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Digitalization in full force

Six projects – six faces






INNOVATION
Pumping up the volume – synthetic fuels

INNOVATION
Smart factory in aviation: More complicated, but worthwhile

AVIATION
Dreamliner to the South Pacific – Air Tahiti Nui






Managing digital transformation
Falk Hinderberger is digital transformation manager at MTU Aero Engines. His job is to connect the analogue and digital worlds.

Using multiphysics simulations to boost efficiency
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Meter-long mathematical functions
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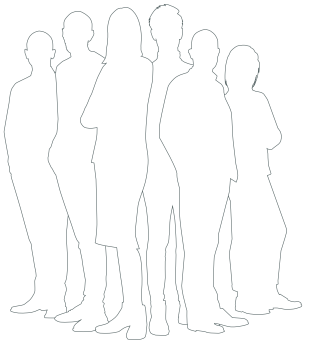
A data scientist for the aviation industry of tomorrow
He analyzes, decodes and finds connections. Data scientist Dr. Oliver Arnold manages the interface between information technology and manufacturing technology.

Interdisciplinary coordinate system
Dr. Anna Wawrzinek is working on joint software for the different disciplines of engine development.



You can read the whole of the **"Digitalization in full force"** *article on pages 6–19.*

COVER STORY

Digitalization in full force

MTU is not just keeping its finger on the pulse when it comes to digitalization—with its innovative approaches and new applications, it's also helping to shape the transformation. Six projects that are already well advanced.

Page 6

INNOVATION

Pumping up the volume

Power-to-liquid and sun-to-liquid fuels may be the aviation industry's key to meeting its ambitious climate targets. But to produce the required quantities as quickly as possible, work needs to start today on building up the necessary infrastructure.

Page 20

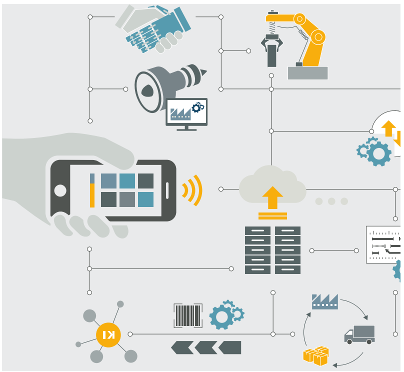
INNOVATION

The future is taking off

More than 100 companies worldwide are currently working on air taxis. Their concepts vary considerably in their planned use cases and their technical details. MTU **AERO**REPORT presents six representative approaches.

Page 28

CONTENTS



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MTU ENGINE EXPERTS (LEFT TO RIGHT)

PERE MASSANÉS PADRÓ / *Project engineer process design manufacturing*
DR. OLIVER ARNOLD / *Data scientist*
DR. ANNA WAWRZINEK / *Digital transformation manager*
FRITZ HOFFMEISTER / *Project engineer simulation manufacturing processes*
FALK HINDERBERGER / *Digital transformation manager*
DR. URŠKA ZORE / *IT planner*

Digitalization in full force

New applications, new technologies and new opportunities. Digitalization is radically changing the engine business. We present the faces behind the transformation.

Text: *Thorsten Rienth*

Sometimes all it takes to understand complex interrelationships is a simple image. “In the future, we’ll still board real aircraft powered by real engines,” says Dr. Pamela Herget-Wehlitz, Head of Information Technology at MTU Aero Engines. “However, the development and production of these engines is increasingly shifting to the digital world.” She immediately adds what this means in concrete terms: “Digitalization won’t make our business superfluous. But it will make it faster and more efficient.”

Back in 2016, MTU took decisive steps for the future and introduced its Digital Transformation Program across the board. The goal was no less than to digitalize the entire company. Three and a half years later, MTU is driving forward some 300 individual digitalization projects. Needs and solutions fit hand in glove.

In its most basic form, the approach spans departments—and often sites as well. It includes ensuring on-time deliveries, minimizing inventories and presenting product progress—alongside the widespread rollout of data analyses, machine-learning algorithms and artificial intelligence. Digital models on computers are increasingly used to simulate costly and time-intensive testing. Networked customer and supplier data mitigate potential disruptions in the supply chain—long before they can jeopardize the company’s sophisticated production logistics processes.

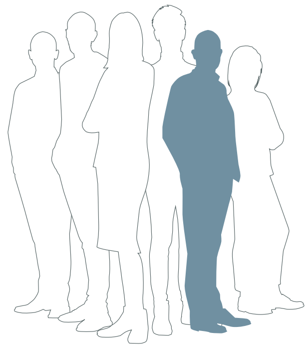
The approach is also firmly anchored in the administrative departments, where it goes far beyond replacing the use of paper by electronic workflows. Robotic process automation supports standard processes, while the new e-learning system provides independent study programs and supports blended learning in the workplace.

“It’s about having the courage to challenge current processes and think about them critically,” Herget-Wehlitz says. But this logic also applies to the future tools themselves, she explains. After all, digitalization is not an end in itself. “Our focus is always on real added value that helps us and our products make measurable progress.”

On the following pages, six project profiles outline this added value in detail.

ENGINE EXPERT:

Falk Hinderberger
Digital transformation manager



Managing digital transformation

Falk Hinderberger is digital transformation manager at MTU Aero Engines. His job is to connect the analogue and digital worlds.

Henry Ford, the man who revolutionized the industrial production of automobiles, is reputed to have once exclaimed: "If I had asked people what they wanted, they would have said faster horses." Now, industry is facing a change of similar magnitude to the one in Ford's time. But today, the change doesn't concern the assembly line per se. Instead, it's all about making business processes digital. This has given rise to a brand-new job profile: the digital transformation manager—which is the title printed on Falk Hinderberger's business card.

The 32-year-old is digital transformation manager at MTU Aero Engines. "Our job is to connect the analogue and digital worlds," he says before describing his role in more detail: "It's about identifying where the potential for digitalization lies, bringing business units and IT together, and ultimately translating this into end-to-end solutions that add real value."

Hinderberger studied International Business in Aalen and Reutlingen, during which he completed placements abroad in Mexico, Thailand and Russia. After completing his studies, he started working at a management consultancy firm and was often involved in digitalization projects in the automotive sector, with a focus on developing digital strategies and designing digital business models.

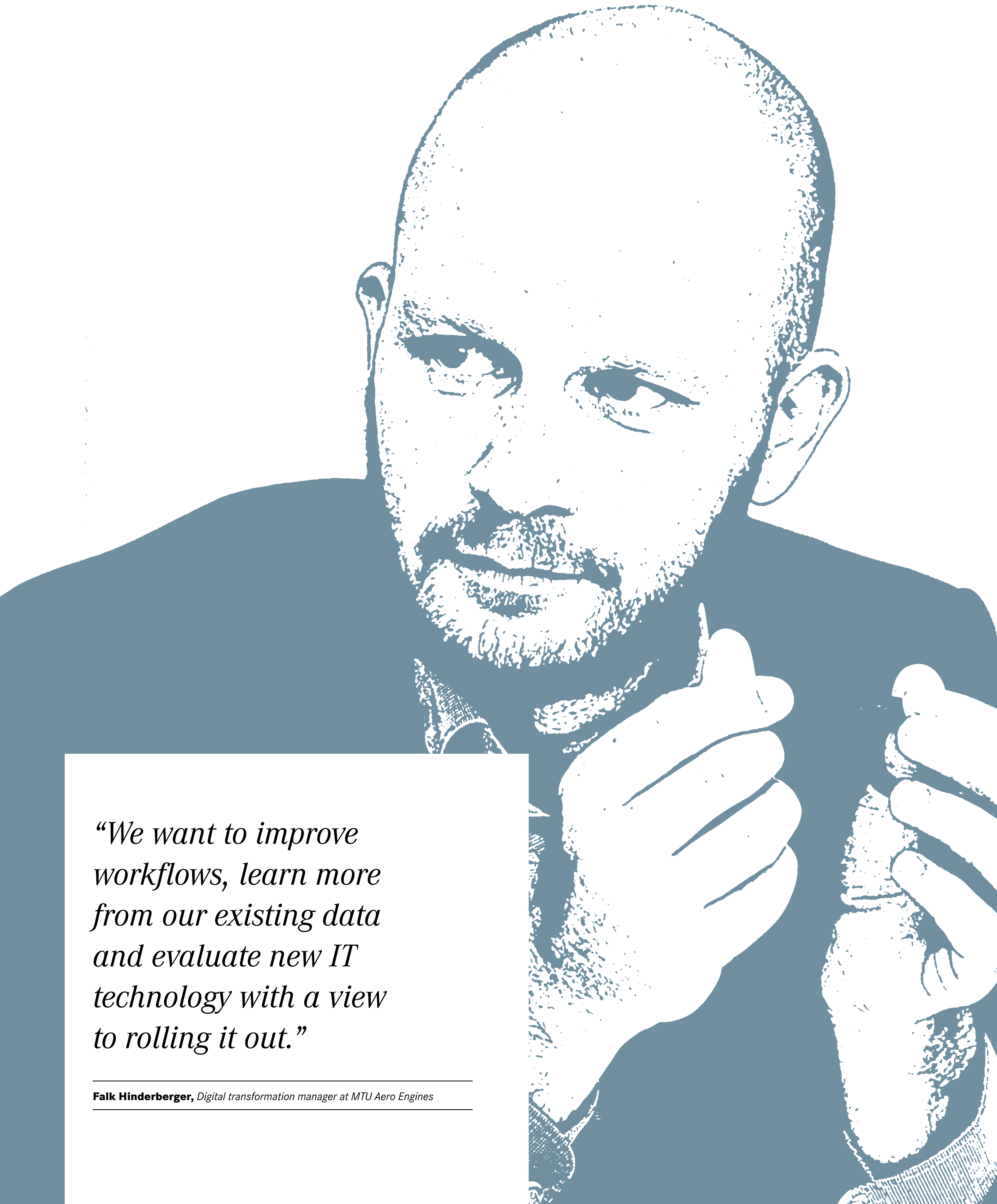
He joined MTU Aero Engines in fall 2018, where he has been busy driving forward the digital transformation of the company's commercial business ever since. "We want to improve workflows, learn more from our existing data and evaluate new IT technology with a view to rolling it out," he says. One of the projects Hinderberger is currently working on involves improving the accuracy of forecasts for spare parts requirements, something that has the potential to make a huge difference at the company.

After all, engine components are often highly sophisticated, made of high-end materials and quickly add up to the cost of a mid-range car. This means they tie up a great deal of capital in the form of inventory. What's more, the procurement chains for such components are very long, with lead times of up to 18 months.

Hinderberger thinks it's unlikely that a purely computer-based algorithm for forecasting future requirements will be developed any time soon. "Future requirements depend on so many different factors, which spare parts planners have to be weighing up all the time. These range from weather and environmental influences, to a component's useful service life since the last engine overhaul, to trends in the flight movements of airline fleets and the oil price." What effect does a falling oil price have on the useful service lives of existing fleets? Would it maybe make sense for airlines to continue operating older, slightly less fuel-efficient aircraft for longer than planned? What would that mean for their spare parts requirements?

"Ten or 15 years ago, advanced data analysis and big data technologies weren't available to us. But now, by tapping into the insights they provide, we are increasingly able to support our colleagues in spare parts requirement planning to make their decision-making processes more transparent," Hinderberger explains. "Once the department has specified the process and the parameters, we then translate them into requirements for an IT tool—ideally one that already exists."

Like fitting together the pieces of a big puzzle, the process involves linking data with research step by step in order to reach the ultimate goal: to have a digital system in place that enables proactive spare parts planning with optimized inventory levels.

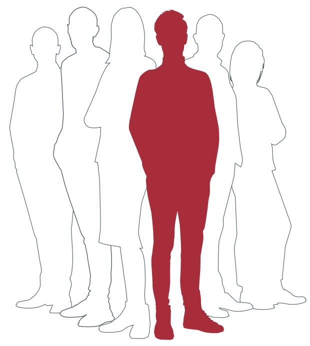


“We want to improve workflows, learn more from our existing data and evaluate new IT technology with a view to rolling it out.”

Falk Hinderberger, *Digital transformation manager at MTU Aero Engines*

"We're developing a simulation model that incorporates chemical reactions, heat transfer, multi-phase fluid flow and the electric field."

Fritz Hoffmeister, *Project engineer simulation manufacturing processes at MTU Aero Engines*



ENGINE EXPERT:

Fritz Hoffmeister
Project engineer simulation manufacturing processes

Using multiphysics simulations to boost efficiency

Fritz Hoffmeister is developing a multiphysics simulation model that will enable a complex electrochemical machining process to be digitally mapped in full for the very first time.

The screen shows two metal workpieces: a small, round one on the left, and a larger oblong-shaped one on the right. Small dots dart between them, resembling a swarm of wasps in a nest. While some take the shortest path, others go the long way—from the upper end of the oblong metal workpiece right around the back of the small round one, for instance. The dots in the swarm represent ions in an electric field.

Acting as minute atom-sized shuttles, the ions dissolve metal from the workpiece. In this process of electrochemical dissolution, the tool used—which serves as the cathode—experiences essentially no wear, offering a revolutionary approach to machining the high-strength materials used to produce engine airfoils. Subtractive machining of such metals would result in tool wear so extreme that it would render the whole process too expensive.

Electrochemical machining, or ECM for short, offers up many questions: Which working current at which feed rate achieves the best geometric results? How does the current density affect the hydrogen generated in the process and the surface quality of the workpiece? And, what effect does the pressure of the electrolyte flow actually have on all that anyway? “In the past, we always had to rely on trial and error to answer these questions,” Hoffmeister explains.

Out of necessity—because there was no other way. This approach commanded a huge amount of time and effort: setting up and running the test, then measuring the part. Changing a couple of parameters. Starting again from the top, and then again from scratch for every new part. All the experience MTU has gained with this process naturally helps to speed things up, but Hoffmeister, who has just turned 29, is looking for a much shorter way to achieve the same results. He asked himself, “What if we were able to simulate all these interactions with micrometer precision?”

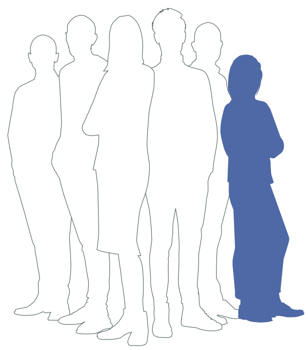
To answer that, Hoffmeister opted to take the multiphysics simulation route: “We’re developing a simulation model that incorporates chemical reactions, heat transfer, multi-phase fluid flow and the electric field. Essentially, by simulating current flow, we can calculate the material removal rate and consequently the final geometries with extreme precision. Put simply, we feed the geometries of a new component into a supercomputer and run through the iterations in a virtual environment. It already works well in 2D, but 3D simulation will be essential for industrial application. We’re working hard on that.”

Hoffmeister earned his bachelor’s degree in mechanical engineering before going on to complete his MSc in computational engineering and simulation at Munich University of Applied Sciences. During his studies, Hoffmeister worked at a company in the automotive industry, where he was responsible for calculating vehicle crash and airbag simulations—the latter using multiphysics. It was his master’s thesis—“Numerical simulation of 3D electrolyte flow and the fully coupled 2D multiphysics of the ECM process”—that brought Hoffmeister to MTU.

And it’s no coincidence that the title of his paper reflects exactly what Hoffmeister does at MTU today. As his master’s thesis was nearing completion, MTU offered him a permanent position at the company, which he gladly accepted.

