Gearing up in record time

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Technology + Science
Titanium aluminide—a class all by itself

Global
Some welcome support
Up and running in a mere four years’ time: Given the huge number of orders received for the PurePower® engine family, MTU Aero Engines plans to increase its in-house blisk production volume to more than 3,000 copies a year. At the same time, preparations for final assembly of the Geared Turbofan™ engine to power the Airbus A320neo are in full swing.

Gearing up in record time

The first GP7000 powerplants for the Airbus A320 are now due to undergo scheduled maintenance. MTU Maintenance is responsible for the engine’s low-pressure turbine. Top-class repair specialists all over the world are well prepared for the new arrivals.

A top-notch repair network

Headquartered in Dallas, Texas, Southwest Airlines is the largest domestic passenger airline in the U.S., and its fleet of Boeing 737s is the largest in the world. MTU Maintenance is taking care of CFM56-3 engines powering Southwest’s older Boeing 737-300 and -500 variants.

Some welcome support

Since late January, four Tiger helicopters have been flying reconnaissance and fire support missions for German and coalition troops in Afghanistan. The MTR390-powered helicopters are demonstrating excellent reliability.

Titanium aluminide—a class all by itself

Blades made from titanium aluminide weigh only half as much as nickel-alloy blades. This new material helps make engines quieter, fuel-thrifter and cleaner. Next year, it will prove its worth in flight operations when the first A320neo with TiAl components onboard will take to the air.
Dear Readers:

2012 marked the most successful fiscal year in MTU's history: The company achieved revenues of more than 3.3 billion euros—an all-time high. We revised all our forecasts upwards in the course of last year and went on to meet each one of them, thanks to the concerted efforts of all business segments. MTU has generated organic growth and has increased its workforce. Our order backlog has climbed to over 11.4 billion euros, which represents a workload of more than three years’ production capacity.

MTU has, without doubt, put up a very strong performance. And it is looking to do even better in the future: Our aim is to achieve six billion euros in annual revenues by 2020. Last year’s results go to show that we are definitely on the right track, and give us every confidence that we will accomplish this objective. The Geared Turbofan™ (GTF™) engine—the first aircraft engine of its size to feature an intermediate gearbox—plays a pivotal role in our success and will continue to do so. Two key components of the GTF engine are made by MTU: the high-pressure compressor developed and built jointly with Pratt & Whitney, with MTU being responsible for the first four stages designed in blisk technology, and the high-speed low-pressure turbine.

Both components have already made headlines this year. Blisks are increasingly used in compressors. To meet the projected high demand, we built a brand new production facility for these high-tech parts on our company premises in Munich. The shop, which was officially opened in April, is MTU’s center of excellence for blisks and will manufacture more than 3,000 copies a year.

Our high-speed low-pressure turbine won us the German Industry’s 32nd Innovation Award in March. MTU has for decades been a leader in low-pressure turbine technology, and the high-speed variant is its masterpiece. For me, the low-pressure turbine proves us right in what we’ve believed all along: that innovation is and remains this company’s driving force and one of MTU’s strategic pillars upon which to build its success.

We have seen innovation in all three areas of our company—the commercial OEM, the commercial MRO and the military engine businesses. Our maintenance experts have won new customers and are excellently prepared to handle the shop visits of the GP7000 engines powering the A380, which are now due to come in for scheduled maintenance for the first time. The Tiger helicopter, powered by MT0390 engines, is proving its reliability in service with the troops in Afghanistan. You can read all about it and more in this edition of our Report magazine.

I hope you enjoy the read.

Sincerely yours,

Egon Behle
Chief Executive Officer
Gearing up in record time

By Patrick Hoeveler

Up and running in a mere four years’ time: Given the huge number of orders received Pratt & Whitney will have to ramp up the production rates of PurePower® engines to an all-time high within a very short period of time. As a result, the company’s German partner will also have some major challenges to tackle: MTU Aero Engines plans to increase its in-house blisk production volume to more than 3,000 copies a year. At the same time, preparations for final assembly of the engine to power the Airbus A320neo are in full swing at MTU’s Munich facility.

Nobody would have believed it a few years ago: The Geared Turbofan™ (GTF™) engine has developed into a real bestseller. To date, Pratt & Whitney has received orders for more than 3,000 engines, and the order books keep filling up. The list of customers is growing as well: Bombardier selected the engine for its CSeries jets, Mitsubishi for the MRJ, Irkut for the MS-21 twin-jet, and Airbus for the A320neo. Now Embraer, too, has opted for the GTF engine: The PW1700G and PW1900G models will power the second generation of the airframer’s E-Jet family of regional aircraft. At the same time, the engine test program is progressing very well: In February, the PW1500G obtained type certification, an essential prerequisite for the first flight of a CSeries aircraft, which is scheduled for this summer. Following the successful first run of the PW1100G-JM to power the A320neo last year, testing of this model is now running at full speed. First flight tests on a Boeing 747 are slated to take place as early as in May 2013. And the third member of the GTF engine family, the PW1200G for the Mitsubishi Regional Jet, has also passed some major milestones, such as the complex telemetry tests of the low-pressure turbine.
MTU has a role in all GTF engine versions. The German engine manufacturer will supply the high-speed low-pressure turbine (LPT)—for which it won the German Industry’s 32nd Innovation Award in March this year—and the forward half of the high-pressure compressor for all PurePower engines. “In terms of overall volumes, the Geared Turbofan engine has become our most important engine program in years,” explains Jürgen Eschenbacher, Vice President, Business Development and GTF Programs at MTU. Under the development program, around 40 LPT modules have already been completed to support the three test series currently underway. Some of these modules were intended for the first flight test engines for the Canadian CSeries. The high-speed low-pressure turbine is a key component for the Geared Turbofan engine concept, according to Dr. Claus Riegler, MTU Chief Engineer, NGPF Programs. “Our low-pressure turbine has been designed for high speeds and improved engine efficiency and is capable of withstanding high mechanical loads. The reduced stage count lowers the module’s weight and helps cut maintenance costs, since there are fewer hot-section parts.” The technology is nothing new for the MTU engineers: After all, the company had started development work in this field back in the 1990s under the Advanced Ducted Propfan (ADP) research program. As regards the high-pressure compressor with its blisk stages, the development team can draw on comprehensive experience, for example with the EJ200 powering the Eurofighter Typhoon. The biggest challenge to tackle now in the industrialization phase are the large quantities. Says Eschenbacher: “Now we must demonstrate that we are worthy of the trust our partner places in us and that we can meet expectations.”

Production ramp-up will start in 2014. Plans are to produce up to 440 engines per year for the A320neo alone a mere four years later. “For MTU, this is the fastest production ramp-up in years,” explains Sven Hugel, Project Manager, New Programs at MTU. “A production rate of at least ten blisks a day is quite a lot. We already had to manage such high volumes under the V2500 program, so that’s not new to us. But in this case, the volumes do not grow gradually over several years, but we are faced with large quantities right from the beginning. Moreover, the components are more sophisticated from an engineering point of view.”
This applies, for instance, to the complex component geometry and the surface finish requirements. According to Riegler, the engineers had borne the need for a fast ramp-up to large production volumes in mind from the early development stage on. “More than under any other engine program we must take care to avoid subsequent modifications. It’s a big advantage for us that the CSeries engine has already reached an advanced stage of development, which provides us with important findings early on.” After all, the PW1100G forms the basis of the PurePower family. “As regards size, the PW1100G is around four percent smaller than the basic model, and the PW1100G-JM is approximately eleven percent larger,” explains the development program manager. Although the detail parts of the MTU components are not exactly identical, the design philosophy is quite similar, for instance as regards the number of stages, the operating conditions or the material selection. Despite the fact that the GTF engine family now has as many as six members, the design effort, at least at MTU, can be kept within reasonable limits. “We benefit from the fact that the parts for the PW1700G and those for the PW1200G are identical. The same applies to the PW1900G and PW1100G as well as to the PW1400G and PW1100G-JM. We essentially develop modules for only three engines, but produce parts for a total of six engines,” says Riegler.

This is why a strong on-time delivery performance is a must for the engine manufacturer. To make sure the delivery commitments under these programs can be met, MTU has qualified suppliers for components of strategic importance, such as blisks and casing parts, and supports the production ramp-up at the suppliers’ through its purchasing function.

Customer Airbus also wants to be kept up to date and requires Pratt & Whitney and MTU to provide continuous documentation of the progress achieved by them and also by their suppliers. It also informs itself on site about the procurement situation. Says Hugel: “This testifies to the great importance the customer attaches to this program. So far, Airbus has been satisfied with the job we’re doing, and we’ll do everything to keep it that way.”

