AEROREPORT 02|18

The aviation magazine of MTU Aero Engines I www.aeroreport.de

Charged up

Electric aircraft: first hybrid, then fully electric?

TECHNOLOGY
Fiber ceramics: Lightweight, temperature-resistant, robust

MARKET
Widerøe – Not so far away in Norway

EXPERTISE
Interview with Klaus Richter, President of the German Aerospace Industries Association

DIGITAL TRANSFORMATION PROGRAM

MTU is looking for Digital Transformation Managers (m/f) who want to shape the future of aviation. Are you an experienced, hands-on kind of person with an in-depth understanding of business processes? Are you passionate about innovation? Do you want to take responsibility and join a great workplace? Lastly: Are you fascinated by one of our missions? If so, we look forward to receiving your application!

digitalexperts.mtu.de

Dear readers,

Is aviation on the cusp of a revolution in propulsion technology? It's safe to say that aircraft will continue to run on kerosene for some time yet—but consuming far less than they did a few years ago. Compared to the engines of the early 2000s, the PW1000G geared turbofan family consumes up to 20 percent less fuel, thus playing a major role in the carbon-neutral growth of this booming industry. After all, a 20 percent drop in fuel consumption also means one-fifth fewer greenhouse emissions. In Germany, for instance, the German Environment Agency calculates this as some 100 kilograms less CO_2 per citizen, based on each person flying an average of four hours a year. And geared turbofan technology has by no means exhausted its potential, which is why MTU Aero Engines is already working on the next generation.

If we want to drastically reduce emissions from air travel however, in roughly 20 years there will be no getting around alternative propulsion concepts for aviation. It really comes down to the energy required for propulsion, which can be generated by non-fossil fuels or electricity instead of by fossil fuels. Technology pioneers all over the world are pondering suitable concepts.

I hope you enjoy reading this issue!

So far the focus has been only on small aircraft, but a 19-seater aircraft powered by a hybrid-electric drive is expected to take to the skies by the year 2021. This is what Siemens, RUAG Aviation, MTU Aero Engines and the German Aerospace Center (DLR) have joined forces to test using the robust Dornier Do 228.

Unlike trains, which can be supplied with electricity during the journey by way of overhead lines, aircraft must have the requisite electrical energy stored on board or generate it during flight—a technical challenge for all involved. Another factor here is the market: airlines will buy hybrid-electric aircraft only when they see a tangible economic advantage.

All these facets of the revolution in aviation are discussed in the cover story of this issue of **AERO**REPORT. We also introduce Norwegian regional airline Widerøe, the launch customer of the Brazilian Embraer E190-E2; the model is powered by the PW1900G engine in which MTU has a 15 percent share. And we report on the textiles used in aviation, a new milling technique and 20 years of MTU Maintenance Canada.

Michael Schreyögg
Chief Program Officer

COVER STORY

Charged up

Electric propulsion is set to revolutionize aviation. And in the long run it will—with particularly good prospects for hybrid aircraft. But for now, getting large passenger aircraft off the ground will continue to be a job for gas turbines.

page 8

MARKET

Not so far away in Norway

It all started in 1934, when Widerøe flew seaplanes to connect Norway's farthest-flung communities with its cities. Scandinavia's largest regional airline is now the first in the world to fly the improved Embraer E2 jets with PW1900G engines.

page 14

MARKET

20 years and 1,100 engines

Over the past two decades, MTU Maintenance Canada—a wholly owned subsidiary of MTU Aero Engines—has overhauled more than 1,100 engines in its shop. "We're very proud of our long success streak," says Managing Director Helmut Neuper.

page 24

CONTENTS

TECHNOLOGY

Fire-resistant and lightweight

Fabrics for seat covers, safety belts and carpets used in aircraft must be flame-retardant and lightweight. In the future, explosion-proof luggage bags and self-illuminating ceiling upholstery made from high-tech textiles may find their way into the cabin.

page 34

TECHNOLOGY

Fiber ceramics take off

"Humans have thousands of years of experience working with metals, but with CMCs, we're only just beginning," says Katrin Schönfeld, Fraunhofer IKTS. Why are they being tested? In engines, CMCs have the potential to reduce weight, optimize combustion and raise efficiency.

page 38

EXPERTISE

Every aircraft in the world has tech made in Germany

German suppliers are a major part of the aerospace industry ramp-up, yet they can hold on to this strong position only through innovation and collaboration in research and production, says Klaus Richter, president of the German Aerospace Industries Association.

page 42

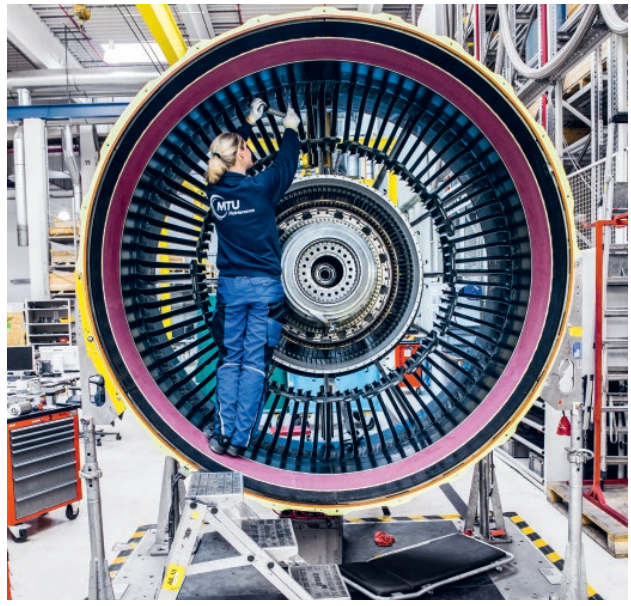
www.aeroreport.de

All articles from the print edition are also available online at www.aeroreport.de, optimized for smartphone and tablet. There you find informative videos, photo galleries, zoomable images and other interactive specials too.

MTU Maintenance set for expansion

MTU Maintenance reported a record-breaking number of shop visits of more than 1,000 in 2017. To keep pace with the continuous growth in maintenance for commercial aviation engines and industrial gas turbines, the company plans to expand capacity by 50 percent by 2027. For this reason, the MTU Maintenance Berlin-Brandenburg location laid the foundations for a new logistics center in August 2018. At 100 meters in length, 50 meters across and up to 16 meters in height, it will be the largest building on site, offering space for about 100 employees with more in the pipeline. Scheduled to open in June 2019, the logistics center will pool all functions of a state-of-the-art supply chain.

And by 2021, capacity is to expand by 50 percent at MTU Maintenance Zhuhai, too, where the company expects to have up to 450 shop visits a year. Plans are also in full swing at the Richmond location near Vancouver, Canada. June 2018 saw the first successful shop visit for the V2500; as many as 40 shop visits are planned for next year.



Cornerstone laid for EME Aero maintenance shop

Cornerstone laid in Poland's Aviation Valley: right now near the Rzeszów airport, one of the most modern maintenance companies in the aerospace industry is being set up. EME Aero (Engine Maintenance Europe) is a joint venture of Lufthansa Technik and MTU Aero Engines. After closing on the site purchase in spring 2018, the JV reached a further milestone when it laid the cornerstone for the facility on September 28 of this year. Derrick Siebert, CEO of EME Aero, says: "We're very happy to have taken a giant step forward in the maintenance of a completely new generation of commercial engines here in Europe." The company specializes in the maintenance of the PW1000G engine series, which flies the Airbus A320neo family and others.

EME Aero is expected to go into operation in 2019 at its location in the town of Jasionka in the Polish province of Podkarpackie. By that point, the JV partners will have invested a total of some 150 million euros in the region. The goal is to continuously expand the workforce until it reaches about 1,000 people in 2026, and to ready the location to handle a minimum of 450 shop visits per year. The site will include a cutting-edge factory building, an administrative building and sufficient test capacity. "Here in Poland's Aviation Valley, with its excellent transport connections, we have the optimum infrastructure for our new MRO company," Siebert says.

Outstanding knowledge

This year, MTU Aero Engines presented the annual Wolfgang Heilmann Award to student Martin Wirth. As part of his master's thesis, the 28-year-old worked on a simulation model to test and optimize fuel injection in engine combustion chambers. In deriving a new, hybrid fluid model from the existing simulation model, Wirth showed how biofuels can be burned cleanly and efficiently to produce energy in the air and on the ground. Dr. Gerhard Ebenhoch, Director Technology Management at MTU, presented the award and praised Wirth's work: "His results forge a path for further research into the use of alternative fuels."

The prize is endowed with 1,500 euros and is awarded annually as part of the German Aerospace Congress (DLRK) to up-and-coming academics who are researching aviation propulsion at the Karlsruhe Institute of Technology (KIT). The institute and MTU share a long and very successful history of collaboration in technology development, the results of which flow into important MTU future projects.

700 kilometers for a good cause

Four days, four stages, 700 kilometers: 50 people (49 men, 1 woman) took part in MTU's "Plant to Plant Challenge" (P2P), cycling from MTU Maintenance Hannover to the company's headquarters in Munich.

Inspired by Pratt & Whitney's charity bike ride, which has already been held successfully several times, the P2P bike ride was the first such event organized by MTU in Germany. Each cyclist raised 10 cents per kilometer to go to various charity organizations-this amounted to 70 euros per participant, and some 3,500 euros for the whole group. MTU chipped in as well to bring the grand total to 6,000 euros. Besides aiding a good cause, the event was intended to bring MTU and its partners together: employees of Pratt & Whitney Canada and Pratt & Whitney USA flew across the Atlantic specifically for the charity ride.

Charged up

Electric and hybrid propulsion systems are set to revolutionize aviation. But for now, large passenger aircraft will continue to rely on conventional engine technology.

Text: *Dennis Dilba*

E-Fan X ——— *Initially, just one of this prototype's four engines will be replaced with an electric motor.*

Starling Jet ——— *This prototype from start-up Samad Aerospace has a range of up to 2,400 kilometers.*

"This opens the door to a new era in aviation."

Dr. Frank Anton
Head eAircraft Siemens

Munich central station in the year 2037:

Below ground, the new, ultrafast regional trains come and go at five-minute intervals. Up on the station's flight deck, electro-hybrid jets with a range of up to 1,000 kilometers serve destinations in Germany and neighboring countries. Meanwhile, at Munich's airport to the northeast of the city, the only connections on offer are long-haul routes to European and transcontinental destinations. Is this science fiction, or something not far from reality?

Flying is getting more popular all the time. And according to virtually every forecast, this trend is set to continue in the years to come. For instance, in its Global Market Forecast 2018, Airbus expects there to be a demand for 37,390 new aircraft over the next 20 years. The European aviation heavyweight predicts that by the end of the year 2037, the current global fleet of 21,453 aircraft will grow to at least 48,800-in other words, it will more than double.

On the one hand, rapid growth is good for business; on the other it represents a massive challenge for the industry and a huge responsibility: without significantly more efficient technologies, aviation's share of global CO_2 emissions will quadruple from the current two percent to more than eight percent by the middle of the century. The electrification of aircraft is one answer to this development, says Dr. Frank Anton, head of the Siemens eAircraft division.

Hybrid-electric prototype already under construction

However, the 62-year-old physicist isn't thinking about purely electric aircraft: together with partners such as Airbus, he wants to install a production hybrid-electric powertrain in a 100-seater regional aircraft and perform a test flight. Dubbed "E-Fan X," this is the largest electro project for commercial aircraft to date. "This opens the door to a new era in aviation," Anton is sure. In this "Toyota Prius of the skies," a kerosene-powered gas turbine in the fuselage drives an electric generator. The turbine can continuously operate within its ideal speed range, which saves fuel. Electricity from the generator powers the electric motors for the rotors. In this way, the necessary thrust can be distributed among several small electric motors driving propellers on the wings or tail. This in turn dictates new forms in aircraft design and should lead to improved aerodynamics.

Depending on safety requirements and on where the aircraft are to be used, such hybrid-electric aircraft would be fitted with a larger or smaller additional battery, Anton says. "The turbine and the generator can be made large enough that they produce sufficient electricity for cruising flight. During the energy-intensive takeoff and ascent, electricity from the batteries provides extra thrust." Fitting a slightly larger turbine would make it possible to recharge the virtually empty batteries in flight. The hybrid technology also makes an additional, elegant charging option possible: during descent, the air current can drive the propellers and hence the electric mo-

Zunum Aero ——— *The start-up expects to launch its nearly 16-meter hybrid jet on the market in four years' time.*

tors, which then operate as generators to charge the batteries-similar to how a hybrid car recuperates braking energy on downward gradients.