ENGINE EXPERT:

Dr. Urška Zore
IT planner



Meter-long mathematical functions

Dr. Urška Zore programs 3D tools that MTU developers use to design even quieter, more fuel-efficient engines.

Although this COBRA does not bite, it does need to be fed—on mathematical and geometric methods containing functions that, if written out, would stretch for several meters in some cases. Filled with variables, three-dimensional objects such as engine blades form on engine developers' screens. The meter-long function defines in high resolution every point of the object in three-dimensional space.

COBRA stands for COnsistent Blade Representations for Aircraft engines. It is MTU's own in-house software for generating the geometries of engine components. This subject takes up most of Dr. Urška Zore's working day.

Without fear of exaggeration, we can say that the COBRA software is a mainstay of MTU engine design. After all, the design intricacies in modern engines that make the difference as regards extra efficiency and service life are becoming increasingly detailed, particularly when it comes to aerodynamics and structural mechanics.

"The greater our geometrical expertise, the faster we can develop new designs that go beyond the industry standard," Zore explains. By geometrical expertise, she means being able to mathematically model all three-dimensional shapes that can conceivably arise in an engine.

The 31-year-old joined MTU after studying mathematics in Ljubljana, Slovenia and then doing a PhD in Linz, Austria. Initially, she came to MTU as part of an EU research project, but at the end she received an offer to stay on.

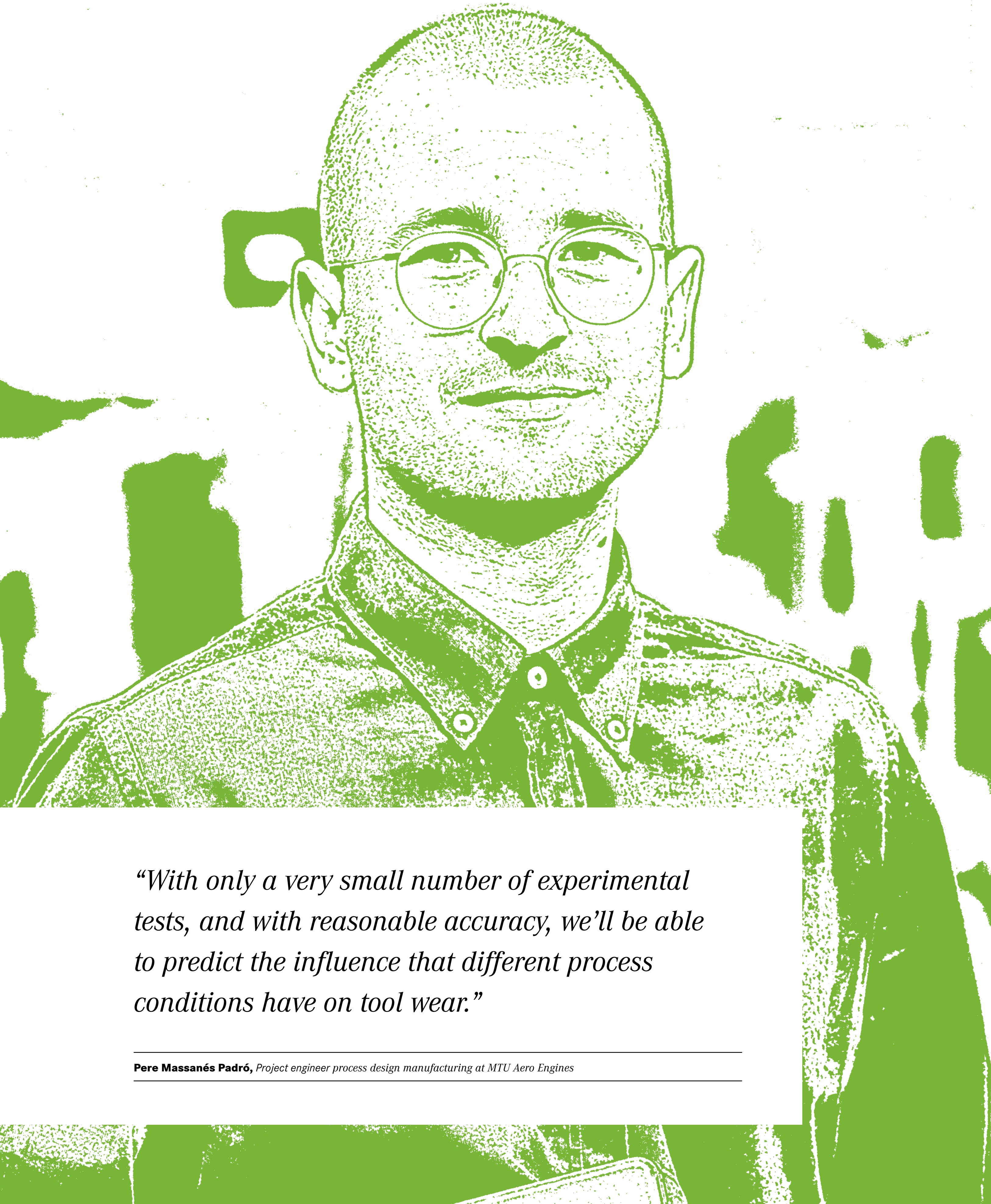
Zore carries out most of her work behind the scenes. In the development of engine parts or modules, this background work is vitally important: "It's all about providing developers with the best possible 3D tools so that they can design the best possible engines," she says, describing her role. "Our colleagues tell us what they need and we think about the mathematics we can apply to meet their requirements. And then we work together to create future-oriented solutions." The subject is very complex, as practically all technical disciplines are involved in the processes and are relevant for the tool in their own specific way.

For that reason, the snake image is appropriate in this regard as well. The COBRA software is not static: it moves. "Together with my colleagues, I program new digital tools, integrate them in COBRA, and take care of support side," the IT planner explains. The quality of the digital models is key, stretching all the way from the new digital tools to the finished component; and from the scanned finished component back into its digital 3D representation.

In all of this, she never loses sight of the big picture. "The greater our geometrical expertise, the faster our developers can create the new designs." In turn, this ultimately means engines that carry aircraft through the air even more efficiently and quietly and with even lower emissions. With a wink, the mathematician explains one of the many new things she has picked up in the whole process: "In addition to Slovenian, English, German and a few programming languages, I'm now also learning to speak the language of engineers."

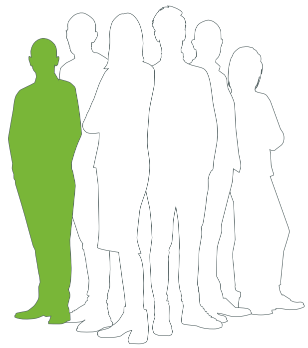
"It's all about providing developers with the best possible 3D tools so that they can design the best possible engines."

Dr. Urška Zore, *IT planner at MTU Aero Engines*



“With only a very small number of experimental tests, and with reasonable accuracy, we’ll be able to predict the influence that different process conditions have on tool wear.”

Pere Massanés Padró, *Project engineer process design manufacturing at MTU Aero Engines*



ENGINE EXPERT:

Pere Massanés Padró
Project engineer process design manufacturing

Digitalization paves the way for predicting tool wear

Pere Massanés Padró is working on a simulation model that enables detailed predictions to be made about tool wear.

Industrial trial and error sounds like an expression from a time when digitalization was nothing more than a vision of the future. “In some cases, though, there are still no alternatives to this approach, and tool wear is a case in point,” explains engineer Pere Massanés Padró. Determining acceptable process conditions that don’t exceed prescribed wear limits calls for experimentation that requires a monumental amount of time and effort. “The only way to gain a thorough understanding of how tool wear develops is by conducting realistic and time-consuming tests in everyday production scenarios,” he says.

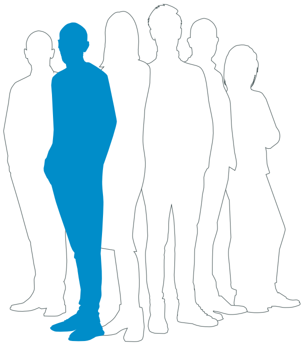
After all, tool wear does not occur in a uniform manner. Its nature is initially degressive, then somewhat linear, before finally becoming progressive. And, of course, it all depends on the material and cutting speed. The matter is so complex that even today, there are no models advanced enough to incorporate tool wear into the design of tools and production processes. Not even the finite element method (FEM), which is usually the go-to option for solving physical problems in engineering calculations, is sufficient for predicting tool wear in industrial applications.

The consequences of tool wear are far from insignificant. If wear causes the shape of a tool’s cutting face to change, this affects the contour of the workpiece. Surface integrity and process stability both suffer as a result. If such tool wear could be calculated in advance, production engineers could precisely offset it during the process by adjusting the cutting speed, tool angle or feed rate, for example. In the aerospace industry, where machining of nickel- or titanium-based superalloys generates high production costs, the potential offered by reliable tool wear prediction is especially significant.

At the age of 18, Massanés Padró enrolled at the Universitat Politècnica de Catalunya in Barcelona to study mechanical engineering. At 22, he went on to earn a master’s degree in materials engineering. “I decided very early on that I wanted to work abroad, where the career opportunities in my field are more attractive,” he says. And his dream became reality when he saw a position advertised online for a master’s student in MTU’s machining simulation department. After five months working there as a student, MTU offered him a permanent position as an engineer in the same department. “This way, I could continue working on my topic,” Massanés Padró says.

The 26-year-old wants to use a hybrid method to solve the problem of tool wear predictability. This involves rolling analytical, empirical, experimental and numerical approaches into one large simulation model. Massanés Padró’s aim is to analytically describe the interrelationships between process parameters (such as cutting speed, feed rate, cutting depth and tool geometry) and material stresses (such as temperatures, stresses and strains) in order to predict how tool wear will develop.

Of course, this in itself is still a complex construct. “But one that could be represented in digital form,” Massanés Padró says. It would also dramatically reduce the amount of trial and error involved. “With only a very small number of experimental tests, and with reasonable accuracy, we’ll be able to predict the influence that different process conditions have on tool wear.”



ENGINE EXPERT:

Dr. Oliver Arnold
Data scientist

A data scientist for the aviation industry of tomorrow

He analyzes, decodes and finds connections. Data scientist Dr. Oliver Arnold manages the interface between information technology and manufacturing technology.

In the engine manufacturing business, there is nothing more important than high-quality components. Take blisks, for example: in these high-tech components that integrate blade and disk, even a hundredth of a millimeter can make all the difference. In the worst case, the entire component may end up being worth only as much as the materials used to make it. Following current procedures, production engineers cannot be sure a blisk meets specifications until after the final inspection, long after the hours-long machining process has been completed.

What if it were possible to detect critical deviations much earlier on? For example, what if it were possible to react to signs of a tolerance deviation during the manufacturing process? Then it would be possible to avoid extensive and costly reworking.

Data that is produced, accessed or processed by manufacturing machinery during the production process can play a decisive role in finding a solution. But there is a huge quantity of information. To be able to utilize it, someone has to determine which information is relevant. This person analyzes the data, decodes it, and finds connections.

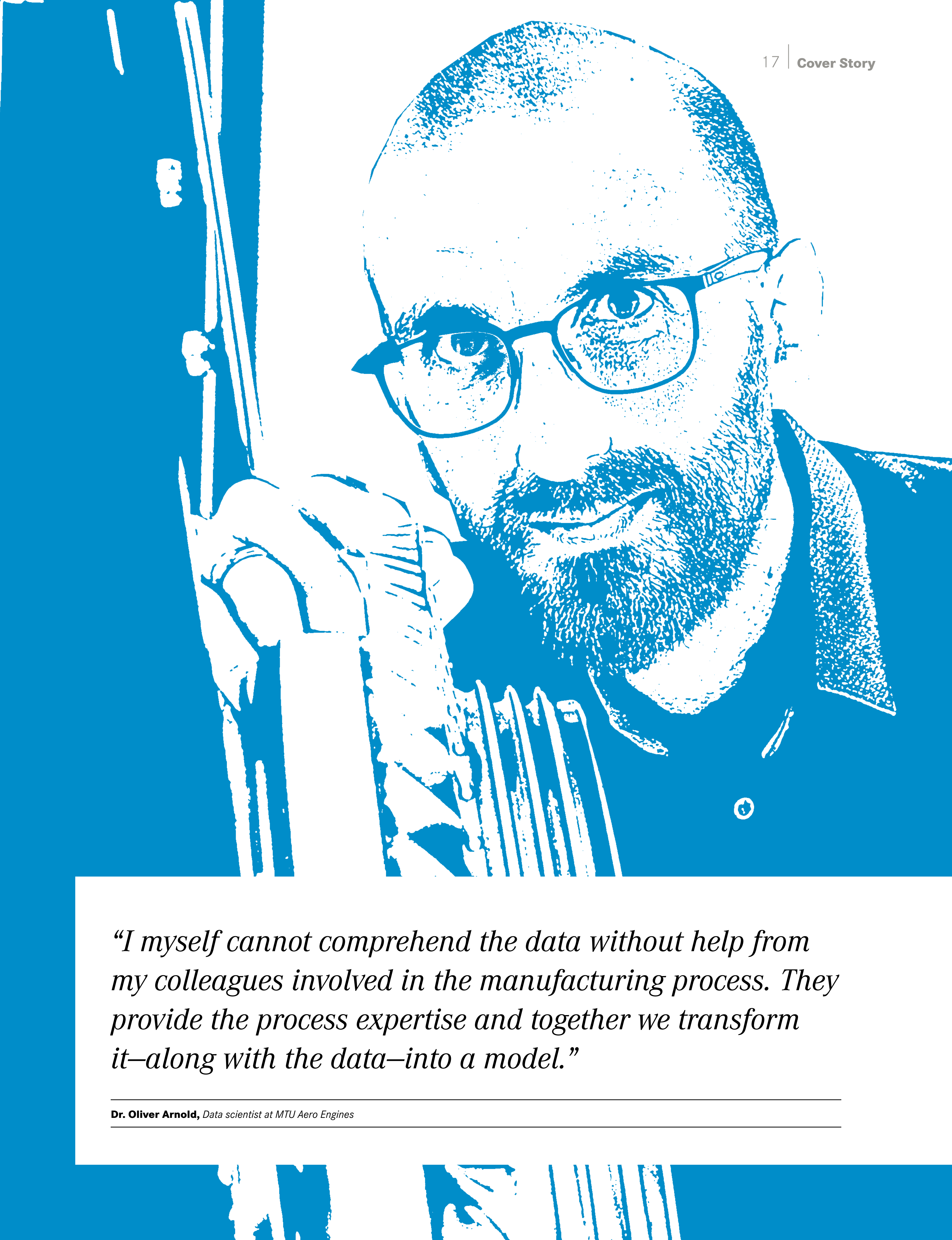
For blisk manufacturing at MTU Aero Engines, Dr. Oliver Arnold is that person. A 35-year-old physicist and data researcher, Arnold left a position at CERN, the European Organization for Nuclear Research, about two years ago for his current job in Munich. In the canton of Geneva he had worked on high-energy experiments in basic physics research. At MTU he wants to create algorithms that bundle valuable data related to the extremely complex blisk manufacturing process.

"In plain words, we take a look at the machine data that is produced in the process of machining the blisks," Arnold explains. "We try to detect patterns and interdependencies in the data that may be reflected in substandard component quality, which doesn't become apparent until later in the manufacturing process." The extraction of reliable trends would provide production engineers with a solid foundation for their decision-making, enabling them to react at an earlier stage, improve processes and cut costs.

