

LIEBHERR

ILA 2014

Experience the Progress.

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F.l.t.r.: Heiko Lütjens, Josef Gropper, André Benhamou, Nicolas Bonleux

Dear reader,

The aviation industry continues to grow. Along with airlines and aircraft operators who benefit from the increase in air transport, aircraft manufacturers and aerospace system suppliers are also engaged in this promising development. And so is Liebherr-Aerospace.

In 2013, our customers once again showed their confidence in our company and awarded us major contracts. Embraer, for instance, selected us for the E-Jet E2 high-lift system and the air management system. Moreover, we are pleased to have supported our customers in reaching key development milestones in their new programs, such as the first flights of Airbus' A350 XWB, Bombardier's CSeries and Learjet 85 aircraft.

Liebherr-Aerospace is strongly engaged in research and development to prepare the future of the aviation industry. With our partners – the European Union, national governments, regional governments, research institutes, universities and private companies – we are working on the more electric aircraft and on other major projects that will contribute to environmentally friendlier and more efficient air transport.

In addition, our commitment to sustainability has further developed: the major sites of our worldwide network obtained the

ISO 14001 certification in 2013, following our European sites, which had been certified in recent years.

With every step we take, we are strengthening our ability to offer our customers innovative, competitive solutions, thus boosting the long-term development of our company. Key factors in the success of Liebherr-Aerospace are the outstanding commitment, broad expertise and remarkable professionalism of all our teams. In 2013, 300 new employees joined us, bringing our total number of personnel to roughly 4,900. We warmly thank all of them for their excellent performance. In this magazine, you will be able to read more about our employees and learn about our recent contracts and most exciting projects for the future.

At this year's ILA Berlin Airshow, we will once again display our state-of-the-art products and our expertise. We look forward to meeting all our customers and partners, and we wish all of you a successful ILA 2014.

Best regards,

The Executive Board of Management of
Liebherr-Aerospace & Transportation SAS

André Benhamou

Managing Director and
Chief Technical Officer,
Air Management Systems,
Corporate Projects

Nicolas Bonleux

Managing Director and
Chief Sales Officer

Josef Gropper

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Information for Visitors



Experience the Progress.

ILA Berlin Air Show 2014 – Welcome to Liebherr-Aerospace

As one of the leading suppliers of the aviation industry, Liebherr-Aerospace is a regular exhibitor at the ILA Berlin Air Show. From 20 to 25 May 2014, visitors to the show can experience the progress with Liebherr-Aerospace at a number of stations.

Exhibition stand

On stand No. 2201 in Hall 2, Liebherr-Aerospace is presenting various systems and components from the fields of flight control, air management and landing gears on an area of 225 m². Among the exhibits are the nose landing gear and the main landing gear of Bombardier's CSeries aircraft. In addition, visitors can find out about the customer services division.

Chalet

Liebherr-Aerospace is welcoming its customers and partners in the 100 m² Chalet No. 25. Guest are able to enjoy drinks and snacks while watching the daily airshow from the terrace.

ILA Career Center

The ILA Career Center is held on 23 and 24 May 2014 in Hall 5. There, Liebherr-Aerospace is presenting itself as an employer, providing information about career opportunities at the company and offering interested visitors the chance to establish contacts.

Joint German Armed Forces Pavilion

The so-called Joint German Armed Forces Pavilion in Hall 3 highlights the successful partnership between the German Air Force and the military aviation industry in Germany. Along with other suppliers, Liebherr-Aerospace is presenting exhibits from aircraft programs such as the Tornado and the Tiger.

Special exhibition "Innovative Production Technologies"

As part of the special exhibition "Innovative Production Technologies", which is held at the International Suppliers Center (ISC) in Hall 1, the Machining Innovation Network e.V. (MIN) is presenting the machining centers and procedures of the future. Watching live performances, visitors are able to learn how complex aircraft components are machined. As a member of MIN, Liebherr-Aerospace is showing how a valve block is machined on a milling machine.

Impressions





Assembly of Flight Control Components

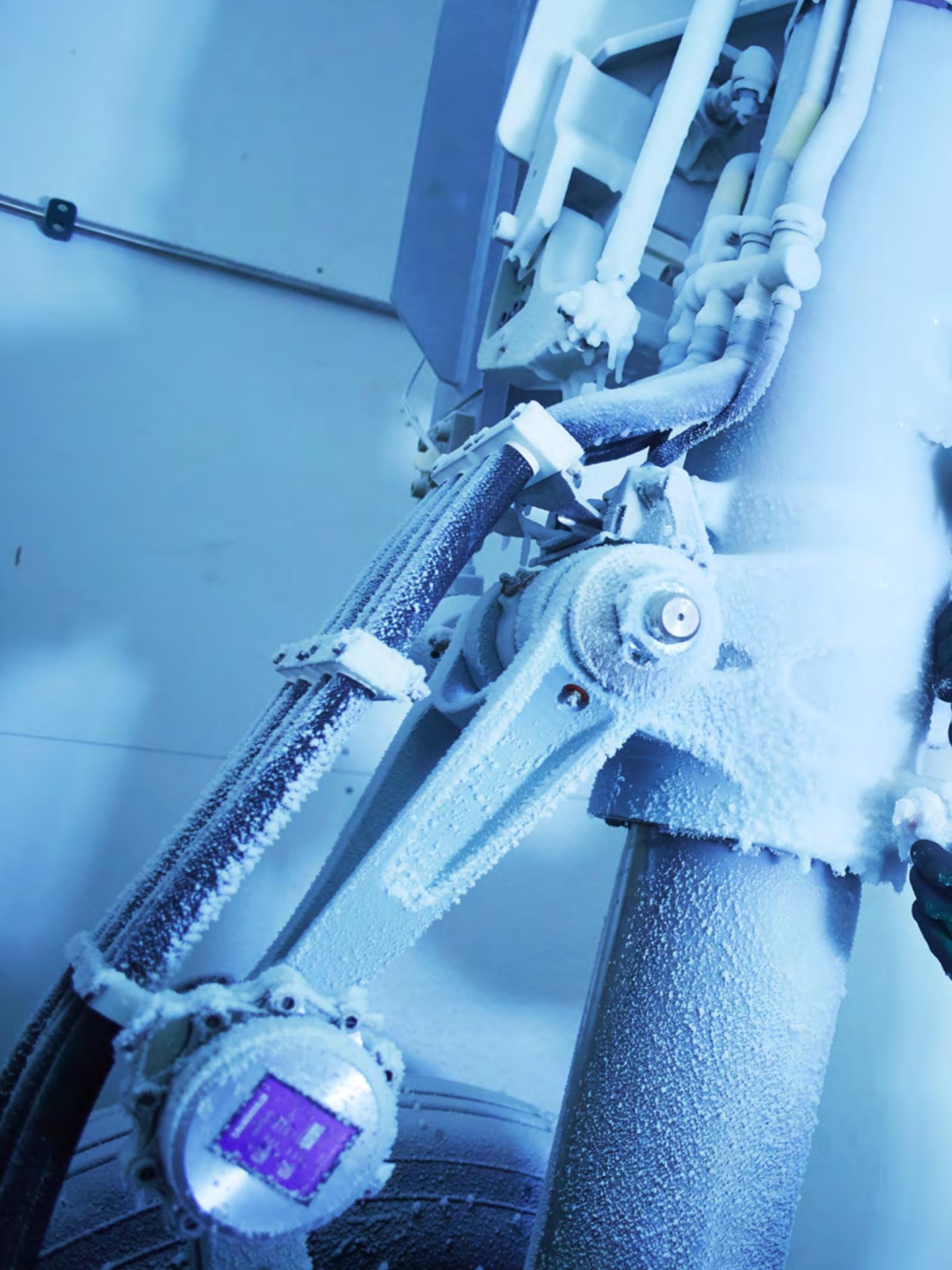
In the assembly, an employee is greasing an annular-toothed ring of a planetary gear set. Afterwards, the ring will be integrated into a rotary actuator for the slat system of an Airbus A320.





Perfectly Balanced

Four air cycle machine rotors prior to their balancing. The turbine expands pressurized air from the engine to generate cold flow (-30°C), and drives the three-wheel rotor at a speed of 40,000 rpm (revolutions per minute). Due to this high speed, the rotor, which is supported by aerodynamic bearings, must be perfectly balanced: the distance from its gravity center to the rotation axis must be smaller than $0.5\ \mu\text{m}$!





Test at -20 °C

An engineer from the testing and qualification division is measuring the thickness of the clear ice layer applied to the main landing gear of a regional jet. The layer must be 6 mm thick. The functionality of the landing gear is then tested at a temperature of -20°C. This so-called icing test is part of the qualification process conducted prior to the certification of the landing gear system.





Machining Scroll Parts

Liebherr-Aerospace's plant in Campsas (France) manufactures scroll parts for Airbus A320 air conditioning systems. These parts are completely machined in a double-spindle, multi-axe machining center that enables turning and milling procedures.





Highest Precision

Employees are adjusting intersection holes that were machined into components for flight control systems. This task is essential for the manufacture of functional parts and requires extremely high precision.



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Programs and New Contracts

Maiden Flight of the Learjet 85 Aircraft with Technology from Liebherr-Aerospace

The latest business jet from Bombardier, the Learjet 85* aircraft, successfully completed its maiden flight on April 9, 2014. Liebherr-Aerospace supplies the integrated air management system and the high-lift system, including the related control systems, for the medium-sized business jet.

