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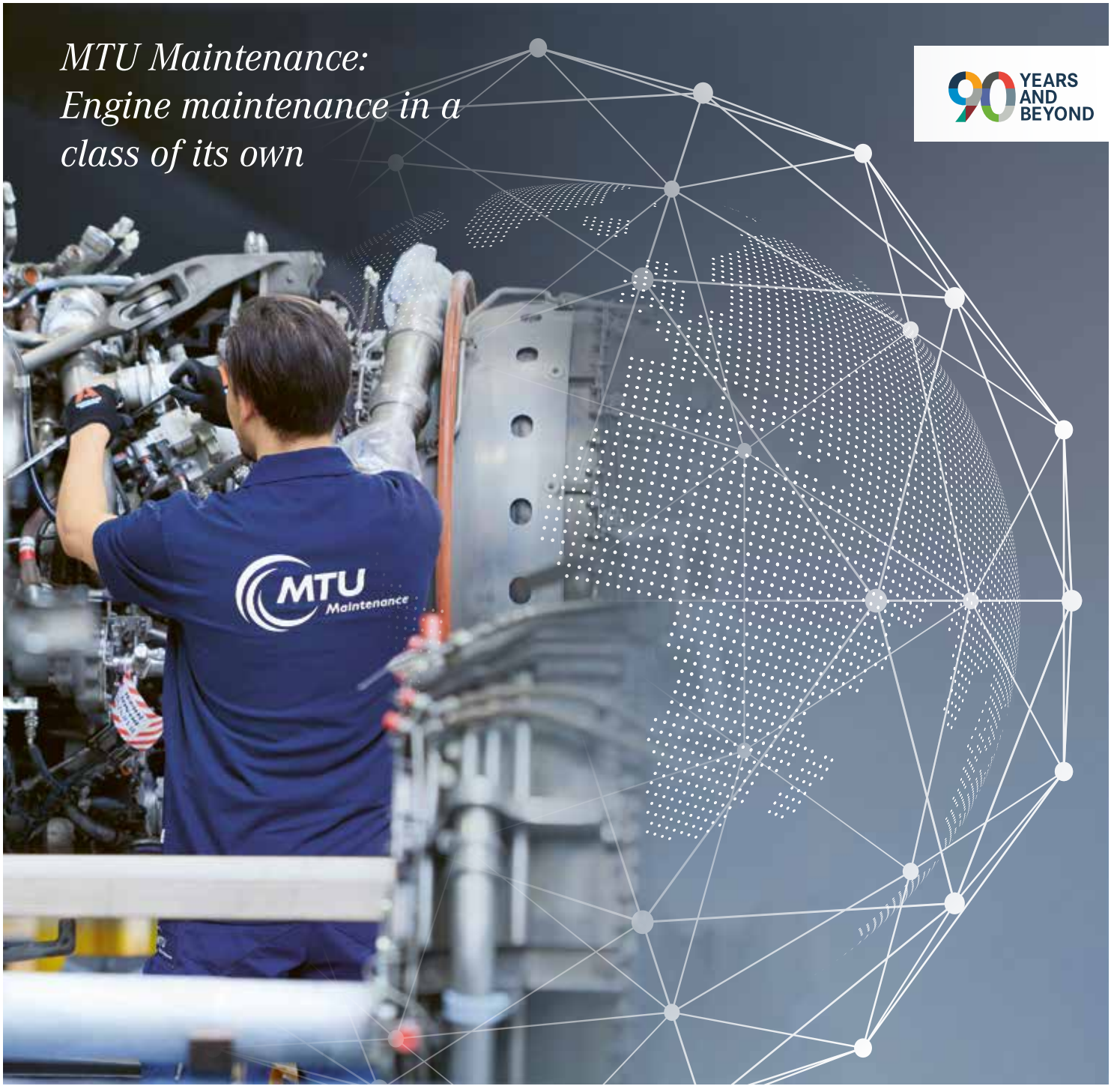


INNOVATION
Digital twin for future engine development

AVIATION
New momentum for the Eurofighter's EJ200 engine

PEOPLE
Sustainable fuels: SAFs as a lever for clean flight

PASSION FOR ENGINES

90 YEARS AND BEYOND

At MTU's 18 locations worldwide, more than 12,000 people from 88 nations are united by a common passion: a fascination for engines.

MORE INFORMATION ON THE TOPIC:

90 years and beyond – Passion for engines

www.mtu.de

Dear readers,

MTU Aero Engines has been at the forefront of the engine industry for nine decades. It's the expertise and passion of our employees that have brought the company this far, and it's they who will carry it into the future together as an even stronger and more innovative company. Today, more than 12,000 people from 88 nations work at 18 MTU locations worldwide.

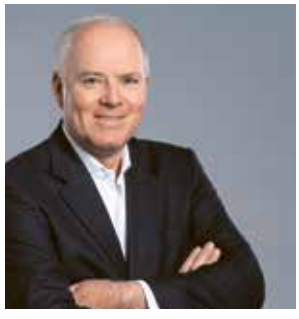
What do they all have in common? Their passion for quality and perfection, which is what drives them to put the safety of passengers and crews first. Our customers can rely on us to be at their side in any situation and at any time—for example, with our on-site service at short notice. This is one of MTU Maintenance's proven strengths: at their ON-SITE^{Plus} service locations across the globe, mobile MTU teams specialize in carrying out repairs on the wing or at the airline to ensure smooth, efficient engine operation.

And that's not all: our engine portfolio has grown rapidly over the past few decades. MTU Maintenance now looks after more than 30 different engine types for over 270 airlines. Our experts have been maintaining, repairing, and overhauling engines for 45 years and have a wealth of experience to draw on. The MTU sites in the MRO network support each other through regular transfers of know-how and a sophisticated training program. That's how we can be sure that our customers always receive the best possible customized service, wherever they are.

In this issue, we take you to our MRO sites around the world. Find out how our teams always go the extra mile for our customers. You will also gain an exciting insight into our capabilities in the field of industrial gas turbines. In this business, our experts can find themselves called away at a moment's notice—whether to a windswept oil platform in the North Sea or to the hot and humid jungles of Brazil.

In another magazine highlight, we consider the Eurofighter EJ200 engine: hardly any other engine has done as much to shape MTU's long history, and now it is experiencing a resurgence. We show you the role this engine has played—and will continue to play—in MTU's technological development. Of course, an issue of this magazine wouldn't be complete without a look at future technologies: we spoke to Fabian Donus, Head of Technology Management at MTU, about the potential and the challenges of sustainable aviation fuel (SAF)—a fuel in which the aviation industry has high hopes.

I hope you enjoy reading this issue!



Yours

Michael Schreyögg
Member of the Executive Board, Chief Program Officer

COVER STORY

Around the world with the engine experts

With a global network, MTU Maintenance ensures around the clock that aircraft are always in the air with minimum downtime and maximum availability—cost-effectively and always to the highest quality standards.

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INNOVATION

The virtual engine

In the future, MTU wants to use digital twins to virtually map an engine's entire lifecycle—from development to flight operations. This is a completely transparent, data-driven process that is unique to each engine type.

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AVIATION

Vancouver's green island hoppers

Harbour Air is Canada's largest seaplane operator; its flight from Vancouver to Victoria takes just 28 minutes. To achieve the goal of electric passenger flight by 2025, the airline will equip its indestructible Beaver bush planes with electric propulsion.

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AVIATION

Resurgence of the EJ200

The EJ200 is by no means ready for the scrap heap: Production of the Eurofighter engine is clearly gaining momentum once again. This modern fighter jet engine remains fit for the decades ahead, not least thanks to a new control unit.

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PEOPLE

It won't work without SAF

They might be scarce and more expensive than fossil kerosene, but sustainable fuels are indispensable for achieving climate goals in aviation. A conversation with Fabian Donus from MTU Technology Management on the potential of sustainable aviation fuels.

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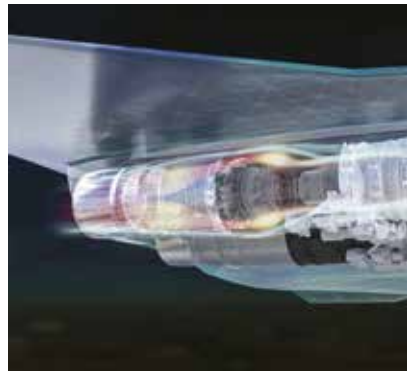

GOOD TO KNOW

The New Generation Fighter Engine (NGFE)

Every partner in the New Generation Fighter Engine (NGFE) contributes their core competencies. But what exactly goes into an entirely new engine for a fighter aircraft?

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58 **It won't work without SAF** A conversation with Fabian Donus from MTU Technology Management on the potential of sustainable aviation fuels (SAFs)

GOOD TO KNOW

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MTU CELEBRATES ANNIVERSARY

For the joy of flying

„90 Years and beyond – Passion for engines“ is the MTU Aero Engines theme this year as it looks back at its history, but especially as it celebrates what makes it stand out: the passion and expertise of its employees for engines.

HERE'S A QUICK RECAP OF 90 YEARS OF MTU—AND A LOOK INTO THE FUTURE:

1934 – BMW Flugmotorenbau GmbH is founded.

1957 – After the war, the plant in Munich-Allach (today's company headquarters) is initially converted into a repair plant for army vehicles and guns. In 1957, BMW founds BMW Triebwerkbau GmbH, which marks the resumption of engine production.

1969 – The company, now under the name "MAN Turbo," merges with Daimler-Benz to form MTU Motoren- und Turbinen-Union München GmbH. Development of the RB199 engine for the Tornado begins.

1971 – Entry into commercial engine production with the CF6-50.

1979 – MTU Maintenance is founded in Hannover.

1985 – MTU becomes a wholly owned subsidiary of Daimler-Benz AG.

2002 – The high-pressure compressor in the PW6000 is MTU's first independent involvement in a commercial core engine.

2005 – MTU Aero Engines Holding AG goes public.

2011 – MTU acquires an 18 percent program share in Pratt & Whitney's geared turbofan. It is still the most eco-efficient engine today.

2019 – MTU is promoted to the DAX.

2024 – More than 12,000 people from 88 nations work at 18 MTU locations worldwide—and the number is growing. Today, one in three commercial aircraft worldwide features MTU technology.

2040s – The new European fighter aircraft is set to take to the skies. MTU is developing the New Generation Fighter Engine together with partners.

2050 – MTU is pursuing a clear vision: emissions-free flight by 2050. To this end, it is developing revolutionary propulsion concepts.

MORE INFORMATION ON THE TOPIC:

90 years and beyond –
Passion for engines

www.mtu.de

FACTS AND FIGURES

The true “workhorses” of aviation


CFM56


V2500


PW2000


PW4000


CF6

Today, almost 13,000 **CFM56-7Bs** and nearly 7,000 **CFM56-5Bs** are in service. These two engine types are expected to complete a combined 53 million flight hours in 2024. This makes the CFM International engines the most popular of all time.

APPLICATIONS: *Boeing 737 (CFM56-7B)* *Airbus A320 family (CFM56-5B)*

Solid and reliable, the **V2500, PW2000,** and **PW4000** engines are rarely in the spotlight, but carry on quietly in the background, reliably performing their duties for airlines. Did you know that collectively, these engines take off more than 65,000 times every week? That’s once every 11 seconds.

In 2022, MTU delivered almost 750,000 parts for these engines. Well over 11,000 shop visits are expected for them worldwide by 2040.

APPLICATIONS:

V2500
Airbus A320 family
Boeing MD-90
C-390 Millennium

PW2000
Boeing 757
Boeing C-17 military transporter

PW4000
Boeing 777-200/-200ER
Boeing 777-300

MTU’s first foray into commercial engines was with the **CF6**. The company has been a partner in this long-standing program since 1971. Today, the engine still powers around 1,300 aircraft and some 70 percent of the widebody cargo fleet worldwide. In the past five years alone, MTU has delivered about 17,000 parts a year to GE Aerospace—mainly for the high-pressure turbine. Over the past 40 years, MTU Maintenance has carried out well over 4,000 shop visits for this engine type.

APPLICATIONS:

Boeing DC-10-10 (CF6-6)
Boeing 747 (CF6-50)
Boeing DC-10-15 (CF6-50)
Boeing DC-10-30 (CF6-50)
Airbus A300 (CF6-50)
Airbus A300 (CF6-80C2)
Airbus A310 (CF6-80C2)
Boeing 767 (CF6-80C2)
Boeing MD-11 (CF6-80C2)
Boeing 747 (CF6-80C2)
C-5M Super Galaxy (CF6-80C2)
Airbus A330 (CF6-80E)

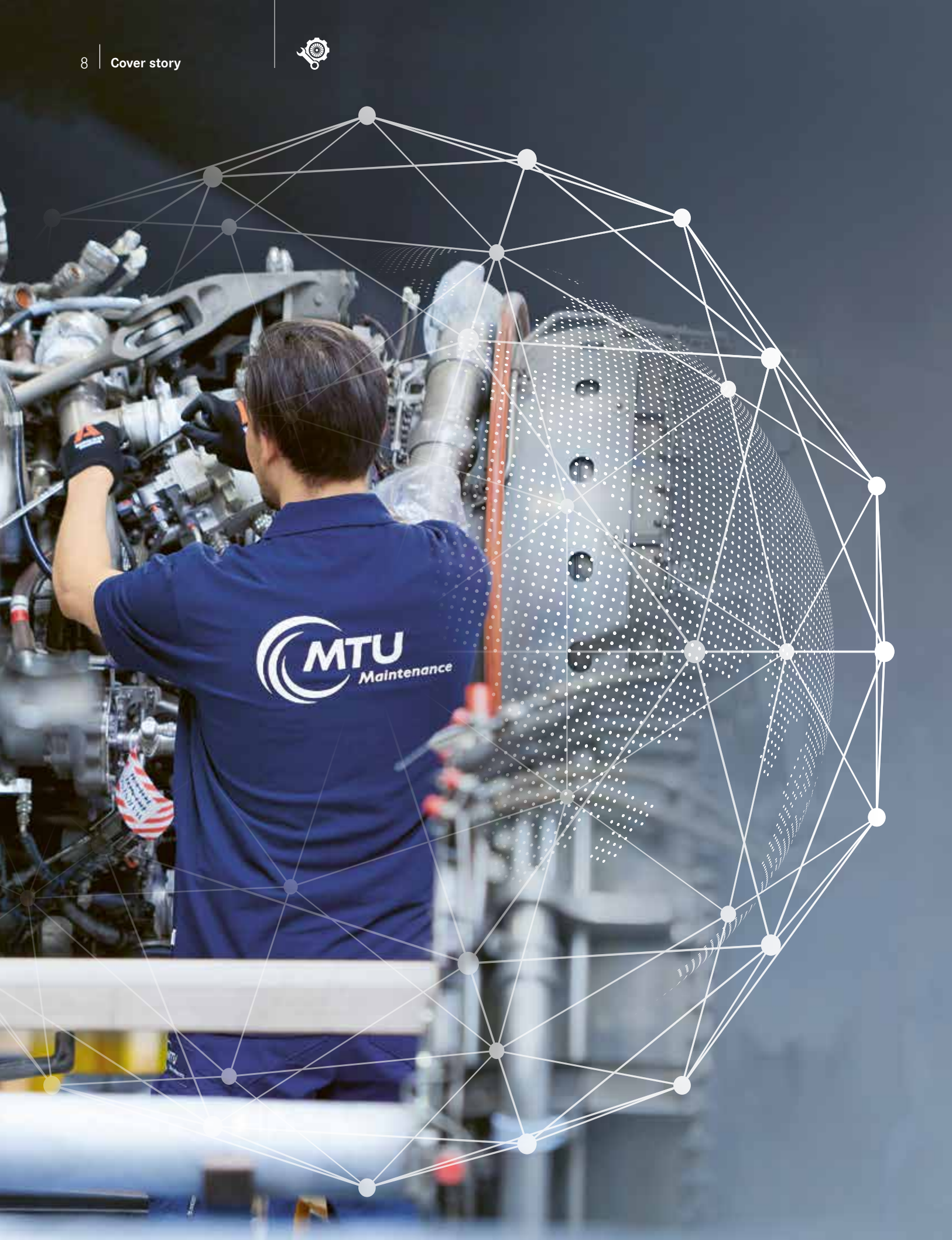
THE FUTURE OF FLIGHT

Successful SAF tests at MTU

The International Aero Engines AG (IAE) engine consortium has successfully tested a V2500 engine with 100 percent sustainable aviation fuel (SAF) at MTU Maintenance in Hannover.

Crucial step ____ *This test underscores MTU’s commitment to increasing the use of SAFs throughout the industry.*

The test was carried out solely with HEFA-SPK (Hydroprocessed Esters and Fatty Acids Synthetic Paraffinic Kerosene). The HEFA-SPK fuel is produced from renewable raw materials such as waste oils or fats and is an ideal sustainable alternative to conventional aircraft fuels. MTU Maintenance Hannover is the first maintenance organization in the world to carry out a V2500 test run with 100 percent SAF.


MTU
Maintenance

Around the world with the engine experts

How MTU sets standards in engine maintenance.

Text: *Nicole Geffert / Thorsten Rienth*

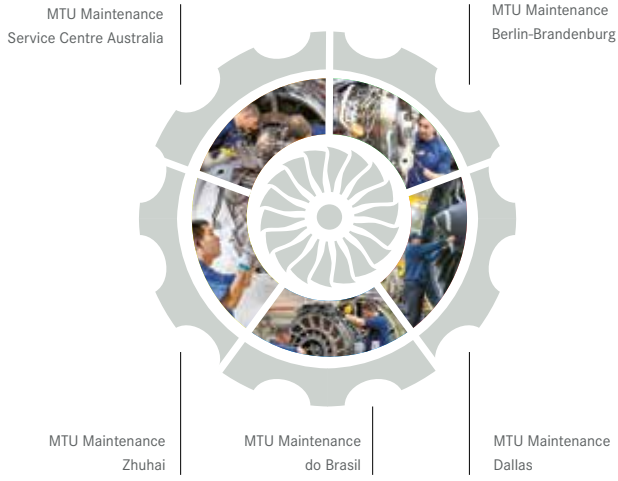
Maintenance, repair, and overhaul (MRO) services are as essential as the oil in a car, the filament in a light bulb, or the shoelace in a shoe–inconspicuous but indispensable for smooth operations. Aircraft engine maintenance, in particular, plays a key role in enabling airlines and passengers around the world to fly safely and reliably.

