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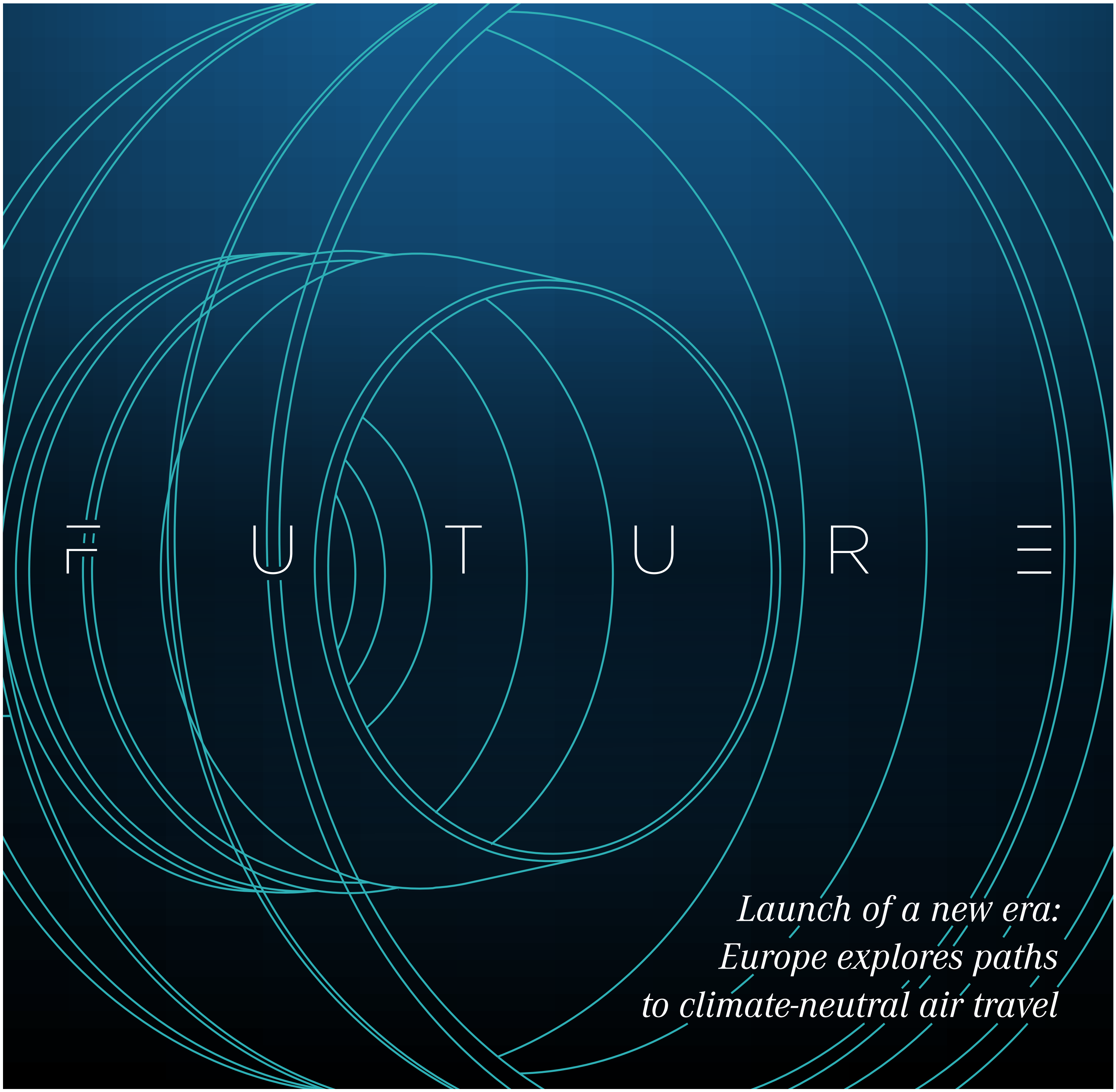

INNOVATION
X-planes: How NASA has conquered new frontiers

AVIATION
40 years and no end in sight: The V2500 engine celebrates its anniversary

GOOD TO KNOW
At a glance: MTU's core competencies


MTU
Aero Engines
YOU CAN FIND OUR TECHNOLOGY IN 30% OF ALL PLANES AND YOU GAVE IT 100%.
THE MOMENT WHEN IT TAKES OFF: UNBEATABLE.
Wanted: team players (all genders) who aim high.
Any other desk job is just a strip of concrete. Turn it into a runway and be part of high-flying projects. With us. At MTU.
Over 11,000 people. 18 locations worldwide. One in three planes flies with our technology. The only thing missing: You.
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Dear readers,

It is my pleasure to introduce myself to you as MTU Aero Engines' new Chief Operating Officer. I became part of the MTU family at the beginning of the year, and what has most fascinated me since then is the enthusiasm for our product that I have encountered when talking with people throughout the company. Every day at MTU, creative minds are working on groundbreaking technologies that will shape the next 20 to 30 years of aviation.

This enthusiasm and innovative strength are essential if we are to pave the way to climate-neutral aviation. At MTU, we firmly believe that climate-neutral flying is feasible—but it will be a challenge. This makes it all the more important for us in the aviation industry to join forces and for everyone to do their part in the pursuit of innovations and new technologies. For us to achieve this goal together, we need revolutionary approaches in all areas.

The EU's Clean Aviation project, launched in 2021, plays a key role in these efforts. Its focus is on novel concepts that promise a quantum leap in climate neutrality. Today, every aircraft is powered by kerosene, but the future will widen the options considerably. For smaller aircraft of up to 20 seats, we envision battery-electric propulsion, and for short- and medium-haul routes, we at MTU are developing a propulsion system called the Flying Fuel Cell™ (FFC). This year, we systematically expanded our expertise in powertrain electrification by acquiring eMoSys GmbH, an electric motor manufacturer based in Starnberg, Germany.

Another area where MTU is active is the gas-turbine-based Water-Enhanced Turbofan (WET) propulsion concept; developed by MTU, it can be used in all thrust and power classes. Together with international partners, we want to explore the potential of the WET concept in the SWITCH project, which is supported by Clean Aviation.

In this issue of **AERO**REPORT, we explain Clean Aviation's plan in detail and take a look at the skies of the future. Dr. Kay Plötner, an urban air mobility expert from the think tank Bauhaus Luftfahrt, analyzes the opportunities and challenges of using air taxis sustainably, especially electric vertical takeoff and landing aircraft. We're also looking at developments in sustainable cargo airships, where more and more players are entering the market with different approaches. In addition, we again offer you an exciting look behind the scenes at MTU, including how the company electroplates engine components.

I hope you enjoy reading this issue!

Yours,

Silke Maurer
Member of the Executive Board, Chief Operating Officer

COVER STORY

Launch of a new era

The EU's Clean Aviation research program aims to drive forward pioneering technologies for the future of air travel. However, it faces a wide range of challenges.

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INNOVATION

All the way to the stratosphere with solar energy

To reach atmospheric layers that lie beyond commercial airspace, researchers are developing remote-controlled ultralight aircraft with an enormous wingspan: high-altitude platforms.

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INNOVATION

X-planes: Portal to the future

Each of the 72 X-plane projects NASA has carried out since 1946 has brought forth innovations that have expanded the frontiers of aerospace. Many of those concepts can be found in today's commercial and military jets and space systems.

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AVIATION

Flying freight to the ends of the earth

Life in Alaska and elsewhere in the Arctic is harsh. Cargo planes are often the only lifeline for residents of remote villages. Food, building materials, online orders – everything is delivered by air.

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AVIATION

It flies and flies and flies

This year, the IAE consortium is celebrating its 40th anniversary—and its V2500 engine is one of the most successful engine programs in the history of commercial aviation. But it is only really halfway through its service life.

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GOOD TO KNOW

Return of the giant flying cigars

First came the zeppelin, then the idea for the CargoLifter. Now Airlander, Pathfinder, and Flying Whales are launching the renaissance of sustainable airships. They want these to be the go-to solution for logistics and humanitarian aid.

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GOOD TO KNOW

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Subscribe to the AEROREPORT Newsletter. Our monthly e-mail newsletter keeps you informed about topics in the world of aviation.

A successful year for MTU Maintenance

Typical shop visits, component repairs, or services directly under the wing: MTU Maintenance is consistently expanding its global network of expertise and specialized sites. This year was full of milestones to celebrate.

SHOP VISITS

4,000

Propulsion for the A320neo ___ *With 35,000 pounds of thrust, the LEAP-1A engine gets the narrowbody airborne.*

MTU Maintenance Zhuhai completed maintenance on its 4,000th engine. A LEAP-1A engine was successfully serviced and delivered to Peach Aviation Ltd., an All Nippon Airways subsidiary. The site serves more than 90 customers worldwide, maintaining engine types such as the CFM56, LEAP, PW1100G-JM, and V2500. A second site in Zhuhai is scheduled to open in 2025. In addition, an engine test stand with 65,000 pounds of thrust was inaugurated in the summer and a training center opened in September—the site thus celebrated three milestones this year.

1,500

This year, **MTU Maintenance Berlin-Brandenburg** celebrated the 1,500th shop visit of the CF34 family. The extension of the GE Branded Service Agreement to 2037 ensures that the company will continue to play an important role in the CF34 arena.

More than 140 million flight hours ___ *Worldwide, the CF34 family is the most widely used engine family in its class.*

10,000

One of the largest commercial engines ___ *The fan blades of the GE90 measure 1.25 meters.*

MTU Maintenance Hannover celebrated its 10,000th shop visit this year. It reached this milestone with a GE90-110/115B engine, which was delivered to DHL Network Operations Ltd. This engine powers the Boeing 777 and is one of the world's most powerful engines. The Hannover site is the heart of MTU Maintenance and the most experienced site in the network.

ENGINES

A new member of the family

This year, the third member of the Pratt & Whitney GTF™ engine family—the PW1900G—joined EME Aero, a 50/50 joint venture between MTU Aero Engines and Lufthansa Technik. The PW1900G powers the second generation of the Embraer E-Jet regional jet and will from now on be maintained in the EME shop. EME Aero is thus expanding its portfolio to include a third GTF engine type: it has maintained the PW1100G-JM since opening its doors in 2020 and the PW1500G since 2021 in Jasionka, Poland.

First on-wing project

The MTU Maintenance Service Centre Australia in Perth has successfully completed its first on-wing project. In Adelaide, three engine experts replaced the main seal of two CF34-10E engines. This innovative on-wing replacement method, originally developed by MTU engineers in 2020, has surmounted previous limitations. Seal replacement used to require cost-intensive engine disassembly. Experts from MTU Maintenance Berlin-Brandenburg and MTU Maintenance Dallas supported the team.

ANNIVERSARIES

10 years of Maintenance Lease Services

It's been ten years since MTU Maintenance ventured into the leasing and asset management business. In 2013, MTU Maintenance Lease Services B.V. started as a joint venture between MTU Aero Engines and Sumitomo Corp. with just three employees and a handful of engines. Since 2021, the company has been a full MTU subsidiary and now has a leasing pool of more than 100 engines as well as offices in Dublin and Singapore. MTU Maintenance Lease Services supports owners, lessors, and operators throughout an engine's entire lifecycle.

ANNIVERSARIES

25 years of MTU Maintenance Canada

MTU Maintenance Canada turns 25 this year. Since day one, the site has successfully met the challenges of the industrialization of the V2500 and CF6-80 engine programs and is MTU Maintenance's military expert. Today, it looks after the F138 and F108 engine fleet. What's more, it is MTU's center of competence for line replaceable units (LRUs) and accessories, managing more than 12,000 accessories per year. On top of that, the site also opened a training center this year.

