A leading edge through geared turbofan technology
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The A400M Atlas—the backbone of military air transport

In early August, the first A400M Atlas arrived at the air force base of Orléans-Bricy and was handed over to the French air force. Now the first military pilots will be able to experience the capabilities of the new Airbus military transport and its four TP400-D6 engines first-hand.

Progress never stops

Under the European Clean Sky Joint Technology Initiative (JTI), which is approaching the home stretch, the successful geared turbofan technology will again be substantially improved. Among the companies participating in this mammoth project is MTU Aero Engines, with responsibility for building a demonstrator engine.

Power rather than thrust

GE’s LM6000 industrial gas turbines (IGTs) are reliable, rapidly ramp up to their rated power and withstand repeated start/stop cycles even in a single day. MTU has successfully developed enhanced protective coatings for the LM6000 Growth versions. These efforts have helped increase the performance of the 50-megawatt IGT and reduce its emissions.
Dear Readers:

On September 16, at 9:55 a.m. local time, Canadian aircraft manufacturer Bombardier’s CSeries flight test vehicle one (FTV1) powered by Geared Turbofan™ (GTF) engines took to the skies for the first time. The CSeries maiden flight has heralded in a new era for MTU: It marked the debut of a generation of engines that has revolutionized engine construction in next to no time. With the innovative technology of the PurePower® engine family, we, alongside our partners, have demonstrated just how much improvement in fuel economy and noise reduction can be achieved.

A few years ago, nobody would have dared to dream that the GTF would be such a huge market success. Today, with the Bombardier CSeries just having made its inaugural flight, orders have been received for some 4,700 of the new GTF-family engines. And every major international air show keeps adding to that number, with the lion’s share of orders being for engines to power Airbus A320neo aircraft. This makes the GTF programs MTU’s key drivers of growth. That said, ramping up production in support of these programs also brings its own challenges. We are very well prepared to fulfill our obligations: Our manufacturing shops, our processes and our supply chain management have all been revamped, and our facilities in Munich and Poland’s Rzeszów expanded to accommodate the additional workload. For the anticipated growth to materialize, we continue to rely on the commitment and dedication of our highly skilled employees. Everyone has their part to play in shaping MTU’s future.

Our engineers’ accomplishments deserve our full respect, not only because of the tremendous technological leap forward that they have made possible. In times of ever scarcer resources, constantly rising kerosene prices and a steady growth in air traffic—at an average annual rate of five percent—travelers and airport neighbors, authorities, organizations and last, but not least the airlines themselves have every right to expect that aircraft and their engines are designed for low fuel burn and excellent environmental performance. By contributing its geared turbofan components, MTU is making a sustainable contribution to our environment and our society.

After six years of service, I will be stepping down as MTU’s CEO at the end of the year. These were six eventful years, which truly seem to have flown by. I wish my successor Reiner Winkler and my fellow members on the Board of Management every success in the future, and the same to you, dear readers.

I hope you enjoy exploring and reading about the exciting topics featured in this issue.

Sincerely yours,

Egon Behle
Chief Executive Officer
Cover Story

A leading edge through geared turbofan technology

By Achim Figgen

Bombardier’s CSeries, a game-changing new family of single-aisle aircraft, entered the flight test phase in September. The first PW1500G engines for production jets will be delivered to the Canadian airframer before the year is out. MTU Aero Engines contributes the high-speed low-pressure turbine and the forward four stages of the high-pressure compressor to this engine.

The successful first flight of CSeries flight test vehicle one (FTV1), a CS100 jetliner bearing Canadian registration markings C-FBCS, was conducted by Chief Flight Test Pilot Chuck Ellis and First Officer Andy Litavniks on September 16. The aircraft was greeted enthusiastically by a crowd of spectators as it touched down and taxied to Bombardier’s flight test center at Montreal–Mirabel International Airport after around two-and-a-half hours in the air.

The maiden flight marked the beginning of an approximately one-year test and certification program involving a total of five CS100s. Upon successful completion of the program the aircraft is expected to obtain certification first by Transport Canada and then by other aviation authorities around the globe. It is certainly no exaggeration to say that with the CSeries family, which includes the basic version CS100 with 110 seats in standard single-class configuration and the larger CS300 with 135 seats, likewise in standard single-class configuration, Bombardier is opening up an entirely new chapter in commercial aviation. Not only because the CSeries is the first all-new single-aisle aircraft since the time the A320 entered into service more than 25 years ago. It also is the first airliner powered by Pratt & Whitney’s highly advanced PW1000G Geared Turbofan™ engine.
With the new aircraft family Bombardier, previously known mainly as manufacturer of regional and business jets, is venturing into the commercial airliner segment, where the company is directly competing with market leaders Airbus and Boeing. In contrast to their smallest models, the Airbus A318 and A319 and Boeing 737-700, respectively, the CSeries is more than just a shrunk version of a 150-seater: It is an aircraft optimized for the targeted market. The jet features a narrower fuselage for a five-abreast seating configuration in economy class and is markedly lighter than any other aircraft in the same seat category. While passengers will certainly appreciate the larger windows and the massive overhead luggage bins that are big enough to hold oversized carry-on bags, the commercial managers of airlines will mainly be interested in the aircraft’s cost-effectiveness: The Canadian airframer promises its customers a 20-percent reduction in fuel burn as compared with similar jets currently in service. And maintenance costs will be down by as much as 25 percent. These cost savings are achieved through the extensive use of highly advanced materials. The fuselage skin consists of aluminum-lithium alloys, while the wings, engine nacelle, rear fuselage and empennage are made from fiber composite materials. As a result, the weight of the aircraft was reduced by more than one ton.

Achievement of the desired improvements over present-day aircraft is owed to a large extent also to the jet’s new propulsion system: As the second aircraft manufacturer (after Mitsubishi) Bombardier in the fall of 2007 opted for Pratt & Whitney’s GTF engine family, which was renamed PurePower® PW1000G in 2008. GTF stands for Geared Turbofan™. What sets this new propulsion system apart is that it features a reduction gearbox between the fan and low-pressure turbine (LPT). In conventional turbofans, the fan is driven directly by the turbine. Here, the gearbox decouples the two components, allowing them to rotate at their respective optimum speeds. As a result, the bypass ratio of the PW1000G is higher than that of any other turbofan engine. The markedly increased efficiencies of the fan and LPT as well as the reduced stage count of the low-pressure turbine more than outweigh the additional weight of the gearbox. The concept is catching on with airframers: Airbus is offering the geared turbofan engine for its A320neo family. Embraer has picked the GTF engine for its new-generation E-Jets, and Irkut has chosen it for its MS-21. To date, Pratt & Whitney has received more than 4,700 firm orders and commitments for the various models of the PW1000G family.
The maiden flight of the first CS100, initially scheduled to take place in the second half of 2012, had to be postponed first to June 2013 and then ultimately to September. But this delay can certainly not be blamed on the engine. After all, the PW1500G, the GTF model powering the CSeries family, which obtained certification earlier this year, has meanwhile largely been completed and preparations for the production of this model are presently underway. Apart from making sure that the requisite production capacities are available both in-house and at its suppliers, the company has to incorporate modifications deemed necessary as a result of the experience gained during the test phase. “What we’re talking about here are minor improvements to detail parts rather than changes to the basic design,” says Dr. Claus Riegler, Chief Engineer, NGPF Programs.

Important aspects to consider include the stability of the components under service conditions and their maintainability. The engineers must also be prepared for potential problems in production. “If we find out, for example, that parts provided by suppliers need to be modified because they cannot be optimally produced in their original configuration, such modifications will be incorporated in this phase,” explains Jürgen Eschenbacher, Vice President, Business Development and GTF Programs at MTU Aero Engines. But MTU’s specialists are making every effort to minimize such risks from the outset by selecting suppliers at a very early stage and involving them in the manufacture of the first test engines. “In addition to our design review process, we’ve put a production readiness review process in place. Throughout the entire development phase, the component designs are reviewed at regular intervals together with our suppliers to ensure manufacturability,” adds Eschenbacher.

Plans are to deliver the first modules for production engines to Pratt & Whitney in late 2013. At about the same time, a PW1500G engine will be subjected to endurance testing on one of MTU’s test stands in Munich. More than one- and-a-half years ago, in early 2012, the company had already conducted a stress and thermal survey on a complete PW1500G at its Munich location. Successful completion of this survey, which serves to measure the thermal and vibrational stresses acting on the LPT components, is an essential prerequisite for certification of the low-pressure turbine.