To be well prepared for the high volumes expected under the new engine programs MTU has built an entirely new shop for blisk production. Up to 3,000 of these integrally bladed disks can be produced there per year. “MTU has been producing blisks for quite some time,” explains Eschenbacher. “The reason why we built a new shop with highly specialized production systems was to ensure high flexibility and high production rates.” Under the project, the shop layout and the production processes were developed in parallel. “This way, we were able to tailor the infrastructure to production needs,” says Dr. Robert Leipold, Assistant to the COO, who coordinates the project. “We wanted to ensure stable production processes from the outset. This can be achieved, for instance, by a uniform temperature throughout the shop and by a central coolant-lubricant supply, so that all machines operate under the same conditions.” In addition, the shop will feature a central chip disposal system and a standardized machine pool. And there will be a high degree of automation. Each machine can accommodate every component, so that blisks for the various GTF engines can be processed at the same time.

Volume production at MTU is scheduled to commence in September 2013. The company does not intend to make use of new technologies to a greater extent, but will rather rely on proven conventional methods, according to Leipold. What the MTU engineers are planning to do, however, is to manufacture casing attachments, such as the borescope bosses for the PW1100G-JM, using novel additive techniques. In the process, the components are produced by depositing multiple layers of a powdery base material molten by means of a computer-controlled laser or electron beam. According to Eschenbacher, additive manufacturing could be used later to make more complex and highly stressed components. “But before we can do so, we must demonstrate that these parts are as reliable as those produced conventionally. Such proof is presently furnished analytically and by means of component tests.”

Another innovation can be found in the low-pressure turbine of the PW1100G-JM. To reduce the weight of the module, the blades of one stage will be made from a titanium aluminide alloy. “TiAl is a new material for us. The blades are not produced by casting but forged by a supplier. In the development of the material and the associated manufacturing processes we were faced with some major challenges, but we were able to solve all problems thanks to a technology program launched for the purpose,” reports Riegler.

Unlike the LPT, the high-pressure compressor will be assembled by Pratt & Whitney in the U.S. MTU will supply a set of blisks per engine and a stator kit consisting of vanes and inner rings. The blisks are joined to the four stages manufactured by P&W in a form-fitting manner using a tie-bolt. Then the rotor is balanced and fitted to the stator: “The turnaround time for such a set, from processing of the blanks to delivery by us, is around seven months,” says the engineer. This is a relatively long period of time, which makes supply chain management difficult. Riegler adds: “The problem we are facing here is that we have to ensure the availability of the components while keeping inventories at the lowest possible level for cost reasons.”

A thoroughly planned approach is needed also in final assembly of the engines. MTU will start assembling PW1100G-JMs for the Airbus A320neo in January 2015. The company’s share in the total number of engines is 30 percent. As from 2018, MTU will build around 150 engines per year at its Munich location. Preparations have already started. “Final assembly of engines is no uncharted territory for us. We’ve already gained experience in this field with the TP400-D6 powering the Airbus A400M military airlifter. But the GTF engine will be MTU’s first major commercial assembly program,” explains Eschenbacher. “What’s new for the company, however, is that it will have a role in the maintenance and customer support activities from the outset: “Our work does not stop once assembly has been completed. We want to take care of them cradle to grave, and provide aftermarket services jointly with the OEM under a contractual arrangement.” Negotiations with Pratt & Whitney are already underway.
The pioneer of no-frills air travel

Headquartered in Dallas, Texas, Southwest Airlines is the largest domestic passenger airline in the U.S. It was the first air carrier to apply the no-frills concept, a business model that has since been copied by practically all of the low-cost airlines and has allowed Southwest to turn a profit for the past 40 years. One of the keys to this success is the airline’s fleet of Boeing 737s, which at almost 700 aircraft is the largest in the world. The older -300 and -500 versions of the 737 are now approaching the end of their service lives, and MTU Maintenance is taking care of their CFM56-3 engines to make sure they can continue to operate highly efficiently for years to come.

The idea to revolutionize the way we fly was born in 1966 on the back of a cocktail napkin. Herbert D. Kelleher, now 83 years old and known throughout the U.S. simply as Herb, was a lawyer in Texas at the time. In a bar in San Antonio, Kelleher and a client of his named Rollin King sketched out on that napkin a business idea for a low-cost airline to connect just the metro areas of Texas. At that time, air travel around the world was subject to stringent controls, as were inter-state flights within the U.S. These controls did not, however, affect flights operated within any one of the U.S. states. After three years of legal battles with public authorities and competitors, Southwest Airlines finally commenced customer service on June 18, 1971, using three Boeing 737-200 aircraft.

Southwest has always prided itself on being different from other airlines. Back in the 1970s, it grabbed customers’ attention not just by running bold advertising campaigns and kitting its flight attendants out in hot pants, but more importantly by offering low fares and paring its service down to the bare essentials. “When I worked on the concept of Southwest Airlines in 1966 only about 15 percent of American adults had ever flown on even a single commercial airline flight,” Kelleher remembers. “Today that number stands at about 85 percent.” The airline he founded certainly played a major role in this development. Successful low-cost carriers
Customers + Partners

MTU Maintenance Canada provides service support for CFM56 and CF6 engines.

Southwest’s fleet of Boeing 737s is the largest in the world. The older 737 variants are now approaching the end of their service lives.

operating on other continents, such as Ryanair in Europe, today continue to acknowledge Southwest as having been their role model.

Over the years, this Dallas-based airline would grow to become the most profitable carrier in the U.S., as well as one of the country’s largest. In its 42-year history, there have been only two quarters in which the company failed to turn a profit. These days, Southwest still exclusively serves short-haul domestic routes; last year, the airline’s 694 Boeing 737s carried a total of 109 million passengers. In 2011, Southwest took the number three spot globally in terms of passenger numbers, behind Delta and American, and in 2012 profits totaled 417 million U.S. dollars. Including the route network of its subsidiary Air Tran, the airline serves 97 destinations in 41 states and operates around 3,520 flights a day, offering everything from short hops within Texas to coast-to-coast flights from Baltimore to Los Angeles. Each Southwest aircraft performs an average of six flights a day, spending a total of ten hours and 55 minutes in the air—figures that are top in the industry. From its very beginnings, Southwest has always put a premium on simplicity, a philosophy that even extends to how the fleet is structured. With brief exceptions, it has historically operated an all-Boeing 737 fleet. “The 737 is a marvelous airplane, but we wouldn’t have bought so many of them if we weren’t quite pleased with them,” says Kelleher.

Again and again, Southwest Airlines was the launch customer for new 737 variants. Just as it was first in line for the -300, -500 and -700 versions, the Dallas-based carrier will be the first to receive the 737 MAX 8. Delivery of the first of the 150 aircraft it has ordered is slated for 2017. Meanwhile, Southwest’s 128 Boeing 737-300 jets as well as 20 Boeing 737-500s are approaching the end of their life cycles. “Southwest has a very fluid exit plan for the 737 Classic fleet which depends on many variables,” says Mandy Gower, Powerplant Supply Chain Manager at Southwest. One of these is the long-term contract with MTU Maintenance, under which the company will see the CFM56-3 engines of the older 737s through to the finish line. “The numbers have to work for us, only by keeping maintenance expenses low, Southwest is able to justify the continued operation of the 737 Classic fleet,” adds Gower. “MTU Maintenance Canada is a big part of the total efficiency of our Classic fleet.”

The principle involved is a simple one: “When an aircraft is withdrawn from service, this doesn’t necessarily mean the engines are retired, too,” explains Christoph Heck, Vice President, Marketing and Sales, The Americas (SMW) at MTU Maintenance Hannover. “They are repaired and overhauled to make them as good as new.” But with the transition to a new generation of aircraft, demand for overhauled CFM56-3 engines is declining. This is why some of Southwest’s CFM56-3s will serve as a source of spare parts for the maintenance of other engines of the same type. “In a nutshell, two engines become one, without compromising engine quality or safety in any way,” says Heck. “Low-cost airlines are incredibly creative in finding ways to keep costs down, but they certainly don’t cut corners when it comes to safety.” Gower adds: “The focus is on harvesting material from owned assets. MTU Maintenance Canada currently tears down our CFM56-3s, routes parts out for repairs, stocks parts and incorporates those owned parts into our repair engines. This cycle minimizes or eliminates the need to purchase new parts which keeps overhaul costs very low.”

Overhaul of the engines takes place at MTU’s Vancouver-based facility, where capacity has recently been expanded. Dan Watson, Chief Commercial Officer at MTU Maintenance Canada: “Southwest is utilizing nearly the entire portfolio of MTU Maintenance, including MTU’s on-site support through our Dallas facility opened in 2011.” Watson underlines that “MTU, as the largest independent maintenance provider in the world, has both the resources and experience to support Southwest in all areas. As a low-cost carrier, Southwest maintains very lean overheads and focuses on integrated solutions for its supply chains—and MTU can offer such customized solutions.”