Both systems contain state-of-the-art technology designed for the business

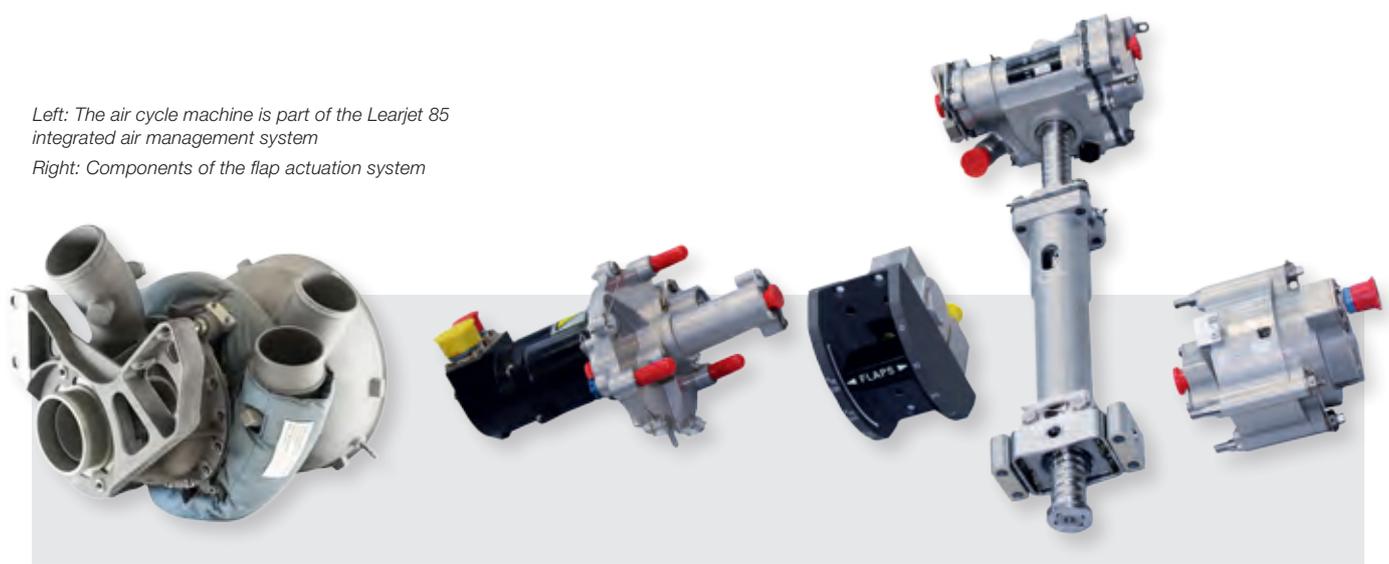
jets of the next generation. The air management system has been developed and is produced by Liebherr-Aerospace Toulouse SAS, the competence center for air management systems located in Toulouse (France). The competence center for flight control systems, actuation systems and landing gears, Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), is responsible for the high-lift system.

Liebherr-Aerospace has put all of its experience in the business aircraft segment, and in particular from its long-standing cooperation with Bombardier, into the development of the systems. This has enabled the system supplier not only to enhance the reliability of the systems, but also to optimize their operating costs and weight.

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Left: The air cycle machine is part of the Learjet 85 integrated air management system

Right: Components of the flap actuation system



Flight-Critical Systems for the Challenger 350 Aircraft

Over the last thirty years, Liebherr-Aerospace has delivered landing gear systems, flight control systems and air management systems to Bombardier for use in numerous aircraft, for example business jets of the Global* and Learjet* aircraft families and commercial aircraft of the Dash 8*Q series*, CRJ* and CSeries* families. The Challenger 350* aircraft, a medium-sized business jet, will feature two flight-critical systems from Liebherr-Aerospace: The flap actuation system and the air management system.

Both systems are based on technologies Liebherr developed for the successful Challenger 300* aircraft. The flap actuation system on the Challenger 350 aircraft will be developed, manufactured and serviced by Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), the center of excellence for flight control and actuation systems and landing gears. Liebherr-Aerospace Toulouse SAS, the



center of excellence for air management systems in Toulouse (France), is responsible for the air management system of the business jet.

With its involvement in the new Bombardier Challenger 350 aircraft, Liebherr-Aerospace is further consolidating its long-standing relationship with the Canadian aircraft manufacturer.

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AW189 Helicopter Obtains EASA Certification

The AW189, the latest member of AgustaWestland's civil rotorcraft family, has obtained its EASA certification. Liebherr-Aerospace supplies two major systems for this 8.3 ton multi-role helicopter – the complete landing gear system and the environmental control system.

All of Liebherr's systems and components were specially designed for the aircraft's high operational requirements in missions such as long-range offshore transport or search and rescue. The landing gear system, which is developed, manufactured and tested by

Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), stands out for its particularly high crash-worthiness. The special shock absorber system ensures that the energy absorption is sufficient when the aircraft is flying at a very high vertical landing velocity. This function is also important for landings on ships or with skis.



The environmental control system, which is based on vapor cycle technology, is developed, manufactured and tested by Liebherr-Aerospace Toulouse SAS, Toulouse (France). The compressors installed in the engine compartment power a two-zone air cooling system for the cabin and the cockpit. In cold conditions, a heating system fed by bleed air provides passengers with warm air. In addition, Liebherr supplies the AW189 cabin and cockpit air distribution, including ducts, valves, fans, diffusers and gaspers.

Liebherr-Aerospace on Board the Bombardier CSeries Aircraft

Liebherr-Aerospace supplies two major systems for Bombardier's CSeries* aircraft, specifically, the complete landing gear system and integrated air management system. The Canadian manufacturer's new commercial aircraft made its first flight on September 16, 2013. The systems feature the latest technologies for the next generation of single-aisle aircraft, and are therefore considerably more efficient.

Liebherr-Aerospace made use of its vast experience in landing gears and air management systems to optimize the reliability and operating costs of its systems for the CSeries aircraft. The latter are designed, developed and manufactured at Liebherr-Aerospace's German- and French-based OEM facilities: Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), is responsible for the CSeries landing gear system, whereas Liebherr-Aerospace Toulouse SAS, Toulouse (France), is in charge of the air management system.

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Delivery of the First Bleed Air System for the C919 Engine Test Bench

After having been selected to develop, manufacture, qualify and certify the integrated air management system for

the C919 single-aisle aircraft in 2010, Liebherr-Aerospace recently delivered the first bleed air system to Chinese aircraft manufacturer COMAC.

The system consists of bleed valves, a pre-cooler, heat exchanger, high-pressure ducting and corresponding pressure and temperature sensors, which are connected to a bleed monitoring controller. It will be used for the test-driven development of the engine LEAP 1C manufactured by CFM. The components were designed to meet

the thermal and mechanical requirements of this new-generation engine. Measuring equipment was fitted on the parts in order to provide COMAC and Liebherr-Aerospace with information on the behavior of the bleed air system during the engine tests.

In the next step, Liebherr-Aerospace will deliver additional components for the engine's ground and vibration test benches, thus preparing the flight test campaign of the C919.



© COMAC



New Contract with Dassault Aviation for Falcon 5X

With the new Falcon 5X, Dassault Aviation has developed a business jet which is characterized by an exceptionally long range and a spacious cabin. Liebherr-Aerospace has been selected by the aircraft manufacturer to develop, produce and service the air management system for the twin-jet business aircraft. This system includes the air conditioning system, the cabin pressure control system and the equipment for air distribution in the cabin.

The new contract consolidates the long-standing relationship between Dassault Aviation and Liebherr. Liebherr-Aerospace Toulouse SAS, based in Toulouse (France), supplies air conditioning systems, cabin pressure control systems and engine bleed systems for several aircraft built by the manufacturer, including for the Falcon program.

KC-46 Tanker Aircraft: New Contract from Boeing

Liebherr-Aerospace Toulouse SAS, Toulouse (France), has been selected by Boeing Commercial Aircraft to

A regulation valve for the nitrogen enriched air inerting system



develop, supply and service the regulation valves for the nitrogen enriched air inerting system (NEAIS) on the KC-46 tanker aircraft.

The highly reliable, weight-optimized pneumatic valves Liebherr-Aerospace has designed for this system are based on components with a proven in-service track record in commercial aviation. They have been advanced and specially adapted to satisfy the extremely demanding requirements of this special mission aircraft. The regulation valves monitor the air ducted to the inerting system. This system inertes the fuel tanks as the fuel leaves the tank, which prevents the fuel vapors from igniting.

Progress in the Embraer KC-390 Program

In 2012, Liebherr-Aerospace was awarded the contract for the bleed system, the cabin pressure control system and the air conditioning system in Embraer's KC-390 program. The first set of components has since been delivered to the Brazilian aircraft manufacturer in São José dos Campos.

The systems for the military transport aircraft are developed and produced by Liebherr-Aerospace Toulouse SAS. This plant in Toulouse (France) is Liebherr's center of excellence for air management systems. The systems are thoroughly tested at the on-site test center. Besides function testing, qualification is also in progress on the system level.

Thanks to the ultra-modern technology of Liebherr-Aerospace, the KC-390 will not only be characterized by a lighter weight and enhanced reliability, but also by a lighter environmental footprint.

The KC-46A is a derivative of the Boeing 767. Compared to the long-range commercial aircraft, it features additional systems, in particular additional fuel tanks and the related safety systems. Boeing is set to deliver 179 of this next-generation tanker aircraft to the US Air Force.

It is the third time that Boeing has selected Liebherr-Aerospace for a critical system: Liebherr previously designed the air conditioning system, the engine bleed system and the anti-icing system for the Boeing 747-8 as well as the auxiliary fuel tank pressurization system for the Boeing 777-200 LR.