Achieving this goal is not as easy as it sounds. How can the truly relevant information be extracted from the enormous quantities of data supplied by the machines? How often would it be advisable to capture the data? What level of data quality is needed to determine which causalities? And what additional sensors might be urgently needed in the future—and should thus already be included in the specifications for new machinery that is about to be procured? "We are still at a relatively early stage," Arnold says. "But we are making our way toward the solutions step by step."

The development of a completely data-driven understanding of processes is still a very new science. For example, the Technical University of Munich (TUM) was one of the very first universities to offer a master's degree in data science, introducing it in 2015. Four years on, professionals in this field are now indispensable in every high-tech industry.

"The fascinating thing about this for me is definitely the interdisciplinary approach," Arnold says. "I myself cannot comprehend the data without help from my colleagues involved in the manufacturing process. They provide the process expertise and together we transform it—along with the data—into a model." One could view Arnold as an interpreter: at the interface between information technology and manufacturing strategy, his analysis provides support for the decision-making process.

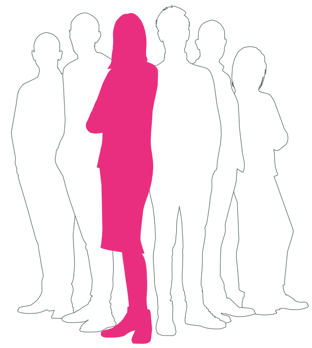


"I myself cannot comprehend the data without help from my colleagues involved in the manufacturing process. They provide the process expertise and together we transform it–along with the data–into a model."

Dr. Oliver Arnold, *Data scientist at MTU Aero Engines*

"I'm working on translating the different methods into a kind of interdisciplinary coordinate system."

Dr. Anna Wawrzinek, *Digital transformation manager at MTU Aero Engines*



ENGINE EXPERT:

Dr. Anna Wawrzinek
Digital transformation manager

Interdisciplinary coordinate system

Dr. Anna Wawrzinek is working on joint software for the different disciplines of engine development.

Dr. Anna Wawrzinek boldly draws a direct line from her work to the original draft of the German Basic Law, which held that "the state is there for the sake of man, not man for the sake of the state." In her view, the situation with the digital transformation is similar. "It's not an end in itself, but should help my colleagues focus on what's important." For example, on the development of new engines for air transport.

Depending on the model, an engine is assembled from up to 30,000 individual parts. Together, they create a complex system that works on the basis of action, reaction and mutual influences. The way in which engines are developed is just as complex—representing a finely tuned balance between design parameters, aerodynamics and structural mechanics.

Technological development has now progressed to such an extent that tangible improvements are possible only if the engine is considered as a whole, if cost effectiveness is to be ensured that is. However, the individual disciplines, which have for the most part always considered their (further) developments as separate entities in the past, have built up their own digital development systems over the years. "To put it simply, they work with different coordinate systems," Wawrzinek explains.

That's where the problem begins that the 33-year-old is looking to solve. She is one of around 20 digital transformation managers at MTU Aero Engines. "I'm working on translating the different methods into a kind of interdisciplinary coordinate system," she says. This would improve speed and efficiency in the development of engines and engine components—after all, it would save time spent time switching between the different coordinate systems.

After graduating from high school, Wawrzinek, who is originally from Poland, studied mathematics at Freie Universität Berlin. She completed her PhD in a field of research that was still emerging—isogeometric analysis and its transformation into industrial applications. Using isogeometric analysis, mathematicians try to combine the geometric description of design and analysis models by introducing what are known as NURBS (non-uniform rational basis splines) as a common basis to define geometrical shapes. This is a suitable method because NURBS are the basis of most CAD (computer-aided design) systems.

Essentially, the need for a comprehensive solution has grown from a historical development. Wawrzinek explains that when computers slowly made their way into industry in the 1960s, the development of digital tools diverged across disciplines: "The designers continued to work in 2D, which stands to reason. But the analysts needed to work with finer 3D elements, such as point clouds and triangles, so that they could process the components digitally."

Looking ahead, however, the common MTU development coordinate system for design, aerodynamics and structural mechanics is more of an intermediate goal. The next step is lossless networking and integration of the existing systems for all partners that are significantly involved in engine development, she says. "Then the prevailing trend to consider the engine as a whole at the development level could also be reflected in the software."

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

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

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

Sun-to-liquid (StL) process

A sun-to-liquid plant produces kerosene from sunlight, water and CO_2. The process is already in use: in Madrid, where the IMDEA Energy Institute built a unique solar facility and tested it extensively over four years. The project was funded by the European Union's Horizon 2020 research and innovation program, with support from the Swiss State Secretariat for Education, Research and Innovation.

Pumping up the volume

Power-to-liquid and sun-to-liquid fuels may be the aviation industry's key to meeting its ambitious climate targets—if they can be produced in the quantities required, and quickly.

Text: *Denis Dilba*

If we compare aircraft fuel consumption levels and the associated CO_2 emissions from the 1960s and today, they have almost halved as a result of more efficient aircraft engines, improved aerodynamics and new, lighter materials. And as it strives to reduce fuel burn further still, the industry will continue to work on these measures. However, given that global air traffic is expected to continue to grow by about five percent a year in the future, such measures alone won't be sufficient to stop the increase in CO_2 emissions, let alone reduce them.

Fuels from renewable electric power and sunlight

"In light of this situation, synfuels hold great promise for achieving aviation's climate goals," says Dr. Andreas Sizmann, Head of Future Technologies and Ecology of Aviation at the Bauhaus Luftfahrt research institution in Munich. He's referring to two specific variants of sustainable aviation fuel (SAF), known as power-to-liquid (PtL) and sun-to-liquid (StL) fuels. The aviation industry has long since recognized the potential of no longer producing aviation fuel from crude oil and has been testing alternative fuels for over ten years now. For a long time, biofuels were regarded as the favorite option, but now it's becoming increasingly clear that their viability as a sustainable fuel source for the global fleet is limited because cultivating the energy crops required would take up way too much land. A huge advantage of SAFs is that they are "drop-in" fuels, which means they can be used without any technical modifications to the aircraft, engine or airport infrastructure.

"In light of this situation, synfuels hold great promise for achieving aviation's climate goals."

Dr. Andreas Sizmann
Head of Future Technologies and Ecology of Aviation at the Bauhaus Luftfahrt research institution

To produce them, water and CO_2 are first converted into hydrogen and carbon monoxide using renewable electric power (PtL) or concentrated sunlight (StL) to form what is known as a syngas. In the PtL process, the water is split into hydrogen and oxygen using electrolysis, and the carbon dioxide is reduced to carbon monoxide by means of a reverse water-gas shift reaction. "With StL, the syngas is produced by a thermochemical redox reaction," says Sizmann, who coordinates the EU-funded SUN-to-LIQUID project. "In simple terms, this process involves using concentrated sunlight to heat a metal oxide and extract part of the oxygen. When the temperature is reduced, the oxide takes the oxygen from the water and the carbon dioxide to form hydrogen and carbon monoxide," he explains.

Power-to-liquid process is ready to scale up

Both in the power-to-liquid and in the sun-to-liquid process, the next step is to apply the established method of Fischer-Tropsch synthesis to produce long-chain hydrocarbons from the syngas. These hydrocarbons are then refined into kerosene, which can be used to refuel aircraft as normal. "When PtL and StL fuels burn, they emit CO_2 in the same way as fossil fuel kerosene. For that reason, they are sustainable only if the CO_2 used to produce them comes from the atmosphere," says Sizmann's colleague Dr. Valentin Batteiger, who heads the alternative fuels research focus area at Bauhaus Luftfahrt. To obtain this atmospheric CO_2, a technology known as direct air capture is applied. Swiss start-up Climeworks, for example, uses large filters to chemically bind the CO_2. However, direct air capture technology still has plenty of room for improvement in terms of efficiency and most crucially cost.

"As things stand today, the aviation industry requires some 300 million metric tons of fuel a year, and that figure will only increase. We'll need huge amounts of CO_2 to meet that demand," Batteiger says. MTU Aero Engines is rising to this challenge and helping bring these fuels to market, also in partnership with other industry representatives. "The technology behind the PtL process has been mastered and is ready to be scaled up—something we believe needs to happen now," says MTU expert Fabian Donus from Innovation Management. After all, larger plants are still extremely few and far between around the world, which is why PtL fuel is so much more expensive than standard kerosene. In light of this, Sizmann is also strongly in favor of scaling up the technology for the StL method—and quickly. "We still need to do some more research into making the process more efficient, but we can do that as we work to establish a plant that operates in the megawatt range."

Aviation could become largely carbon neutral

All of today's approved production routes for SAFs involve an admixture of at least 50 percent fossil fuel kerosene. "But research is already underway into production routes that don't require this admixture. A wide-scale rollout of SAFs would

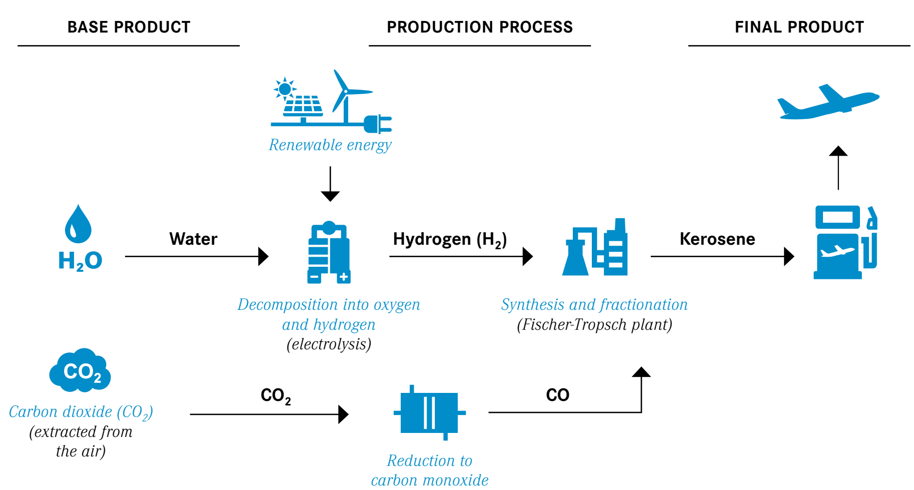
HOW WATER AND CARBON DIOXIDE BECOME KEROSENE

Power-to-liquid (PtL):

Renewable energy
+ Water
+ CO_2

= Kerosene

Power-to-liquid process (PtL)
The power-to-liquid process is a pioneering approach that uses renewable energy to produce hydrogen, synthesizes it with carbon dioxide to form hydrocarbons and processes these into a liquid fuel.



A greener way to refuel ——— *Synthetic fuels must become viable for aviation as soon as possible if the industry is to meet the targets it has set itself to reduce CO_2 emissions.*

immediately improve the aviation industry's carbon footprint—and appreciably so," Donus explains. MTU is keeping a close eye on the development of StL technology, he says: "At the moment, though, PtL seems to be a step ahead." However, he believes that development of a PtL industry isn't viable without subsidies. Sizmann and Batteiger agree. "How quickly we can roll these technologies out hinges on political will and how the costs of using crude oil develop. A sun-to-liquid plant covering some 38 square kilometers could produce around 300,000 liters of synthetic kerosene a day—that's almost enough to refuel one Airbus A380. It would take about the same area of solar panels to generate the power for a PtL plant with the same output," Batteiger explains. While a wind power solution would take up less space, people are less accepting of wind turbines.

But given that the transport costs for liquid fuels are comparatively low, very sunny or windy areas would be most suitable for large-scale production of synfuels. According to Batteiger, an area covering about one percent of the world's deserts would be adequate to produce synfuels in volumes sufficient to meet the aviation industry's demand worldwide. This equates to around 300,000 square kilometers—almost the size of Germany. "Biofuel production would call for an area at least ten times as large, plus the land would have to be arable," says Batteiger. "So, despite all the challenges they bring, PtL and StL are still our best bets for making aviation carbon neutral."

JOINING FORCES TO DRIVE SYNTHETIC FUELS

MTU Aero Engines participates in research into SAFs through its memberships in the Bauhaus Luftfahrt research institution in Munich and the Berlin-based Aviation Initiative for Renewable Energy in Germany e.V. (aireg) where it heads the working group on fuel utilization. As a non-profit initiative, aireg works to find solutions for aviation to meet the ambitious CO_2 reduction targets by promoting the availability and use of renewables in the industry. To this end, aireg joins forces with various scientific institutes in Germany, including the Karlsruhe Institute of Technology (KIT), the Jülich Research Center, the German Aerospace Center (DLR) and the Hamburg University of Technology. These research institutions are all aireg members alongside a host of other companies and organizations, including Bauhaus Luftfahrt.

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

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

“We put innovation on the fast track”

Dr. Carsten Subel, Head of the Inno Lab at MTU, on the global search for technology trends and the significance of a company culture that lets innovation thrive.

Text: *Thorsten Rienth*

Mr. Subel, MTU is renowned the world over for its advanced engine technology. Why does the company need an independent Inno Lab?

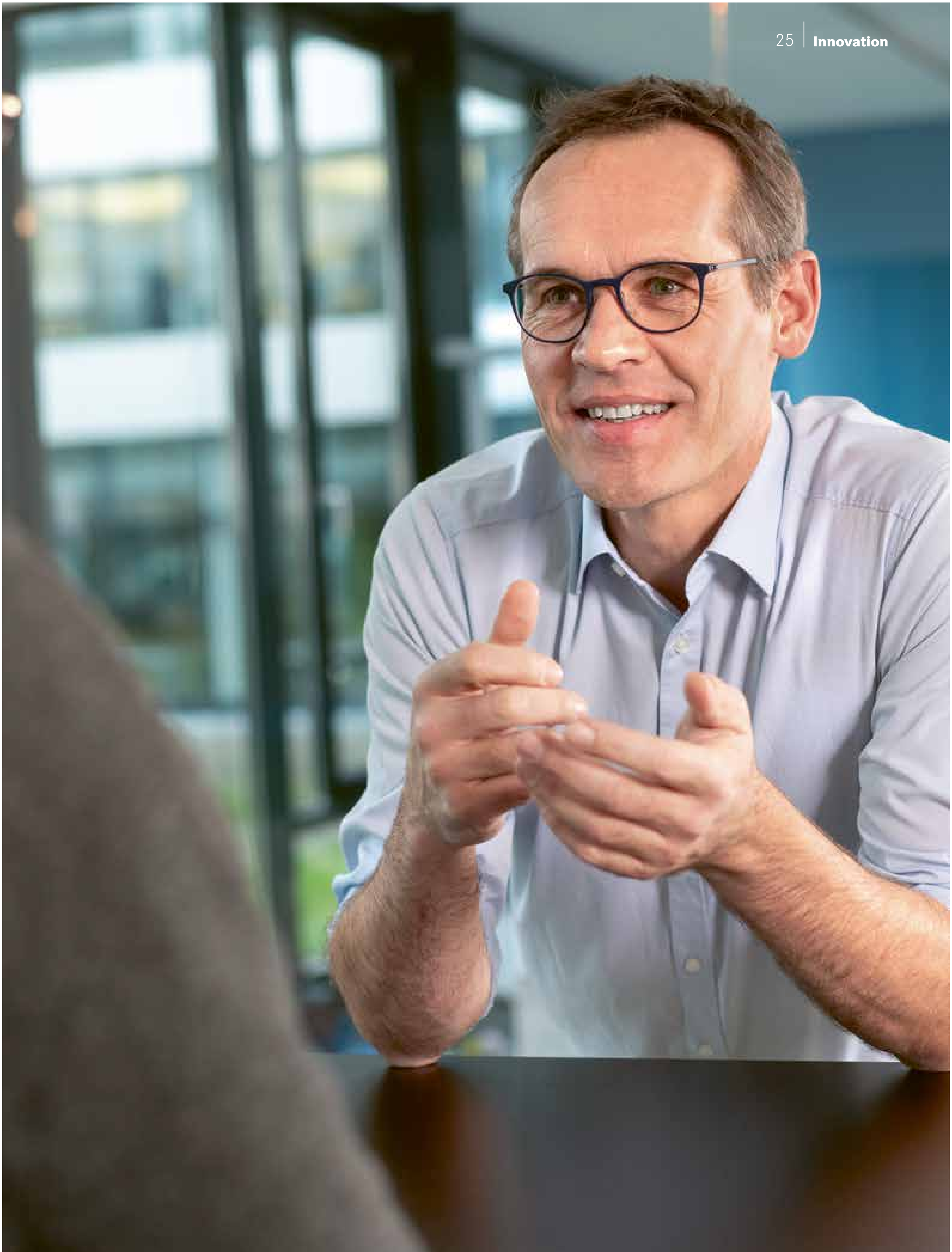
Dr. Carsten Subel: MTU is a creative and innovative company. Our development engineers have been pushing the technology envelope for decades and are plugged in to an excellent network of universities and research institutions. The Inno Lab doesn’t compete with any of our development departments. Rather, it expands our capacity for innovation by keeping an eye on processes, product improvements and new services and business models. It is another way for us to fast track ideas in house. Our slogan says it all: “new ideas quickly prototyped.” But it’s not just about ideas, it’s also about innovation. The only way an idea can become an innovation is if customers like it and it catches on. Prototyping allows us to discover whether the demand is really there for a new product or idea. Speed is our competitive edge.