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For interesting multimedia services associated with this article, go to www.mtu.de/report.
Fine-tuned teamwork

By Silke Hansen

On a standard business day, UPS delivers 15.8 million packages and documents to destinations around the globe, which makes it the world’s largest parcel and express delivery company. The number one in the business operates one of the biggest airlines on the planet. In the fast-paced airfreight business, it is reliability and on-time delivery performance that count. The logistics group therefore has some pretty high standards when it comes to the maintenance of its PW2000 engines, and relies on MTU Maintenance Hannover as its service provider. The shop has established itself as a trusted service partner for customers in the freight industry.

More than 400,000 packages an hour pass through the sorting system at the UPS facility in Louisville, Kentucky. This is where UPS, which was founded in Seattle in 1907, has set up its largest international air hub for its own freight airline, UPS Airlines. In terms of the size of its fleet, which comprises 230 UPS-owned and 301 chartered aircraft, UPS Airlines is one of the world’s largest air carriers. 75 Boeing 757-200 cargo aircraft that serve the North American routes form the backbone of the fleet. MTU Maintenance has been supporting the PW2000 engines from UPS Airlines’ fleet since 2009, under a ten-year maintenance contract covering an estimated total of 150 shop visits.

“We are proud of the trust that UPS places in our capabilities, quality and service,” says Christoph Hock, Vice President, Marketing and Sales, The Americas (SMW), about this important customer that expects its maintenance provider to offer more than just standard shop visits.

MTU customers expect on-time and reliable delivery service at competitive pricing that adds value. In order to meet these high customer expectations, UPS relies on world class service providers such as MTU to provide reliable, regulatory-compliant and on-time engine repair services. The repair services must be provided at cost-competitive pricing and comply with UPS technical and regulatory requirements. It is essential that MTU meets our expectations, in order for UPS to meet the high expectations of our valued customers.”

57 shop visits have already been completed at MTU’s maintenance facility in Hannover to the customer’s utmost satisfaction.
For monitoring that MTU’s employees have met all repair, quality and documentation requirements the U.S. parcel delivery service has its own representative in Hannover to facilitate the running of the daily business between UPS and MTU. “We work together as partners to manage the PW2000 shop visits,” says Bettina Syperrek, MTU Maintenance Customer Account Manager, who cooperates closely with UPS representative Syed Ahmed. He supports MTU by acting as a liaison with the customer, making sure information is exchanged quickly and directly across the Atlantic. MTU Maintenance’s “one face to the customer” strategy proves its worth in practice: Each customer within MTU’s global MRO service network is provided with a single point of contact to deal with all matters relating to that customer’s engines. As Syperrek explains: “It’s my job to take care that the customer’s requirements are fulfilled. I oversee the entire maintenance process for the PW2000 engines sent in by UPS, placing particular emphasis on cost-effectiveness, quality and customer satisfaction.”

The close partnership is a win-win proposition: MTU Maintenance earned top marks in its UPS supplier rating, and the U.S. parcel delivery company can rest assured that its engines are in the best possible hands, with a service provider that goes the extra mile. Delivering on time is a top priority for cargo companies to retain a competitive advantage. That’s why the spare engine level for UPS is unusually high. “UPS cannot afford to have aircraft grounded due to engine failure, since it guarantees its customers on-time delivery of letters, documents and packages. With our e.pool leasing service we ensure that we have spare engines available when needed.”

The tightly knit UPS delivery network spans the entire globe, and includes 382 U.S. and 323 international airports. Every day, 252 aircraft take off and land at UPS Airline’s home base in Louisville, from where the carrier is able to reach all important U.S. destinations within three flying hours. UPS first started shipping parcels by air in 1920, initially as baggage onboard regular scheduled flights—until the Great Depression caused the airfreight concept to be abandoned later that same year. In 1953, UPS took up the idea of shipping parcels coast to coast within two days and founded UPS Blue Label Air, the predecessor of today’s UPS Airlines.

Business grew to the extent that UPS started its own flights in the early 1980s, operating out of Louisville with 727-200 cargo aircraft, initially flown by other carriers. In 1988, UPS obtained approval from the Federal Aviation Administration (FAA) to operate its own aircraft, thereby officially becoming an airline. In a bid to make better use of the capacities of its aircraft, UPS even offered passenger flights on weekends in the 1990s, for which it used special 727-100 Quick Change aircraft that could easily be converted from freight to passenger use and back again. Transporting passengers, however, marked just a brief chapter in the UPS history books.

Competition has since become much fiercer, making efficiency extremely important. “What’s impressive is that UPS constantly optimizes its processes,” says Syperrek. UPS and MTU Maintenance are pulling together to achieve a common goal. “Since entering into an agreement with MTU, we have been faced with many challenges. Working together, we have been able to meet these challenges and implement solutions that have since proved effective. Going forward, I’m sure that the future has further challenges in store, and I am confident that MTU will tackle them just as successfully,” says Roberts. A technology leader like MTU never sits back and rests on its laurels. “We’ve invested in new repair techniques, for example, that improve the performance of the PW2000 engine,” explains Heck. MTU developed and patented its own MTUplus repair techniques for abradable linings and blades in the high-pressure turbine, which significantly improved the EGT (exhaust gas temperature) margin. Turbines are expected to remain on wing for a longer time between shop visits.

MTU Maintenance, the number one independent maintenance provider, has many years of experience working on PW2000 engines, as the program has been part of its portfolio since 1989. Customers that send their PW2000 engines to MTU Maintenance for repair also include DHL, Aero Express and Cargo Aircraft Management, a leasing company specializing in cargo aircraft. “Freight airlines from all over the world account for a major portion of our customer base,” says Heck. MTU Maintenance offers its comprehensive services for all of the more common engines powering cargo aircraft, such as the PW2000, CFM56, CF6 and GE90. Its offerings include the provision of spare engines from MTU’s lease engine pool, high-tech repairs and service packages tailored to customers’ needs, including all-round carefree solutions, such as Total Engine Care or Total Part Care. Regular customers like Atlas Air, China Postal Airlines, Air Atlanta Icelandic, Air Contractors, Air Bridge Cargo and DHL. Air UK entrust MTU with the job of looking after their work horses, relying on the company’s proven capabilities. Under exclusive arrangements, MTU Maintenance Hannover moreover supports the GE90 engines powering AeroLogic’s and Southern Air’s large cargo aircraft.
Venturing into new markets

By Bernd Bundschu

Control systems are becoming increasingly important in aviation; the value share of such embedded systems can be as high as 30 percent. A new player in this growing market is Munich-based Aerospace Embedded Solutions GmbH. The 50/50 joint venture of MTU Aero Engines and Sagem Défense Sécurité has already accumulated experience in this field through major projects such as the development of the control and monitoring system for the TP400-D6 engine powering the A400M military airlifter.

With the setting up of Aerospace Embedded Solutions (AES) on January 1, 2013, Germany’s leading engine manufacturer and the French avionics specialist are pooling their expertise in the area of safety-critical hardware and software for military and commercial aviation applications. “Our focus is on the development of engine control, monitoring, and information systems as well as safety-relevant solutions for controlling landing gears and brakes,” explains AES Chief Executive Officer (CEO) Christophe Bruneau.

“With our team of around 200 engineers, we’re covering all stages of development: from design, verification and validation all the way to certification of safety-critical control and monitoring systems and the associated software,” adds AES Chief Technical Officer (CTO) Thomas Fähr. Specifically, AES’s expertise lies in the design of safety-critical software and hardware, in printed circuit board design, and in standard-compliant system qualification.
Collaboration between MTU and Sagem began with the development of maintenance software for the TP400-D6 engine powering the A400M military airlifter. "The hardware for the engine control system came from Sagem, while MTU was responsible for the application software," says Jean-Marc Bonillo, AES Software Director. The new joint venture is an important platform for both parent companies from which to enhance their competitiveness. Hüdepohl explains: "It gives MTU access—via Sagem—to new markets that go well beyond engine systems. In return, in MTU, Sagem gains a partner with many years of experience in the field of safety-critical embedded systems."

Over the past three decades, MTU has developed various control systems for military engines, among them the RB199 for the Tornado, the EJ200 for the Eurofighter Typhoon, the TP400-D6 for the Airbus A400M, and the MTR390 for the Tiger helicopter, as well as the control software for the Barracuda unmanned aerial vehicle. The Silencer noise emission control system for engines also came from Munich, as did the safety-critical components of the innovative hydrogen tank control system for the experimental BMW Hydrogen 7 vehicle. "MTU has contributed its entire expertise in developing control and monitoring systems to the joint venture, but retained systems expertise for itself," explains Fähr. "In other words, MTU continues to define the requirements for a control system, and AES develops the electronic modules or complete control units on the basis of these requirements and is responsible for programming of the requisite software. In addition, MTU supports the joint venture in the areas of IT services, procedures, occupational safety and health, environmental protection, and export control."