Technology

Subjected to Stringent Tests: The Systems for the Bombardier CSeries Aircraft Family

For Bombardier's CSeries* family of aircraft, the first completely redesigned single-aisle aircraft family, Liebherr-Aerospace supplies two highly complex systems: the air management system and the landing gear system. Due to the aircraft's innovative configuration, developing and testing these systems was particularly challenging. Both systems underwent rigorous trials at Liebherr-Aerospace's test centers and also at Bombardier. The goal was to ensure the functionality of the systems and thus the safety of the passengers on the ground and in the air.

The Landing Gear System

For the CSeries aircraft family, Liebherr-Aerospace developed a state-of-art landing gear system. The system includes nose and main landing gears, hydraulic actuation components for extending and retracting the landing gears and steering the nose landing gear, a computer and related cockpit controls. Testing, qualifying and certifying such a highly complex system – thus ensuring that it operates flawlessly on board the aircraft – is a joint effort that demands a lot of hard work, technical expertise and cooperation between the supplier and the aircraft manufacturer.

Testing the landing gear started in an early development phase of the system. First, engineers carried out trials on prototype landing gear components in order to validate

their design concepts and to develop standard components. After these components had been manufactured and tested, technicians and engineers integrated them into subsystems and systems. The latter, in turn, underwent various structural, performance, endurance and environmental trials at Liebherr-Aerospace's test and qualification center in Lindenberg (Germany).

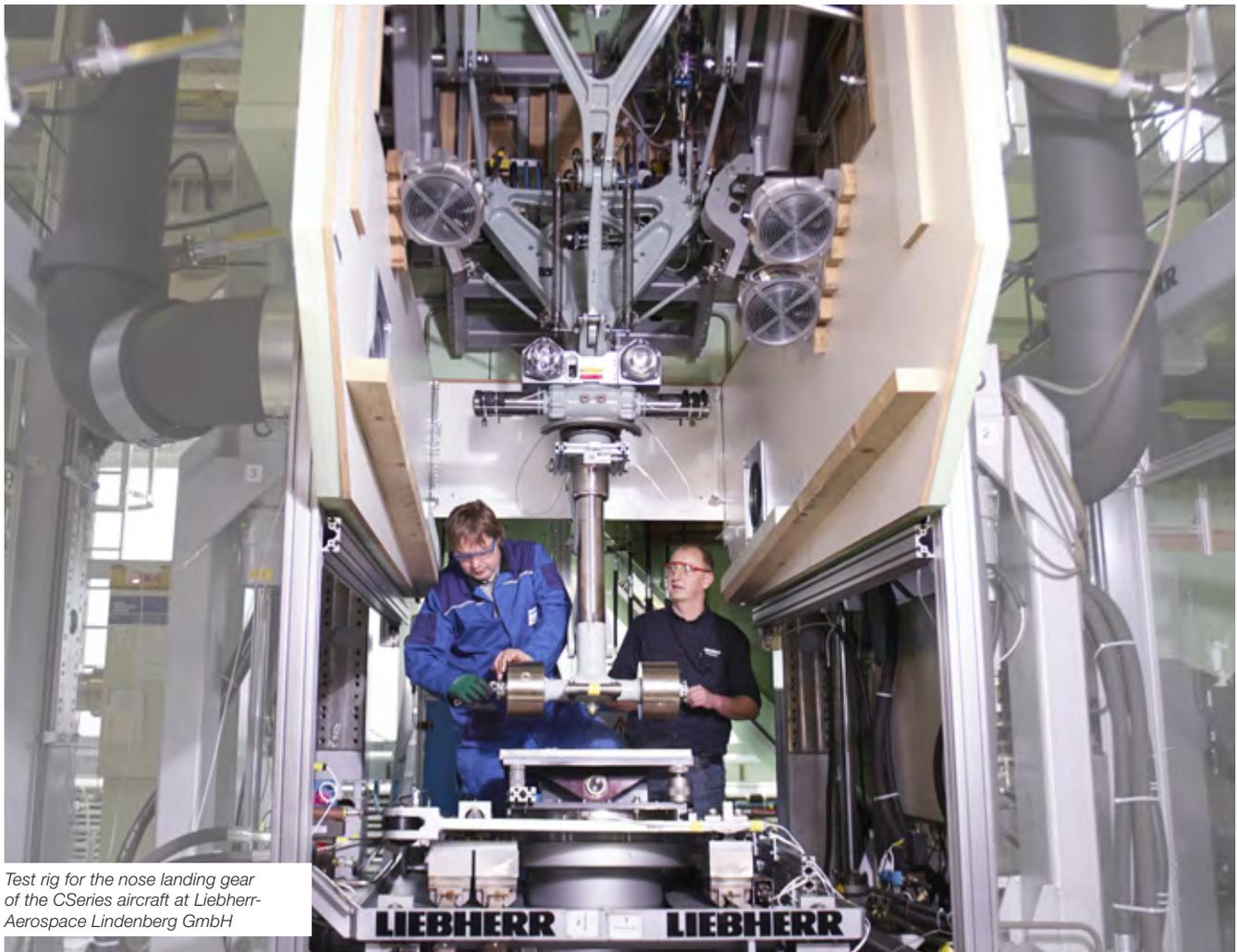
Functionality meticulously tested

In a nutshell – what exactly did the company's specialists examine in all these tests? Structural tests, for instance, were conducted to verify if the legs of the landing gear were robust enough to support the enormous loads that act on them when the aircraft touches down. In order

to carry out performance trials, technicians installed the landing gear system in a huge test rig that simulated the CSeries aircraft. This way they checked if the gear could be extended and retracted quickly enough – that is within the specified time. In endurance tests, the extension and retraction process was repeated several thousand times to verify that the mechanisms would function throughout the entire life of the aircraft. Would the landing gear system operate without any problems if the aircraft was hit by hail, or if it was exposed to sand and dust, or extreme temperatures ranging from a scorching +70 °C to a freezing -55 °C that caused icing? All these conditions were simulated in environmental tests to ensure that the landing gear system would operate in any such scenario.

Taxiing, taking off and landing safely

In parallel to the trials at the Lindenberg test center – months before the first flight of the CSeries aircraft – several engineers, technicians and mechanics joined Bombardier's engineering and test teams in Montreal and Mirabel (Canada), where the aircraft manufacturer's headquarters and final assembly line are located. They supported Bombardier's specialists in integrating the landing gear system into CSeries flight test aircraft as well as in testing these aircraft on ground and airborne. In low and high speed taxiing trials, for example, they checked if the nose landing gear could be steered smoothly and precisely, and if the wheels shimmied. During the first flight and the following flight test campaign, tests were conducted to verify that the extension and retraction mechanisms would work in the extreme case of hydraulics failure. All these tests served one purpose – to make sure that future passengers of the CSeries aircraft would take off and land safely.



Test rig for the nose landing gear of the CSeries aircraft at Liebherr-Aerospace Lindenberg GmbH

Finally, the joint effort in the final assembly and test phases of the aircraft has proven beneficial to both companies. Bombardier has gained from Liebherr's experience and competence. And vice versa, by working face-to-face with

Bombardier's technicians and getting immediate feedback, Liebherr's specialists have been able to remain up-to-speed with aircraft development and to make enhancements to the CSeries aircraft's landing gear system.

The Air Management System

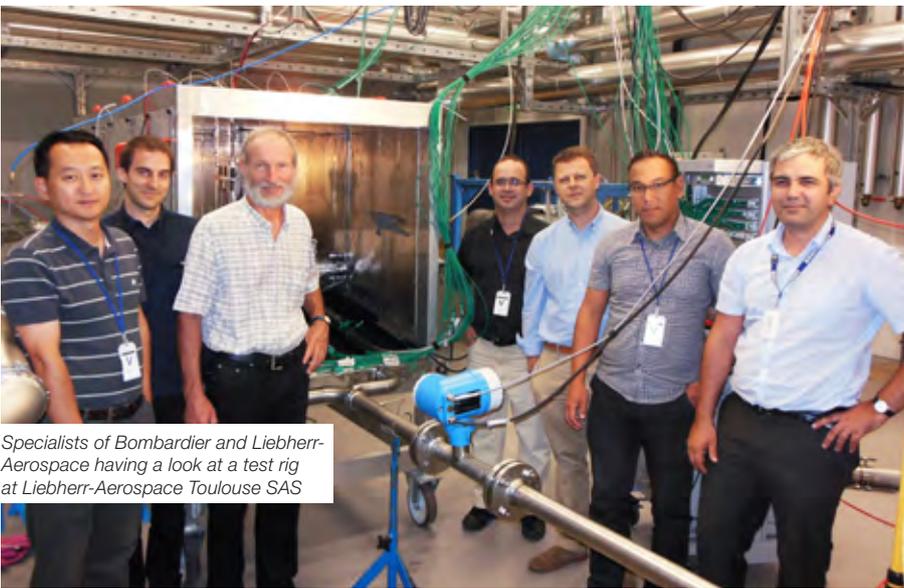
The bleed air and environmental control systems, the cabin pressure control system, the air distribution, the avionics cooling and extraction systems, the wing ice protection system and the overheat detection system – all these systems are part of the integrated air management system that Liebherr-Aerospace designed for the CSeries family of aircraft.

In order to obtain the certification for this high-tech system, engineers and technicians performed integration testing at the company's test center in Toulouse (France). There, development, qualification and maturity tests for all types of air management systems and key system components such as air cycle machines, valves, air conditioning packs, heat exchangers, motors and power electronics can be carried out on a 7,000 m² test area. The center is equipped with state-of-the-art test benches and chambers in which environmental conditions relating to pressure, temperature, air flow rate and humidity are simulated.