Preparations for the aircraft’s entry into service are in full swing not only at Pratt & Whitney, MTU and the other program partners. Bombardier, too, is stepping up production activities. If testing and certification continue to go forward as planned the first CS100 will be delivered in late 2014. Among the first European airlines to operate CSeries jets will be Sweden’s Malmö Aviation, followed, a little bit later, by Swiss, a subsidiary of the Lufthansa Group. Lufthansa had become the launch customer back in July 2008 when it signed a letter of intent for the purchase of the aircraft. The German carrier is not only a customer, but also a partner to Bombardier. Its subsidiary Lufthansa Flight Training (LFT) will train pilots and cabin crews, and Lufthansa Technical Training (LTT), a Lufthansa Technik AG subsidiary, will provide technical training for maintenance specialists for European-based operators of Bombardier CS100 and CS300 aircraft. So far, the number of CSeries customers in Europe is rather limited. While Airbus, Boeing and Embraer were able to win hundreds of orders for their A320neo, 737 MAX and E-Jet E2 families developed not least in response to the launch of the CSeries, Bombardier has received a mere 373 firm orders and options so far. But the Canadian airframer firmly believes that further orders will follow now that the maiden flight has been successfully completed. There is no doubt that both the aircraft and its propulsion system hold great promise of long-term success.
The geared turbofan—
a driver of growth

Michael Schreyögg, member of MTU Aero Engines’ Board of Management, Programs, since July 1, 2013, is responsible for marketing the Geared Turbofan™ engines. The PW1000G family has developed into a real bestseller boosting the company’s order books to the highest level ever.

Mr. Schreyögg, orders for the PW1000G have reached a record high. How will this reflect in MTU’s business development?

The PW1000G Geared Turbofan™ family is a resounding success for MTU, there’s no doubt about that. Never before has a new engine sold in such huge numbers even before it entered revenue service. More than ever, airlines are looking for fuel-thriftier, cleaner and quieter engines. They opted for the geared turbofan because they were quick to see that this new technology fitted the bill on every count. As from the middle of this decade, when these engines will enter into service on the Airbus A320neo and on Bombardier’s and Embraer’s regional jets, they will make a substantial contribution towards ensuring continued growth in MTU’s revenues. The engines powering these aircraft types account for the major part of the worldwide engine market.

Did anybody expect the GTF to be such a success?

We’d never expected the geared turbofan to gain such an enormous market share within such a short period of time. If anyone had said five years ago that orders for geared turbofan engines would stand at 4,700 units in 2013 nobody would have believed it. So, to be able to comply with our high standards in terms of on-time delivery performance and quality we are now focusing all our efforts on the production ramp-up. An important step to prepare for the high volumes expected was the setting-up of our center of excellence for blisk production, which was inaugurated in April this year. About 90 percent of the high-tech components to be produced in the new shop will go into the geared turbofan programs. As a result, production volumes will quintuple over the next few years as compared with today’s levels. MTU contributes the high-speed low-pressure turbine and the forward four stages of the high-pressure compressor to the geared turbofan. In addition, 30 percent of the engines to power the A320neo will be assembled in Munich and delivered directly to Airbus. In a first for the company, MTU has taken on responsibility for the final assembly of a commercial engine.

Given this huge order backlog, do you have any concerns about MTU’s ability to deliver on time?

We are very confident that we will be able to fully meet all our delivery commitments. For some years now, we’ve been making preparations for revamping our production lines, restructuring our supply chain management and streamlining our processes to suit the needs of the production ramp-up for the new programs. We’ve launched various efficiency improvement projects, decided to expand our facility in Poland and taken a number of other measures, some of which have already been implemented. To secure a timely supply of parts and materials we’ve concluded long-term agreements with our most important suppliers. All these projects required a lot of hard work and dedication on the part of our highly committed staff during the last few years and will continue to do so. But investing in the future of our company will pay dividends down the road.

What’s your outlook for the future of the geared turbofan?

For MTU the geared turbofan engines will be a major driver of growth, that’s for sure. With this game-changing technology jointly developed by Pratt & Whitney and MTU as its partner, the company is making a major contribution towards ensuring ecological sustainability: In a first step, our innovative GTF technology will reduce fuel burn and CO2 emissions by 15 percent each. In addition, the perceived noise level will be halved, which is a big relief for people living in the vicinity of airports. The three-liter aircraft has already become a reality. With a future generation of engines which combines geared turbofan and other new technologies, we could make a big step forward towards the two-liter aircraft.

The quality of our products not only reflects in the success they have in the marketplace. It also earns us prizes and distinctions: Earlier this year, for example, MTU won the German Industry’s 32nd Innovation Award and the German Innovation Award. In both cases, we received the recognition for our high-speed low-pressure turbine, a key component of the geared turbofan. All this goes to show that we are on the right track.

Michael Schreyögg, member of the MTU Aero Engines’ Board of Management, Programs.
The A400M Atlas—
the backbone of military air transport

The A400M Atlas has landed! In early August, shortly after the European Organisation for Joint Armament Cooperation OCCAR had granted Initial Operating Clearance, the first production aircraft arrived at the air force base of Orléans-Bricy and was handed over to the French air force. Now the first military pilots will be able to experience the capabilities of the new Airbus military transport and its four TP400-D6 engines first-hand. In the meantime, production at MTU continues at full speed.

Weeks before the arrival of the A400M, the military air base approximately 120 kilometers south-west of Paris was bustling with activity as the personnel set about preparing the site for the new airlifter. Transport squadron 1/61 “Touraine” is replacing its Transall C-160s with the A400M. In all, some 171 million euros have been spent on the modernization of the infrastructure and the construction of a new maintenance hangar and a new control tower. The number of parking spots on the apron has been doubled to accommodate the new military transport, of which France has ordered a total of 50 units. And two flight simulators are being installed in a new, purpose-built simulation center, the first of which is expected to be up and running this fall.

Full civil type certification for the aircraft in the spring of 2013 marked the temporary end of the test program for the basic version of the A400M; further development efforts will focus primarily on the military systems. Before, in December 2012, the functional and reliability (F&R) flight test campaign was successfully completed.
“The aircraft was in the air for up to 20 hours per day. In total, it clocked up 300 flight hours in a little less than five weeks,” reported former EPI President Simon Henley who passed the helm to his successor, Ian Crawford, in July 2013. “The engine performed perfectly and even turned out better on fuel burn than predicted.” The test pilots were impressed by the engine’s responsiveness and performance.

In mid-2012, the functional and reliability flight tests had to be interrupted by Airbus after the discovery of cracks in a cover plate of the TP400-D6 gearbox. All engines built to this standard had to be returned to the final assembly line at MTU Aero Engines in Munich, where they were dismantled to install a redesigned version to replace the defective component. The engines were then shipped to MTU Maintenance Berlin-Brandenburg in Ludwigsfelde for reassembly and acceptance testing. “We solved the gearbox problem and retrofitted all engines with the redesigned parts. This incident permitted MTU to demonstrate the capacity of its assembly lines much earlier than originally planned,” commented Henley. And indeed, the company had delivered the first four production engines on April 17, 2012.

Gerhard Bähr, Director, TP400-D6 Program at MTU, describes the next steps to be taken: “The TP400-D6 program now enters its crucial phase as we make the transition from development to production and service.” This will require huge efforts on the part of the EPI partners ITP, MTU, Rolls-Royce, and Snecma, who must rapidly ramp up production to be able to meet the agreed delivery schedule. Plans are to assemble 40 units of the turbo-prop engine this year, and twice as many in 2014.
The work of the software engineers is by no means over now that the A400M has entered into service. As Bähr explains: "Many of the problems encountered during the in-service phase can be resolved with the aid of software modifications, and we expect to see further upgrades in the years to come. Since the beginning of 2013, software development has been the responsibility of Aerospace Embedded Solutions (AES), a joint venture between MTU and Safran, set up with the aim of consolidating the two companies’ control system expertise in the long term.

The hardware developed by MTU performed flawlessly in the A400M engine. "The intermediate-pressure compressor is an extremely highly engineered component and its development involved high risks. Our team did an excellent job implementing the requirements, and the compressor meets the specification in full," concludes Dr. Wolfgang Gartner, Director, Engineering, Military Programs at MTU. "All modules of the TP400-D6 are functioning without a hiccup, including the intermediate-pressure compressor and intermediate-pressure turbine supplied by MTU," confirms EPI Technical Director Dr. Michael Göing.

Although the first engines have only just left the final assembly line, preparations are already underway for their maintenance. For sooner or later all powerplants return to the respective national manufacturer. Here they are disassembled into their constituent modules, which are in turn sent to the partner companies in charge of them for the necessary work. MTU will be responsible for maintaining the engines operated in Germany. In the first few years, the traditional model of military maintenance will apply: "In the event of damage, the engine is returned to the manufacturer, which takes care of troubleshooting and repairs and invoices the work done on the basis of a time-and-materials contract," explains Bähr. He believes that at a later date, it is conceivable to change over to an approach that resembles that followed in the commercial aviation business. He is referring to fly-by-hour contracts, under which the customer pays a fixed amount per hour of flying time in return for a guarantee of full engine availability. "This will, however, only be possible once we have sufficient operating data to establish realistic failure rates, which will not be the case before 2025," as Bähr points out.

Now that the A400M is in operation, the experience gained may help boost export sales. "The TP400-D6 is one of our most important military programs at present, and exports are of vital importance to the program," says Bähr. "Airbus estimates the total demand worldwide at 300 aircraft. Among interested potential buyers are countries in the Middle East, South-East Asia, Australia, and South Africa. No doubt the most attractive export market would be the United States, where there is a basic need for airlifters with the A400M’s capabilities." In any case, the program partners cannot complain about lack of work: "With more than 750 engines on order, we have enough work to keep us busy for several years," said EPI President Simon Henley.