There are basic MRO services aimed at repairing damage immediately or complying with legal requirements. And then there is MTU Maintenance's MRO: with a global network of engine experts, MTU Maintenance ensures around the clock that aircraft are always in the air with minimum downtime and maximum availability–cost-effectively and always to the highest quality standards.

Worldwide, 365 days, 24/7

On-site service is their passion

Germany, USA, Brazil, Australia, China



MTU has set up shops around the world for urgent repairs. The mobile teams specialize in carrying out repairs on the wing or at the airline to ensure smooth engine operation and can handle even complex challenges: from borescope inspections and top case repairs on high-pressure compressors to the replacement of entire modules.

"In our MRO network, we regularly share our expertise, learn from the best in the field, and carefully review our standards."

Michael Kautzschmann
Quality Manager at MTU Maintenance Berlin-Brandenburg

For two decades, Michael Kautzschmann was at the helm of quality assurance at MTU Maintenance Berlin-Brandenburg in Ludwigsfelde, and he's still at the forefront of MTU's Group-wide quality initiatives. "Quality means safety, which is a key consideration in aviation," he says.

Due to rising cost pressure, airlines are increasingly demanding smaller and more targeted repairs instead of extensive maintenance. And the engine architecture is also increasingly changing so that work can be carried out on the wing. Kautzschmann says: "Instead of sending an engine halfway around the world to be repaired in a shop, they wanted us to repair it locally if possible."

This on-site service is one of MTU Maintenance's strengths. At their ON-SITE^{Plus} service (OSS) locations across the globe, mobile MTU teams specialize in carrying out repairs on the wing or at the airline to ensure smooth engine operation.

As the demand for rapid service increased, MTU expanded its locations in Dallas (U.S.), São Paulo (Brazil), and Perth (Australia) into service centers for aviation, with support from Kautzschmann and teams of MTU experts from Ludwigsfelde. At these new centers, engines such as the CF34, PW800, and CFM56 are now being made ready for use again in hangars with special docks for smaller scopes of work and urgent repairs. For even more customer service, the teams have now extended their capabilities to include complex repair services: from borescope inspections and top case repairs on high-pressure compressors to the replacement of entire modules.

Kautzschmann says: "If an airline calls us, MTU Maintenance is able to send a specialized team anywhere in the world within 24 hours. This happened recently when an OSS team with people from Ludwigsfelde, Hannover, and Dallas got a GE90, the world's largest engine, ready for takeoff again."

Quality is a dynamic process. "Customer needs and market trends are changing, and technologies are being further developed. We have to adapt our work to this," Kautzschmann says. How, exactly? "In our MRO network, we regularly share our expertise, learn from the best

Working on-wing ____ *MTU Maintenance's OSS assignments usually have to be carried out quickly. Like here with the GE90, the world's largest engine, which the experts have made ready for take-off again.*

in the field, and carefully review our standards—always with the aim of delivering maximum quality and safety worldwide."

Join us as we travel to four destinations to see MTU's expert MRO teams demonstrate their engine skills and expertise.

Perth, Australia

A Christmas party at over 40 degrees Celsius, barbecue instead of cookies: for Sven Zimmermann, an engine mechanic from MTU Maintenance Berlin-Brandenburg, this was the satisfying conclusion to a successful five-week training course in Perth, Western Australia. The CF34-10E engine expert works for the on-site service team in Ludwigsfelde, and his assignments mainly take him all over Europe.

In November 2023, however, the flight to his deployment site took longer than usual—all the way to the MTU Maintenance Service Centre Australia. This time it wasn't a customer who rolled out the welcome mat, but the Australian MTU team. On the agenda was a special training session on the CF34's high-pressure compressor (HPC).

The MTU site in Perth specializes in services for industrial gas turbines from GE Vernova's LM™ series. At the beginning of 2023, the site received approval from the Australian Civil Aviation Safety Authority (CASA) to carry out maintenance on the GE CF34-10E engine. This makes it the only on-site provider of engine service in the South Pacific.

"Our customer in Australia had requested an HPC top case repair for its CF34-10E engine," reports Matiu Cox, Customer Program Manager at MTU in Perth. "The training gave us two benefits: one, we were able to show the airline how well MTU's OSS network works, and two, we had the opportunity to expand our skills for this engine."

Top case repair is one of the most extensive procedures that an engine can undergo on-site. To gain access to the high-pressure compressor's nine-stage rotor, the technicians have to dismantle countless pipes, pumps, and valves. "The repairs are complex," Cox says. "We're basically doing open-heart surgery," Zimmermann adds.

"We may be a smaller site than Ludwigsfelde, but we place just as much emphasis on quality," Cox says. "The fact that we share our knowledge and resources in the MRO network is invaluable. For our customers, this creates confidence in the reliability and safety of MTU products."

Full concentration ____ *Repairing the high-pressure compressor is highly complex. Sven Zimmermann trains his Australian colleague in this discipline on a CF34.*

"The mobile teams in Perth and Dallas carry out a lot of on-wing repairs; these account for half their assignments."

Michael Eng
Certifying Staff at MTU Maintenance Berlin-Brandenburg

Dallas, U.S., and Perth, Australia

Michael Eng is not easily rattled. That's a good thing, because his job requires a steady hand. For 20 years, the most important tool for this MTU engine specialist in Ludwigsfelde has been the borescope. "I use it to inspect the inside of an engine to check the quality or wear of components," says Eng, who is a member of MTU's Certifying Staff and is authorized to approve modules for operation after assembly.

"Borescoping is also in demand for on-site services," Eng says. During these operations, MTU's mobile teams repair the engine directly on the wing, if possible, without having to dismantle it. This saves the airline time and money.

But borescoping is an acquired skill. Only a trained eye can detect the tiniest of faults, and only experience allows the specialist to assess it correctly. Eng and other MTU experts have therefore developed a training concept for borescope inspections to qualify engine professionals at MTU's MRO sites worldwide. This required Eng to travel to the MTU Maintenance Service Centre Australia for several weeks, then to MTU Maintenance Dallas in the U.S. He brought with him a training concept he had prepared with these two sites in mind.

"The mobile teams in Perth and Dallas carry out a lot of on-wing repairs; these account for half their assignments," Eng says. That's why the program included intensive training for borescoping the CF34-8, CF34-10, and CFM56-7 engines. "Carefully borescoping a CFM56-7 takes around ten hours," the MTU expert says. "It's crucial for the measurement results and the damage assessment to be reliable."

In addition to highly trained personnel, it's also vital to have the right tools. Naturally, MTU's Perth and Dallas sites have state-of-the-art borescope equipment. "The exciting thing about training sessions like this is that I get to learn from the experiences of others as well," Eng says. "Everyone benefits from the in-depth exchange."

São Paulo, Brazil

GoI Airlines is a long-standing MTU customer. MTU was one of the selected MROs to support a GOL project to perform quick-turn replacement of high-pressure turbine blades on some of its CFM56 engines.

Kay Annemüller, an engine specialist and Certified Engineer from MTU's on-site service in Ludwigsfelde, was sent out along with two engine mechanics. Their destination was Belo Horizonte in the southeast of Brazil, where GoI's MRO Aerotech I is based. A team from MTU Maintenance do Brasil was already waiting there to carry out the blade replacement together with the Ludwigsfelde experts.

For the MTU expert team from São Paulo, the job also served as on-the-job training to learn how to carry out these demanding repairs themselves in the future. The MTU site in São Paulo is an on-site service center for aircraft engines and industrial gas turbines. The team is certified for borescope and end-of-lease inspections and for top-case repairs on the high-pressure compressor. It also carries out fan blade and gearbox replacement, and repair and replacement of parts on different engine modules, including high-pressure turbine blades.

"The high-pressure turbine is the most highly stressed module in the engine, subject to extremely high pressures and temperatures," Annemüller says. The disassembly depth is particularly tricky, and the experience of an expert is essential here. Annemüller has been working at MTU in Ludwigsfelde for 14 years; he is more than happy to share his knowledge with the MRO expert network.

Both the repairs and the training were a success, and the team in Brazil is ready for the challenges ahead. Thomas Heinhold, Head of MTU Maintenance do Brasil, says: "Not only do we have the expertise, but we also have the necessary approvals from the aviation authorities in Brazil, Europe, and the U.S. This means we don't have to send the engines across the Atlantic, but can reliably repair them on-site."

Teamwork ____ *The team from Brazil received support from Ludwigsfelde for the replacement of high-pressure turbine blades on the CFM56-7.*

MTU Maintenance Zhuhai ____ *The site maintains not only the CFM56-5/-7 but also the LEAP-1A and -1B, the PW1100G-JM, and the V2500.*

Expert knowledge ____ *Liang Yongtong (l.) and Wei Li (r.) are both specialists in the maintenance of CFM56-7B*

Zhuhai, China

In 2023, engine mechanics Liang Yongtong and Wei Li from MTU Maintenance Zhuhai traveled to Berlin. They are both specialists in the maintenance of CFM56-7B engines, and their knowledge is in demand from the expert teams at MTU Maintenance Berlin-Brandenburg. The CFM56-7B is no stranger to Zhuhai, but it's still a new sight in the Ludwigsfelde shop.

"We have more than 18 years' experience maintaining the CFM56-7B, and we share this expertise within the MRO network," says Christian Ludwig, COO and Director of Technical Operations at MTU Maintenance in Zhuhai. In Ludwigsfelde, Liang and Wei demonstrated the workflows and special tools used in assembly and disassembly at the Chinese site. The pair worked side by side with the teams in Ludwigsfelde for two months.

Zhuhai maintains not only the CFM56-5/-7 but also the LEAP-1A and -1B, the PW1100G-JM, and the V2500, with a large in-house repair portfolio. The location has more than 90 customers and its teams can carry out up to 450 shop visits a year. A state-of-the-art training center and a second test cell were opened there just recently to support the growth strategy of MTU Maintenance Zhuhai.

When Zhuhai was still a young MTU location, MTU Maintenance Hannover trained the Chinese teams on-site. "We've since built on that to develop our own training system, based on our experience in production and our culture," says Li Hao, who heads the training center in Zhuhai.

Amsterdam-based MTU Maintenance Lease Services, a specialist in leasing and asset management, recently benefited from this training as well. The leasing teams are very well versed in engine maintenance, which makes them unique in the industry. Training courses, such as the one for the V2500-A5 engine, are key to their success. "Before the training, we got a clear picture of what the leasing experts wanted to know," Li says. After all, there's no such thing as off-the-rack training: just like MTU's MRO services, the training courses in the MRO network are also tailor-made.

"We have more than 18 years' experience maintaining the CFM56-7B, and we share this expertise within the MRO network."

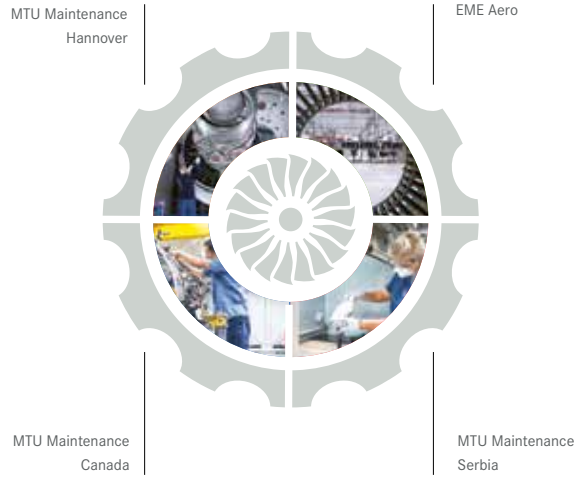
Christian Ludwig
COO and Director of Technical Operations at MTU Maintenance Zhuhai

CFM56-7B ____ *The widely used engine is now also being overhauled at MTU Maintenance in Ludwigsfelde.*

From beginner to specialist

A talent factory for takeoff

Germany, Canada, Poland, Serbia



Theory and practice ____ *The DAT training course teaches the basics of engine disassembly, assembly, and testing.*

"Word has gotten around in the region that the program is an attractive one."

Steffen Schreiber
Technical Trainer at MTU Maintenance Hannover

MTU Maintenance qualifies new specialists at its locations worldwide in creative and well-thought-out ways: In Hannover, six-week compact DAT training courses offer an attractive entry-level opportunity. In Vancouver (Canada) and Nova Pazova near Belgrade (Serbia), the company cooperates with local educational institutions as part of unique programs. At EME Aero in Jasionka, Poland, it uses unusual teaching methods to impart knowledge.

From practice for practice

When Steffen Schreiber walks around the MTU Maintenance Hannover site, he sees many familiar faces. It's not just because as a technical trainer, he sooner or later has to deal with almost everyone who maintains engines there. No, it's more because for people who changed careers to work at Langenhagen, his was often one of the first faces they encountered.

Schreiber is one of the inventors and teachers of the compact DAT (disassembly, assembly, and testing) training courses at MTU Maintenance Hannover.

"It's no secret that our industry is increasingly struggling to find skilled workers. Why not approach people who've already completed training in other metalworking professions and recruit them for MTU Maintenance Hannover?" However, the DAT concept is not a large-scale program for retraining people to become aircraft maintenance engineers.

"It's more a kind of MTU-specific training that acts as a gateway for us. It ultimately authorizes, say, a car mechanic to work on aircraft engines according to our internal specifications," says Schreiber.

The six-week compact DAT training courses include a theoretical part with English, basic knowledge, and an introduction to engines, audits, and IT programs. It also has a practical section that focuses on real-life scenarios such as working on fan casings, high-pressure compressors, and low- and high-pressure turbine modules. From practice for practice, that's the motto.

"Word has gotten around in the region that the program is an attractive one," Schreiber says. "We get a large number of applicants, and the ones we admit are highly motivated." One reason is because DAT is about much more than getting a taste of MTU for six weeks. "We want to prepare these new colleagues for the next step, which is actually much more important: on-the-job training in the individual MRO areas, such as module assembly."

This on-the-job training lasts up to a year, depending on previous qualifications and skills.

Hands-on ____ *Once the DAT training has been completed, intensive on-the-job training follows, during which the MTU colleagues can then practice on the engine.*

The final hurdle participants have to pass is the Level 2 test. “This is based on an internal MTU qualification that allows our colleagues to work on our engines extensively,” Schreiber explains. Since DAT was launched, several hundred new colleagues have joined via this route at the MTU Maintenance Hannover site alone.

Word has gotten around about this as well, only this time within MTU. Numerous other MRO locations in the MTU network have since adopted the DAT training concept and adjusted it to fit their requirements.

MTU Training Academy

The group of trainees could not be more diverse: some are only in their early 20s, others are already over 40. For some, handling tools is familiar territory, while others may be holding a wrench in their hands for the first time in their lives. While some participants have never had the opportunity to look at an engine up close, others already have a basic knowledge of its construction.

However, this diversity in the participants’ prior knowledge and experience is not an obstacle. On the contrary: MTU Maintenance Canada’s training concept is specifically designed to enable career changers to make a successful start at MTU Maintenance. Because all the trainees have a common goal: to maintain engines in the future.

The apprentices spend the first 26 weeks of their training at the British Columbia Institute of Technology (BCIT), which is comparable to a vocational school from a German perspective, where they acquire theoretical knowledge. This theoretical phase forms the basis for the subsequent 20 weeks of intensive practical experience in MTU’s MRO shop in Delta, British Columbia.

“Hands-on” is the motto there. “Above all, they learn on original parts that are no longer ‘flyable’ for a variety of reasons,” explains Matthias Voss, trainer at MTU Maintenance Canada. “This gives them a very quick idea of the tasks that the parts perform in the engine.” The basics of materials science, mechanics, and trouble-shooting procedures are also taught.

“We’ve set up a kind of ‘company within the company’ for the program,” says Voss. “It’s a separate area, but one in which students work with MTU tools, processes, IT, and documentation from day one.” Each class that goes through the training program–the only one of its kind in Canada–consists of 12 students. Three classes start at different times throughout the year.

The genuine “MTU flavor” that Voss can attest to in the learning and working area is deliberate. “Graduates of the program don’t automatically get a regular job with us, but that’s clearly our goal.”

Career changers welcome: ____ *Anyone can apply for the joint MTU and BCIT program. Brayden Eagles is actually a biologist - now he wants to get off to a flying start as an engine mechanic.*

From trainee to trainer ____ *Jasminka Marković was one of the first people to be trained as a trainee at MTU Maintenance Serbia. She now passes on her knowledge there as a trainer.*

"Together with Serbian vocational schools and academies, we're currently setting up a dual-track training system based on the German model."

Hans Triebenbacher
Support Team, MTU Maintenance Serbia

Snowballing knowledge

When the decision was made in summer 2019 to build a new MTU repair site in Nova Pazova near Belgrade, the designated project lead for trainings and qualifications immediately got to work. "Serbia did have some maintenance companies in the metalworking sector," recalls Hans Triebenbacher from the Support Team. But even though the country has a long history of aviation, the market needed some support. We had to come up with something, especially for the start of operations."

Developing a training center at MTU Maintenance Serbia proved to be a challenging but rewarding journey. The first step was to initially train and qualify people. "Many colleagues from MTU Maintenance Serbia received their on-the-job training in Germany according to a plan tailored to our needs. By acquiring skills and competencies, they were able to bring the knowledge back to Serbia and share it with newcomers, now as trainers and instructors," Triebenbacher says.

Jasminka Marković was one of the first to join MTU Aero Engines in Munich and MTU Maintenance Berlin-Brandenburg in Ludwigsfelde in this way as a trainee—and right in the middle of the pandemic. It's no coincidence that she was one of those selected. "I was already quite familiar with coordinate-measuring machines, or CMMs, from my previous job," she explains. "But aviation applications and the measurement software used at MTU were new to me."

