Testing down to the last detail

Customers + Partners
Power for the Jumbo Jet and the Dreamliner

Technology + Science
Hardfaced tips for top efficiency

MTU Global
MTU support for the “flying gas station”
Dear Readers:

Finally, yes finally, the bird is on the wing.

Late last year, the new A400M military transport aircraft successfully completed its long-awaited, eagerly anticipated maiden flight above the Spanish city of Seville. The relief was palpable throughout the industry; delays to the project had been creating too much turbulence all round. Now, the ongoing flight test program is demonstrating the superior capabilities of both the aircraft and its TP400-D6 engine.

This merely confirms what tests on the ground and on the flying test bed had already proved: The propulsion system as a whole, including its control system, meets all specification requirements—from its enormous 11,000-shaft-horsepower output and impressive fuel consumption data to its vibration behavior and thermal efficiency. And the highly complex engine control software is also operating as it should.

The A400M is the only transport aircraft in its class in the Western world. It promises a unique operational spectrum and permits completely new mission profiles. The same can be said for its engine: Never before have the Western nations produced such a powerful turboprop, and never before has such a complex engine control system been developed for a propulsion system. The A400M and its TP400-D6 engine are effectively pushing the limits of what is currently technologically achievable. I believe we should all be proud of the fact that this in its entirety system has been created in Europe. The A400M is tangible proof of the tremendous engineering expertise that exists within our companies.

Sincerely yours,

Egon Behle
Chief Executive Officer
Germany’s leading engine manufacturer is a partner in the EPI Europrop International engine consortium and is responsible, among other things, for the extremely complex software used in the TP400-D6’s control unit.

MTU also supplies the intermediate-pressure compressor, turbine and shaft for the engine and is in charge of final assembly. Some 20 engines have already been delivered, including those for the second and third prototypes of the A400M. In the course of the development process, the engineers had to come up with a whole range of technical solutions in order to meet the very ambitious performance and weight requirements.

Developing a new engine from scratch is always a challenge but, in the case of the TP400-D6 for the Airbus A400M, more than just one challenge was involved. The TP400-D6 comes as a three-shaft configuration and is the most powerful turboprop engine in the Western world. “We made every effort to reduce the engine’s weight,” explains Dr. Jörg Henne, Senior Vice President, Engineering and Technology at MTU. As a result, the five-stage intermediate-pressure compressor can do without variable geometry, and all the rotors have been designed as weight-saving blisk components. Quite apart from saving production costs and reducing the engine weight, these innovations also enhance performance because the flow losses associated with variable vanes and leakages no longer occur. As Henne points out: “A further difficulty was the extremely asymmetrical inlet, which is located behind the propeller and influences the air flow. But we managed to solve that problem by carrying out an integrated simulation of the inlet and the compressor and making appropriate design alterations based on the results.”

The job wasn’t made any easier by the demanding scenarios in which military transports have to operate. In contrast with commercial engines, their military cousins need to withstand much higher forces during maneuvers such as narrow curves and steep approaches. This is why, for example, the engine casing has to be much more rigid. In addition, as take-offs and landings on unsealed runways are par for the course, the engines have to be robust enough to cope...
with the ingress of foreign objects. All these aspects have to be tested down to the last detail, which involved a total of more than 3,500 hours of trials with 12 engines on different test rigs. “Except for special tests, such as sand ingestion testing, the general test procedure is similar to that for engines destined for commercial aircraft,” explains Henne.

This is where MTU was able to benefit from its noncontact blade vibration measurement system, which enables engineers to study the behavior of the compressor blades using laser optics. Put simply, the system focuses on a point attached to the blade, which is forecast to be in a certain position at a certain time. If the spot appears later than the calculations predict, the blade has been deformed as a result of vibrations. Sophisticated software then analyzes the extent of the deformation detected. As Henne explains: “We have been using this technique on compressors for many years now. It requires less effort than the mechanical method using strain gages and could soon be used in areas of the engines where temperatures are higher.”

Another key step in the approval process were the bird strike tests, which also fell within MTU’s responsibility; after all, the company had gained invaluable experience in this field with its experiments on the EJ200 engine powering the Eurofighter Typhoon. The specialists carried out two simulated bird strikes on a test rig at Techspace Aero in Belgium. Although the tests themselves took only seconds, months were needed both for preparation and for conversion of the test rig. The first test involved a bird dummy weighing almost two kilograms hitting a predefined part of the engine at a certain speed. In the second, the TP400-D6 had to handle two smaller test birds of an equivalent mass, as Gärtner explains: “The intermediate-pressure compressor can be directly hit by any foreign object, not just by birds. By contrast, turbofans are better protected: the fan intercepts the majority of foreign objects, diverting them into the bypass stream. Both of the tests we carried out were successful.”

The control system has a key role to play in the smooth functioning of the new engine, as Gärtner outlines: “Its job is a highly complex one. The number of interfaces to the aircraft alone has grown by a factor of ten in comparison with the control unit used in the Eurofighter Typhoon engine.” Although MTU was able to draw on the knowledge it had gained with the EJ200, the engineers were nevertheless entering uncharted waters with the TP400-D6 because certification of EPI’s military engine by the civil aviation authority was also required. “That meant a much more comprehensive process for validating the systems’ capabilities as well as a lot more paperwork,” says Henne. “A stacked printout of the documentation would probably be at least one meter high. The actual programming was only a small part of the work. The software isn’t tangible—we have to measure its effectiveness by the job it does. And only a seamless series of tests can reveal how well the job is done.”