ANNIVERSARIES

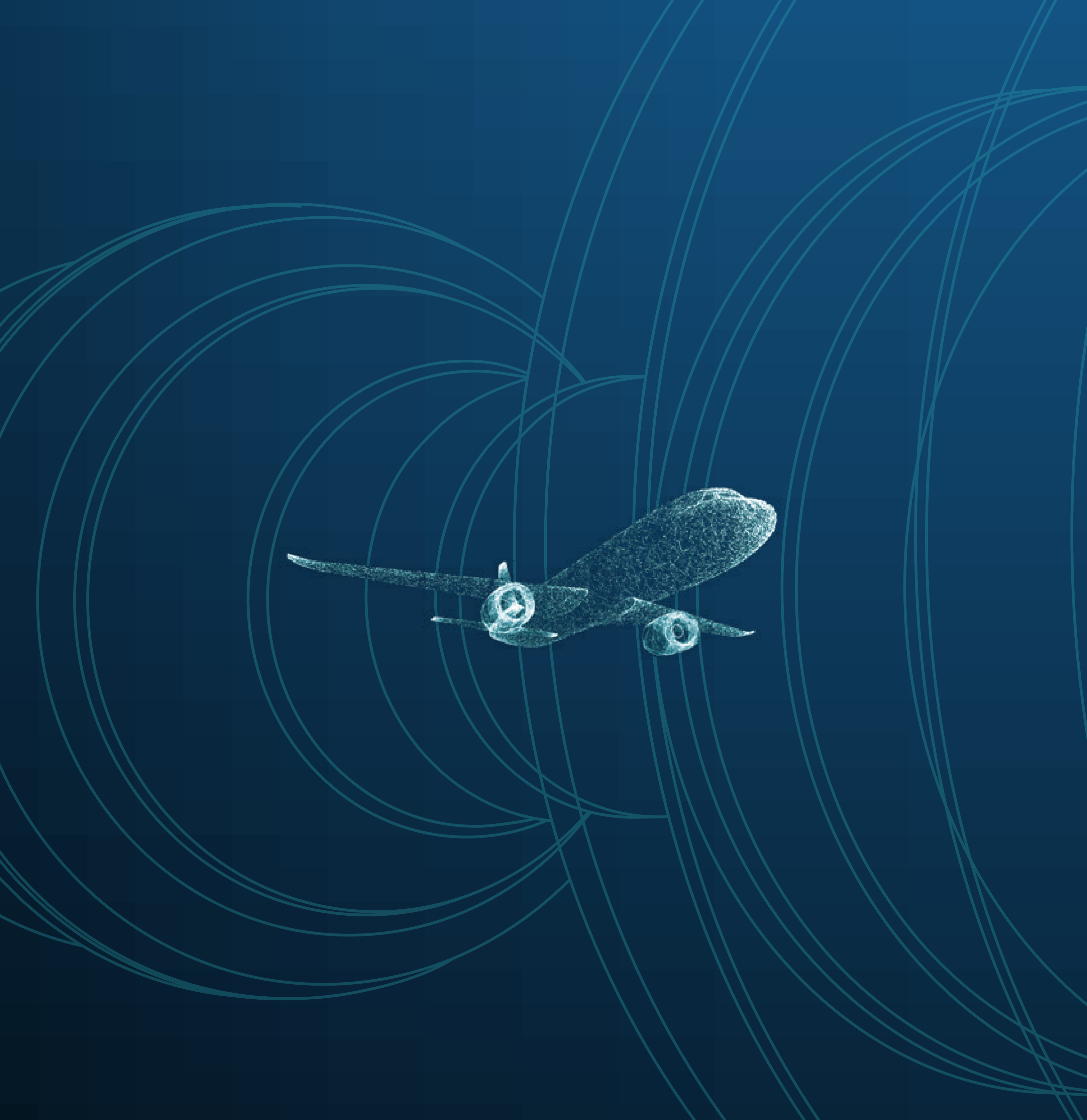
20 years of ASSB

Airfoil Services Sdn. Bhd. (ASSB for short), the joint venture between MTU Aero Engines and Lufthansa Technik, turns 20 this year. The company is MTU's center of excellence for engine profile repairs in Malaysia.

A successful joint venture ___ *The site specializes in repairing blades for high-pressure compressors and low-pressure turbines.*

Groundbreaking ceremony for expansion ___ *After expanding in 2020, the site can now repair 900,000 parts a year.*

Since 2003, ASSB has maintained some 7,000,000 components for various engines, including the CFM56 family, the V2500, the CF6, and the GP7000. Recently, the company added Pratt & Whitney's PW1100G-JM to its portfolio and is expanding its capacity to meet the requirements of future engine generations.



F U T

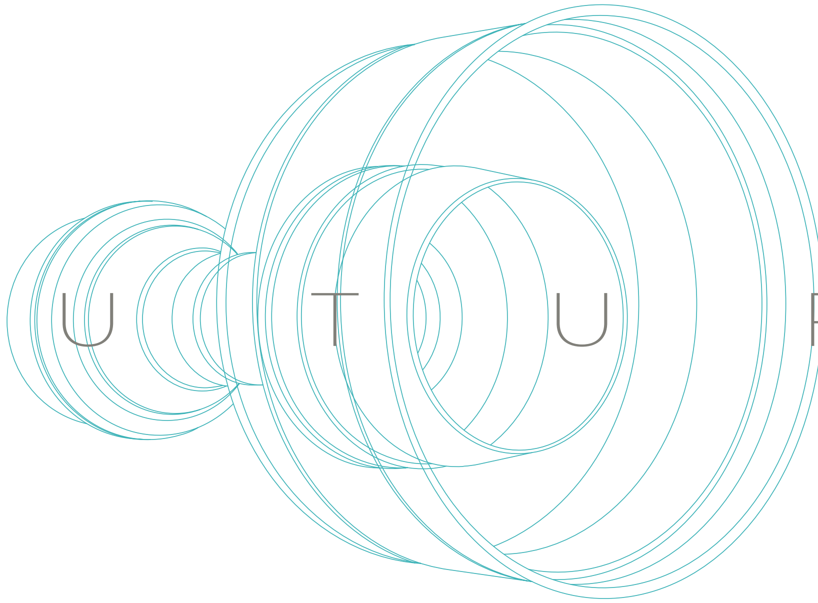
Launch of a new era

Achieving climate-neutral air travel by 2050 would mean we can continue to fly with a clear conscience. Researchers are working hard to make this happen.

Text: *Patrick Hoeveler*

U R E

FUTURE



CLEAN AVIATION

Disruptive new technologies ___ *The Clean Aviation Joint Undertaking is the European Union's leading research and innovation program for transforming aviation toward a sustainable and climate-neutral future. It will develop disruptive new aircraft technologies to support the European Green Deal, and climate neutrality by 2050. These technologies will deliver net greenhouse gas reductions of no less than 30 percent, compared to the 2020 state of the art. The program is built on three main pillars, each with demonstration efforts driving the energy efficiency and the emissions reduction. Clean Aviation is to receive EUR 1.7 billion in funding. It is embedded in the EU's Horizon Europe framework program.*

SWITCH
A Clean Aviation Project

Emissions-free flight in sight ___ *SWITCH (Sustainable Water-Injecting Turbofan Comprising Hybrid-Electrics) is a project to advance hybrid-electric and Water-Enhanced Turbofan (WET) technologies. The project focuses on combining two revolutionary technologies: MTU's WET concept, and hybrid-electric propulsion system components. The SWITCH concept aims to significantly enhance efficiency and substantially reduce emissions across the full operating envelope of an aircraft. These new technologies are also suitable for operation with sustainable aviation fuels (SAF). The future use of hydrogen as an energy source continues to be evaluated.*

With refueling complete, the crew of the narrowbody jet can start preparing for takeoff. At the same time, a turboprop airliner lands and taxis to its place on the apron without any of the typical noise. This is because it's powered by fuel-cell electric motors. Welcome to life at a commercial airport in the year 2050—a place completely devoid of climate-damaging emissions. According to the European Union, this vision could become reality within just a few decades: the EU Green Deal aims to achieve zero net greenhouse gas emissions by 2050 and thus make Europe the first climate-neutral continent.

"This is the most ambitious legislation ever passed to enshrine climate neutrality, which makes the European Commission and the European Union pioneers," says Gunnar Klaus, Representative for International Technology Collaborations and Demonstrator Programs at MTU Aero Engines. But although achieving these ambitious targets is still a fair way off, in the aviation sector, the EU's Clean Aviation research program ought to significantly speed up developments. Established in 2021, this joint undertaking brings together 27 founding members and additional partners from industry, academia, and research and is being funded by the EU to the tune of EUR 1.7 billion.

Launched in 2021, the project's main objective is to deliver technologies that will enable aircraft to be launched from 2035 with net greenhouse gas emissions more than 30 percent lower than those of the latest generation of state-of-the-art aircraft from 2020. In contrast to its predecessor program, Clean Sky 2, which centered around advancing evolutionary technologies, Clean Aviation focuses on novel concepts that promise a quantum leap in climate neutrality.

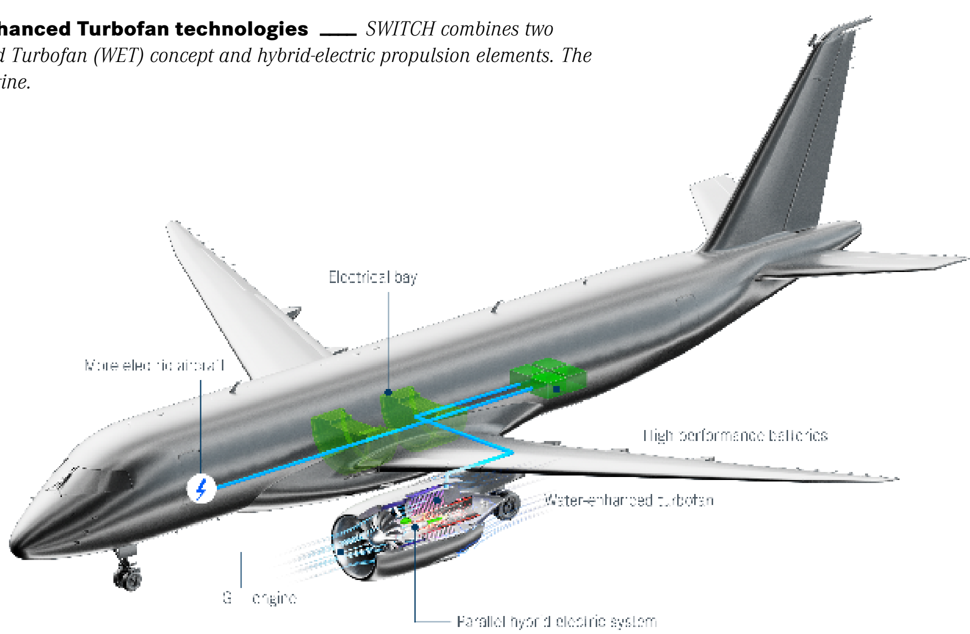
Three pillars for green flying

In its strategic research and innovation agenda (SRIA), the Clean Aviation Joint Undertaking has defined its three main pillars: The first focuses on regional aircraft powered either by hybrid or fully electric propulsion systems. The second concerns the designs for most efficient narrowbody aircraft with up to 200 seats. Here, combining innovative design with extremely energy-efficient and highly integrated engines is expected to lead to drastic reductions in fuel consumption at the overall system level. The third covers disruptive technologies, which are chiefly concerned with tapping the potential of using liquid hydrogen as a fuel to power future aircraft. “This is clearly heading in the direction of zero-emission propulsion systems,” Klaus explains. “Some of the technologies we’re dealing with as part of Clean Aviation were originally intended to be addressed through our Technology Roadmap for 2040 or in subsequent years.” However, the European Commission wants to bring these pioneering technologies forward by at least a decade so that they can be tested and rolled out as soon as possible.

MTU is involved in two of these three pillars. It leads a consortium overseeing the Sustainable Water-Injecting Turbofan Comprising Hybrid-Electrics (SWITCH) project, which is attached to the second pillar and is about combining tried-and-true technologies with new approaches. This work is based on the GTF™ engine as well as on the insights gained during Clean Sky 2 that were channeled into optimizing the compressor and the turbine. The GTF is receiving not one but two upgrades. First, MTU’s Water-Enhanced Turbofan (WET) concept allows for residual heat from the engine’s exhaust gas stream to be used to significantly reduce fuel consumption, CO_2 and NO_X emissions, and the formation of contrails. Second, the consortium partners are developing a hybrid-electric version of the engine, which will be more efficient.