The specialists at AES have chalked up lots of experience working to develop the control systems for the TP400-D6 engine powering the A400M military airlifter.

MTU delivered the engine control software required for aircraft certification in December 2012. "The first flight-worthy engine control software, which was used for the maiden flight in 2009 and ensured that flight testing could be carried out safely, did not yet include the full range of functionalities. The latest version features additional maintenance functions that make it easier for pilots and flight engineers to diagnose faults and trace their origin," says Dr. Frank Grauer, Senior Manager, Control System Definition and Validation, TP400-D6 at MTU.

The Airbus A400M Atlas will be the backbone of future military transport in Europe. With a power output of 8,200 kilowatts, the TP400-D6 built by EPI Europrop International (EPI) is the most powerful turboprop engine in the Western world. And it is the first military aircraft engine program based on a commercial approach in which the development phase is financed by industry and the necessary capital expenditure has to be recovered by revenues generated during the in-service phase.

"This approach ensures a clearly defined framework for cooperation between the nations and industry, which simplifies project management. EPI has no direct contractual relationship with any of the buyer nations," explains Gerhard Bähr, Director, TP400-D6 Program at MTU. Each customer signs a contract for the entire aircraft, including its engines.

"In addition, the TP400-D6 is the first military engine that was designed with civil aviation approval in mind from the outset," adds Dr. Wolfgang Gartner, Director, Engineering, Military Programs at MTU. "Since the seven nations each have their own approval procedures, the project partners and the OCCAR procurement agency opted for the only common standard, that of the European Aviation Safety Agency (EASA)," said EPI President Simon Henley. As a result, the TP400-D6 is also the first turboprop engine approved by EASA for use in heavy-lift transport applications.

For additional information, contact
Gerhard Bähr
+49 89 1489-8542
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Aotearoa, the native Māori name for New Zealand—"the land of the long white cloud"—is home to some four and a half million people and over 60 million sheep. This population swells by over two and a half million people that come to visit the country every year, tourism being the largest export industry of this small country in the Pacific. Almost all tourists arrive by airplane, many choosing to fly with Air New Zealand. The country's national airline started out as Tasman Empire Airways Limited (TEAL) in 1940, operating flying boats on trans-Tasman routes. The carrier was renamed Air New Zealand in 1965 and has been flying with the koru symbol adorning the tail of its aircraft since 1973. This symbol is a stylized representation of an unfurling silver fern frond that signifies new life and growth. Air New Zealand joined the Star Alliance network back in 1999 and operates a dense route network of flights especially to destinations in the South Pacific and Asia. It also offers up to 20 flights per week from Los Angeles and San Francisco to Auckland. Europe is served by means of daily flights to London Heathrow via Los Angeles. Air New Zealand used to be the only airline to offer a round-the-world service, however it recently axed its Hong Kong-to-London route as it was no longer profitable.

Carrying 13 million passengers last year with a fleet of 104 aircraft, Air New Zealand is not a large airline. But despite its modest size, the airline certainly masters the art of drawing public attention, for example by developing its own products that it is now selling profitably to other airlines, too. These innovations include the "Skycouch", a row of three Economy seats which can be turned into a flat bed, and the Premium Economy Class "Spaceseat".

Air New Zealand caused a stir with its promotion for the most recent part of the Hobbit trilogy, which saw the airline present itself as "the airline from Middle-earth" including a Boeing 777-300ER covered by a huge decal inspired by the movie. Equally popular are the airline’s hilarious inflight safety videos, which have had millions of clicks on the Internet. Former CEO Rob Fyfe even appeared in an advertising campaign as a baggage handler wearing only body paint—a clip that also proved massively popular online.

Innovation in a remote corner of the globe

By Andreas Spaeth

New Zealand is a small country and geographically remote from the world’s major centers. It takes a long flight to get to this destination known as the “most beautiful corner of the world”. No wonder that its national flag carrier, Air New Zealand, plays a crucial role in connecting its home country with the rest of the world. Few other airlines have come up with more ideas to improve the customer experience and make air travel more convenient and passengers happy—its innovations, which range from ground-breaking seating design to cheeky safety videos, have become a rage on the web. The airline has been a satisfied MTU customer since 2007.

A
"We can’t afford advertising campaigns in our big markets, so we need leverage to create a bigger personality of ourselves than we deserve with our size," explained Fyfe about the philosophy behind the campaigns. His successor Christopher Luxon states: "We are an airline that is successful, we can be very proud about the journey we have been on in the last ten years, but we are not going to be complacent." Air New Zealand may have required a government bailout in 2002, but in the meantime the airline has seen profits soar, and since 2008 has even returned profits on long-haul routes for the first time.

Air New Zealand has been relying on MTU Maintenance’s expertise for the maintenance, repair and overhaul of its long-haul aircraft engines since 2007. The first MRO contract was signed for the CF6-80C2 engines powering Air New Zealand’s Boeing 767-300s (of which five are still part of the fleet) and 747-400s (with two still in operation). Recently the agreements were extended until these aircraft are retired from service, which is expected until 2016. MTU Maintenance Hannover has so far carried out maintenance work on 47 CF6-80C2 engines from New Zealand, including 40 shop visits with major overhauls. "Air New Zealand is an innovative and successful airline, and an important partner for us," emphasizes Holger Sindemann, Managing Director of MTU Maintenance Hannover, MTU’s center of excellence for the repair and overhaul of large and medium-sized engines. "This makes us all the more happy about the excellent working relationship we’ve always enjoyed with the customer."

Air New Zealand is currently undergoing a renewal process. "The complexity of our fleet will diminish tremendously, I think we will end up with Boeing 777s and 787s in widebody aircraft and Airbus A320s for short-haul," explains Luxon. The airline has placed an order for ten Boeing 787-9s, destined for use on its Shanghai, Tokyo, Perth, Honolulu and Papeete routes. After a series of delivery delays, Air New Zealand is supposed to receive the aircraft as launch customer between July 2014 and 2017.

2014 will also see two more 777-300ERs join the carrier’s current fleet of eight Boeing 777-200ERs and five 777-300ERs. MTU Maintenance will also be responsible for maintaining the GE90-115B engines powering these new aircraft; the corresponding contract was signed in 2011 and runs until 2023. "The deal covers 16 engines," explains Oliver Skop, Customer Account Manager at MTU Maintenance Hannover. MTU obtained the license to maintain the higher-thrust GE90 variants in 2010. "These new engines are expected to have an average on-wing time of 25,000 hours, equivalent to five to six years in service," according to Skop. "So we’re not expecting to see the first engine from Auckland in Hannover before 2015."

GE90 at MTU Maintenance

In August 2013 the first GE90-115B was delivered to MTU Maintenance in Hannover for full performance restoration. The customer is Virgin Australia, a partner to Air New Zealand. "We completely disassemble the modules, focusing on the hot section in particular," explains Thomas Michailidis, Senior Manager, Engine Testing at the Hannover-based shop. This time-consuming procedure takes 4,000 to 5,000 man-hours. "We manage that in 95 days," says Michailidis, compared to an industry standard of around 120 to 140 days. MTU Maintenance plans to reduce the turnaround time to only 80 days by 2014.

A GE90 engine in the shop at MTU Maintenance Hannover.

The last preparations on a GE90 engine in the test cell at MTU Maintenance Hannover.

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A GE90 engine due to undergo overhaul will then be sent as air freight via Singapore to Amsterdam or Brussels, from where it will be transported by road to Hannover. Cost each way: 90,000 U.S. dollars. "We are in all practical terms ‘half a world’ apart, but the overhaul services we receive from MTU are truly world-class," says Mick Burdon, Fleet Powerplant Manager at Air New Zealand. "MTU’s commitment to quality, engineering excellence and support of our operation counters the time zone and physical distance." MTU holds its customer in equally high regard, as Wim van Beers, Vice President Marketing & Sales, Asia, confirms. "Air New Zealand has strong engineering capabilities, we have a great deal of confidence in one another and working together is a lot of fun." And with such a close partnership—as both sides agree—it’s possible to bridge even the greatest distances with ease.

For additional information, contact Wim van Beers +49 511 47806-2390

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The beginnings of US Airways were humble: The company, then known as All American Aviation, started operations back in 1939, delivering airmail to small western Pennsylvania and Ohio Valley communities. Ten years later, the airline was renamed All American Airways and made the transition from airmail to passenger service, operating a Douglas DC-3. All American Airways then started to boom and quickly grew into Allegheny Airways, US Air and finally US Airways after several buyouts and mergers. For 20 years now, US Airways has been relying on the expertise of MTU Maintenance.

By Nicole Geffert

Professional, trusting and dependable—Christoph Heck, Vice President, Marketing and Sales, the Americas at MTU Maintenance Hannover does not have to think twice when asked to describe the collaboration with US Airways. The airline has been a customer of MTU Maintenance since 1993. At that time, it placed a contract for the maintenance of its V2500 engines—an agreement which will continue to run for some time. In 2011, MTU Maintenance won another contract from US Airways, covering MRO services for the airline’s General Electric CF6-80s. “To date, we have repaired over 300 US Airways engines in our shop,” says Heck.
customers with an even more extensive range of travel options.