Extreme temperatures and pressures

Single parts, subsystems or complete systems can be tested in two high-altitude chambers, with a volume of 70 m³ and 120 m³ respectively. Connected to a high-output compressed air and vacuum circuit, these chambers enable the simulation of all environmental conditions that may be encountered in flight, with temperatures from -60 °C up to +600 °C and pressures from a few mbar to 40 bar. Testing specialists validated the CSeries aircraft's air management system architecture in real aircraft configuration with full pressure and temperature operation conditions. This was particularly important, as the CSeries aircraft is equipped with new Pratt & Whitney engines (PW1000G), which differ from previous engines in terms of bleed pressure, bleed temperature and fan pressure.

Moreover, the CSeries aircraft's leak detection system was successfully tested at the Toulouse facilities. As the aircraft's wings are made of innovative composites, it was crucial to ensure that the composite surfaces would never be exposed to bleed air that reaches a temperature of 600 °C. Liebherr-Aerospace has therefore developed a new, optimized leak detection system that



Specialists of Bombardier and Liebherr-Aerospace having a look at a test rig at Liebherr-Aerospace Toulouse SAS



© Bombardier

traces leaks in the bleed air system and monitors the temperature in the zones made of composites.

A low acoustic level

In order to ensure that the acoustic level inside the aircraft's cabin would be low, specialists tested Liebherr-Aerospace's latest-generation outflow valves in an ultra-modern anechoic chamber. With its cut-off frequency of 90 Hertz, its low residual noise level of 20 dBA and, in particular, with its capacity to test air systems in real environmental conditions, this chamber is unique in Europe. The air intake temperature can range from $-40\text{ }^{\circ}\text{C}$ up to $+160\text{ }^{\circ}\text{C}$ and the ambient temperature from $-40\text{ }^{\circ}\text{C}$ up to $85\text{ }^{\circ}\text{C}$. Specially designed for the CSeries aircraft, the outflow valves with smart actuators are installed at the main entrance of the jetliner's fuselage fairing. This resulted in a totally new configuration for the CSeries aircraft, which was reproduced for the tests in the anechoic chamber.

Furthermore, due to the complexity of the systems and the tight program schedule, Liebherr-Aerospace set up a so-called "Hardware-In-the-Loop" (HIL) test bench. It is used



Air conditioning pack on its test bench

to test real hardware system controllers with all relevant electric components and actuators, and it simulates all system control logics. The HIL is a major improvement that permits software innovations to be validated in an early development phase.

In September 2013, Bombardier reached a significant milestone in the development of its new jetliner: The CSeries aircraft safely completed its first flight.

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Sites

Liebherr-Aerospace Widens Its Scope of Activities in Brazil



Checking a valve

Liebherr Aerospace Brasil Ltda., Guaratinguetá (Brazil), a specialist in the precision machining, surface treatment and assembly of high-tech and precision parts for flight control and actuation systems, landing gear and air management systems, is widening its scope of business activities.

The company is preparing to manufacture, treat and pre-assemble complex medium-size structural parts made from aluminum, such as ribs, beams and brackets for the wings and fuselage of aircraft, and to deliver its products directly to Brazilian aircraft manufacturer Embraer. To date, it has mainly been supplying its sister companies in Europe, the OEMs Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), and Liebherr-Aerospace Toulouse SAS, Toulouse (France). With this new approach, Liebherr Aerospace Brasil Ltda. is pursuing the goal to establish itself as a competitive player in Brazil's aeronautic supply chain and to gear up for future challenges.

In parallel to this, new work processes for the painting and assembly of structural mechanical parts as well as for the assembly of electrically driven manifolds are being implemented. In addition to this, the company is preparing

the introduction of an environmental management system compliant with DIN EN ISO 14001 in order to make its procedures even more sustainable and environmentally friendlier.

Liebherr Aerospace Brasil Ltda. employs approximately 250 people in total in production, design, procurement, quality control and administration roles. In 2011, the plant was completely destroyed by a blaze. Reconstruction work started at the same site at the beginning of 2012, and as early as February 2013, the company restarted operations. The new plant covers a surface area of 8,080 m², which is 10% larger than before.



Highest precision



Flow control valves

Construction Progress at the Lindenberg Site on Schedule

The Lindenberg site is growing. In order to boost production capacity for the long term and thus meet the increasing demand, Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany), began a large-scale expansion in the summer of 2012. At the end of 2013, the first buildings were completed to schedule. On a ground area of some 15,700 m², a hall was built for the logistics department and flight control systems assembly. Sales and customer services will also move into new offices in this building. In addition, a building with a ground area of 2,900 m² was constructed to accommodate – amongst other things – landing gear assembly and the fire-fighting service.

Logistics, which includes the incoming goods section, the warehouse, the shipping section and customs section, moved into the new hall at the beginning of 2014. Due to the growing order volume and increasing customer requirements regarding lead times, it was not only necessary to increase the capacity of the warehouse, but also to adjust the processes employed. In the small parts store, which now has space for 45,000 containers, up to 1,232 containers per hour will be processed in the future by the four storage and retrieval systems. The new large parts store has capacity for 7,000 euro-pallets. There, up to 234 pallets an hour can be moved by three storage and retrieval systems. The containers and euro-pallets are conveyed fully automatically from the fourth basement level of the warehouse, which is 20 m underground, to the ground floor for order picking.



In the background: the two new buildings of Liebherr-Aerospace Lindenberg GmbH

The relocation of the assembly section is well underway. Dismantling and reassembling more than 130 test benches and taking them into operation again are the greatest challenges there. At the start of the year, the first work stations for the assembly of flight control components were set up in the hall. Using the "cardboard engineering" method, employees designed their work stations themselves. They developed new assembly lines, which were set up as cardboard models, true to scale with fine detail. Simulating the work processes and documenting the requirements to the supporting sections such as methods services, design of manufacturing equipment, logistics, IT, procurement and scheduling enabled an optimal logistical process to be developed.

In the planning of the hall, importance was attached to sustainability. The entire building has a green roof, which allows rain water to be collected and fed into a newly built reservoir. Moreover, a heat pump is used to generate energy for heating from process heat.

The previous assembly halls are being renovated and converted, and will be used for production in the future. Once construction work is completed in 2018, the plant of Liebherr-Aerospace Lindenberg GmbH will have grown from its original size of 127,000 m² to more than 160,000 m². The production area, currently 65,000 m², will then cover 75,000 m².



Test benches for flight control components in the new assembly hall



A conveyor belt in the new area for incoming goods



Customer Service

Liebherr-Aerospace China Obtains CAAC's Maintenance Organization Certificate

Liebherr-Aerospace China, Shanghai (China), has received its Maintenance Organization Certificate per CCAR part 145 from the General Administration of Civil Aviation of China (CAAC).

The new maintenance station was set up to offer repair services to airlines based in mainland China and thus to improve component support and repair turn-around times. Having started by maintaining Liebherr components installed in Airbus aircraft, Liebherr-Aerospace China will progressively extend its scope of services to Liebherr components in Bombardier, COMAC and Embraer aircraft.

With its Shanghai station, Liebherr-Aerospace extended its infrastructure in China, which had consisted of technical support, the distribution of spare parts to operators of Airbus aircraft and engineering activities for COMAC's ARJ 21 and C919.



Liebherr-Aerospace Receives the ATR Silver Award



Representatives of Liebherr-Aerospace Toulouse SAS were awarded the prize.

Liebherr-Aerospace has received the ATR Silver Award in recognition for its involvement in the ATR aircraft program in the years 2011 to 2013. French aircraft manufacturer ATR presented the award to representatives of Liebherr-Aerospace at the 6th ATR Suppliers Conference in Toulouse (France) in November 2013.

Based on the criteria of performance, quality, service and technical solutions, the prize recognizes the commitment of Liebherr-Aerospace in servicing the ATR 42 and ATR 72 aircraft, for which the company supplies the cabin pressure and anti-icing systems.

First E-Jet 170 Landing Gear Overhauled in Europe

In the past year, Liebherr-Aerospace overhauled the first landing gear system of an Embraer E-Jet 170 aircraft at its facilities in Lindenberg (Germany). It was the first time that such a landing gear was maintained in Europe. The system supplier, who has many years of experience in the field of overhauling, was thus able to mark an important milestone in customer services.

At the start of the overhaul, specialists examined the landing gear and dismantled it into its component parts. All bushings were removed. The individual components were stripped of paint and other coatings and examined for cracks, corrosion and dimensional accuracy. Repairs were performed on any discrepancies found.

Moreover, the bushing bores and chrome surfaces were re-machined, and the components were recoated and subjected to new surface treatment. The components were then primed, painted and reassembled. After final examination, the landing gear was reassembled and certified according to the customer's wish.

The landing gear system, including the brake system, for the E-Jet family E170, E175, E190 and E195 was developed by Liebherr-Aerospace. The components of the main landing



The team in charge of the overhaul with landing gear components

gear are produced at the Lindenberg plant, whereas parts for the nose landing gear and actuators and for the brake sub-systems are produced by partners in Brazil and in the USA.



People and Opportunities

Dual Studies at Liebherr-Aerospace – a Success Story for More Than 30 Years

Dual studies – in Germany, this is the possibility of studying at a so-called dual university and additionally gathering professional experience in a company. Liebherr-Aerospace Lindenberg GmbH, Lindenberg (Germany) has been offering dual studies since 1980. Over a period of three years,

students enrolled in such courses are intensively prepared for a Bachelor's degree, which entitles them to enrol in a Master's degree course afterwards. Half of the time, they work in different departments within the company, whereas they spent the other half acquiring theoretic knowledge at the

Friedrichshafen campus of the Dual University of Baden-Württemberg, Ravensburg (Germany).