Ten months later, back in her home country, Marković became a trainer and began to pass on what she had learned. One of her students was Jovana Bosiljković. "Although Jasminka is my trainer and supervisor, we work together as equals," Bosiljković says. "I think that's great, and also important, because it makes things much easier for me—for example, if I don't understand something the first time I tackle a topic."

Meanwhile, MTU Maintenance Serbia has expanded its training portfolio. "Together with Serbian vocational schools and academies, we're currently setting up a dual-track training system based on the German model," Triebenbacher says. "In the long term, we want to be able to train our skilled workers locally, of course." Specifically, the focus is on training people to be aircraft maintenance engineers, industrial mechanics, CNC operators, inspectors, and welders.

Triebenbacher: "Although we are now highly independent, we continue to share experiences and learn from each other across locations. Knowledge is nothing if it is not shared, so as standards are set every day, we continue on the path to Business Excellence."

Learning through play ____ *Daria Witek and Natali Fudali from the quality team introduce the new employees to the topic of quality through puzzles in the Escape Room.*

An escape room for quality control

Didactics not only imparts knowledge, but also promotes teamwork, a sense of responsibility, a solution-oriented approach, and mutual respect. Skills that are essential in engine maintenance as well.

That's exactly the thinking that Łukasz Zając, who is in charge of the training programs at EME Aero in Jasionka, Poland, and trainer Dominik Weber share. "One of the most important things in our business is to make sure our colleagues on the lines can apply their theoretical knowledge without making mistakes," Zając says. "With the Quality Escape Room, we do this in a playful way—but with real-life topics."

It is embedded in the EME Campus, one of the largest training facilities in the MTU network. Constructed in the style of an independent service workshop, the 4,000 square meter facility is equipped with all the tools and systems that EME Aero uses to maintain the engines of its global fleets.

It was inaugurated in 2023 to cope with the ever-increasing number of shop visits and at the same time ensure the qualification of the EME Aero team. "In this way, we've separated the most important service work from the training process and created a space dedicated to on-the-job training," Zając says.

Part of the training is the Quality Escape Room game for all new employees. With the support of the quality team, this is the last step before they enter the EME Aero facility and start their work.

"In the Escape Room, a group must solve various tasks and puzzles to find the key to the exit and leave the room in as little time as possible," explain Daria Witek and Natalia Fudali, both Quality Engineers and Auditors at EME Aero. In this case, the key topic is quality and the associated aspects of daily work.

Once the door to the six-by-five-meter box has closed, a small group has eight minutes to mark ten "findings." "A 'finding' could be an expired chemical, a foreign object on the floor, or a tool that's been put away incorrectly," Weber explains. When the door opens again, the trainer and the group talk through all the "findings," both identified and overlooked. "We've built up a pool of around 60 'findings' we can choose from depending on the group."

Since the beginning of the year, EME Aero colleagues who don't work directly on the engines have also been able to book a certain number of slots for the Escape Room. "A high level of awareness of quality issues is necessary in all other jobs at our company as well," Zając says.

"One of the most important things in our business is to make sure our colleagues on the lines can apply their theoretical knowledge without making mistakes."

Łukasz Zając
Head of Training Programs at EME Aero

Crash course for customers

“We underpin the confidence and trust that airlines have in us.”

Germany

MTU Maintenance
Hannover

Customer insights ____ *Yannic Düring (r.) and Christoph Garms (l.) want to use training to show their customers transparently when and why certain repairs are carried out.*

Yannic Düring, Customer Service Manager, and Christoph Garms, Power Plant Engineer at MTU, explain how MTU uses technical customer training to help airline customers better understand the interplay between individual maintenance activities.

AEROREPORT: ***Mr. Düring, isn’t it somewhat counterproductive to bring airline representatives to the engine training course in Hannover? Next thing you know, they’ll be overhauling their engines themselves!***

Yannic Düring: I’m not too worried about that. For one thing, any airlines that wanted to do that would’ve built up the necessary competencies a long time ago. For another, a two-day training course isn’t nearly enough to be able to carry out even small repairs with the necessary care and safety. To put that in perspective, training to be an aircraft maintenance engineer in Germany takes three years. Our technical customer training is about something completely different.

The idea was born during an airline visit to MTU Maintenance Canada in Vancouver. Customer representatives had occasionally taken part in internal training courses there, just to get a better understanding of some technical issues. Then the question arose as to whether we could offer something similar for the CF6-80 engine. We were of course happy to do that. A short time later, we had eight engineers from five airlines standing in the MTU Maintenance Hannover shop.

AEROREPORT: ***What exactly is the goal of a course like this?***

Christoph Garms: Anyone who works in the technical area of an airline thinks first and foremost from a fleet and airplane perspective. Naturally, their expertise can hardly extend down to the engine component level or even how those components interact in specific airline operations. But it’s precisely this expertise that’s important in order to be able to accurately assess and evaluate ongoing operations and maintenance costs. The resulting common understanding facilitates communication in both directions.

Let’s say you bring your car in to have the tires changed. The mechanic, who’s a good mechanic, calls you from the shop and says, “Listen, we jacked up the car and happened to notice that the brake shoes are pretty worn down. Should we change them now, too?” That’s how you save the customer time and money.

Complex MRO solutions ____ *Airlines think primarily from a fleet or aircraft perspective. The training should help them to better understand the engine perspective.*

AEROREPORT: ***And you apply this approach to aircraft engines, too?***

Düring: Exactly. We've been repairing the CF6-80 engine in Hannover for over 35 years, so we know very well which repairs make technical and financial sense in which situations. What other work might make economic sense to carry out while the engine is already here in our shop? Or are there any signs of wear that let us deduce possible problems that may only occur after a few more hours of flight, so we can offer preventive solutions? We want to be very transparent with our customers about why we need to carry out certain repairs. At the same time, by sharing our expertise in this way, we want to underpin the confidence and trust the airline has in us, so that they'll also choose our repair services for their next fleet.

"We've been repairing the CF6-80 engine in Hannover for over 35 years, so we know very well which repairs make technical and financial sense in which situations."

Yannic Düring
Customer Service Manager at MTU Maintenance Hannover

ABOUT THE AUTHORS

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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.

MORE INFORMATION ON THE TOPIC "MRO":

Maintenance services for our customers and partners

https://www.mtu.de/maintenance/

The state of the industry: Attitude determines altitude

*In this exclusive interview with **AERO**REPORT, Michael Schreyögg, Chief Program Officer at MTU Aero Engines, talks about current trends and market influences within the engine maintenance world as well as flexibility, growth, and pressure.*

Text: *Victoria Nicholls*

Michael Schreyögg
Chief Program Officer
at MTU Aero Engines

"We always believed in the fundamental strength of our industry."

Michael Schreyögg
Chief Program Officer at MTU Aero Engines

AEROREPORT: ***Following on from the pandemic, the aviation industry is back in full swing. Growth is occurring across the board and there is more demand than capacity in the market–from the backlogs of original equipment manufacturers to maintenance providers. And MTU, of course, is both. Where is this growth coming from?***

Michael Schreyögg: The aviation industry is international, and at its core, it enables mobility–in the fastest and safest way worldwide. But more than that, it connects people. The growth of the industry essentially comes down to lots of people wanting to travel and connect.

This was particularly apparent during the pandemic years, when travel was limited or nonexistent. It's something we all experienced, myself included. After weeks and months of isolation, we wanted to see our friends and family and experience the world again.

Luckily, we are now back to pre-Covid level. But the pandemic also had consequences for business, from the workforce to the supply chain. The world ground to a halt across the board, and many companies let go of staff. That wasn't a switch that could just be turned on again.

AEROREPORT: ***How did MTU deal with the situation?***

Schreyögg: We always believed in the fundamental strength of our industry. So we used every option at our disposal to retain our talented workforce and continue to invest in our facilities worldwide. For instance, our new repair facility, MTU Maintenance Serbia, was built through the pandemic and opened in 2022.

And now that the industry is back on track, we're working extremely hard to ramp up at all levels. From our delivery of new engines and spare parts to serving our maintenance customers as efficiently as we can.

Going the extra-mile ____ *MTU consistently invests in the MRO-network, increasing capabilities such as the introduction of new engine types, tooling, certifications, and authority approvals as well as facilities.*

AEROREPORT: ***With so much going on, what is your focus for 2024?***

Schreyögg: In a word: flexibility.

AEROREPORT: ***Meaning ...***

Schreyögg: Demand being higher than capacity is a "good" problem for companies. But it is also a tightrope when it comes to keeping customers and partners happy. So as an organization, we need to be flexible and find the best solution to meet all our commitments.

AEROREPORT: ***There is a fair bit of business jargon in that answer. Can you give us a concrete example of what you mean?***

Schreyögg: For instance, the supply chain is under a lot of pressure. On the maintenance, repair, and overhaul (MRO) side, that can mean sourcing used serviceable material (USM)—in simple terms "used parts"—to fulfill part requirements when the engine is in the shop for an overhaul, instead of relying on new parts while there are persistent bottlenecks in the supply chain.

This sounds easier than it is, though, as the market for USM is very volatile and there is high demand at the moment. The team needs to be quick and it needs a good technical, financial, and market understanding.

AEROREPORT: ***You just mentioned MRO. How would you describe MTU Maintenance in simple terms?***

Schreyögg: Flexible. (laughs)

All jokes aside, MTU Maintenance is many things: first, it's an expert MRO organization that not only carries out necessary checks and repairs of aircraft engines, but also goes above and beyond to get the most performance and life out of the engine. The team is the best at overhauling engines in the most efficient and cost-effective way for the customer.

"MTU Maintenance is an expert MRO organization that not only carries out necessary checks and repairs of aircraft engines, but also goes above and beyond to get the most performance and life out of the engine."

Michael Schreyögg
Chief Program Officer at MTU Aero Engines

Second, it's a global network of facilities and on-site service centers. So it is international, fast, and available 24/7. And it offers services for over 30 engine types—more than any MRO provider worldwide.

Third, it's entrepreneurial. The teams are close to the customers and find innovative solutions to any problem—whether technical, in fleet management, or on the asset side, as a lessor.

AEROREPORT: ***MTU Maintenance will be turning 45 this year. What do you think is the secret to its growth and success?***

Schreyögg: The people. It's no coincidence that "expert," "international," "fast," and "entrepreneurial" are all words you can use to describe a person or a team, as well as an organization.

AEROREPORT: ***What surprised you most when the MRO division of MTU Aero Engines became part of your program responsibilities back in 2016?***

Schreyögg: The mindset. I have an engineering background, and I spent the lion's share of my career on the OEM side of the business. MRO is a very different kettle of fish.

There's a speed and urgency in MRO because it's customer-facing. Every day that an engine isn't flying costs a customer money. If they can't use it, they need to find a spare engine from their pool or source a lease engine. In turn, the customer is very interested in the status of their engine and how soon they can have it back.

My experience has always been that our MRO colleagues always go that extra mile to make the customer happy.

"My experience has always been that our MRO colleagues always go that extra mile to make the customer happy."

Michael Schreyögg
Chief Program Officer at MTU Aero Engines

AEROREPORT: ***Speaking of going the extra mile. MTU is focusing even more on its on-site service network, correct?***

Schreyögg: Yes. We have an expert team who carried out well over 1,000 on-site events for over 500 customers last year across the MTU organization. Our aim is to significantly expand this offering in the coming years.

To do this, we're consistently investing in the network, increasing capabilities such as the introduction of new engine types, tooling, certifications, and authority approvals as well as facilities. For instance, MTU Maintenance Dallas moved to a new 41,000 square meter facility in 2023, which significantly increases our ability to support airlines in the region. MTU Maintenance Berlin-Brandenburg will introduce PW812D capabilities in 2024 and MTU Maintenance Service Centre Australia started work on CF34-10E engines last year, to name just a few examples.

AEROREPORT: ***Could you explain the background to these growth plans?***

Schreyögg: Of course. There are various factors that come into play here. One is the technology. The current generation of engines, such as the V2500 and CFM56, were designed and built to enable more on- or near-wing workscopes for faster and better maintenance for operators and more efficient repair processes have also been developed since they entered service. And this trend has continued in the newer generation of engines, such as the PW1100G-JM and the LEAP—with even more maintenance expected to take place in the field.

In addition, there are market influences. The pandemic created an increased focus on on-site services for cost reasons, as airlines were looking to avoid shop visits and keep their engines on wing for as long as possible. These were essentially "quick fixes" to delay more time- and cost-intensive shop visits.

It's important to note, though, that this is a balancing act. Due to life-limited parts, which are parts that have to be exchanged after a certain number of flight hours or cycles, a shop visit can't be postponed forever. Also, if parts stay on wing too long, they can become worn to the point of no repair and need replacing, which can, in turn, also increase costs.

AEROREPORT: ***How can airlines manage this balancing act?***

Schreyögg: The most important thing here is the dialogue between the customer and the

"Quality isn't optional in our industry. It's the basis of it."

Michael Schreyögg
Chief Program Officer at MTU Aero Engines

MRO provider. The more transparency over requirements, status of engines, and fleet plans, the better.

We have a proprietary fleet management planning tool, CORTEX, which can create MRO shop visit scenarios for an entire fleet at the click of a button, and plan right down to the life-limited part level (parts with a restricted number of flight cycles before they need exchanging). It's an extremely powerful and helpful tool that our customer support and engineering teams use in these discussions.

AEROREPORT: ***But even a tool can't help when there is more demand than capacity in the market...***

Schreyögg: Yes and no. MTU has an incredible range of services at its disposal. So while we might not be able to perform miracles at the drop of a hat, at least in the current environment, we can look at green-time [cycles remaining before parts must be exchanged and the engine needs to come into the shop], for instance. We then make a suggestion to a customer of perhaps switching engines to different aircraft in their fleet to maximize engine usage—in essence, winning additional time. Or we'll look at leasing options, to give a customer immediate power and lift. Or on-wing maintenance to prolong time out of the shop. It all comes down to what I was saying before, flexibility is the key.

AEROREPORT: ***With all this pressure and growth, how can you ensure quality standards?***

Schreyögg: Quality isn't optional in our industry. It's the basis of it. At MTU, we focus on structure and processes. For instance on the on-site service side, we recently introduced a central organization unit. We also place huge importance on training, qualification, and knowledge sharing across our entire global network.

The passenger never sees us, and they may never know who we are. But they sure as hell rely on us to do our job properly. Their lives depend on it.

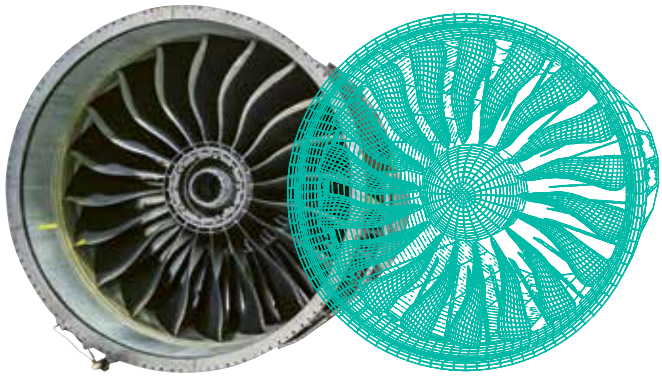
ABOUT THE AUTHOR:

Victoria Nicholls is an international communications expert. At MTU, she specializes in engine programs and market trends.

The virtual engine

In the future, MTU wants to use digital twins to virtually map an engine's entire lifecycle–from development to flight operations.

Text: *Tobias Weidemann*



“A digital twin is much more than a static model that provides a snapshot of a particular stage in development. Rather, it’s a virtual representation that tracks how a given product has evolved over time.”

Dr. Martin Engber, *Chief Engineer Virtual Engine at MTU Aero Engines*

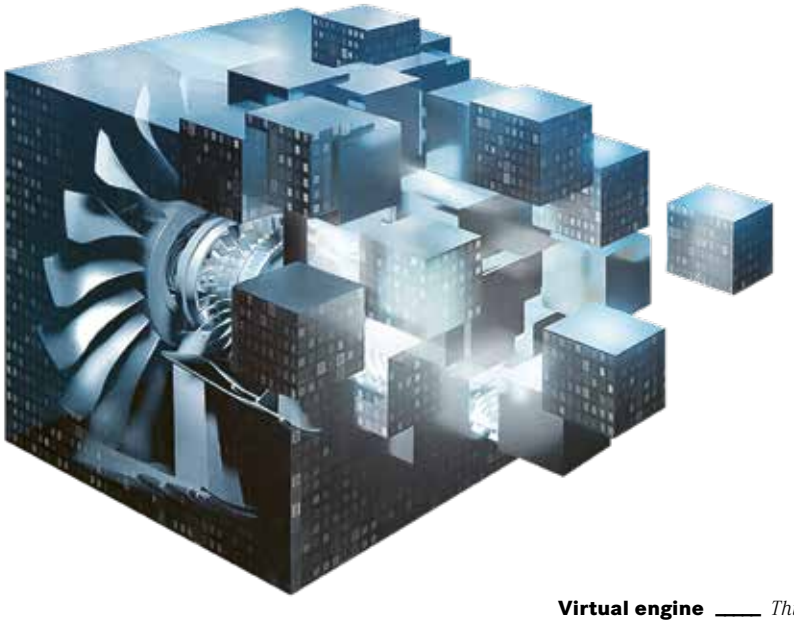
Aircraft engines are high-tech products in a class of their own. Back when passenger air travel was in its infancy, engineers would spend long periods hunched over the drawing board to design these complex machines. The introduction of computers simplified and speeded up the process immensely, and the innovations don’t stop there: “Collaboration among the different disciplines involved in developing an engine is something that works particularly well in the virtual world,” says Dr. Anna Wawrzinek, Digital Transformation Manager in the field of engine development at MTU Aero Engines in Munich. “It makes it easier to coordinate the various product requirements.” MTU’s primary focus here is on developing future engines such as the second generation of the geared turbofan, on which MTU is collaborating with partner Pratt & Whitney, or, in the military sector, the New Generation Fighter Engine.