“We think that this concept, in combination with a sufficiently optimized airframe, has the potential to achieve the desired fuel savings of 30 percent. Moreover, it will let us make a noticeable reduction in climate impact,” Klaus says. Christoph Niebling, Program Director for Clean Aviation / SWITCH at MTU, adds: “There’s no doubt that these technologies are disruptive. We estimate that pursuing the evolutionary development of the previous generations of our products would yield maximum fuel savings of 10 percent.” Integrating WET and hybrid-electric technology into a propulsion concept is a great deal more complicated, he says. “Timing is the major challenge. Clean Aviation is determined to demonstrate technological maturity by 2030 so that new products can be brought to market starting in 2035. That’s a tall order because we’re still working with a basic version of this technology. But that means it has all the more potential.”

Hybrid-electric and Water-Enhanced Turbofan technologies ___ *SWITCH combines two technologies: MTU’s Water-Enhanced Turbofan (WET) concept and hybrid-electric propulsion elements. The basis is Pratt & Whitney’s GTF^{TM} engine.*



Flying Fuel Cell™ (FFC) *In the FFC, hydrogen and oxygen react to form water, thereby releasing electrical energy.*

Regional aircraft featuring fuel cells

As regards the third Clean Aviation pillar, MTU is focusing on the use of a fuel cell as part of the electric propulsion system for regional aircraft with 50 to 70 seats. These efforts are benefiting from a joint project between the German Aerospace Center (DLR) and MTU that aims to test such a system on a Dornier 228 during flight. As part of the Clean Aviation program, the Hydrogen-Electric Zero Emission Propulsion System (HEROPS) project is attempting to prove that the 600 kW system intended for the Flying Fuel Cell™ (FFC) can also be scaled up for an application in the multi-megawatt range. "Although the Dornier 228 test is running entirely separately, the groundwork being done for that project will surely provide valuable insights for system and line development for HEROPS. It'll then be possible to scale up the propulsion system," Klaus explains.

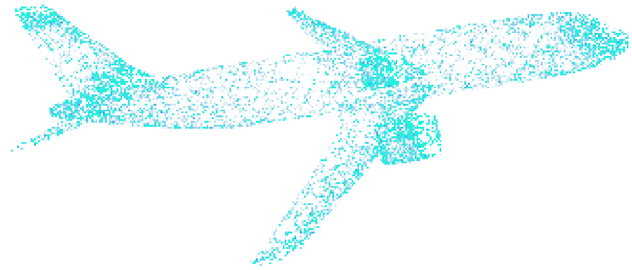
The timelines for HEROPS and SWITCH are running virtually in parallel. Phase 1 of Clean Aviation—technology development—will run until 2025 and conclude with an assessment by the review board, which will select the most promising technologies. These will proceed into Phase 2—demonstration—ideally with a view to testing overall systems by 2030. "Progress hinges on proving that the technologies developed have reached maturity and have a chance of being implemented," Klaus says.

"Clean Aviation is also in good company internationally," Klaus adds. On the other side of the Atlantic, the U.S. aviation industry continues to search for ways to make air travel more climate-friendly, including through the Continuous Lower Energy, Emissions, and Noise (CLEEN) program, which was launched by the Federal Aviation Administration (FAA) in 2010. The U.S. government funded the first two phases of CLEEN with USD 225 million over ten years. Preparations are currently underway for the fourth phase, which is scheduled to begin in 2025 and will also focus heavily on product applications.

Global challenges

Not all the global challenges, however, are related to technology. After all, demand for air travel is not going down. In fact, quite the opposite is true: "It's conceivable that by 2050, the volume of air traffic will be three times what it is today," says Dr. Florian Linke, Deputy Director of the Institute of Air Transport at DLR. What's more, new technologies will require extensive new infrastructure. Hydrogen alone would require entirely new tank systems, as it must be cooled to around minus 250 degrees Celsius. "Right now, everywhere is set up for kerosene, but this hydrogen infrastructure would have to be installed at every airport from scratch. Besides, air travel is a global phenomenon. Even if airports here in Germany had the required infrastructure, destination airports in other countries would also need it to allow aircraft to refuel for the return journey. This means that for the whole thing to work, the rollout would have to be global," Linke says.

In addition, the hydrogen used would have to be produced in a sustainable way. Aviation would be competing with other players in the transport sector and with industry. Linke also highlights the non-CO_2 effects of aviation, like other emissions and the formation of contrails: "Burning hydrogen doesn't produce carbon dioxide, but rather water vapor and—depending on the combustor—also nitrogen oxide emissions. As a fuel, hydrogen is carbon neutral, but it doesn't count as climate neutral unless this water vapor is released somewhere other than the lower stratosphere, and the nitrogen oxide emissions are reduced to



"Burning hydrogen doesn't produce carbon dioxide, but rather water vapor and—depending on the combustor—also nitrogen oxide emissions. As a fuel, hydrogen is carbon neutral, but it doesn't count as climate-neutral unless this water vapor is released somewhere other than the lower stratosphere, and the nitrogen oxide emissions are reduced to zero."

Dr. Florian Linke, *Deputy Director of the Institute of Air Transport at DLR*

zero. And the hydrogen must of course be produced using green electricity." This last point is an essential part of the future of aviation.

New aircraft in the skies

Electric unmanned air systems (UASs) also offer a vast array of potential applications—they are intended to ease congestion on the roads in the future. These range from the express transport of essentials like banked blood and medications to deliveries of packages and food. According to Linke, even if these new players become popular very quickly, they are unlikely to pose a threat to traditional air travel: "There's a great push to integrate these vehicles into our airspace, and progress is being made. The question is whether there's really a market for all the use cases currently under discussion." In the case of air taxis, for instance, a special infrastructure will have to be created. The push for UASs is also linked to higher energy expenditure, which might call into question their positive effect on the climate. Then there are the industry's high safety and security standards, which must be met during piloted and automated operations alike. "There's still research to be done in these areas, which means that integration into airspace is really the lesser problem."

So there's plenty to do, and although the aviation industry faces a massive number of challenges, Linke thinks there's not one that can't be solved. After all, thanks to Clean Aviation and others, a quarter of a century from now air travel could well look completely different. Indeed, the industry is no stranger to rapid developments: back in 1927, when Charles Lindbergh made his spectacular solo flight across the Atlantic, who would have thought that just 25 years later, jets would be regularly transporting thousands of passengers across the pond—and in a fraction of the time?

MORE INFORMATION ON THE TOPIC:

A brief guide: How the Flying Fuel Cell™ works
www.aeroreport.de/en

A brief guide: How the WET concept works
www.aeroreport.de/en

ABOUT THE AUTHOR:

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

All the way to the stratosphere with solar energy

German Aerospace Center (DLR) —— *DLR is Germany's research center for aeronautics and space. Its 55 institutes and facilities conduct research and development activities in the fields of aeronautics, space, energy, transport, security, and digitalization.*

One day, ultralight aircraft with an enormous wingspan are set to document changes on the Earth's surface and improve telecommunications.

Text: *Monika Weiner*

To test the 27 meters of wing (roughly the wingspan of an Airbus A320), the team at the German Aerospace Center (DLR) needs a lot of space. That is why the bending tests for this lightweight construction take place in the massive hangar at the DLR site in Stade, Germany. A specially designed structure allows the engineers to lift the 35-kilogram wing several meters into the air and simulate the forces that occur in flight.

In real life, the wings are pushed upward during gliding. Since these upward forces are difficult to simulate on the ground, the wing is mounted on the structure with the top facing down and weights are applied for the bending test. That way, the downward gravitational force simulates the uplift forces, pulling the wing tips down roughly two meters toward the ground. The engineers use a laser to determine the exact distance before checking for microcracks potentially caused by the load. In the air, such cracks would have disastrous consequences.

Two years from now, this wing is set to lift DLR's first high-altitude platform (HAP) into the air. At first glance, the design team's construction sketch is reminiscent of a glider. That's no accident—after all, the HAP is designed to be an extremely energy-efficient super glider capable of generating lift even at an altitude of 20 kilometers. The HAP is powered by two electric motors with a peak power of 2.5 kilowatts each. Solar cells on the wing's upper surface supply the necessary electricity.

"Only through advances in solar and battery technology has it become possible to design solar-electric aircraft capable of generating and storing enough energy to reach very high layers of the atmosphere and stay up there for several days and nights," explains Florian Nikodem, head of the HAP-alpha project at DLR.

Helios prototype — *Developed by NASA, the solar-powered HAP achieved the world record for maximum altitude in 2001, when it stayed at 29,413 meters in the air for 40 minutes.*

Wingspan of a narrowbody — *Its enormous dimensions become clear once the construction team stands underneath. The lightweight wing is 27 meters long–roughly the wingspan of an Airbus A320.*

“The stratosphere, which begins at an altitude of roughly 18 kilometers, beyond commercial airspace, is peculiar in a number of ways: There are no clouds, no weather. The air tends to be calm, clear, and thin. These are ideal conditions for observing the Earth. At the same time, building a high-altitude platform that can fly this high and return safely to the ground poses an enormous technological challenge.”

High stability is the way forward

Before HAP-alpha can take off, it has to undergo a series of tests. The bending test carried out at DLR in Stade is just one of them. A ground vibration test for the entire aircraft is scheduled for next year. The engineers want to use these measurements to back up the analytical models on which the design is based.

Strong squalls, or even storms, pose the biggest threat to HAP-alpha: the ultralight aircraft is supposed to weigh only 136 kilograms. The platform is primarily designed to soar through the stratosphere’s thin air, where turbulence is rare. “What’s dangerous, however, is the flight to get there and back down to Earth,” Nikodem says. “Ascent and descent take many hours, during which the platform is exposed to the elements. Although we consult all available forecasts and fly only in ideal conditions, we have to expect the weather to suddenly change during the flight.” That is why a stable design is critical for a successful mission.

Ever longer, ever higher: The race of the stratosphere gliders

High-altitude platforms have entered the stratosphere over a dozen times, with Airbus holding the record for the longest successful mission: the flight of the Zephyr S lasted 26 days. The unmanned solar-electric aircraft took off in Arizona on August 6, 2018, and safely returned to Earth after completing its mission. While one of its successor models, the Zephyr 8, broke this record–the platform cruised through the stratosphere for a full 64 days–it ended up crashing. The world record for the highest altitude was set by NASA’s solar-powered HAP, Helios, in 2001. Fitted with solar cells and 14 electric motors, this 580-kilogram giant ascended to an altitude of 29,413 meters.

The race for ever longer and ever higher flights is fueled by the vision of one day revolutionizing Earth observation with a network of high-altitude platforms. At present, geodesists, glaciologists, climate scientists, and disaster management officers rely on aircraft- and satellite-aided measurements to help them look for leaks in pipelines or determine things like the movement of weather fronts or forest fires, the thickness of the ice on waterways, the pace at which glaciers calve, changes in the air quality in particular regions of the planet, and the migration routes of herds of animals.

But observation time is limited. Aircraft can circle above a given place for no more than a couple of hours, and most satellites used in remote sensing aren’t geostationary, meaning they move relative to the Earth so the time they can keep their focus on any particular place is limited. This makes it difficult to obtain detailed long-term measurements. Unmanned solar-electric aircraft could fill this gap: they can circle above the same region for days or even weeks, collect data, and send it back to Earth.

For telecommunications, too, high-altitude platforms open up new possibilities. Flying at enormous altitudes allows HAPs to establish radio contact across large areas. NASA’s Sunglider, a solar aircraft that is powered by ten electric motors and resembles a gigantic wing, can cover an area of 200 square kilometers, for instance. This makes HAPs a compelling alternative to satellite-aided telecommunications.

Flying high for science

Various research and industrial companies have developed a whole range of HAPs. “But we don’t see them as competitors,” Nikodem says. “Our goal is to generate knowledge. It’s our job as a German research institution to support industry. That’s why we’re focusing on setting up a testing platform to help DLR as well as companies develop and test new technologies such as new propulsion technologies, sensors, measurement electronics, and telecommunications.”

Much research and development work still needs to go into DLR’s HAP mission. Materials have to be found that are ultralight yet stable, such as carbon-fiber-reinforced polymers, for example for the ribs and longerons, or highly UV-resistant films for covering the wings. What’s more, to be able to ascend to an altitude of 20 kilometers and stay in the air for several days requires extremely powerful batteries. These have to not only supply sufficient power for takeoff, but also store enough energy during sunshine hours when light hits the solar cells so as to make it possible for the aircraft to fly at night. Due to the extreme temperature fluctuations in the stratosphere, the batteries also require good insulation. Temperatures of up to 50 degrees Celsius in the aircraft during sunshine hours may cause overheating, while at night, ambient temperatures as low as minus 90 degrees Celsius could spell death from freezing.