Unlike for MTU, developing control systems is a core business for the onboard electronics specialist Sagem, which is part of the French Safran Group. Sagem’s expertise is not limited to engine control systems, but encompasses all fields of avionics. Especially valuable for AES is Sagem’s wealth of experience in the certification of control systems for commercial applications: As a manufacturer of control and monitoring systems, the company has roles in a large number of the big manufacturers’ engine and aircraft programs. Sagem is also supporting the joint venture by providing reusable solutions for software and software parts, by contributing its expert knowledge in specific fields, such as processes, libraries, and certification, and by offering continued training programs.

The AES engineers will continue to support their parent companies’ respective programs—for instance the TP400-D6—with their know-how and experience, and will also work for new customers in future. As Bruneau explains: "We have already started acquiring new projects in other industrial sectors as well. After all, we want to become a leading player in the space and automotive industries and we want to be a project partner in all major aviation programs of the future. We will soon start raising our profile in the sector, for example by participating in the Paris Air Show at Le Bourget in June."

Bruneau and Fähr are optimistic about the joint venture’s future. The management duo want to get the best out of the know-how of the engineers, the comprehensive AES service portfolio, and Sagem’s market access, to put it to work for the good of the fledging joint venture. "We are already the leader in the field of military and commercial engine control systems in Europe. Our challenge now is to expand our presence worldwide and to venture into new markets."

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The first new projects of AES include the development of electronic components for the Embraer KC-390 military transport aircraft and the Chinese Comac C919 airliner. "On behalf of Sagem, we are developing printed circuit boards and programmable integrated circuits for the brake control system of the KC-390 and the thrust reverser control system of the C919," explains Dr. Axel Hüdepohl, Director, CMS Hardware, who is responsible for the development and testing of electronic hardware for safety-critical systems at AES. According to Hüdepohl, the roadmap is similar for both projects: "We completed the definition of the detail design early this year, so that first hardware components can be delivered this spring." Hüdepohl continues: "Commissioning and the start of various qualification processes for military engines, among them the RB199 for the Tornado, the EJ200 for the Eurofighter Typhoon, the TP400-D6 for the Airbus A400M, and the MTR390 for the Tiger helicopter, as well as the control software for the Barracuda unmanned aerial vehicle. The Silencer noise emission control system for engines also came from Munich, as did the safety-critical components of the innovative hydrogen tank control system for the experimental BMW Hydrogen 7 vehicle. "MTU has contributed its entire expertise in developing control and monitoring systems to the joint venture, but retained systems expertise for itself," explains Fähr. "In other words, MTU continues to define the requirements for a control system, and AES develops the electronic modules or complete control units on the basis of these requirements and is responsible for programming of the requisite software. In addition, MTU supports the joint venture in the areas of IT services, procedures, occupational safety and health, environmental protection, and export control."

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The AES engineers will continue to support their parent companies’ respective programs—for instance the TP400-D6—with their know-how and experience, and will also work for new customers in future. As Bruneau explains: "We have already started acquiring new projects in other industrial sectors as well. After all, we want to become a leading player in the space and automotive industries and we want to be a project partner in all major aviation programs of the future. We will soon start raising our profile in the sector, for example by participating in the Paris Air Show at Le Bourget in June."

Bruneau and Fähr are optimistic about the joint venture’s future. The management duo want to get the best out of the know-how of the engineers, the comprehensive AES service portfolio, and Sagem’s market access, to put it to work for the good of the fledging joint venture. "We are already the leader in the field of military and commercial engine control systems in Europe. Our challenge now is to expand our presence worldwide and to venture into new markets."

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The requirements next-generation aircraft will have to fulfill are enormous: They are expected to burn less fuel, be quieter and more environmentally compatible. The engines to power them are key to meeting these goals. More efficient jet engines will make air travel cheaper and cleaner. In a nutshell: Airlines, passengers and the environment will benefit alike.

To achieve the ambitious targets, MTU Aero Engines’ design engineers have for years been working on the development of the Geared Turbofan™ (GTF™) engine, which will soon power the Airbus A320neo and other aircraft. The unique feature of the GTE engine is a reduction gearbox that permits the fan and low-pressure turbine to rotate at different speeds. What sounds simple was in fact quite a remarkable feat. After all, the materials used in the low-pressure turbine—today mostly heavy nickel-base alloys—have to meet new and exacting requirements. Because of the significantly higher speeds, they have to withstand higher loads, in particular loads resulting from the increased centrifugal forces. For this reason, the MTU engineers were looking for a new light-weight material which at the same time offered enhanced creep and high-temperature properties.

Titanium aluminide—a class all by itself

Titanium aluminide is a game-changing material. Blades made from this intermetallic compound weigh only half as much as nickel-alloy blades. They are characterized by lower density, a high melting point, and excellent corrosion resistance. This new custom-tailored material helps make engines quieter, fuel-thrifty and cleaner. It will have to prove its worth in flight operations as early as next year when the first A320neo with TiAl components onboard will take to the air. And that’s only the beginning: Experts are convinced that the material has immense potential.

By Daniel Hautmann
High-temperature materials and their properties.

“Usable” Strength
(Breaking Length of a Wire)

Composites
Alloys
Aluminum
Titanium Alloys

Advanced Composites
Titanium

Oxidation Stability
Oxidation Protective Coatings Required

500 1000 1500 2000
Temperature °C

PM 1000, PM 2000
Superalloys
Strengthened Dispersion-
Single Crystals
Ceramics/Graphite
Graphite C/C
Refractory Metals

500 1000 1500 2000
Temperature °C

Conventional Titanium Alloys
Aluminum Alloys
Aluminum Composites

Turbofan engine blades are among the most highly stressed engine components. They have to withstand extreme temperatures and pressures.

"We’ve been mulling the use of titanium aluminides ever since we started work on the high-speed low-pressure turbine for the Geared Turbofan engine,” says Dr. Wilfried Smarsly, Representative Advanced Materials at MTU. Titanium aluminide, or TiAl for short, is a material in a class all by itself, a compound of several metals the composition of which is determined at an atomic level with precisely defined percentages of the constituent titanium and aluminum atoms. “The resulting so-called intermetallic compound has a well-ordered crystal structure,” explains Prof. Dr. Helmuth Clemens, material scientist at Montanuniversität Leoben, MTU’s development partner and one of the most experienced specialists pioneering the development of TiAl. “Each atom has its predefined place in the structure. That’s the characteristic feature of titanium aluminides and the reason for their special properties.”

Clemens and Smarsly have known each other for years, during which they exchanged their experience with TiAl and jointly explored possibilities to optimize its properties to permit the material to be used on a larger scale. For there is one thing they—and other scientists—have known for sure for about 30 years: Titanium aluminides will revolutionize the world of aviation. They perfectly combine the beneficial properties of metals with those of ceramics. Or, as Smarsly puts it: “It’s like a mixture of a metal and a ceramic material.”

But until recently the light-weight material did not lend itself to production use. It was difficult to form and to process since it was too brittle. Thanks to the interdisciplinary and comprehensive research work by MTU and its partners Pratt & Whitney, Montanuniversität Leoben, material suppliers, a forging company and other specialists, things have thoroughly changed by now. “Both the big manufacturers and smaller companies had the courage to venture into uncharted territory and to make the necessary investments,” sauds Dr. Jörg Ellinger, Director, Materials Engineering at MTU.

What also accelerated matters was the immense pressure of the market. Engine manufacturers around the globe are investigating new materials and exploring options to increase the efficiency of their powerplants. They have all set their sights on TiAl. At the beginning, it took a lot of convincing to win people at MTU over to the idea of using this novel material, recalls Smarsly. “Everybody favored metals.” This surprised him, all the more so given that he had been hired in 1987 specifically for the purpose of studying intermetallic materials. He had almost given up hope that TiAl would ever be a success, when in 2008 he experienced a breakthrough moment: With a spin test, Smarsly wanted to show his colleagues what intermetallic blades were capable of. “Everybody expected the blades to suffer substantial damage when tested at overspeed.” But the blade survived the test entirely unscathed. “That impressed even me,” adds Smarsly.

Then, in 2009, MTU finally decided to use the new material in its next-generation GTF engines. The compelling reason: “Titanium aluminides are key to the GTF engine turbine blades because of the high speeds involved,” according to Smarsly.