Is the Inno Lab set up more for in-house or external customers?

Subel: Our focus is largely in-house. We don’t act as a service provider for external customers. We make sure that MTU takes up new topics. Our three basic goals are to search for trends, generate ideas and promote a company culture that lets innovation thrive.

Is it really possible to generate ideas?

Subel: Yes, and in all sorts of different ways! Each and every MTU employee can submit ideas to us whenever they want. A few weeks ago, the Inno Lab held an open call for ideas. Lots of MTU employees submitted ideas and pitched them in person. The spectrum of proposals was enormous, ranging from specific product designs like a bionic heat exchanger to



Dr. Carsten Subel
The Head of the Inno Lab at MTU finds the process of quickly developing new ideas into prototypes fascinating. That is the only way to discover whether the demand is really there for a new product or idea.

"We start in the Inno Lab by selecting a technology with potential; then we determine specific areas of application for it at MTU."

Dr. Carsten Subel,
Head of the Inno Lab at MTU Aero Engines

a new lighting concept promoting employee wellbeing and even improved communication processes based on interactive digital platforms. Sometimes, ideas can emerge from a series of face-to-face conversations. In the past few months, for instance, we've noticed there's a topic that colleagues from across different business areas are already working on because they can see it has huge potential: machine vision.

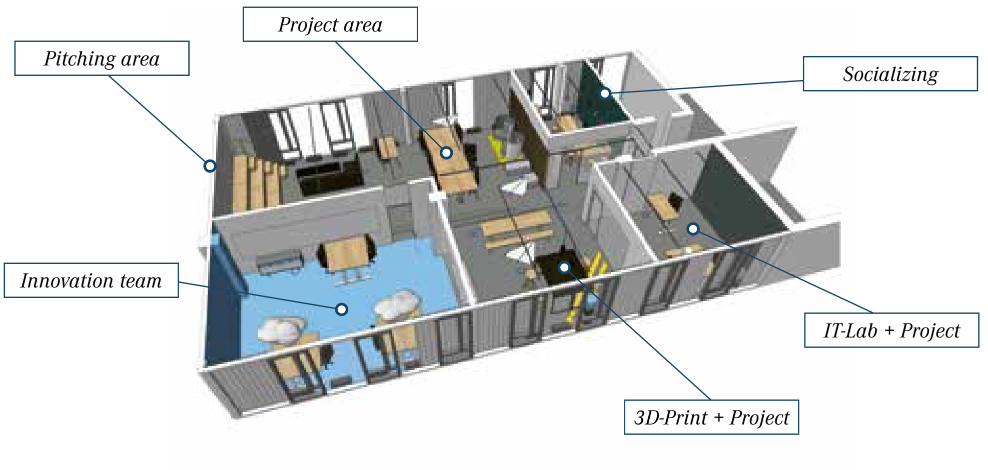
What's that about?

Subel: Machine vision is essentially about carrying out tasks with the aid of a computer in a way that takes its cue from humans' ability to see—and then act. Put simply, these are camera-computer systems that can identify deviations in material quality or automatically record components following disassembly. It's a branch of artificial intelligence. We've realized that MTU performs countless tasks that could benefit from the application of machine vision. And there are quite a few colleagues out there who are clued up about this technology and who we can now bring together. Basically, this topic was destined to be championed by the Inno Lab as an innovation accelerator.

Artificial intelligence is undoubtedly one of today's most exciting topics. You mentioned that you also do a bit of trend scouting in the Inno Lab. Why is that so important?

Subel: On the face of it, scouting is about us being attentive and not letting any technological developments pass us by that others are already successfully employing. In addition to that, we aim to identify emerging technology trends early on. To that end, we tap into new resources. For example, we hunt for conspicuous recent spikes in patent applications in particular areas. We also take a look at what start-up companies are up to. And we conduct web analyses to note the trends motivating companies and people around the world as a way to identify megatrends, like mobility and connectivity, and find ways to

INNO LAB: OFFERING THE SPACE TO BRING SKILLS TOGETHER



Plenty of room for ideas

MTU's Inno Lab is not located directly on the premises of the Munich site, but is adjacent to it. In its bright rooms, everything is set up to promote creative work. A cozy kitchen serves as an area for socializing. The pitching area offers a small audience stand and a stage on which to present new concepts. And there is an area housing a 3D printer on which to produce prototypes.

make them work for us. In 2019, many trends revolved around human-machine interaction. We know we're moving in the right direction whenever we identify a trend we were already aware of, and when we do find one that had slipped past us, we immediately pick up on it. We start in the Inno Lab by selecting a technology with potential; then we determine specific areas of application for it at MTU. In the case of machine vision, we also contacted some start-ups and got them on board to help us develop it, and now we're working together on prototypes.

And this type of cooperation fosters the creative company culture you have set out to achieve?

Subel: Exactly. It's all about always creating a bridge between the problem and the solution. Not everyone who comes to us has an idea. Colleagues who make us aware of problems are just as valuable to us. People who have developed a sense of innovation can come up with brand new ideas simply by talking to other people—even quite by chance, say over lunch.

Have you ever experienced that?

Subel: Recently, two colleagues were sitting together in the cafeteria. One of them was talking about his hobby as an astrophotographer and how difficult it was to take a photograph of two bright stars against a dark background because the light sources outshine each other. But he knew how to solve the problem because he had some filter software that he could use to reduce overexposure. This piqued the other colleague's interest because it reminded him of a work-related issue where imperfections on reflective and shiny turbine blades are difficult to spot during optical quality inspections. The two colleagues then approached us at the Inno Lab with the idea of using this technology at MTU.

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

The future is taking off

More than 100 companies worldwide are working on air taxis. Their concepts vary considerably in their use cases and their technical details. Six approaches.

Text: *Denis Dilba*

The race for the airspace beneath the clouds is well underway: almost daily, we hear stories about start-ups and older companies alike claiming to have developed an air taxi (usually fully electric and autonomous) that is on the cusp of breaking through. Often these reports are exaggerated, and many blueprints are destined to return to the drawer they came from—but the sheer variety of different projects is leading experts and other observers to believe that it won't be long before the first air taxis are ready for service. A current study by management consulting firm Horváth & Partners, for example, is founded on the assumption that air taxis will already be carrying passengers on initial, defined routes in big cities as early as 2025. Indeed, test operations are expected to begin in just a few months' time. However, use of the small aircraft need not be restricted to congested metropolises: companies also see useful application scenarios in areas where the infrastructure is not as well developed, such as islands and mountain regions. In short, wherever a direct route through the air saves a lot of time. Companies can smell a big business opportunity. Analysts from Morgan Stanley Research estimate that the market for autonomous air taxis could reach 1.36 trillion euros by 2040. It remains to be seen which concepts will have proved successful by then. MTU **AERO**REPORT presents six representative development approaches.

Cora — *The vertical takeoff aircraft has 12 rotors on its wings that span 11 meters.*

Cora by Wisk — *Founded in 2019, Wisk is a joint venture between airframer Boeing and start-up Kitty Hawk.*

Kitty Hawk Cora—Rotors on the wing

In October 2017, the Cora air taxi could already be found circling in the skies of New Zealand's South Island. At the time, only aviation experts knew what they were looking at. It took another six months before the U.S. start-up Kitty Hawk, which is financed by Google cofounder Larry Page, confirmed the secret test flights of its fully electric and autonomous aircraft. Twelve rotors on the two wings, which span around eleven meters, enable Cora to take off vertically. With a further propeller at the rear, it flies like a conventional aircraft once airborne. Kitty Hawk gives its initial range as "40 kilometers plus reserves." At the same time, the company announced a commercial air taxi service in New Zealand. Although Kitty Hawk would not be drawn on a specific launch date, Prof. Florian Holzapfel, Chair of the Institute of Flight System Dynamics at the Technical University of Munich (TUM), estimates that test operation will begin in 2020: "The Cora project is at a very high stage of maturity and will probably be one of the first commercial air taxis in the skies."

Since 2017, the Cora self-flying air taxi has completed over 1,000 test flights.

Volocopter 2X
The 18-rotor prototype recently took to the skies above Singapore. In the future, it's set to fly in San Francisco, too.

Volocopter— Drone with multiple rotors

Another contender hoping for the title of "first commercial air taxi" is the German manufacturer Volocopter. The company, in which the automobile groups Daimler and Geely have a stake, already made aviation history back in 2011 when it completed the first ever manned flight of an all-electric vertical takeoff and landing craft. In mid-August 2019, the company unveiled the fourth generation of the aircraft, which goes by the name of VoloCity. It is due to start scheduled service in Singapore in 2021. A cross between a drone and a helicopter for two people, the aircraft has 18 rotors and is slated to fly 35 kilometers on power obtained from lithium-ion batteries. Although this makes the range comparatively small, Volocopter claims that its configuration makes it "the ideal on-demand air taxi for the city center." Expert Florian Holzapfel sees such helicopter-type concepts as at a disadvantage to air taxis that can use wings for cruising. "Winged aircraft are a much more efficient solution, at least as regards the big advantages in terms of range."

VOLOCOPTER

Volocopter GmbH
In 2011, software engineer Stephan Wolf co-founded Volocopter GmbH with his childhood friend and entrepreneur Alexander Zosel. Their company is based in Bruchsal, near Karlsruhe in Baden-Württemberg. It now employs over 150 people and has offices in Munich and Singapore.

Down the line, the drone taxi will take off from the roofs of high-rise buildings and soar above traffic jams.

This jet is set to provide direct connections between cities in the future.

Lilium GmbH

Founded in 2015, the young start-up from Weßling near Munich already employs some 350 people.

Lilium—swiveling ducted fans

Although the Lilium Jet will need a few years before it's ready for autonomous, all-electric scheduled service, its developers are so convinced of its potential that they have already announced the building of an air taxi factory. As of 2025, several hundreds of the jets are to be produced each year near the headquarters of Lilium GmbH in Oberpfaffenhofen near Munich. The five-seater aircraft with 36 electric engines and the same number of swiveling ducted fans made its first unmanned flight in May 2019. According to information from Lilium, the aircraft successfully completed its first test phase at speeds of up to 100 kilometers an hour. However, many aviation experts are skeptical as to whether the vertical takeoff and landing aircraft mini jet will actually reach a top speed of 300 km/h and then travel 300 kilometers on one battery charge, as the company boldly claims. But Lilium CEO Daniel Wiegand maintains that development work has progressed swiftly as planned. Starting in 2025, the company plans to launch passenger operations at several locations worldwide.

A total of 36 all-electric jet engines provide the five-seater vertical takeoff air taxi with a maximum output of 2,000 hp.

The Silent Air Taxi transports four passengers, plus pilot, for a range of up to 500 kilometers without making a stop.

e.SAT

e.SAT GmbH *The hybrid electric aircraft manufacturer was founded in 2018. Headquarted in Aachen, the company is headed by three RWTH professors: Frank Janser, Peter Jeschke and Günther Schuh.*

Silent Air Taxi—straightforward, quick to implement

Unlike other air taxis, the Silent Air Taxi (SAT) cannot take off and land vertically; neither is it fully electric, nor will it fly autonomously, at least initially. But that is exactly how the company e.SAT from Aachen, which is developing the aircraft, says it wants it to be: capable of flying at 300 km/h and with a range of up to 500 kilometers, the small aircraft has a hybrid electric powertrain, space for four passengers plus pilot, and is to enable direct services between existing airfields starting in 2024. “We don’t have to build any new infrastructure, and neither do we need any new regulations—moreover, our hybrid drive minimizes the need for heavy batteries,” says e.SAT co-CEO Prof. Peter Jeschke. MTU will participate in the development and construction of the hybrid powertrain. Detailed engineering is due to begin in 2021. “We hope to be able to take off for the first time in 2022,” Jeschke says.

A flyover by the aircraft cannot be distinguished from everyday background noise thanks to its ultra-low-noise fan.

ALAKA'I TECHNOLOGIES

Alaka'i Technologies *Founded in 2015, the start-up is based in Hopkinton, Massachusetts.*

skai

Skai *With their fuel cell powertrain concept, the people behind Skai take a different approach to other air taxi projects.*

The aircraft's maximum payload will be 450 kilograms—which is sufficient to carry five people.

Skai—taking off with hydrogen

In the opinion of start-up Alaka'i Technologies from Massachusetts, lithium-ion batteries are too heavy as an energy source for air taxis—and so the company has based its concept, which was developed jointly with BMW Designworks, on fuel cells. Skai, the prototype unveiled at the end of November 2019, has space for five passengers, is powered by six electric motors, and is planned to offer a range of 640 kilometers. Such distances are possible, says company founder Brian Morrison, because a pound of compressed hydrogen contains 200 times more energy than a battery of the same weight. At an average speed of 137 km/h, Skai can fly for four hours on electric power, says the start-up. The prototype is fully functional, the company adds, and the first flight will take place soon.

Although TUM researcher Florian Holzapfel does not rule out such a fuel cell powertrain on principle, he observes that "without additional batteries capable of rapid discharge, a fuel cell air taxi won't be able to lift off. Taking off requires a lot of energy all at once—that's simple physics."

Skai takes less than ten minutes to refuel with enough hydrogen to fly 640 kilometers.

Uber Air will take off and land from what are known as verti-ports–found, for example, on the roofs of parking lots.

Uber Air—the design surprise

Ridesharing company Uber also plans to take to the skies from 2023: "Uber Air," the San Francisco-based company's air taxi service, is due to launch in the U.S. cities of Dallas and Los Angeles and in the Australian city of Melbourne. Test flights are already planned there for 2020. However, it is still unclear what the aircraft that will be taking off then will look like: although Uber has designed three different reference models and created technical specifications for them, the development of the air taxis will be handled by various partner companies, including Aurora Flight Sciences (Boeing), Bell, Pipistrel and Embraer. What is clear at this stage is that the Uber aircraft are supposed to carry four passengers plus the pilot just under 100 kilometers at a speed of around 240 km/h. The company does not rule out an autonomous flight option in the future.