The integration into a complete aircraft will commence in 2024. After that, HAP-alpha will take off for its maiden flight from the DLR testing ground in Cochstedt, Germany. Since the aircraft will be equipped only with skids rather than an undercarriage, the engineers plan to get it up to takeoff speed by pulling it with a towing vehicle with a specially designed trailer. HAP-alpha will be operated from the ground station by an experienced pilot using radio commands. The plan is for this first flight to ascend no higher than 500 meters. For landing, the propellers have to be stopped and tilted sideways. This marks an especially critical juncture, because from that moment on, the pilot can no longer do a go-around. “Our goal is not to break records but to collect data and test the technology,” Nikodem says. The team wants to evaluate and use the information recorded by a flight recorder between takeoff and landing for fine-tuning purposes.

More test flights are planned for the following years, before HAP-alpha flies to the stratosphere for the first time in 2027. For that flight, the platform will be fitted with additional solar cells: while the prototype is equipped with only one square meter of photovoltaics, the “second expansion stage” will have 12 square meters of gallium arsenide cells on its wings. The electricity these generate will enable the platform to transport a load of five kilograms to an altitude of 20 kilometers. “That doesn’t sound like much, but it’s enough to accommodate a miniaturized radar or a high-resolution camera system on board. Both systems are also being developed as part of the project,” Nikodem says. “For future industry partners, this project presents a unique opportunity to test sensors and technologies for Earth observation and telecommunications in real conditions.”

Long-term record of the Airbus model — *To date, Zephyr is the only fixed-wing HAP that has been shown to survive day and night in the stratosphere. Its record is 64 days.*

ABOUT THE AUTHOR:

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.

The latest X-plane project — *As part of its sustainable flight demonstration program, NASA selected Boeing's Transonic Truss-Braced Wing (TTBW) concept.*

X-planes: Portal to the future

NASA began its landmark X-plane series with the X-1, which in 1947 became the first supersonic aircraft. More than 70 years later, the new X-66A experimental jet is being hailed as the future of commercial flight.

Text: *Andreas Spaeth*

X-2 (maiden flight 1952)

The Bell X-2 was a rocket-powered aircraft that, like its predecessor, the X-1, was drop-launched into its cruising altitude from a Boeing B-50 bomber. Its mission was to push the supersonic flight envelope. On September 27, 1956, X-2 test pilot Mel Abt became the first person to travel at three times the speed of sound, recording Mach 3.2 (3,370 km/h). Shortly afterwards, the aircraft lost control and crashed. Abt did not survive.

The X-1 was the first aircraft to break the sound barrier and the X-5 the first to fly with variable-sweep wings. The X-15 achieved higher and higher altitudes of over 100,000 meters and still holds the record for the fastest manned flight: Mach 6.7 (7,274 km/h) in 1967. Other aircraft in this series were used to test exotic alloys or unconventional aerodynamics and propulsion concepts.

All of these pioneering aircraft were what are known as X-planes. For many in the industry, this moniker for NASA's experimental aircraft and test vehicles has somewhat magical connotations, immediately conjuring up memories of past glories. Back in 1946, right after the Second World War, with the United States yet to launch its National Aeronautics and Space Administration (NASA), two type XS-1 (later renamed X-1) experimental aircraft performed test flights over Muroc Army Airfield (now Edwards Air Force Base) in California.

Chuck Yeager paved the way for U.S. dominance in this field

This was the site of acts of pioneering aviation that aimed to break new ground, coordinated by NASA's predecessor NACA (National Advisory Committee for Aeronautics). The first of these took place on October 14, 1947, when test pilot Chuck Yeager and the rocket-powered X-1 broke the sound barrier for the first time. Over the following decades, what began with the X-1 would develop into a highly illustrious hall of fame featuring 72 X-planes to date—although many of these weren't in fact planes at all, and some never even made it off the ground.

The research engineering used in the X-1 program is still firmly embedded in the DNA of all X plane projects. The techniques and the personnel employed back then paved the way for the U.S. space program of the 1960s. But it was in the 1940s that the U.S. launched a program for experimental aircraft, set up by NACA in collaboration with the U.S. Air Force and the U.S. Navy, and later coordinated by NASA. Today, it's the U.S. Air Force that has the privilege of awarding the coveted X-plane designation to research projects, even commercial ones. The U.S. Department of Defense has established stringent criteria for doing so. What's more, not all aircraft with a name beginning with an X are in fact X-planes: the North American XB-70 Valkyrie, the famous experimental supersonic bomber of the 1960s, was not a member of the club.

Some X-planes don't make it as far as their maiden flight

X-planes have much in common: typically, their mission is to test concepts and technologies that can then be transferred to other aircraft designs. However, they are not prototypes for production aircraft, and the projects are not always a success. Some X-planes don't even make it off the ground. One example is the X-57 Maxwell, the proposed electric test aircraft, which was awarded X-plane status in 2016 and scheduled to have its maiden flight in 2023. But the program has now been cancelled due to safety concerns that couldn't be resolved within the given time frame and budget.

"Not making it to flight is not a great feeling," says Bradley Flick, Center Director at NASA's Armstrong Flight Research Center. "But despite this letdown, the project has given the industry some fundamental insights into electric flight." Safety is a major issue when it comes to X-planes, as they tend to operate at the limits of what is possible, which can lead to accidents. Since the program began in 1946, there have been 15 serious incidents and four pilots have lost their lives. Despite these tragedies and the cancellation of the X-57, optimism has returned in the shape of two very ambitious X-plane projects that are currently underway.

The mission for the X-59: To show that supersonic flight can be quiet

The maiden flight of the Lockheed Martin X-59 QueSST (Quiet Supersonic Transport) is scheduled for 2024. Measuring 29 meters in length, this single-seater's elongated flat front section, similar to the nose of an ant eater, gives it a somewhat unusual appearance. Flying at Mach 1.42 at a maximum altitude of 16,800 meters over a populated area, the X-59 has a single purpose: to test whether this new aircraft design is sufficient to reduce the noise of the sonic boom to no louder than a car door slamming. This could make it possible for supersonic flights to pass over land, which is not permitted today.

X-1 (maiden flight 1946) ___ *Both the first and most famous X-plane was the Bell X-1, which was the first aircraft to break the sound barrier, piloted by Chuck Yeager, on October 14, 1947. By 1955, a total of seven X-1 variants had been built, each one setting new altitude and speed records. On December 12, 1953, Yeager achieved Mach 2.44 (3,012 km/h) at an altitude of almost 23 kilometers.*

X-43A (maiden flight 2001 – failed) ___ *NASA's X-43A Hypersonic Experimental Vehicle, or "Hyper-X," was developed to flight test a dual-mode, integrated scramjet propulsion system at speeds from Mach 7 up to Mach 10. Unlike rockets, which must carry both their fuel and oxidizer, scramjets carry only fuel; they take oxygen from the atmosphere. The first flight attempt of the X-43A was in June of 2001. But, the booster failed and had to be destroyed early in flight. As a result, the research vehicle was not tested because it never reached test conditions.*

X-3 Stiletto (maiden flight 1952) ___

The Douglas X-3 was surely the sleekest X-plane ever built, with a shape like a dagger. Its mission was to test a design that prolonged supersonic flight. The X-3 was the first in the series to have fuselage sections built largely out of titanium. But the aircraft disappointed its creators: it was so lacking in power that it didn't manage to break the sound barrier even once.

X-5 (maiden flight 1951)
The Bell X-5 was the first aircraft to feature variable-sweep wings, which were able to adjust their shape to meet a variety of speed requirements. The concept can be traced back to a Messerschmitt design Germany abandoned during the Second World War. Although the X-5 suffered from stabilization issues, it was instrumental in validating the variable-sweep wing concept that was later added to many fighter jets.

X-15 (maiden flight 1959)
The North American X-15 was a rocket-powered hypersonic aircraft that broke altitude and speed records in the 1960s. On its 199 test flights, several pilots reached altitudes of over 80 kilometers and several more broke the 100 kilometer mark to reach outer space—technically making them astronauts. On October 3, 1967, William Knight took the X-15 to Mach 6.7 (7,274 km/h), which remains the record for the fastest manned flight to this day. The X-15 was drop-launched into its cruising altitude from the wing of a B-52 bomber.

X-29 (maiden flight 1984)
The Grumman X-29 was a groundbreaking aerodynamics concept based on forward-swept wings and canard wings at the front of the fuselage. Made partly out of composite materials, the X-29 featured a computerized fly-by-wire control system to manage its aerodynamic instability. But its engineers' hopes that their design would achieve increased agility and a noticeable reduction in air resistance were dashed.

1997 *A collection of NASA's research aircraft on the ramp at the Dryden Flight Research Center in July 1997: X-31, F-15 ACTIVE, SR-71, F-106, F-16XL Ship #2, X-38, Radio Controlled Mothership, and X-36.*

The X-66A, the most recent X-plane project, gained that status only in June 2023. Hopes are high that it will revolutionize the development of future commercial aircraft. As part of its program of sustainable flight demonstrators, NASA selected Boeing's Transonic Truss-Braced Wing (TTBW) concept. Boeing's Chief Technology Officer Todd Citron was thrilled: "We're incredibly proud of this designation because it means that the X-66A is the latest in a long line of experimental aircraft used to validate groundbreaking designs that have changed the course of aviation." The X-66A is unlike the other X-planes of the past 80 or so years in that it is to serve as the basis for the next generation of commercial aircraft, with business expectations riding on the outcome of the tests. Success would only add to the X-plane legend.

MORE INFORMATION ON THE TOPIC "AVIATION":

Germany as pioneer: The dream of vertical takeoff
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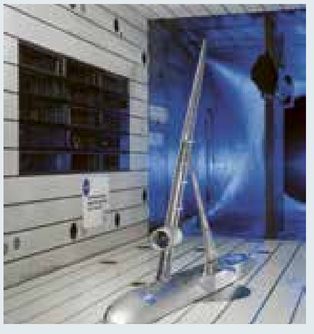
ABOUT THE AUTHOR:

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

The latest addition to the X-plane family

The largest X-plane ever built could be ready for takeoff as early as 2028 or 2029. The great hope is that it will enter production as the commercial aircraft of the future by the late 2030s. The X-66A is a heavily modified Douglas MD-90 that was once operated by Delta Air Lines. While the new design retains the cockpit and T-tail, its brand-new wings feature a high aspect ratio and are extremely long and thin, which leads to less resistance. Its wingspan is 44 meters, which is around 50 percent longer than that of a conventional commercial aircraft of similar size. To make this form structurally sound, trusses anchored in the fuselage run to the middle underside of each wing to provide lift. Since the aircraft straddles the sound barrier at transonic speeds of between Mach 0.8 and 1.2, the concept is called Transonic Truss-Based Wing (TTBW). The wing design alone is expected to shave 10 percent off fuel consumption. In combination with other aerodynamic improvements and new engine concepts, this means that the X-66A could prove up to 30 percent more efficient than today's conventional jets.

Initially, the X-66A, which will carry 154 passengers in a two-class cabin, will be powered by two Pratt & Whitney GTF™ engines.. This is the first time since the Boeing 757 that Pratt & Whitney engines have been used on a Boeing standard fuselage aircraft.



Wide bird — *A model of the narrow, strutted wing in NASA's Ames Research Center wind tunnel. The wingspan is 44 meters in its original size, which is about 50 percent longer than a conventional commercial aircraft of comparable size.*

TTBW — *Since the aircraft is to reach transonic speeds of Mach 0.8 to Mach 1.2 around the sound barrier, the concept is called Transonic Truss-Braced Wing (TTBW).*

Hardworking acids ___ *To remove thermal coatings, used parts are often immersed in a bath of nitric acid. This image shows an EJ200 rotor suspended in the green-tinged solution.*

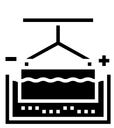
Pickling and plunge pools for engine parts

MTU has 150 baths that it uses for plating and stripping engine parts. Electroplating plays an important role in the testing and manufacturing of geometrically complex blisks.