Digital twin for future engine development

For some time, MTU’s propulsion engineers have been working on the virtual engine, which is made up of a series of digital twins. “A digital twin is much more than a static model that provides a snapshot of a particular stage in development. Rather, it’s a virtual representation that tracks how a given product has evolved over time,” says Dr. Martin Engber, Chief Engineer Virtual Engine at MTU. A digital twin allows developers to simulate an unlimited number of scenarios and draw conclusions about product development, manufacture, operation, and maintenance.

First to emerge is the “as-designed twin,” which describes what the ideal product should be like. This is used to plan the manufacture and assembly of the real product. With the data gathered from this physical product, the engineers can create a virtual “as-built twin.” “That means the as-built twin isn’t an exact copy of the as-designed twin, but differs from it in several respects, since it contains all deviations that occurred during manufacture and assembly,” Engber says.

Having both these digital twins available makes it possible to analyze how they differ. As a result, the engineers can determine whether or not the finished product not only fulfills stringent quality and efficiency requirements, but is also cost-effective to manufacture and maintain. The next step is for the as-built twin to go through acceptance testing and internal validation



Virtual engine ____ *This maps a physical engine's entire lifecycle, enabling consistent product improvements–starting right in the development stage.*

before being used in flight operations. Any wear and damage that occurs during these operations represents further deviations and is documented in what's called the "as-used twin."

Charting the evolution of every engine over its entire lifecycle means that each one also exists as a virtual engine and a corresponding digital thread, which documents all flows of data for that engine. "Each engine has its own traceable life story, which over time steadily moves away from its original as-designed twin," Engber explains. The sum total of all these deviations, and all the associated data, ultimately allow the engine experts to draw conclusions about how a product will perform in the future. In turn, they can predict when the engine will require maintenance and gauge when it makes sense to replace parts or take the engine out of service.

Processing massive datasets

Predictions like these are based on vast amounts of data–and evaluating it calls for comprehensive models. Engber is aware of the sheer scale of this challenge: "To be able to access all the relevant data at all times, we have to harmonize the different data systems used for analytics, design, production, and flight operations." The digital thread plays a key role here as the sum of all the data that links the individual phases and disciplines.

Wawrzinek has identified three factors that will be crucial to achieving success here in the future: "These are: a high level of automation in gathering, providing, and processing data; a high degree of collaboration and interdisciplinary processes within the company; and, last but not least, artificial intelligence, which can help make the forecasts and analyses more accurate." At present, the artificial intelligence (AI) applications used in engine development tend to be for approaches–structural mechanics, for instance–designed to assess a component's natural vibrations. But the hope is that AI will gradually start to deliver a wider range of insights and make it possible to analyze and optimize complex engines.

Customizing engines through virtualization

One of MTU's first lighthouse projects concerns the digital twin for compressor blades. "Aerodynamics and structural mechanics have an antagonistic relationship, and there's always

a need to reconcile the two," Engber says. "While the interests of aerodynamics are served by having blades with edges that are particularly thin and sharp, structural mechanics' pursuit of robustness favors thicker, more rounded components," he adds to explain the tightrope that developers must walk.

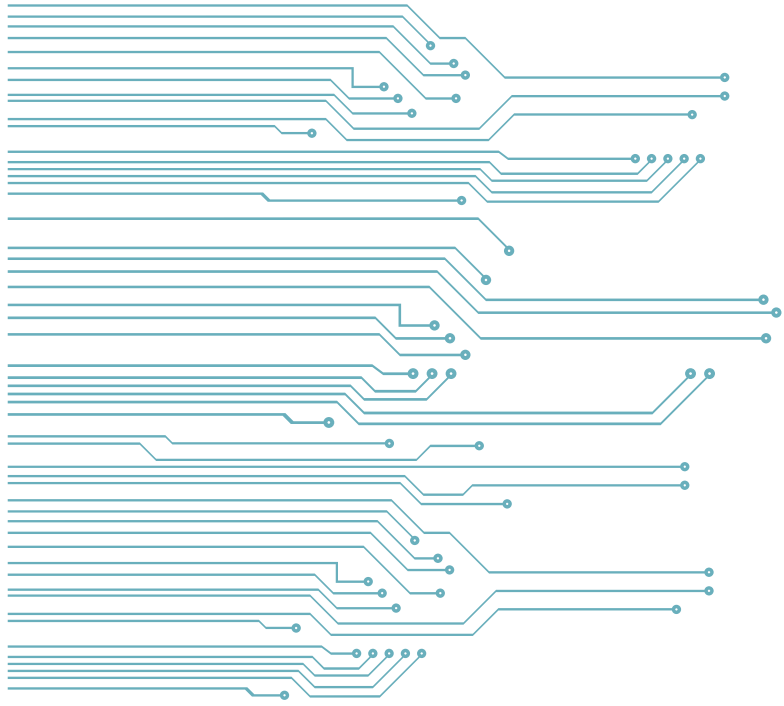
That, Engber continues, is why aerodynamics and structural mechanics have been designated as key processes in designing blades for compressors. In the medium term, MTU wants this approach to accelerate and enhance product design as well as to reduce costs. "We'll soon be in a position to automate optimization of any target variable and develop the right product for each use case," he says. The field of tension for optimization always consists of the technical requirements, such as efficiency and weight, as well as the manufacturing and maintenance costs. And, of course, the product must be sufficiently robust.

Following the digital thread

MTU's main focus in this area is currently still on the as-designed twin—in other words, on the development processes in engineering and on data transparency between technical departments. In the medium term, the focus will shift more toward production and operations, which will involve the as-built and as-used twins. "We want to draw a map of the entire digital thread—from development to production and operations to decommissioning," Engber explains. To this end, at the beginning of 2024, MTU set up a dedicated team of experts to coordinate the virtual engine agenda and drive it forward in collaboration with the various technical departments.

MTU is receiving active support from research institutions. One of these is the Institute of Test and Simulation for Gas Turbines run by the German Aerospace Center (DLR), where innovations are first developed and tested on the laboratory scale before they are rolled out to the industry.

End-to-end digitalization applications like these for development, manufacturing, and maintenance are a huge opportunity for companies, but they also pose a challenge to the MTU engine experts from the various technical disciplines and areas of the company—one that will require them to rethink how they do their job. "We must draw employees' attention to the potential that



digitalization methods hold, and we have to reinforce their digital mindset and data-driven thought processes. In short: we need to take them with us on this digital journey," Wawrzinek says. "At the end of the day, coming up with a virtual version of a product that's as complex as an aircraft engine is definitely a marathon task involving countless tiny steps–but with each step, we inch closer to making improvements." There's still a long way to go before the vision of capturing and mapping an entire engine and its functions in the virtual world can be realized. "But the journey has begun," Engber says.

ABOUT THE AUTHOR:

Tobias Weidemann has been working as a journalist and content consultant for more than 20 years. He writes about technology and business topics, often with a focus on business IT, digitalization, and future technologies.

GLOSSARY

Virtual engine: *A virtual engine is a virtual version of a physical engine. It comprises the "as-designed twin," the "as-built twin," the "as-used twin," and the digital thread that runs through the object's entire lifecycle. Creating and assessing a virtual engine calls for special skills, tools, processes, and data.*

As-designed twin: *The as-designed twin describes a product's geometry and behavior based on target data gathered from analytics and its design.*

As-built twin: *The as-built twin describes the geometry and behavior of a specific, real product and contains all deviations that occurred during manufacture and assembly.*

As-used twin: *The as-used twin maps a product's geometry and behavior during operation. It features deviations resulting from operational wear and damage.*

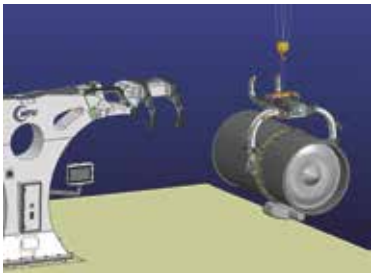
Digital thread: *The digital thread charts the data flow over a product's entire lifecycle.*

Innovative assembly system for the PW800

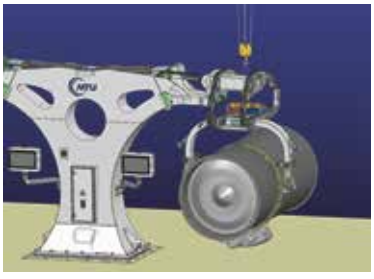
High-grade transport goods ____ *The two mechanics control the overhead crane carrying the PW800 engine such that it can be carefully suspended in the FOSng.*

MTU breaks new ground in (dis)assembly for maintaining the PW800 engine.

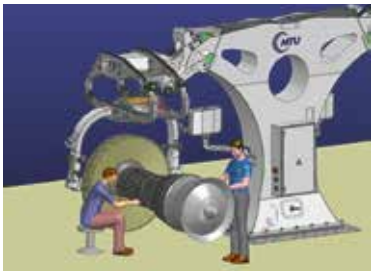
Text: *Tobias Weidemann*



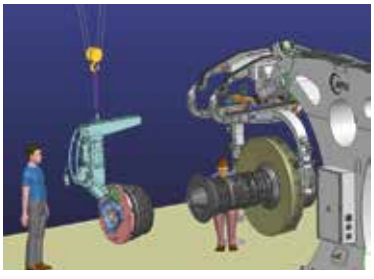
First step ____ *To bring the engine to the FOSng, it must be hooked into the overhead crane.*



Second step ____ *The overhead crane suspends the engine from its mounting in the FOSng.*



Third step ____ *Mechanics can now adjust the engine's height so they can work on it in an ergonomic position.*



Fourth step ____ *The engine can be disassembled into its individual modules with the help of the smart lifter.*

Repairing an aircraft engine is not just a procedure that must be planned right down to the smallest detail. When dismantling, turning, and inspecting the engine to gauge its repair needs, it's essential not to damage any of its components. This is literally a weighty task: the engine itself weighs several metric tons, while each of its modules weighs several hundred kilograms. To work on these modules, each one must be turned from the horizontal position it occupies in the engine to a vertical position in a way that doesn't risk any damage.

There are plenty of shop floor repair concepts, and deciding which one is the right solution depends on the number and extent of potential maintenance steps. Sometimes the engine is positioned on a central dock and worked on there from start to finish; other times it travels from station to station along an assembly line.

MTU was tasked with developing a shop floor repair concept for Pratt & Whitney Canada's PW814GA and PW815GA engines, which power the Gulfstream G500 and G600 business jets. MTU Maintenance Berlin-Brandenburg has been carrying out repairs on the low-pressure turbine for these propulsion systems for years, but 2024 will see it repairing whole engines for the first time. This work will be performed using a stationary system that is unlike any other in the world—and that's because there's something special about this engine series: the PW800 features the same core technology as the Pratt & Whitney GTF™ engine family. Only two locations worldwide repair the PW800, and one is MTU Maintenance Berlin-Brandenburg in Ludwigsfelde.

Cross-site collaboration for a custom solution

Known as FOSng, which stands for fixed overhaul system next generation, the chosen assembly and disassembly system is the result of two years of intensive cross-site collaboration between the team at MTU Maintenance Berlin-Brandenburg and their design colleagues at MTU Aero Engines in Munich. MTU decided to build on the existing FOS assembly concept, which was developed several years ago for EME Aero, a joint venture between MTU and Lufthansa Technik, in Jasionka, Poland. The concept is an essential part of maintaining the Pratt & Whitney GTF™ engine family at that location and is applied in the same way at MTU Maintenance Zhuhai.

"The alternative would have been to procure an assembly bay solution from Pratt & Whitney Canada (P&WC)," reports Dr. Nico Koppold, Head of Process Engineering Operations at MTU in Ludwigsfelde. But the system that the MTU experts examined at P&WC's location in West Virginia would have taken up roughly twice as much space and been incompatible with the crane system available at the MTU facility.

"We then looked at what's involved in fully disassembling a PW800 engine and realized that it made more sense to develop a new assembly and disassembly concept," explains Benedikt Lechner, Process Engineer for assembly systems at MTU in Munich. As it happens, there was a solution that would allow the engine to be suspended in a central location, freely accessed by the overhead crane, and fully repaired.

A universal interface for good adaptability

FOSng features a T-shaped dock that allows two engines to be suspended, one from each arm, and thus worked on simultaneously. It is designed to bear 5.5 metric tons each side—plenty for two PW800 engines. As FOSng is taller and wider than its predecessor, it can be used to work on larger engines. A positive side effect is the increased space between engine and the FOSng supports, which means work can be carried out ergonomically.

FOSng should also offer greater flexibility: "While previous FOS systems were designed for the GTF™ engine family, we wanted FOSng to be compatible with a variety of narrowbody engine types. That would make it suitable for several of MTU's MRO sites, where it could be adapted to meet the needs of the local engine portfolio," says Stefan Hofner, Assembly Systems Design at MTU in Munich. The only engine-specific element is the shuttle that connects the engine and FOSng.

This is why FOSng features a universal interface that can accommodate different custom adaptor plates, which as Hofner says is "a mechanically

Intelligent lifter arm ____ *The smart lifter lives up to its name. It automatically recognizes what module it is currently lifting and what tooling equipment it requires.*

very simple yet low-maintenance and highly robust solution." With the plate in place, the crane can follow the shuttle principle that proved so successful with the first FOS generation. The transport vehicle brings the engine into the maintenance shop and positions it beneath the overhead crane. Then the crane, which has already been equipped with the adapter shuttle that corresponds to the given engine casing, gently lifts the 1.5-meter-tall engine off the vehicle and hangs it on one of the FOSng supports. The engines suspended on each side can be moved up and down independently of one another so that the mechanics can always work on the engines in an ergonomic position. The system lets them maneuver each engine into the desired working height as well as angle.

Smart lifter as a fitting addition to the system

Attached to the crane is a core component for intelligent working: a smart lifter. This "intelligent crane hook" docks with individual engine modules and can lift and rotate loads of up to 750 kilograms. "This smart lifter can be specifically adapted to any fixture on any engine variant. It automatically recognizes which tooling equipment is currently attached and thus which module is hanging on the hook," Hofner explains.

As soon as the smart lifter is connected to the fixture, it adopts the appropriate settings and positions the crane hook based on the given program. In addition, sensors measure the weight and center of gravity of empty as well as loaded fixtures. "Our top priorities are to provide our mechanics with optimum support during the assembly and disassembly process, avoid errors, prevent the engine from being put under undue strain, and ensure that none of the components gets damaged," Koppold explains. "For us, the smart lifter is a fitting addition to all the other tools that allow us to complete the assembly and disassembly process without error and as quickly and efficiently as possible."

FOSng as a blueprint for other MTU sites

By the end of 2023, the FOSng system had completed its test phase and was installed in Ludwigsfelde, where it was gradually taken into operation using a training engine. At the same time, teams of inspectors, assembly mechanics, and certifiers completed the necessary training at Pratt & Whitney Engine Services in Savannah, Georgia, and Dallas, Texas, before going to work on PW800 engines at the company's location in Bridgeport, West Virginia. These professionals are familiar with every single component as well as the correct sequences for assembly and disassembly. They also possess in-depth knowledge of the features particular to this engine and the corresponding maintenance processes. "Simplifying the handling and height-adjustment processes means we can shave our preparation time down to just half an hour," Koppold says.

MTU's Ludwigsfelde site is already planning to add a second FOSng. In total, MTU currently has 18 active FOS systems and more are in the pipeline. Through this new innovative maintenance solution, MTU has also acquired a wealth of expertise that it can apply in other areas and adapt to the given requirements.

So it's clear that FOSng also serves as a blueprint for other MRO locations and stands as a success story built on in-house knowledge management between MTU's maintenance and operating resources design teams.

ABOUT THE AUTHOR

Tobias Weidemann has been working as a journalist and content consultant for more than 20 years. He writes about technology and business topics, often with a focus on business IT, digitalization, and future technologies.

Vancouver’s green island hoppers

Seaplanes are a normal means of transportation in Western Canada. Starting in 2025, the largest operator, Harbour Air, aims to fly sustainably using electric propulsion with the eBeaver.

Text: *Andreas Spaeth*

HARBOUR AIR

Pioneer in electric flight — *In 2019, Harbour Air performed the first electric flight of a passenger aircraft with a converted de Havilland DHC-2 Beaver. Its vision: to be the first airline in the world to offer commercial tickets on scheduled flights with electric aircraft.*

Route network ___ *Vancouver Harbour to Victoria Harbour is the airline's most important route, with up to 28 flights a day in each direction. Its longest routes are from Vancouver to Seattle Lake Union and to Tofino, each with a flight time of 50 minutes. The tourist destinations of Tofino, Comox, and Whistler are served only during the summer season. Harbour Air's route network also includes five other destinations in the region, including Richmond, which is located directly at Vancouver International Airport and offers an electric shuttle bus to the main terminal.*

Water as blue as the sky shimmers in the morning sun against the imposing mountain backdrop of Vancouver harbor. It's the perfect time to use a typical means of transportation for the most frequently flown route on Canada's west coast: a seaplane operated by the largest provider, Harbour Air. Nowhere else is flying so relaxed–the cozy terminal at the Vancouver Harbour Flight Centre is within walking distance of downtown, so no one has to wait long. Just before departure, the pilot personally picks up his passengers and takes them to the plane's dock. "Boarding starts five to ten minutes before departure, so it's enough to be there shortly beforehand," Bert van der Stege says.

The 45-year-old Dutchman has been CEO of Harbour Air since September 2022 and lives with his family in Victoria on Vancouver Island, the charming capital of British Columbia. The city of Vancouver, population 2.5 million, is just 95 kilometers away as the crow flies, or 26 minutes by plane. Van der Stege, like many of his passengers, commutes between the two cities. As is so often the case in Canada, seaplanes offer the fastest way to get from A to B; there's water almost everywhere, but not airports. In Vancouver and Victoria, passengers board and disembark right in the middle of the city.