The big difference with the proposed Uber Air service, which will take off from and land on platforms on top of high-rise buildings, parking lots, or multi-story mega-skyports, is price: flights are meant to cost no more than an ordinary Uber ride in a car.

The final design of the Uber air taxi is still a work in progress–but it could look something like this.

Uber

Uber Air ——— *The San Francisco-based provider of ridesharing services is working to expand into air transportation.*

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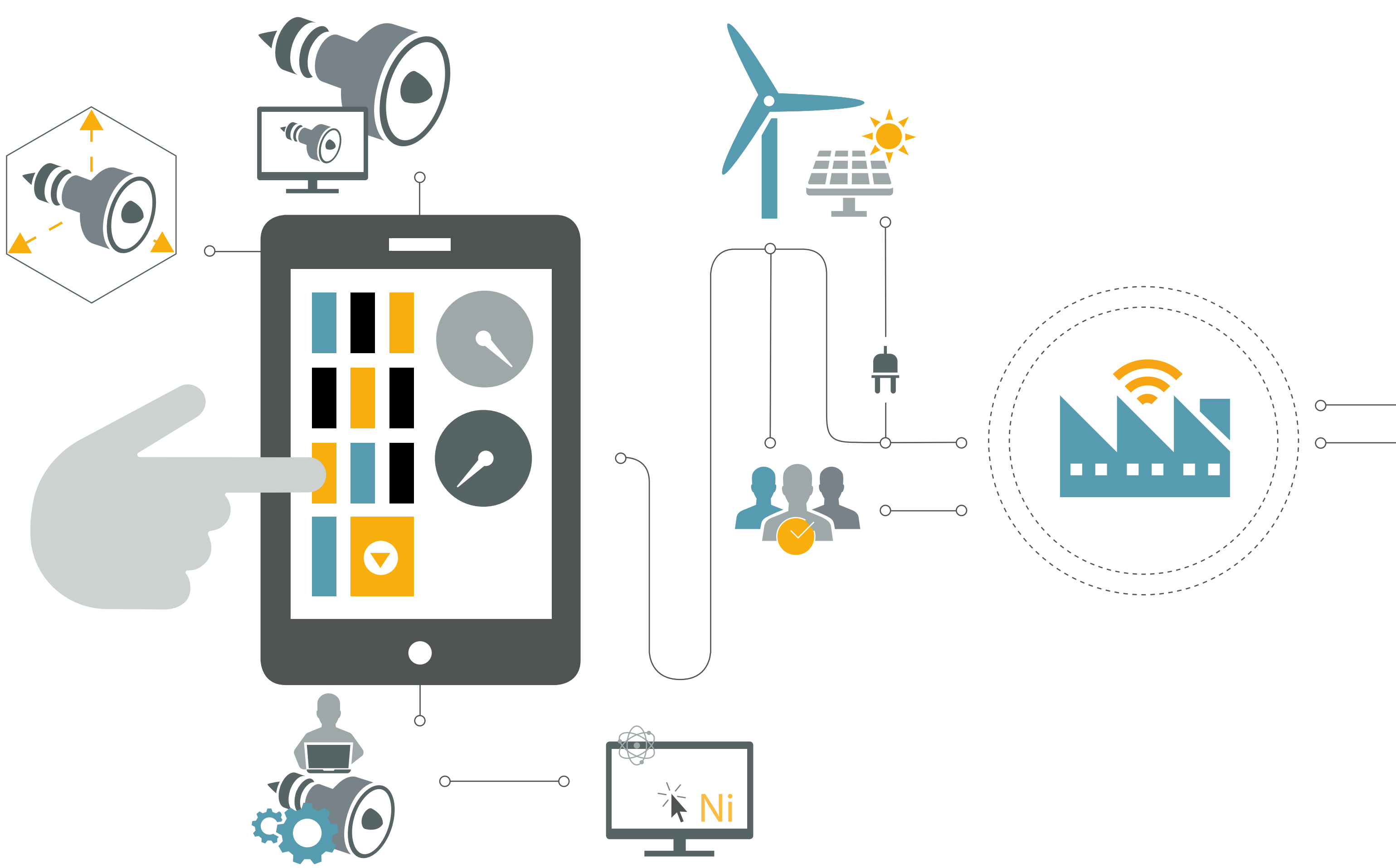
Flexibility in production

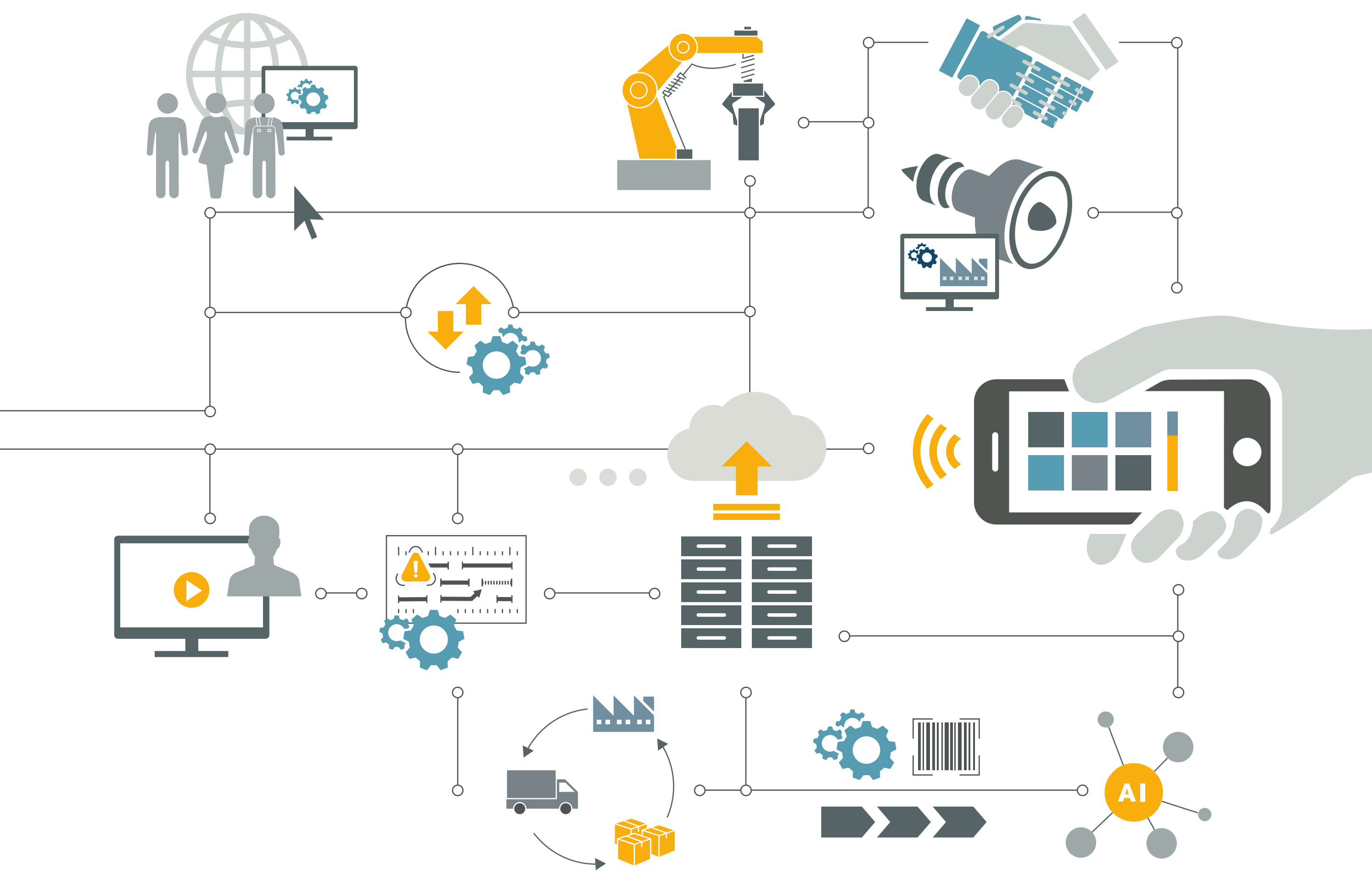
Intelligent automation helps keep manufacturing costs manageable, even for small batch sizes and individual components. This way, large-scale production of batch-size 1 can become a reality, in turn reducing production costs, shortening development cycles, improving quality and, at the same time, increasing production volumes.



Running the hurdles to the smart factory

Aviation companies have to overcome additional challenges as they move toward smart manufacturing operations. MTU Aero Engines shows that the effort pays off.

Text: *Denis Dilba*



When Ulrich Peters joined MTU Aero Engines in 1985, the smart factory was light-years away. “Back then, every department had precisely one computer. If you wanted to use it, you had to book a slot by putting your name on a list,” recalls Peters, who is now Senior Vice President, Production. When you entered a factory floor in those bygone days, there were dozens of machines that worked as isolated systems and had nothing to do with each other. And in between the machines, there were lots of people working. Some were operating the machines, others were supplying raw materials and tools, while yet others were carrying out sample inspections and, in the case of deviations, trying to determine the cause and fix the problem. Then came the march of the computers, which picked up even more speed with the advent of the internet and increasing connectivity. Today, many areas of production at MTU are highly digitalized. The end point of this development is the smart factory.

Cyber-physical production systems make autonomous decisions

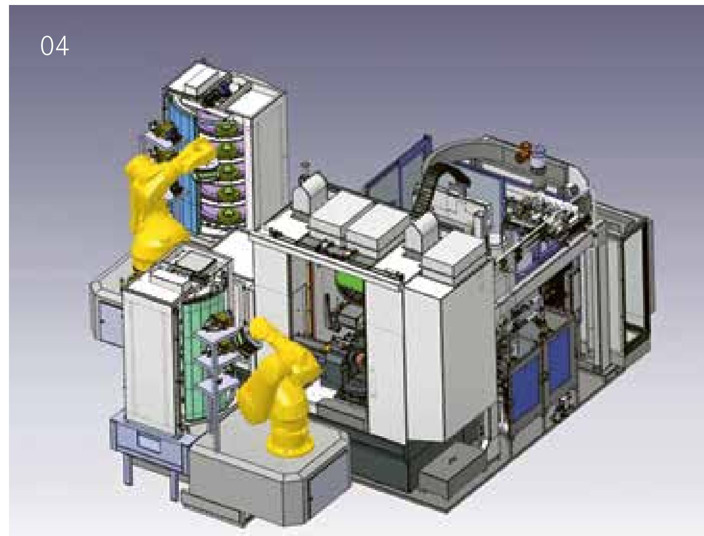
Behind the vision of a smart factory lie manufacturing processes that can operate autonomously via the increasing use of artificial intelligence—that is, without direct human intervention in the production process. Not only will this revolution reduce production costs, shorten development cycles and improve process stability, it will also enable higher production volumes at the same time. To this end, machines in the smart factory are connected with each other mechanically as well as digitally. By virtue of sensors and smart algorithms, they recognize the current actual situation, compare it against the specifications in the digital component definition and adjust their programs accordingly. Experts such as Peters speak of cyber-physical systems. Even today, these smart machines are no longer individually operated or supplied with components by employees. Modern production machines are part of a logistics system that is centrally supplied with materials by a few workers.

At MTU today, such production systems can sometimes run fully autonomously for several days. “We’ve already come a good deal closer to the goal of the smart factory,” Peters says. Nevertheless, it will still be a challenge, he adds, to bring all parts of production to smart-factory level over the years to come. The main reason is that there is no such thing as “the” smart factory; rather, it takes different forms depending on the industry and the state of digitalization within the respective company. There is no standard blueprint for implementation. “Compared to other sectors, the aviation industry certainly has some specific characteristics that make progress towards the smart factory even more complicated,” says Richard Maier, Senior Vice President, Production Development at MTU Aero Engines. These include elements such as the long product lifecycles and the small batch sizes, Maier says.

The aviation industry makes higher demands of the smart factory

In other words: the aviation sector builds fewer products, but the ones it does make last longer. “With engines, we’re talking about service lives of 25 to 30 years,” Peters says. As regards volumes, MTU currently assembles 100 GTF™ Engines per month in partnership with Pratt & Whitney. By comparison, automotive manufacturers assemble tens of thousands of vehicles in

01 ___ *The patented track-guided assembly system for the engine that powers the A320neo enables assembly to be performed in eight steps, similar to an assembly line.*
02 ___ *In the blisk shop, a computer-controlled logistics system ensures the autonomous flow of components and tools.*
03 ___ *Robots used in the production of turbine blades operate without any human intervention.*
04 ___ *Mobile robot systems that move around on their own will soon fully automate the storage of parts and tools.*



the same period, and their product life cycle lasts between just five and seven years. This explains why automakers are already further advanced in the implementation of the smart factory. The aviation sector generally cannot optimize toward such large batch sizes: “Our products are just too expensive for us to first build several prototypes and then do pilot runs and test runs,” Peters says. And for very low quantities all the way down to piece production—batch sizes of one—the flexibility and precision requirements on our machines are much higher. “We also have to be able to manufacture individual components without disrupting the entire production flow,” Peters explains.

At the same time, aviation products and especially engine products are subject to much higher requirements with regard to quality and safety, and therefore also for things like production monitoring and documentation obligations, making the smart factory more expensive. Dr. Martin Roth, expert for Industry 4.0 projects at MTU Aero Engines, expands on some further difficulties: “Our manufacturing processes are subject to strict conditions and are frozen once they are certified. That means we can’t simply change methods or parameters, since that would entail going through another costly process approval.” Then there are the high cybersecurity requirements. In addition to the painstakingly detailed cost-effectiveness analyses, individual smart factory projects thus need time above all else. That being said, technologies such as sensor systems, 3D printing, big data analyses and, most of all, simulation using digital twins are so far advanced that many smart-factory projects are beneficial even for the aviation sector with its additional hurdles, Peters adds.

No way around more smart automation in the future

In more and more areas, MTU no longer has a choice in any case: “With the geared turbofan, smart automation is already essential. Otherwise, we’d have no chance of manufacturing components with the requisite tight tolerances and process stability and achieving the required unit quantities,” Peters says. Incidentally, he adds, MTU’s successful journey to the smart factory does not mean job cuts. “In fact, we’ve strongly increased employee numbers over the past few years.”

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Birds of prey lend a wing

Birds that enter the airspace over an airport pose a real threat to air traffic. Airports often use birds of prey to scare other birds off.

On a collision course at 300km/h

In aviation, colliding with one bird or part of a flock can have devastating consequences. Various strategies help to avoid damage.

Text: *Monika Weiner*

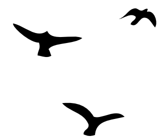
Collisions with birds, known as bird strikes, are often mild, but still cause some two billion U.S. dollars in damage each year. "In Germany alone, we see about 2,500 instances per year, affecting mostly engines, radomes, the wing leading edge and the landing gear," reports Christian Hellberg, managing director of DAVVL e.V., a German association for biological flight safety. The association was established in the 1960s to draw up actions for preventing bird strikes. Members include all German commercial airports, airlines, but also aircraft manufacturers and pilot associations.

Takeoff and landing are the most dangerous times: at altitudes of up to 500 meters, aircraft find themselves sharing the airspace with their natural predecessors—and their feathered friends don't stick to air traffic or statutory regulations. "Flocks of birds are the worst. They can cause serious damage. Airports near the sea, where there are geese and gulls, are at particular risk and continuous monitoring of the airspace is essential." emphasizes Hellberg.