"The visit from US Airways is a clear indication that both parties are interested in continuing the collaboration," says Heck. The long-term partnership was given further impetus by a five-year contract for the maintenance of US Airways’ CF34-1066 engines. This contract was signed by the two companies this summer and marks a new chapter in a story of successful cooperation. Up to 44 engines powering the airline’s Embraer E190 fleet will be maintained and repaired at MTU Maintenance Berlin-Brandenburg, which in 2002 was the first independent provider of maintenance services in the world to obtain a license for the repair and overhaul of General Electric’s CF34 series. The Ludwigsfelde facility is an authorized GE-CF34™ service provider and the first maintenance organization within this worldwide network to support and maintain all three models of the engine: the CF34-3, CF34-8 and CF34-10: "US Airways is a long-standing, loyal MTU Maintenance customer," affirms André Sinanjan, MTU Maintenance Berlin-Brandenburg’s Managing Director & Senior Vice President. "With this new CF34-10 contract we’ve laid the foundations for a successful continuation of our business relationship."

The high-tech repair techniques “made by MTU” guarantee first-class performance of the repaired parts, extending the service life of engines while keeping costs at an affordable level. "Our high-tech repair processes are also used in the maintenance of V2500 and CF6-80 engines," says Norbert Möck, Director, Engine Programs at MTU Maintenance Hannover. "For our customer US Airways we have developed special, flexible solutions to make sure that maintenance work is carried out as cost-effectively as possible. Such maintenance packages are available, for instance for the V2500-A1 engine powering the A320, which over many years has served as a faithful workhorse but is now aging and will gradually be retired over the coming years,” says Jay Aiken, Director, Marketing & Sales Americas at MTU Maintenance Hannover. During this outphasing period, airlines want to make best use of their engines’ residual service life. Most comments: “In this phase, the low cost of repairs as compared with the prices of new parts and MTU’s expertise in procuring suitable engine-run parts help airlines optimize their maintenance costs until to the planned phase-out date is finally reached.”
It seems like a relationship that’s here to stay: For many years now, MTU Aero Engines has been partnering with Pratt & Whitney Canada to build business and regional jet engines. Many successes have come out of this long-term collaboration, cases in point being the PW300 and PW500 engine families. The propulsion systems are continuously being improved and upgraded, not least also thanks to MTU’s expertise. The PW300 family’s latest member is the PW306D, which features a low-pressure turbine developed by MTU.

Martin Wiedra, Director, P&WC Programs at MTU, explains: “At 25 percent, our share in the PW306D program is higher than in any other program in MTU’s commercial engine business.” For the PW306D program, too, Pratt & Whitney Canada (P&WC) bets on Germany’s leading engine manufacturer to provide the low-pressure turbine, this technology being an MTU core competency. Moreover, MTU will contribute the turbine exit case and mixer. Transport Canada Civil Aviation, the Canadian regulatory authority, gave the engine its stamp of approval in June of this year. The PW306D builds on the PW306C and has been selected to power Cessna’s New Citation Sovereign business jet, which is now being added to its successful line of Citation business jets. The upgraded aircraft made its maiden flight in April, and is slated to enter into service in 2013. Since 2004, 349 copies of its predecessor model, the Citation Sovereign powered by the PW306C, have been sold. The engine, too, features a low-pressure turbine made by MTU.

The PW306D incorporates enhanced aerodynamics, advanced materials and a modified engine control system. This gives the engine more thrust, cuts fuel burn and boosts the New Citation Sovereign’s range to 5,500 kilometers—convincing arguments in favor of this variant. Cessna has also selected the PW306 engine to power its new Citation Latitude mid-size business jet, which is expected to enter into service in 2015.
Extended range: Cessna’s New Citation Sovereign is powered by two Pratt & Whitney Canada PW306D engines.

MTU also contributes components to the new Bombardier Learjet 85, which is due to go into service in 2014. The German engine company has a 15-percent share in the aircraft’s PW307B engine and is once again responsible for the rear part of the engine: the low-pressure turbine, turbine exit case and mixer. The lighter low-pressure turbine rotor helps increase the engine’s efficiency. “New engineering analysis tools allowed our structural analysis experts to optimize the design and achieve a reduction in weight with no need for additional testing,” says Klaus Pirker, MTU Engineering Representative at P&WC in Canada. “After Dassault’s Falcon 7X, the Learjet is the second aircraft application for the PW307,” Wiedra is pleased to report. The biggest Learjet ever will be the first in the Learjet family to feature a composite structure. The all-composite aircraft is expected to make its first flight sometime before the end of the year. “Manufacturers are currently working on a number of new business jet models that will come onto the market over the next few years,” observes Wiedra, adding that while the market has stabilized again following the slump in 2009, delivery volumes are still way below pre-crisis levels.

MTU has shares in three PW300-series engines—the PW305, PW306 and PW307—for a total of nine aircraft applications. The successful partnership between P&WC and MTU began almost 30 years ago, when the two companies signed the first collaboration agreement for the PW305 in 1985. “We’ve built up a very close relationship over the years, one that is based on mutual trust and appreciation of our technical expertise. This has earned us a strong position as senior partner in the programs,” says Pirker. In addition to its PW300 participations, MTU shares in the PW530 and PW545 programs for Cessna Citation jets, again with a 25 percent stake in each of these engines, the work shares being the same. To date, MTU has delivered more than 5,800 PW300 and PW500 turbine modules. “The PW300 and PW500 have an excellent reputation for their outstanding reliability, and that is in no small part also thanks to the MTU low-pressure turbine driving the fan,” he adds. P&WC appreciates being able to rely on MTU, and this year awarded the company the Supplier Gold Award for the sixth consecutive year in recognition of the outstanding quality of its products, its on-time delivery performance and a high level of customer satisfaction. MTU is renowned worldwide for its engineering expertise, particularly when it comes to low-pressure turbines, its key product.

In return, the strategic partnership with P&WC has opened the door to the business jet market for MTU. According to Pirker, P&WC introduced a strong culture of teamwork and integrated product development back in the early 1990s. “We openly discuss technical issues and challenges in our joint meetings, and this ultimately reflects in the quality and technical maturity of our products,” he says. Pirker has been MTU’s low-pressure turbine contact at P&WC headquarters in Longueuil, Quebec, for three years. “I spend most of my time facilitating the collaboration between P&WC and MTU by working to bridge the 5,600-kilometer gap and six-hour time difference separating their two engineering teams.”

This works exceptionally well, with the partners continuing to improve the “old” PW300. “As a technology leader, we never rest. We’re always striving to improve our core competencies, these being our low-pressure turbines, high-pressure compressors, manufacturing processes and repair procedures. We do so by incorporating new design features to increase efficiency and by developing innovative materials for our high-tech components,” Wiedra says. Both partners pull together to achieve these aims.

For additional information, contact Martin Wiedra
+49 89 1469-3554

MTU contributes the low-pressure turbine to the PW300 family, as well as the exit case and mixer.
On-wing inspection of a PW300 engine.

"We never forget that your engine has our name on it," is the promise that Pratt & Whitney Canada, as the original equipment manufacturer (OEM), makes to its customers. That's why it offers a comprehensive customer service network. MTU Maintenance is a reliable partner in this global network. "We act as representatives for Pratt & Whitney Canada as the OEM, which is proof of its confidence in our expertise and the quality of our services," explains Carsten Behrens, General Manager of the P&W Customer Service Centre Europe (CSC), a 50/50 joint venture between MTU and Pratt & Whitney Canada. Founded in 1992, the CSC is based at MTU Maintenance Berlin-Brandenburg in Ludwigsfelde, near Berlin, and is responsible for marketing, sales and customer service in Europe, Africa and the Middle East. "We look after over 1,200 customers in these regions; they appreciate us being so close and in a similar time zone," says Behrens.

PW300 and PW500 series engines are sent to MTU Maintenance Berlin-Brandenburg, the MTU Group’s specialist for engines made by the Canadian company, for their shop visits. The portfolio includes the PT6A, PW200, PW300 and PW500, and MTU also has a mobile repair team to provide on-site maintenance support. "This strong team offers a gamut of services, from repairs such as blending of defects on blades, borescope inspections and work on the gearbox to hot section inspections on wing," explains Jan Bierkamp, Director, P&W Programs at MTU Maintenance. Hot section inspections involve the replacement of high-pressure turbine and combustion chamber components that are subject to severe thermal stresses. The mobile repair team is called out some 50 times a year, and is available on stand-by 24 hours a day, seven days a week. "We adapt to perfectly suit our customers’ requirements. To get the aircraft back in service quickly, we might only swap parts kits on site and then repair the parts in our shop."

40 to 50 PW300 and PW500 engines are sent to MTU Maintenance Berlin-Brandenburg for shop visits each year. "We fulfill the OEM’s every specification. The joint venture gives us direct access to technical data or updates, and allows us to resolve any technical questions that may pop up quickly," explains Bierkamp. For him, the small engines from Canada are truly big power packs. "They have a high power density and in terms of the utmost precision they require, they are almost comparable to Swiss clockwork. Even the slightest change, say in the clearance, has a huge impact. "At MTU, these sophisticated high-performance engines are in the best possible hands. Just as the PW306D will be in a few years’ time, when MTU maintenance specialists carry out the first on-site maintenance work to get it flying again, or when it comes in to Ludwigsfelde for its first shop visit.