Today, almost five years later, the first TiAl blades are installed in production engines, with certification expected in 2014. The MTU experts have succeeded in maturing an entirely new class of material for production in record time. “We took quite a smart approach and performed many processes in parallel. What also accelerated matters was the immense pressure of the market. Engine manufacturers around the globe are investigating new materials and exploring options to increase the efficiency of their powerplants. They have all set their sights on TiAl. At the beginning, it took a lot of convincing to win people at MTU over to the idea of using this novel material, recalls Smarsly. “Everybody favored metals.” This surprised him, all the more so given that he had been hired in 1987 specifically for the purpose of studying intermetallic materials. He had almost given up hope that TiAl would ever be a success, when in 2008 he experienced a breakthrough moment: With a spin test, Smarsly wanted to show his colleagues what intermetallic blades were capable of. “Everybody expected the blades to suffer substantial damage when tested at overspeed.” But the blade survived the test entirely unscathed. “That impressed even me,” adds Smarsly.

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Today, almost five years later, the first TiAl blades are installed in production engines, with certification expected in 2014. The MTU experts have succeeded in maturing an entirely new class of material for production in record time. “We took quite a smart approach and performed many processes in parallel. Otherwise, it would have taken us much longer to get where we are now,” emphasizes Dr. Marc Haltrich, Senior Consultant, TiAl Blades Production Project.

In fact, many research and development activities—funded by the Federal Ministry of Economics and Technology under its aeronautical research program—were pursued simultaneously: Montanuniversität Leoben developed the alloying concept for the new material, suppliers refined processes, for instance forging or milling, and MTU made sure the quality of the material meets the high standards in engine construction, took care of qualification and established the turbine parameters that the use of TiAl would change. One thing is clear: A material that weighs only about half as much as conventional nickel alloys opens up entirely new design possibilities. As a result of the lower weight of the blades other engine components, such as the disks, can be of a more light-weight design as well. In the end, the entire engine will weigh less, and so will the aircraft wing which carries the engine. Says Haśtrich: “The use of such a material requires considerable technical expertise, in particular in the mate-
It is truly groundbreaking work that was performed here. Using state-of-the-art scientific methods and techniques, the specialists have succeeded in unraveling the material’s inner secrets. They counted the individual atoms in the material with the aid of atom probes and performed investigations at atomic level using high-resolution transmission electron microscopes to find out which phases, as the individual constituents of the microstructure are called, match well. These phases are indicators for the mechanical properties of a material. Furthermore, the experts analyzed phase transitions with the aid of neutrons and high-energy X-rays to determine the temperature at which the material can be formed best.

Investigative instinct and scientific curiosity helped the material specialists find the optimum treatment for the material. And finally they also devised a solution to the fundamental problem of forming TiAl into the desired shape of a blade. “The material is extremely difficult to form,” says Clemens. Casting is not considered a viable option for TiAl, since this manufacturing method does not produce the mechanical properties required for use in the GT6 engine. Therefore, the research efforts focused on forging. But this method, too, can be tricky, since the material is very hard and forming on large presses would take too long. In this situation, the experts were able to draw on their previous research work. They had found out which phases were best suited for forming. What needed to be done, therefore, was to deliberately alter the phase composition prior to forming and to partly reverse the changes afterwards. “We performed thermodynamic calculations to determine the optimum temperature range and phase configuration for forging,” explains Clemens. “Forging can now be carried out on conventional forming machines—and that’s the true revolution.”

The research and development effort was characterized by intensive cooperation with partners. Casting of the base metals and forging and machining of the TiAl blades are carried out by suppliers, while MTU performs material tests and finishing operations, according to Peter Schneider, Director, Procurement, Airfoils, Castings and Indirect Materials, adds that MTU has rarely shared its know-how with suppliers to such an extent before. From the suppliers’ perspective, too, this form of cooperation is something new. “The joint work on TiAl requires a strong strategic commitment on the part of our suppliers. They perform a major part of the value-adding activities and share their secrets with us—something that is only possible when there’s a high degree of trust among the partners.”

Meanwhile, the material specialists have started work on the fourth generation of titanium aluminides. Because one thing is for sure: The material still has enormous potential. Current development work aims to further improve the high-temperature resistance of TiAl so that the material can also be used further upstream in the turbine. The experts will do all they can to make future engines even more efficient and environmentally compatible.
Ultrasonic inspection using multiple-element probes

By Jan Oliver Löfken

The PurePower® PW1000G family of engines has been developed by Pratt & Whitney and MTU Aero Engines as the powerplant for the next generation of single-aisle aircraft and business jets. The high production volumes involved call for sophisticated techniques for verifying the integrity of the titanium materials used for key engine parts. A pioneering development is phased-array ultrasonic inspection, an optimized method which offers a fast and efficient means of inspecting titanium alloys for material defects before processing begins. This technique was developed by MTU and Pratt & Whitney.

The Airbus A320neo, the Bombardier CSeries, the MRJ Mitsubishi Regional Jet, the Irkut MS-21 and the new Embraer E-Jet will all be equipped with the innovative Geared Turbofan™ (GTF™) engine, which makes them much more fuel-thrifty, cleaner and quieter. More than 3,000 orders have already been placed for the GTF engine. "Phased-array technology will play a key role in the upcoming production of Geared Turbofan engines," says Frank von Czerniewicz, Project Manager, Compressor Technologies at MTU. This is because the high-pressure compressor disks MTU contributes to the new engines are produced from a titanium material. In operation, these disks have to withstand extremely high speeds and temperatures of well above 300 degrees Celsius. But they can do so only if they are free from defects.
The raw material used to produce the disks consists of large ingots of a special titanium alloy which are forged into meter-long cylindrical billets, typically with a diameter of 25 centimeters. "Ultrasonic inspection is the only method we can use for such a large diameter because the billets are far too bulky for radiographic inspection," explains Dr. Joachim Bamberg, an expert in non-destructive testing at MTU in Munich. Ultrasonic inspection of the titanium billets requires no direct contact and does not harm the material in any way. With the ultrasonic probes currently available, this process takes more than three hours to complete. "But the phased-array technology makes inspection a good 30 percent faster, with the achievable accuracy being the same or even better," says Bamberg.

Unlike the single-element transducers previously used by quality inspectors to verify the integrity of titanium billets, the new transducer is made up of 116 elements. The basic physical principle of the inspection process, however, remains unchanged: The ultrasonic waves emitted by a piezoelectric module penetrate into the titanium alloy. Any tiny discontinuities in the material, for example ceramic inclusions or pores, cause the ultrasonic waves to break, reflect and return to the transducer in a modified form. They are captured by the piezoelectric module, which functions as both the transducer and the receiver, thus providing the data required to create an ultrasound image on which tiny defects smaller than one millimeter in size can reliably be detected. In most cases, however, quality inspectors do not detect any anomalies, as Bamberg explains: "It happens very rarely that we have to scrap a titanium billet. This quality inspection is nonetheless still absolutely crucial to ensure maximum reliability of the disks."

Prior to further processing, titanium billets are inspected using the phased-array method.
PICASSO enhances flight safety

Defect-free materials are a basic prerequisite for building reliable engines and aircraft. Before any component can be delivered, it must first pass so-called non-destructive ultrasonic and X-ray inspections. And even once these tests are passed, the materials continue to be checked for tiny flaws as part of scheduled maintenance and overhaul throughout the entire service life of the components.

By participating in the PICASSO European research project, MTU Aero Engines contributed to making the detection of material fatigue and even cracks significantly faster and easier in the future. Working together with Rolls-Royce, EADS, the Fraunhofer Institute for Nondestructive Testing (IZFP) and a number of other companies and research institutes, researchers developed a method for creating computer simulations of potential material flaws in complex parts. Among other things, these simulations show how even the tiniest defects can be identified with a high level of probability of detection in an ultrasonic or X-ray image.

Previously, engineers produced real parts with artificial defects and then subjected the parts to testing. The disadvantage of this approach was the limited number of samples and defect types. This limitation has now been eliminated thanks to computer simulations that can be carried out much quicker, with a far greater variety of defects being detected. The PICASSO project was completed last year. So this method of computer simulation could reduce both the cost and the time involved in material inspection processes once official approval has been obtained.

The high levels of accuracy required for the ultrasonic inspection of titanium billets call for a correspondingly elaborate measurement process. First, the metal billets are immersed in a water bath. “The ultrasonic waves travel through the water and then penetrate into the material. So there’s no need for contacting probes,” Bamberg explains. In the past, the probes used by quality inspectors for these measurements had only one ultrasonic element. As a result, the ultrasonic waves had to be re-focused for each different depth within the billet. To cover the entire billet volume, it was therefore necessary to scan the billet several times in succession. The phased-array probe makes this process significantly simpler and faster, requiring just one scan to capture all the data. This is made possible thanks to the time-delayed (phase-shifted) control of the 116 ultrasound elements, known as the array. “Using an array enables you to electronically focus the beam to different depths at the speed of sound,” says Bamberg. Because of this phase-controlled transmission and reception of the ultrasonic waves using an ultrasonic array, the new technique was dubbed phased array.