Text: *Monika Weiner*

Wax bath — *Components that require selective plating–here, a V2500 exit case–are first immersed in a wax bath, which is kept at 95 °C.*

Platinum airfoils — *Highly heat-resistant platinum coatings protect against oxidation on, for example, high-pressure turbine airfoils.*



Electroplating — *Electroplating is the electrochemical deposition of metallic coatings on objects. The principle behind it was discovered in the 18th century by Luigi Galvani.*

Suspended two meters above a row of huge plastic tanks filled with chemicals, a gigantic, box-like steel construction glides smoothly along the rails with nothing more than a gentle hum. With a slight judder, the transport robot comes to a halt directly above a tank of nickel sulfamate. A hatch opens in the bottom of the steel box, and a rack loaded with two blisks begins its descent. Blisks—a portmanteau of blade and disk—are high-tech components where the disk and the blades are made from a single piece of material. As well as making them lighter and more stable than traditional compressor rotors, this integrated production method also makes them more aerodynamic. Due to their complex geometry, however, they are extremely complicated to manufacture.

Centimeter by centimeter, the blisks are lowered into the nickel bath. Once the rack reaches the electrode bar, it clicks into place—and the plating process can begin. An electrical current starts to flow between the anode (positive electrode) and the cathode (negative electrode), to which the blisks are connected. This causes positively charged nickel ions to migrate to the cathode, where they are deposited. “It’s this deposition process that allows us to build up a stable nickel coating on the blisks’ blade tips atom by atom,” says Michael Blümel, who is responsible for optimizing the electroplating process at MTU Aero Engines.

One-of-a-kind plating line for blisks

As the nickel atoms accumulate on the blade tips, an electric motor integrated into the rack slowly rotates the disks, keeping them constantly in motion. “Rotating the components ensures a highly uniform nickel coating. It also enables us to modify the properties of the plating by incorporating specific substances,” Blümel says. During the plating process, boron nitride particles are sprinkled onto the narrow blade tips from a container. These sharp-edged particles similar to industrial diamond find their way directly into the

“This plating line is the only one in the world that can handle complex blisk geometries with micrometer precision.”

Ali Cimen
Head of Electroplating at MTU

layer of nickel, which partially encloses them and locks them in place to form the perfect hardfacing coating.

"This plating line is the only one in the world that can handle complex blisk geometries with micrometer precision," says Ali Cimen, who heads up electroplating at MTU. "Hardfacing the blade tips is incredibly important because it ensures that the blisks can bed into the hard lining of the casing that surrounds them in the engine without being damaged. Using this kind of plating enables the design engineers to minimize the gap between the blisk and the casing, which significantly improves engine efficiency."

Technology dating back centuries

The principle behind electrochemical deposition was discovered in the 18th century by Luigi Galvani while conducting experiments on a frog. He noticed that the legs of the frog twitched when he touched them with two electrodes made of different metals connected together. However, it wasn't until the early 19th century that electroplating was first put into technical use to plate metals with gold and silver.

Nowadays, electroplating is widely used to give substrates the precise properties they need for specific applications. For example, chrome plating is used to increase surface hardness, platinum plating to promote corrosion resistance, and nickel or dispersion plating to improve wear resistance. Whatever the type of electroplating process, the metal to be deposited is connected to the anode (positive electrode) and the component to be plated is connected to the cathode (negative electrode). The greater the current and the longer the plating time, the more ions migrate to the cathode and the thicker the coating becomes. Connect a component to the anode, however, and the whole process runs in reverse: the metal atoms on the component's surface dissolve, disassociate into metal ions, and migrate through the solution, moving away from the substrate and toward the cathode. This reverse process is also used in electroplating shops, for example to reveal defects on a component's surface.

That means plating baths can be used not only to apply coatings, but also to strip them away. "It's that amazing versatility that makes electroplating so fascinating," Cimen says. "In engine construction, for example, we can use it to etch away surfaces to reveal their microstructure, and it's also a useful technique for applying anti-corrosion and anti-friction coatings as well as hardfacing."

Electroplating for quality assurance

The principles of electrochemical deposition play an important role in blisk manufacturing. As soon as the blanks have passed through the initial steps in the production process, they are immersed in an acidic solution that removes a micrometer-thick layer of metal. This process, which is known as pickling, activates the surface of the metal. The components are then immersed in an alkaline bath. This causes a blue oxide layer to form on the component's surface, making it easier to see the grain boundaries in the metal. MTU experts use this method to spot distinctive patterns in surface microstructure that might indicate weak points in the metal. Such material defects are dangerous, because they could lead to cracks forming during flight; in the worst-case scenario, they could even cause the entire disk to shatter. That's why any defective blisks are removed at the visual inspection stage.

Highly concentrated "washing liquid" — *Parts are cleaned by immersing them in an alkaline detergent solution. In some processes, this step is performed multiple times.*

Non-electric nickel plating — *In this nickel bath, components are plated without the need for an external electrical current. This method is used to apply a very thin, even plating to components like the TP400-D6 blisk seen here.*

The science and applications of electroplating

MTU's electroplating shop has some 150 different baths containing acids, alkalis, and organic solutions. As well as plating new parts, the baths are used to repair used parts whose geometry has been affected by engine vibrations, rotation, and wear.

For **chrome plating,** components are immersed in a tank containing 4,000 liters of chromic acid. This is the largest plating bath at MTU. Because chromium forms very hard coatings that are also highly temperature-resistant, it is used to restore engine parts to their original state following exposure to high temperatures and significant mechanical stress, for example in engine bearings.

Cobalt plating involves immersing components in a cobalt sulfate bath. Powdered solids can also be sprinkled onto the component during cobalt plating. By incorporating powders into the coating, it is possible to obtain the precise sliding and grinding properties required for each application. Cobalt plating is used to repair combustor casings, for example.

Nickel plating uses baths of nickel chloride and nickel sulfamate. This form of plating is used for components that suffer rapid wear and require the deposition of several millimeters of metal to regain their original dimensions. It is also possible to modify the component's sliding and grinding properties by incorporating diamond powder. The hardfacing obtained by depositing a nickel-diamond coating gives the blisk tips the best chance of properly bedding into the casing.

Platinum plating uses baths of platinum solutions. Deposited in ultra-thin layers just a few micrometers thick, these coatings provide extremely robust protection against high-temperature oxidation. Platinum plating is applied to the blades during the production of new high-pressure turbines, for example.

Only blisks that have successfully passed each and every stage of the quality assurance process—which focuses heavily on crack testing as well as microstructure testing—are returned to the plating bath for the final step of blade-tip hardfacing. To ensure the nickel-diamond coating is deposited only on the outermost tips of the blades, all the other parts of the component must be masked: “That’s no easy task when you’re dealing with such complex geometries,” Blümel says. To start with, a protective layer of paint is applied to the blades and then scraped off the areas to be plated. Experts use a scalpel and magnifying glass to expose the surface of the blade tips, a task that requires a steady hand. Finally, the disk bodies are encased in protective covers and each of the specially developed rotating racks is loaded with two blisks.

The remainder of the process is fully automatic: the transport robot picks up one rack at a time, moves along the rails to the first of the plating baths, and lowers its cargo into the solution. It takes only a few minutes for the acids to etch away a micrometer-thick layer from the tips of the blades. The rack is then immersed in another acid bath where the surface of the components is activated. Finally, the blade-tip hardfacing is applied. All in all, this process takes a few hours. Once it is completed, the transport robot picks up the rack and immerses it in a tank filled with a special solvent that removes the paint from the blades. This is followed by a final visual inspection; the blisks are then ready for final testing and acceptance.

Electroplating applications for used engine components

Plating baths are used not only to apply the final coating to new blisks, but also for repairing engine components. Over time, frequent contact with sand and dust in the air can alter the components’ shape and technical properties. However, new plating can only be applied to a component once any old coatings have been stripped off. MTU has a special installation where it removes coatings using a high-pressure water-jet system. The rotating jet of water is sprayed at the component’s surface at pressures of up to 3,500 bar. Alternatively, coatings can also be removed from used parts using chemical solutions. The surfaces must then be thoroughly cleaned, degreased, and activated before the electroplating process can start anew.

ABOUT THE AUTHOR:

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.

Thermal coatings in engines

Precision required — *To ensure that the components are coated in the right places, the areas to be protected are covered beforehand with great precision.*

More than half of all engine components are given coatings to ensure they have exactly the properties prescribed, such as wear resistance, run-in capability, or corrosion resistance. Selecting the right coating materials and techniques is an art that requires years of experience to master. This is because each component is different and requires custom solutions.

Variety of methods

Thermal spraying alone offers a vast array of options, including flame spraying, high-velocity oxygen fuel spraying, wire arc spraying, and plasma spraying. These can be applied using a variety of burners and gases. Coating materials include hard and soft metals, alloys, ceramics, and composites.

YOU CAN FIND THE FULL ARTICLE ONLINE:

Coatings in engines:
Thermal techniques

www.aeroreport.de/en

Putting the engine through its paces

Certifying and validating an engine is a rigorous process that takes years. It concerns flight safety as well as energy consumption and maintenance intervals.

Text: *Tobias Weidemann*

New business jet ___ *The Citation Ascend is designed to bring an all-new cockpit, improved performance, and a more luxurious cabin to the midsize business jet market. It will be powered by Pratt & Whitney Canada PW545D engines.*

It should come as no surprise that the aviation industry has the highest safety standards. The aircraft as well as the engines and their individual components undergo rigorous testing and inspection. Nothing's left to chance. But what exactly happens before an engine gets the green light?

If you listen to Dr. Stefan Gehring, who is in charge of type approval at MTU Aero Engines, it quickly becomes clear that this is a challenging process involving both certification through an aviation authority and validation of additional requirements. "Here, we differentiate between certification and qualification. Certification through the authority concerns only safety and airworthiness; it's a flight-safety-related proof of functionality." It serves to ensure that an engine never jeopardizes flight safety in any situation or environment throughout its lifecycle; for instance, when it comes to taking off safely under snowy or icy conditions. In addition to the independent assessment of the design itself, an extensive test program is carried out that includes demanding endurance runs, the sucking-in of foreign bodies, and operation at high temperatures or when icing occurs. After the first certification, the engine can go into operation. Subsequent enhancements and repair methods are developed based on the experience gained from operation and have to be approved for use as well.

"For us as the manufacturer and for our customers, the safety of MTU products is a top priority. But we also look at efficiency, energy consumption, maintenance intervals, and numerous technical measurements," Gehring says. Naturally, MTU strives to use less fuel and energy and therefore produce fewer emissions to make flight operations as efficient as possible. That's why the validation program encompasses a wide range of engine tests in coordination with technical departments and collaboration partners so as to learn as much as possible.

A modified engine with a number of tried-and-true components

All of this sounds theoretical at first, which is why MTU validation engineer Philipp Kreppenhofer explains the process using the PW545D as an example. This is an engine MTU is collaborating

EASA
European Union Aviation Safety Agency

EASA
European Union Aviation Safety Agency

EASA is the European Union's safety authority for civil aviation. Its headquarters are in Cologne, Germany.

Federal Aviation Administration

FAA
Federal Aviation Administration

The FAA is the United States Federal Aviation Administration. It is headquartered in Washington, D.C..

"The block test, which is always mandatory, is an endurance run that provides a lot of relevant data on the engine's service life, in particular regarding its hot section, as well as on its behavior in typical operating situations, including under extreme conditions."

Philipp Kreppenhofer
Validation Engineer at MTU

on with Pratt & Whitney Canada for the Cessna Citation Ascend. In this particular case, Pratt & Whitney Canada is in charge as Textron Aviation's engine manufacturer and contractor. Since Pratt & Whitney Canada is located near Montreal, the certification for approval is done by Transport Canada (TCCA), the department within the Government of Canada responsible for aviation safety, among other things. Usually, this certification is then adopted by the U.S. Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA) due to bilateral agreements. MTU in turn supports Pratt & Whitney in advance through comprehensive documentation of parts coming from the company.

In contrast to an initial certification, such a type extension requires only a selected engine test program. This gives MTU the opportunity to focus attention specifically on new components and to carry out particularly comprehensive and careful tests for components that have changed significantly. "The parts of the engine that have been used unchanged for years on previous models have already been certified. This applies to a large proportion of the PW545D's components," Kreppenhofer says. Because, as the name indicates, this is the D series, the fourth and, to date, most powerful variant of the PW500 series. It consumes less fuel and is more efficient than its predecessors. But although few components have changed completely from the C to the D series, the latter represents much more than just a facelift. "Changes include the turbine case and the mixer," Kreppenhofer says. "But the low-pressure turbine and the turbine exit case are identical to the C version."