A PW300 engine is being assembled at MTU Maintenance Berlin-Brandenburg in Ludwigsfelde.

For additional information, contact
Jan Bierkamp
+49 3378 824-796
Thanks to its efficiency and markedly reduced noise emissions the geared turbofan will make an important contribution towards climate protection in the years to come. But there is still great potential for improvement: Under the European Clean Sky Joint Technology Initiative (JTI), which is approaching the home stretch, the successful technology will again be substantially enhanced. Among the companies participating in this mammoth project is MTU Aero Engines. Germany’s leading engine manufacturer is responsible for building a demonstrator engine.

The targets to be met by the year 2020 are clearly defined: Aircraft are expected to emit 50 percent less carbon dioxide (CO₂) and 80 percent less oxides of nitrogen (NOₓ) as compared with year 2000 levels. Moreover, the perceived noise level is to be halved. These are the ambitious goals laid down by the Advisory Council for Aeronautics Research in Europe (or ACARE for short) in its Strategic Research Agenda. Dr. Joachim Wulf, Chief Engineer, Technology Demonstrators at MTU in Munich, is well aware of the big challenges ahead. After all, he is already working on the technologies for the next-generation Geared Turbofan (GTF), while his colleagues are still celebrating the big success of the current generation of this engine type. The GTF burns an impressive 15 percent less fuel and is only half as loud as conventional engines.
"Of course, we're more than pleased that the GTF has become so popular in the marketplace. In a few years' time, it will be flying in hundreds of new narrow-body airliners, demonstrating its superior environmental performance," says Wulf. "But if we want to achieve the ACARE targets we must continue working at full speed." The development of the requisite technologies is currently being pursued within the framework of Clean Sky. With an overall budget of 1.6 billion euros, this joint technology initiative is the biggest research program ever undertaken by the European Union. Clean Sky is aimed at developing more efficient aviation technologies to reduce the environmental impact of flying. As part of the program's "Sustainable and Green Engines" (SAGE) platform six demonstrator engines will be built. MTU has taken on responsibility for the SAGE 4 sub-project. Plans are to have the demonstrator assembled and ready for testing in the first quarter of 2015.

"We don't have too much time left, but we are confident that we'll meet the ambitious schedule," explains Wulf. To this end, the team members put their heads together at the end of the concept phase in October 2012 to define the technologies actually to be developed. Since then, the specialists have been focusing on the detail design of the entire demonstrator engine. And the team is well on track, according to the Clean Sky chief engineer: "On July 12, the SAGE 4 team passed design review 4 with flying colors and is now mid-way through the SAGE 4 sub-project." But, as Wulf goes on to point out, there is no reason for the team to sit back and rest on its laurels. The design of the demonstrator engine must be completed before the year is out. In other words, all components must be released for production by that time. Comments Wulf: "We're having rather busy times ahead of us."

The first component prototypes have already arrived in Munich. Just like many of the modified engine parts that will follow in the first quarter of 2014, these prototypes "will be put through their paces in components tests," explains Module Team Manager Dr. Stefan Busam. Testing serves to demonstrate that the new components perform exactly as predicted. For the purpose, the modified engine parts are provided with a variety of sensors that measure, for instance, the temperature and pressure distribution under simulated load conditions. They also permit the engineers to analyze the behavior of the parts when subjected to vibrations at different frequencies. "By mid-2014, component testing will be completed," says Busam.

If all tests are successfully passed the components can be installed. The experts in Munich will assemble and instrument MTU's high-speed low-pressure turbine and the turbine exit casing developed by British-Swedish GKN Aerospace, another partner in the Clean Sky initiative. Then the test engine can be fully assembled and installed in the test cell. "Testing is slated to begin in April 2015," according to Busam.

One thing is for certain already at this stage: The engine built for the SAGE 4 sub-project is lighter than any of its predecessors. In the high-pressure compressor, for example, new seals made from carbon-fiber reinforced plastic (CFRP) will replace the previously used titanium parts. Wulf: "These CFRP seals weigh less than their counterparts in the rare metal titanium and are less expensive."

Further savings in weight will be achieved by the use of components made by additive manufacturing processes, such as inner rings with integrated honeycomb seals for the high-pressure compressor. These other words, all components must be released for production by that time. Comments Wulf: "We're having rather busy times ahead of us."
parts are built up from a metal powder bed using the selective laser melting (SLM) technique. "Additive manufacturing makes production much easier and provides engineers with substantially greater freedom of design. We no longer need to mill parts from the solid, which saves a considerable amount of material. What’s more, the components weigh much less," explains MTU engineer Wulf. In addition, these new manufacturing processes are much faster. Previously, three to four suppliers used to be involved in the production of the inner rings: One of them produced the inner rings and another the honeycomb. A third supplier did the brazing of the two constituent parts. Much time was also lost on transportation between the individual production sites. "Additive manufacturing involves but a single work step and production proper is completed virtually overnight," says Wulf.

Another innovative technology, which likewise helps reduce the weight of the geared turbofan, will make its debut in the low-pressure turbine of the SAGE 4 demonstrator. Normally, the airfoils of the individual turbine stages must be of a particularly rigid design to prevent them from vibrating as they are exposed to the hot gases flowing between them at high velocities. But the good vibration-resistance properties come at a price: The airfoils weigh more. The newly developed airfoils with integrated vibration damping are capable of withstanding the critical frequencies occurring in operation without suffering damage. "The airfoils are lighter and leaner. This affords aerodynamic advantages that have a positive effect on the overall efficiency of the engine," explains Wulf.

To further increase the efficiency of the next-generation geared turbofans MTU’s air system specialists and design engineers are currently working to optimize the use of cooling air in the low-pressure turbine. "We can reduce the amount of cooling air required by routing the air precisely to those areas where it is actually needed," says the Clean Sky Chief Engineer. And since the cooling air is part of total airflow to be compressed further upstream in the engine, less cooling air saves energy and the engine can produce more thrust as a result. The reduction of noise continues to be a topic featuring high on the engineers’ agenda. In a first, acoustic damping liners will be used on the turbine exit casing built by SAGE 4 partner GKN Aerospace. Such liners, which attenuate the propagation of certain frequencies, have already proved their worth in the bypass duct upstream and downstream of the fan. For use in the hot engine section they had to be modified to make them resistant to elevated temperatures.

"With the technologies we are developing for SAGE 4 we want to reduce the engine’s fuel burn by around three percent as compared with current geared turbofans. Our long-term goal is a five- to eight-percent reduction," explains Wulf. Such a reduction would be a major step forward: "Although today’s engines achieve extremely high efficiencies each additional tenth of a percent makes a whole lot of a difference, helping cut down on fuel burn and hence reduce CO₂ emissions." According to Wulf, the new SAGE 4 technologies might be mature for use in production engines by 2020.

"Under Clean Sky we’re not only facing challenges of a technical nature. What’s equally important is the smooth organization of a project on the other. The various project activities, which span the whole concept, are coordinated by the Clean Sky Joint Undertaking (CSJU) especially set up for the purpose.

“Our associates in the SAGE 4 sub-project with a total volume of around 68 million euros are the British-Swedish GKN Aerospace group and Italian engine manufacturer Avio Aero. Other partners include a number of small and medium-sized enterprises (SMEs), research institutions as well as universities," explains Taferner. These partners had been invited to participate in SAGE 4 via open Calls for Proposals (CfP). They work on specific, directly funded SAGE 4 development tasks defined by MTU and its associates for a limited period of time. The European Commission encourages the participation of SMEs and research institutions in the development of aviation technologies, the aim being to strengthen their international competitiveness. "The partners develop their own technologies, thus gaining a competitive edge for the future, and SAGE benefits from the highly advanced components provided by the partners," according to Taferner.

A budget of around 15 million euros has been allocated to the SAGE 4 sub-project for such development orders. "Our CfP budget has been fully exhausted by now. We were looking for development partners who are ready to also invest their own money in tasks defined by MTU, GKN Aerospace or Avio Aero, the aim being a technical solution that creates a win-win situation for MTU and the partners alike," says Taferner. Contracts for MTU’s last three CfP projects are currently being drawn up. They cover the maturing of a stable production process for a new turbine casing material, the development of a less expensive alloy for engine rotors and the improvement of the manufacturing process for single-crystal blades in nickel-base alloys.

"By next year, important technologies developed for the demonstrator under CfP arrangements must have achieved an appropriate level of maturity, and integration into the demonstrator must have been completed to a large extent to allow them to be successfully validated in the SAGE 4 engine tests," explains Taferner. "We’re now approaching the home stretch of Clean Sky and as far as we can tell today the overall Clean Sky program and our SAGE 4 sub-project will be a huge success." The European aviation industry, therefore, would definitely welcome a Clean Sky successor program. Preparations are currently underway for Clean Sky 2, which might be integrated in Horizon 2020, the EU’s upcoming Framework Program for Research and Innovation. Taferner believes that a decision will be made before the next year is out. "If the project goes forward we’ll of course be in again."
Efficient and powerful

By Christiane Rodenbücher/Martina Vollmuth

Tomorrow’s engines will need innovative control systems and increased electric power, to name but two of the requirements to be met by next-generation propulsion systems. In the development of the requisite technologies, MTU is relying on a tried and tested approach: The company has been maintaining a close cooperation with the Universität der Bundeswehr München (University of the Federal Armed Forces in Munich) for several decades. The most recent success to come out of this collaboration is MexJET, an engine test vehicle based on the EJ200 engine powering the Eurofighter Typhoon and used to validate an entirely new control concept.