Liebherr-Aerospace in Lindenberg offers five different courses of dual study: mechanical engineering, IT, aerospace technology, business informatics and industrial engineering. The number of places available has steadily increased, and now six school leavers have the chance of taking a dual course of study with Liebherr-Aerospace each year. The requirements for candidates are high, particularly in the technical courses: Very good grades in Maths and Physics are a prerequisite for a place in these courses.

Graduates of dual studies make a decisive contribution to the success of Liebherr-Aerospace Lindenberg GmbH: Initially employed as experts in project management, they partly move on to assume management responsibility later.



"Girls' Day" in Lindenberg – School Girls Find out About Technical Professions

On this year's "Girls' Day", Liebherr-Aerospace Lindenberg GmbH opened its doors to girls from schools in the region of Lindenberg (Germany) for the sixth time. In total, 20 girls aged 10 to 14 years took the opportunity to spend a day finding out about the company and about working in technical professions.

How is a landing gear system developed and manufactured? While touring the different stations of the Lindenberg plant – from design to production to final assembly – the participants got to the bottom of this question. Members of staff from technical product design, industrial mechanics, surface coating and materials testing were at hand to answer questions and to engage in discussions. The girls found out just how exciting technology and science can be in practice while building their own miniature model aircraft.

The objectives of Girls' Day are to introduce girls to the subject of technology,



to get them interested in technical professions and to give them contact to relevant companies, training institutions, universities and research centers. The Germany-wide professional orientation day is sponsored by the German Federal Ministry of Education and Research, the German Federal Ministry of Family Affairs, Senior Citizens, Women and Youth, and it is partly funded by the European Social Fund for Germany.

At the end of Girls' Day at Liebherr-Aerospace, the girls appeared to be very impressed. The large machines on which the landing gear components are built left them especially astonished. All in all, the experience did not just arouse their curiosity about working in technical professions in the aviation industry, but also their interest in Liebherr-Aerospace.

Start of "Program for Technical Expertise" in Toulouse

For the professional advancement of its employees, Liebherr-Aerospace Toulouse SAS, Toulouse (France) has introduced a new careers program, the so-called "program for technical expertise". There are two sides to this program. Firstly, the company should be able to better identify necessary competence and build-up know-how in order to anticipate and devote itself to the technological challenges of the future, for example in the sections more electric aircraft, optimized energy management, new materials, air management and comfort. Secondly, the employees should be able to advance within an attractive and motivating career offering numerous benefits: outstanding training, participating in different projects, working with and within a group of experts, and a substantial proportion of time to concentrate on their own technical subjects and to keep up

with topics that go beyond their subjects, for example by reading publications in scientific journals and by taking part in specialist conferences.

The program for technical expertise is a real alternative to the management program and is aimed at management staff and engineers who have great technical talent. It underlines the company's appreciation for employees who show an interest in innovation and the technical development of products, strengthening their bond to the company. In short: With this program, Liebherr-Aerospace will, in the long term, be able to secure its excellent level of its air management technologies, its capacity for innovation and its competence in giving its customers solutions with highest added value.





3 Questions for Yan Lin Goh

Executive Technician, Liebherr-Aerospace Singapore

What is your job?

With a background and an education in electronics, I work in the avionics shop at Liebherr-Aerospace's customer service center in Singapore. My main tasks are testing, repairing, modifying and overhauling pneumatic and avionics components. Most avionics components are from the A320 and A330, but an increasing amount is also from the A380.

What are your most challenging responsibilities?

As a senior staff member, I'm responsible for the day-to-day activities in my section. I need to ensure that we meet the delivery deadlines, which requires proper planning and liaising with all departments within Liebherr-Aerospace Singapore. It is a challenging but very rewarding work: knowing that our components are delivered on time and that we meet our customers' requirements, we feel a great sense of achievement.

Moreover, I'm a member of the certifying staff for avionics components and authorized to release the relevant certificates for serviceable avionics components after each repair. This is the final part of the entire repair process, the authorized stamp and signature that legalizes the reuse of the components on an aircraft.

What do you particularly like about Liebherr-Aerospace?

Liebherr-Aerospace offers a very good and versatile working environment. I'm a technician with a background in avionics, and here I was given the chance to learn about pneumatic systems and the way their components function. Using this knowledge when I troubleshoot a component during repair, I can be confident that the fault will be found and fixed. There are always opportunities to learn about new products. Also, my colleagues and I can always give constructive feedback for improvement. Therefore, we feel that we are part of a group of companies that is privately owned and whose culture is the culture of a huge family.



3 Questions for Herbert Sohler

Head of Landing Gear Production, Liebherr-Aerospace Lindenberg GmbH

What are your tasks and responsibilities?

I am Head of Landing Gear Production at the Lindenberg plant, and I am supported by a total of 150 members of staff. During the launch phase of a new project, it is first defined which parts of the landing gear are to be outsourced and which are to be produced in-house based on the company's production strategy. The components that we produce ourselves – that is in particular the high-strength and safety-critical structural components such as housings, tubes, axles and bolts – are developed and industrialized in my field of responsibility, closely coordinated with the development department. In other words, we define suitable production processes. These parts are then manufactured in four different production cells and delivered pre-assembled to the landing gear assembly section. Integrated production management and testing guarantee that the quality of the components is compliant with specifications and that they are delivered on time to the assembly section.

What excites you about your job at Liebherr-Aerospace?

Even as a child, I was really interested in technical matters. So, later, it stood to reason that I should do an apprenticeship

as an industrial mechanic, and study mechanical engineering majoring in production. Also, I always wanted to work with people. At Liebherr-Aerospace, these factors, technology and collegial teamwork, are embodied in the corporate culture, and I experience them every day at first hand with the tasks I face in the production of parts and systems for aircraft. The enormous depth of production, with different procedures and processes, makes the manufacturing of landing gear a fascinating challenge.

One very special experience for me is to support the set-up of the production plants in Brazil and Russia. I find the intercultural and technological challenges extremely exciting.

What is particularly important to you as a member of management staff?

At Liebherr-Aerospace, I can feel the freedom that is granted to members of management staff to realize their ideas and tasks, and I value the trust that is put in me. My aim is to pass this on to my employees as motivation.

3 Questions for Katharina Folkers

Central Controller, Liebherr-Aerospace Toulouse SAS

What is your job?

I work as a “central controller” in the controlling department of Liebherr-Aerospace Toulouse SAS in Toulouse (France). On a monthly basis, my main tasks are the management report, delivery performance, the profit and loss statement, cost center accounting and the reporting to the Liebherr Group. On an annual basis, I also work on the overhead budget and its consolidation. One of my specific tasks is, for example, the transfer pricing analysis.

Apart from that, I work on the financial controlling for the Aerospace and Transportation Systems division, which Liebherr-Aerospace Toulouse SAS is part of. This includes monthly reporting, an annual consolidation of the division budget and tasks like providing figures for the Board or for the “Main Figures” booklet.

Moreover, I have inter-divisional tasks such as participating in Liebherr Group wide reporting workshops for the elaboration of the short-term profit and loss statement.

Why did you decide to join Liebherr-Aerospace?

The company appealed to me for several reasons. As I had worked for an international company in the aeronautical sector in Germany and enjoyed this work, I was looking for a similar working environment when I moved to France for family reasons. I also liked the idea of working for a company whose site and structure are smaller. This simplifies many internal processes, and I really appreciate the atmosphere here.

Working in France, I can improve my French skills. For certain tasks, however, I also need English and German, which is my mother tongue.

Finally, Liebherr-Aerospace gives me the opportunity to combine my personal life and my professional life; it's common to work part-time and still have the same responsibilities as in a full-time job.

What is special about the atmosphere at Liebherr-Aerospace in Toulouse?

It almost seems like everyone knows everyone here. Cohesion among colleagues is strong, and there are a lot of activities. For example, with colleagues, I used to participate in courses about wine and winemaking, and I go swimming with friends from work once a week during our lunch break.



3 Questions for Manfred Schlosser

Liaison Engineer, Flight Control and Actuation Systems, Liebherr-Aerospace Lindenberg GmbH

What are your tasks within Liebherr-Aerospace?

As a so-called liaison engineer, I am in direct contact with our customer Boeing as the primary contact person for any technical questions relating to flight control and actuation systems. As my office is located near Boeing in Seattle, Washington (USA), the major time difference to Europe is not an issue: Our customer can contact me any time throughout the day, and I can immediately respond to questions and accomplish tasks promptly. For larger work packages, I work together with the specialist project teams at our site in Lindenberg (Germany). My job then is to ensure transparent communications and close coordination with Boeing.

In addition, I work on preparing invitations to tender for various flight control systems, I prepare presentations for Boeing about our product portfolio and our research projects and I organize meetings with our customer.

For ongoing research projects, my job includes the preparation, evaluation and documentation of results. For these tasks, the proximity of our liaison office to the customer has again proven to be highly beneficial because results can be discussed directly with Boeing.

Why did you choose to work for Liebherr-Aerospace?

Liebherr-Aerospace offers engineers a wealth of highly interesting and challenging tasks, for example in the development of innovative high-quality systems for the aircraft of the future.

Moreover, after spending a semester of my degree course in Cape Town (South Africa), I was very keen to work abroad. As a globally active company, Liebherr-Aerospace offers this opportunity. For me, work experience abroad is very motivating. It broadens professional and private horizons and creates a greater openness to the world. My wish has now been fulfilled with my job as a liaison engineer.

What do you find special about your work?

For me, the working atmosphere at Liebherr-Aerospace has remained that of a family business, despite the company's growth and global activities. A good working climate, even across national borders, and job security are important for me. The plant expansion in Lindenberg represents a commitment to the future and gives me greater security for my long-term planning.





3 Questions for Soraya Buermann

Project Buyer, Procurement, Liebherr-Aerospace Lindenberg GmbH

What tasks and responsibilities does your job entail?