And the tests are as diverse as they are comprehensive. First off, sub-routines are tested on a computer, with test programs simulating an input; the technicians then compare the output with the requirements. In the next step, they connect parts of the software to the control unit. The final phase involves the so-called Iron Bird, a complete mock-up of the aircraft and all its systems set up by Airbus to study how they interact. A separate computer is used to simulate the behavior of the engine itself. The testing process is not a one-way street: If problems occur during the final phase, appropriate solutions are integrated in the updated versions, and the testing loop begins again.

Software development and tests do not end once certification for the TP400-D6 has been obtained, as the functional scope will continue to grow and findings from the flight testing phase also need to be integrated. “It’s an ongoing process,” says Gärtner. “We’ll be able to use many of the lessons learned in future programs.”

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Power for the Jumbo Jet and the Dreamliner

By Achim Figgen

It was a moment of great joy for both Boeing in Seattle and MTU Aero Engines in Munich when in October 2009 American Airlines announced that it had selected the GEnx-1B engine to power its Boeing 787 fleet. The world’s second-largest airline will equip 42 jets for which it has placed firm orders, plus 58 on option, with the new General Electric engine. The German engine manufacturer will be supplying the turbine center frame (TCF) for this propulsion system starting in early 2012.

If American Airlines does indeed purchase all 220 engines as planned, MTU can count on revenues of around 150 million euros from this order alone. And that’s not the end of it. So far, General Electric has logged firm orders and options for more than 1,400 GEnx engines, and there are still buyers of the 787 that are yet to decide between the two alternative engines on offer. Wolfgang Hiereith, Director, GE Programs at MTU, estimates the demand for the two engine versions—the GEnx-1B for the Dreamliner and the GEnx-2B as the sole engine for the 747-8, the newest version of the Jumbo Jet—at some 4,400 units over the next two decades.

In December 2008, MTU took a 6.7-percent stake in the GEnx. As of 2012, MTU will be supplying the turbine center frame (TCF) for this engine, a component the company is building also for the GP7000 engine that powers the Airbus A380. Weighing in at around 200 kilograms and positioned between the high-pressure and low-pressure turbines, the TCF is a key component. Its function is to route the gases exiting the high-pressure turbine at a temperature of about 1,100 degrees Kelvin past structural components and tubes toward the low-pressure turbine, making sure the aerodynamic losses are kept to a minimum. The development and production of this extremely thin-walled cast gas-duct component poses a major challenge, given the high mechanical and thermal stresses resulting from the difference in temperature between ambient air and the engine exhaust gases, and the requirement to keep its weight as low as possible.
Even though the GEnx-1B engine for the Boeing 787 Dreamliner received FAA certification back in March 2008 already, and the GEnx-2B successfully completed its maiden flight on the Boeing 747-8 in February this year, the engineers at GE and its partners still have a great deal of work ahead of them. Some of the components need optimizing to make sure the new engine meets Boeing’s fuel consumption targets for the Dreamliner. On the GEnx-1B, for instance, General Electric has modified both the combustor and the cooling-air ducts in the blades of the first stage of the high-pressure turbine. The first flight of this engine on the Dreamliner is planned for May 2010. In addition to these modifications, the low-pressure turbine will be upgraded as part of the so-called Performance Improvement Package 1 (PIP 1), with initial tests of this module being slated for the summer.

MTU, too, will have more development work to complete before production can commence. The Munich engineers won’t just be producing the TCF as designed by General Electric based on the TCF in the GE90 powering the Boeing 777, but make a number of modifications; for instance, the hot-gas ducts, whose complex three-dimensional geometry makes them extremely difficult to produce, require redesigning. Moreover, the engineers will look into options to use new materials to reduce the weight of the component. The U.S. engine maker has already given MTU the go-ahead for its plans, says Hiereth. New production processes will be introduced to ensure that the TCF can be produced at the lowest cost.

According to current plans, production of the first components will commence in the fall, with the first complete TCF being delivered to General Electric for testing by the fall of 2011. Then, at the very latest, it will become clear whether the extent of testing to which the new materials and production processes were subjected at MTU is sufficient to obtain approval for the new TCF as a derivative of the original design, or whether additional test runs of the entire engine are required.

Regardless of the outcome, the setting-up of the new production line is proceeding as planned to make sure a delivery rate of 20 to 25 TCFs per month can be achieved as from 2011, when production will be launched.

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A boost for the MRJ

The Japanese Mitsubishi Regional Jet (MRJ) program is gaining momentum as Mitsubishi Aircraft Corporation has acquired its first large customer. U.S.-based Trans States Holdings intends to buy up to 100 aircraft. In addition to the 78- and 92-seat versions, the holding company is also interested in the 100-seater recently proposed. The MRJ will be powered by Pratt & Whitney’s new geared turbofan, in which MTU Aero Engines holds a stake.

By Tobias von Wangenheim/Martina Vollmuth

In October last year Mitsubishi Aircraft Corporation and Trans States Holdings, which is headquartered in St. Louis, Missouri, signed a letter of intent (LOI) covering a firm order for 50 MRJ aircraft and options for another 50. “The world has high expectations for the MRJ. One area where this is especially true is the U.S. with many routes where airlines operate 50- to 90-seat regional jets, so we are extremely proud to receive this order from one of the largest regional airline holding companies in the U.S.,” said Mitsubishi Aircraft President Hideo Egawa, who continued to add: “We would like to take this opportunity to further ramp up our sales activities around the world.”