Seeing whales from the window

"Most of our frequent flyers fly back and forth two or three times a week. No one reads the newspaper or looks at their phone; they're always looking out the window. Just now, a regular customer was all excited to tell me about the whales he'd just seen. It's a different way of traveling–and unique for Canadians to show up for work like this," the CEO explains. The seaplane pilots fly visually, so they're almost always on time in summer when the weather is good. At the serviced ports, the wet runways are marked by buoys, and to improve punctuality and safety in poor visibility, the pilots are now starting to use instruments as well in their approach to some destinations, such as Victoria. The larger landing sites have their own control tower for seaplanes.

More than half of Harbour Air's passengers (approximately 440,000 in 2023) fly between Vancouver and Victoria on planes equipped with 6 to 18 seats. Harbour Air deploys 55 percent of its total flight capacity on this route, with its aircraft making the trip up to 28 times a day in each direction. Boasting a "floating fleet" of 45 aircraft, the private Canadian airline is the world's second largest operator of scheduled seaplane flights, after Maldivian Air Taxi in the Indian Ocean.

HARBOUR AIR BY THE NUMBERS:

Harbour Air was founded in British Columbia in 1982. With growing success and an increasing demand on both commuting and touring service, the company quickly expanded over the years adding daily, frequently-scheduled flights between Vancouver and the Lower Mainland, Vancouver Island, the Gulf Islands, the Sunshine Coast and Whistler.

440,000
Passengers flown in 2023

280 - 300
Daily flights in summer

Fleet in 2024:

1x Cessna 208B Grand Caravan EX
(9 seats)

14x DHC-2 Beavers
(6 seats)

23x DHC-3T Otters
(14 seats)

4x DHC-6 Twin Otters
(18 seats)

Fleet of seaplanes ___ *Boasting a "floating fleet" of 45 aircraft, private Canadian airline Harbour Air is the world's second largest operator of scheduled seaplane flights.*

Wet runway ___ *As is so often the case in Canada, seaplanes offer the fastest way to get from A to B; there's water almost everywhere, but not airports. In Vancouver and Victoria, passengers board and disembark right in the middle of the city.*

World premiere at Harbour Air: The first electric flight

In December 2019, the small company made headlines around the world: "First electric flight of a passenger airplane." Curiously, the star of the day was an aircraft that was built back in 1957 and hasn't been made since 1967: the de Havilland DHC-2 Beaver, the legendary Canadian bush plane. Harbour Air operates 14 of these 6-seaters and affirms that the well-maintained workhorses are, technically speaking, as good as new. The first electric flight over Vancouver lasted only 15 minutes, but the previously front-mounted Pratt & Whitney P-985 Wasp Junior piston engine had been replaced with a Magni500 electric motor from the U.S. manufacturer MagniX, which delivers 559 kW (750 hp).

The first battery was supplied by a U.S. manufacturer. In August 2022, following the pandemic, the world's first all-electric point-to-point flight of an "ePlane" took place, lasting 24 minutes and covering 72 kilometers. "By fall 2023, we had completed 78 takeoffs and landings and around 50 flight hours with the first electric Beaver, but we're noticing that the battery from 2019 is deteriorating over time," van der Stege says. "We're now replacing it with a new, lighter version from H55, a Swiss company that supplies the battery for the prototype of the second aircraft that we want to get certified."

A new battery from a solar flight pioneer

The co-founder of H55, a company with 120 employees, is André Borschberg, who set a new flight record with his fellow pilot Bertrand Piccard in 2015–2016: they circumnavigated the globe in the Solar Impulse, an aircraft powered purely by solar energy. "As a pioneer, Harbour Air is a very interesting example. They have independently decided to push ahead with electrification, and we need partners who really want to take that first step," Borschberg says. MagniX from Seattle is again supplying the propulsion system, this time the more powerful Magni650 electric motor with 640 kW (850 hp). The new "eBeaver" is currently awaiting approval from the federal authorities in the U.S. and Canada. "We're working on getting a certified aircraft by 2025. If we manage that, it'll have a range of 30 to 35 minutes plus 25 reserve minutes, which is enough for most of our routes," van der Stege says. "Our hope is that we'll be able to take three, maybe even four passengers on these flights starting at the end of 2025," van der Stege says.

An entire fleet could fly emissions-free in ten years

Including a potential hydrogen hybrid Twin Otter, the largest aircraft with 18 seats, it could take around ten years until the entire fleet is powered by environmentally friendly fuels. "Maybe in less than two years, we'll be the first airline in the world to sell commercial tickets on scheduled flights from A to B with electric aircraft," van der Stege speculates. So far, the eBeaver's test flights have gone surprisingly smoothly: "We're almost disappointed that not much is happening and everything is going according to plan. There aren't a lot of surprises." Nevertheless, some of the findings are new: "Battery performance and charging time depend in part on the water temperature. The longer the aircraft is parked in cold water, the longer it takes. Fortunately, we fly at a very low altitude, so we need much less energy for takeoff than others."

Plenty of money, sweat, and new hurdles

Harbour Air's experience makes it an important trailblazer. It is investing five million Canadian dollars in the project—a lot of money for a small company. However, it's long played a pioneering role when it comes to sustainability. Since 2007, the company has been the first in North America to feature completely carbon-neutral operations thanks to offset payments.

Now it wants to do everything it can to once again be a pioneer in producing no emissions at all, even if the goal is ambitious. "Innovation isn't easy; there are many hurdles to overcome," as van der Stege well knows—and there are probably many more awaiting him on the way to green flying.

"Maybe in less than two years, we'll be the first airline in the world to sell commercial tickets on scheduled flights from A to B with electric aircraft."

Bert van der Stege
CEO of Harbour Air

Flying by eye ___ *The pilots fly their seaplanes quite low and visually. At the serviced ports, the wet runways are marked by buoys, and to improve punctuality and safety in poor visibility, the pilots are now starting to use instruments as well in their approach to some destinations, such as Victoria.*

Pilot careers at Harbour Air

The ideal pilot career at Harbour Air begins with young people starting out as “dockhands”—basically, harbor workers who help with docking and undocking the aircraft and with loading luggage. This way, they’re already very close to their dream job and learn the basics first. Just like their boss, Bert van der Stege: he started out with an internship in Lufthansa baggage tracing. Today, he says: “Most interested parties come to us with a pilot’s license and want to fly themselves. But it’s difficult for young pilots to find their very first job,” van der Stege says. “They start off working in ground handling for a year or two and then they can switch to the cockpit. That’s what every new First Officer in the Twin Otter has done.”

Harbour Air currently employs 80 pilots. The company purposely recruits new talent from its own ranks. “Most of the pilots love flying here and won’t even consider a career in the cockpit of a Boeing 787,” van der Stege says. “Here they get to go home every evening, and we also offer a great work environment.” Some do switch to major airlines to fly jets, but van der Stege says: “Many pilots who’ve moved elsewhere come back at some point and say: I miss this, I want to fly seaplanes again.”

A special kind of pilot career ___ *Anyone who wants to make it into the cockpit as a pilot at Harbour Air must first have spent some time working as a dockhand, performing ground handling for the seaplanes. This is the training that every new First Officer in the Twin Otter has undergone.*

ABOUT THE AUTHOR:

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 to discuss current events in the sector.

Lessor and MRO expert ___ *MTU Maintenance combines the know-how from many years of MRO business with the expertise in short-term engine leasing and asset management. This provides airlines with optimum support.*

Engines for hire

Leasing is a smart option for engine management. Airlines save the purchase cost, increase their flexibility, and access an alternative to maintenance.

Text: *Nicole Geffert*

In 2023, more than 50 percent of all passenger and cargo aircraft in service worldwide were leased. By comparison, that figure was just under 25 percent in 2000. The trend toward leasing engines is also increasing–and with it the demand for flexible solutions.

“Engine leasing does more than provide airlines with replacement engines so they can continue to operate their fleets during shop visits,” says Patrick Biebel, Managing Director at MTU Maintenance Lease Services. “It also gives them the advantage of not having to invest capital in buying engines.” All this affords the airlines flexibility when responding to market demand and minimizes the risk of depreciation and overcapacity.

“We provide flexible engine leasing solutions to offer airlines exactly what they want without them having to pay for services they don’t need,” says Alistair Forbes, Senior Market Analyst at MTU Maintenance Lease Services. Based in Amsterdam, this company is the leasing and asset management arm of MTU Maintenance. For the past ten years, it has been providing tailored services to airlines and engine owners. The company also gives airlines the option of taking any engines currently not in use into its leasing pool so it can then market these engines to other airlines at short notice. “We can either buy the engine or lease it from the airline, depending on their long-term plan for the asset. Either way it boosts the airlines’ liquidity and gives us the opportunity to further expand our pool, which is now over 100 engines,” Forbes says.

Lessors and MRO experts

Engines are attractive assets that appeal to investors. Finance companies have been players in the leasing business for a long time now. But MTU Maintenance has a crucial advantage: because the company specializes in maintenance, repair, and overhaul (MRO), it has many years of experience and expertise in this field. MTU experts can be trusted to reliably assess the technical condition of an engine and its components. They know when it’s worth making repairs on a given engine and when it would be more cost-effective to lease a different one. Plus, they can gauge whether leasing is still the customer’s best option or whether this might be the right time to tear an engine down into individual parts or modules that can then be reused. “Our MRO expertise allows us to acquire assets that would make little sense for other lessors, especially banks,” Forbes says.

MTU Maintenance Lease Services focuses on short-term leases that run anywhere from three months to two years. “The demand for short-term leasing is growing all the time. Now that the aviation industry has recovered from the effects of the pandemic, business is booming for many airlines and lessors but capacity in MRO shops remains extremely limited,” Biebel says. Leasing can also be a viable alternative to maintenance, especially when it’s cheaper for the airline to lease an engine rather than have their old one repaired. The biggest cost driver for a shop visit is the materials, which really takes a bite out of the budget, even for older generations of engines. “MRO activities tend to die down when an engine is about to be decommissioned,” Forbes says. It’s not uncommon for airlines with older fleets to realize that it’s no longer worth making large-scale repairs to their engines.

MTU Maintenance Lease Services B.V.

Based in Amsterdam, MTU Maintenance Lease Services B.V. is the leasing and asset management arm of MTU Maintenance. The team has many years of experience in the MRO business and offers airlines and lessors comprehensive solutions for every stage of an engine's lifecycle. The company's core business is in short-term engine leasing and cost-effective asset management, including technical consulting.

MTU Maintenance Lease Services provides these consulting services as part of its technical asset management services (TAMS). It also manages entire engine fleets, schedules shop visits, and provides engine owners with logistical support for their assets through transport and storage solutions.

More than 70 experts working in Amsterdam, Dublin, and Singapore with cutting-edge tools developed in-house form the backbone of MTU's asset management services.

Optimizing the remaining service life

Which solution is the most economical depends not just on the condition of the engine but also on its remaining service life. If the engine needs to fly reliably for several more years, repairs can be the best solution. This is where MTU Maintenance comes in. The company expertly performs efficient repairs on older engines using certified used parts with a remaining service life that matches the customer's requirements. "If it's not worth it for the operator to commission a repair, we can provide them with a 'green-time engine'—one that is cost-effective to buy or lease and whose remaining service life is tailored to their requirements," Forbes says. "Especially when an engine is reaching the end of its service life, owners want to maximize the profits from their asset."

In such situations, the asset management arm of MTU Maintenance Lease Services optimizes the engine's value to the customer's benefit.

Let's say that an airline owns several older engines and sends these to the MTU Maintenance shop. A team of experts there determines which of the engines are suitable for repair and which will be dismantled entirely. Components taken from the dismantled engines are then reconditioned and become part of those engines that are being repaired. In such cases, the airline becomes its own materials supplier—a solution that cuts costs dramatically.

"The essence of asset management is really about coming up with tailored services that meet the various different customer requirements," Forbes says. There are also solutions for those components recovered from a teardown but not immediately rehomed in another engine: MTU Maintenance Lease Services sells these used components on behalf of the owner.

Engine leasing is a form of financing in which an engine owner makes an engine available to an aircraft operator, for example an airline, for a certain period of time and at an agreed price. The airline saves the cost of purchasing the engine, minimizes downtime, and remains flexible.

Lease engines are engines that are rented instead of purchased for a certain period of time and at an agreed price.

Short-term leasing of engines usually covers a period of a few months to a maximum of three years. Short-term leasing is ideal if a replacement engine is required for the duration of a shop visit.

A **replacement engine** is made available to the customer—if this is contractually agreed—if the customer's own engine fails or comes into the shop for maintenance. The customer can continue to operate their aircraft with the replacement engine and minimize downtimes.

As a spare parts dealer, the company also deals in materials and individual parts that are fed into MTU's global MRO network. "Today, asset management accounts for more than half of MTU Maintenance Lease Services business," Forbes says. Also in demand are technical asset management services (TAMS).

The TAMS team advises airlines on topics such as fleet planning. Forbes: "Our expert teams can make recommendations as to what has to be done to an engine before it is returned to the lessor. Aircraft leasing contracts usually contain clauses on the minimum service life of the engine, for example 2,000 cycles (take-offs and landings). Sometimes the airline's planned flying would mean the engine would not have enough life remaining when the aircraft is returned and the airline would have to pay penalties to the lessor. This is where a leased spare engine can help. It can be used from when the aircraft engine reaches the minimum life condition until the end of the lease and is then replaced with the original engine. Although this involves the cost of two engine changes and a leased spare engine, it avoids the cost of an expensive shop visit or penalty charges. To be able to provide this kind of expert technical and legal contract knowledge is particularly helpful for airlines that don't have experts in all necessary areas in house.

Spare parts are highly sought-after

Decommissioned engines are a veritable treasure trove of spare parts for maintenance procedures or for assembling green-time engines. "During the pandemic, surprisingly few aircraft were decommissioned," says Marko Niffka, Director MRO Business Development at MTU Aero Engines. "Contrary to expectations, airlines continued to operate their existing fleets due to delays in the delivery of new aircraft. This meant that older engines remained in service longer and thus couldn't serve as a source of spare parts."

Prior to the pandemic, some 160 widebody aircraft were decommissioned every year. In 2021, that number dropped to 104 and in 2022 to 97. Although decommission rates are now rising again, the effects of this dip are still being felt throughout the industry. There is a particular shortfall in spare parts and used materials for popular older engine models such as the GE90-115, which powers the Boeing 777, and the CF6-80C2, which powers the Boeing 767 and others.

Nevertheless, MTU Maintenance managed to procure engines to dismantle, for instance by establishing a partnership with Aircraft End-of-Life Solutions (AELS), a Netherlands company that dismantles decommissioned aircraft. Together, the two companies purchased a decommissioned aircraft, complete with engines, from Virgin Australia. While AELS got to work on the airframe, MTU's expert teams dismantled the engines to harvest their valuable parts.

Biebel: "Such partnerships allow MTU Maintenance to tap new markets because when airlines decommission an aircraft, they usually want to sell the whole thing and not just the engines." And MTU customers benefit from this supply of highly sought-after spare parts.

MORE INFORMATION ON THE TOPIC:

The MTU engine leasing and asset management specialists
www.aeroreport.de

ABOUT THE AUTHOR:

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.

Green-time engines are engines that have a certain remaining service life before they have to go into the shop for maintenance. By leasing green-time engines, airlines and lessors can avoid or postpone extensive repairs to their own, often older engines and thus save costs.

Asset management is a service that aims to maximize the value of an engine for the benefit of the owner. The services range from evaluating the engine and analyzing its residual value, to purchasing or leasing the entire engine, to comprehensive parts management.

Technical asset management services (TAMS) include defining the scope of service, planning and managing shop visits, replacing engines, supporting the return of leased engines, and checking engine documents.

Teardown means that an engine is disassembled into its individual parts in order to inspect and evaluate them. Teardown can take place during maintenance, after a certain number of flight hours, or at the end of an engine's service life.

Power at the touch of a button

Aeroderivative industrial gas turbines (IGTs) are in a class of their own: compact and lightweight, these IGTs offer quick start-up capabilities in power generation.

Text: *Nicole Geffert*

Wide range of applications — *Stationary gas turbines are used in energy supply and marine propulsion systems as well as pumps and compressors for oil platforms and pipelines.*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STATOIL

Under control — *Once an IGT has completed around 50,000 operating hours, it heads to the shop for basic maintenance, where MTU's specialists also conduct regular inspections, remote monitoring, technical consulting, and customer training.*

Physical fitness and nerves of steel are part of the job description for Matthias Witt and his team. As experts in industrial gas turbines (IGTs) at MTU, they can find themselves called away at a moment's notice—whether to a windswept oil platform in the North Sea or to the hot and humid jungles of Brazil. There are plenty of other workplaces that are more comfortable, but few that are quite as exciting.

Witt heads the Field Services and Package Services business units at MTU Power, the MTU Aero Engines brand for services and solutions in the field of IGTs. MTU Power is based in Ludwigsfelde at the MTU Maintenance Berlin-Brandenburg site. Since 1995, this has been the hub of MTU expertise in IGTs, with a focus on maintaining the LM™ series of IGTs manufactured by GE Vernova (GE). To date, MTU's specialists have completed more than 1,400 shop visits for LM2500™ and LM6000™ IGTs, including on-site services at operators' premises.

MTU Power's international customers are as varied and diverse as the array of IGT applications, which ranges from energy supply and marine propulsion systems to pumps and compressors for oil platforms and pipelines. "Demand is consistently high," says Henrik Harksen, who is responsible for sales of IGT services at MTU. Business is booming thanks to the construction of new terminals for liquefied natural gas (LNG) and the switch to renewables. Demand also comes from the turbine-powered frigates, cruise ships and modern high-speed ferries that sail the world's oceans.

Worldwide support

"We have customers on every continent," Harksen says. To support these customers, MTU operates a worldwide network of IGT service centers, including sites in Australia, Brazil, Thailand, Norway, Germany and the United States. Its field service teams can reach any location in the world within 24 hours. Speed can be crucial, particularly in the case of unplanned repairs that require a fast response. One of the reasons reliable service is so important is that downtime is expensive.