As a project buyer in the procurement department, I mainly select component suppliers for our landing gear systems, flight control and actuation systems as well as hydraulics. I coordinate the requirements of the projects with the departments that are involved – for example engineering, scheduling, procurement or sales – and with our suppliers. Also, I control and monitor the processes at our suppliers to make sure that they deliver good-quality products on time.

Furthermore, I'm in charge of negotiating contractual agreements for given projects, taking into consideration the market conditions and the requirements of our customers, the aircraft manufacturers.

What are the greatest challenges in your job?

The most challenging part, in general, is to adhere to the very tight schedules of the projects and to keep within budget – despite design changes aircraft manufacturers may request. Currently, I'm working on the Airbus A350 nose landing gear. This is a very demanding project due to the rapid ramp-up of the program and the high requirements concerning qualification that need to be fulfilled before the aircraft can enter into service.

Daily challenges, such as defining the targets of the projects on a short-term basis together in a team, and mitigating the risk impacts in collaboration with our suppliers, make my job particularly interesting.

In your opinion – what is special about working at Liebherr-Aerospace?

Having worked for 15 years at Liebherr-Aerospace in Lindenberg, I can tell that the aerospace business is a small world led by big international companies. Considering that the Liebherr Group is still a family business, it's quite amazing that Liebherr-Aerospace has succeeded in becoming one of the major suppliers of aircraft systems worldwide. I'm proud to be part of it.

Also, I still find it astonishing that a company located in a rather rural area attracts people from all over the world: At Liebherr-Aerospace in Lindenberg, there are employees from Brazil, China, Russia, the USA, and Italy. I come from France, and I joined Liebherr-Aerospace in 1999 because I wanted to work for an international company and improve my German. I had planned to stay for one year only, but I've been working here ever since. I almost need to refresh my French now!

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 A318/A319/A319CJ/A320/A321

- Air Chillers
- Air Conditioning 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 A320neo

- Air Conditioning System
- Engine Bleed Air System
- Fuel Tank Inerting System - CSAS
- High-Lift System
- High Pressure/Power Transfer Unit Manifolds
- Rudder Servo Control
- Safety Valve

Airbus A330/A340/A340-500/A340-600

- 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)
- 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
- OBOGS Control Unit
- OBOGS Air Supply 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

- Gears for Main Gearbox

AS365 Dauphin

- Environmental Control System

BK117

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

EC120

- Environmental Control System Components

EC130

- Environmental Control System

EC135/EC635

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

EC145

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

EC145T2

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

EC175

- Environmental Control System Components

Airbus Helicopters

EC225/725

- Environmental Control System Components

NH90

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

Super Puma MKI

- Environmental Control System

Super Puma MKII

- Environmental Control System Components
- Heating System

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

X4

- Main Rotor Actuators
- Environmental Control System Components

Alenia

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

Antonov

AN-74/AN-140

- Cabin Pressure Control System

AN-148/AN-158

- Integrated Air Management System

ATR

ATR 42/72

- Cabin Pressure Control System
- Anti-Ice Valves

AgustaWestland

AW109

- Environmental Control System

AW139

- Environmental Control System
- Landing Gear System

AW149

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

AgustaWestland

AW169

- Environmental Control System

AW189

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

T129

- Environmental Control System

Boeing

B747-8

- Air Conditioning System
- Engine Bleed Air System

B777-200LR

- Auxiliary Tank Pressurization 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

CSeries

- 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

Learjet85

- Flap System
- 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

- 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 5X

- Integrated Air Management System

Falcon 7X

- Air Pre-Cooling System
- Cabin Air Humidification 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-Jet E2

- Nose Wheel Steering Control Module
- High-Lift System
- Integrated Air Management System

Embraer 135/145/Legacy 650

- Cabin Pressure Control System
- Flap System
- Nose Landing Gear

Embraer 170 /175/190/195

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

Embraer Lineage

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

KC-390

- Air Conditioning System
- Cabin Pressure Control System
- Engine Bleed Air Valves
- 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

LCA

- Cabin Pressure Control System

Hawker Beechcraft

750 /850XP /900XP

- Cabin Pressure Control System

IAI

Elta

- Environmental Control Unit

G200

- Cabin Pressure Control System Components
- High-Lift System

Korean Aerospace Industries

KHP

- Cabin Pressure Control System Components

KT-1

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

Northrop Grumman

Litening

- Environmental Control Unit for POD

Rafael

Litening

- Environmental Control Unit for POD

RUAG Aerospace

Dornier 228 New Generation

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

Snecma

Silvercrest

- Engine Bleed Air System

Sukhoi Civil Aircraft Company

SuperJet 100

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

Thales

Damocles

- Environmental Control Unit for POD

RECO NG

- Environmental Control Unit for POD

MELTEM II

- Environmental Control Unit



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Liebherr-Transportation Systems

Greater Ride Comfort and Less Wheel Wear with Anti-Buckling Systems

The hydraulic anti-buckling system, which Liebherr-Transportation Systems has developed specially for low-floor trams, fulfills a safety-critical function: it guarantees that the specified clearance profile is maintained at all times. In addition, it improves ride comfort and reduces wear on the wheels because the car bogies are hydraulically coupled. The complete anti-buckling system includes hydraulic actuators and an integrated electronic controller.

Zhuzhou Electric Locomotive Co., Ltd. of Zhuzhou (China) is the second Chinese rail vehicle manufacturer after Tangshan Railway Vehicle Ltd., Tangshan, to select Liebherr-Transportation Systems as the supplier of anti-buckling systems. A prototype vehicle has already been equipped with the system and will be tested by the end of 2014. Series production of the low-floor trams is due to begin in Zhuzhou after the test phase.

Liebherr-Transportation Systems has also secured an important contract in Europe. The company is set to supply anti-buckling systems for a total of 18 low-floor trams to the Polish manufacturer Solaris Bus & Coach S.A. of Owińska (Poland). These trams will be operated on the

network of the Braunschweiger Verkehrs-AG in Braunschweig (Germany). This contract – like the contracts from China – has impressively demonstrated the competitiveness of Liebherr-Transportation Systems' solutions in the field of hydraulic actuation systems.



Anti-buckling system

The Prize for the Best Technological Innovation Goes to Liebherr and Bombardier



Electro-hydraulic actuator

roll compensation system FLEXX* Tronic WAKO*. The prize for the best technological innovation in Europe was awarded at the European Rail Congress, which was held in London in November 2013.

The FLEXX Tronic WAKO system features integrated active lateral suspension including electro-hydraulic actuators that were developed and manufactured by Liebherr-Transportation Systems. Additionally, it can be upgraded with active radial steering (FLEXX Tronic ARS).

and improving ride comfort. Thanks to roll compensation, speed can be increased and travel time reduced. The first Bombardier double-deck trains with this innovative bogie technology, the BOMBARDIER TWINDEXX* Express, will be operated by Swiss Railways (SBB).

**BOMBARDIER, FLEXX, WAKO and TWINDEXX are trademarks of Bombardier Inc. or its subsidiaries*

Liebherr-Transportation Systems and Bombardier* Transportation received the "European Rail Congress Award 2013" in the category "Excellence in Technology" for their jointly-developed

During curves, rail cars tend to tilt inwards. The FLEXX Tronic WAKO system compensates for this roll movement, thus reducing wheel and rail wear

Efficient Cooling of Li-Ion Batteries

Liebherr-Transportation Systems has been selected by the rail vehicle manufacturer Bombardier Transportation GmbH of Mannheim (Germany) to develop and produce a compact and reliable cooling system for an innovative Li-Ion battery. These batteries will be employed in the next generation of electric drive systems, which are set to power urban transit buses and light-rail vehicles in the future.

The highly efficient cooling system will ensure that the battery runs under optimal thermal conditions. Prototypes of the system are being tested both at Liebherr's ultra-modern test facilities and on demonstrator vehicles at Bombardier.

The Li-Ion battery is an integral component in Bombardier's highly innovative inductive battery charging system PRIMOVE. This system enables the main battery of the electric drive system to be recharged without contact to the trolley wires, so the vehicle does not have to interrupt its operation. The battery charging system will play a major role in reducing CO₂ emissions in urban traffic.



Light-rail vehicle with charging system PRIMOVE

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Liebherr Equips Additional FLEXITY Classic Trams with HVAC Systems

Liebherr-Transportation Systems is supplying heating, ventilation and air conditioning (HVAC) systems for another four of Bombardier Transportation's FLEXITY* Classic 6NGTW Series trams. The delivery is based on a contract both companies signed in October 2012.

For each one of the four trams, which will be operated by the city of Plauen (Germany), Liebherr is supplying two driver cab

units and one saloon unit. The high-efficiency, high-reliability and low-weight HVAC systems offer optimal comfort for the driver and the passengers, and reduce power consumption and maintenance costs.

**FLEXITY is a trademark of Bombardier Inc. or its subsidiaries*



Flexity Classic 6NGTW tram

Air Conditioning Systems for Thameslink Rolling Stock Program

Liebherr-Transportation Systems GmbH & Co KG, Korneuburg (Austria), signed a contract for the delivery of air conditioning systems with rail vehicle manufacturer Siemens and operator Cross London Trains (XLT). These systems are meant for the Thameslink Rolling Stock Program, which is led by the UK Department of Transport.

The 1,140 passenger compartment units and 230 driver cab units covered by the contract are light-weight and maintenance-optimized, and feature low power consumption.