Trans States is betting on the improved efficiency of the new Japanese aircraft. The MRJ is expected to burn 20 percent less fuel than comparably sized aircraft currently available in the market. The holding company expects a competitive edge from the new jet and hopes for additional contracts from the large American airlines. Privately owned Trans States Holdings owns and operates two regional carriers, Trans States Airlines and GoJet Airlines, that offer around 350 flights daily serving 50 cities on behalf of United Airlines and US Airways. Around five million passengers are carried annually.
It is not yet clear which MRJ version Trans States will eventually order, but the company is interested in all versions: the 78-seat MRJ70, the 92-seat MRJ90 and the recently proposed 100-seater. “We believe that the MRJ is a game-changing regional jet that takes into account the environment, as well as passenger and airline needs. The MRJ will reduce fuel consumption, noise and NOx emissions—this means savings on operating costs,” explained Trans States Holdings President Richard A. Leach.

The innovative engine makes a crucial contribution here: the MRJ is powered exclusively by Pratt & Whitney’s PurePower® PW1217G geared turbofan. MTU has a 15-percent stake in this highly innovative engine. Germany’s leading engine manufacturer develops and manufactures the high-speed low-pressure turbine and contributes the forward stages of the high-pressure compressor. The ground-breaking geared turbofan architecture offers a number of advantages: “The GTF reduces fuel consumption and associated CO2 emissions by double-digit percentages. It is considerably quieter than conventional engines, and is substantially more cost-effective in operation,” according to Dr. Christian Winkler, Director, Business & Partnership Development and New Programs at MTU in Munich. He continues: “The engine’s NOx emissions are 50 percent lower than the stringent standard in force since 2008.”

The MRJ is setting new benchmarks not only in terms of improved environmental compatibility and innovative engine design, but also thanks to its sophisticated aerodynamics and lightweight construction. Its cockpit will reflect the latest state-of-the-art, thus ensuring efficient flight control. The regional jet’s cabin, too, has much to offer: It is more spacious than that of any other aircraft in its class and provides an unprecedented level of comfort, comparable only to that of the most advanced long-haul aircraft, for example Boeing’s new 787 Dreamliner. The noise level in the cabin is very low thanks to the ‘whispering engines’, and airport neighbors should also be pleased with these low-noise engines.

The new Japanese aircraft is currently in the final design phase and is due to take off for its maiden flight in the second quarter of 2012. The first variant will be delivered to customers during the first quarter of 2014; the smaller MRJ70 variant will follow a year later. Mitsubishi has already also proposed a third version, which would seat 100 passengers in the standard configuration. Assuming the response to this proposal is positive, development of the MRJ100 could begin within the next two years.

Including the All Nippon Airways’ launch order for 15 aircraft and an option for another ten, current orders and options stand at 125 aircraft. Says Winkler: “We cautiously estimate the market for regional jets at 3,850 aircraft over the next 20 years.” Mitsubishi Aircraft pegs the demand at around 5,000 units. Since the MRJ is its only new development on the horizon, the Japanese manufacturer hopes to secure a major share in this market.

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For further information on this article, go to www.mtu.de/110PW1000G

Russian aircraft manufacturer Irkut will launch a new aircraft, the MS-21, which will also be powered by the geared turbofan.

*Highest precision: An MTU employee dimensionally inspects a stage 2 disk for the PW1000G low-pressure turbine.

Leaner, greener, cleaner

The geared turbofan (GTF) is U.S. manufacturer Pratt & Whitney’s most recent engine program. The engine is being developed in close cooperation with MTU. Two versions are currently being built: the PurePower® PW1217G (takeoff thrust: 17,000 pounds) for the MRJ and the PurePower® PW1523G, a 23,000-pound thrust version, for Bombardier’s CSeries.

Russian aircraft manufacturer Irkut is also opting for the GTF and wants to use it in its MS-21, a new narrow-body in the A320 class. The geared turbofan is also being discussed as a potential propulsion candidate for a re-engined A320 family; negotiations with Airbus are already underway.
Hardfaced tips for top efficiency

By Denis Dibba

In a high-pressure compressor, it is important to keep the clearance between the tips of the rotor blades and the hard lining of the casing to a minimum, so as to ensure the consistently high engine efficiency that goes hand in hand with lower fuel consumption. To keep the clearance as small as possible, the blades need to be particularly robust. MTU Aero Engines has invented and submitted a patent application for a new method of hardfacing blade tips by electroplating to increase their wear resistance.

Until now, the hardfacing material for blade tips consisted of particles of cubic boron nitride (cBN) brazed onto the blade tip. “This ceramic material is second after diamond on the hardness scale, and is correspondingly expensive,” explains MTU joining expert Bernd Daniels. To achieve the smallest possible clearance between the casing and the rotor of the high-pressure compressor—as a means of minimizing leakage flow and the resulting power losses—it is common practice to use blades without hardfacingsthat carve out their tracks in a relatively soft lining in the casing. The problem is that the clearance widens over time because the soft abradable lining of the casing becomes eroded. The result is a drop in engine efficiency, higher fuel burn, and shorter maintenance and repair intervals.

To substantially increase the service life of future generations of aero engines, such as the geared turbofan being developed by U.S. engine maker Pratt & Whitney (P&W) in collaboration with MTU, harder, more wear-resistant materials will be used for the casing lining and the blade tips will be provided with a hardfacing. The hardfacing must ensure that the blade tips can accurately grind their tracks in the new, hard casing lining and provide the blade material with adequate protection. “The hardfaced blade tips rub against the hard casing lining, abrading the material in much the same way as a grinding wheel cuts into a component,” says Josef Linska, MTU development engineer for electroplating techniques.
According to Linska, MTU had two reasons for wanting to develop a similar but lower-cost method. Firstly, the company had already achieved positive results with the use of hardfacings brazed in place on blade tips in military engines, especially in the high-pressure compressor of the EJ200 engine powering the Eurofighter Typhoon. And secondly, the company wanted to use this technology in high-volume production projects in the future.