Not every call-out is an emergency, however. "We also offer scheduled maintenance services," Harksen says. Once an IGT has clocked up around 50,000 operating hours, it heads to the maintenance shop for basic maintenance. MTU's IGT specialists are experts in what they do: from disassembly and repairs to assembly, installation and commissioning. They are also responsible for regular inspections, remote monitoring, vibration analysis, technical consulting and customer training.

MTU in Ludwigsfelde is also home to one of the world's largest and most modern IGT test stands. "If the operator needs a replacement gas turbine during the shop visit to keep their operations running smoothly, we can help by leasing them an IGT," Harksen says.

MTU's specialists are also in demand for their expertise in package services. The term "package" refers to the complete gas turbine system and all its components. As well as the control, air, oil and fire-extinguishing systems, it includes the electrical generators, fuel supply and in some cases a water-injection system to reduce nitrogen oxides, plus various other components. Package services sometimes take the team to surprising places—for example, one of the jobs Witt and his team had to tackle involved the complete overhaul of a gas-fired power plant for an energy provider in the Manaus rainforest, all while braving temperatures of 40 degrees Celsius, 95 percent humidity and torrential rain. The result was a successfully upgraded LM6000 – and a very satisfied customer.

IGT services all around the globe

Always available ___ *Whether in the Americas, Asia, or Europe: the IGT experts at MTU Maintenance can support their customers quickly and flexibly. This is thanks to the service centers in Germany (Ludwigsfelde), Brazil (São Paulo), Australia (Perth), the U.S. (Dallas), Thailand (Ayutthaya), and Norway (Mongstad).*

A special kind of assignment ___ *The MTU Maintenance field service team is used to dealing with extremes. Whether torrential rain, humid jungle heat, or storms at sea–they are ready to come to their customers' aid even under the harshest conditions.*

Derived from aircraft engines

IGTs are divided into different power categories. For example, LM™ series IGTs are derived from various versions of the CF6 aircraft engines used to power the Boeing 747. Known as aeroderivative IGTs, these are a lightweight class of gas turbine. They work on the same principle as their airborne counterparts. Unlike aircraft engines, however, they do not have fans; instead, they harness rotational energy and convert it into electrical energy or mechanical propulsion.

The client base in this sector is very different to that of the aviation industry. “The IGT market is heavily fragmented,” says Daniel Giesecke, an expert in strategy and market analysis at MTU Aero Engines. “Airlines will often order dozens of identical engines, while IGT customers usually only buy one gas turbine, or a few at most.”

MTU has been providing maintenance services for the LM2500 since 1981. It is the most widely used gas turbine in the 20–25 megawatt power category, with enhanced versions available up to almost 37 megawatts. More than half of these powerhouses are used in the oil and gas industry.

Its “big sister”—the LM6000—produces up to 54 megawatts of power; in 90 percent of cases, it is used to generate electricity. Both these aeroderivative IGTs achieve high efficiencies of over 40 percent. They are lightweight, compact and efficient. At the other end of the scale are heavy-duty turbines, which are specifically designed for stationary continuous operation in large power stations. These deliver up to 340 megawatts of power.

Quick start-up capabilities

Heavy-duty turbines cannot match aeroderivative IGTs when it comes to flexibility, however, which is why aeroderivative IGTs now play such an important role in power generation. “Aeroderivative IGTs can be started up and shut down quickly to respond to fluctuations in electricity demand,” Giesecke says. “This makes them a key part of the system, especially now that the share of renewables is on the rise.”

The availability of wind and sun varies minute by minute, so power grids need strategies to help them cope with the intermittency of supply. Extended periods of low wind and limited sunshine pose a particular challenge. “Peaking power plants are necessary to ensure a reliable electricity supply,” Giesecke says. “Peakers are brought online during periods of peak demand, and the quick-start capabilities of aeroderivative IGTs make them the ideal candidate for this task.” The LM2500 and LM6000 can both be stepped up to maximum output in a matter of minutes, delivering electricity almost at the touch of a button.

In this respect, they are similar to aircraft engines, which are designed to deliver maximum thrust on takeoff. “Peaker plants are used in conjunction with baseload power plants, which provide a continuous supply of electricity and district heating but offer less flexibility,” Giesecke says. Since peaker plants are not in continuous use, they reach a maximum of perhaps 1,000 operating hours a year. These IGTs can be in operation for up to 30 years.

Hydrogen-ready gas-fired power plants

The future of IGTs is also closely tied to the goal of decarbonization. Hydrogen is increasingly being used as an alternative fuel as part of efforts to reduce CO_2 emissions in the energy supply. Hydrogen-ready gas-fired power plants are gaining traction, with new facilities being built and existing plants being converted. Their job is to ensure a reliable supply of electricity at times of low wind or solar output. “As long as we continue to see bottlenecks in hydrogen supply, hydrogen will need to be mixed with natural gas and burned to power IGTs,” Giesecke says.

Whether the transition to 100 percent hydrogen ultimately succeeds will also depend on whether enough climate-neutral hydrogen is available in the future. This is a challenge that the IGT sector shares with aviation, which is also relying on sustainable fuels and green hydrogen as it moves toward emissions-free flight.

MORE INFORMATION ON THE TOPIC:

MTU Power is the MTU Aero Engines brand for all services relating to gas turbines.

https://www.mtu.de/maintenance/industrial-gas-turbines

ABOUT THE AUTHOR:

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.

An unusual mission

Myanmar has been under a state of emergency since the military seized power in February 2021. Located in Southeast Asia, the country is bordered by Thailand, Laos, China, India and Bangladesh. Last year, a team comprising field service technicians from the MTU Maintenance Service Centre Ayutthaya in Thailand, the MTU Maintenance Service Centre Australia and MTU Maintenance Berlin-Brandenburg carried out a joint assignment there under stringent security arrangements.

Their destination was a power station in Yangon, formerly known as Rangoon. This facility supplies 50 percent of the city's energy—so the pressure was on to come up with a solution. Such missions are only possible if volunteers can be found and if MTU decides to grant approval for the trip based on the security situation. The safety of MTU's employees is always the paramount concern.

The team was deployed to Myanmar during the rainy season and had to battle extreme heat, high humidity and many other adversities. After 15 days, they succeeded in restoring the electricity supply to Yangon. "Once we entered Myanmar, we found that the road to the facility had been partially blocked by a landslide, so all the material had to be unloaded from the large truck onto small pick-up trucks and driven through the jungle. We spent the entire first day cleaning and sorting our dirty tools, some of which had been damaged, and getting them back into working order," says Marvin Kuhlbrodt, a field service mechanic at MTU Maintenance Berlin-Brandenburg.

The team then unloaded the IGT, which was driven to the power station's workshop via a circuitous route to avoid a nearby river. Despite the difficult circumstances, the team ultimately managed to carry out "one of the most complex repairs you can perform on a low-pressure turbine outside the shop," Kuhlbrodt says. This required additional spare parts from Germany, which were airfreighted to Bangkok and then couriered to the workshop in just five days.

Resurgence of the EJ200

Thanks to new orders, production of the Eurofighter engine is gaining renewed momentum.

Text: *Patrick Hoeveler*

Nowhere near the end ____ *The EJ200's four partner nations have built almost 1,500 of these engines to date and production is far from over. This modern fighter jet engine remains fit for the decades ahead, not least thanks to a new control system.*

Broad MTU participation ____ *As part of its 30 percent share in the program, MTU manufactures its high- and low-pressure compressor components as well as the control system for all engines. And, like every partner nation, it has its own final assembly line.*

When it comes to engines, what's better than plenty of power? Normally, the answer is even more power. But in the case of the engine for the Eurofighter, this notion appears to be superfluous. Right from the start, the EJ200 met its thrust requirements and to this day, more than 20 years later, even the most discerning pilots say it leaves nothing to be desired. Its entry into service in 2003 marked the beginning of a new era in fighter jet engine construction. This was the first time that four European partners—MTU Aero Engines, Rolls-Royce, Avio Aero, and ITP Aero—joined forces. Their mission: to develop the engine for the new fighter, and with it a thrust delivery system that remains state-of-the-art today. Compared to its predecessor, the RB199 for the Tornado, the EJ200 is in a similar thrust class yet offers a vastly better thrust-to-weight ratio. What made this possible was a genuine technological leap forward, from which MTU continues to benefit.

Breakthrough in compressors

When the EJ200 was being developed back in the 1990s, MTU was best known in the commercial engine business as a producer of low-pressure turbines. But that was about to change. For the Eurofighter engine, MTU was for the first time also responsible for the low-pressure compressor. Inspired by this experience, the company's engineers began tinkering with a technology demonstrator for a commercial high-pressure compressor and got the chance to make it part of the PW6000 engine program for MTU's strategic partner Pratt & Whitney. "A high-pressure compressor is actually a core module that manufacturers are loath to hand off to another company. The one for the PW6000 was our ticket into this important area," says Christian Koehler, Chief Engineer for the EJ200 at MTU. "Our current share in commercial engine programs is a result of the expertise we gained by working on the original EJ200."

EJ200

The EJ200 is the result of a European consortium (EUROJET Turbo GmbH) comprising MTU, Rolls-Royce, Avio Aero, and ITP Aero. It is one of the most advanced engines in its class and powers the Eurofighter and its export version, the Typhoon. With a production share of 30 percent, MTU plays a major role in the Eurofighter engine.

20,000 lbf Max. thrust with afterburner	13,500 lbf Max. thrust without afterburner	0.4:1 Bypass ratio
approx. 4 m Length	approx. 1,000 kg Weight	26:1 Pressure ratio

The engineers' pioneering work on the compressor also included the introduction of blade integrated disks, known as blisks. These sophisticated blade-disk combinations ensure more power with less weight, which is why they are now the standard for modern compressors. The EJ200 was the first engine to feature blisks in fully six compressor stages.

Almost 1,500 engines in service

To date, the four partners have built almost 1,500 EJ200 engines and delivered them to the core markets of Germany, Italy, Spain, and the United Kingdom, as well as to export customers. As part of its approximately 30 percent share in the program, MTU manufactures its high- and low-pressure compressor components as well as the control system for all engines. And, like every partner nation, it has its own final assembly line for the EJ200.

Ask a Eurofighter pilot from any country what it is about the aircraft that they are most satisfied with, and chances are they'll say the engine. MTU expert Norbert Schmette from EJ200 flight test operations in Manching, Germany, knows why: "It's because the pilots don't have to worry about the engine. Instead, they can devote their full attention to their mission. They also praise the engine's impressive power and excellent acceleration rates." Making the engine easy to handle was one of the stated development goals: pilots just have to adjust the thrust lever and the ingenious control system does the rest. This principle has remained the same, even though many modifications have been made to the aircraft over the years. Originally designed purely as an air superiority fighter, the Eurofighter was given more and more capabilities. "Nevertheless, the engine's basic design still meets all the requirements of this weapon system's expanded mission profile," says Thomas Lippert, Senior Service Engineer at MTU.

Still the best in power

Given the high amount of power available, operators can equip the aircraft with several metric tons of external load. Even when this brings the aircraft's weight from the usual 11 metric tons up to more than 23 tons, it still flies like a fighter. Installing new equipment with higher energy demand—such as a radar system with electronic phase scanning—adds another challenge, as it calls on the engine to deliver more power via the gearbox. Low-altitude, supersonic flight tests conducted over the North Sea showed, however, that the EJ200 still has sufficient reserves of power.

The EJ200's record for repairs is equally positive. Its current failure rate is just under one incident per 1,000 flight hours, which is excellent for a model in this power category. This is far better than the specification hoped for in the original design. It also means that the EJ200 has exceptionally long maintenance intervals, often requiring a shop visit only once the specified service life of individual components or certain limits have been exceeded. "Some engines achieve reliability stats that even commercial engines can barely match. Many can get close to 2,000 flight hours without having to undergo any major overhaul," Lippert says.

Teamwork ____ *Maintenance of the EJ200 takes place at MTU's operational facility in Erding.*

When blade and disk became one ____ *MTU engineers blazed new trails when they introduced what are known as "blade integrated disks" (blisks). The EJ200 was the first engine to feature these in fully six compressor stages.*

Manufactured as a single part, these blades and disks have long been a fixture in aircraft engines. The high-tech components not only save space and weigh less than conventional rotors with individual blades, but they also provide for better blade aerodynamics. Furthermore, they reduce assembly work and thus costs. As a result, engines become more compact and lighter overall and consume less fuel.

A unique approach to repairs

In addition to the more than 300 engines operated by the German Air Force, MTU currently looks after the engines in service with the Austrian Armed Forces as well as MTU modules for export customers. For the engines operated by the German Air Force, MTU doesn't do this alone but rather together with the German Armed Forces. With this engine repair cooperation, the EJ200 ushered in yet another new era. In the past, industry and armed forces kept their maintenance capabilities separate. But as the Eurofighter fleet was smaller than that of previous aircraft, parallel MRO capacity was not economically viable. So in 2002, the German Armed Forces and MTU forged a pioneering partnership.

Since then, repairs have been coordinated by industry, with soldiers always involved in the various relevant areas and key positions at MTU. This opens up both a direct line to the operational units and a dialogue about processes. "In this way, we've managed to establish an optimum repair process that incorporates the experience gained by both sides," explains Stefan Burger, Head of Program Management EJ200 and RB199 MRO at MTU. This work model proved so successful that it was later applied to other programs, such as the MTR390 helicopter engine.

Production gains renewed momentum

Following delivery of the last production engines to the core markets in 2019, the focus lay squarely on repairs. Just two years ago, it looked like volume production for the entire EJ200 engine would peter out and manufacturing would be limited to the spare parts required to repair the existing fleet. But now the situation has turned around and the Eurofighter engine is experiencing a resurgence. This is in part due to the most recent orders from Germany and Spain as well as additional letters of intent from international customers. The program is therefore of great importance to MTU: "The EJ200 still accounts for a significant share of MTU's annual military revenue and is only midway through its lifecycle," says Martin Majewski, Director of EJ200 and RB199 Programs at MTU. "We've still got new volume production deliveries coming up, as well as what is now a relatively large fleet in operation that has to be supplied with spare parts and services."

A resurgence is also happening to the Eurofighter as a pillar of the European air defense system. The German Air Force plans to fly this aircraft up through 2060 and it is still finding customers. Indeed, Spain recently decided to order a second batch, and Germany reordered as part of the Quadriga program with scope for an additional order: "As the F-35 Lightning II can't do everything the Tornado can, the potential for future Eurofighters is there," Majewski says. Another option could be a mix of manned and unmanned aircraft. "Tranche 5 of the Eurofighter could come into play here, acting as a link to controlling the unmanned weapon systems," says Wolfgang Sterr, Senior Manager EJ200/ RB199 Programs and Export. What's more, as Sterr explains, there are several export campaigns such as in Saudi Arabia: "The Eurofighter is nowhere near the end of volume production. This will run at least until 2029, perhaps longer."

New control system in the pipeline

Sterr notes that the Eurofighter's engine continues to perform with excellent stability: "Because it works so very well, we've made only minimal modifications." At present, just one major change is in the offing, not due to a lack of power, but rather simply because of a shortage of electronic components. This is making it increasingly difficult to manufacture and repair the existing engine control unit. MTU is therefore completely redesigning this unit–that way, the company can continue to supply and repair such control systems in the future.

Eurofighter

Like the EJ200 program, the Eurofighter program is a consortium based on the strength of the same four nations: the United Kingdom, Germany, Italy, and Spain–and correspondingly their leading aviation and defense companies: BAE Systems, Airbus, and Leonardo. These three companies are shareholders in a joint holding company for project management, Eurofighter Jagdflugzeug GmbH (Eurofighter).

Europe's New Generation Fighter (NGF) is being developed as part of the Future Combat Air System (FCAS). For this fighter jet's engine, the NGFE, this new Digital Engine Control and Monitoring Unit (DECMU-NG) will provide the technological basis. However, the control system being developed in collaboration with Safran Aircraft Engines is essentially entirely new.

The new propulsion system will belong to a much higher thrust class, offer a better thrust-to-weight ratio, and possess stealth capabilities. This calls for another technological leap forward. MTU is drawing here on the technology basis established through the Eurofighter engine and subsequent programs—including in the area of digital control. "MTU wouldn't be working on control technology today at all without the EJ200. That's how it all started. We'll be applying at least a portion of this expertise to the NGFE as well," Majewski says. And it's possible that advancements made as part of the new military engine could at some point find their way into future commercial programs—just like the blisks that were first used in the EJ200 and are now an indispensable part of commercial engines. "The EJ200 was a pioneer there and led to innovations in the world of commercial aviation."

As one chapter ends, another begins.

Unique in Europe ___ *MTU employees and the German Armed Forces soldiers have been working together on EJ200 maintenance for over two decades.*

ABOUT THE AUTHOR:

Patrick Hoeveler is a freelance aviation journalist working for FLUG REVUE and other publications.

5.28 m
Height

15.96 m
Length

10.95 m
Wingspan

Mach 2.0
Maximum speed

> 55,000 feet
Altitude

Faster than sound – with no afterburner

The Eurofighter is a single-seat, all-weather, multi-role combat aircraft. It can perform air defense (air-to-air) and air attack (air-to-ground) roles. The multi-role fighter jet is powered by two EJ200 engines from the Eurojet consortium. In contrast to the Tornado, the Eurofighter takes off with no afterburner during normal flight operations. This reduces noise pollution at military airfields. The Eurofighter can also accelerate into the supersonic range with no afterburner and fly at supersonic speeds for long periods of time. Only a few fighter aircraft in the world currently have this capability, known as "supercruise."

Interview —— *Fabian Donus from MTU Technology Management on the potential of sustainable aviation fuels.*

It won’t work without SAF

When it comes to climate-neutral aviation, there’s no getting around sustainable aviation fuels. Fabian Donus from MTU Technology Management explains why.