The world's first production hybrid concept for aircraft was unveiled in 2011. Anton was one of the people who worked on the redesigned two-seater DA36 E-Star power glider made by Austrian manufacturer Diamond Aircraft. Now, the E-Fan X is to provide an opportunity to more closely examine the potential for using hybrid propulsion in larger aircraft. This starts with replacing just one of the four engines on the BAe 146 test aircraft with a two-megawatt electric motor. Anton says this is enough to test efficiency. A second hybrid unit will be added after a successful first test. "We expect to see significant fuel savings in the double-digit percentage range as well as a massive reduction in noise." A passionate pilot and flying instructor, Anton predicts that by the year 2035, hybrid-electric aircraft will be transporting up to 100 passengers over distances of 500 to 1,000 kilometers.

The need for at least a 20 percent drop in fuel consumption

It will be interesting to see whether aircraft with such propulsion systems can offer a genuine economic advantage, says Prof. Mirko Hornung, Executive Director Research and Technology at research institution Bauhaus Luftfahrt in Munich, who has been looking into the potential of hybrid aircraft for years. It's not as if the aviation industry has been idle up until now, says Hornung: billions are invested every year in developing more efficient technologies. "On average, each new generation of aircraft uses 15 percent less kerosene than the previous one," Hornung says. "Hybrid aircraft concepts must offer fuel savings of at least 20 percent, and ideally more." Hornung's experience tells him that the final efficiency payoff is always a few percentage points short of the initial estimate. And that's the danger: "If hybrid aircraft can't deliver at least 15 percent, no airline will buy them."

Hornung warns against too much hype for hybrid aircraft: giving them electric motors, batteries and gas turbines with generators effectively means giving them the power they need three times over, which will make them heavier. "Can the aerodynamic advantages of distributed electric motors really offset a weight drawback of this scale? There is as yet virtually no reliable data on this," Hornung says. A project such as E-Fan X, which lays bare the fundamental problems of hybrid propulsion and brings greater certainty to the discussion, is in his view the right way to go.

Hybrid jet for regional routes by 2022?

Ask Zunum Aero, however, and it seems that all questions have essentially been answered: the U.S. start-up from Kirkland, a suburb of Seattle, is aiming to get its hybrid jet for 12 passengers onto the market by 2022. Measuring almost 16 meters in length, this small aircraft's two 500-kilowatt electric motors should allow it to reach a speed of 550 kilometers per hour and give it a range of 1,130 kilometers.

Through fuel savings and lower maintenance costs for the more straightforwardly installed electric motors, Zunum expects a 40 to 80

"Hybrid aircraft concepts must offer fuel savings of at least 20 percent, and ideally more."

Professor Dr.-Ing. Mirko Hornung
Executive Director Research and Technology, Bauhaus Luftfahrt e.V., and Professor of Air Transport Systems and Aircraft Design at the Technical University of Munich

Booming industry
New start-ups all around the world plan to take the aviation business to new heights with their electric aircraft prototypes.

Ampaire
With two versions of its TailWind™ model, the U.S. company is moving into electric flight.

EVIATION

Eviation
The Israeli company focuses on fully electric aircraft and has already developed two prototypes.

SAMAD aerospace

Samad
Based in the UK, the company develops prototypes for hybrid and fully electric aircraft. Starling Jet, its hybrid prototype, is scheduled to go into production in 2024.

JOBY AVIATION

Joby Aviation
Engineers at the U.S. company are developing the first prototype of an eVTOL–an electric aircraft that can take off and land vertically.

percent reduction in operating costs and a 75 percent drop in noise compared to conventional aircraft. "This would get around the ban on night flights, which would make operation more profitable," says Zunum's head of marketing Sandi Adam. The start-up's big break is the significant cost advantage it hopes to achieve. "In the United States, many of the aircraft in use for regional routes still use entirely inefficient technology from the 1960s," Adam says. The old planes are burning money, which is why the airlines are open to the notion of replacing their fleets. California-based charter airline JetSuite actually announced at the end of May that it intends to purchase up to 100 of Zunum's small hybrid aircraft. Adam also sees good sales opportunities in many other countries, estimating the overall size of the global regional aircraft market at a trillion USD.

No doubt this figure is also what won over Boeing's venture capital division, Horizon X: together with JetBlue Technology Ventures, Boeing bought a stake in the start-up almost a year ago. But no details have been released as to the extent of the investment or the battery technology being used. The latter in particular gives experts like Hornung cause to doubt that the version that is scheduled to take off four years from now can be anything more than a prototype. Zunum's CEO Ashish Kumar is very optimistic and also sure that we can expect great advances in batteries in the future. He foresees that by the year 2035, his hybrid jet will have a range of some 2,400 kilometers. "Perhaps we will be able to do away with the gas turbines and the power generator altogether," Kumar says. Dr. Jörg Sieber, who is in charge of innovation management at MTU Aero Engines, is skeptical: although batteries are getting better bit by bit, there's been no discernable breakthrough in the technology.

The industry is changing

"For flight operations, batteries must be at least five to ten times more powerful than they are today," Sieber says. He is currently working with partners including Bauhaus Luftfahrt and Airbus to test the pros and cons of electric and hybrid-electric flight. "Of course we want to know when the technologies are ready for market, so that we are then in a position to offer the relevant propulsion systems." Sieber agrees that electrification offers new freedoms in aircraft design, but he feels that at present, purely electric propulsion is an option only for lightweight motor gliders, sport aircraft or short-range air taxis. As for an electro-jet for 180 passengers with a range of 540 kilometers, which the California start-up Wright Electric has promised low-cost airline easyJet for 2027, Sieber doesn't think it will happen. He also considers the schedule set by Norway's state-owned airport operator Avinor to be vastly ambitious: from the year 2040, all domestic flights are to be purely electric. Nevertheless, the coming year will see the first electric aircraft prototypes take to the skies, Sieber says.

This has been announced by a host of start-ups, including Eviation from Israel, Ampaire and Joby Aviation from the United States and Samad Aerospace from the UK. Exactly when their small electric aircraft get off the ground and how far they then fly remains to be seen, says Sieber. "But we already know today that the road to commercial applications is a very long one-even for hybrid-electric flight. When it comes to aircraft the size of the Airbus A320, we'll still be seeing traditional gas turbines even in the year 2050," Sieber says. But they will be much more efficient: "For the geared turbofan, which we have just launched on the market, further refinements are bound to yield improvements in fuel consumption of 10 to 15 percent," Sieber says. Further efficiency improvements for air-breathing engines put new kinds of cycle processes on the horizon, such as the composite cycle. This pioneering concept uses piston machinery and allows for superb pressure ratios of over 300, compared to a mere 60 for the latest turbofan engines. The result: 15 percent lower fuel consumption and a 10 percent drop in NO_x emissions.

Sieber says that everyone in the industry knows increasing electrification will change aviation over the coming decades. "That's exactly why we're closely monitoring the developments and preparing for them."

But there's no reason to expect the aviation industry's challenges to be resolved overnight. "We won't be able to meet any climate goals," Sieber says, "without additional and far-reaching investment in more efficient engines and aircraft systems and also sustainable fuels."

Inside MTU ___ *Development of hybrid-electric powertrain*

Together with Siemens, Swiss aerospace company RUAG and the German Aerospace Center (DLR), MTU Aero Engines intends to venture into development of hybrid-electric powertrains. A Dornier Do 228 is to serve as tester for exploring the potential; a hybrid-electric version is to take to the skies in 2021. The four partners are hoping to test the electric propulsion systems with a short purely electric flight in 2020, and together they have the necessary industrial and scientific expertise for the job.

Model Do 228 ___ *What a model with a hybrid-electric powertrain might look like.*

Hybrid-electric engines ___ *Siemens, RUAG, the German Aerospace Center (DLR) and MTU Aero Engines are venturing into the development of hybrid-electric powertrains. They will test the concept on the Dornier Do 228, with a hybrid-electric version set to take to the skies in 2021.*

"We won't be able to meet any climate goals, without additional and far-reaching investment in more efficient engines and aircraft systems and also sustainable fuels."

Dr. Jörg Sieber
Head of Innovation Management, MTU Aero Engines

Do you have any questions, requests or suggestions? Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Denis Dilba holds a degree in mechatronics, is a graduate of the German School of Journalism, and founded the "Substanz" digital science magazine. He writes articles about a wide variety of technical and business themes.

Not so far away in Norway

Norway is the longest country in Europe. Regional airline Widerøe is crucial to keeping the country connected. Its fleet now features new E2 jets.

Text: *Andreas Spaeth*

Norway is the land of seafaring pioneers, polar explorers and fjords–that's its image to the world and among Norwegians themselves. Yet it is also a major country for air travel, mostly due to necessity. Measuring 2,500 kilometers from the Oslo Fjord to the Arctic Ocean bordering Russia, Norway is not only the longest country in Europe, but given the fjords and mountains that crisscross its landscape, it is also one of the most difficult to traverse by land. For a long time, the sparsely populated northern reaches in particular were virtually cut off from the capital city of Oslo and other population centers in the south. Mailboats, which used to be the only type of transportation, needed several days to travel from the arctic Finnmark down to Bergen. But Norwegian regional air service has slowly been coming into its own since 1934, when five friends joined together to found the Widerøe airline. Its planes were fitted with floats instead of landing gear, and for decades their operations were limited to places that had enough water for takeoff and landing.

Widerøe – It all began with a two-seater biplane

February 19, 1934
Founded by five friends near Oslo as Widerøes Flyveselskap AS. One of them is Viggo Widerøe, the company's namesake. At the start, most of the flights were made with the de Havilland Moth, a two-seater biplane.

1936-1939
Widerøe flies mostly five-seater Stinson Reliant seaplanes.

1946
After the war, the airline acquires two four-seater Messerschmitt Taifuns for commercial passenger flights; these aircraft remain in service until 1954.

1949
With the ten-seater Noorduyn Norseman seaplane, of which Widerøe operates a total of 16 up until 1960, passenger traffic begins to really take off.

1954
Seven de Havilland Canada Otters form the backbone of the fleet. These 13-seaters with floats fly until 1971.

1956
Widerøe begins flying a 20-seat Junkers Ju 52 on scheduled flights.

1962
With the DC-3 and the Nord 262, for the first time Widerøe operates larger aircraft with up to 26 seats.

From water to the sky and back

Even after World War II, Norway still had hardly any permanent airfields. For this reason, air travel first began from the water, primarily with the Noorduyn Norseman, a single-engine Canadian bush plane for ten passengers. Widerøe started its post-war service in 1949 with the Norseman before switching to the more modern DHC-3 Otter. The Otters flew in Norway until 1971; by then, enough airports were equipped with short takeoff and landing (STOL) runways that Widerøe could switch to the robust DHC-6 Twin Otter, a larger aircraft with room for 22 passengers, and do away with seaplanes altogether. The Twin Otter needs just 800 meters for takeoff or landing, and Widerøe lobbied for the construction of 19 small airports of this scale across the country. The first route was opened from Bodø in March 1967, where a Twin Otter with the call sign LN-LMN went into service as of 1968. Today, this aircraft can be seen in the Norwegian Aviation Museum in Bodø. Widerøe operated a total of 18 Twin Otters, and didn't take the last of them out of service until 2000.

Bodø, where Widerøe has its headquarters, sits directly on the Arctic Circle and is thus no stranger to feelings of isolation: its local soccer team, as well as all other teams from the northern part of the country, was not allowed to play in the national league until 1972. The logistical hurdles for transporting the other teams there for games were simply too great. It wasn't until the early 1970s that a network of regional airports developed to the point where air travel was possible. Since then, the northern Norwegians have been able to join the top league—both in soccer and in travel.

Same-day travel to Oslo and back for (almost) all Norwegians

Today, Norway has scheduled flights to nearly 50 domestic airports, which enable 99 percent of the population to travel from their homes all the way to Oslo and back in a single day. "There's no other network like this in the world," says Stein Nilsen, CEO of Widerøe, which is now Scandinavia's largest regional airline. Its fleet of 46 aircraft flies some 2.8 million passengers annually to 46

Exclusive engines ——— *With their two PW1900G engines, E2 jets use 17.3 percent less fuel than their predecessors. This makes them a fast and economical alternative to the slower turboprop aircraft that Widerøe has flown exclusively to date.*

Range ——— *The new jets are set to carry Widerøe customers not only from one end of Norway to the other, but also to new European destinations.*

„The E190-E2 represents a big step for Widerøe. We need more capacity on longer routes, such as from Bergen to Tromsø or Bodø. “

Stein Nilsen
CEO Widerøe

destinations, most of them in Norway, and thus serves twice as many domestic destinations as its competitors. Over 3,000 employees help operate more than 450 flights every day. For remote villages, especially those in northern Norway, Widerøe offers a lifesaving connection to the outside world. This is reflected in the fact that 40 percent of its network consists of subsidized routes operated as a public service. “During 84 years, Widerøe has grown its network to serve nearly every airport in Norway,” Nilsen says. “And that’s not because it’s easy, but because it was important to offer transport to our customers.”