The first experimental tests of MTU’s new method for applying electroplated hardfacings onto blade tips took place in the summer of 2008. The team led by Linska and Daniels chose to perform these tests on individual blades from the high-pressure compressor of the EJ200 engine, because their geometry is very similar to that of future blades and, furthermore, they require only minor adaptation of the existing test rigs. Since July 2009, the new electroplating has been applied on to components of next-generation engines, a result attributable not least to the excellent cooperation among the various MTU development and production departments involved. “It was nevertheless a long, stony road, where the obstacles strewn in our path were, as so often, due to the finer details,” concludes Linska.

This is how the process works: Firstly, before the hardfacing layer can be deposited, the component has to be masked almost all round, leaving only the tiny surface at the tip of the blade exposed. Then a microscopically thin layer of nickel is applied to a thickness of around ten micrometers. The next stage, involving the application of cubic boron nitride (cBN) particles with a size of 75 micrometers, required a certain amount of ingenious thinking on the part of the MTU engineers. For, as Linska explains: “We normally plate components by immersing them in an electroplating bath with the coating substance, in this case nickel.” When a current is passed through the plating solution, the nickel migrates from the positive pole and is deposited on the negative pole, that is the component. At the same time, the nickel gradually infiltrates and encloses the previously applied, evenly distributed layer of hard cBN particles, fixing them to the surface of the blade tip.

The downside of this method is its high cost, because several hundred kilograms of cBN would be required for an electroplating bath with a volume of 1,000 liters. At a current commodity price of approximately 7.50 euros per gram, the cost of the material would quickly rise to several million euros per bath.

To solve this dilemma, Linska designed special baskets for the plating process, which fit around the blade tips. Each basket contains a small quantity of cBN particles, providing a highly concentrated source of the hard material in precisely the place where it is needed, namely at the blade tip. The big advantage is that it considerably reduces the required quantity of the costly cBN. “We have submitted a patent application for this system,” reports Dr. Max Niegl, Senior Manager, Surface Technology, Chemical and Mechanical Processes at MTU in Munich. The process has two advantages: It not only prolongs the service life of the blade tips but also facilitates their repair. In basic terms, this means that the old, possibly damaged protective layer can easily be removed by chemical stripping and replaced. By comparison with the old brazing approach, it will help reduce costs to around one fifth once further improvements have been made. Niegl’s goal is to stabilize the costs of the process by 2013, when the PurePower® PW1500G geared turbofan is scheduled to go into production. A significant milestone along the way will be met when the engine undergoes its first series of tests (the FETT or First Engine to Test stage). Scheduled for mid-2010, they will serve to demonstrate that the first blade tips hardfaced using the new electroplating method are as efficient in an engine as they have hitherto been on the component test rig.

“When all the manufacturing skills for this process in-house represents a huge saving of time and costs,” Niegl adds. If this wasn’t the case, MTU would have to call on the services of Pratt & Whitney or a subcontractor to apply the hardfacing to the tips of the high-pressure compressor blisks airfoils to suit the casing that is being built and coated by the U.S. company. Sending the components over to a coating vendor would take at least one month. “Our aim is to reduce the turnaround time to less than one week,” according to Niegl.

The surface engineer would prefer not to think about the things that could happen if the blades of a high-pressure compressor were not adequately protected. In the worst case, the titanium alloy could burst into flames under the high operating temperatures, an exothermic reaction that is known as titanium fire. According to Niegl this is “a virtually uncontrollable situation, which ultimately could lead to total engine failure.”

Against this background, the MTU engineer’s work also involves flight-safety engineering responsibility. Niegl and his team have an essential role to play in ensuring that the processes they develop are capable of protecting the costly components against the extreme conditions they are exposed to in operation. The challenge is enormous: The centrifugal forces generated during flight operations when the engine is operating at very high speeds can cause the blade tips to come into contact with the casing. As Niegl confirms: “TIP hardfacing, therefore, is a definitive must.”

Pratt & Whitney and MTU are jointly developing a new high-pressure compressor.
Fiber-reinforced materials for future engines

Without the increased use of lightweight and highly robust fiber-reinforced composites the aviation industry will not be able to achieve its ambitious climate targets. Experts all agree on that. The most important representative of this class of materials is carbon fiber-reinforced plastic (CRP). While the manufacture of an aircraft’s structural components, such as wings, fuselage parts and vertical tail fins, from this material is difficult enough, the use of CRP for engine components presents a real challenge.

By Denis Dilba

The reason lies in the extreme temperatures and enormous mechanical stresses to which engines are exposed in operation. This is why fiber-reinforced composites can replace metallic materials only to a limited extent. "Before we select a particular material we have to check whether its use for a given application makes sense from a performance and cost-efficiency perspective," says Dr. Jörg Esslinger, Director, Materials Engineering at MTU Aero Engines in Munich. MTU’s many years of experience in materials engineering help immensely here, according to the expert. "To be able to pick the optimum material you need to have a pretty good idea of the benefit it offers, if its development and classification are to pay off," Esslinger says.

Apart from the performance of new materials, their availability, cost-effectiveness and maintenance costs must be taken into account from the outset. These are high hurdles for fiber-reinforced plastics to clear, especially when compared to metals, which have proven their worth for decades and continue to account for the lion’s share of the materials used in engines. However, despite the qualities inherent in metals and sustained efforts to enhance the efficiency of the materials even more, no further quantum leaps in performance can reasonably be expected, Esslinger explains. New composite materials promise a remedy.