To avoid collisions, all airports have their own bird strike and wildlife management officers who specialize in making the airport grounds less attractive for birds: plants that provide nourishment or serve as hiding places or places to nest and brooks and ponds are a no-go. Long-stemmed grasses are best suited as vegetation as small birds cannot alight there and birds of prey cannot hunt.

Another method used alongside "passive deterrence" by manipulating the ecosystem is monitoring: radar and IR cameras are used to detect larger birds or flocks. The information is gathered by the bird strike and wildlife management officers, who then, where necessary, send warnings to air traffic control and pilots.

In the event of an emergency, it is usually only a bird controller who can help. They use active deterrence methods to drive the birds out of the airspace above the airport. These measures range from scarecrows, pyrotechnics, lasers and oxyhydrogen explosions to regular visits by professional falconers who hunt the grounds with their falcons, buzzards and owls. Birdlike drones, Robirds, which are already in use at airports in the United Kingdom, the Netherlands and the United States, are not authorized in Germany—at least, not yet.



“Our goal is to increase safety by using appropriate structures to prevent catastrophic damage. The components have to be designed in such a way that a bird strike does not result in them being destroyed but only deformed, while, at the same time, retaining their function so that the aircraft is able to continue to fly safely.”

Dr. Nathalie Toso,
Institute of Structures and Design at the German Aerospace Center (DLR)

Hellberg reports that the various preventive measures taken in Germany have succeeded in reducing bird strikes—known as wildlife strikes—by 60 to 80 percent over the last 40 years, while the risk of serious damage to some bird species has risen, because the number of large birds such as geese, cranes, herons and cormorants has increased significantly in some cases. This is due to nature conservation measures and the clampdown on hunting in Europe.

Simulating emergency scenarios

The forces an aircraft has to withstand when it hits a bird weighing up to four kilograms during takeoff at several hundred kilometers per hour are enormous. “They are particularly difficult to calculate as, in aviation, we mainly expect constant, i.e. static, forces to occur during the flight. However, a collision with a bird produces a dynamic structural load that acts for only fractions of a second,” explains Dr. Nathalie Toso from the Institute of Structures and Design at the German Aerospace Center (DLR). Her team develops special computer models and verifies them based on experiments employing an artificial bird—a bird dummy. Using these models, the researchers can digitally simulate collisions at different flight speeds, collision angles and with different sizes of bird. The virtual test environment helps to design components that are particularly vulnerable to bird strikes—wing leading edges, cockpit windows, tail unit leading edge and landing gear—so that they can withstand the impact. “Our goal is to increase safety by using appropriate structures to prevent catastrophic damage. The components have to be designed in such a way that a bird strike does not result in them being destroyed but only deformed, while, at the same time, retaining their function so that the aircraft is able to continue to fly safely,” explains the head of department.

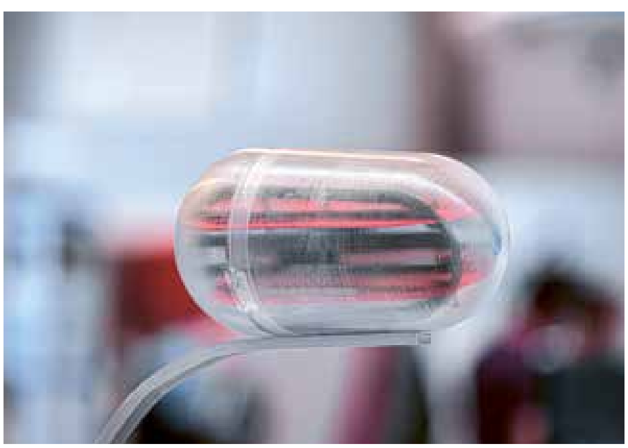
Ensuring the aircraft is still able to fly in an emergency situation is also of paramount importance for engine developers. To this end, engineers factor in an engine’s ability to withstand the high dynamic loads that occur in a bird strike right from the design phase.

Moment of truth on the test stand

Certification testing is the acid test for a new engine. Every new engine must pass the tests defined by the European Union Aviation Safety Agency (EASA) and the U.S. Federal Aviation Administration (FAA). An examiner is present while a bird strike is simulated on the test stand. An engine only passes the test if it still runs at at least 75 percent of its capacity following the impact and a defined recovery period, and if it successfully completes a subsequent test program. “The test criteria have been chosen in such a way that the aircraft can still land safely after a bird strike,” explains Volker Westphal, Head of Validation at MTU.

Natural enemies help prevent bird strikes ______ *To help keep birds away from airports, operators often hire falconers who deploy specially trained birds of prey to hunt on the airport grounds.*

Preventing bird strikes on the ground ______ *Mice and rabbit populations at the airport attract predators. Polecats help to hunt them out and drive them away.*



Artificial birds for safer airspace ______ *A team of researchers at DLR has developed a bird dummy used to determine the loads that a collision with a bird would generate. Its physical properties are comparable to those of a real bird of the same mass.*

Investigating the impact ______ *In the firing facility, a gas canon projects the bird dummy through the air at high velocities. This enables researchers to simulate a bird strike and investigate its impact on different aircraft parts.*

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

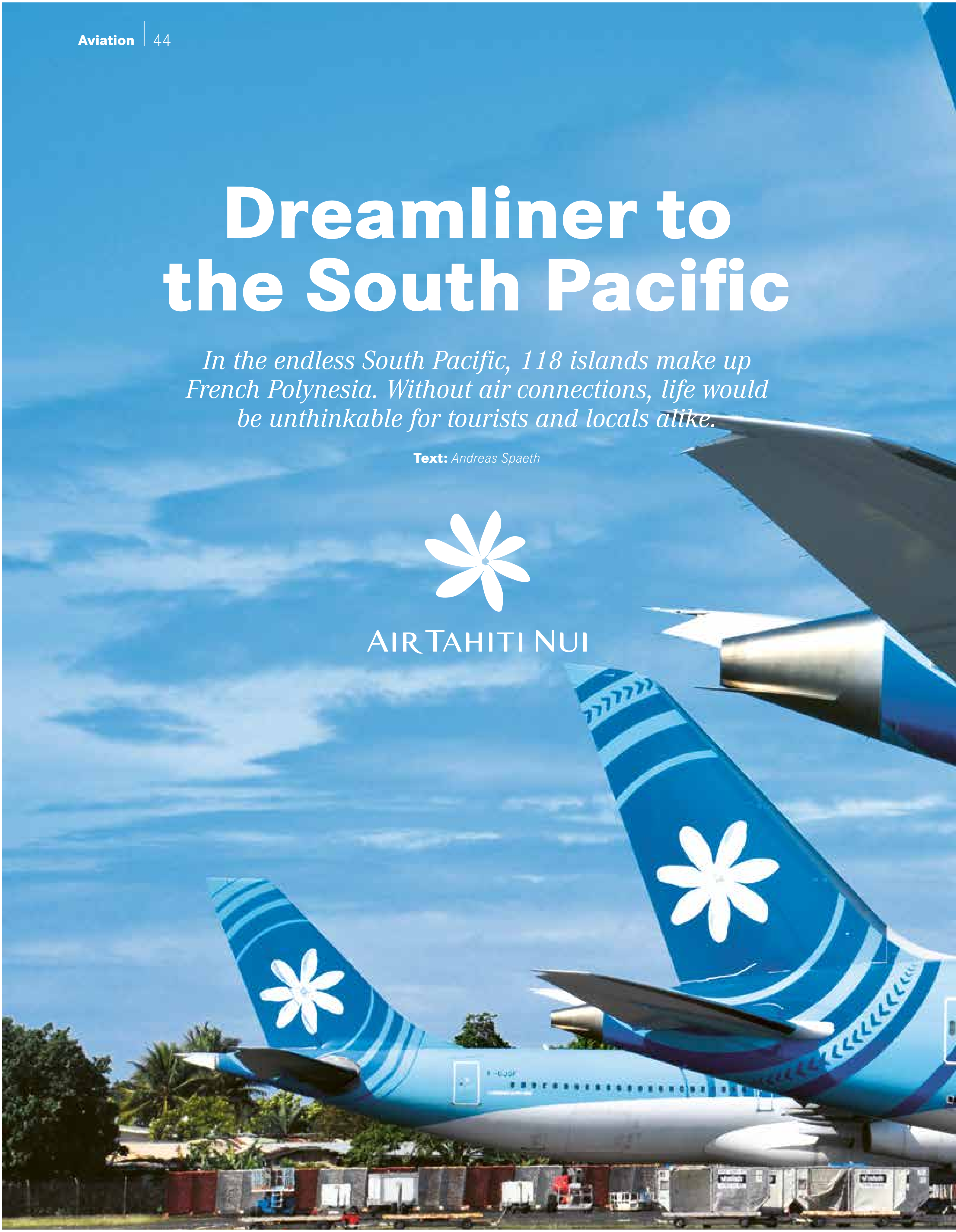
More on this topic: **www.aeroreport.de**

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

Dreamliner to the South Pacific

In the endless South Pacific, 118 islands make up French Polynesia. Without air connections, life would be unthinkable for tourists and locals alike.

Text: *Andreas Spaeth*



Blue like the Pacific
The airline has already received several awards for its extraordinary livery.

AIR TAHITI NUI

Air Tahiti Nui *French Polynesia's flag carrier has been bringing tourists to the archipelago in the middle of the Pacific since 1998.*

Eye-catcher *Four brand-new Boeing 787-9s in a special livery have replaced the previous fleet of five Airbus A340-300s.*

Once glance at the globe makes it clear that the magical island paradise of French Polynesia lies far out of reach of all major centers of civilization, somewhere in the endless blue of the South Pacific. Tahiti, the main island, and the entire French overseas territory, with its 283,000 inhabitants spread across 118 islands and atolls, owes its livelihood to visitors. But they are also prisoners of their remote location—flying to Los Angeles takes around eight hours; the nearest metropolis is Auckland in New Zealand, a five-hour flight away. No wonder, then, that all the islands together welcome only as many tourists each year as Hawaii, the U.S. state further to the north, sees in just one week.

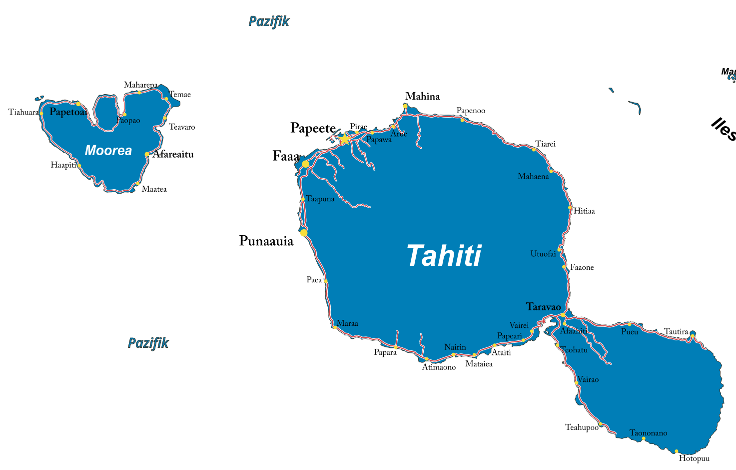
But French Polynesia could never survive without tourism; it has no other economic activity to speak of. This means that good air connections are essential—at all levels. Long-haul connections carry the stream of tourists from the mother country, France, a good 21 hours away, and from North America, which lies a little closer, to the palms of the Bora Bora atoll and the territory's other island beauty spots. Inter-island air connections carry tourists to their destinations and gives locals access to the wider world.

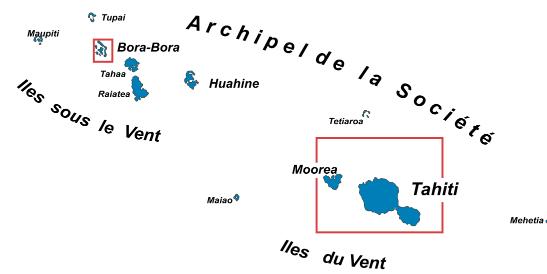
The "big" Air Tahiti

Air Tahiti Nui is the national airline of French Polynesia; "Nui" means "big." Founded in 1998, for many years it flew a fleet of Airbus A340-300 aircraft, which most recently numbered five. In mid-2019, however, the airline completely reinvented itself and now operates a fleet of four brand-new Boeing 787-9s in a newly designed livery that makes them a real eye-catcher wherever they appear. Their radiant shade of blue immediately brings to mind the turquoise waters of the South Pacific. Their tails sport the white tiaré flower, the national flower; each passenger receives a real one when they board. And the rear section of their fuselage is decorated with light-blue designs based on typical tattoos

Experience Tahiti *Tahitian dancers introduce passengers to the local customs and traditions in their country. Air Tahiti Nui's aim is for passengers to feel like they're stepping into paradise as soon as they board the aircraft.*

Tahiti





In the heart of French Polynesia *At 1,042 km² Tahiti is the biggest island in this overseas territory. This is where the majority of the population live.*

from the remote Marquesas islands, including stylized manta rays, albatross, fishhooks, ocean waves and tiki symbols from ancestor worship.

Extremely long and thin routes

“We wanted the Boeing 787-9 because it’s a perfect fit for our extremely long routes with medium passenger numbers,” says Air Tahiti Nui Managing Director Mathieu Bechonnet. And the island airline ultimately got its way despite considerable political pressure to consider its French heritage and buy the Airbus A350 or A330neo. What’s interesting is that almost all the other carriers serving Tahiti—LATAM, Air New Zealand and United Airlines—also do so with the 787, which really is perfect for such long, “thin” routes. Air France flies the Boeing 777-300ER there, while low-cost carrier French Bee has started services using the A350.

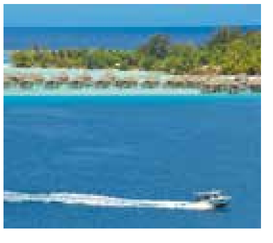
Air Tahiti Nui’s route network comprises just a handful of destinations: flights from its Papeete hub on Tahiti to Tokyo, Auckland, Los Angeles and Paris. The company’s growth is directly connected to the tourism industry. “We have no transferring passengers or sixth freedom passengers—guests we would carry from one foreign country to another with a stop in our home country. We are completely dependent on the destination and on the number of available hotel rooms. Recent hotel closures mean this number is now considerably smaller, which makes it hard for us to expand,” says Christopher Korenke, the German national who is Senior Vice President Commercial & Marketing for the airline. He adds that the most important thing is to ensure that they always offer enough capacity to serve Tahiti, since the number of other airlines serving the island fluctuates wildly.

New fleet increases efficiency

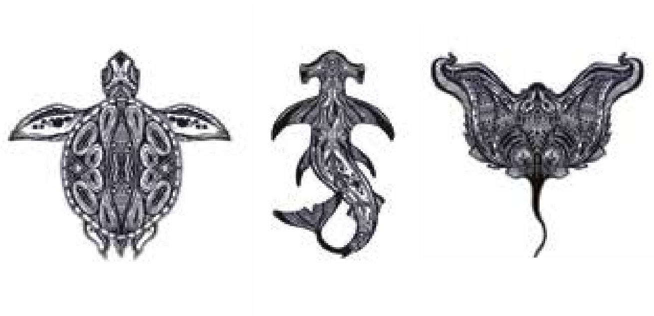
Tourists account for 80 percent of Air Tahiti Nui’s business. The company has been profitable for many years, and welcomes the efficiency gains that it has achieved by renewing its fleet. Air Tahiti Nui’s Dreamliners are powered by GE Aviation GEnx engines, in which MTU has a program share. Not only do they burn 23 percent less kerosene than the engines that power the A340-300, they also make the 787 markedly faster: the flight time to Paris has been reduced by a whole 90 minutes. “And the maintenance costs are an impressive 35 percent lower than for the A340,” states Executive Vice President Operations Raymond Topin. He is particularly happy that his new fleet is now also certified for ETOPS 225. This means it can opt for the shortest route between Los Angeles and Papeete, which saves another 15 minutes of flying time.