From turboprops to jets

April 24, 2018 marked the dawn of a new era for Widerøe: the Jet Age. Having ordered three Embraer E190-E2 aircraft back at the start of 2017, the airline is now the world’s first operator of this model, which was developed from the successful predecessor E-Jet series. The crucial difference lies in its new engine, the Pratt & Whitney PW1900G, which in the E2 is attached to a completely new kind of wing. As a result, the E2 is over 17 percent more fuel-efficient than its predecessor.

1967
The first four regional airfields open between Bodø and Trondheim, beginning the shift of air travel from water to land.

1968
Widerøe switches its fleet over to the de Havilland Canada Twin Otter because of the aircraft’s excellent STOL capabilities. Up until 2000, the airline flies 18 of this 22-seater in total.

1970
Widerøe undergoes restructuring to establish itself as the leading airline serving the 19 new regional airports.

1981
The four-engine de Havilland Canada Dash 7 with 52 seats becomes the linchpin of the Widerøe fleet, which will feature eight of them in total before 1994.

1992
Widerøe operates three Embraer EMB 120 Brasilia aircraft, a 30-seat turboprop, until 1998.

The era of the de Havilland Canada Dash 8 starts with the Dash 8-100. Today, the Widerøe fleet consists almost exclusively of four versions from this turboprop family.

2001
The Bombardier Q400, the largest and newest Dash 8 version, enters the fleet. Currently, the airline operates 11 of this 78-seater model.

2018
Widerøe’s “Jet Age” begins as it becomes the first airline in the world to operate the Embraer E190-E2 jet, commissioning three of them with 114 seats each.

"The E190-E2 represents a big step for Widerøe," says Nilsen. "We need more capacity on longer routes, such as from Bergen to Tromsø or Bodø. These are currently flown with the Bombardier Q400, which takes two and a half hours. With the E2 we can do it in under two hours while increasing capacity from 78 to 114 seats." The new aircraft is also giving Widerøe the boost it needs to expand to Germany for the first time: since August, the Norwegian airline has been flying its new E2 jets nonstop from Bergen to Hamburg and Munich. However, Nilsen says that the company wants to "remain under the radar of the completion and out of their markets"—in other words, not get in the way of SAS or Norwegian.

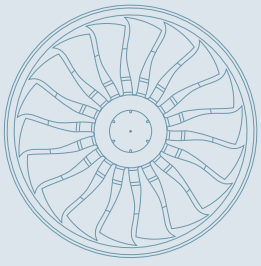
Return to Brazil

For Widerøe, this marks a return to Embraer: from 1992 to 1998, their fleet had three Embraer turboprop planes, the 30-seat EMB 120 Brasilia. "It is a pleasure to be, one again, part of the Embraer family," Nilsen said upon taking delivery of the first new aircraft at the manufacturing plant in São José dos Campos near São Paulo. And since the launch of the three E2 jets went so well, Widerøe can imagine going even further: "We'll have to come back here and see if we can be the launch customer of the E175-E2," said Nilsen—a statement enthusiastically received by Embraer and suppliers in South America.

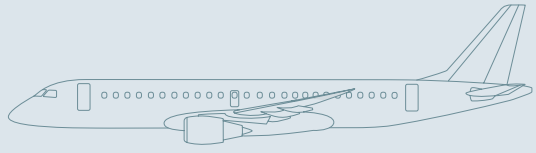
Inside MTU ___ *“Problem-free launch of the PW1900G with the E190-E2”*

Embraer’s E190-E2 is the third model featuring an engine from the PW1000G Geared Turbofan™ (GTF) family to go into scheduled service. The first was the Airbus A320neo, which premiered with its PW1100G-JM in January 2016. Other aircraft models come equipped exclusively with a GTF engine: the Bombardier C Series, now the Airbus A220, debuted in July 2016 with the PW1500G, and the Embraer E190-E2 is powered by the PW1900G, which is largely identical in construction to the PW1500G. By 2020 or 2021, the Mitsubishi Regional Jet will have the PW1200G, and the smaller Embraer 175-E2 will fly with the PW1700G.

Because they have a gearbox between the fan and the low-pressure turbine, GTF engines can produce a high bypass ratio of 9:1 to 12.5:1. MTU’s workshare in these programs ranges from 15 to 18 percent. “We develop and produce the low-pressure turbines and the forward four stages of the high-pressure compressor, install the low-pressure turbines and—for the PW1100G-JM—part of the engine as well. We are also involved in the aftermarket business,” says Martin Wiedra, Director of P&W Programs at MTU. His enthusiasm is plain to see as he lists the advantages of the GTF: “It consumes significantly less fuel, creates less noise and pollution, and its lifecycle costs are lower.” So far he has only good things to say about



PW1000G ____ *Pratt & Whitney’s new Geared Turbofan™ engine family offers double-digit percentage improvements in fuel consumption, pollution and noise emissions as well as operating costs.*



Embraer E190-E2 ____ *The second generation of E-Jets are not only quieter and more economical, they also boast an additional 800 kilometers of range. Each can seat a total of 114 passengers.*

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Andreas Spaeth has been traveling the world as a freelance aviation journalist for over 25 years, visiting and writing about airlines and airports. He is frequently invited to appear on radio and TV programs.

365 days. 24 hours. 14 locations. 1 goal.

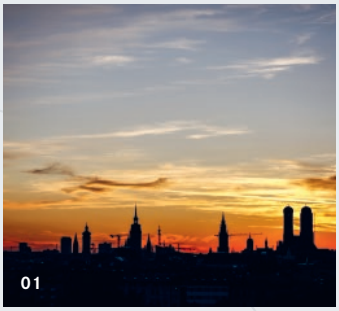
Fascinating insights into the world of MTU Aero Engines– its locations, products and services.

Text: *Eleonore Fähling*

Through its subsidiaries and joint ventures, MTU is globally active at 14 locations in Germany, Poland, the Netherlands, Spain, China, Malaysia, the United States and Canada. This means the company is represented in all key markets and regions. As the working day draws to a close in Asia, in Europe it's just beginning–so MTU is working for its customers around the clock, 365 days a year.

The key to MTU's success are high-tech products of the highest quality as well as tailored services, whether these be in development, production or maintenance. Thanks to innovative manufacturing and repair processes and the expertise of the company's employees, MTU's locations around the globe can grow and keep on improving. Precision at every stage has top priority in order to guarantee an engine's service life and operational performance.

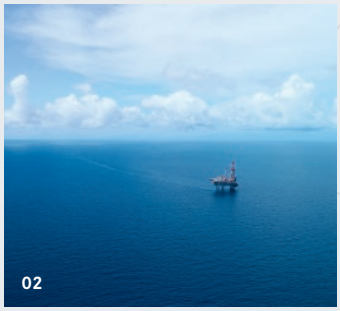
MTU's goal is to shape the future of aviation. Engines should become cleaner, more efficient and quieter. Another important goal is fruitful collaboration with the company's partners. To get closer every day to achieving this goal, all locations work together around the clock.



Munich,
5:15 a.m. CET

Final assembly of the A320neo engine

The early shift begins. MTU's final assembly line for the PW1100G-JM engine that powers the A320neo began operations in 2016. It was designed by the company itself and is unique in the world.



Norway,
9:00 a.m. CET

Industrial gas turbine experts at work

Industrial gas turbines made by GE Power, which are looked after by MTU Maintenance Berlin-Brandenburg, are is use all over the world. Here they supply an offshore oil rig with electricity. The experts from Ludwigsfelde carry out small jobs like this one on site; for more complex repairs or complete overhaul, the gas turbine must visit the shop.

The processes for maintaining the LM model ranges are continuously improved and refined.

Amsterdam,
10:00 a.m. CET

Engine leasing and asset management in the Netherlands

In their office in Amsterdam, leasing experts from MTU Maintenance Lease Services B.V. (MLS) discuss the final details of a leasing deal. More and more airlines are leasing aircraft including engines in order to benefit from greater flexibility and lower capital costs. Today almost 40 percent of all aircraft are leased.

Worldwide 24/7

Development, production, maintenance.
MTU works around the clock to serve customers across the globe.

Seville,
11:00 a.m. CET

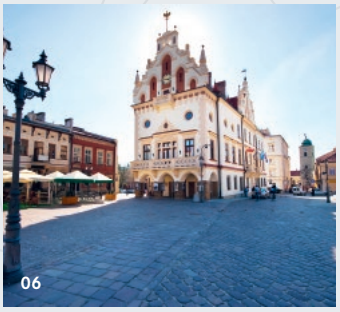
A military transporter is taking shape

Final assembly of the A400M military transporter takes place under the Andalusian sun. It takes around 100 days to put together an A400M. Just eight of those days are set aside for the assembly of the two TP400-D6 engines and propellers. Only once comprehensive test flights and checks have been performed does the customer take delivery of the aircraft.

Hannover,
12:00 noon CET

Giant on the test rig Test run of the Boeing 777 engine

In Langenhagen, approximately ten kilometers north of Hannover, a GE90-115B—the largest and most powerful engine in the world—is lifted onto the test stand following overhaul. The engine will be run at full capacity for around ten hours, during which time all relevant information appears on monitors in real time.



Rzeszów,
2:00 p.m. CET

Success story in Poland's Aviation Valley

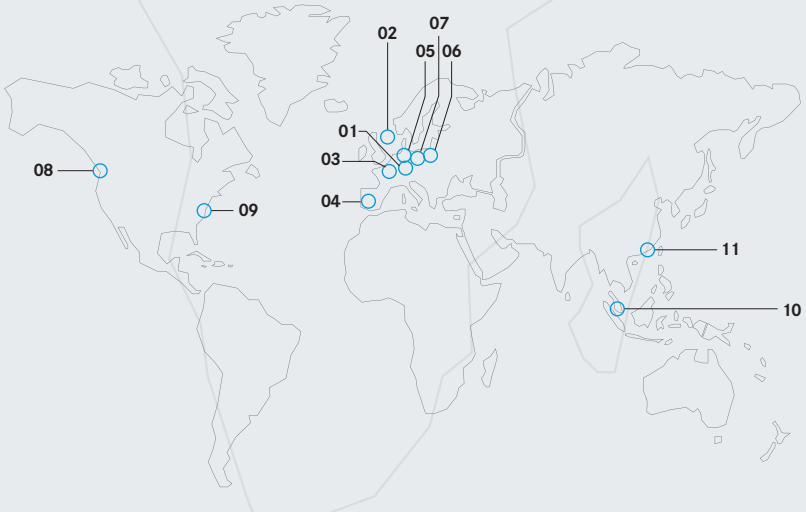
Final preparations are underway in southeast Poland for shipping the fully assembled GEnx turbine center frame to MTU's partner GE Aviation.

Since its founding in 2009, the location has grown considerably. The jump from 200 to more than 700 employees is thanks to the fruitful German-Polish collaboration and a highly motivated team.

Ludwigsfelde,
4:00 p.m. CET

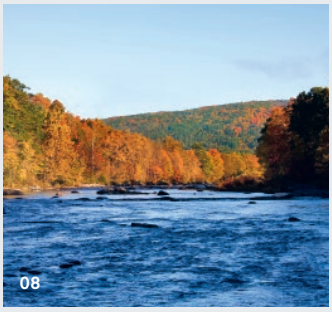
Largest CF34 maintenance provider in the world

Mechanics are in the middle of maintenance work on the 1.7-metric-ton CF34 engine. Every part of the most common and best selling engine in its class is put through its paces and repaired or replaced as needed. MTU Maintenance Berlin-Brandenburg specializes in all variants of the CF34 engine.

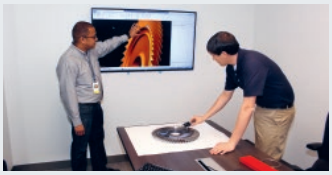


Locations worldwide

Through its subsidiaries and joint ventures, MTU has a strong presence in all key markets and regions worldwide. MTU has locations in Germany, Poland, the Netherlands, France, China, Malaysia, the USA and Canada.

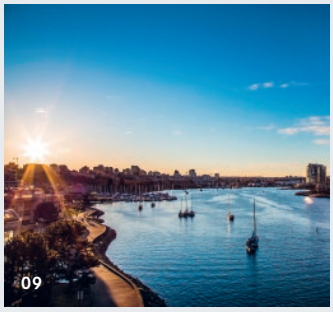


Rocky Hill,
7:00 p.m. CET



Key members of the global MTU network

On the other side of the world in Connecticut, innovations are developed, designed and modeled–no matter whether they relate to individual parts, the management of comprehensive programs, or complex systems. Due to its proximity to Pratt & Whitney, one of MTU's most important partners, the fast growing MTU AENA oversees projects that MTU is realizing together with its partner.



Richmond,
11:00 p.m. CET

Accessory specialists master maintenance

At 2:00 p.m. local time at the location in British Columbia, engine accessories are disassembled, cleaned, checked and gauged at MTU's Accessory Repair Centre. After all, defective accessories risk giving the engine the equivalent of a heart attack and in the worst case scenario, the aircraft cannot fly. Thanks to some 450 different repair processes, even complex challenges can be mastered within 24 hours.