Today, between five and ten percent of the components that make up an engine are manufactured from these composites. "In the next ten years, this share will double," estimates Siegfried Skorski, Esslinger’s colleague and composite materials specialist at Germany’s leading engine manufacturer. The main objective is to reduce the engine’s overall weight, thus cutting down on fuel consumption and CO2 emissions. This is particularly important for new generations of engines, such as the geared turbofan. Says Esslinger: "The additional gearbox offers significant advantages, but adds to the weight of the engine. If we use new materials elsewhere in the engine we can compensate for the weight increase and further improve the overall balance."

Seal carriers made from glass fiber-reinforced plastic protect the metallic part they hold.
Fiber-reinforced composites will not only benefit engines of the future; they have already proven their worth in some production engines or are close to being introduced in production. For example, the rotating nose cone, the fan and the fan casing for the GE9x engine are made of carbon fiber-reinforced plastic. Sikorski: “Composites can also be used for plugs, cable clips, levers or seals.” The fibers used for these parts are considerably shorter than those required for larger components such as the fan blades, so that these parts can be produced using the cost-effective injection molding process. The current temperature limit for fiber-reinforced plastics is around 260 degrees Celsius. In future, the use of optimized resin mixtures to bond the fibers will permit the operating temperature range to be expanded to 300 to 350 degrees Celsius. But that’s about the ceiling for plastics, the MTU expert explains.

Fiber-reinforced ceramics offer a markedly improved high-temperature resistance but practical applications are not in sight as yet. These high-tech materials consist of ceramic fibers which are embedded in a matrix of the same material. Micro-cracks cannot propagate as easily as in normal ceramics; their growth is blocked by the fibers. “This way, the otherwise highly brittle material is rendered quasi-ductile, which makes its failure behavior more predictable,” explains Professor Dr.-Ing. Walter Krenkel of Bayreuth University’s department for ceramic materials. To become a potential alternative to superalloys, fiber-reinforced ceramic materials still need to be further optimized in terms of rigidity, heat resistance, wear properties and service life. Their main advantage lies in the low specific weight. “We are talking about a factor of three as compared with nickel-base alloys. That’s worlds apart in materials engineering,” confirms Dr. Jürgen Göring, an expert for fiber-reinforced composites at the German Aerospace Center (DLR). What’s more, the ceramic materials can cope with temperatures 150 to 200 degrees Celsius higher than the nickel-base alloys can withstand.

MTU had investigated this class of materials as early as the 1990s. “Back then, the manufacturing costs in particular were still too high and the quality achieved was inadequate,” materials expert Esslinger recalls. It was therefore decided to keep track of further developments for the time being. Now that fiber-reinforced ceramics have found their way into the automobile industry, “their production has been brought under control, although component costs remain very high,” Sikorski explains. He believes that the technology will be matured for production use in the engine industry within the next five to ten years and that some metallic materials will gradually be replaced with ceramics. First candidates to be manufactured from the new material will be stationary components, such as casings or vanes.

The effort can only be successful if suppliers and research institutes cooperate more closely and with greater focus, and if they are adequately sponsored, the composites specialist is certain. MTU already plays a major role in pushing developments. Cooperation in the field of fiber-reinforced ceramics already exists with Professor Krenkel’s department, for example, and discussions are underway with the DLR’s materials specialists. “So we are well positioned for the future,” says Esslinger.

In fiber-reinforced ceramics, also known as ceramic matrix composites (CMC), silicon carbide (SiC), carbon (which is counted among ceramic materials here) and aluminum oxide (Al2O3) are used as fibers. The matrix can likewise consist of SiC, Al2O3 or mixtures of Al2O3 and silicon dioxide (SiO2).

During the production process, the fibers are first fixed in place in the component mold. The material is then added using various techniques. In fiber-reinforced ceramics, also known as ceramic matrix composites (CMC), silicon carbide (SiC), carbon (which is counted among ceramic materials here) and aluminum oxide (Al2O3) are used as fibers. The matrix can likewise consist of SiC, Al2O3 or mixtures of Al2O3 and silicon dioxide (SiO2).

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< Inner rings made from carbon fiber-reinforced plastic weigh 60 percent less than conventional rings in a titanium alloy.

Brake disks made from CMC materials are mainly used on luxury-class sports cars.
MTU support for the “flying gas station”

By Bernd Bundschu

They fly anti-terror missions and support humanitarian operations around the globe: The KC-10 Extenders operated by the U.S. Air Force can simultaneously carry troops, cargo and fuel. They are powered by CF6-50 engines, for which MTU Maintenance provides service support. The company is a partner in the U.S. bidding consortium which recently won the contract.

After three and a half years of negotiations, the U.S. Department of Defense finally announced on October 1, 2009 that the contract to maintain the KC-10 fleet had been awarded to Northrop Grumman and its partners—among them MTU Maintenance. The contract has a term of six years (with the option to extend it by a further three years) and is worth a total of 3.8 billion U.S. dollars. “MTU’s share will come to around 500 million U.S. dollars over the initial six-year term of the contract,” says Christoph Heck, Vice President, Marketing & Sales, The Americas. “We will be responsible for maintaining a total of 204 CF6-50 engines, providing depot maintenance, engineering, field service support and engine condition monitoring.” The work will be carried out primarily at MTU Maintenance Canada in Vancouver, though some tasks will also be assigned to MTU Maintenance Hannover.