“Use of the phased-array method is already standard practice in the realm of medical technology,” Bamberg notes. This ultrasonic technique has become an indispensable tool in many areas of medicine, helping create fascinating, detailed images of unborn babies in the womb and detect critical changes in internal organs. Applying this technique to metals is more difficult because the propagation of ultrasonic waves in metal is far more rapid and complex than in the human body. But several years of joint development by MTU and Pratt & Whitney have now made phased-array technology available in this field, too. In numerous tests, the developers demonstrated the technique’s ability to reliably detect tiny material discontinuities of just 0.4 millimeters in size. According to the detection of material fatigue and even cracks. The PICASSO project was completed last year. So this method of computer simulation could reduce both the cost and the time involved in material inspection processes once official approval has been obtained.

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By the time that level accuracy is achieved, the partners will have a much clearer idea of exactly how much time and money they can save by using the approved phased-array method. Numerous titanium billets will need to pass ultrasonic inspections using the new method over the next few years before they can be forged into disks. These are used as the blanks for “blisks,” high-tech components in which the disk and blade are machined from a single piece—hence the name blisk, which is a portmanteau of the words blade and disk. This solution cuts down on the use of raw materials, reduces weight and speeds up the assembly process. “In the future we will be manufacturing very large numbers of blisks—several thousand units a year—for the next generation of fuel-thrifty Geared Turbofan engines,” says von Czernicewicz. And the phased-array method will enable the foundries and forge shops to supply the large quantities of titanium billets with a “zero-defect” seal of approval.

For additional information, contact
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Five years ago, the first GP7000-powered Airbus A380 was delivered. Now, the first engines of this type are due to undergo scheduled maintenance, and MTU Maintenance is well prepared for the shop visits of the low-pressure turbines expected this year. Top-class repair specialists all over the world are ready to make sure that the maintenance work is carried out to the highest standards, the top priorities being on-time delivery, quality, and reliability.

The GP7000 partner companies have set up a worldwide network of shops to make sure that the modules and components are repaired and overhauled only by the specialists knowing them best. “On behalf of Engine Alliance, a joint venture of General Electric and Pratt & Whitney, MTU Maintenance will be responsible for the low-pressure turbine,” says Wolfgang Gärtner, GP7000 Program Director at MTU Aero Engines. The six-stage low-pressure turbine is being developed and produced by Germany’s leading engine manufacturer. Thanks to this production share in the GP7000 the company was able to secure itself a role also in the maintenance of this engine.

“Our experts are thoroughly familiar with this module down to the smallest detail,” explains Gärtner. “One of the keys to our success is the effective transfer of knowledge from design engineering and production to maintenance and vice versa. In the event of damage, the repair specialists at MTU Maintenance can immediately consult the design and stress engineers in Munich. Short communication lines and optimum coordination help us save time and hence costs.”
The first stop of the GP7000 engines is the shop of GE Aviation Wales in Great Britain. There, they are disassembled into the individual modules. Each module is then sent to the partner company responsible for it for repair and overhaul. As soon as the low-pressure turbine arrives at MTU Maintenance Hannover, it will be stripped to the required level, cleaned and inspected. Some of the necessary repairs are carried out in the Hannover shop, while certain components are sent to specialist partners: Airfoil Services Sdn. Bhd. (ASSB), a joint venture of MTU and Lufthansa Technik, in Kota Damansara, Malaysia, MTU Aero Engines in Munich and MTU Aero Engines Polska in Rzeszów in the south-east of Poland. “With our network of shops, we can make sure that the individual repair processes are performed exclusively by the MTU locations specializing in them. Thus, we can offer our customers repaired parts that meet the highest quality standards,” explains Thomas Okaty, Customer Account Manager at MTU Maintenance Hannover (SMPC).

Five years ago, the first GP7000-powered Airbus A380 was delivered. Now, the first engines of this type are due to undergo scheduled maintenance. Given the large size of the GP7000 low-pressure turbines, MTU Maintenance Hannover had to clear space in its shop to accommodate the modules.
ASSB, the center of excellence for airfoil repairs, is responsible for restoring the low-pressure turbine rotor blades to serviceable condition. The outer air seals are sent to MTU in Munich, and MTU’s Koszalin-based location takes care of accessory parts, such as the active clearance control (ACC), a system has been developed to thoroughly familiarize the team with the A380 engine. Moreover, the team brings comprehensive repair expertise to the table.

True to the company’s motto “Repair beats replacement”, the MTU Maintenance specialists can repair even heavily damaged complex components. The result: high-class parts that are as good as new in terms of quality and reliability. MTU customers appreciate this expertise. After all, the innovative, high-tech repair techniques developed by MTU reduce maintenance costs, ensure top performance of the repaired parts, and extend the service life of engines.

But MTU does not sit back and rest on its laurels: The company is busy refining existing processes and developing new ones. “At MTU’s Munich location, we expect approval of specific repair processes, among them stripping and application of coatings on the outer seals, to be granted soon,” reports Michael Häusel, GP7000 Technical Program Manager at MTU Aero Engines. “To obtain OEM approval, we must furnish proof that we are able to perform the repairs correctly and in conformity with the specified quality standards. This applies in particular to special processes and life-limited parts.”

ASSB, too, is all geared up for the engine powering the A380: “We are the first MRO shop to repair the airfoils of the GP7000 low-pressure turbine rotor,” says Steffen Richter, ASSB Managing Director. “Last year, we modified our low-pressure turbine blade line to prepare for the GP7000 and to build the necessary capacities.” An interdisciplinary team successfully completed the restructuring without interrupting ongoing operations. In addition, a comprehensive training system has been developed to thoroughly familiarize the team with the A380 engine.

The company also invested heavily, spending 1.2 million U.S. dollars on a new coating furnace. “The furnace currently used was already running at 95 percent of its capacity. In view of the planned extension of our business, therefore, we had to acquire an additional furnace,” says Richter. The planned upgrade of the chemical cleaning shop and the procurement of a new grinding machine for the low-pressure turbine components offer further potential for improvement.

The roadmap is clear: This year, the first GP7000s will arrive at the shops for scheduled maintenance. As from 2014, business will pick up: “In the next few years, MTU Maintenance expects more than 50 low-pressure turbine shop visits annually,” according to Häusel.

MTU Maintenance Hannover had to clear space in its shop to accommodate suitable cleaning baths and other facilities. According to Okaty, however, preparing the shop was by no means the trickiest part. “Ensuring a smooth flow of information was an even greater challenge,” he says. This applies to communication within MTU’s repair network and also to coordination among the Engine Alliance partners. Regular meetings and weekly telephone conferences were established, processes were better aligned with one another—particularly those involving several companies—and contact persons were designated. “We’ve completed all preparations quickly and assembled an efficient team with highly motivated members,” says Okaty. Moreover, the team brings comprehensive repair expertise to the table.

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The company also invested heavily, spending 1.2 million U.S. dollars on a new coating furnace. “The furnace currently used was already running at 95 percent of its capacity. In view of the planned extension of our business, therefore, we had to acquire an additional furnace,” says Richter. The planned upgrade of the chemical cleaning shop and the procurement of a new grinding machine for the low-pressure turbine components offer further potential for improvement.

The roadmap is clear: This year, the first GP7000s will arrive at the shops for scheduled maintenance. As from 2014, business will pick up: “In the next few years, MTU Maintenance expects more than 50 low-pressure turbine shop visits annually,” according to Häusel.

Given the relatively large size of the turbine module, MTU Maintenance Hannover had to clear space in its shop to accommodate suitable cleaning baths and other facilities. According to Okaty, however, preparing the shop was by no means the trickiest part. “Ensuring a smooth flow of information was an even greater challenge,” he says. This applies to communication within MTU’s repair network and also to coordination among the Engine Alliance partners. Regular meetings and weekly telephone conferences were established, processes were better aligned with one another—particularly those involving several companies—and contact persons were designated. “We’ve completed all preparations quickly and assembled an efficient team with highly motivated members,” says Okaty. Moreover, the team brings comprehensive repair expertise to the table.

True to the company’s motto “Repair beats replacement”, the MTU Maintenance specialists can repair even heavily damaged complex components. The result: high-class parts that are as good as new in terms of quality and reliability. MTU customers appreciate this expertise. After all, the innovative, high-tech repair techniques developed by MTU reduce maintenance costs, ensure top performance of the repaired parts, and extend the service life of engines.

ASSB will offer the full scope of airfoil repairs from summer 2013. For additional information, contact Thomas Okaty +49 511 7806-4122 For interesting multimedia services associated with this article, go to www.mtu.de/report

On the upswing

Airfoil Services Sdn. Bhd. (ASSB), a 50/50 joint venture of MTU Aero Engines and Lufthansa Technik, is based in Kota Damansara, Malaysia. Innovative high-tech repair techniques and short turnaround times make the company a center of excellence for the repair of airfoils. Its portfolio includes CF6-50, CF6-80, V2500, GP7000 and CFM56-series engines. The company has a workforce of 400 employees, with numbers set to increase. Last year, the state-of-the-art shop was restructured without interrupting ongoing operations, to further optimize processes and work flows.