When Dr. Jörg Henne, Senior Vice President, Engineering and Technology at MTU, attended a celebratory event held by the Universität der Bundeswehr München (UniBw) in Neubiberg, south-east of Munich, he explained: “The MexJET test vehicle, which has meanwhile successfully entered into operation, provides an outstanding basis for highly promising technology developments in the fields of More Electric Engine and innovative control concepts. It is the only experimental platform of its kind in Germany.”

He expressed his belief that “the technological developments underway will lead to significant increases in operational safety and cost efficiency, and a reduction in life cycle costs.”

On the occasion of the official commissioning of MexJET (More electric experimental Jet Engine Test vehicle) in spring 2013, Professor Dr. Reinhard Niehuis, Head of the Institute of Jet Propulsion (ISA) at UniBw, lauded the joint project as “particularly efficient and powerful”, referring not only to the technologies involved, but also to the cooperative partnership between MTU and UniBw.
The close-knit research alliance between UniBw and Germany’s leading engine manufacturer has existed for decades. Construction of an engine test facility for educational purposes began just a year after UniBw was founded in 1973. Joint research and teaching commenced following the setting up of the Institute of Jet Propulsion in 1980, with the activities focused on the future requirements of aircraft engine systems from the outset. Flight systems of the future will require more electric power, which in turn places higher demands on aircraft operating behavior and generator efficiency. This is why MTU and UniBw decided to launch a joint More Electric Engine (MEE) center of competence in 2007, aimed at pooling their activities and at promoting research into various aspects of electrical and electronic systems.

Front and center in the cooperative effort is the integration of new, more efficient electrical system components, such as the starter generator, and components of the oil and fuel systems. The development and integration of new control systems is also playing an increasingly central role. Under the Advanced Control System and Model-based Control projects, next-generation control concepts were defined and validated using the MexJET test vehicle. For the first time, a direct thrust control system was developed that will allow engine performance and fuel consumption to be further optimized. The new control concept offers a number of additional advantages: It improves continuous on-board monitoring of engine operating conditions and facilitates fault detection and isolation checks, which increases engine reliability. As the control system reduces the engine’s fuel burn it also helps bring down life cycle costs. All these improvements are made possible thanks to a modification of the engine control software. “Test results already confirm the potential benefits afforded by this new control concept,” sums up Dr. Gerhard Kahl, Senior Manager, Compressor Technology at MTU in Munich.

To validate these research concepts, UniBw and MTU are using the MexJET test vehicle, which bases on the EJ200 engine for the Eurofighter Typhoon, one of the most advanced jet engines in the world, and features special equipment for the tests to be carried out in Neubiberg. The test vehicle’s first run at UniBw took place in late November 2011 and was followed by a comprehensive series of tests that were successfully completed in time for the official commissioning in March this year. “It was indeed a big challenge for the entire team to install the EJ200 engine in the test stand. After all, the test vehicle’s thrust and flow rate are significantly higher than on all preceding models,” explains Kahl. But the outcome of the first tests was worth all the effort.

MexJET also is a fine example of the benefit that can be derived from close collaboration between MTU and various departments of the German Ministry of Defense. “Funding of defense technology developments is very important to MTU,” explains Dr. Gerhard Ebenhoch, Director, Technology Management at MTU. “We use it for pre-competitive technology development, which also benefits the commercial area. Through our work in this field, we are able to identify potentials for improvement in engines currently in service. What’s more, using our military customer’s existing facilities and infrastructure allows us to increase the leverage of defense development programs.” The various activities underway in this field at present go to show that military development funding is an indispensable and efficient way to greatly help strengthen Germany’s position as a high-tech country.

“The collaboration with MTU is something we value very highly,” states Niehuis and enumerates a series of cooperation projects that include the MexDemo project funded by the state of Bavaria, and in particular the varied joint research activities at the high-speed cascade wind tunnel in Neubiberg. “This alliance, which is the only of its kind in Germany, provides us with an excellent opportunity to conduct research work into cutting-edge technologies and to launch new initiatives.” Niehuis says. “A major project we’re currently working on is the joint development of novel airfoils for low-pressure turbines intended for geared turbofan applications.”
MTU Aero Engines has great expectations of the PurePower® PW1000G engine, and rightfully so: The highly efficient Geared Turbofan™ engine sold extremely well at this year’s Paris Air Show. It has been selected to power the Airbus A320neo, the Bombardier CSeries, the MRJ Mitsubishi Regional Jet, the Irkut MS-21, and the new generation of Embraer E-Jets in future. To ensure safe flight operations once the engine has entered into service, it is put through its paces in a comprehensive test program. Some of the testing is conducted at MTU’s test facilities in Munich.

Kurt Scheidt, Senior Manager, Engine and Flight Test at MTU, explains: “Before an engine can go into production, it has to undergo between 3,000 and 5,000 hours of testing. The PW1000G has now been in this test phase for a year and a half.” MTU’s stake in Pratt & Whitney’s geared turbofan program varies between 15 and 18 percent, depending on the engine version. The workshare of Germany’s leading engine manufacturer includes the high-speed low-pressure turbine, one of the key components of this engine. In the spring of this year, the company received two German innovation awards for its highly advanced turbine. MTU is the only manufacturer worldwide to offer this technology. “We have already conducted two series of stress tests on the low-pressure turbine for the PW1100G-JM, the version destined for the A320neo, at our facility in Munich,” reports Christian Steffen, who heads up the test activities for commercial and military programs at MTU. “Further tests in our large development test cell III are planned for the end of this year; preparations are already underway.”
Stress tests are highly complex and a major element of the flight certification process. Their purpose is to ensure that an engine module or entire engine is capable of withstanding the stresses it must sustain to meet the certification requirements, such as high speeds and temperatures, or meeting continuous operation requirements, without difficulty. “Measurements of the stresses and temperatures acting on the components provide us with vital information that allows us to determine their stress limits,” says Steffen. To obtain this data, it is necessary to fit sensors at as many as 2,000 measuring points. Steffen: “Given the limited space inside the engine and the minute size of the sensors, this is a task that requires utmost precision. The most challenging tests are those involving remote measurements on rotating parts.”

Remote measurement or telemetry is a technique in which measurement data is captured by a sensor and transmitted to a distant recording point. MTU has developed its own systems for this highly sophisticated measuring method. Miniature strain gages are attached to specific areas of blades and disks. They consist of thin strips of metal connected to a power source. As the component expands during engine operation as a result of heat or centrifugal forces, the strain gage expands as well, causing its electrical resistance to change—even if the deformation is as small as a thousandth of a millimeter. The recorded data is then transmitted via a wireless connection to the computer and evaluated.

MTU has many years of experience in the testing of commercial and military aircraft engines. As Scheidt points out, stress tests are not the only type of tests that can be conducted at MTU’s test facilities: “We’re also able to carry out any type of test required for engine certification, including performance and system testing, endurance testing, vibration tests, emission measurements, simulation of hot-day conditions, bird-strike tests, destructive testing, ice, water and sand ingestion tests to simulate extreme weather conditions, and high-altitude testing.” Sand ingestion tests are currently underway in Munich on a GE38 turboshaft engine for the Sikorsky CH-53K heavy-lift transport helicopter. The purpose of these tests is to demonstrate the engine’s enhanced resistance to erosion by airborne sand particles.

In a first for MTU’s test facilities in Munich, lightning strike tests on a V2500 engine for the Embraer KC-390 military transport are being conducted by a specialized U.S. company. The tests began in August. “The engine casing is exposed to defined high-voltage spikes and their effect on the engine control system is analyzed,” explains Technical Program Manager Werner Striegl, who at MTU is responsible for the V2500 and other engine programs. Another V2500 is currently being used by the MTU test engineers as a platform for trials on behalf of a customer: “We are testing a next-generation lubricant under extreme operating conditions such as elevated oil temperature or reduced oil pressure,” says Striegl. “If all components of the engine are still in perfect working order at the end of the tests, the new lubricant can be approved for use.”

As engine performance requirements continue to increase, so do the demands on test equipment and methods. “For example, as a result of the trend toward ever-larger engines, most of the tests we previously carried out at the high-altitude test facility are now conducted during flight tests,” says Scheidt. “At the same time, we are continuously investing in measures to enhance the performance and measurement capabilities of our test facilities and improve their noise insulation. By constantly updating our facilities in this way, we keep abreast of the latest technological developments.”