Kuala Lumpur,
2:00 a.m. CET

Blade repair in Asia

In Malaysia's capital, engine blades are replaced as part of the Airfoil Services joint venture between MTU and Lufthansa Technik. Over the past few years, repair capacity has significantly increased and the business has grown considerably. ASSB was the world's first shop to handle the complete scope of repairs, which has made it very successful.

Zhuhai,
4:00 a.m. CET

Number one in China

Maintenance of a V2500-A5 engine, used to power the Airbus A320, reaches successful completion. Every 15,000 to 30,000 flight hours, each V2500 is laboriously checked and repaired so that the strict safety regulations for aircraft engines can always be met. No problem for MTU Maintenance Zhuhai, which can draw on the experience from the more than 1,000 V2500 shop visits performed since the location was founded in 2001.

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Eleonore Fähling is MTU's Editor in Chief for **AERO**REPORT and has been in charge of the MTU employee magazine since 1999.

20 years and 1,100 engines

MTU Maintenance's first location outside Germany has survived some turbulent times and chalked up many successes.

Text: *Nicole Geffert & Victoria Nicholls*

Know-How _____ *The technicians specialize in repairs to accessories, which makes MTU Maintenance Canada a highly sought-after expert in this area.*

Good location _____ *The MTU subsidiary's shop for repairing engines and accessories and conducting engine tests is located right next to the international airport in Vancouver.*

Special services _____ *Maintenance work focuses on the CF6, CFM56 und V2500 engines as well as all services for accessories and line replaceable units (LRUs).*

Together with customers, business partners and employees, MTU Maintenance Canada is celebrating its 20th anniversary at its site near Vancouver airport in combination with its appearance at the Abbotsford Airshow.

MTU Maintenance Canada has been part of the MTU Maintenance network since 1998. Specializing in maintenance of the CF6, CFM56 and V2500 engines, the company also handles all services for accessories and line replaceable units (LRUs) for a range of engines–from the CF34 to the GE90.

Over the past two decades, the wholly owned subsidiary of MTU Aero Engines has overhauled more than 1,100 engines in its shop. In 2011, it set up the Accessory Repair Center: a center of excellence that maintains more than 11,000 accessories every year. Employing nearly 400 highly qualified experts, the subsidiary is one of the region's valued employers in the aerospace sector.

“We can look back proudly at our long history of success in looking after commercial and military customers in North and South America,” says Helmut Neuper, Managing Director of MTU Maintenance Canada. “And I'm delighted to be continuing this success story with the maintenance services for V2500 engines that we launched in December 2017.”

The first shop visit for a V2500 was successfully completed in summer 2018. The overhaul took place as part of an agreement made last year between IAE and MTU, which stipulated that MTU Maintenance Canada provide MRO services for V2500 engines within the IAE customer service network.

And all signs point to further growth: “MTU has invested 17 million Canadian dollars in establishing the new maintenance line at the Richmond site in British Columbia,” Neuper says. “Some 25 overhauls for the V2500 engine are to take place at MTU Maintenance Canada this year, and next year we expect to handle up to 40 shop visits.”

01 ___ *In summer 2018, MTU Maintenance Canada joined Hannover and Zhuhai to become the third MTU location for V2500 maintenance.*
02 ___ *Highly trained technicians work on repairing accessories at the plant.*
03 ___ *At MTU Maintenance Canada, young technicians work side by side with their more experienced colleagues. The workforce represents some sixty different countries.*
04 ___ *The Accessory Repair Center, which opened in 2011, maintains more than 11,000 accessories every year.*
05 ___ *Technicians at work on a V2500 engine. In 2019, the plant is expected to have up to 40 shop visits for the V2500.*

Inside MTU ____ *Four MTU Maintenance Canada employees tell their "20th anniversary stories"*

Helmut Neuper

"When I was 20 I lived in Berlin. The Wall had just come down and it was one of the most exciting places to be in the world at that time. I was studying Aeronautical Engineering at the TU Berlin. We were the first intake of students from both East and West."

Helmut Neuper is president and CEO of MTU Maintenance Canada. He has been in this role since 2016, but was also in Vancouver from 2007 to 2013 as Director of Accessory Business. His vision for MTU Maintenance Canada? Become the airlines' choice for V2500 MRO in North America, building on MTU Maintenance's leading position worldwide for this engine type. Neuper also wants to maintain and grow the facility's reputation as a strong and reliable partner to the military.

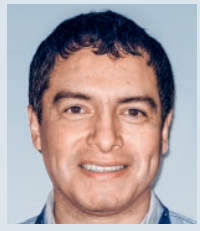
Tracy Osadchuk

"When I was twenty, I could not wait to travel. I worked in three jobs while doing my degree in operations management at the British Columbia Institute of Technology. I'd originally wanted to be an air force pilot, but my eyesight wasn't good enough, so when it came to writing my dissertation, it had to be aviation based—anything else was out of the question. I've never looked back!"

Tracy Osadchuk is VP MRO Programs and Chief Commercial Officer at MTU Maintenance Canada. She re-joined the company in 2017, having been with MTU for four years in early 2000's. Her outlook for the coming years? Grow and succeed!

Nestor Rubia

"Our future looks promising," says Nestor Rubia, Line Inspector for CFM56, CF6 and V2500 engine modules, referring to the recent introduction of the V2500 line at MTU Maintenance Canada. He originally started in Vancouver under Canadian Airlines, who owned the facility before MTU Maintenance came on board in 1998. "I just celebrated my individual 20-year anniversary with the company, and now we are coming together for the company's birthday too."



Ivan Valdivia

Resilient is a word that Ivan Valdivia would use to describe the workforce during the past 20 years at MTU Maintenance Canada. He is a system analyst and provides on-site support on site for various software systems. A lot of things make him proud, among which, "knowing that my daily work is part of an integrated effort to assure safe and reliable flights for so many air travelers."

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Nicole Geffert has been working as a freelance journalist covering topics such as research and science, money and taxes, and education and careers since 1999.

Victoria Nicholls is a specialist for aftermarket topics such as engine MRO, leasing and asset management, as well as international market trends. The British-born editor lives in Berlin and works for MTU's corporate communications in Hannover and Ludwigsfelde.

Under observation _____ *Engine Trend Monitoring makes it possible to detect unusual activity in the engine even during flight. This early identification makes maintenance cheaper and more efficient.*

Under constant surveillance

Engine Trend Monitoring provides important information about engine condition. Early diagnosis prevents costly consequential damage and paves the way for predictive maintenance planning.

Text: *Nicole Geffert*

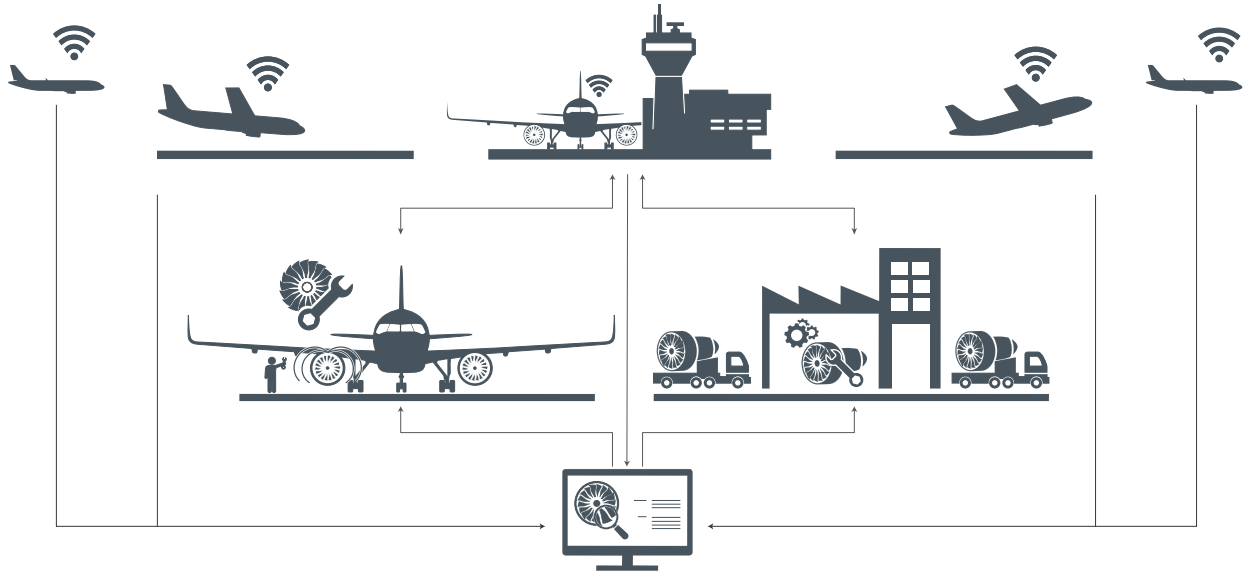
Running a practiced eye over the data, Ivaylo Krastev, engine engineer at MTU Maintenance Hannover, sees that an engine is experiencing a drop in efficiency while cruising. The outlet temperature has risen, the high-pressure spool is speeding up and the engine is consuming more fuel. A warning is immediately sent to the airline, which has its entire fleet of engines looked after by MTU Maintenance. At the aircraft's next stop, the engine is examined while still on the wing by two of the airline's maintenance mechanics using a borescope.

They discover that a foreign body has found its way into the compressor. The engine is immediately removed from the wing and sent to the MTU Maintenance shop for repair. There, the fears are confirmed: the foreign body has damaged several blades. Had this comparatively minor damage gone unnoticed, it could have caused major consequential damage to the engine and led to costly repairs– the airline is now spared both of these.

This early detection and analysis of abnormalities is thanks to MTU Maintenance's Engine Trend Monitoring (ETM): a comprehensive software solution developed by MTU in house for monitoring engine parameters. "During flight, the aircraft computer records the key engine parameters including speed, pressure, temperature and vibration," says Norman Schwarz from Performance Engineering at MTU Maintenance Hannover. The ETM system evaluates these parameters at certain points during a flight cycle– typically during takeoff and cruising–by comparing the data with expected values for a corresponding engine model. "This means that we can detect abnormal changes, such as in the engine's thermodynamic behavior, and identify even the tiniest of deviations," Schwarz says.

Thanks to the early detection system, MTU experts can analyze the data and look into potential abnormalities long before a serious problem surfaces. If they notice a deviation, they recommend a clear course of action for the necessary maintenance.

ENGINE TREND MONITORING



Early warning system for engines _____ *Data recorded previously by the aircraft computer is evaluated by the ETM system while the aircraft is still in flight. The system never sleeps, so when MTU specialists see an alert, they can take action immediately and send the engine to the MTU Maintenance shop. ETM also makes it possible to generate forecasts, thus improving the planning of engine overhauls.*

Fleet under control

ETM is a key component of the fleet management service that MTU Maintenance offers its customers. The concept ensures that all the fleet's engines have maximum availability and efficiency and can be operated as cost-effectively as possible. Performance Engineer Schwarz explains: "ETM also offers a forecast function that can predict the number of remaining cycles. This helps improve the planning of more comprehensive engine overhauls and to optimize shop visit intervals from both a technical and an economic perspective."

Two more benefits for fleet customers are that all engine types can be monitored with a single tool and that MTU Maintenance is in a position to tailor its expertise to individual customer requirements; for example, it can introduce new alert rules that focus on certain parameters.

24/7 engine monitoring

ETM and its fully automatic alert function for deviations are active around the clock, seven days a week. Schwarz says, "For many of the new kinds of engine and aircraft, data analysis can already begin during the flight. Trend analyses can be called up online 24 hours a day, virtually in real time. Specialists at MTU's Hannover, Zhuhai or Vancouver locations can then evaluate them.

Developed in house by MTU experts, the flexible system has been in use since 2006 and is continuously being expanded and optimized. And in the future, customers will benefit from further innovations.

Mobile and straightforward

"We're currently preparing to change platforms and use new software so that in the future, we can track the data not only on PCs but also on tablets and with a smartphone app," says Christian Preuss, who is responsible for test systems and ground support equipment at MTU Aero Engines. IT specialists in Munich and Rzeszów are handling the programming. The new interface will be more cutting edge, more streamlined and more straightforward—genuine added value for customers.

And there's a further optimization in the pipeline. "With the current system, we can ascertain the loss in efficiency of the engine as a whole, but we're developing the ETM so that it will show which engine modules are contributing to the loss in efficiency," says Jürgen Mathes from

“Analysis at the modular level offers the benefit of allowing maintenance to be planned in a more targeted way. This is because it lets our maintenance specialists know which components to concentrate on during the shop visit.”

Jürgen Mathes
MRO Performance Support at MTU Aero Engines

MRO Performance Support at MTU Aero Engines. “Analysis at the modular level offers the benefit of allowing maintenance to be planned in a more targeted way. This is because it lets our maintenance specialists know which components to concentrate on during the shop visit.”