The McDonnell Douglas KC-10 Extender is a tanker and cargo aircraft that is deployed worldwide under the direction of the Air Mobility Command of the U.S. Air Force. It can simultaneously carry cargo, troops and up to 161.5 tons of fuel. The “flying gas station” can even be refueled in flight, which means that its range is practically unlimited. The KC-10 is powered by three CF6-50C2 engines, which generate 233.31 kilonewtons of thrust each. Heck continues: “In the past it was the manufacturers—General Electric and Boeing—who maintained this fleet of aircraft and engines, which are now at least 20 years old.” Boeing had taken on responsibility for airframe maintenance in 1997 when the company acquired its smaller competitor McDonnell Douglas. “When the new invitation to tender was issued in June 2006, Northrop Grumman decided to enter the race and began looking for partners to maintain the CF6-50 engines.”
MTU has demonstrated superb expertise in maintaining this engine type, the company having repaired and overhauled a total of 1,400 CF6-50 engines at its maintenance locations in Vancouver and Hannover since 1981. To prepare the bid for submission to the U.S. Air Force a special team was set up, which was composed of employees from both Vancouver and Hannover. “That was a fantastic example of sales, engineering and production teams working together at different locations,” recalls Daniel Watson, Chief Commercial Officer at MTU Maintenance Canada. “The team was particularly successful in ensuring that we leveraged MTU’s extensive engineering and repair capabilities. Additionally, our history of delivering CF6-50 engines for our commercial customers with world-class performance and on-wing times was highly appreciated by the Air Force.”

The contract award was initially scheduled for 2008, but the decision was pushed back several times as a result of intensive contract reviews. “The reason the contract was scrutinized so closely is that a number of U.S. Air Force orders have recently had to be canceled as a result of government audits,” Watson explains. Northrop Grumman and its partners, which also include Chromalloy and AAR Corporation in the United States, were ultimately awarded the contract to maintain the KC-10 Extender because they had submitted the most appealing overall concept. One of the promises that Northrop Grumman made to set up a special shop in Louisiana to maintain the KC-10 aircraft.

Induction of the engines is now being supervised by a cross-location project team. The work will be split between the Vancouver and Hannover locations. All the CF6-50 engines of the KC-10 tankers are delivered to MTU Maintenance Canada, based in Richmond, to be stripped and inspected. Once component repair has been carried out—on activity that is performed in collaboration with MTU Maintenance Hannover—assembly and testing are again carried out in Canada. Ralf Schmidt, President and CEO of MTU Maintenance Canada, expects around 40 shop visits a year during the initial contract term of six years. According to Schmidt, adherence to the contractually agreed turnaround times will be an important criterion for an extension of the contract. “The U.S. Air Force has high expectations regarding turnaround times and requires us to continuously improve our performance. This will certainly not be easy, but our team is well prepared and has the necessary experience to rise to the challenge.”

The CF6 is a two-spool turbofan engine for medium- and long-haul wide-body aircraft. MTU has been a partner in this General Electric engine program since 1972, manufacturing components for the turbine and compressor. One of the first additions to the CF6 engine family was the CF6-50 for the Airbus A300, Boeing 747 and McDonnell Douglas DC-10/KC-10. The three-engine KC-10 Extender took off for its maiden flight on July 12, 1980. Between March 1981 and April 1990, McDonnell Douglas delivered a total of 60 units to the U.S. Air Force. Presently, 59 of them are still in service, with 32 stationed at McGuire Air Force Base in New Jersey and 27 at Travis Air Force Base in California.

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Engine maintenance in Canada

MTU Maintenance Canada is the North American member of the MTU Maintenance network of companies, the world’s largest independent provider of commercial engine services. The company was founded in November 1998 as a joint venture with Canadian Airlines (since acquired by Air Canada). MTU Maintenance Canada became a wholly-owned subsidiary of MTU Aero Engines in 2003. The MTU Maintenance shop is located in Richmond, British Columbia, in close proximity to Vancouver International Airport and employs a staff of around 170 people. This is where General Electric CF6-50 and CFMI CFM56-engines are inspected, repaired, overhauled and tested. The company repairs accessories and also offers LRU (Line Replaceable Units) management services, arranging for the repair of all units replaced within the scope of day-to-day flight operations.
Very few fighter jets have proved as enduring as the McDonnell Douglas F-4 Phantom II. Even its designers probably never dreamed that around 500 of these aircraft would still be in service more than 50 years after the fighter first took to the sky. Back in the early 1960s, MTU Aero Engines began manufacturing General Electric’s J79 engine under license. Now the company is doing its bit to keep the F-4 Phantom II flying well into the next decade, retrieving usable or repairable spare parts from J79s ex-aircraft parked in the desert.

By Patrick Hoeveler

The F-4 is in service all around the world, and some of these aircraft have notched up a very impressive 10,000 flight hours. However, neither the airframe, nor the J79 engine manufactured by General Electric were originally designed to fly for so long. There are only a few suppliers left these days, and the manufacture of new parts has practically come to an end. As a result, it is becoming increasingly difficult to maintain the almost legendary engine, of which, near 17,000 units were produced. Phantom operators have repeatedly asked GE to resume manufacturing spare parts, but since production ceased a long time ago, that would involve significant relaunch costs. Consequently, a different solution was required, and was indeed found in the desert, or, more precisely, in the U.S. state of Arizona.

The U.S. Armed Forces store their disused materiel at Davis-Monthan Air Force Base near Tucson. The dry climate and hard ground make the site an ideal location for the 309th Aerospace Maintenance and Regeneration Group (AMARG). Hundreds of Phantom jets are stored there, wingtip to wingtip, and the desert base is also home to around 800 J79 engines, some of which are known to have flown very few hours since their last overhaul. It therefore seemed an obvious solution to use the best of them for spare parts. GE set about finding a partner for the job, and issued an invitation to tender in February 2008. MTU Aero Engines was ultimately awarded the contract—thanks to the company’s superb overall service package and global market presence.