MTU Aero Engines has various high-performance ground test facilities configured for different purposes. At its Munich headquarters, the company operates four test cells for turbojet engines and one for turboshaft engines, plus component test rigs. Additional test facilities for turbojet and turboshaft engines are operated by MTU Maintenance at its various locations in Germany and abroad. For high-altitude tests, MTU has access to Stuttgart University’s high-altitude test facility. The engineers use these facilities to test turbojets with a thrust of up to 400 kilonewtons, such as the GP7000 for the Airbus A380 and the EJ200 engine for the Eurofighter Typhoon, and for testing turboshaft engines with an output of up to 15 megawatts powering helicopters and propeller aircraft, such as the Sikorsky CH-53K (GE38) or the Airbus A400M military transport (TP400-D6). The full range of tests required for engine certification can be carried out at these facilities, including structural, load, and reliability tests, ingestion tests, and destructive testing. Tests are conducted on individual components, assemblies and modules, as well as on complete engines for commercial and military applications.

The majority of these tests form part of contractual agreements with MTU’s OEM partners, including Pratt & Whitney, General Electric and Rolls-Royce, or the International Aero Engines (IAE) consortium. Other tests are performed on behalf of external customers.
Industrial gas turbines (IGTs) are rugged and reliable, rapidly ramp up to their rated power and withstand repeated start/stop cycles even in a single day. One such IGT is the General Electric LM6000, of which more than 1,000 copies have been sold worldwide. To ensure that this success story continues, MTU Aero Engines’ specialists have been developing enhanced protective coatings. In the program, MTU has worked on the René 104 alloy for the first time. These efforts have helped increase the performance of the 50-megawatt IGT and reduce its emissions.

Many industrial gas turbines are aeroderivatives designed for stationary applications. They are used in a multitude of ways. Combined with a power generator, they produce power for land-based electricity consumption and off-shore use on oil rigs. They also supply the mechanical energy needed to operate pumps and compressors to transport petroleum and natural gas through pipelines. One of the most popular IGTs is the General Electric LM6000, a derivative of the CF6-80 engine. The first LM6000 began commercial operation 20 years ago. To date, the LM6000 has achieved more than 26 million operating hours, with more than 1,000 units shipped to customers globally; four times more experience has been gained with this IGT than with all other competing gas turbines in the 60-megawatt class combined.
Germany’s leading engine manufacturer is a risk-and-revenue-sharing partner in the LM6000 program. “MTU’s main line of business are aircraft engines,” says Uwe Kaltwasser, Director, Sales and Customer Support, Industrial Gas Turbines at MTU Maintenance Berlin-Brandenburg in Lüneburg. “Aircraft engines are often subjected to higher loads than their engine cousins, because they are required to operate continuously at full load,” Kaltwasser points out. Florian Brecht, Senior Manager, Operations, CF6/LM explains: “GE wanted to leverage its existing CF6 technology and use it for a wider range of applications, just like its competitors.” MTU essentially contributes components for the high-pressure turbine, such as internally-cooled rotor blades and stator vanes, seal rings and disks.

The stationary gas turbines differ from aeronautical designs in several respects: “Aircraft engines are provided with a large fan at the front that generates much of the thrust,” explains Kai Philippewitz, Configuration Management, CF6/LM Programs. “By contrast industrial gas turbines don’t have a fan and rely primarily on the rotational energy. The thrust produced is negligible, but the exhaust energy can be used for additional purposes. Otherwise they work in the same way as a jet engine.” One of the most significant and immediately obvious differences is that IGTs have large flanges on the underside allowing them to be securely fixed to a base plate. The customer market structures for the two types of product are fundamentally different: Whereas airlines often order hundreds of engines of the same configuration, individual IGT customers tend to buy only one unit. “In this respect, the IGT and aero-engine markets are worlds apart,” comments Brecht.

The highly successful LM6000 aeroderivative gas turbine is now available in two new versions: the LM6000-PG with single annular combustor (SAC) and its dry low emissions (DLE) equivalent, the LM6000-PH. In the PH version, the injection nozzles are optimally arranged in multiple levels to provide more efficient combustion. GE markets both products as Growth versions, in reference to their enhanced performance. The stage 2 high-pressure turbine blades and vanes, which are manufactured by MTU in Munich, are provided with a new coating that increases their thermal resistance by up to 80 degrees Celsius. This extends their service life, or allows them to operate at higher loads. So how do these improvements come about? “Basically we’re using techniques that we adopted in the manufacture of aircraft engines some time ago,” says Philippewitz. “In this case, we apply a zirconium oxide coating by vapor deposition.” The full name of the technique is Electron Beam Physical Vapor Deposition (EBPVD). The process is carried out at Ceramic Coating Center (CCC), a joint venture of MTU and Snecma, and has been used to coat stage 1 high-pressure turbine blades and vanes for some time. Over a period of roughly eighteen months, the process has been adapted to suit the demands of the more complex geometry of stage 2 blades and vanes. “The trickiest thing were the motion parameters in the coating chamber,” explains Philippewitz. “It’s essential that the translational and rotational movements of the part are precisely controlled, to ensure that the vaporized particles are deposited to form a ceramic film of the desired thickness on all areas of the part,” says Brecht, explaining the details of this particular challenge.

Another challenge for the production engineers in Munich was learning how to machine René 104, an innovative powder metal used in the production of the disks and seals. “We had never had to deal with a material that was so difficult to machine,” reports Philippewitz. “René 104 is a GE material. We don’t know its precise composition—in a sense, it’s a black box for us.” Nonetheless, the MTU experts successfully developed manufacturing processes and tools that met GE’s demanding requirements, in particular lathes and broaches for producing the inner splines. Philippewitz: “We are the production responsible partner and so it’s our job to check which parts are to be produced using which processes. And that can sometimes be a real brain teaser.”

“GE was quite impressed by the quality of our solutions and processes,” says Brecht proudly. MTU was ably assisted by experts from RWTH Aachen University, who helped establish suitable tool parameters. Brecht is aware, though, that it will be difficult to enhance performance further, because the limits have already been reached for the majority of geometries and materials. But then again, the experts on either side of the Atlantic no doubt still have a few new ideas up their sleeves that will allow efficiency to be boosted beyond today’s limits.
Global

IGT maintenance: on the customer’s premises as quickly as possible

In the LM6000 program MTU is responsible for manufacturing key components and for providing maintenance and package services for this industrial gas turbine (IGT).

Maintenance of the heavyweights is handled by MTU Maintenance Berlin-Brandenburg in Ludwigsfelde, MTU’s center of excellence for industrial gas turbines. Since 1995, the company, a GE-authorized service provider for LM2500, LM5000 and LM6000 gas turbines, manages all of MTU’s IGT activities. The MTU engineers provide a 24/7 service and take care of the entire maintenance management.

“We offer our customers on-site repairs, on-site removal, overhaul and re-installation, and testing and commissioning services,” says Stephen Naumann, Field Service Director. “The challenge is to be on the customer’s premises as quickly as possible,” adds Uwe Kaltwasser, Director, Sales and Customer Support, Industrial Gas Turbines. Field service experts will be on site within 24 hours, no matter where in the world they are needed.

Next to the shop in Ludwigsfelde, MTU operates Level II shops in Thailand, the United States and Brazil.

In addition to maintenance, MTU also provides package services to upgrade the entire IGT system, including the gas turbine, control and monitoring systems, hydraulic starter system, air supply and exhaust system, fuel supply, fire extinguishing system, optional water injection systems for NOx reduction or cooling, the engine mounting and casing, plus, of course, the generator or compressor.

Here is an example of a package contract successfully completed in Brazil: At a power station operated by a public utility company in Manaus on the Rio Negro in the Amazon basin, two LM6000 PA IGTs were upgraded to the LM6000 PC standard. The job included all subsystems and the installation of a water injection system for NOx control. “We know all there is to know about the industrial gas turbine,” says Johannes-Peter Hölzle, Field Service Engineer, who oversaw the installation activities on-site, “but integrating a new system into an existing facility, including all subsystems and installing a water injection system, was something we’d never done before.” So the MTU specialists put their heads together, devised new processes, and looked for competent suppliers, including local companies in Manaus. The team spent several months on the job in Brazil. The result was a successfully completed first package project and a very satisfied customer.

For additional information, contact Uwe Kaltwasser
+49 3378 824-250
The end of an era

By Christiane Rodenbücher

It is late July and the sun is shining brightly in a clear blue sky—perfect weather conditions for the historic flight that is about to take place at the military airfield in Manching, Bavaria. Shortly after 2 p.m. the engines slowly start to turn. Then a voice from the cockpit announces "Dixi one six is ready for departure" and the McDonnell Douglas F-4 Phantom takes off into the sky over Germany for the very last time. This flight also marked the retirement of the fighter jet’s J79 engines, which MTU had built under license and repaired and overhauled for decades.

Lieutenant Colonel Stefan Ritter had flown the F-4 almost daily for 23 years and piloted its last one-hour. "I’m very sorry to say goodbye to this remarkable combat aircraft," he said. On its final journey, the Phantom took off from Manching and flew over the military airfield in Neuburg on the Danube, where it had previously been based, for a final salute. Its route continued via the German Aerospace Center in Oberpfaffenhofen, and on to Kaufbeuren, home of the German Air Force School of Engineering, and then to Erding and the Bavarian Forest, before the aircraft returned to the Bundeswehr Technical and Airworthiness Center for Aircraft (WTD 61) in Manching.