One dataset every second

In the future, engine data is to be recorded, transmitted and stored throughout the flight–in essence, one dataset every second. “This means that trend deviations can be detected even earlier compared to the current system, which can do just two to three snapshots per flight,” Mathes says. As such, maintenance experts will be able to react even faster to trend deviations. It’s all about predictive maintenance, or in other words efficiency through advance knowledge.

“New avionics can continuously record and transmit data. The necessary hardware is already installed on newer aircraft types,” Mathes says. And it can be retrofitted to older models. However, the future ETM system does pose certain challenges for the IT experts. The sheer volume of data must not only be stored, but analyzed and evaluated as well. Alongside sufficient storage space, the efficient analysis method is the key to success for targeted and predictive maintenance. As Preuss puts it: “We’re testing various data analysis concepts, such as machine learning, so that we can then offer our customers an ideal early detection system.”

Inside MTU ___ *All inclusive*

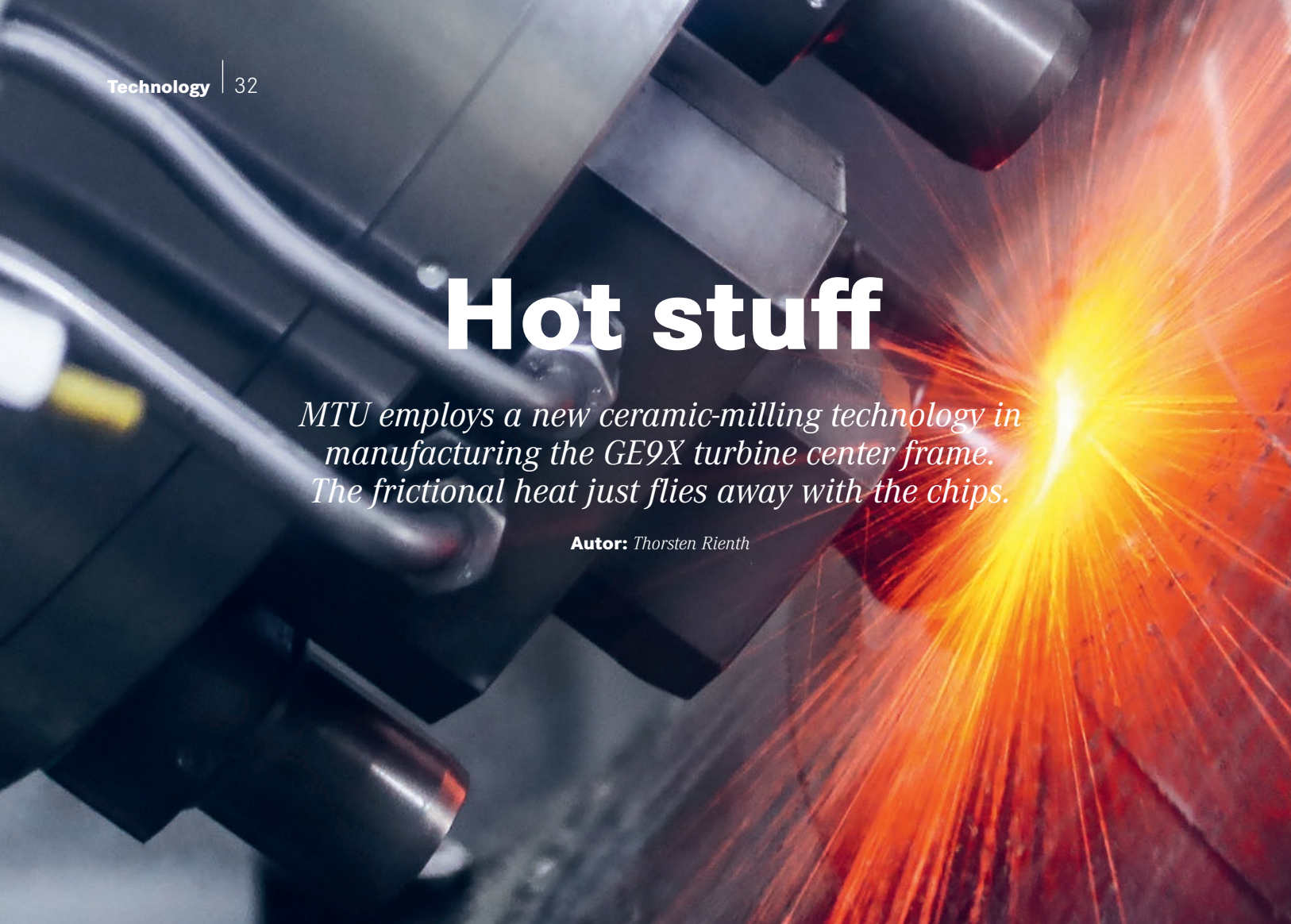
To ensure smooth flight operations, MTU Maintenance offers its customers all-inclusive service packages. These modular service solutions can be flexibly combined or pooled to form a comprehensive offer. In addition to engine maintenance, this may include global on-site service, effective fleet management including the Engine Trend Monitoring early detection system, and reliable supplying of replacement engines during shop visits.

Further service modules include everything from logistics services to the provision and management of accessories and line replaceable units (LRUs). MTU Maintenance also provides services for materials and asset management. This frees up MTU customers to concentrate on what’s important: flying.

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Nicole Geffert has been working as a freelance journalist covering topics such as research and science, money and taxes, and education and careers since 1999.



Hot stuff

MTU employs a new ceramic-milling technology in manufacturing the GE9X turbine center frame. The frictional heat just flies away with the chips.

Autor: *Thorsten Rienth*

Whenever Alexander Steurer wants to see how the youngest offshoot of the MTU technology family is doing, he doesn't have far to go: out the office, down the center aisle of the nearest manufacturing hall, a right turn into the corridor, up four steps. And there it is—right in front of him is the MCM Clock 1800, the new machine for an equally new technology: ceramic milling. In this kind of milling, the cutters are made of ceramic, not carbide.

At MTU Aero Engines, Steurer heads NC programming for frame construction—that is, creating software to run the manufacturing machinery. He indicates the bright orange dot between the milling head and the GE9X turbine center frame (TCF). "Almost 1,200° Celsius," he says. "That's pretty damn hot."

In conventional production methods, this is precisely what engineers are doing their best to avoid, but in ceramic milling, it's the whole point. Inconel 718, a nickel-chrome superalloy, has to be heated to a high temperature for it to change from a superhard material into one that is soft and malleable. "Then the milling head can literally tear the material out."

Cooling included

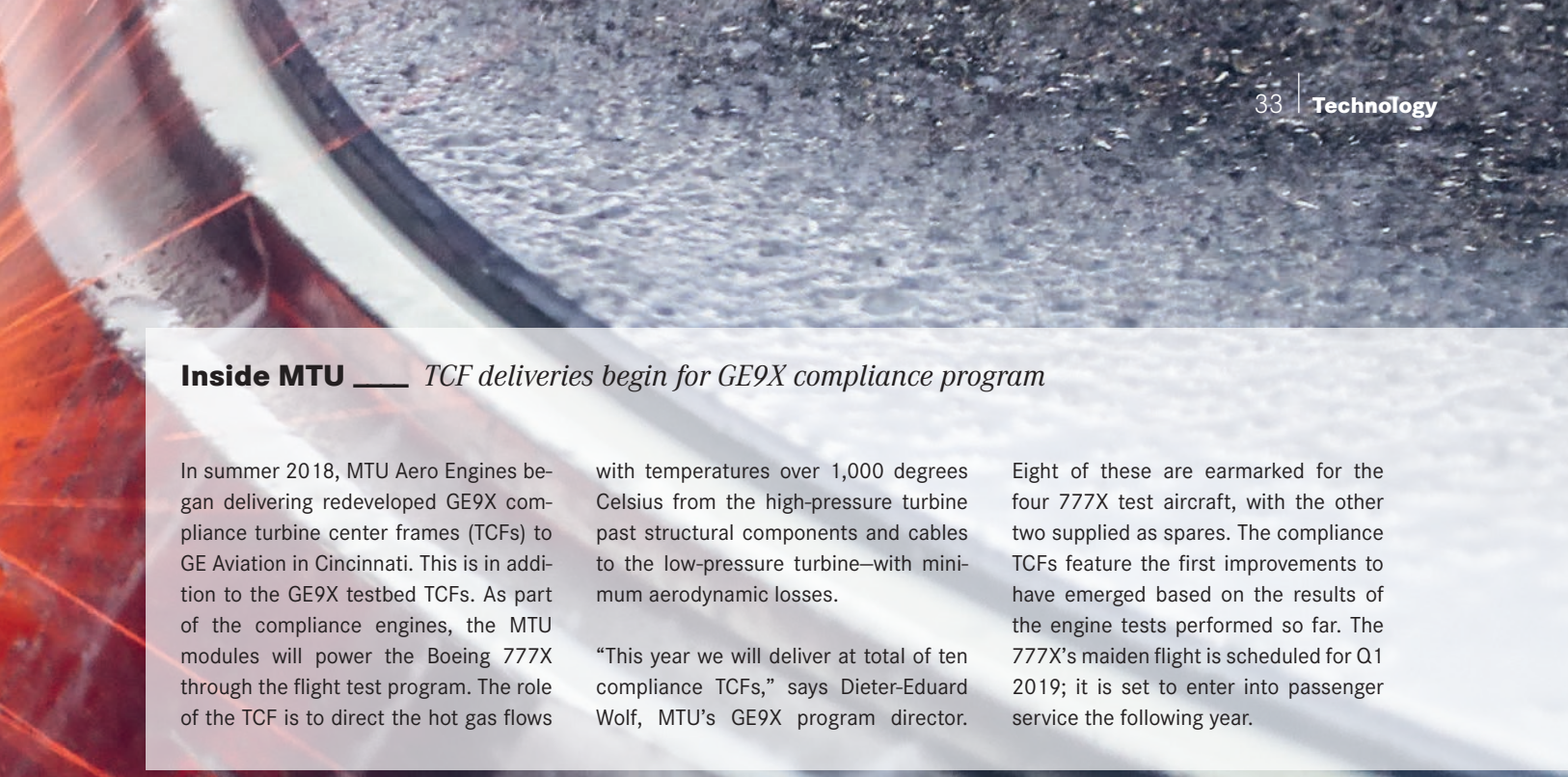
What's the point of this brutal process? As the dough-like chips fly away from the part being milled, they take the heat with them. And that is a vital feature: "Cooling lubricants would be counterproductive here and lead to thermal shock," explains Steurer. The temperature of the part is moderately reduced solely through the air-cooled spindle, starting from the end of the part that is not currently being milled.

Steurer's team has been researching this method since 2013, but they didn't procure the MCM Clock 1800 until last year. Finally, they had a machine that could deliver the breakthrough. Its spindle reaches speeds of up to 14,000 revolutions per minute. Ceramic plus Inconel 718 plus speed—all three combined produce the necessary amount of heat. The machine's predecessor was only able to do somewhat more than 4,000 rpm.

In dozens of tests, the programmers developed additional special sequences of entry and exit movements. Their goal was to figure out the optimum combination of forward feed, approach path, revolutions, and depth of cut. "I don't think there's anyone else in the world who has tested this as thoroughly."

Altered milling process

Frictional heat requires changes to the individual milling steps. "Normally you would process a frame in one go," explains Stefan Gremminger, one of the NC programmers on Steurer's team, "but that doesn't work with ceramic milling." If an operator tried to mill adjoining sections one right after the other, that would stretch the material too much. The circular center frame would become slightly egg-shaped, and even if the eye can't see it, the



Inside MTU ___ *TCF deliveries begin for GE9X compliance program*

In summer 2018, MTU Aero Engines began delivering redeveloped GE9X compliance turbine center frames (TCFs) to GE Aviation in Cincinnati. This is in addition to the GE9X testbed TCFs. As part of the compliance engines, the MTU modules will power the Boeing 777X through the flight test program. The role of the TCF is to direct the hot gas flows with temperatures over 1,000 degrees Celsius from the high-pressure turbine past structural components and cables to the low-pressure turbine–with minimum aerodynamic losses.

"This year we will deliver at total of ten compliance TCFs," says Dieter-Eduard Wolf, MTU's GE9X program director. Eight of these are earmarked for the four 777X test aircraft, with the other two supplied as spares. The compliance TCFs feature the first improvements to have emerged based on the results of the engine tests performed so far. The 777X's maiden flight is scheduled for Q1 2019; it is set to enter into passenger service the following year.

distortion would have a dangerous impact on measurements that have to be painfully accurate. Although MTU uses this technique only to process the approximate shape, tolerances are still measured in just tenths of millimeters. "That's why after every pass with the milling cutter, we rotate the part another 60 degrees," Gremminger says. "It takes time–but the higher milling speed more than makes up for it."