Mutalle Ulucay, who is responsible for J79 business development at MTU, says: “We’re a one-stop shop for our customers, offering everything, including modifications and repairs. Our reconditioned parts are as good as new, and meet or even exceed all the technical specifications laid down by the U.S. Air Force.”
The containers are carefully opened and the engines removed and inspected.
“A professional, constructive and reliable partnership” is how André Sinanian, CF34 Program Director at MTU Maintenance Berlin-Brandenburg, describes his company’s business relationship with Adria Airways. The airline was the first customer to have its CF34 engines maintained by the Ludwigsfelde-based company after the shop in 2002 became the world’s first independent MRO provider to obtain a license from General Electric for the repair and overhaul of the CF34 family of engines. The exclusive deal now inked to also cover the airline’s CF34-8s represents another major boost for the cooperation.

The new fly-by-hour contract for the CF34-8C5 fleet was signed in March this year. Apart from comprehensive maintenance services, it also covers on-site support by the CF34 Mobile Repair Team and the provision of spare engines. “We are currently providing support for the 15 CF34-3s powering Adria Airways’ Bombardier CRJ200 regional jets, as well as for the ten CF34-8s for their 90-seat CRJ900s,” Sinanian states.

Adria Airways, Slovenia’s national airline, was founded as a charter carrier in 1961. In the 1980s, it began offering scheduled flights and became a member of International Air Transport Association (IATA). Today, the company primarily serves scheduled flights to more than 25 European destinations from its base in Ljubljana. Its fleet of aircraft notches up 250 flights a week, and its charter flight offerings vary according to season and primarily include destinations in the Mediterranean area.

The origins of the successful collaboration between Adria Airways and MTU date back to the 1990s when the airline placed its first order with another MTU affiliate, MTU Maintenance Hannover. “Adria was the first customer to send the V2500 engines powering its A320s to our shop for maintenance,” recalls Andreas Kalina, Vice President, Marketing & Sales Europe/Middle East/Africa at MTU Maintenance Hannover. The Slovenian airline was also one of the first to fly the CRJ-100 and CRJ-900 regional jets. Adria Airways now comprises a total of 12 aircraft: one Airbus A320, six Bombardier CRJ200, one CRJ100 and four CRJ900 regional jets. Adria Airways maintains a number of long-standing partnerships with European airlines, in particular with the German carrier Lufthansa, and joined the Star Alliance network as a regional member in December 2004. In January 2010, Adria transitioned to full Star Alliance membership.

Kalina and Sinanian both agree that cooperation with Adria Airways is very constructive: “It has been a pleasure for us working with the same people for so many years. That is one of the key reasons why we expect this successful partnership to thrive for many years to come.”

MTU Maintenance Berlin-Brandenburg provides service support for the entire CF34 family.

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For interesting multimedia services associated with this article, go to www.mtu.de/110CF34
Roaring through the desert at 1,000 mph

By Andreas Spaeth

Already a spectacular performer in the skies, the EJ200 engine powering the Eurofighter Typhoon is now set to become one on terra firma as well. Next year, British fighter pilot Andy Green wants to set a new land speed record with his supersonic vehicle Bloodhound SSC, accelerating from 0 to 1,000 miles per hour in 40 seconds. And, the car being powered by EJ200 engines, he might just succeed. In Britain, this latest attempt at the land speed record is part of an official mission to inspire young people to pursue careers in technology and engineering.

Speed records have always had a special fascination for the British. “Britain has held the record for a quarter of a century,” explains Andy Green. “This country has held the World Land Speed Record for longer than any other country put together, since the first record was set in 1898.” A Royal Air Force fighter pilot with decades of experience on missions all over the world, he currently works for the British Ministry of Defense (MoD). What he doesn’t mention is that he himself has held the world land speed record since October 15, 1997. He broke the record in his ThrustSSC vehicle in the Black Rock Desert of Nevada, achieving an incredible speed of 763 mph and becoming the first human being to break the sound barrier on the ground. In the long history of land speed records, which has been dominated by British and American drivers, his achievement stands out because he topped the previous record by a staggering 130 mph, or more than 20 percent—the biggest-ever margin since land speed record attempts began. But Green is fully aware that his success won’t last forever; at least three teams have been hot on his heels for years. In his own words: “There’s nothing quite like the promise of losing it—or actually losing it—to keep us focused on getting the record back... and we’re not going to let it go without a fight!”
The EJ200 engine, which powers the Eurofighter Typhoon, in a pole position.

At the moment, Green is fighting a campaign of epic proportions to shake off his pursuers by setting a phenomenal new record. The attempt is likely to take place next year on a stretch of dried-up salt bed in the northwest of South Africa. In a unique vehicle made of titanium and carbon fiber, Green plans to top his existing record by more than 31 percent. “The target... is to get as close as possible to 1,000 mph, and exceed that figure if we can,” explains Ron Ayers, a veteran engineer and chief aerodynamicist for the project. He also coined the name of the project—Bloodhound—and chief aerodynamicist for the project. He was a former race car driver, is clear: “Drayson wanted a new iconic project with science and technology school projects, and the attempt at the record, in conjunction with science and technology school projects, is designed to drum up enthusiasm for science and technology. Drayson describes the task they have set themselves as “certainly a formidable challenge”: “When we commenced the Bloodhound SSC project, it was clear that, if we were to make a really big increase on top of the 763 mph achieved, something radically different was needed.” No one on earth has ever got anywhere close to reaching the 1,000 mph mark. Even the official air speed record at low altitude (which is no longer competed for) is only 994 mph. “For that reason we are exploring the potential of jet + rocket combination,” says Ayers. Lord Drayson, then Minister for Defense Equipment and Support, agreed to support their plans.