Test pilot Ritter, who has accumulated over 3,700 flight hours on various aircraft types, has nothing but praise for the Phantom: "It was a safe, robust, and reliable aircraft and operating costs per hour were low. And you could always count on its availability," he says, summarizing the characteristics that Phantom crews appreciated so much in this combat aircraft.
Military aircraft enthusiasts from all over the world flocked to Manching to witness the last flight of a German Phantom over its home territory. Ritter adds: “The aircraft has remained in service for a long time—no less than four decades—which clearly shows just what a valuable asset it was to the German armed forces.”

In Germany, the F-4 was initially intended as an interim solution to bridge the gap between the F-104 Starfighter and the Eurofighter Typhoon. In all, the German air force and the WTD operated over 270 F-4E and F-4F PhDs. In the 1970s, the Federal Republic of Germany’s F-4 fleet was second in size only to that of the United States. The Phantom F-4 was built in larger numbers than any other modern-day combat jet of the Western world. The German air force used the aircraft as a reconnaissance jet, fighter-bomber, and interceptor. In future, all of these roles will be assumed by the Eurofighter Typhoon. The Phantoms based at WTD in Manching were deployed in a multitude of roles: They served as flying laboratories for high-speed tests and as airborne experimental platforms for testing guided missiles and special external payloads.

“The Phantom was our preferred workhorse for all heavy tasks, in the truest sense of the word, and it always performed to our utmost satisfaction,” says retired Lieutenant Colonel Gerd Stein. During his time as a test pilot and weapon systems instructor, he had every opportunity to get to know the Phantom and its predecessor, the Starfighter, very well. He vividly remembers the early, difficult days of some of the new aircraft’s capabilities: “But over the years, we’ve come to appreciate its versatility and mission flexibility—and above all, to trust in its safety. The Phantom was an exceptionally robust aircraft.”

The F-4 was powered by two J79 engines, the development of which had been launched by General Electric back in 1952. MTU started to build this engine, which also served as the powerplant for the F-104 Starfighter, under license from GE in the 1960s. According to Ulrich Ostermair, Director, License Programs & German Air Force Cooperations, the J79 was one of MTU’s most important programs ever. “The license manufacture, as well as in-service support, maintenance and further development of this engine played a major role in helping MTU join the league of the world’s technology leaders.” Between 1960 and 1965, a total of 632 engines were built for the Starfighter in Munich, along with 601 parts kits. Ostermair:

“On average, 22 engines and an equivalent number of parts kits left the factory each month.” Another 687 engines were produced for the Phantom in subsequent years.

“The J79 engine for the Phantom represented a major step forward in technology-wise, thanks to its incredibly safe design,” says Christian Knoll, who at MTU used to be responsible for supporting this engine type. “The J79 was particularly appreciated for its trouble-free operation, reliability, and cost-efficiency.” MTU introduced a number of modifications over the years that contributed to the engine’s further optimization. These included a gearbox damping system that eliminated vibrations of the gearbox, thus preventing the formation of cracks in the gearbox housing. This in turn reduced costs, because fewer housings had to be replaced. And overall, fewer new parts needed to be procured from the OEMs (Original Equipment Manufacturers) than before. Moreover, MTU developed its own standards, which helped solve technical problems more quickly.

The J79 engines operated by the German armed forces accumulated a total of 2.7 million flight hours. More than 6,870 engines were sent to MTU’s shops for repair and overhaul. Thanks to its comprehensive expertise in this field, Germany’s leading engine manufacturer was able to offer its customer the full range of maintenance services. Mutalle Ulucay, Senior Manager, EJ200/RF199 Support Services, who had been responsible for J79 business development at MTU, explains that the company used some 200 repair techniques developed in-house in addition to those defined in the U.S. Air Force Technical Orders (USAF T.O.), the U.S. Air Force’s manual of maintenance procedures. Ulucay: “This approach ensured higher engine availability and gave the customer greater independence in maintenance matters. At the same time, it resulted in lower costs, especially for the procurement of new parts.” MTU drew up 1,400 repair notes and 500 instructions for inclusion in the German Air Force Technical Orders (GAF T.O.), which formed the basis for a German maintenance manual tailored to the Bundeswehr’s specific needs.

Since 1991, the F-4 Phantom fighter has been gradually retired from service. As part of the NATO defense aid program, Germany transferred some of its surplus aircraft to the air forces of Greece and Turkey, where many of them are still in service today. The last overhaul of a German J79 at MTU two years ago marked the end of an era for the company.
Joining forces

MTU Maintenance and Japanese Sumitomo Corporation, one of the largest trading companies worldwide, have set up two new joint venture companies to expand their commercial aircraft engine leasing business. MTU Maintenance Lease Services B.V., an 80/20 joint venture of MTU Maintenance and Sumitomo Corporation, is based in Amsterdam, The Netherlands and will offer short- and medium-term lease solutions for airlines, providers of maintenance, repair and overhaul (MRO) services as well as lessors. Sumisho Aero Engine Lease B.V., a 90/10 joint venture of Sumitomo Corporation and MTU Aero Engines, the parent company of MTU Maintenance, will focus on long-term lease solutions. Both joint ventures are subject to approval by the competent anti-trust authorities.

As part of their cooperation, MTU Maintenance will provide Sumitomo with technical assistance and technical expertise, especially in the field of engine programs that are part of MTU’s portfolio. These include the CFM56, the V2500, the GE90, the CF34, the CF6, and the PW2000 as well as emerging engine programs. In turn, Sumitomo’s involvement as a risk-and-revenue-sharing partner allows MTU Maintenance to optimize its lease business and to expand its worldwide sales channels. At the same, the cooperation opens up new financing solutions. MTU Maintenance’s lease portfolio currently generates annual revenues of more than 30 million U.S. dollars. The annual revenues of MTU Maintenance Lease Services B.V. are expected to increase to well above 100 million U.S. dollars in the medium term. With the new joint venture, further engines, including the GE90, will be added, allowing MTU Maintenance to significantly strengthen its presence in the engine lease business.

U.S. Navy contract for Vericor

The U.S. Navy has ordered eight more ETF40B engines from Vericor Power Systems, which brings its total fiscal-year 2013 requirement to 16. In addition, the two partners have signed a five-year contract for the delivery of up to 27 spare engines of this type from 2014 to 2018. All of the future propulsion systems will come equipped with a new full-authority digital engine control (FADEC) unit. The engines will be used to power the U.S. Navy’s high-speed, fully amphibious LCAC air-cushioned landing craft. The vehicle is capable of carrying payloads of up to 75 tons at speeds of around 75 kilometers an hour and over a nominal range of up to 370 kilometers, traveling over land and water.

The first LCACs were manufactured in 1984 and designed for a service life of 20 years. As part of the U.S. Navy’s service-life extension program (SLEP), the LCACs in its fleet will be upgraded, and the engines replaced, to extend their serviceable life to 30 years, enhance their performance and reduce their operating costs. This is where Vericor’s gas turbine comes in: The ETF40B engine is uniquely qualified for this role, since it delivers almost 20 percent more power than the engine it replaces on the LCAC.

The craft are an integral part of the U.S. Navy’s amphibious capabilities, they were in service in Iraq and have supported various disaster relief and humanitarian assistance missions. Vericor has also developed a new digital engine control unit, which equips all new ETF40BIs delivered from June this year on. This FADEC was Vericor’s most important development project in these past three years.

Under the new five-year contract, a total of up to 27 engines will be delivered to the U.S. Navy by 2018. These will be used as spare engines for existing engines installed on hoveringcraft that need to be removed for maintenance.

MTU’s facility in Poland expanded

MTU Aero Engines Polska in Rzeszów in the south of Poland: MTU Aero Engines Polska, located in the Polish Aviation Valley, will add a new, 9,200-square-meter building, which will increase the area occupied by buildings by 50 percent. The total investment that will go into the project amounts to some 40 million euros. The expansion of its Polish affiliate is part of MTU’s investment and growth strategy. With this move, MTU is laying the foundation for the production and volume ramp-up for the geared turbofan programs.

At its plant in Poland, which boasts highly advanced production facilities, MTU manufactures engine components, such as turbine airfoils, for the PW1000G family of geared turbofan engines and performs preparatory work. Furthermore, the German engine manufacturer is concentrating its module assembly activities for a variety of its commercial programs in Rzeszów. Another of the shop’s areas of expertise is the repair of engine parts, for example tubings. In the field of development, MTU Aero Engines Polska’s focus is on uncooled airfoils, fixture design, and software.

The new buildings will additionally house the shop floors where work for MTU’s customers will be performed with the increase of MTU’s stake in the V2500 for the Airbus A330 will be performed. This work is currently being carried out in rented buildings. Moreover, plans are to step up the low-pressure turbine assembly activities and concentrate them in Rzeszów, and to beef up research and development at the Polish plant.

MTU Aero Engines Polska was set up near Rzeszów Airport on a stretch of land seven hectares in size in 2009. Construction work on the new building will commence in the fall of 2013. Production is expected to be up and running in late 2014 and to run at full capacity by 2017. Some 250 new jobs will be created in Rzeszów by 2020 as a result of the new expansion. At the moment, MTU Aero Engines Polska has a workforce about 500 employees.

The joint venture’s lease engine pool will also include the GE90.