So far MTU has produced upwards of ten GE9X turbine center frames with the new technology, most recently including the first flying parts for the Boeing 777X. The aircraft's maiden voyage is scheduled for 2019, with the first models to be delivered to customers a year after that.

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

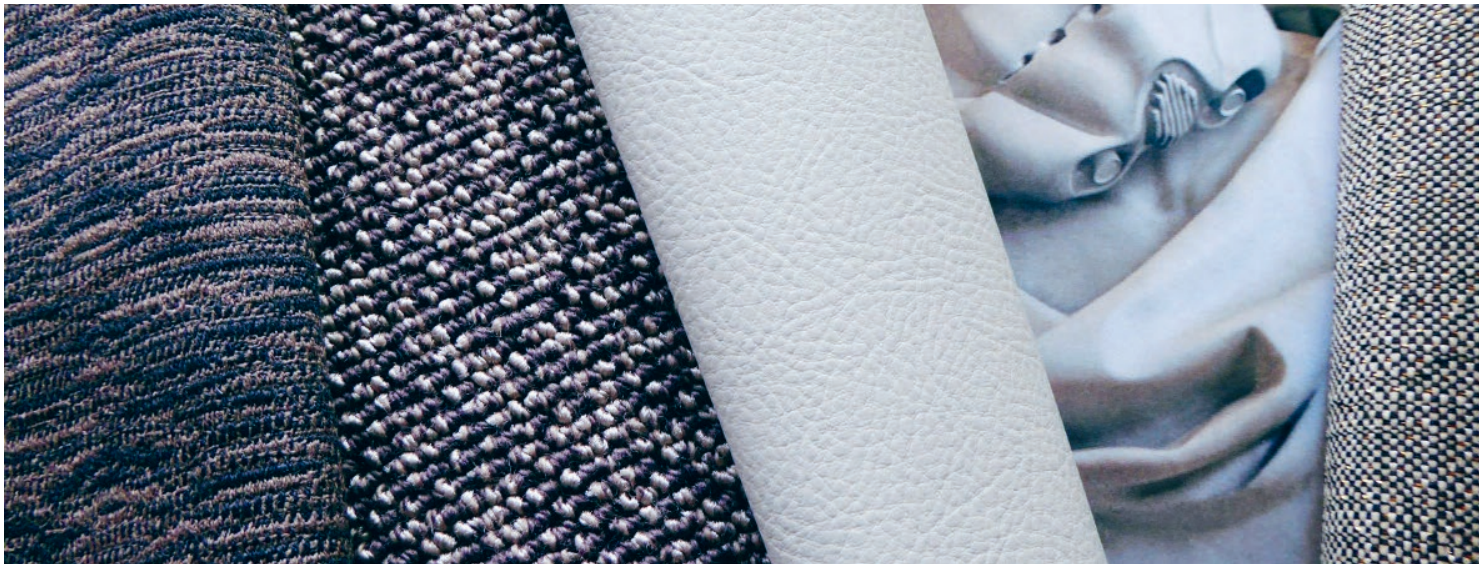
Text:
Thorsten Rienth writes as a freelance journalist for **AERO**REPORT. In addition to the aerospace industry, his technical writing focuses on rail traffic and the transportation industry.

Fire-resistant and lightweight

Seat covers, safety belts and carpets used in aircraft must be flame-retardant and lightweight. In the future, high-tech fabrics will fulfill a broader range of applications.

Text: *Denis Dilba*

Comfort and safety ——— *Air travel safety requirements are particularly demanding. That goes for on-board textiles, too, from carpets, cabin dividers and wall coverings to seats and seatbelts. Aircraft seats also have to look good, feel comfortable and weigh as little as possible. Upholstery that uses air instead of foam (center) saves up to five kilograms of weight per seat and some airlines are already using these seats in business class.*



Look and feel ——— *Seat covers for aircraft can be made of a wide range of materials, from blended fabrics containing wool, rayon and synthetic fibers to leather. Next to weight, it's a seat cover's look and feel that are the decisive characteristics.*

At almost 1,000 degrees Celsius, yellow-orange flames shoot out of the blowtorch to a length of some 30 centimeters. For nearly two minutes now, the flames have been relentlessly barbecuing the aircraft seat from the left-hand side. Then, after precisely 120 seconds, the torch goes out. Any remaining pockets of embers are immediately extinguished and a light veil of smoke fills the test cabin. Once it clears, we can see the extent of the damage. How much remains of the seat cushion, backrest and cover will decide whether or not this particular mix of materials will get its wings. As per FAR/CS 25.853, the flammability regulation that applies to Europe and the United States, the fire must not spread more than 43.2 centimeters from the source. That's the width of the narrowest aircraft seat.

“All textiles used in aircraft cabins must be flame-retardant,” says Daniela Grunder, Director Brand Communication & Product Management at Lantal Textiles AG. Based in Langenthal, Switzerland, the company specializes in fabrics for the aviation industry and manufactures products including seat covers, carpets, curtains and wall coverings. All the major aircraft manufacturers as well as more than 300 airlines—including Swiss Air, Lufthansa, Delta and China Airlines—place their trust in the expertise of this company located in the Canton of Bern. This makes Lantal a world leader in its industry.

Every decigram counts

According to Grunder, having flame-retardant properties is just the first requirement fabrics must fulfill if they are to be used in aircraft cabins. “Aircraft textiles should also be wear-resistant, stain-resistant, non-toxic and—most importantly—as light as possible,” she says. After all, the lighter the aircraft, the lower the airline's fuel consumption and, in turn, its CO_2 emissions. Extrapolate that to the level of an entire fleet of some 100 aircraft and reductions of even a tenth of a gram per seat cover can quickly result in six-figure savings. Still, more lightweight textiles have their drawbacks; for example, a slimline aircraft carpet is thinner and often less resistant to wear than its heavier counterparts. Plus, the more lightweight versions tend to get dirtier faster.

Look and feel

Another key factor for seat upholstery is that it feels good against the skin. Wool does this best, partly because it absorbs moisture and as such doesn't feel “sweaty,” Grunder explains. But compared to artificial fibers like polyamide or polyester, fabrics made from natural fibers can be heavier. “Given the many, often varying, requirements that aircraft textiles must fulfill, there is no one best fabric or carpet for every case,” Grunder says. “The decision as to which material or material blend gets used and where depends on the individual customer's requirements.” While one customer might place greater emphasis on comfort, another will be more concerned with reducing fuel consumption—and yet another will want both.

But occasionally it's simply a matter of taste: when it comes to carpets, European airlines almost always favor products with a very high wool content, while US airlines are just as adamant about having the synthetic material polyamide. “A more

SMART TEXTILES

Up to 5 kg

of weight per aircraft seat can be saved using upholstery manufacturer Lantal's Pneumatic Comfort System (PCS), which replaces foam cushioning with air cushions.

Each 1 kg weight reduction

in an aircraft seat saves some 80 euros per seat annually.

LOI

(limiting oxygen index) This value expresses the percentage oxygen concentration in the air at which a fiber will start to burn.

Wool LOI 25

In normal air with an oxygen concentration of 21 percent, wool won't even smolder.

technological look simply goes over better in that market," Grunder says. A blend of wool and polyamide is the standard for seat covers, with wool fibers accounting for 89 to 95 percent of the fabric. Grunder says polyester's use in seat upholstery is dependent on being combined with what are known as fire-blocking materials. This may for instance be Kynol®, a special heat- and flame-resistant fiber used for electrical insulation in high-performance electronics as well as other applications.

Fighting fire with physics

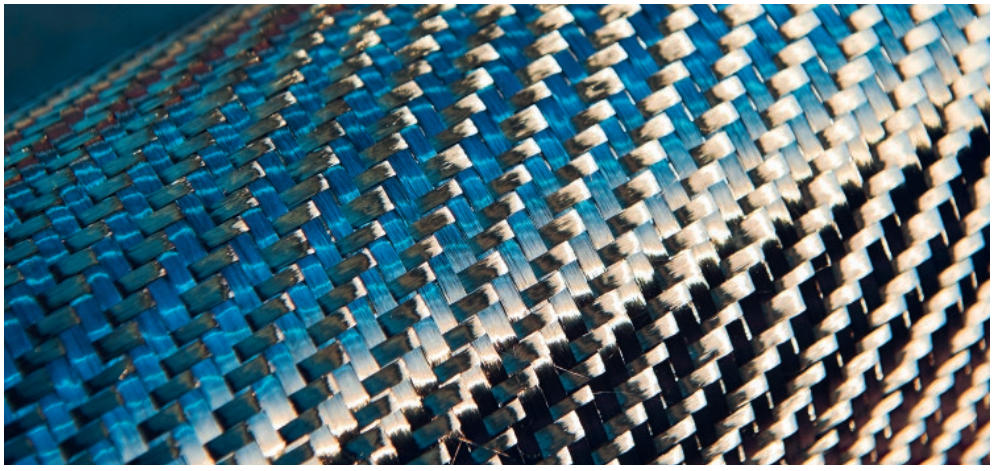
What sets this high-performance textile apart is its high limiting oxygen index, or LOI for short. Expressed as a percentage, this describes the oxygen concentration in the air at which the fibers start to burn. Kynol® has an LOI of 30. Oxygen generally makes up 21 percent of the air we breathe; at that concentration, this special fiber won't even smolder. Wool has an LOI of 25. This is why polyamide and polyester–with their LOI of 20–are blended with a very high proportion of wool; it's the natural material that makes this fabric flame-retardant. "How well textiles burn can, however, be influenced by the technology used to make them," says Wilko Reinck, Chief Aviation Engineer at safety belt manufacturer Schroth, based in Neheim, Germany. "Tightly woven fabrics allow very little oxygen to reach the surface of the fibers, which keeps fire from spreading." In addition, technical weaves can be given a flame-retardant coating. This is just one method Schroth employs to make its polyester safety belts fire-retardant as well as extremely mechanically robust: its belts can withstand loads of at least 2.2 metric tons.

Safety and security thanks to the Fly-Bag

If worst comes to worst, even higher demands are placed on the four-layer aramid fibers used in the Fly-Bag. Made from the same fiber used in the better-known DuPont brand Kevlar®, this flexible luggage container is designed to provide protection from explosions. The basic idea is that items of luggage or suspicious objects are placed inside the Fly-Bag. Should a hidden explosive device detonate, the high-tensile layers of heat-resistant aramid make sure the blast waves, heat and shrapnel remain inside the bag. "What the Fly-Bag does is dissipate the energy of the explosion, which in turn prevents the aircraft from sustaining major damage such a hole in its fuselage–the very thing that caused the Lockerbie air disaster in 1988," says Heike Illing-Günther, Research Director at the Sächsisches Textilforschungsinstitut (STFI), Chemnitz University's institute of textile research.

Durable and elegant ——— *Real leather has a high-quality look, and with ultrathin coatings it is still a popular material for aircraft seat covers.*

High-tech straps ——— *Seat belts in aircraft must of course have high tensile strength, but they must also be resistant to light and acids, have flame-retardant properties and keep their shape. These qualities rely both on the fiber material itself and on special weaving and sewing techniques.*



Safety first ——— *One property of all textiles on board aircraft is non-negotiable: they must be flame-retardant in air with a normal concentration of oxygen. High-tech fibers such as aramid, better known under the brand name Kevlar, can even withstand explosions.*

Illing-Günther, who played a major role in the development of the Fly-Bag, believes that a compact version for use in the aircraft cabin could enjoy success on the market.

"In addition to being lighter than the large versions, the main advantage of a small Fly-Bag is that it wouldn't affect loading procedures," she says. The larger safety bags designed for the hold add at least one step to the process: the cargo has to be put into the bag, which must then be sealed. This costs time, which is enough for the airlines to reject the idea. A small Fly-Bag wouldn't have to be loaded, making it simply another way to increase safety. "If an unclaimed object–say a mobile phone–is found in the cabin after takeoff, current safety protocol is for the aircraft to land immediately," says Illing-Günther. But if the crew could put the suspicious object in a small Fly-Bag, the airline would have the option of allowing the flight to proceed as planned.

Smart textiles

Regardless of whether the Fly-Bag makes it on board, Thomas Stegmaier, Research Director for technical textiles at the German Institutes of Textile and Fiber Research Denkendorf, says we can all expect a great deal from the development of textiles for aircraft applications. "What's going to be really interesting are smart textiles with additional functions," says Stegmaier. Take the work currently being done on self-illuminating textiles, which incorporate metal fibers that emit light when electrified. "Upholstering the aircraft cabin ceiling with this kind of fabric would mark a significant reduction in weight," says Stegmaier. "Ultimately, that's what all developments in textile technology are trying to achieve."

ARAMID

Five times as strong as steel

Aircraft seat upholstery contains up to 95 percent wool. Wool is flame-retardant and is more pleasant to the touch than synthetic fibers, but is heavier. For their part, synthetic fibers are lighter and more wear-resistant.