Drayson supplied the team with three EJ200 engines that had flown in flight testing of the Eurofighter Typhoon and didn’t have many flight hours left, according to Mark Chapman, Senior Design Engineer at Bloodhound SSC. The necessary thrust could have been achieved with just two EJ200 engines, but then the air intake would have been too big. The original concept had called for a twin-rocket configuration, but would not have allowed sufficient control of the thrust. You can only start the rocket cycle with the push of a button, whereas the engines can be carefully controlled using a throttle pedal, according to the chief engineer.

What Chapman particularly likes about the EJ200 is the fact that all its parameters are monitored automatically. The EJ200 will initially accelerate the Bloodhound from zero to 80 mph, then the afterburners will be activated, kicking in at 130 mph. At 320 mph, Green will ignite the Falcon rocket, its impact being felt from around 440 mph onwards. The equivalent of almost 135,000 horsepower, or 1,800 compact cars, will catapult the vehicle to its maximum speed of 1,050 mph. That’s about the length of four football pitches per second and, depending on the temperature, around 1.4 times the speed of sound. After that it’s up to the airbrakes, parachutes and wheel brakes to slow the vehicle down. By the time it comes to a standstill, the Bloodhound will have covered a whole of ten miles—in just 85 seconds. That’s the theory anyway. In practice, no one has any idea how the vehicle will behave at speeds this high. “That’s unknown territory,” says Chapman.

A powerful engine

Eurojet’s EJ200 is an innovative two-spool turbofan that powers the Eurofighter Typhoon in pairs. “The engine was specially designed with interceptor missions in mind and reaches its maximum output at Mach 1.8 and an altitude of 11 kilometers,” says Klaus Günther, EJ200 Program Director at MTU in Munich. Germany’s leading engine manufacturer supplies the low-pressure and high-pressure compressors for this powerhouse, as well as its electronic control and monitoring unit.

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www.mtu.de/110Bloodhound

Repar of the EJ200 engines is performed at MTU in Munich.

For further information on the article, go to
www.mtu.de/110Bloodhound
Gold award for MTU Aero Engines

MTU Aero Engines has achieved gold status, the highest level in the supplier rating program of Pratt & Whitney’s parent United Technologies Corporation (UTC). The UTC Supplier Gold Award is given every year to select suppliers and partners. The criteria used to evaluate suppliers include superior quality and delivery performance, and customer satisfaction.

The award presentation took place at MTU in Munich in early March. It was part of a ceremony witnessed by senior Pratt & Whitney Canada and MTU officials to celebrate a major milestone: the delivery of the 5,000th low-pressure turbine for the PW300 and PW500 series of engines. MTU holds stakes of up to 25 percent in these two programs, the propulsion systems power mid-size to large business jets.

MTU CEO Egon Behle (left) and Pratt & Whitney Canada President John Salesas during the award presentation ceremony.

New representation offices in the U.S. and in China

MTU Aero Engines has two new representation offices: The Shanghai office, which was opened early this year, is managed by Melody Liu, whose job it is to coordinate the company’s various activities in China. In Atlanta in the U.S. state of Georgia, Dr. Rainer Fink and his team market the full range of maintenance services offered by MTU Maintenance. Atlanta was picked as the location for the new office due to its proximity to the home bases of all airlines, leasing companies and other major industry players in North and Central America.

Republic Airways bets on geared turbofan

New contract win for the geared turbofan: Republic Airways has signed a purchase agreement with Bombardier for 40 CSeries aircraft and has taken options on up to 40 additional jets. The twin-engine airliner is exclusively powered by Pratt & Whitney’s PurePower® PW1000G engine. MTU Aero Engines has a major stake in this innovative, next-generation propulsion system. The overall contract covers more than 160 engines, for Germany’s leading engine manufacturer, it could translate into sales of over 200 million euros at list price.

Fiscal 2009: business results fully in line with forecasts

Last year was not an easy one for MTU Aero Engines. “The global economic and financial crisis, coupled with the persistently strong euro and reviving oil prices, has left its marks on our industry,” summed up Egon Behle. At the company’s annual press conference held in late February MTU’s Chief Executive Officer presented the results for fiscal 2009 and explained: “I am delighted that MTU achieved a solid performance in 2009, meeting all quantitative targets. We have laid the foundations for a stable development in this year.”

MTU has fully met its business forecasts for the financial year 2009: The company’s revenues amounted to around 2.6 billion euros and the EBIT adjusted to 292.3 million euros, which is slightly higher than the upwardly revised forecast of approximately 290 million euros. Net income amounted to 14.0 million euros and, at 120.2 million euros, the free cash flow was 20 percent higher than the 2009 guidance.

MTU CEO Egon Behle (left) and Pratt & Whitney Canada President John Salesas during the award presentation ceremony.

Jetstar Airways buys V2500

MTU Aero Engines benefits from a big contract placed by Australian Jetstar Airways. The wholly-owned Qantas Airways subsidiary has ordered International Aero Engines (IAE) V2500 engines and concluded a contract for after-sales services. The total value of the deal will be around 2.5 billion euros. Since MTU has a stake of approximately 11 percent in the V2500, its share in the business will amount to some 270 million euros.

Jetstar Airways has selected the V2500 to power a new fleet of 50 additional A320 family aircraft, and has taken out options on engines for another 40 aircraft. In addition, the airline has concluded an IAE aftermarket services agreement covering these engines, plus those installed on 44 V2500-powered A320s from the current fleet.

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