“Our shop consists of a service line, a high-pressure compressor airfoil line, and a line for low-pressure turbine airfoils,” explains ASSB Managing Director Steffen Richter. ASSB is confident that continuous improvements, qualified employees and the introduction of novel repair techniques will help the company expand its portfolio. From this summer, ASSB will be the first shop in the world capable of carrying out the entire scope of airfoil repairs, including welding and coating. As Richter says, “we anticipate a workload of around 55,000 GP7000 blades by 2017. Once the ramp-up has been completed in 2017 we expect an annual volume of 70,000 airfoils.”
The thermography facility in MTU Aero Engines’ rotor blade production shop is roughly the same size as a compact car. About once a minute its doors open, an operator removes a blade and replaces it with a new one. The doors close, and there is a hissing sound, signaling that the next check is underway. MTU has for many years been a pioneer in the use of thermography as a non-destructive inspection technique. Now, MTU engineers, in cooperation with Carl Messtechnik, have developed a fully automated procedure to inspect cooling holes for blockages and obstructions. The benefit: The new method triples throughput.

By Daniel Hautmann

Instead of pumping water through the tiny channels and checking to see whether it comes out of each and every minute hole, a precisely controlled jet of compressed air is fed through the system. This is what makes the hissing sound. A pressure of around four bar is generated inside the blade’s cooling system. If the hole diameter is as it should be, the compression heat inside the blade and the cold produced by expansion of the air at the exit of each hole generate a specified temperature signal. If the diameter is constricted, signal amplitude and signal field are diminished, and the thermal signal disappears completely if holes are blocked. A thermographic camera records the process at a rate of 120 images per second. Then an image-processing system automatically evaluates the results,” explains Günter Zenzinger, inspection engineer at MTU in Munich.
Thermography was considered the method of choice because of the enormous know-how relating to thermal imaging technology already on hand at MTU. As Dr. Hans-Uwe Baron, Senior Manager, Non-Destructive Testing, says: “MTU started developing the enabling technologies around 25 years ago.”

Initially, this method was intended to measure the thickness of coatings on blades and vanes. During trials, the inspectors came up with the idea that it might be worthwhile looking into the possibility of inspecting holes in the same way. “Thermography is one of very few methods that lend themselves to the inspection of holes,” explains Baron. One of the main advantages of thermography over other inspection methods is that it allows 100 percent of the parts to be checked, rather than random samples. According to Baron, MTU has carved out a leading position in the field of non-destructive inspection of metallic materials.

The facility, which has been in use for about a year now and has inspected around 30,000 blades during this time, has proved its worth. Particularly noteworthy is that it only took the specialists two years to design and build the facility and to integrate it into production. And as Süss says, “we’re talking about a prototype that’s being introduced in production.”

The time needed to inspect one blade is now only one minute, which is three times faster than before and hence more cost effective; moreover, automated inspection is more reliable than manual inspection. The method is used to inspect high-pressure turbine blades for GP7000 and CF6 family engines.

“Technically speaking, the little 0.2 to 0.3 millimeter holes aren’t exactly round, but have a polygonal cross-section because they are laser drilled,” explains Robert Wagner, Senior Manager, Quality Inspection, Blades/X-ray. After drilling the cast blades are provided with a coating to protect the base material against heat and abrasive wear. According to Wagner, this process can cause clogging. “The coating material can penetrate into the cooling holes and obstruct them.” After coating the blades are ground to size. During grinding, particles of the ductile coating material can cover up the tiny holes or reduce their cross-sectional area. To remedy this, a wire is poked through all the holes in a next operation to unblock them. It sometimes happens that little pieces of wire break off in the process and get stuck in the holes. “The inspector doesn’t always notice,” says Wagner. But thanks to thermal imaging these fragments no longer escape detection.

Thermography reduces the time needed to inspect one blade to no more than a minute.
In December 2012, the German soldiers stationed at Mazar-i-Sharif air base in Afghanistan finally received the first two of the eagerly awaited Tiger helicopters. The Tigers had made the trip to the Hindu Kush onboard an Antonov AN-124 transport aircraft. Another two helicopters arrived about a week later. Since late January, the four helicopters have been flying reconnaissance and fire support missions for German and coalition troops. First experience has been positive throughout, with the MTR390-powered helicopters demonstrating excellent reliability.

By Achim Figgen

The Tiger HAP (Hélicoptère d’Appui et Protection = support and escort helicopter) has been in service in Afghanistan with French Army Light Aviation since 2009, and now the German Armed Forces, too, will operate this helicopter—one of the most advanced in the world—to provide effective air support to German and coalition forces. On January 30, earlier than expected, Colonel Ulrich Ott declared the helicopters “mission ready.” Their first mission as air escorts for a convoy of coalition troops followed shortly afterwards. Ott is the commanding officer of the 36th Combat Helicopter Regiment in Fritzlar, the unit to which the four helicopters are assigned, and at the same time commodore of the Mazar-i-Sharif air wing.

For the Tiger UHT (Tiger support helicopter), of which the German Armed Forces have ordered a total of 80, Afghanistan marks the first deployment to an active combat zone. The helicopters, officially designated EC665, had been delivered to the 36th Combat Helicopter Regiment in the summer of 2012. Manufacturer Eurocopter equipped the helicopters for Afghanistan by installing an number of additional defensive systems. The ASGARD-F (Afghanistan Stabilisation German Army Rapid Deployment - Full) package includes additional armor to protect the cockpit from heavy-caliber fire, a fourth satellite-linked radio and a digital recorder to log the entire mission. Furthermore, it comprises sand filters fitted at the engine intakes, an improved Electronic Warfare System, as well as a general software update.

According to Martin Majewski, Director, MTR390 Program, absolutely no modifications were required to be made to the Tiger’s MTR390-2C engines, which are jointly developed and
produced by MTU Aero Engines, Turbomeca and Rolls-Royce, prior to their deployment to Afghanistan. After all, they have already proved their worth for some time now in the French Tigers deployed in Afghanistan’s Hindu Kush region. The only thing the German engine manufacturer had to do before the helicopters left for Mazar-i-Sharif was to put together a spare parts kit at short notice.

So far, however, little use has had to be made of these spare parts, since the Tiger fleet was soon fully operational, much to the satisfaction of Colonel Ott. Two of the four helicopters form an Air Weapon Team that flies reconnaissance and air escort missions. The other two, says Ott, serve as a technical reserve. As part of the multinational ISAF (International Security Assistance Force), the Tigers of the 36th Combat Helicopter Regiment provide support to units of the German Armed Forces as well as to the contingents of other nations.

Still, Colonel Ott stresses how important it is especially to the German soldiers that “their” Tiger, for which they have had to wait long enough, has now finally arrived in northern Afghanistan.

Ott says that initial experience has been positive throughout. The commodore of the air wing squadron is highly satisfied with the new weapon system and particularly with the reliability of all systems. Ralf Barnscheidt, Senior Vice President of Eurocopter Germany, is pleased as well: “The ASGARD version impressively shows that the Tiger’s highly flexible mission design permits the helicopter to be adapted easily to suit the needs of current and future deployments.” Barnscheidt is convinced that Eurocopter, in cooperation with the German Armed Forces, “has succeeded in opening up a new chapter in the history of military helicopters.”

Colonel Ulrich Ott is the commanding officer of the 36th Combat Helicopter Regiment in Fritzlar, and commodore of the Mazar-i-Sharif air wing.

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The four German Tiger support helicopters (UHTs) sent to Afghanistan are part of the Mazar-i-Sharif air wing, a temporary unit of the German Armed Forces which has played an active role in ISAF since May 2004. In addition to the Tigers, the air wing also operates seven Transall airlifters, five CH-53GS transport helicopters and three Heron 1 reconnaissance systems.

The Tiger contingent consists of around 60 soldiers, including three helicopter crews. Each crew is made up of a pilot and a commander, who can change roles when needed. For all of the pilots, this is the first deployment to Afghanistan; some of them had participated in the EU’s EUFOR peacekeeping mission in Bosnia-Herzegovina with Bo105 helicopters earlier.

In the meantime, the 36th “Kurhessen” Combat Helicopter Regiment has taken delivery of another four ASGARD Tigers. Initially, these are being used to train the crews prior to their deployment to Afghanistan, but they will also be making the trip to Asia as soon as the helicopters currently stationed at Mazar-i-Sharif have to return to Germany for scheduled maintenance.