Simulations — *In the future, MTU plans to use a full computer simulation known as a digital twin to test certain issues across the engine's entire lifecycle.*

An extensive process even for modifications

Although the new Cessna business jet is set to go into regular operation no earlier than 2025, the development and the certification process began much earlier. At the time of publication, the verification and validation phase has been completed with the first development tests and performance runs. The team, the OEM, and the certification authority have decided which areas to validate and how, as well as what test scenarios can be used to reliably gather the desired data. "For the tests that ran this year, we'd already adapted, instrumented, and delivered the hardware over the course of last year to ensure that everything's there on time," Kreppenhofer says.

The actual certification test—the certification endurance test, or "block test"—took place at the beginning of this year. "The block test, which is always mandatory, is an endurance run that provides a lot of relevant data on the engine's service life, in particular regarding its hot section, as well as on its behavior in typical operating situations, including under extreme conditions," Kreppenhofer explains. This test simulates numerous takeoffs and landings and alternately starts the engine up and shuts it down to simulate, as best as possible and in a very short time, the engine's consumption throughout its entire service life, especially in the hot section. The goal here is to gain the quickest possible overview of the engine's mechanical state up to its first scheduled overhaul and to demonstrate its flight safety. The test thus allows for inferences about part behavior across a wide range of loads, such as vibration excitations due to different rotor speeds, as well as about its mechanical integrity up to the first scheduled repair.

A secondary air system (SAS) test was also carried out to check the engine's air system. "This can sometimes reveal the extent to which the real pressures and temperatures measured in the test match MTU's analytical models. Verifying the computational models is an important step in product development," Kreppenhofer says. Such tests lend themselves particularly well to collecting and evaluating large amounts of thermal data. These nondestructive test scenarios allow engineers to assess very

The Cessna Citation Ascend	
4 Passenger Range	1,900 nm / 3,519 km
Maximum Cruise Speed	441 ktas / 817 km/h
Maximum Passengers	12
Full Fuel Payload	850 lb / 386 kg
Takeoff Field Length	3,660 ft / 1,116 m

Reliable business jet propulsion *MTU has held a 25 percent stake in the PW500 since 1993. The PW545D engines use new materials and technologies to improve fuel efficiency, increase thrust, and extend time on wing.*

accurately if individual components could get damaged or cause problems and are thus unfit for standard operations.

"After the validation and certification runs, we take a detailed look at the hardware to find out if it shows the expected wear and tear or anomalies or whether it needs optimizing," Kreppenhofer explains. MTU then thoroughly assesses the data and analyzes the lab results. The technical departments issue certification reports for Pratt & Whitney based on the data and results gathered. Pratt & Whitney Canada collates all relevant data to undergo certification by the TCCA certification authority, followed by the FAA and EASA.

Full engine test on-site yields important findings

The components are developed at the Munich site and at MTU Aero Engines Polska in Rzeszów. Many engineers are located in Rzeszów, where they are driving forward the further development of the PW545D, for example in project management and analytics. Conversely, many of the departments responsible for providing the development hardware are located in Munich, where the procurement, manufacturing, and instrumentation of the development-specific hardware (casings and mixers) took place. The engine was assembled and fully tested by Pratt & Whitney in Canada. As was the case with the PW545C, the rotor and stator parts supplied by MTU Aero Engines Polska are assembled later in production, while accessories such as the exit cases and mixers are provided in individual parts. The components that hadn't changed from the PW545C standard and were used for the development tests came from MTU Aero Engines Polska's existing standard production.

While this may sound like a lot of effort, there is no alternative when it comes to ensuring safety: "A full engine test yields important findings for the technical departments involved and will therefore remain important for us in its entirety. Certifying only the individual parts in Germany wouldn't provide all the relevant data; it would not satisfy the requirements for the overall engine," Gehring explains.

Yet, simulations are already being used as far as possible. In the future, MTU plans to use a full computer simulation known as a digital twin to test certain issues across the engine's entire lifecycle. With the help of increasing computing power, it will be possible to map more and more test scenarios and thus accelerate and simplify development immensely. Simulations will also be able to calculate a large number of variants much faster, enabling MTU to further optimize engines specifically for different application scenarios.

ABOUT THE AUTHOR:

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

Ends of the earth — *Without air transport, life in many remote parts of Greenland would be impossible. There's a special role for helicopters in this.*

Flying freight to the ends of the earth

There are no roads in the Arctic, so anything the people there need has to be brought in by cargo plane. Some of these aircraft will soon be 80 years old.

Text: *Andreas Spaeth*

A vast, largely deserted landscape in the northern reaches of the globe, often with extreme weather and immense distances. That's an apt description of the Arctic. Just a few figures make it clear that life here would be unthinkable without the airplane: Alaska, the 49th state of the U.S., is larger than all of Western Europe, but has a population of only 730,000. Roughly 300,000 live outside the only two major cities. Or take Greenland, the largest island in the world, where the distance from north to south is a whopping 2,670 kilometers. A full 82 percent of its land mass is covered by a permanent sheet of ice, which can be up to 3,000 meters thick; only on the west coast are there ice-free patches. The Canadian north is one and a half times the size of Greenland and measures almost ten times the land mass of Germany. There are 118,000 people scattered across the region, which has just five airports with paved runways.

Air Greenland has the only widebody jet in the Arctic

The west coast of Greenland is home to most of the country's 56,000 inhabitants, just about the same number as in the German town of Baden-Baden. Greenland has no roads, but Air Greenland flies to all 13 of the country's commercial airfields. So far, only two of them can handle jets, but starting in 2024, this will go up to five. The only airport for widebody aircraft at the moment is Kangerlussuaq. Located at the head of a fjord in

West Greenland, it opened as a U.S. military base in 1941. From here, Air Greenland operates its scheduled intercontinental service to Copenhagen; since 2023, it has been doing so with a fresh-from-the-factory Airbus A330neo—the only long-haul commercial jet stationed in the Arctic. Called Søndre Strømfjord in Danish, the hub offers access to all remote villages, often with hardly more than a good dozen inhabitants. Serving this purpose are the 47 heliports nationwide, where at least supply flights can land.

Online orders delivered to world's end

Alaska's main airport is in Anchorage and, oddly enough, is one of the world's largest cargo airports. In 2022, it ranked third globally in terms of cargo volume handled and in transit at 3.4 million metric tons, behind Hong Kong and Memphis but ahead of Shanghai. This is partly because a large proportion of goods are delivered by air to the northernmost part of the U.S., but also because of the airport's geographical location between East Asia and the U.S. East Coast. Even the latest Boeing 747-8F freighters have to make their refueling stops here, right in the middle of one of the most important goods flows in the global economy.

Every day shortly before noon, the jumbo jets line up like pearls on a string on their approach to land. A Boeing 747 freighter touches down on one of the two runways every minute, each carrying up to 120 metric tons of cargo in its hold. Nowhere else in the world can you see so many of these mighty aircraft at once. They had taken off five, eight, or nine hours earlier from the U.S. East Coast, Europe, or Asia. Barely two hours later, the apron is half empty again, the planes long since on their way to their actual destination, their bellies full not only with cargo moving from continent to continent, but also with goods for and from Alaska.

Washing machines at postal rates

In addition to the global cargo jet set, there are also small local companies here in Alaska and next door in northern Canada that specialize in delivery to the vast wilderness, supplying just about everything people need to live: from lumber and fuel to fresh fruits and medicines. Alaska has a unique system for this: even washing machines and other large appliances can be sent, or rather flown, to the farthest-flung communities at cheap postal rates. “We get the difference between the postal rates and the actual air freight costs back from the government, which is cheaper for them than building roads,” explains Edward Peebles, CEO of Warbelow's Air. From Fairbanks, Alaska's second-largest city, his company makes such supply flights to, say, Fort Yukon on the Yukon River, just 233 kilometers away.

Jumping into the car and arriving at your destination after two hours on a deserted road—in Alaska, it's not that simple. People here are widely dispersed in many remote villages, but water is always nearby. This makes seaplanes the most common means of transportation. “The middle part of Alaska alone is bigger than California—but now imagine California without roads,” Peebles says. He and his company make a living from the fact that many people in Alaska can't reach their homes by car. Even Alaska's capital, Juneau, is accessible only by air or by boat. Warbelow's Air operates a dozen six-seat Piper Navajos. “We're the lifeline for many villages. Warbelow's serves 28 towns from Fairbanks alone,” the CEO explains.

Boxes of diapers for Fort Yukon

Outside the small aircraft terminal on this bright blue spring day, a Piper is being loaded for a flight to Fort Yukon. Stacks of boxes full of baby diapers, laundry detergent, and toys surround the aircraft. Pilot Richard carefully distributes everything in the cargo area located in the plane's nose and behind the cabin. Even the small luggage compartments in the wings behind the two propellers get a couple rolls of toilet paper; all stowage possibilities are used. Each passenger can take up to 18 kilograms of luggage. The round-trip flight between Fairbanks and Fort Yukon costs more than 200 U.S. dollars—a lot of money for the inhabitants of the latter, most of whom are Alaskan Athabaskans. The community there, just 13 kilometers north of the Arctic Circle, has up to 800 residents in summer; in winter, sometimes only 200. Their livelihood is based on hunting and fishing. Just three passengers are booked today, so a few more boxes can be loaded to ensure the excellent capacity utilization at Warbelow's Air as usual.

Of course, large and heavy goods like construction materials or boats also have to be flown to each village. The little Pipers at Warbelow's Air can't manage that, but there are plenty of suitable aircraft just across from the General Aviation terminal at the Fairbanks airport. Alaska's subsidy system and similar schemes in the Canadian Arctic have kept alive entire squadrons of piston-engine freighters from the 1940s and 1950s, aircraft that have long since been scrapped everywhere else in the world. Despite costly maintenance, these indestructible evergreens have an irreplaceable robustness in the far north. Right next to the hangar where Everts Air is currently servicing one of its 1954 DC-6s is a Curtiss C-46 cargo plane, nearly a decade older still: it was delivered to the U.S. Air Force in February 1945 and at the time was the largest twin-engine aircraft in the world.

High noon for freighter jumbos ___ *At Anchorage Airport in Alaska, dozens of Boeing 747 freighters converge in the middle of the day, stopping here to refuel on their way between Asia and North American destinations.*

Vital supply route ___ *Twin-engine aircraft like this Piper are a typical choice to guarantee the transport of people and goods between regional centers and remote Alaskan villages.*

Bright red courier ___ *Air Greenland mainly uses Dash-8s to provide connections within Greenland to the most important larger settlements, which often have only a few hundred inhabitants.*

Indestructible oldies ___ *Everts Air in Fairbanks operates 1950s-era DC-6s and several 1944 Curtiss C-46s, which are still used today to fly cargo and fuel to settlements in the wilderness where no roads lead.*

The crew climbs aboard via a steep ladder; the massive hold is stacked full of sheetrock and cement bags for the Far North. “No one can believe this plane was built in 1945,” says Rob Everts, head of Everts Air, who also flies the veteran aircraft himself. Just a few steps away, work is also being done on a C-46 of the same vintage, used by subsidiary Everts Air Fuel to fly fuel to remote areas. The name of the sturdy twin-engine aircraft says it all: “Hot Stuff.” For cargo pilots in Alaska, no task is too difficult: “I used to fly the DC-6 to the Aleutian Islands,” Everts recalls. “We had to use the road as a runway and could rarely touch down anyway because of the extreme weather—but when we did make it, it was like Christmas for the locals.”

ABOUT THE AUTHOR:

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

The Century Club

KLM was first in 2019; Finnair and Czech Airlines this year and then Lufthansa in 2026: many airlines are celebrating their centennials in the 2020s.

Text: *Andreas Spaeth*

On September 12, 1919, Queen Wilhelmina of the Netherlands bestowed the title “royal” on her country’s first airline. The young company was also one of the first of its kind in the world. Many years later, it became the first airline to exist under its original name for over a hundred years. No other company in the Netherlands has ever had this royal privilege right from the start. However, the importance of the airplane as a means of civilian transportation increased shortly after World War I, and the founding of the Koninklijke Luchtvaart Maatschappij (Royal Aviation Company), or KLM, was a clear reflection of this.