ANCESTOR WORSHIP

Ancestors from the Marquesas *These carved sculptures—known as Tiki—can be found on the remote Marquesas islands.*



Island paradise *Overwater bungalows are typical hotel accommodations on the island of Bora Bora.*



Diverse fauna *The many coral reefs offer an excellent habitat for countless creatures—including sharks, rays and all kinds of colorful fish.*

Most people traveling to Tahiti want to fly on to Bora Bora, the major resort island, a 50-minute flight from the capital city's airport. To reach this unspoiled Pacific Island paradise, passengers climb aboard an ATR-72 operated by Air Tahiti, the regional carrier and lifeline for island transportation. Even though Air Tahiti's 11 ATRs connect Papeete to 46 islands, the Bora Bora "run" accounts for almost one-fourth of its passengers, which recently totaled 826,000 (2018).

Island-hopping with legs of up to four hours

The main challenge the island airline must cope with is French Polynesia's geographical extent. Some islands and atolls are almost four hours away from Papeete in a turboprop—roughly the distance from Paris to Stockholm. Meanwhile, the least frequented routes sometimes attract less than 300 passengers—in a year. As a majority private company, the regional airline receives no state subsidies, so it needs to find other ways to make ends meet. One way is through cross-subsidy, as Air Tahiti CEO Manate Vivish explains: "We get the tourists to help pay for the local services."

Those who can afford it hire themselves an exclusive helicopter on Tahiti, neighboring Mo'orea or on Bora Bora. Air Tahiti Nui set up a subsidiary with Franco-Swiss market leader HBG especially to cater to this segment. Sightseeing flights taking in the lush rainforests cloaking Tahiti's Mount Orohena, which rises to over 2,000 meters, or breathtaking aerial panoramas over the islands of Mo'orea and Bora Bora add a stunning new dimension to this island paradise.

A view of Paradise *The Air Tahiti Nui Helicopters subsidiary offers sightseeing flights over the islands of Tahiti, Mo'orea and Bora Bora aboard modern Airbus helicopters.*

Tahitian Dreamliner ——— *The Boeing 787-9 sports two red lines on either side to represent the flag of French Polynesia.*

GEnx

GEnx ——— *This engine powers the Boeing 787 Dreamliner and the Boeing 747. MTU Aero Engines covers the entire lifecycle of its turbine center frame.*

The GEnx is GE Aviation's next-generation engine family designed for medium-capacity long-range aircraft. Based on the proven architecture of the GE90, the GEnx is intended to succeed GE's highly successful CF6 series, the best-selling engine family for widebodies. The engine uses latest generation materials and design processes to reduce weight, improve performance and lower noise and maintenance cost.

MTU Aero Engines participates in the GEnx program as a risk-and-revenue sharing partner and has a 6.65-percent stake. MTU is responsible for the design, manufacture, assembly and MRO of the turbine center frame. In the process, the company can draw on the experience gained with the turbine center frame for the GP7000, which has proved to be a very reliable and successful component.

Do you have any questions, requests or suggestions?
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More on this topic: **www.aeroreport.de**

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

jetBlue Airways —— *The U.S. airline is headquartered in New York City. More than 22,000 crew members handle over 1,000 flights daily.*

Panache without the price tag

Low-cost airline JetBlue Airways drives down prices on every route it flies and still affords customers luxury. Soon it will be adding transatlantic flights to its repertoire.

Text: *Victoria Nicholls*

If Robin Hayes, CEO JetBlue Airways, could change anything about aviation, it would be to bring panache back to air travel. Over the years, the focus on cost has seen airlines stripping back on additional services and luxury, he says. “One of my best flying experiences was on Concorde,” he says. “But today, flying can be like a bus journey in some cases, the flair has been lost.” Nonetheless, according to the executive, JetBlue shows this can be done differently. “We bring the humanity back,” he adds. Hayes doesn’t believe that customers should have to choose between service and low fares. He is proud that JetBlue offers the most legroom in economy on U.S. flights, free, high-speed WiFi on board as well as drinks and snacks without charge.

Despite the comforts on offer at JetBlue, there are some things that cannot be changed about the flying experience—for instance jetlag. Hayes’ best trick for beating this travel woe is to get in to the destination time zone as soon as possible. Say for instance he’s flying from New York to London at 8 p.m. Eastern Time, then it is 1 a.m. in London, so he’ll try to sleep as soon as possible once on the plane.

This will come in handy when JetBlue introduces its transatlantic flights from the U.S. beginning 2021. Currently, the airline plans to fly from New York, where the airline is based, and Boston, New England, to London, UK. And with 26 A321 Long Range (LR) and Xtra Long Range (XLR) on order, Hayes is confident new routes within Europe will follow and he also has further Latin American destinations in his sights.

The LRs and XLRs are in addition to more than 120 A220 and A321neos on order that will expand JetBlue’s existing fleet of 60 E190 aircraft as well as nearly 200 A320 and A321s.

The secret sauce

Hayes feels that the culture at JetBlue is what differentiates the airline from its competition. Having a motivated and inspired crew is important to him, “because a happy crew passes this on to customers and offers better service,” he explains. Hayes also likes to sit in the cockpit and talk to the crew when he gets the chance and also pitches in when it comes to cleaning the aircraft during turnaround at an airport. “Every JetBlue crew member that flies with us, that’s our word for employee, helps

Robin Hayes
Robin Hayes is CEO of JetBlue Airways. The Brit has been with JetBlue since 2008 and took over the role at the head of the company in 2015. Previously, he spent 19 years with British Airways in various roles. Hayes has been in aviation for over 30 years and holds degrees in engineering and avionics.

JetBlue Mint ____ *A more personalized service, tailored to the needs of today's traveler.*

JETBLUE AIRWAYS

42 m
passengers each year

More than **22,000**
crew members

More than **1,000**
daily flights

Nearly **100**
cities served. Latin America and Caribbean cities account for one-third of all JetBlue destinations.

out at the end of the flight from inflight crew to chief executive officer." It is also why he prefers the aisle seat over the window, as he's in a better position to offer his support. Hayes also travels to Florida every two weeks to take part in the orientation of new employees.

The approach seems to be working. In 2019, JetBlue had a great year. The company's share price increased nearly 20 percent and they were able to increase earnings per share for their shareholders. In a region as consolidated as North America, where the top four legacy airlines have 80 percent market share, this is no mean feat. JetBlue currently has 5 percent of the market in the region and Hayes feels the airline offers an important alternative to customers. "When two legacy airlines compete on a route, they essentially compete to see who can charge the most," he says. "But when JetBlue offers that route, prices go down. When JetBlue started flying from the Northeast to the West Coast of the U.S. back in 2014 with our Mint experience, we saw premium fares halve, and the market's expanded since."

He expects the same to happen on transatlantic flights in the near future. "The fares are so obscenely high that it is ripe for a low-cost carrier to come in and discipline the market, lower fares and create more availability. It's a good thing."

Reducing cost

Of course, when passing on cost benefits to customers, the airline also needs to ensure its own cost base is as efficient as possible. JetBlue committed to a cost reduction of 250-300 million U.S. dollars annually by 2020. As part of this, the airline signed an exclusive 13-year contract for the airline's V2500 pre-select fleet—powering around half of its Airbus A320ceo fleet of 193 aircraft in 2019. Alongside maintenance, repair and overhaul for the engines, the contract covers the supply of green-time and leased engines in order to avoid costly engine overhauls. MTU will also support JetBlue with fleet management, engine trend monitoring as well as teardown and material salvation, not only improving cost-efficiency but also increasing predictability and flexibility. Both parties have worked together since their first V2500 contract in 2005 and expanded their cooperation to include a component agreement signed in 2014.

Engine MRO is the biggest maintenance cost for most airlines, including JetBlue. “We wanted to get the best deal possible for the airline and worked hard to do so, but never want to compromise on quality, safety or reliability,” he explains.

“We outsource much of our maintenance, so to us service providers are trusted partners as opposed to simply vendors,” Hayes adds. “Our relationship with MTU is therefore extremely important to us. MTU understands our needs and we have a shared sense of values, it helps both of us be successful.”

Industry future

But cost is not the only serious topic on the agenda at airlines worldwide. Sustainability is generating a lot of debate and headlines. The aviation industry emits carbon dioxide and through, for instance, CORSIA, the Carbon Offsetting and Reduction Scheme for International Aviation, has made commitments to reduce its carbon dioxide emissions to half that of 2005 levels by 2050. “As an industry, we need to fly newer, more fuel efficient engines, such as the geared turbofan, which reduces fuel burn by 16-20 percent,” Hayes explains, referring to the next generation A320neo PW1100G-JM engine in which MTU has an 18 percent program share. Hayes also comments on the need for a scalable, sustainable aviation fuel market. “Furthermore, we need to push air traffic control systems for more efficiency around the world. Airplanes circling and waiting to land is not as efficient as it could be. The system is operating safely, but it’s based on old technology.” JetBlue continues to advocate for the Federal Aviation Authority’s (FAA) efforts towards implementing the Next Generation Air Transportation System (NextGen). NextGen will enable more direct routes and reduce fuel use by optimizing trip durations and improving descent patterns.

JetBlue also invests in start-ups through JetBlue Technology Ventures. “We’ve taken JetBlue’s original mission to bring humanity back to travel and we’re expanding it to an unprecedented scale: we want to improve the end-to-end experience for travelers everywhere, whether they’re flying or not,” Hayes says.

To this end, JetBlue is set to be an airline that makes travel “quicker, greener and less miserable” in 2020 and beyond, too.

The JetBlue effect
Flying in style–at affordable fares.

JetBlue is set to be an airline that makes travel “quicker, greener and less miserable” in 2020 and beyond, too.

Robin Hayes
CEO of JetBlue Airways

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

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

Visualization

Artificial smoke makes the vortices visible during test flights.

Landing planes in faster succession

Tests show that plates installed at the end of runways help dangerous wake turbulence from previous aircraft to decay much more quickly.

Text: *Thorsten Rienth*

Plates vs. vortices *Measuring nine meters long and four meters tall, these plates essentially cancel out vortices–generated, for example, by this Airbus A380.*

"In the meantime, we can confidently state that the plates reduce the duration of long-lasting vortices by some 30 percent."

Dr. Frank Holzäpfel,
DLR Institute for Atmospheric Physics, Cloud Physics and Transport Meteorology

Dangerous wake turbulence
Vortices pose a real safety risk for any aircraft in the flight path behind.

They still look a bit like they've come straight from a brainstorming session in the workshop: dark-green tarps pulled tightly over wooden frames, measuring nine meters long by four meters high. Hinges have been integrated on the underside so that the boards can be raised, all in a row, over a fixed base in the ground. Tension lines hold them in position. Yet setting up what has been dubbed the "Plate Line" is anything but a game: once in place just in front of the runway, the configuration patented by the German Aerospace Center (DLR) can shorten the intervals of time between landing aircraft.

Currently, small and midsized aircraft have to maintain a safe distance of some ten kilometers from heavier jets flying in front of them, such as an Airbus A380. The reason is wake turbulence, specifically vortices that roll over the aircraft's wingtips where the low pressure above the wing meets the high pressure below it.

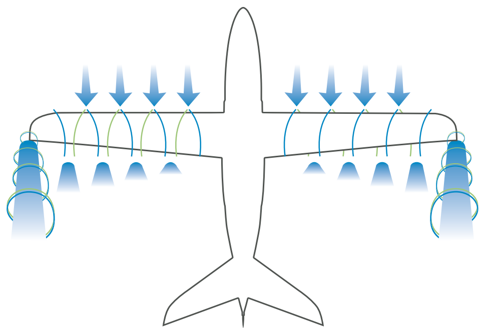
"Long-lasting vortices can be quite powerful," explains Dr. Frank Holzäpfel from the DLR Institute for Atmospheric Physics, Cloud Physics and Transport Meteorology. "They can pose a real problem for any aircraft flying behind them."

State-of-the-art test equipment

The danger arises mainly from the occasional tendency of the vortices to persist for some time right in the flight path of subsequent aircraft. They can even damage the ground and nearby buildings. Holzäpfel calculates that the vertical plates will cause the vortices to decay more quickly, and ideally even dissipate altogether. When the vortices meet the plates, they generate secondary vortices that counteract the initial ones. In other words, the vortices essentially cancel each other out.

Holzäpfel and his colleagues have already been able to demonstrate the basic underlying relationship, using the water towing tank, flow simulations and a G550 research aircraft for initial flight testing at DLR's Oberpfaffenhofen location. Now the DLR has teamed up with Austro Control, an Austrian air traffic control pro-

How vortices form



Counter-rotating vortices _____ *Vortices form when low pressure from above the wing and high pressure from below the wing collide. Generated primarily at the wingtips, the vortices then rotate outward in the shape of a corkscrew.*

vider, and several other partners on a project entitled "Wake turbulence separation optimization." Supported by EU research program SESAR, this collaboration aims to demonstrate the effectiveness of the plate configuration in live operation at Vienna International Airport.

To this end, the partners had state-of-the-art test equipment installed. For example, a novel cloud radar system, now being tested at an airport for the first time; it delivers deep insights into the wind direction and shearing in complex cloud and precipitation scenarios. A microwave radiometer provides a vertical temperature and humidity profile, and a wide range of other sensors monitor the setup. The equipment had to undergo an enormous approval process for the partners to get the permission they needed to install it all right in front of a runway.

But their efforts have clearly paid off. "Initial analysis of the measurement data shows that vortices near the plates do indeed dissipate more quickly," Holzäpfel reports. "In the meantime, we can confidently state that the plates reduce the duration of long-lasting vortices by some 30 percent."

Opening the door to reduced landing intervals

That figure is staggering. "Very encouraging" is how Christian Kern, head of Air Traffic Management at Austro Control, describes it. "Should this figure be confirmed, the Plate Lines could improve safety at all airports for the next aircraft in line to land—and in a best-case scenario, boost capacity at those airports as well." That's because if the vortices vanish more quickly, approaching aircraft can land in more rapid succession. The method would also avoid expensive and time-consuming construction work for expanding the infrastructure.

All this of course depends quite heavily on the rules and regulations for aircraft landings, such as those issued by the European Union Aviation Safety Agency (EASA). Nevertheless, the validated effect of the plates would be a good basis for further considerations about reducing the intervals between aircraft landings.

For now, the DLR wants to take some time to further refine the plate combination of tarps, wooden frames and hinges. "We are already working on the specification and production of a permanent plate installation," Holzäpfel says.

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

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

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

Inspiring talent to soar

Women with a science or technical degree have excellent career opportunities. An interview with Dr. Mihaela Sorina Seitz from MTU Aero Engines on supporting female STEM students.

Text: *Nicole Geffert*

Dr. Mihaela Sorina Seitz ___ *The Senior Manager, Advanced Materials at MTU mentors female STEM students.*

Dr. Mihaela Sorina Seitz, born 1968, has been Senior Manager Advanced Materials at MTU Aero Engines since 2018. Before that, she was Leader Program Management for GE engine programs. Further career highlights include serving as a manager in Repair Engineering for MTU Maintenance Hannover and MTU in Munich; Senior Manager, Marketing, Sales and Customer Support; and Executive Business Assistant to the President Commercial MRO. Dr. Seitz joined MTU in 1999 as an engineer in process development. She holds a degree from the University Politehnica of Bucharest, Romania and earned her doctorate in materials science and engineering for metals from Friedrich-Alexander Universität (FAU) in Erlangen-Nürnberg.