Driver cab air conditioning unit

IRIS Certification for Sites in China and Bulgaria

Liebherr Zhongche Transportation Systems Co., Ltd. based in Zhuji (China) has for the first time been certified in accordance with the International Railway Industry Standard (IRIS). The company – a joint venture between Liebherr-Transportation Systems

GmbH & Co KG, Korneuburg (Austria), and Guangzhou Zhongche Railway Vehicles Equipment Joint-Stock Co., Ltd., Zhuji (China) – develops and produces air conditioning systems, supplying these primarily to Chinese rail vehicle manufacturers. The successful

IRIS certification is an important step in the further expansion of the business activities of the joint venture.

Liebherr-Transportation Systems' Bulgarian site, Liebherr-Transportation Systems Marica EOOD in Radinovo, successfully renewed its IRIS certification in 2013. The auditors of the German certification agency DQS GmbH, which performed the audit, praised the improvement processes implemented and extended the certificate until December 2015. The company's overall rating by DQS GmbH has also improved.



Bogie Coupling Systems for Alstom's H3 Hybrid Locomotives

Liebherr-Transportation Systems has delivered the first hydraulic bogie coupling system for the new three-axle H3 hybrid shunting locomotives to ALSTOM Lokomotiven Service GmbH, Stendal (Germany).

Liebherr is responsible for the manufacturing of the system, which was jointly developed by Liebherr and Alstom. It couples the three axes of the locomotive so that the vehicle can round curves easily despite large axial distances. Thus, the bogie coupling system helps to reduce wear on both wheels and tracks, and also to decrease noise emissions.

The H3 hybrid locomotive can be used for especially heavy shunting operations thanks to Liebherr's technology. Liebherr-Transportation System's bogie coupling system is hence another application that gives proof of the benefits and the efficiency of electro-hydraulic actuators.



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Continual Expansion of Production in Bulgaria



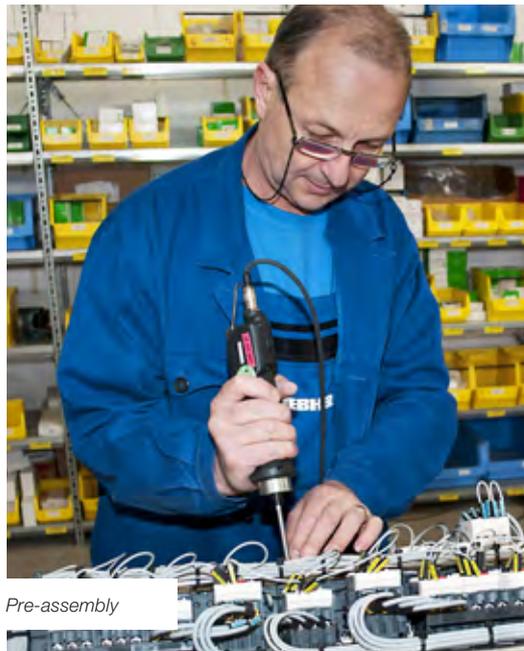
Assembly line of HVAC systems

Liebherr-Transportation Systems GmbH & Co KG, based in Korneuburg (Austria), has been advancing the strategic orientation of its production network for several years. Part of this process is the continual expansion of the activities of Liebherr-Transportation Systems Marica EOOD, the production facilities in Marica, near Radinovo (Bulgaria): In 2004, production of components such as ducting sets and heaters commenced on an area of 300 m². This area was enlarged to 10,000 m², and since 2010, complete heating, ventilation and air conditioning systems (HVAC systems) for rail cars have been produced there.

Today, Liebherr-Transportation Systems Marica EOOD is responsible for the series production of air conditioning systems and additional parts for all major contracts that Liebherr is awarded worldwide. The production range is being continually expanded: Besides the necessary know-how, the infrastructure has also been expanded so that in the future, it will also be possible to build battery cooling systems in series production on an area of 10,000 m².



Welding



Pre-assembly



Functional testing

The employees play an essential role in the growth and success of the company at Marica, as do the management and production systems. The latter guarantees fluid production, transparent processes and safe products, and includes a continual improvement management system.

Enhanced applications include, for example, "synchronized logistics" or the "supermarket system". Synchronized logistics means that in final assembly, production runs in the same rhythm as it does at the Liebherr-Transportation Systems customers, the rail vehicle manufacturers. With the "supermarket system", the employees in production take pre-selected parts from a shelf, upon which the employees in the warehouse immediately refill the shelf with new parts. This simplifies management of the materials substantially and allows a continuous workflow with reduced lead time. Moreover, improved transparency guarantees a high level of process reliability.

Thanks to the continuous expansion of production capacity and investment in the infrastructure, more than 1,950 HVAC systems could be assembled in Marica in 2013. In addition, the approximately 270 employees were able to celebrate the milestone ten-thousandth air conditioning system in the autumn of the past year. These systems are sold not only to customers in Europe, but also overseas. In addition to these successes, Liebherr-Transportation Systems Marica EOOD was able to successfully renew its certification according to the International Railway Industry Standard (IRIS) and is now preparing for certification in accordance with the international standards DIN EN ISO 14001 and BS OHSAS 18001.



The Liebherr Group

Maritime Cranes

New Fixed Cargo Crane Lifts Passenger Tour Boats at Niagara Falls

The new Fixed Cargo Crane (FCC) from Liebherr completed its first job at a famous location. On 31st October 2013, the crane lifted passenger tour boats of the local company Maid of the Mist out of the water for winter storage at the foot of the Niagara Falls.

With a lifting capacity of 441,000 lb (200 tonnes) at a radius of 49 ft (15 m) this FCC is the first of its kind for the heavy lift crane segment.

A short time before the crane was installed on the new drydock facility on the US side of the river. Since this facility is located in a gorge below the waterfalls, the FCC is the perfect crane for this site. It is fitted on a fixed pedestal and provides a space-saving solution for installation on narrow docks thanks to its slim design.

In the run-up to this lift especially the last part of the transportation

proved to be challenging. Due to the gorge's limited road access the single parts of the FCC had to be lowered to the crane's final position with the help of a ring crane. The new

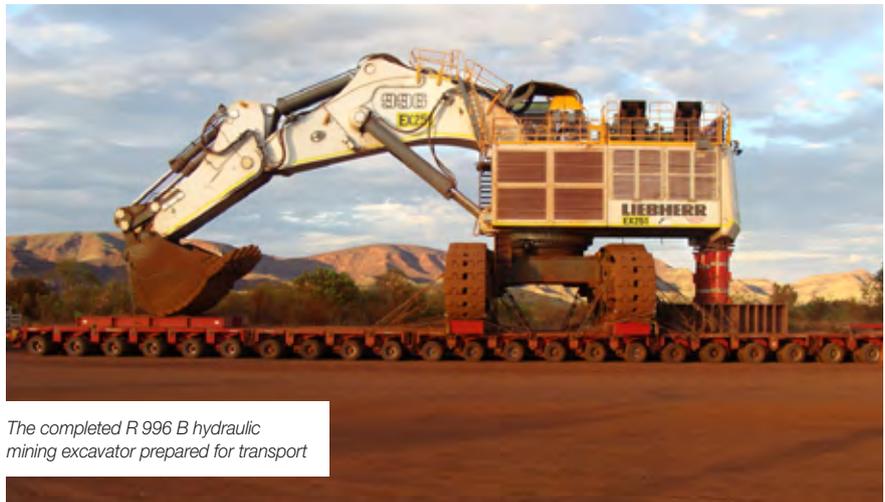
heavy lift crane is part of a 32-million-dollar project for the construction of the new dockside. The facility is planned to be completed in summer 2014.



Mining

The Transport of a Liebherr R 996 B Sets Records

The transport of a fully-assembled Liebherr R 996 B hydraulic mining excavator between two mine sites proved to be the largest complete excavator moved in Australian history. Six Prime mover trucks were required to tow and push this 675-tonne (744-short ton) machine from the Fortescue Metals Group (FMG)-owned Christmas Creek mine site to its Solomon mine site. Fortescue contracted Mammoet Australia for this undertaking, and 20 Mammoet employees were required to load the machine onto 24 twin-axle (384 wheels) Goldholfer platforms and move it to its new work site. Traveling up to 12 hours per day at 4 km/h (2.5 mph), it took a total of six days to move the R 996 B the 230 km



The completed R 996 B hydraulic mining excavator prepared for transport

(142 miles) to the Solomon mine. This newly-commissioned excavator will join thirteen other Liebherr mining machines at work at the Solomon mine site.

Domestic Appliances

HCB 2060 Refrigerator with GlassLine Shelving

Show off the materials and design of your custom kitchen to the fullest with the stylish fully integrated HCB 2060.

The new 36" (91-cm) single door model features strong hinges for a convenient closing of doors as well as LED lighting and elegant GlassLine shelving including door storage of gallon containers. The two BioFresh drawers are individually usable as HydroSafes with high humidity or as DrySafes with low humidity to enable versatile storage. In this way the ideal climate is provided for all varieties of food.

An automatic IceMaker featuring the most technically advanced water filter provides an ample supply of perfect ice cubes.



The HCB 2060 features two BioFresh drawers individually usable as HydroSafes or DrySafes.

Tower Cranes

Derrick 200 DR 5/10 Litronic Dismantling Crane Removes Luffing Jib Crane From Hotel Roof

The Liebherr Derrick 200 DR 5/10 Litronic carried out a job at an extreme altitude on the roof of the newly built Courtyard Marriot Hotel in Montreal (Canada). The crane operated in a very constricted space to remove the Liebherr 355 HC-L 12/24 Litronic luffing jib crane safely and reliably.

The 355 HC-L climbed with the IC tower system in the building to a final hook height of over 427 ft (130 m). After completing the hoisting work, the rigging team dismantled the 355 HC-L within four days from the hotel roof using the derrick crane. In contrast to conducting dismantling work from the ground, this job did not require any major road-blocks which would have adversely affected the other construction work.