It was a mere 16 years earlier, on December 17, 1903, that the Wright Brothers had flown their primitive Wright Flyer over the dunes of Kitty Hawk, North Carolina—marking the first time people had ever successfully taken off and landed in a heavier-than-air aircraft. But now things began moving very quickly, and many parts of the world saw the founding of their first airlines. A good dozen of those that have lasted into the present day are celebrating their centennials in the 2020s. **AERO**REPORT presents a list of these long-lived airlines in the order in which they were founded.

ABOUT THE AUTHOR:

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

KLM Royal Dutch Airlines

HEADQUARTERS:	Netherlands
FOUNDED:	Oct. 7, 1919
FIRST FLIGHT:	On May 17, 1920 / De Havilland DH-16 from London-Croydon to Amsterdam-Schiphol
FLEET SIZE IN 2023:	110 aircraft
PASSENGERS IN 2022:	25.8 million

As early as 1924, KLM began offering long-haul flights to Batavia (now Jakarta) with a Fokker F.VII. In 1934, KLM ordered aircraft from Douglas in the U.S., starting with the DC-2 and followed by the DC-3, DC-4, and DC-6. Long-haul routes were resumed soon after World War II in 1946, initially to New York. KLM introduced the DC-8 as its first jet in 1960 and later remained loyal to Douglas with the DC-10 and MD-11, while also relying on the Boeing 747 as of 1971. In 2005, KLM merged with Air France.

Avianca

HEADQUARTERS:	Colombia
FOUNDED:	Dec. 5, 1919
FIRST FLIGHT:	December 5, 1920 / Junkers F 13 from Barranquilla to Puerto Colombia
FLEET SIZE IN 2023:	110 aircraft
PASSENGERS IN 2022:	24.6 million

International flights from Colombia to neighboring countries began in the mid-1920s. As the oldest airline in the Americas, now under a new name, in 1946 Avianca began offering international flights to the U.S. and Europe as well, using first DC-4s and then Lockheed Super Constellations as of 1951. It leased its first jets, two Boeing 707s, in 1961, and in 1976 became the first Latin American airline to lease Boeing 747s. Avianca survived two Chapter 11 bankruptcy protection proceedings in 2005 and 2021 and started over again each time.

QANTAS

HEADQUARTERS:	Australia
FOUNDED:	Nov. 16, 1920
FIRST FLIGHT:	November 2, 1922 / Avro 504 biplane
FLEET SIZE IN 2023:	125 aircraft
PASSENGERS IN 2022:	21.25 million

After initially transporting passengers from western Queensland to other parts of Australia, Qantas started offering flying boat services from Darwin to Singapore in May 1934. Beginning in December 1947, the airline served London with the Lockheed Constellation; the route took four days each way. Qantas began the jet era with delivery of its first Boeing 707, and from 1971 through 2020, Qantas was a major operator of the Boeing 747.

ČSA CZECH AIRLINES

HEADQUARTERS:	Czech Republic
FOUNDED:	July 29, 1923
FIRST FLIGHT:	October 29, 1923 / Aero A-14 from Prague to Bratislava
FLEET SIZE IN 2023:	2 aircraft
PASSENGERS IN 2022:	(no data)

The airline opened its first international route (to Zagreb) in July 1930 and began procuring DC-2s and DC-3s in 1937. After the German occupation, the company was dissolved and not re-established until 1945; operations restarted with three Junkers Ju 52s and DC-3s. Starting in 1949, only Soviet aircraft types were used. ČSA was privatized in 1992, and since the separation of Slovakia, it has been operating as Czech Airlines. Currently owned by low-cost carrier Smartwings, the company has shrunk to a minimum after a near-bankruptcy in 2021, and now flies only to Paris.

FINNAIR

HEADQUARTERS:	Finland
FOUNDED:	Nov. 1, 1923
FIRST FLIGHT:	March 20, 1924 / Junkers F 13 from Helsinki to Tallinn
FLEET SIZE IN 2023:	79 aircraft
PASSENGERS IN 2022:	9.1 million

Finland began using permanent airfields in 1936. Flights to Europe began after the war in November 1947 with the DC-3, and as of 1953, the brand name used was Finnair. With the Convair 440, the company now offered longer routes as far as London. The Caravelle launched its jet era in 1961, and transatlantic services began in 1968 with the DC-8. Beginning in 1983, Finnair pioneered services from Europe via shorter northern routes to Asia with the DC-10; this remained a lucrative business model until the Ukraine war in 2022.

DELTA

HEADQUARTERS:	U.S.
FOUNDED:	March 2, 1925
FIRST FLIGHT:	June 17, 1929 / from Dallas, Texas, to Jackson, Mississippi, with two stops in between
FLEET SIZE IN 2023:	936 aircraft
PASSENGERS IN 2022:	141.6 million

Starting in 1934, Delta initially operated airmail flights; the company adopted its current name, Delta Air Lines, in 1945. It flew its first international routes as early as 1953, and in 1959 its jet era began with the DC-8, which Delta was the first to use. It also became the first operator of the DC-9 in 1965. Intercontinental expansion began in 1981 with the first London flights, followed by transpacific routes in 1987. Delta is the world's top-selling airline and third in the world in terms of passenger numbers.

Lufthansa

HEADQUARTERS:	Germany
FOUNDED:	January 6, 1926
FIRST FLIGHT:	April 6, 1926 / Fokker F.II from Berlin Tempelhof to Zurich via Halle, Erfurt and Stuttgart
FLEET SIZE IN 2023:	328 aircraft
PASSENGERS IN 2022:	93 million

In addition to its dense European network, Luft Hansa spread to other continents at an early stage. Its pilots flew nonstop from Europe to America for the first time in 1928, and a passenger route to Tokyo was soon established, as well as subsidiaries in Brazil and China. On April 1, 1955, the post-war Lufthansa took off and quickly made a name for itself all over the world. In March 1960, its jet era began with the Boeing 707. Lufthansa has been fully privatized only as of 1997.

American Airlines

HEADQUARTERS:	U.S.
FOUNDED:	April 15, 1926
FIRST FLIGHT:	April 15, 1926 / De Havilland DH-4 biplane from St. Louis to Chicago
FLEET SIZE IN 2023:	948 aircraft
PASSENGERS IN 2022:	199.2 million

In the early 1930s, 82 smaller airlines flew under their own names but under the American Airways umbrella brand. On June 25, 1936, American Air Lines launched scheduled services as an independent brand, flying a DC-3 from Newark to Chicago. The company was soon to become the largest airline in the world in every respect. American began its jet era back in 1959 with the Boeing 707. Its focus was always on domestic traffic; it wasn't until 1982 that it operated its first flights to Europe—specifically, to London. American expanded into transatlantic services with the acquisition of TWA in 1991, and today serves 48 countries.

IBERIA

HEADQUARTERS:	Spain
FOUNDED:	June 28, 1927
FIRST FLIGHT:	December 14, 1927 / Rohrbach Ro VIII from Barcelona to Madrid
FLEET SIZE IN 2023:	89 aircraft
PASSENGERS IN 2022:	12.2 million

In the beginning, DLH played an essential role in Iberia's flight operations, delivering Junkers Ju 52s from Germany as late as 1939. As early as 1946, Iberia was the first European airline to fly to South America, when it began a service to Buenos Aires with the DC-4, and starting in 1954, with the Lockheed Super Constellation. Jets joined the fleet in 1961: the DC-8 and the Caravelle. Iberia was privatized in 2001.

IAE celebrates 40 years of cutting-edge technology

IAE has delivered 7,850 engines; currently, more than 2,300 aircraft at over 160 airlines in 80 countries fly with 5,280 V2500 engines.

It flies and flies and flies

This year, the IAE consortium is celebrating 40 years of its V2500 engine, one of the most successful engine programs ever.

Text: *Thorsten Rienth*

“Forty years ago, there was no such thing as a quick phone call to the U.S. or a video conference with Japan,” says Klaus Diederichs with a smile. Today, the engineer serves on the Executive Board of the Friends of MTU Engine Technology association. The reason his memories are so vivid is because he was one of the first MTU employees to work at the headquarters of the International Aero Engines (IAE) consortium after it was founded in 1983.

Back then, the spirit there in East Hartford, in the U.S. state of Connecticut, was one of real optimism. “A joint venture that brought together five nations on three continents to develop and produce a new short- and medium-haul engine: well, that was quite an extraordinary thing,” Diederichs says.

Optimism gives way to disillusionment—but then comes IAE’s breakthrough

Those early years demanded stamina. Certified in 1988, the first V2500-A1 entered service a year later on an Adria Airways Airbus. “My main responsibility was the MTU low-pressure turbine. Much of the focus was on cost issues and delivery capabilities,” Diederichs recalls. It turns out this was a lucky break: on the engine’s other modules, the partner companies’ representatives had to spend most of their time overcoming teething problems.

IAE’s breakthrough only really came in 1991, when United Airlines opted for the V2500 to power its order of 100 new aircraft from the A320 family. A short time later, Lufthansa selected the

1983

Founding of International Aero Engines AG (IAE): *Bob Rosati becomes IAE’s first President and CEO*

1984

IAE sets up headquarters in East Hartford, CT

January: *V2500 program starts*

1985

January: *Adria Airways and Cyprus Airways order the V2500*

First V2500 installed

December: *First test run*

1986

First V2500 engines tested on shareholders’ test stands

1987

V2500 goes into production

1988

May: *Maiden flight of a V2500 on a B720*

June: *FAA grants type certification for the V2500-A1 with 25,000 pounds of thrust*

July: *Maiden flight of an A320 with V2500 engines*

September: *V2500 and A320 debut at Farnborough Airshow*

1989

A320 with V2500 engines enters regular service with Adria Airways

MTU Maintenance starts V2500 MRO

V2500 ___ *The V2500 is now available in four variants: the -A1 and -A5 for the Airbus A320, the -D5 for the McDonnell Douglas MD-90, and the -E5 for the Embraer C-390 military transporter.*

When it all began ___ *The first V2500 engines were tested on shareholders' test stands in 1986.*

engine for its new Airbus A321 aircraft. From that point on, the engine became a firm favorite in the aviation world. Since first taking to the skies in 1986, V2500 engines have completed 135 million flights and a good 255 million flight hours; they will log almost 16 million flight hours in the course of 2023. More than 2,300 jets currently use them to take off, fly, and land for over 160 airlines. Every ten seconds, a V2500-powered aircraft takes off somewhere in the world.

Virtually all MTU employees have some connection to the "V"

Without the "V," as MTU colleagues affectionately abbreviate it among themselves, the company would likely have missed out on much of its growth over the past two decades: with a 16 percent share of the program, MTU is responsible for the development of the low-pressure turbine (LPT), the casing, and the accessories and externals. In addition, the company produces a range of LPT components as well as the casing.

The V2500 is now available in four variants: the -A1 and -A5 for the Airbus A320; an uprated and downrated -A5 for each of the Airbus A321 and the Airbus A319; the -D5 for the McDonnell Douglas MD-90; and the -E5 for the Embraer C-390 military transporter, which went into large-scale production only a few years ago. And the engine is now in the process of reaching another important milestone: MTU's Hannover site is currently testing the addition of 10 percent sustainable aviation fuel (SAF), and the engine experts believe that as much as 100 percent is possible.

MTU's component manufacturing operations are mainly concentrated at its sites in Munich and Rzeszów. Maintenance, partly on behalf of IAE and partly directly for airlines, is performed at MTU's Hannover, Vancouver, and Zhuhai locations. Nova Pazova in Serbia and Kota Damansara in Malaysia are involved in parts repair. And of course, MTU Maintenance Lease Services also has the V2500 in its portfolio. MTU employees who have

1992
V2500 is granted 120-minute ETOPS (extended operations) certification
FAA certifies V2500-A5 (A321) and -D5 (MD-90)

1996
China Southern Airlines becomes the 50th IAE customer
Fiat Aviazione leaves IAE

1998
1,000th V2500 *goes to Lufthansa*

2002
2,000th V2500 *delivered*
V2500 engines reach 20 million flight hours

2008
V2500 SelectOne™ enters service

2009
4,000th V2500 *delivered together with 4,000th A320*

2010
V2500 reaches 85 million flight hours

2011
V2500-E5 selected for Brazilian military transporter KC-390
IAE collaboration agreement extended to 2045

Shop visits *About 30 percent of the 5,286 engines in service still have their first scheduled shop visit ahead of them.*

Careful scrutiny *Maintenance is performed at MTU's Hannover, Vancouver, and Zhuhai locations.*

never had anything to do with this engine are thin on the ground.