400° C

is the point at which aramid textiles slowly begin to smolder without flames.

Four layers of aramid

make up the "skin" of the Fly-Bag. This flexible luggage container can withstand the energy of an explosion caused by a device hidden in luggage.

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Denis Dilba holds a degree in mechatronics, is a graduate of the German School of Journalism, and founded the "Substanz" digital science magazine. He writes articles about a wide variety of technical and business themes.

Close look _____ *The 50x magnification shows the fracture surface of a silicon carbide composite. The ceramic fibers are embedded in a ceramic matrix and as such form a compound that can withstand great stress.*

Fiber ceramics take off

Lightweight, temperature-resistant, robust—ceramic matrix composites are the ideal materials for making engines. These new materials have the potential to reduce weight, optimize combustion and raise efficiency.

Text: *Monika Weiner*

Ceramic fiber-composite materials ___ *A fiber-composite material is made up of two main constituents: an embedding material (matrix) and the fibers embedded in it. Through interactions at the interface between the two constituents, the compound material has a much higher damage tolerance than each of the constituents separately. The arrangement and volume of the fibers can be adjusted as needed. In this way, it is possible to set the desired component characteristics.*

The Porsche 911 GT2 has them and so do the Ferrari 488 GTB and the Lamborghini Aventador: lightweight brake discs made of ceramic matrix compounds. These discs don't rust, don't abrade and don't smolder even when the driver slams on the brakes at 300 kilometers an hour.

What has proved itself in automotive manufacturing is now set to become an asset in aviation. "Ceramic matrix composites open the door to significant weight reductions. Their lightweight properties alone make them extremely attractive for engine construction," says Dr. Bertram Kopperger, head of composite materials at MTU Aero Engines. "Another benefit is that they are highly temperature-resistant. This means we can develop new, powerful and efficient engines with material temperatures of up to 1,400 degrees Celsius." Ceramic matrix composites, or CMCs for short, require less cooling than metals. This means air that would previously have been compressed and fed through cooling channels is now available to aid propulsion, which in turn makes the engine more efficient. Kopperger sees these new materials as an aid to achieving the European Commission's Flightpath 2050 targets, which MTU maps out in its Claire initiative. Claire stands for Clean Air Engine. Through Claire, MTU is striving to reduce fuel consumption by 40 percent by the year 2050, compared with today's V2500 engine.

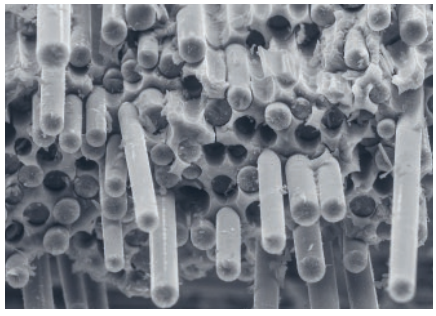
Eight times thinner than a human hair

These materials, the stuff of dreams for engine developers, are reinforced with ceramic fibers in order to give them the required robustness. These fibers are eight times thinner than a human hair and are characterized by their extremely high break resistance. Also the ceramic matrix in which the fibers are embedded is robust and virtually non-malleable. Amazingly, the combination of these two ceramic components produces materials that can cope with high loads. Although small cracks do appear in the material, these cannot spread because they are diverted by many thin fibers and are robbed of the energy they would need to grow. The key to this behavior lies in the way the fibers bond with the matrix, what's known as the interface, where interactions happen that must be properly "adjusted," as the material specialists say.

"Ceramic fibers embedded in a ceramic matrix–what are known as CMCs–don't have the brittleness of traditional ceramics and as such can be used in structures that have to withstand high loads–such as aircraft engines. Compared to metal materials, they can tolerate significantly higher temperatures, which in turn raises the turbine's efficiency."

Dr. Friedrich Raether
Director of the Fraunhofer Center for High Temperature Materials and Design HTL in Bayreuth, Germany.

"Since ceramic fibers embedded in a matrix don't have the brittleness of traditional ceramics, they can be used in structures that have to withstand high loads–such as aircraft engines," says Dr. Friedrich Raether, director of the Fraunhofer Center for High Temperature Materials and Design HTL in Bayreuth, Germany.



Ultra-thin _____ *The ceramic fibers–seen here magnified 1,000 times–are eight times thinner than a human hair. Reinforcing the matrix with the fibers increases its break resistance, allowing for the material's use in engine construction.*

"Producing CMCs still represents a major challenge," explains Katrin Schönfeld from the Fraunhofer Institute for Ceramic Technologies and Systems IKTS, who is developing new CMCs for the aviation industry. "Humans have thousands of years of experience working with metals, and we know all about what they can do. But with CMCs, we're only at the beginning of the story: We have to establish and optimize new production processes; it's about finding out what the materials can withstand and how to use them in practice."

The challenge of production

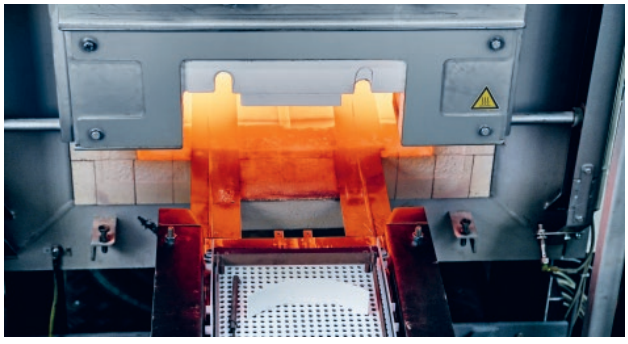
Even the embedding of the fibers in the ceramic matrix is tricky enough. It starts with a basic structure of fibers, which is encased in a liquid smelt that then hardens. Imagine pouring concrete onto a framework of steel supports. This method is called liquid-phase infiltration. To produce a composite that is good enough to be used in an engine, this process must be repeated multiple times. An alternative is chemical-vapor infiltration, in which the fiber framework is placed in a reactor and bathed in the matrix in gas phase. Here, the ceramic matrix accumulates around the fibers, one layer of atoms at a time. But this takes time: it can take months to produce a single part.

What counts for the properties of the finished workpiece is the chemistry of the ingredients: if aluminum oxide fibers are encased in an aluminum oxide matrix, the result is oxidic CMC–what the developers also call Ox/Ox. This is very robust because neither air nor aggressive chemicals can harm it. While this "white CMC" can be produced relatively cheaply, it can withstand temperatures of only 1,200 degrees Celsius. More temperature-resistant–up to 1,400 degrees Celsius–and more robust is non-oxidic "black CMC." This is made of silicon carbide fibers in a silicon carbide matrix, or SiC/SiC for short. Since this combination does not have sufficient corrosion protection when oxygen penetrates the surface, parts must also receive a protective layer known as the environmental barrier coating. Production is therefore complex and expensive.

"Both white and black CMCs are suitable for manufacturing turbines. Which material gets used depends on the environmental conditions," Kopperger explains. "Being particularly temperature-resistant and able to withstand mechanical loads, non-oxidic SiC/SiC materials are used for components such as blades. In contrast, gas-feeding housing parts can be manufactured from oxidic CMC."

Start your engines

The first CMC parts have already passed muster in engine construction. CFM International has been using SiC/SiC sealing rings in the LEAP turbine since 2016. The GE9X engine made by GE Aviation is also equipped with CMC parts. And Boeing tested a CMC acoustic exhaust nozzle, designed to reduce noise, for the Trent 1000 from Rolls-Royce.



Heat test _____ *A development part made from oxidic CMC is being tested in an oven heated to as much as 1,100 degrees Celsius to see how it holds up under extreme conditions.*

Research for aviation _____ *After testing, the parts are thoroughly inspected to ascertain how the manufacturing processes can be further optimized.*

Special properties _____ *White CMC cannot be used at temperatures as high as black (SiC/SiC) CMC can, but it doesn't have to be protected from oxygen when exposed to high temperatures.*

For its part, MTU wants to first use the new materials in the further development of today's geared turbofan engines, which is scheduled to enter production in the early 2030s. CMCs are to be used in the manufacture of moving and static turbine blades as well as housing parts. "These materials are not available off the rack, so we work with our partners in research and industry to come up with new materials," Kopperger reports. Partners include BJS Ceramics in Gersthofen, the Schunk Group in Heuchelheim, DLR in Stuttgart, the Fraunhofer Center for High Temperature Materials and Design HTL in Bayreuth and the Fraunhofer Institute for Ceramic Technologies and Systems IKTS in Dresden.

"Our goal is to expand on MTU's expertise in designing suitable engine components and to establish an accessible supply chain for manufacturing said components," Kopperger explains.

Development in the EU project

MTU engineers have already gathered key experience in the EU Clean Sky technology project. In the initial phase, protective layer segments for the interior coatings for housings were produced and tested. The project partners are currently working on parts for flowpath hardware. Kopperger notes that the design and manufacture both of the demonstrator engine and of the test run are of particular interest, because this is where they can test how to produce hardware that meets to aviation regulations and how ceramic parts interact with metal ones: "Metals expand when they are heated, much more so than ceramics. If we're looking to replace more and more metal parts with CMC ones, we need to be prepared for the kinds of design solutions this might entail."

In the future, a significant number of turbine components could be made from CMCs. But does this make economic sense? At the moment, it costs much more to make a part out of CMCs than out of metal. "But the cost will go down once the materials and parts manufacturing are scaled for mass production," Kopperger is sure. And: "The reduction in fuel consumption brought about by greater efficiency will justify the extra costs for ceramic matrix composites."

Do you have any questions, requests or suggestions? Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

Text:
Monika Weiner has been working as a science journalist since 1985. A geology graduate, she is especially interested in new developments in research and technology, and in their impact on society.

“Every aircraft in the world has tech made in Germany”

German aerospace OEMs hold a key technological and economic position, says president of the German Aerospace Industries Association Klaus Richter.

Dr. Richter, the German aerospace industry currently employs some 110,000 people. The German automotive industry, by contrast, employs 820,000 people. What makes you say that aerospace is a key industry for Germany and for Europe?

Dr. Klaus Richter: Everybody thinks of Germany as a country that makes cars, not aircraft. But while seven percent of all cars worldwide come from Germany, fully 17 percent of the world's aircraft are made here. The reason for this success is our innovative power: the aerospace industry invests a tenth of its revenue in R&D-almost twice as much as other sectors do. And the spillover effects are substantial. Whether it's the autopilot or lightweight construction in the automotive industry, the anti-lock braking system or shark-skin surfaces for wind turbines, numerous technological innovations originate in the aerospace sector. Other industries and the country as a whole benefit from the pioneering advances made in this field.

What's your assessment of the German aviation industry's position in the world market, and in the global value chain of aircraft construction?

Richter: Every aircraft in the world contains technology made in Germany. Today, one out of every six passenger airplanes delivered to airlines around the globe is manufactured in Germany, totaling some 300 each year! The German supplier industry is a major part of the ramp-up that's currently underway. I'm especially pleased to see that SMEs-our hidden champions-are acquiring more and more stakes in programs on the global market. Aviation is an international growth market, forecast to expand at an outstanding five percent annually. We're expecting contracts for more than 30,000 widebody aircraft over the next two decades, adding up to an impressive five trillion U.S. dollars. Right now we have to pour all our efforts into ensuring that our aircraft remain the world's best and most efficient for the next five, ten and twenty years, as that's the only way to achieve success on the global market.

Alongside the big players-Airbus, MTU Aero Engines, Lufthansa Technik and Rolls-Royce Deutschland-there are a whole host of SME suppliers in Germany's aviation industry. What challenges are there for this national supply chain?

Richter: The supplier business is seeing strong growth and can benefit from the ramp-up in production and the increase in global air traffic. There are of course challenges, too. Suppliers should work more closely together, branch out internationally and improve their operational performance by adopting new technologies and digitalization. To provide them with optimum support, BDLI has joined with regional associations and the industry organization SPACE Germany in launching the Supply Chain Excellence Initiative. Its goal is to make suppliers fit for the future.

Technological progress is one thing, but stable and reliable aircraft production is another. There is a wide range of relationships and interdependencies among OEMs and suppliers. How resilient is this network?

Richter: Global air traffic doubles every fifteen years, and the resulting demand is a challenge for the production capacity of the entire industry, no question. However, when the OEMs have full order books, this lends suppliers a certain degree of security as they plan for the next few years, while also strengthening the OEM-supplier network. In addition, as many SME suppliers become more international, they spread their capacity across a broader base and can thus improve their competitiveness.

What needs to be done to ensure that the supply chain for aircraft manufacturing continues to work in the future?

Richter: To keep from risking our competitive position, Germany, which is a high-wage country, must avoid putting further strain on the industry. Since we produce primarily for export-our industry has an export rate of more than 70 percent-such burdens hit us harder than other industries where Germany has a large domestic market. And naturally, we have to ensure that we have skilled staff and competitive working conditions.