Text: *Nicole Geffert*

AEROREPORT**: Mr. Donus, sustainable aviation fuels, or SAFs for short, are a key issue in aviation. What are their characteristics?**

Fabian Donus: SAFs can already be used in today’s air traffic, as they meet the same standards. But they have a much smaller impact on the climate than kerosene from fossil sources. The logic behind SAFs is that the CO_2 emitted in flight is recycled in the production of the fuel, thus creating a CO_2 cycle that is as closed as possible. To this end, the CO_2 must first be extracted from the atmosphere in the best possible way. Another positive effect is that the combustion of SAFs produces fewer soot particles. These are partly responsible for the formation of contrails, which in turn contribute to global warming alongside CO_2 and nitrogen oxides. Today’s SAF production processes are based either on biomass or on renewable energy and CO_2. However, the quantity of SAF actually used is currently still far too low.

“Increasing the proportion of SAF in fuel has great potential to reduce its climate impact.”

Fabian Donus,
Head of Technology Management at MTU Aero Engines

AEROREPORT**: How much SAF does aviation need?**

Donus: If we want to achieve climate-neutral aviation by 2050, then the widespread introduction of SAF in the existing fleet is a fundamental prerequisite. Aircraft entering service today and in the years ahead will continue to use kerosene-powered gas turbines. The only way to significantly reduce the climate impact of these aircraft is with SAFs. Current forecasts assume a demand of around 600 million metric tons per year. However, only around 0.1 percent of the industry’s global fuel requirements can currently be met by sustainable fuels. That’s why the European Union (EU) adopted the ReFuelEU aviation initiative, which sets a minimum proportion of SAFs for all flights from EU airports. ReFuelEU aviation obligates fuel suppliers to ensure that the share of SAFs reaches 2 percent by 2025, 6 percent by 2030, and 70 percent by 2050. For synthetic fuels, a quota of 1.2 percent will apply starting in 2030; this will increase to 35 percent by 2050. Other countries are also making efforts to increase the proportion of SAFs. In the U.S., the main focus is on providing incentives through the Inflation Reduction Act, whereby fuel suppliers receive tax breaks if they sell SAF. The aim of all these measures is to create a binding framework to stimulate demand.

Another reason why SAFs aren’t yet a true alternative on the market is that they’re significantly more expensive than fossil kerosene.

AEROREPORT**: How can these quotas be achieved?**

Donus: The industry needs to attain the required production volumes very quickly. Synthetic fuels, known as synfuels, are a particularly interesting prospect, but they aren’t yet available on the market. Although the manufacturing processes for them have been developed and approved, there are very few demonstration plants worldwide. An analysis by the Potsdam Institute for Climate Impact Research suggests that of the 60 or so new synfuel projects planned by 2035, only around 1 percent have secured the investment commitments they need to proceed. Even a single project on an industrial scale requires an investment of several billion euros. No producer is going to build such a plant without being sure that there will be demand for the fuel in the long term. And that, of course, puts fulfillment of the quota at risk.

AEROREPORT**: What SAF manufacturing processes have already been approved?**

Donus: SAFs are currently manufactured mainly from biogenic residues. There are various certified manufacturing methods based on different raw materials and processes. One well-known process, which is employed to produce almost the total volume of today's SAFs, is to hydrogenate vegetable or animal fats and oils into kerosene, also known as hydroprocessed esters and fatty acids (HEFA). Other approved methods, which in turn process other biomasses, can be used to maximize the amount of SAFs. Always on the condition of not competing with food production, of course. But abiding by that condition makes it impossible to establish a sustainable supply of enough SAFs to power the global aircraft fleet.

AEROREPORT**: Power-to-liquid (PtL) is considered a very promising process. Why is that?**

Donus: In the PtL process, hydrogen is produced using electricity from renewable sources such as wind, water, or solar power. It is then synthesized with CO_2 to form hydrocarbons, which are processed into liquid fuel. To make the cycle carbon-neutral, this CO_2 must first be extracted from the atmosphere. Given these requirements, it makes most sense to produce large quantities of synthetic fuels in regions with plenty of wind and sun. According to an estimate by the Bauhaus Luftfahrt think tank, it would take less than 1 percent of the area covered by the world's deserts to meet the aviation industry's global demand for green energy for the production of synthetic fuels. In the short term, offering PtL processes economically on an industrial scale calls for large, subsidized demonstration plants. These would allow experience to be gathered on the optimal arrangement of the individual process steps. A subsequent market ramp-up would require sufficient green electricity and CO_2 to be available, preferably from sustainable sources.

AEROREPORT**: Aircraft are already allowed to use SAFs, but not fuel that is 100 percent SAF. Why is that?**

Donus: We have to differentiate here between drop-in and non-drop-in fuels. Drop-in fuels can already be used today with no technical modifications to engines, aircraft, or airport infrastructure. They are mixed with at least 50 percent conventional kerosene, as this contains substances that are still required for safe operation. These include aromatics, which are organic compounds that improve the lubricity, density, and material compatibility of aviation fuel. They are needed to ensure that particular seals used in engines swell correctly. Most SAFs are free of aromatics, which means 100 percent pure SAF is currently regarded as non-drop-in.

AEROREPORT**: What are the disadvantages of aromatics?**

Donus: Aromatics lead to increased formation of soot particles in the course of the combustion process in the engine. These, in turn, serve as condensation nuclei for water vapor, which then freezes into ice crystals. Under certain conditions, these crystals can form long-lasting contrails, the significant climate impact of which is well known.

AEROREPORT**: Initial studies show that SAFs greatly reduce the formation of contrails.**

Donus: And that can also reduce the impact of what are known as non-CO_2 effects. This is due to the lower aromatics content of SAFs compared to fossil kerosene, which I've already mentioned. DLR flight tests have shown that a reduction in particle numbers also reduces the number of ice crystals. This means that increasing the proportion of SAF in fuel has great potential to reduce its climate impact. As predicted by all manufacturers, the next generation of engines will no longer require aromatics.

AEROREPORT**: But even if future engines manage without aromatics, there will still be older aircraft in use that rely on fuel with aromatics.**

Donus: That's right. After all, aircraft have a service life of 25 years or more, so an aircraft that goes into operation today will still be flying in 2050 and beyond. As a result, we'll see a mix of older and new aircraft in the skies in the coming decades. And that's why I believe the first 100 percent SAF fuel won't be free of aromatics.

AEROREPORT**: What additional technologies could help reduce climate impact?**

Donus: To make the production of synthetic fuels sustainable, the CO_2 required must be extracted from the atmosphere. This is where carbon capture technology comes into play, the purpose of which is to remove CO_2 from the atmosphere. In the case of SAFs, this CO_2 is then recycled in fuel production. As the absolute amount of CO_2 in the atmosphere is already too high, thoughts are now generally also turning to its long-term storage in reservoirs.

AEROREPORT**: But won't this act as a brake on the development of technological innovations in aviation?**

Donus: Absolutely not. We need to keep working to reduce the energy consumption and climate impact of aircraft engines. Especially in times when the amount of green energy available is limited, it's important to use as little of it as possible. On top of that, energy consumption will always have a significant influence on price. That means we're dependent on technological innovations in aviation if we want to make flight climate-neutral in the future. Nevertheless, I believe that carbon capture technology is an important building block for achieving the ambitious climate targets across all sectors.

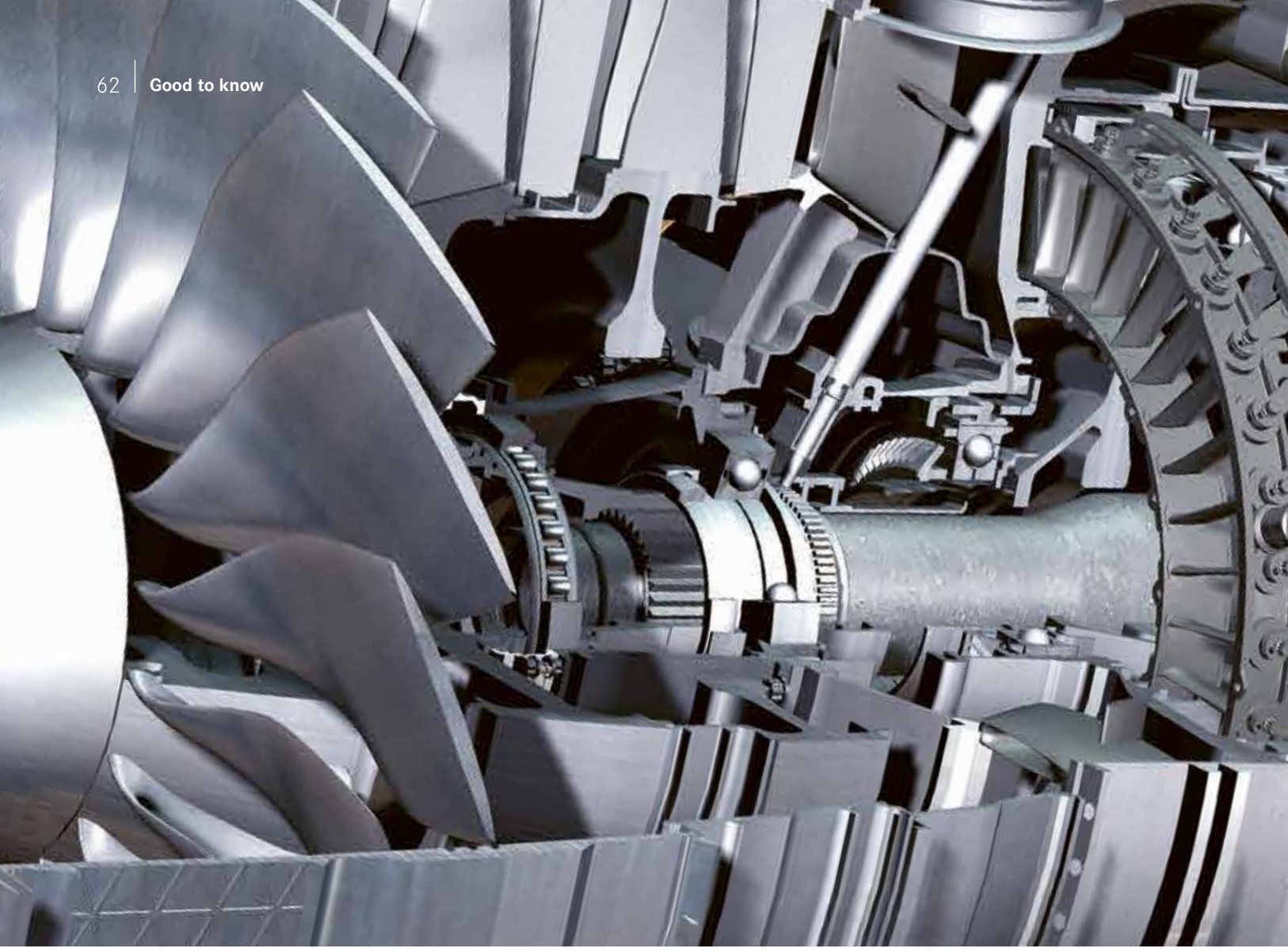
A brief bio

Fabian Donus

Before Fabian Donus joined MTU Aero Engines in 2008, he studied aerospace engineering at the University of Stuttgart. In 2019, he switched to innovation management, where he worked in-depth on the topics of climate impact and sustainable aviation. He has been Head of Technology Management at MTU since the beginning of 2024.

ABOUT THE AUTHOR:

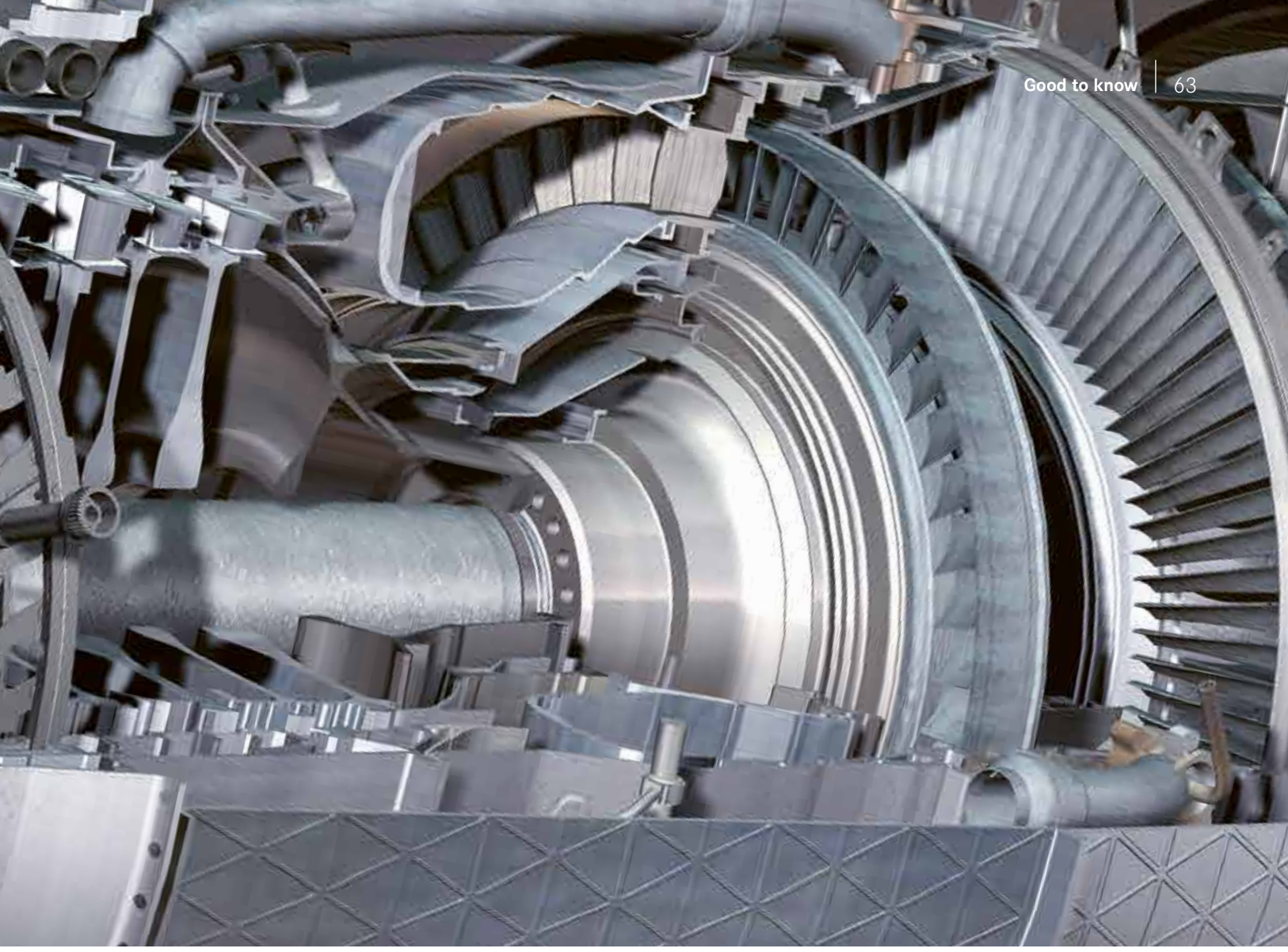
Nicole Geffert has been working as a freelance journalist covering topics such as research and science, money and taxes, and education and careers since 1999.



How does a turbojet engine work?

Propulsion for the most demanding conditions: turbojet engines are highly specialized for military applications. But how do they actually work?

Text: *Patrick Hoeveler*



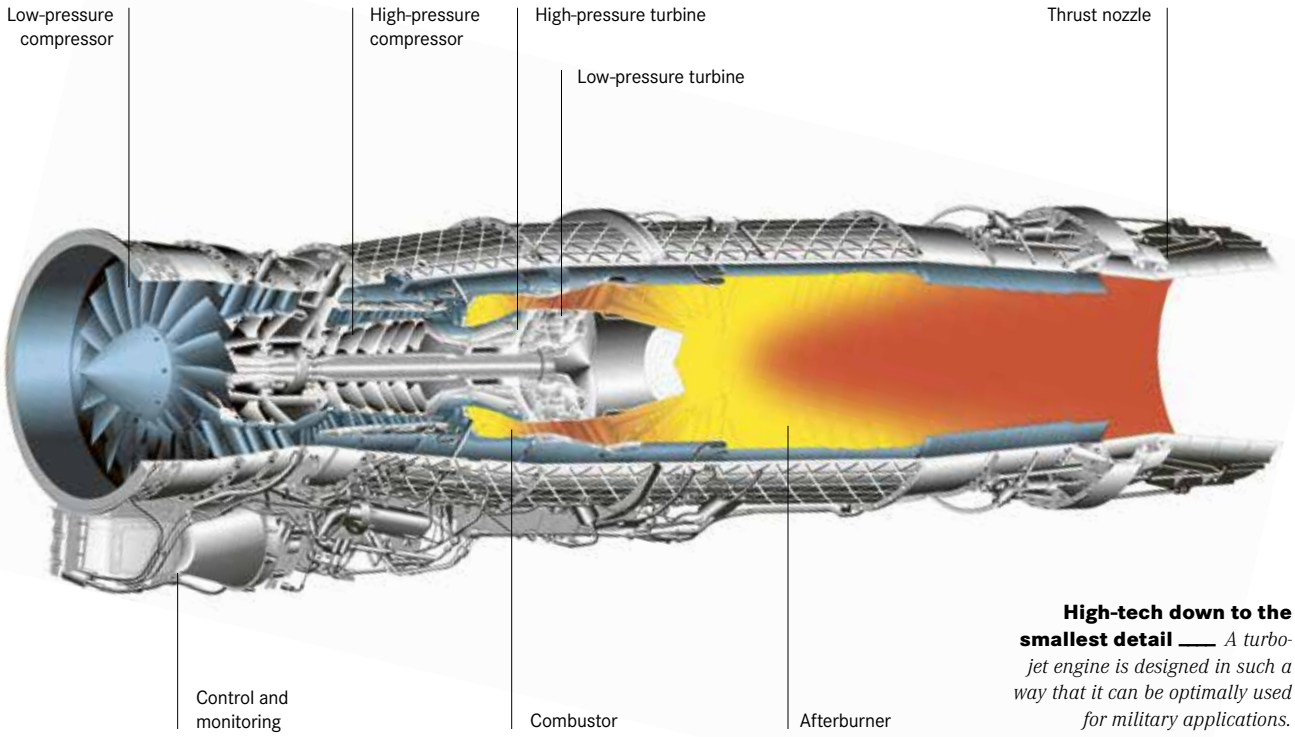
Maximum performance ___ *Military engines are similar to commercial engines in their basic function, but are designed for the most demanding conditions. The EJ200 achieves a maximum thrust of 20,000 lbf with afterburner.*

Next to a commercial turbofan engine with its giant fan, a sleek military turbojet looks almost a little lost. But in fact they function in basically the same way: air is compressed, mixed with fuel, and ignited. This generates an enormous amount of energy, which both drives the turbines and provides forward thrust. However, the requirements for the respective engines couldn't be more different.