Although the German Tigers are still equipped with the MTR390-2C engine, rather than the enhanced MTR390-E, Colonel Ott is completely satisfied with their performance. Admittedly, one cannot predict their behavior in summer when temperatures can reach 40 degrees Celsius, but that doesn’t give Ott much of a headache. After all, the Tigers have already demonstrated their capabilities in hot and high conditions last summer, when they took part in the Falcon 2012 exercise in Holloman in the U.S. state of New Mexico. And Majewski visibly takes pride in stating that “we thoroughly examined the engines following the exercise, and were able to return them to the German Armed Forces without having to repair or replace any parts.” And he has every reason to be proud, as the engines “even met the pass-off criteria applicable to new powerplants.”

For additional information, contact
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+49 89 1489-5369

For interesting multimedia services associated with this article, go to www.mtu.de/report

Colonel Ulrich Ott is the commanding officer of the 36th Combat Helicopter Regiment in Fritzlar, and commodore of the Mazar-i-Sharif air wing.
A record year for MTU

For MTU Aero Engines, 2012 was the most successful financial year in its history, with increased revenues, improved profits, and a bulging order book. Germany’s leading engine manufacturer reported revenues at a record level of more than 3.3 billion euros, an operating profit (EBIT) of 374.3 million euros and an EBIT margin of 11.1 percent. MTU’s net income improved 18 percent to a new peak of 233.4 million euros. MTU CEO Egon Behle is pleased: “We revised all of our forecasts upward in the course of the year, and met all of these ambitious targets. And to crown these achievements we set a string of new records in 2012. This gratifying result has taken us one big step closer to realizing our goal of six billion euros in revenues by 2020.” MTU’s order backlog reached more than three years’ production capacity. Said Behle: “Our order backlog achieved a very high level in 2012—despite the recession—representing a workload of more than three years’ production capacity.”

MTU Aero Engines – key financial data for 2013

<table>
<thead>
<tr>
<th>MTU Aero Engines</th>
<th>2011</th>
<th>2012</th>
<th>Change</th>
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<tbody>
<tr>
<td>Revenues</td>
<td>2,932.1</td>
<td>3,378.6</td>
<td>+ 15.2%</td>
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<td>of which OEM business</td>
<td>1,846.5</td>
<td>2,106.4</td>
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<td>1,401.1</td>
<td>1,603.1</td>
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<td>of which military engine business</td>
<td>445.5</td>
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<td>1,305.7</td>
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<td>EBIT (calculated on a comparable basis)</td>
<td>329.6</td>
<td>374.3</td>
<td>+ 13.6%</td>
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<td>of which OEM business</td>
<td>238.9</td>
<td>264.7</td>
<td>+ 10.8%</td>
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<td>of which commercial MRO business</td>
<td>93.7</td>
<td>112.1</td>
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<td>11.2%</td>
<td>11.1%</td>
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<tr>
<td>for OEM business</td>
<td>12.9%</td>
<td>12.6%</td>
<td>- 0.3%</td>
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<tr>
<td>for commercial MRO business</td>
<td>8.4%</td>
<td>8.6%</td>
<td>+ 2.5%</td>
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<td>233.4</td>
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<td>Net income (reported)</td>
<td>159.2</td>
<td>173.9</td>
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<td>165.8</td>
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<td>96.1</td>
<td>80.7</td>
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<td>R&amp;D costs recognized as expense</td>
<td>131.6</td>
<td>113.0</td>
<td>- 14.1%</td>
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<tr>
<td>Capital expenditure on property, plant and equipment</td>
<td>113.7</td>
<td>99.4</td>
<td>- 12.5%</td>
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Dec. 31, 11 | Dec. 31, 12 | Change |
<table>
<thead>
<tr>
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<tr>
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<td>10,537.1</td>
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<td>5,839.2</td>
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<td>Employees</td>
<td>8,202</td>
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</table>

* excluding IAE share increase

C-Series engine obtains certification

Successful debut: The PurePower® PW1500G is the first Geared Turbofan™ engine to have obtained type certification. As announced by U.S. engine manufacturer Pratt & Whitney and Canadian airframer Bombardier Aerospace, the engine was approved by the Civil Aviation Administration of China and Transport Canada Civil Aviation to power the new C Series aircraft. The engine had completed over 4,000 hours of rigorous testing. The comprehensive PW1500G test program had been launched in September last year and included 140 hours of flight testing on Pratt & Whitney’s experimental Boeing 747 aircraft. MTU Aero Engines has a 17-percent stake in this engine program. It contributes the high-speed low-pressure turbine, a key component that is absolutely essential for building GTF™ engines, and is the only manufacturer in the world capable of offering this technology. Moreover, together with Pratt & Whitney, MTU develops and builds the high-pressure compressor.

Award-winning technology

And the winner is—MTU Aero Engines: For the second time in its annals, Germany’s leading engine manufacturer has won the German Industry’s Innovation Award. In early March, MTU CEO Egon Behle collected the award at a ceremony in Frankfurt. MTU took the honors in the Large Companies category for its high-speed low-pressure turbine, a key component of the propulsion system of the future, the Geared Turbofan™ (GTF™) engine. “Our high-speed low-pressure turbine is the result of a superb engineering job,” said Behle. MTU has for decades been a technological leader in the field of low-pressure turbines. More than 3,000 orders have been received for GTF engines to date.

MTU Aero Engines will have a new Chief Executive Officer as of January 1, 2014: Chief Financial Officer Reiner Winkler will take the helm of the company, succeeding current CEO Egon Behle. In his new role, Winkler will continue to serve as Chief Financial Officer and take on responsibility for additional central functions. Michael Schreyögg, Senior Vice President, Defense Programs, has been newly appointed to the Board of Management. From July onwards, Schreyögg will be responsible for all of the company’s military and commercial OEM programs.

Reiner Winkler to become MTU CEO

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In Brief

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At the German Industry’s Innovation Award presentation ceremony (from left): Jürgen Eschenbacher, Dr. Erich Steinhardt, Dr. Stefan Wibier, Egon Behle, Dr. Jörg Henné, Dr. Claus Riegler.
In March this year, International Aero Engines (IAE) celebrated its 30th company anniversary. Since 1983, the consortium has been responsible for the marketing of the V2500 engine, which powers the A320 family of aircraft. MTU’s stake in the program is 16 percent; the company contributes the low-pressure turbine and provides MRO services for the propulsion system. The V2500 is a best-selling engine in the portfolio of Germany’s leading engine manufacturer: More than 5,400 V2500 engines are currently in revenue service with close to 290 airlines around the world. The engine has a market share of about 50 percent in the single-aisle segment. Last year, 500 of the engines were delivered to customers, which marked an all-time record. MTU provides MRO services for the propulsion system at two of its facilities—MTU Maintenance Hannover and MTU Maintenance Zhuhai.

MTU sends engines to MTU

MTU Maintenance Hannover, centerpiece of the MTU Maintenance Group and a specialist for the repair of medium- and large-size commercial engines, successfully completed its GE90 test cell correlation program. “We are very proud of this milestone,” commented Holger Sindemann, MTU Maintenance Hannover Managing Director. “We are one of a few maintenance providers worldwide to hold a full repair license for the GE90-110B und -115B. Now we’ve added engine test runs to our range of services as well.”

At MTU’s second maintenance location in Germany, too, a test stand was upgraded to the latest standard: MTU Maintenance Berlin-Brandenburg expanded its portfolio of services to include the LM6000PF and LM2500-G4 industrial gas turbines. The Ludwigsfelde-based company boasts the only LM6000 test cell in Europe.

New shop and center opened

At MTU, a new production shop and a new logistics center are now up and running. At the company headquarters in Munich, the blisk shop was officially opened in early April. The blisk center of excellence is housed in a new, 10,000-square-meter building on MTU Aero Engines’ premises. MTU expects to produce more than 3,000 blisks a year in this shop.

Late in March, MTU Maintenance Hannover opened its new logistics center after a construction phase of just eight months. The storage building for spare parts has a floor space of 7,500 square meters and comes equipped with state-of-the-art logistics management systems. Now that the spare parts are picked up on site, rather than from the external warehouse where they used to be stored, transportation routes are appreciably shorter. This saves costs, optimizes processes, and boosts MTU’s competitive position.

Test stands revamped

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MTU sends engines to MTU

MTU Maintenance has signed a new agreement with GOL Linhas Aéreas Inteligentes for the maintenance and on-wing support of the Brazilian airline’s CFM56-7B engines. The five-year exclusive contract is valued at 440 million U.S. dollars. Dr. Stefan Weingartner, MTU Aero Engines President, Commercial Maintenance, said: “We are very happy to have added one of the fastest growing airlines in Latin America to our customer portfolio. This long-term maintenance contract with GOL is a major milestone for MTU Maintenance and a sign that we are strengthening our activities in the emerging markets.”