lay in achieving high levels of turnover and, on the other hand, in removing not only sediment but also larger stones. For this reason Zeta S.r.l. opted for a hydraulic clamshell grab from the Italian manufacturer Rossi with a filling capacity of 22 m³.

Zeta S.r.l. installed the HS 8300 HD without crawlers on its new dredger Maria Vittoria Z, on which a total of 3,000 metric tons of material can be loaded. Thanks to the large volume of the grab and also the short working cycles of only 45 seconds, the Liebherr duty cycle crawler crane handled 2,000 metric tons of material per hour meaning it required less than two hours to fully load the Maria Vittoria Z.

The duty cycle crawler crane is equipped with Liebherr's own hydraulic hybrid drive system Pactronic®. Through the storage and subsequent reactivation of surplus energy the turnover can be increased and, at the same time, the fuel consumption can be significantly reduced. In combination with Pactronic® the 725 kW diesel engine achieves a system performance that is comparable to a conventional drive system with 1,250 kW. Despite high levels of turnover, the duty cycle crawler crane has up to 50% lower diesel consumption (60 l/h) in comparison to similar models. The work in the Port of Piombino clearly confirmed that the HS 8300 HD is a machine for heavy duty material handling.



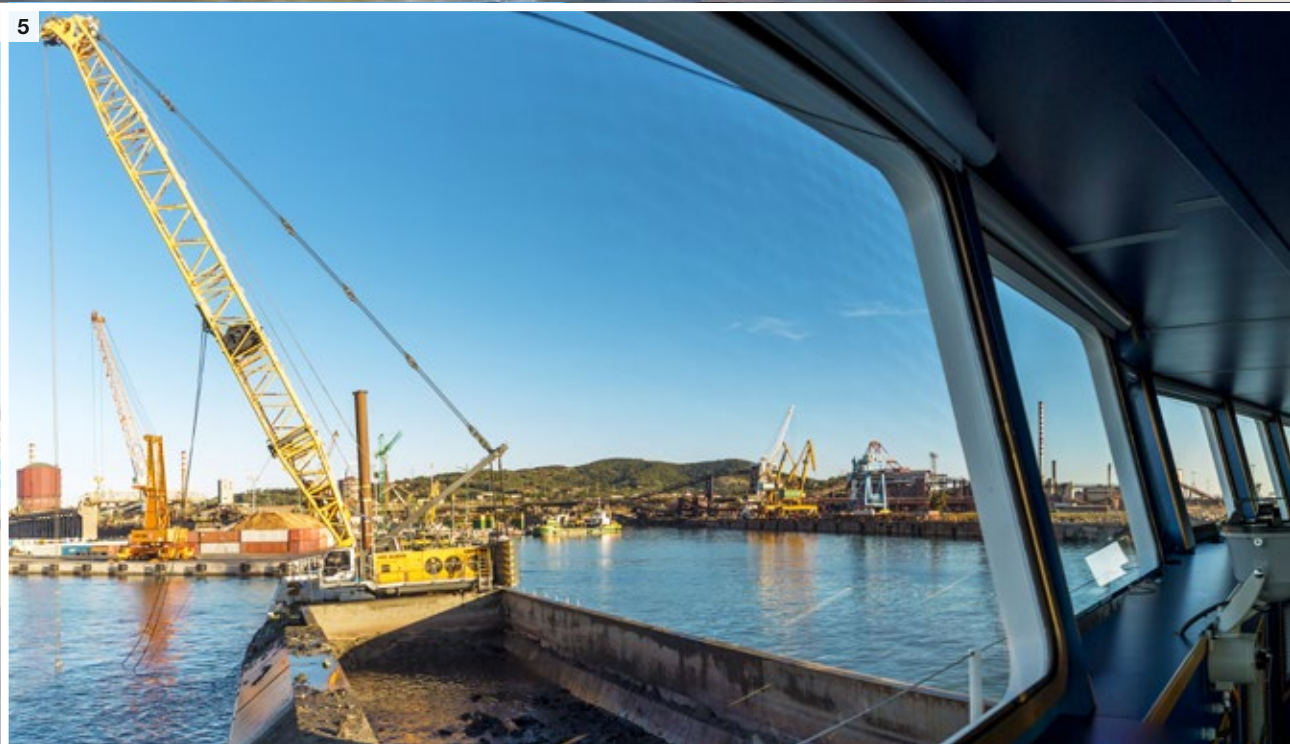
1. Green light for shipping traffic after the removal of deposited sediment.
2. Great tasks require great machines.
3. The vessel and duty cycle crawler crane work as one unit.
4. The HS 8300 HD allows a turnover of 2000 metric tons per hour.
5. Dredging assignment with a view, in the Port of Piombino.



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