Every value chain starts off with good ideas. Who drives their development forward? The OEMs? The customers? Start-ups, research institutions?

Richter: All of us together! Our motto is "nonstop innovation." The aviation research program in particular takes on a key role here, bringing science and industry together. OEMs today are no longer aircraft manufacturers in the traditional sense; instead, they're more like system architects and integrators within the value chain. Yet this is just one aspect of innovative change. Airbus, for example, acquires and integrates start-ups, but also works on revolutionary concepts itself, such as at the Center of Applied Aeronautical Research (ZAL) in Hamburg. Industry 4.0 is one of the most interesting topics for aviation. For our complex products, digital solutions that cover the entire life cycle from development to operations offer enormous potential. This is why Germany needs to be a driver of digitalization and not merely an observer.

You yourself used to work in the automotive industry. What can aircraft manufacturers learn from automakers?

Richter: We can learn a lot from each other. An aircraft is much more complex than a car: while a car contains up to 15,000 individual parts, a widebody aircraft has several million. On the other hand, the batch sizes in the automotive industry are much larger. That's why we can learn a lot from automotive, especially when it comes to industrial-scale production. A car today features complex software and connected systems, just as an airliner does. What both industries have in common is that they produce incredibly complex products with a huge proportion of electronics, and both have the strictest requirements regarding functional safety. In up to 70 percent of all innovations, electrics and electronics are the most important drivers.

Give us a glimpse of what's down the road: what new developments can we expect from aerospace over the next few decades?

Richter: Aerospace conducts research more intensively than any other industry. Right now we're working on flight that is virtually emissions-free. Electric drives already work well enough for smaller aircraft, and we are aiming towards launching hybrids with up to 100 seats by 2030. The second major breakthrough is autonomous flight, whether with cargo drones or air taxis. The aerospace industry drives technology forward; after all, requirements are nowhere so stringent as in the air and in space.

Dr. Klaus Richter _____
President of the German Aerospace Industries Association (BDLI)

Dr. Klaus Richter became BDLI President in 2017. Since January 2015, he has served as Chief Procurement Officer and an executive committee member of Airbus Group SE. He is also the Chairman of the Board of Airbus in Germany and heads the Supervisory Board of Premium AEROTEC Group.

Richter's responsibilities cover procurement across the entire Airbus Commercial Aircraft organization as well as strategic procurement topics for the Group. Before joining Airbus in 2007, Richter was Senior Vice President Materials Purchasing for BMW.

Born in Munich in 1964, he began his career at McKinsey & Company in 1993 as a management consultant for automotive, electronics and aviation businesses and product development. He earned his doctorate in mechanical engineering from the Technical University of Munich in 1991, and after that spent two years as a researcher and teacher at the University of California at Berkeley.

Do you have any questions, requests or suggestions?
Contact the editors here: **aeroreport@mtu.de**

More on this topic: **www.aeroreport.de**

How things work: Winglets

A little bend makes aircraft quieter and more fuel-efficient: winglets-upturned or downturned extensions at the tips of wings-improve an aircraft's environmental performance by reducing drag and increasing lift.

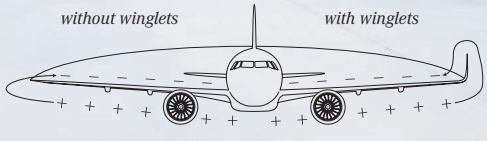
Inspired by nature: *Birds of prey have long wingtip feathers that they can spread out like a fan, which reduces air resistance and increases lift and speed. Richard T. Whitcomb, a specialist in aerodynamics at NASA, adapted this principle for aviation in the 1970s, at a time when the oil crisis had caused prices for aviation fuel to skyrocket. According to Whitcomb's calculations, an additional vertical wing saves fuel because it increases the lift-to-drag ratio.*

Evolution: *Wingtip designs can be very different. Airbus initially fitted commercial aircraft with wingtip fences, which have surfaces extending both above and below the wingtip. Boeing developed blended winglets, which are attached to the wing to form a smooth curve. More recent Airbus models have Sharklets, which curve up and back.*

Taller than a man: *Depending on the design, winglets can be quite large. The largest examples, measuring 3.45 meters, are fitted to the wings of the Boeing 767-300ER.*

5 % fuel consumption

Net benefit: *Winglets increase the weight of an aircraft, both with their own weight and also because of the structural reinforcements that need to be made to the wings. However, this negative effect is compensated for by the reduction in fuel consumption, particularly on long-haul flights. The net outcome is that winglets lower fuel consumption by up to five percent.*



How it works: *Winglets break down the vortices at the wingtips into smaller eddies, which partly cancel each other out. This reduces flow resistance and improves lift–the aircraft rises faster and therefore generates less noise while taking off. It also needs less energy in flight, which increases its range.*

The principle: *An aircraft's lift is generated by low pressure on the upper surface of the wing and high pressure on the lower surface of the wing. Air flows up around the wing to balance out the low pressure. This air movement creates vortices, particularly at the wingtips, which counteract lift and increase kerosene consumption. Winglets are able to reduce these vortices.*

“This is the start of something big”

The year 1968 was a momentous one, including for the aviation industry: new airplanes, vertical takeoff, supersonic passenger flights, and the first high-bypass engine dominated the headlines.

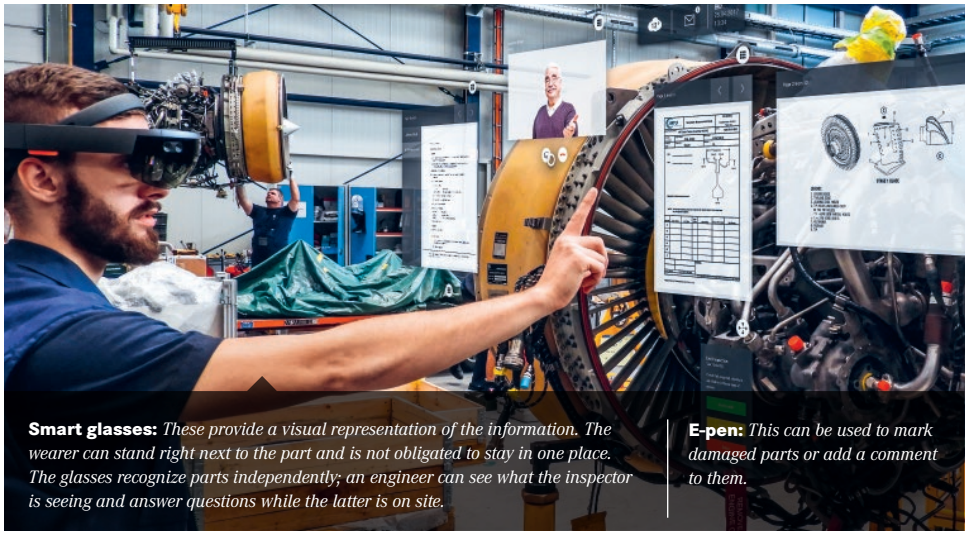
A SELECTION OF THE KEY EVENTS IN THE AVIATION INDUSTRY FOR THE YEAR 1968:

FEBR	**The Boeing 737-100** enters regular commercial service with Lufthansa powered by JT8D engines. In total, more than 14,750 of this engine type were built; in its more powerful version, the JT8D-200, it also powered the MD-80. MTU took a 12.5 percent share in this version in 1984.
MARCH	Even 50 years ago, digitalization was already a topic in aviation: “Aviation Week & Space Technology,” the industry’s leading global journal, reported on the use of **“computers” in flight training.**
APRIL	The seventh international Hannover Air Show kicked off the annual cycle of aviation trade fairs. Among the highlights were European development work on vertical takeoff and the **A300** aircraft produced by Airbus, the new manufacturer that wouldn’t be officially founded until 1970: a two-page ad in “Aviation Week” announced that this was “the start of something big.” In fact, the A300 would take off for its maiden flight on October 28, 1972.
MAY	A Grumman **Gulfstream II** became the first business jet to cross the Atlantic.
JUNE	The **Lockheed C-5 Galaxy** military transporter completed its first flight.
AUG	Construction started on a new airport to the north of Paris. **Paris Charles de Gaulle** would eventually open its doors to the public in March 1974. CDG is now Europe’s second-busiest passenger airport after London Heathrow.
SEP	Flight testing plans were drawn up for western Europe’s supersonic passenger jet, the Concorde. It would complete its maiden flight in March 1969—two months after its Russian rival, the **Tupolev Tu-144**, took to the skies on December 31, 1968. Visitors to the Farnborough Air Show in autumn 1968 could marvel at the elegant aircraft as it stood on the tarmac.
OCT	The **Tupolev Tu-154**, a three-engine medium-range airliner that would be the workhorse for Russian commercial aviation until the mid-2000s, took its first flight.
NOV	General Electric presented the **CF6**, the first engine to feature a high bypass ratio. The planned **Tornado** European fighter jet began to take shape; MTU was founded in 1969 precisely to deliver Germany’s share in the engines for this aircraft. At the International Air Transport Association (IATA) meeting, discussions centered on **short and vertical takeoff and landing** (S/VTOL) aircraft as a way to ease the pressure at already congested airports.

The “Inspection 4.0” project

The inspection process in engine maintenance

Run by MTU Maintenance Berlin-Brandenburg, the project is intended to make the inspection process in engine maintenance more efficient, safe and ergonomic. The test phase is scheduled to continue until July 2019 and conclude with a demonstrator.



Smart glasses: *These provide a visual representation of the information. The wearer can stand right next to the part and is not obligated to stay in one place. The glasses recognize parts independently; an engineer can see what the inspector is seeing and answer questions while the latter is on site.*

E-pen: *This can be used to mark damaged parts or add a comment to them.*

Inspection data management ___ All relevant data on the various engine types is collected and made available in a central system.

Technology-enhanced maintenance ___ The employees are assisted in the diagnosis by innovative technologies. This simplifies work processes and makes them more efficient.

Inspection ___ The part is inspected for damage and categorized. The inspector decides whether the part should be scrapped or repaired, or whether it is in working order. The decisions that the inspector makes are recorded in the system.

Free newsletter

Sign up for **AERO**REPORT as a newsletter! We send all the latest reports, background articles and news featured in **AERO**REPORT straight to your desktop or mobile device – it’s completely free and you may unsubscribe at any time. To subscribe, simply visit the **AERO**REPORT website – and never miss out on a story again.

Sign up for the free newsletter at:

https://www.aeroreport.de/en/newsletter

AEROREPORT 02|18
The aviation magazine of MTU Aero Engines | www.aeroreport.de

Editor
MTU Aero Engines AG
Eckhard Zanger
Senior Vice President
Corporate Communications and Public Affairs

Managing editor
Dongyun Yang

Editor in chief
Eleonore Fähling

Print version
Antje Endter

Online version
Patricia Hebting

Address
MTU Aero Engines AG
Dachauer Straße 665
80995 Munich, Germany
aeroreport@mtu.de
www.aeroreport.de

Editorial staff
Denis Dilba, Eleonore Fähling, Nicole Geffert, Isabel Henrich, Victoria Nicholls, Thorsten Rienth, Andreas Spaeth, Monika Weiner

Layout
SPARKS CONSULTING GmbH

Photo credits
Cover Shutterstock
3 MTU Aero Engines
6_7 MTU Aero Engines
8_13 Shutterstock, Airbus, Samad Aerospace, Zunum Aero, Siemens, Bauhaus Luftfahrt, Ampaire, Eviation, Joby Aviation
14_19 Shutterstock, Widerøe, MTU Aero Engines
20_23 Shutterstock, iStockphoto, MTU Aero Engines
24_27 MTU Aero Engines, Shutterstock
28_31 MTU Aero Engines, Shutterstock
32_33 MTU Aero Engines
34_37 Lantal, Schroth, Shutterstock
38_41 MTU Aero Engines
42_45 Airbus
46_48 Shutterstock, MTU Aero Engines, Alejandro Hernández, Adrian Munro

Printed by
EBERL PRINT GmbH, Immenstadt

Online
ADVERMA
Advertising und Marketing GmbH, Rohrbach

Translation
Klein Wolf Peters GmbH, Munich

Geared Turbofan™ is a trademark application of Pratt & Whitney.


MTU
Aero Engines
LIFETIME EXCELLENCE
Our approximately 10,000 employees worldwide ensure top performance over the entire engine life cycle and that MTU Aero Engines enjoys a leading position in the aviation industry: in development, series production and aftermarket services. By providing tailor-made development and further training programmes, flexible working time models and comprehensive health management, we offer our employees outstanding prospects while creating the basis for maximum performance. Join us in shaping the future of aviation – and your own!
www.mtu.de/careers
top EMPLOYER GERMANY 2018
CERTIFIED EXCELLENCE IN EMPLOYEE CONDITIONS

AEROREPORT

MTU Aero Engines AG, Dachauer Str. 665, 80995 Munich, Germany
aeroreport@mtu.de, www.aeroreport.de