The heavy components of the luffing jib crane were lowered safely and at an adequate distance from the building since the 200 DR has a variable radius of up to 82 ft (25 m).

Subsequently, the derrick crane was used for a further two months on the hotel roof to help with the roofing work. Afterwards the Derrick 200 DR 5/10 Litronic was also dismantled. Its low package weights and compact dimensions meant that the crane components could be lowered to the ground using a load elevator.

The derrick crane can be used to dismantle tower cranes in 100 mt, 200 mt or 300 mt and more load capacity. The supports on the crane can be swiveled

and adjusted to the static situation of the sub-structure on the surface to ensure excellent distribution of the support forces. Depending on the requirement, this special crane can be used with or without supports, its so-called stiff legs.

The safety PLC controller of the Derrick 200 DR 5/10 monitors all the movements with the time-tested functions of Liebherr luffing jib cranes. Sensors monitor the hoist height, load moment, jib angle and slewing gear and keep them to safe levels. The remote control enables the crane driver to operate the machine from the best possible location. So safety is guaranteed, even in heights of several hundred meters.



Machine Tools and Automation Systems

Palletizer Cell Allows Modern Production Concepts

How can we optimize logistics for raw parts and finished parts? Standardized transport containers with basket technology harmonize the logistics and allow a flexible production sequence. Throughout the entire material flow, the work pieces remain in a wire basket or work piece carrier, allowing the interface between the machine and the automation device to be harmonized with substantial cost reduction potential. The Liebherr palletizer cell enables machine capacities to be greatly increased compared to less flexible production systems.

Stacks of finished parts are formed and transported to the next processing point or to a station for automatic onward transport with materials handling equipment. The logistics concept allows the following operation to be individually defined, depending on the processing task and work piece concerned. Thanks to a modular building block concept, the palletizer cells are particularly flexible. Depending on the production process concerned, Liebherr offers versions with two, three or four cells with additional functions. Particular attention was paid to



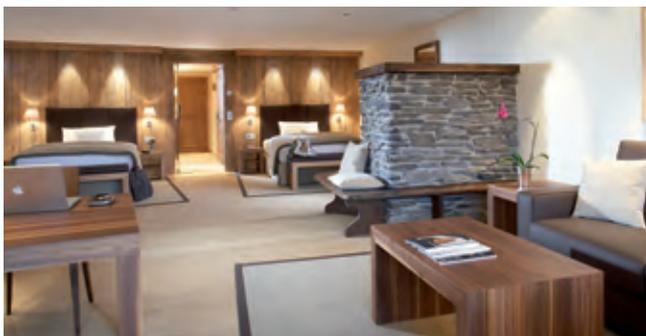
the graphic visualization of the palletizer cell. The intelligent control supports the user in exchanging a work piece and makes it easier to monitor the overall process. The result: Short exchange times, fast production start-up and high levels of acceptance.



Hotels

„Löwen Hotel Montafon“ Re-opened

November 2013 saw the re-opening ceremony of the "Löwen Hotel Montafon" in the Austrian region of Montafon. With its new façade, the fully renovated building has changed even at a first glance. On the ground floor, the new bar forms the central point of attraction. The new layout features a new restaurant, a cigar room and a fireplace room. The bedrooms have also been completely refurbished.



Since 2012, the "Interalpen-Hotel Tyrol" has been listed among the "Leading Hotels of the World" and the "Leading Spas" – an umbrella organization of the most exclusive hotels and spas worldwide. The 5-star Superior Hotel on the Seefeld plateau in Tyrol, Austria, has recently had three new rooms added: the Salon Bellevue, the Café Wien and the Smokers' Lounge.



Three more Liebherr hotels are located in and around the town of Killarney (Ireland). The 5-star "The Europe Hotel & Resort" was named "Best Resort Hotel 2013" and "Best Overall Hotel Winner 2013" in the National Hospitality Awards. The restaurant has won numerous awards as well. Killarney is also the home of "The Dunloe", which has fantastic views over the Gap of Dunloe, and the "Ard na Sidhe Country House" on the shores of Caragh Lake. The "Hotel Falken" in Memmingen (Germany) is the sixth hotel owned and operated by the Liebherr Group.



Vladimir Chagin, team leader and coach of Kamaz Master, and Eduard Nikolaev, Kamaz Master driver, in front of the racing truck no. 500 at Liebherr Machines Bulle SA. The truck with the Liebherr V8 engine won the third place in the Rallye Dakar 2014.

Components

Successful Rallye Dakar Racing Team Visits Liebherr Machines Bulle SA

Among the 71 trucks that started in the Rallye Dakar in January 2014 were five trucks from Kamaz Master, the racing team of the Russian company Kamaz OJSC. Three of the trucks were equipped with 8-cylinder Liebherr diesel engines. Two of the trucks came in third and fifth in the overall ranking. The third truck had to drop out in the second stage due to an accident on extremely difficult terrain. On March 12th, one of the trucks that participated in the rallye and its driver Eduard Nikolaev visited Liebherr Machines Bulle SA, where the engines had been developed and built.

The Rallye Dakar is one of the toughest challenges for drivers, vehicles and their components and has taken place

in Latin America since 2009. The Kamaz Master team has been dominating the race in the truck competition for years and has won the race twelve times in total – in 2013 with the team built around driver Nikolaev and in 2014 with team Karginov.

For the Rallye Dakar 2014, three out of five trucks of the racing team Kamaz Master were equipped with Liebherr V8 engines model D9508 A7 with 16.2 liters displacement. Both companies jointly developed a racing configuration with a special turbocharger. In this configuration, a nominal power of 720 kW (965 hp) and a maximum torque of 4,000 Nm could be achieved. The engine accelerates from 0 to 100 km/h in 10 seconds.

The average speed during the race varied between 20 and 140 km/h.

During their visit, the Kamaz Master representatives stressed their enthusiasm for the straightforward, cooperative partnership with Liebherr. They also praised the outstanding performance and superb reliability of the engine during the rallye.

For the Rallye Dakar 2015 Kamaz Master plans to use Liebherr engines in all of its racing trucks. The preparations have already started.

Deep Foundation Machines

New Rotary Drilling Rig LB 44

The 381,000-lb (173-tonne) heavy LB 44 expands Liebherr's series of rotary drilling rigs at the upper end of the scale. It is driven by a V8 diesel engine offering 677 hp (505 kW); this engine complies with the exhaust certification Tier 4i/IIIB. Possible applications are Kelly drilling, drilling with double rotary head, continuous flight auger and full displacement tool. The innovative rotary drive offers a torque of 376,000 lbf-ft (510 kNm) and is thus one of the most powerful drilling rigs currently available. The main advantages of the hydraulic drive manufactured by Liebherr are automated torque adjustment, continuous speed optimization and four electronically adjustable speed ranges.

The high-performance rope crowd system with its pull force of 123,000 lb (56 tonnes) allows utilization of the entire length of the leader, and therefore ensures maximum performance and reliability even in the most difficult soil conditions and operating circumstances.

Despite its size, the LB 44 can easily be moved from place to place and, if necessary, dismantled so that the weight of the heaviest element does not exceed 90,000 lb (41 tonnes).

The first two LB 44 are currently employed in the construction of a particle accelerator in Darmstadt (Germany) to stabilize the subsurface with cast-in-place drilled piles. These operations form the basis for the construction of the international particle accelerator FAIR. In total, some 1,400 foundation piles with a length between 131 and 203 ft (40 and 62 m) are being set in the ground since March 2013. All drilled piles are installed down to the final depth completely cased. That means that during the drilling process, the excavated material is removed under the protection of an advancing casing. The efficiency of the rotary drilling rigs working in the rotary drilling method means that the boreholes can be excavated down to the final depth completely cased, without the need for a casing oscillator.



After its planned completion in 2018, the FAIR particle accelerator will be one of the largest research facilities in the world.

Earthmoving

New Logistics Center

In July 2013, the Liebherr Group began construction of a new logistics center near Kirchdorf an der Iller (Germany). In future, this will be the point from which spare parts for Liebherr earthmoving machinery will be supplied around the world. In the long term, spare parts logistics for other construction machinery divisions will also find its home there.

It is currently anticipated that the first building extension phase will be completed in the third quarter of 2014. This phase covers, for example, site development, erection of a logistics warehouse over an area of approx. 505,903 ft² (47,000 m²) as well as the construction of a separate administrative building. The site should be operational within the first quarter of 2015.

In the final extension phase, Liebherr will have a warehouse area of about 1,829,864 ft² (170,000 m²) as well as an administrative building covering an area of 48,437 ft² (4,500 m²) on the 3,875,007 ft² (360,000 m²) site.

Several factors were decisive in selecting this location. Among these, for example, were the proximity of the A7 autobahn as well as the available area for further expansion. Another important factor was also the large number of Liebherr construction machinery plants in Southern Germany, Austria and France.

For efficient storage of the spare parts, a high-bay store with 60,000 spaces for pallets and a height of approx. 125' (38 m) will be built. In total, this warehouse will offer an area of 505,903 ft² (47,000 m²) to store spare parts. For logistics on the premises, there will also be an innovative 95'-high (29-m-high) container warehouse for 122,000 containers and a potential goods handling output of 3,500 containers per hour.

In the remaining 65'-high (20-m-high) part of the building, provision is to be made for manual storage areas with 25,000 pallet spaces and a storage zone as well as workspaces for customer-specific consignment, packaging and dispatch. Using 22 transport loading bridges, the spare parts are then loaded onto HGVs and vans and sent to customers and dealers via the quickest route possible.

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Editor: Liebherr-International Deutschland GmbH · 88400 Biberach an der Riss · Germany

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