Commercial engines are naturally optimized for cruising flight, as this is the flight envelope in which the aircraft spend most of their time. The focus is on keeping fuel consumption and noise to the lowest possible level. Military propulsion systems have to accelerate a relatively small mass to very high speeds and also deliver thrust in the supersonic range. In contrast to commercial turbofans, which use a large fan to achieve high propulsion efficiency, turbojets have a much smaller fan to ensure a high exit velocity. This means that less air flows through the engine, but the acceleration is higher.

Turbojets are highly specialized engines designed for maximum performance under the most demanding conditions. Although they basically function in a similar way to commercial engines, their focus is clearly on the specific requirements of military applications.

DESIGN AND FUNCTION OF A TURBOJET ENGINE:



High-tech down to the smallest detail ___ *A turbojet engine is designed in such a way that it can be optimally used for military applications.*

01 Ingestion **02** Compression **03** Combustion **04** Expulsion

01 Ingestion The air is sucked in through the engine's front opening, called the inlet. At high speeds, especially in supersonic flight, the design of the inlet plays a critical role as it must efficiently direct the airflow to the compressor while minimizing shock waves and drag.

02 Compression After the air has been ingested, it first flows through the low-pressure compressor and then through the high-pressure compressor. Each stage compresses the air further, increasing its pressure and temperature. This compression is essential to maximize the efficiency of the subsequent combustion and thus generate greater thrust.

03 Combustion After compression, the air flows into the combustor. This is where fuel-injection nozzles create a mix of fuel and air, which is then combusted at a temperature of over 2,000 degrees Celsius. The buildup of heat causes the gas to expand to several times its original volume and escape at high energy from the combustor, where it is responsible for driving the turbines, which also power the compressors.

04 Expulsion (with afterburner) After the gases have flowed through the turbine, they enter the afterburner, where additional fuel is injected directly into the hot exhaust gas flow and ignited. This further combustion significantly increases the temperature and thus the exit velocity. As the gases are now expelled at an even higher speed, this generates much greater thrust.

OVERVIEW OF COMPONENTS

Low-pressure compressor

The air is compressed in the compressors. The low-pressure compressor (LPC) is significantly smaller than in commercial engines. Unlike commercial engines, pure turbojets have no bypass flow; instead, all the air flows through the core engine.

Did you know?
The first time blisks (blade integrated disks) were ever used was in the LPC for the EJ200.

High-pressure compressor

The air already pre-compressed by the low-pressure compressor is further compressed in the high-pressure compressor. These days, the high-pressure compressor also features blisks, since they enable a higher power density per stage.

Did you know?
The pressure ratio here is generally not as high as in commercial versions, as the air in fighter aircraft is dammed up due to their high speed.

Combustor

Here, fuel is injected into the compressed air, which is already at a high temperature, and the mixture is ignited. This unleashes a huge amount of energy, which is used by the turbines.

Did you know?
Because the flame temperature of over 2,000 degrees Celsius is above the melting point of the alloys used, air from the compressor must be blown in for cooling.

High-pressure turbine

The exhaust gas stream drives bladed disks (rotors). The high-pressure turbine sits on the same shaft as the high-pressure compressor and thus provides the necessary momentum for the latter.

Did you know?
The temperature at the inlet of the turbine in the EJ200 is more than 1,500 degrees Celsius, which is why the turbine blades are also cooled with bleed air from the compressors.

Low-pressure turbine

As with the high-pressure turbine, the low-pressure turbine drives the low-pressure shaft. The combustion gases then escape from the engine and use their remaining potential to provide thrust.

Did you know?
The EJ200 has a single-stage turbine made of a single-crystal nickel alloy with a ceramic thermal insulation layer.

After-burner

A special feature of military engines is that fuel can be injected into the remaining air after it exits the turbines and then reburned. This enables a considerable increase in performance and speed in the short term.

Did you know?
Only fighter jet engines feature an afterburner. In the EJ200, the afterburner can increase thrust by 30 percent.

Thrust nozzle

For optimum engine function and maximum exit velocity, the thrust nozzle at the rear end of the engine must be variable. The higher the temperature and thus the pressure in the exhaust pipe, the further the nozzle opens.

Did you know?
In contrast to commercial engines, the thrust nozzle in military engines is equipped with an adjustment mechanism to change the outlet diameter.

Control and monitoring

All engine processes are monitored and controlled by the engine control unit fully automatically. The broader range of tasks means military engine control systems must take on more functions than a commercial control unit.

Did you know?
When firing guided missiles, hot exhaust gases can be sucked into the engine. In this situation, the control system closes the vanes slightly and opens the nozzle a little.

MORE INFORMATION ON THE TOPIC:

How does a turbojet engine work?
www.aeroreport.de/en

How does a turbofan engine work? – The structure of an engine
www.aeroreport.de/en

ABOUT THE AUTHOR:

Patrick Hoeveler is a freelance aviation journalist working for FLUG REVUE and other publications.

A BRIEF GUIDE:

The brain of the engine

The DECMU is a fully digital engine control and monitoring unit that also helps ensure safe operation. For the EJ200, it does even more.

The Digital Engine Control and Monitoring Unit (DECMU) ___ *This unit controls and monitors all processes in the engine. The broader range of tasks means the engine control system must take on additional functions, such as controlling the afterburner and thrust nozzle. The pilots simply specify their thrust requirements via the thrust lever; the control unit does everything else.*

Welcome to the nerve center: not for nothing is the control unit considered the brain of an engine. Like neural pathways, numerous wires feed the system with information, which is processed in a compartment no bigger than a shoebox. Whether it's pressure levels, temperatures, or position signals–with the help of sophisticated algorithms, the special software processes the data and creates the appropriate commands for actuators and other subunits. In other words, all matters of engine control run via the fully digital controller.

DECMU: Digital control unit for the EJ200

The Digital Engine Control and Monitoring Unit (DECMU) is responsible for controlling the Eurofighter engine and manages all advanced engine settings. The pilots simply specify their thrust requirements via the thrust lever; the control unit located toward the front of the engine does everything else. No matter what setting is selected, the computers ensure that everything remains within the given limit. This makes pilots' lives a lot easier as it means they can devote their full attention to their mission.

For safety reasons, the DECMU features two parallel channels, with each one monitoring the other. If a problem arises with one channel, the system automatically switches to the other. The pilots in the cockpit are generally unaware of this; only if there's a serious problem do they receive an error message. Otherwise, the system logs the event so that the ground crew can read out the data after the aircraft has landed.

Control and monitoring in one

As the name suggests, the DECMU combines engine control with the monitoring and gathering of data relevant to maintenance activities. The top priority is naturally to ensure safe operation during flight. To this end, the sensors recapture the signals every ten milliseconds on average to check that engine parameters are always set correctly for the prevailing conditions. As a result, impending problems can be addressed as quickly as possible and in extreme cases the engine can be shut off before it can suffer severe damage. The DECMU also stores a wealth of operational data that can be evaluated after landing to gain valuable information pertaining to engine maintenance.

Interestingly, the current version of the control unit requires less computing power to perform its tasks than is available in a contemporary mobile phone. However, all calculations must be completed quickly and with a high degree of precision and certainty.

Fit for the future

Despite the undisputed performance of the existing DECMU, MTU Aero Engines is currently working on an upgraded version. The reason for developing the DECMU-NG (NG stands for next generation) is really the age of the electronic components. Many components are simply no longer

available, which comes as no surprise given the rapid pace of development in the electronics industry. After all, the design for the original DECMU will soon be 20 years old. The next generation of the DECMU will solve this obsolescence problem.

"The old DECMU is equipped largely with military electronic components, but the importance of these is fading worldwide. More and more, the entire military industry is opting for the kinds of industrial components found in cars," says Werner Oberndorfer, Head of Project and Order Management for Engine Control Unit Development at MTU. "In this regard, the lifecycles of aeronautical equipment and of electronics couldn't be less compatible. This is especially true of military equipment, which can have a service life of up to 60 years. Meanwhile, in the electronics market, development cycles are getting shorter all the time and fundamental shifts occur every couple of years."

This is why MTU's engine experts check all components every six months and divide them into risk categories. The higher a component's risk category, the closer it is to the end of its service life and thus its availability. This helps identify any problems early on with a view to proactively finding replacement components while these are still available. As the DECMU is made up of up to 20,000 electronic components, this is no mean feat.

The new DECMU is now being given a completely new interior, with features including more computing power, larger memory, and enhanced interfaces. This paves the way for incorporating additional maintenance functions into the software in the future. "These will include improvements that can help further reduce the engine's maintenance costs," says Stephan Lang, DECMU Chief Engineer at MTU. Nevertheless, the DECMU-NG will retain full backward compatibility. This means that in the future, it will be possible for a Eurofighter to be equipped with one engine featuring the old control unit and the other featuring the new control unit. Initial tests of the new version in an EJ200 are scheduled to take place on the MTU test stand over the coming year.

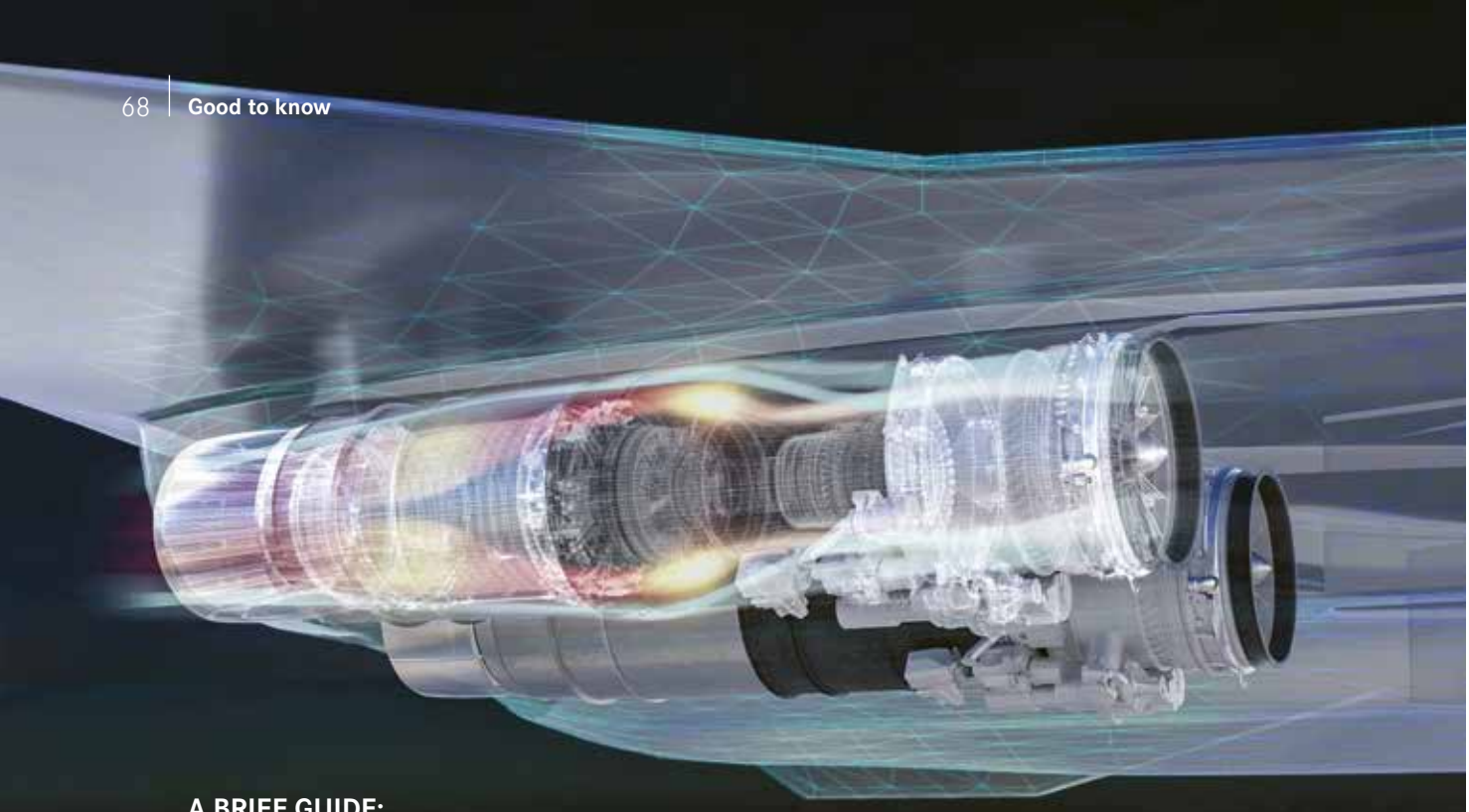
The next "next generation"

Europe's New Generation Fighter (NGF) is being developed as part of the Future Combat Air System (FCAS). For this fighter jet's engine, the New Generation Fighter Engine (NGFE), the DECMU-NG used in the EJ200 will once again provide the technological basis for multiple functions. However, the system being developed in collaboration with Safran Aircraft Engines is essentially entirely new. Here, the engineers are also exploring concepts that use distributed intelligence, which means that computing operations no longer all flow into one box, but rather take place closer to the sensors or in smart actuators. This would offer the benefit of shorter control loops and thus even faster response times.

ABOUT THE AUTHOR:

Patrick Hoeveler is a freelance aviation journalist working for FLUG REVUE and other publications.

Brain of the engine ____ *The DECMU is attached to the front end of the engine. There, numerous wires feed the system with information, which is processed in a compartment no bigger than a shoebox. All matters of engine control run via the fully digital controller.*



A BRIEF GUIDE:

New Generation Fighter Engine (NGFE)

NGFE powers the next-generation fighter that is the centerpiece of Europe's FCAS. We offer some insights into the key technologies behind it.

The Future Combat Air System (FCAS) is the European air defense system that is set to enter into service in 2040. Germany, France, and Spain are working together on this. The centerpiece is the New Generation Fighter, a next-generation jet with a human pilot.

Engine specialists MTU Aero Engines, Safran Aircraft Engines, and ITP Aero are developing the engine for the New Generation Fighter under the leadership of EUMET (European Military Engine Team), an MTU and Safran joint venture. MTU is responsible for its core competencies of high-pressure and low-pressure compressors and the compressor intermediate case as well as for parts of the control systems. It is also the lead company for aspects of engine maintenance. Safran is in charge of engine design and integration, while ITP Aero is responsible for the low-pressure turbine and the thrust nozzle.

What are the core elements in developing an entirely new engine for a fighter jet?

Fighter aircraft like the New Generation Fighter are generally designed to perform a wide range of missions, which calls for reliability, versatility, and cost effectiveness in equal measure. This puts the focus on key operating parameters such as extensive range, high speed (mostly in the supersonic range), good maneuverability, and reduced visibility. Based on the interaction between an aircraft and its engines, these factors can easily lead to snowball effects in system design: a larger aircraft—carrying multiple or larger weapons or more fuel—requires a larger, heavier engine, which in turn calls for a larger aircraft. At the engine level, this creates some particular challenges: the goal is to achieve the greatest possible thrust within a compact and lightweight casing as well as optimized fuel consumption and thermal and power management.

EUMET

Joint venture ___ *EUMET GmbH stands for **EU**ropean **M**ilitary **E**ngine **T**eam. The joint venture is responsible for the design, development, manufacture, and support of NGFE as part of FCAS.*

To overcome these challenges, the future engine is to feature numerous innovative technologies:

- **A high-load, distortion-tolerant compressor** ensures stable and optimal performance even in tough operating conditions. Located at the "heart" of the aircraft, this technology ensures that the combustor has a continuous supply of compressed air.
- Using **state-of-the-art materials, such as advanced alloys and composites**, enhances engine performance even in completely new temperature ranges while simultaneously extending the service life under demanding operating conditions.
- A **high thrust-to-mass ratio** is crucial for fighter jets, as this facilitates high performance at minimal weight. The result is a more compact, less visible aircraft with superior combat capabilities, including short response times and fast high-speed maneuvers.
- The engine will feature **state-of-the-art thermal and power management with hybrid technologies for core components**. It will also be optimized to cope with the limits of aircraft operation.
- The **variable cycle engine (VCE) architecture** supports flexibility in adjusting to operating requirements, which leads to high specific thrust and low fuel consumption. What really sets the VCE architecture apart from conventional propulsion systems is its adjustment mechanism and additional flow channel. The adjustment mechanism helps the engine control system manage how much ingested air flows through each channel and the core engine. Thanks to this variable adjustment, the engine's thermodynamic cycle can be optimally adjusted to the most likely operating requirements, which in turn ensures high specific thrust and low fuel consumption.
- **A thrust vectoring nozzle** gives the fighter jet exceptional maneuverability and control–particularly useful in aerial combat. The engine nozzle can direct the thrust in different directions, allowing the aircraft to change direction with speed and precision.

New Generation Fighter ___ *A sixth-generation fighter jet that enables connectivity between the fighter and unmanned components. It uses more advanced key technologies–particularly in the field of electronics and sensors.*

MORE INFORMATION ON THE TOPIC:

A brief guide:
The Future Combat Air System
www.aeroreport.de.

MASTHEAD

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