When it comes to studying the natural sciences or technical fields, women in Germany are still underrepresented. You wish to change that by supporting driven, talented female students. What specifically do you aim to accomplish?

Throughout my career, it has become increasingly important to me that I personally advise young women studying a so-called STEM subject—science, technology, engineering, or mathematics—and support them in their careers. It is also important because there is still a growing demand for highly qualified, technically trained junior employees. At the same time, there is an overall shortage of STEM graduates. My efforts are aimed at encouraging young women in scientific and technical courses of study to use their strengths in these professions and later to take on the challenges of a management position. Supporting women in engineering careers will remain crucial for as long as men continue to outnumber them.

Can you provide details on how you support female STEM students?

For several years now, I have been involved in a mentoring program coordinated by the University of Stuttgart and supported by managers from MTU. As a mentor in this program, I advise and support female doctoral students in technical and scientific courses of study. The younger generation is tremendously motivated. Many of these young women have very high expectations of themselves and want to do everything perfectly, which can sometimes lead to self-doubt. But it's possible—and necessary—to learn how to stand up for yourself and for what you can do. I was fortunate to have had superiors in my career who recognized and rewarded my performance. If this is not the case, you have to be the one to take the first step; to stand up with confidence and draw attention to your own achievements. Although many men don't find this too difficult, we women have some catching up to do.

What topics are important to up-and-coming female engineers?

They expressly want feedback: Where do I stand? How can I improve? What is my potential? This has been my experience not only as a mentor, but also in my volunteer work on the management board of the MTU Studien-Stiftung, which I've been chair of since 2019. Once a year, we organize a multi-day training course on a specific topic for female STEM students. The course participants, who've all made outstanding professional achievements, are open to new ideas and have the ambition to make things happen. They use their time together to exchange ideas and build networks. Intensive networking lets them benefit from these contacts, enabling them to share information about internships, assignments abroad, professional issues and the like.

Could you give an example of when a STEM graduate benefited from your advice and successfully launched a career in a technical field?

In the mentoring program at the University of Stuttgart, I advised a young woman who had just completed a technical master's degree and so had to decide whether or not to continue on to do her doctorate. No one in her family had an academic education, and she herself had little idea at first whether a doctorate was the right move for her and what kind of job in industry she might like to do afterward. Through our conversations, I was able to help her make a clear decision about the next step in her career. She completed her doctorate at a leading German research institute and was also team leader there. At another crossroads later in her career, she contacted me again to find out what it's like to work for the management board. She wound up joining a German industrial company as a project manager in the technology division where she reports directly to the company's Chief Technology Officer.

Your team at MTU Aero Engines is evenly split between men and women. Do you support both groups equally?

I give everyone on the team the space to contribute their own individual strengths and abilities. However, young employees in particular—women and men alike—are still developing their potential. For them, it is ideal if they have not only a supervisor to support them, but also an employer like MTU. In this company, we have an excellent range of training courses and an environment that encourages people to keep developing their skillsets. As an employee here, you have access to opportunities for lifelong learning. I always encourage my employees to take advantage of that. I myself am a person who is always looking for new challenges, and look within myself to find ways to improve. I enjoy inspiring talented people by showing them their potential and prospects.

They say that mixed teams work together more successfully. Is that true in your experience?

Yes, especially teams that are made up of new and experienced colleagues, women and men. Nowadays, due to the high complexity of engineering projects, it's not individuals who find answers, it's interdisciplinary teams. In my experience, this kind of teamwork benefits women in particular. After all, many women have great communication skills plus a certain amount of empathy and foresight. They are in no way inferior to men in terms of technical knowledge; they work in a structured, solution-oriented manner and get right to the heart of the matter. It is often said that more than anything, women want to be appreciated in their jobs. As do men! And in closing, I'll share a little secret with you: managers are also happy to receive positive feedback from their employees.

Do you have any questions, requests or suggestions?
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Text:
Nicole Geffert has been working as a freelance journalist covering topics such as research and science, money and taxes, and education and careers since 1999.

Quiet landing

The German Aerospace Center (DLR) hopes to improve quality of life for people living near airports with the LNAS pilot assistance system.

Time and again, the Airbus A320 ATRA flying testbed did its rounds. For each of the 70 approaches to runway 14 at Zurich Airport, the test crew made tiny adjustments to the parameters: engine performance, flap position, air brakes, landing gear. “We need this number of similar approaches to ensure we have a sufficient breadth of data,” explains Dr. Fethi Abdelmouda from the DLR Institute of Flight Systems.

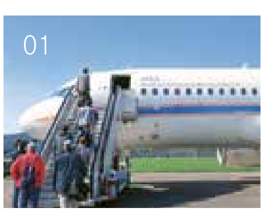
All this effort is in the interests of a new pilot assistance system called LNAS, which stands for Low Noise Augmentation System. In the future, DLR wants this system to support pilots during complex approach procedures to keep descents as quiet as possible. “Conditions that are constantly changing, such as wind and flying weight, make it extremely complicated to fly precise vertical profiles for a low-noise approach,” says DLR test pilot Jens Heider, one of the people in the cockpit of the A320 ATRA for the test flights. We might not be able to change fundamental principles of physics, but we certainly can change the number of unfavorably noisy approaches.

The system aims to optimize energy management during the approach, in other words to make the descent as continuous as possible. This means pilots must adhere to a precise descent profile and they must extend the landing gear and flaps at specific times. The reason this is important is that when landing—unlike during takeoff—it’s not the engines that are responsible for most of the noise, but rather the air that passes over the flaps and around the landing gear.

Displaying pilot guidelines on a tablet

Of course, approaches have always kept the crew hard at work in the cockpit. That’s why LNAS is designed as a pilot assistance system. It features a display—the Electronic Flight Bag—that shows the pilot at a glance the optimum point in time to extend the flaps and the latest possible time to extend the landing gear. Provided pilots follow the instructions, says DLR, the system minimizes noise and fuel consumption during the approach from the cruising altitude down to the stabilizing altitude of 1,000 feet above airport elevation.

The purpose of September’s test flights was to validate the underlying LNAS algorithm using noise measurement stations set up along the approach path. In addition to the DLR test pilots,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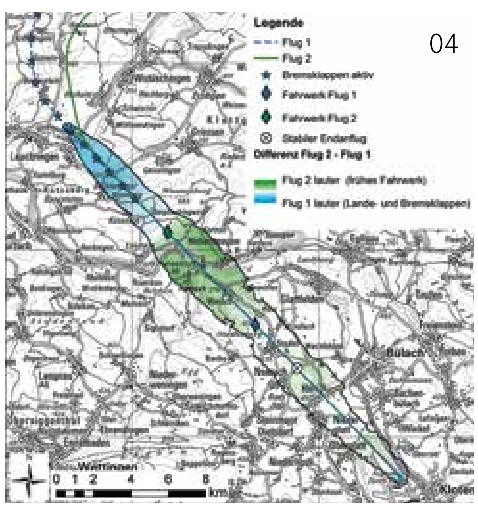
02

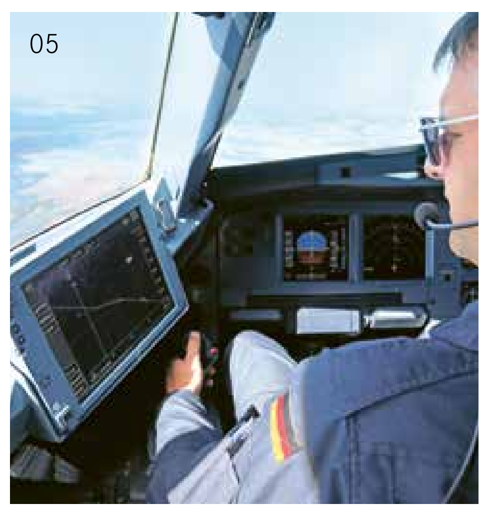
> *"Conditions that are constantly changing, such as wind and flying weight, make it extremely complicated to fly precise vertical profiles for a low-noise approach."*
>
> **Jens Heider,** *DLR test pilot*

25 participating airline pilots sat at the sidesticks to test the system's practicability.

During the test flights, the system displayed its suggested course of action on a tablet fitted above the normal controls. However, DLR thinks there is a good chance that its new system will become an integrated part of aircraft onboard computers in the future.

One sign pointing in this direction is that the go-ahead was given for endurance testing of the system following the Zurich test flights. Since October, LNAS has been in test operation on board 86 of Lufthansa's A320 family aircraft at Frankfurt Airport. The aim is to collect comprehensive data that will allow statistically reliable predictions of flight noise and fuel consumption in normal operations.

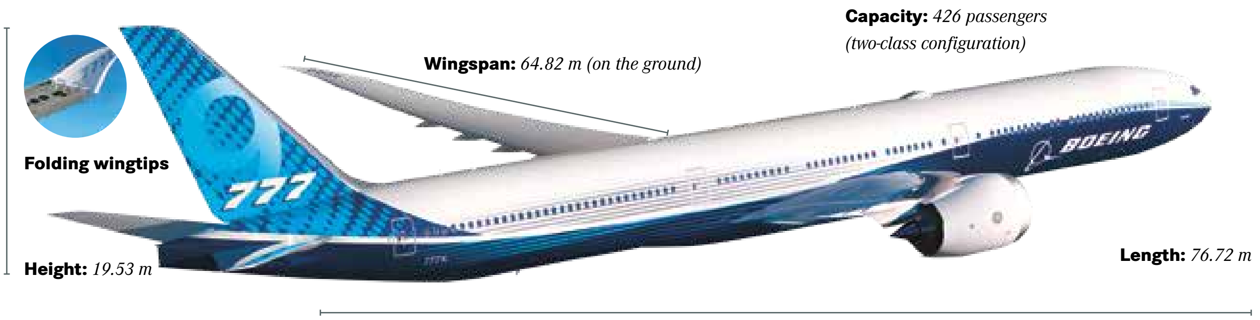




01 ___ *The DLR's A320 ATRA research aircraft is used as a flying testbed.*
02 ___ *From the monitoring station for the flight-test instrumentation on board the ATRA research aircraft, DLR scientists track the flight tests in Zurich.*
03 ___ *One of the seven noise measuring stations in Empa's Acoustics/Noise Control lab that are used to record the sound pressure during flight testing.*
04 ___ *The descent profile and the times at which the pilots extend the flaps and landing gear determine the noise emissions during the approach.*
05 ___ *The LNAS assistance system features a display that shows DLR test pilot Jens Heider when exactly to perform which action to minimize the noise of the approach.*

A dynamic duo

In January, the new Boeing 777X-9 powered by GE9X engines took to the skies for the first time.



The **folding wingtips** *reduce the wingspan on the ground from 71.75 to 64.82 meters–taking it below the critical 65 meter mark and enabling the 777X to fit into "normal" airport gates.*

Adding length to the **CFRP wings** *also makes sense from an aerodynamic perspective: Boeing says this improves the lift-to-drag ratio and increases the fuel efficiency in cruise.*

The interior of the 777X is inspired by that of the Boeing 787 Dreamliner. But the 777X has added selling points that include an even **quieter cabin** *and* **higher levels of humidity**–*the latter improving the air quality in the cabin for passengers.*

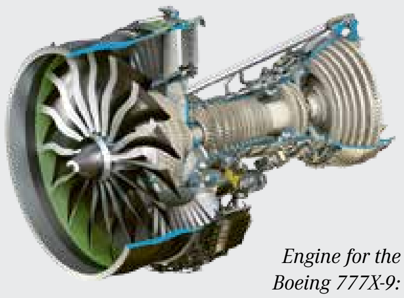
The Boeing 777X-9 is the **world's longest twinjet,** *featuring a* **fuselage that measures 76.72 meters.**

Boeing gives the **aircraft range** *as 7,285 nautical miles for 426 passengers in a two-class configuration. This is equivalent to* **nearly 13,500 kilometers.** *At 69.79 meters, the slightly shorter 777X-8 can fly for an even longer range of 8,730 nautical miles (16,170 kilometers) with 384 passengers on board.*

The 777X is powered by **two GE9X engines**, *each equipped with an* **11-stage high-pressure compressor** *that delivers a pressure ratio of* **27:1.** *The engine's overall pressure ratio is* **60:1.**

In the summer of 2019, the GE9X **set a Guinness World Record as the most powerful commercial aircraft jet engine:** *under test conditions, the engine* **reached 134,300 pounds of thrust**–*appreciably higher than the previous record holder, the GE90-115B, which delivers 127,900 pounds of thrust.*

According to GE, the GE9X **consumes ten percent less** *fuel than the GE90-115B, the engine that powers the Boeing 777-300ER.*



Engine for the Boeing 777X-9: the GE9X–big and efficient

MTU is a four-percent shareholder in the GE9X program, assuming development and production responsibility for the turbine center frame (TCF). For MTU, the engine provides a firm foothold in today's cutting-edge generation of widebody aircraft. The TCF is one of the most sophisticated components in the commercial engine business: exposed to extreme stresses, it serves a duct for the hot gas flowing from the high-pressure turbine past structural components and cables to the low-pressure turbine at temperatures of up to 1,000 degrees Celsius–with minimum aerodynamic losses. MTU has many years of experience with this module, which it also develops and produces for the GP7000 (Airbus A380) and the GEnx (Boeing 787 Dreamliner, 747-8) engine programs.

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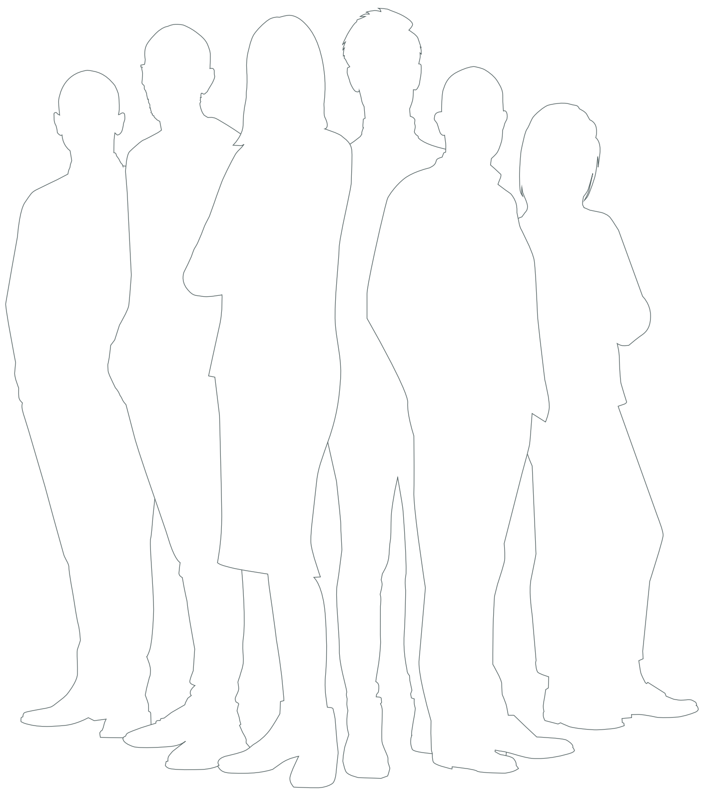

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