And yet, in IAE's 40th anniversary year, the program has only just reached the peak of its commercial viability. "Between 2014 and 2017 in particular, IAE was delivering up to 500 engines a year," says Reiner Wenig, Head of Business and Operations for the V2500 LPT. "That means the engine fleet is still comparatively young: of the nearly 5,300 engines currently in service, around 30 percent haven't even had their first shop visit yet, which is due after seven years of operation." At the same time, a great number of older engines are still in use. "So the demand for spare parts remains high," Wenig says.

Having different companies and cultures come together as IAE back in the early 1980s could have proven to be a weakness. But it might also be the secret of IAE's success. One thing is clear: no one will ever be able to deny that IAE produced one of the most successful engines in the history of commercial aviation.

ABOUT THE AUTHOR:

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.

500,000 *people fly in V2500-powered aircraft every day.*

5,286 *V2500 engines are currently in service worldwide.*

135 million *flights have been carried out with V2500s since the engine's maiden flight in 1986. That's* **more than 255 million** *flight hours.*

50 percent *is the approximate market share of the V2500 in narrowbody aircraft.*

Every ten seconds *a V2500-powered aircraft takes off somewhere in the world.*

2012
- **5,000th V2500** *delivered*
- *V2500 reaches 100 million flight hours*
- *Rolls-Royce sells its IAE shares, and MTU increases its share to 16 percent*

2014
- *V2500 SelectTwo™ goes into operation*

2015
- *Maiden flight of the KC-390 with V2500-E5 engines*

2018
- *V2500 reaches 200 million flight hours across 3,100 aircraft*

2019
- *C/KC-390 with V2500-E5 enters service with the Brazilian Air Force*

2023
- *IAE celebrates 40 years of cutting-edge technology*

Dr. Kay Plötner
Interview with the Head of Economics and Transportation at Bauhaus Luftfahrt.

Flying in the city

Dr. Kay Plötner from Bauhaus Luftfahrt, a think tank, analyzes the opportunities and challenges of using air taxis sustainably, especially electric vertical takeoff and landing aircraft.

Text: *Nicole Geffert*

"Aviation always performs particularly well when it comes to covering great distances or when there's no efficient way of getting from A to B by land or sea. In regions characterized by certain geographic obstacles like islands or mountains, air taxis could provide real value to people by reducing travel times and increasing accessibility."

Dr. Kay Plötner, *Head of Economics and Transportation at Bauhaus Luftfahrt*

Dr. Kay Plötner
Head of Economics and Transportation at Bauhaus Luftfahrt

Prior to joining Bauhaus Luftfahrt in 2010, Dr. Kay Plötner completed his degree and doctorate in aerospace technology at the Technical University of Munich.

Since 2016, he has served as Head of Economics and Transportation at Bauhaus Luftfahrt, where he and his team plot the potential future development of the air transport system and identify key drivers at the socioeconomic, political, and ecological level.

They research promising integrative solutions for urban and rural areas around the world, taking into account aspects such as economics, ecology, fairness, and urban planning.

Less congestion, lower CO_2 emissions, and enhanced mobility in cities and conurbations: the expectations placed on urban air mobility (UAM) are high. All over the world, established companies and start-ups are working on air taxis—especially on electric vertical takeoff and landing (eVTOL) models—and hoping that these small aircraft will turn into big business. But how realistic is this vision? Dr. Kay Plötner, Head of Economics and Transportation and expert in urban and regional air mobility at Bauhaus Luftfahrt, a think tank, talked to **AERO**REPORT about the outlook for these new aircraft.

AEROREPORT: ***Dr. Plötner, what is urban air mobility?***

Plötner: Urban air mobility is a transport system for passengers, freight, and services in and between cities. In addition to smaller drones, air taxis—especially eVTOL models—play a central role in this concept. Thanks to new technologies such as electric propulsion systems and enhanced battery capacity, eVTOL systems are becoming a viable option. These aircraft carry out similar functions to those of helicopters, but are quieter and more economical to operate.

AEROREPORT: ***Bauhaus Luftfahrt sees urban air mobility as a supplement to conventional modes of transportation, not as a replacement. Your position is that air taxis will not be a game-changer for urban mobility. Why not?***

Plötner: Urban air mobility's potential time advantage over driving exists really only in extremely congested areas and under the proviso that the vertiports can be reached and accessed easily. Vertiports are special takeoff and landing points for eVTOL aircraft; these require sizeable infrastructure on the ground and have yet to be planned, financed, and established. For a vertiport to serve around 100 customers per hour, it would have to be the size of a soccer field. But vertiports will be very limited in size and number due to a shortage of space—in cities, space is tight and precious—as well as for reasons of noise pollution and safety.

AEROREPORT: ***Could air taxis go a long way toward easing congestion on the roads?***

Plötner: It's unlikely that air taxis will solve the problem of congestion in cities because only a select group of people will be able to afford to ride in air taxis on a regular basis. eVTOL aircraft can transport only small payloads and typically offer four to six seats. The predictably high fare must then be split among a small number of passengers. Most UAM studies estimate that in the long term, air taxis will achieve a 1 percent market share, particularly due to high investment costs for aircraft, infrastructure, and staff. It's likely that the first air taxis will be piloted rather than automated. Given this low market share, urban air mobility is not expected to achieve a noticeable reduction in congestion on the roads.

AEROREPORT: ***Does urban air mobility offer an ecological benefit?***

Plötner: The only way air taxis could reduce CO_2 emissions would be if they replaced journeys currently made in cars powered by

CenterAirStation — *The concept of this downtown airport aims to significantly increase the capacity of the air transportation system by shifting existing and future city connections from conventional airports to this type of urban air hub. CenterAirStation was developed by Bauhaus Luftfahrt together with students from the Glasgow School of Art.*

combustion engines. Since vertical takeoff and landing aircraft represent the most energy-intensive way to fly, the power consumption and necessary battery mass is much higher than for electric cars. This means that in most scenarios, air taxis are less resource-efficient than other electric modes of transport. Another aspect to consider is noise emissions. It's scientifically proven that high noise levels can adversely affect the health and quality of life of urban populations. European cities in particular will not tolerate high noise levels.

AEROREPORT: ***Several eVTOL manufacturers are already heading for the runway. Volocopter, for instance, wants to offer passenger services during the 2024 Olympic Games in Paris. What do you make of this development?***

Plötner: It will surely be an attraction for visitors. Although we expect eVTOL aircraft to remain a niche product, there are attractive business models out there for manufacturers and operators. Even if air taxis occupy a niche, the production of eVTOL aircraft could surpass current helicopter production should air taxis demonstrate lower overall costs or noise emissions. Aviation always performs particularly well when it comes to covering great distances or when there's no efficient way of getting from A to B by land or sea. In regions characterized by certain geographic obstacles like islands or mountains, air taxis could provide real value to people by reducing travel times and increasing accessibility.

AEROREPORT: ***Are there other ways that urban air mobility could improve people's quality of life?***

Plötner: Air taxis could appeal to certain user groups, such as tourists or business travelers, who are prepared to pay for a special experience or time advantage. eVTOL aircraft could also serve as feeders for long-haul flights as a quick and convenient way of transporting passengers to and from airports and hubs. Urban air mobility also has value to offer when it comes to paramedic call-outs or transporting lifesaving equipment or drugs. And beyond commercial passenger transportation, there are any number of applications in freight and support services.

Bauhaus Luftfahrt
The Aviation Think Tank

Bauhaus Luftfahrt was founded as a registered association in 2005. It is a nonprofit research institution and derives its name from the original Bauhaus in Dessau. Its members are four renowned aviation companies—Airbus, IABG, Liebherr-Aerospace, and MTU Aero Engines—as well as the Bavarian State Ministry of Economic Affairs, Regional Development, and Energy. The German Aerospace Center (DLR) was added as a funding member in 2020.

VoloCity ____ *The two-seater aircraft with its distinctive halo of 18 rotors currently has a range of 35 kilometers and a top speed of 110 km/h. In the initial phase, the VoloCity will have a pilot on board.*

AEROREPORT: ***You say that turning urban air mobility into a future-proof concept hinges on identifying social, ecological, and economically sustainable applications. What exactly does that mean?***

Plötner: It means applications will have to cater to the needs and expectations of users and society, minimize the environmental fallout, and demonstrate viability. Looking to Europe, applications should be designed using co-creative processes—in other words in collaboration with a variety of interest groups. The goal is to establish a fair, sustainable transport system that better connects rural areas with major cities. Achieving this will mean promoting both research and development activities and a close collaboration among industry, politics, and society.

"20 years from now, we'll be able to look up and see new kinds of aircraft and other flying machines that employ a wide range of technologies."

Dr. Kay Plötner,
Head of Economics and Transportation at Bauhaus Luftfahrt

AEROREPORT: ***What's the latest on other concepts like regional air mobility?***

Plötner: For urban air mobility we're talking about distances of 20, 30, or 50 kilometers, perhaps more. This soon crosses over into the world of regional air mobility, which could also be based on aircraft powered by batteries or hydrogen. These aircraft could transport 19 or more passengers at a time using the existing infrastructure of regional airports. But to establish this kind of new regional air mobility, it will take more than simply developing, certifying, and producing new aircraft. One key precondition is to have in place the infrastructure for battery charging and hydrogen refueling. The aviation industry is changing, but one thing is clear: 20 years from now, we'll be able to look up and see new kinds of aircraft and other flying machines that employ a wide range of technologies.

ABOUT THE AUTHOR:

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

Short-haul eVTOL aircraft

Air taxis ready for takeoff: experts expect the first commercial eVTOL flights to be launched on fixed routes within the next few years. We take a look at ten key developments.

The aviation industry is in the midst of a dynamic transformation. Manufacturers are aiming to revolutionize mobility within and between cities with their electric vertical takeoff and landing (eVTOL) aircraft. This technology has many applications—including short-haul air taxis and autonomous delivery drones—and eVTOL aircraft makers say it could be the solution to growing problems of urban mobility, such as congestion and air pollution. Yet the industry is still facing plenty of unanswered questions, especially in the areas of safety, certification, acceptance, and infrastructure.

The requirement for commercial operation of an eVTOL aircraft is an official flight permit, which means that the legal and regulatory framework must be clarified. eVTOL aircraft will also need to meet stringent safety standards and gain the trust of potential users. Other challenges include the creation of suitable takeoff and landing points, charging facilities, and maintenance hubs. Experts expect to see the launch of the first commercial eVTOL flights on fixed routes sometime within the next few years, but it is still too early to predict how quickly and to what extent this new form of mobility will make a tangible impact. **AERO**REPORT presents ten examples of the latest developments in eVTOL technology.

YOU CAN FIND MORE ON THE TOPIC OF AIR TAXIS ONLINE:

Developments in eVTOL:
What lies ahead for
air taxis and drones?

www.aeroreport.de/en

Joby Aviation

Wisk Aero

Volocopter

Lilium

Archer Aviation

AutoFlight

Beta Technologies

Eve Air Mobility

Ehang

Elroy Air

AT A GLANCE:

MTU’s core competencies

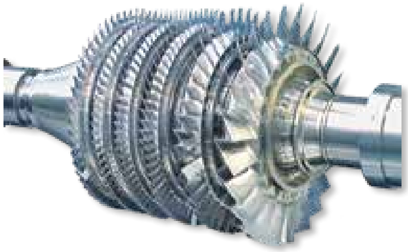
Highly efficient and advanced: engine components “made by MTU” are world class.

Compressors are the centerpiece of an engine. MTU Aero Engines has been developing, manufacturing, and repairing high-pressure compressors (HPCs) for over 50 years. HPC design is the supreme discipline in engine construction. Those who master it are right at the top of the engine league.

MTU initially acquired its compressor expertise in the military sector. It developed its first commercial HPCs for the PW6000, the engine for the A318. The current flagship is the HPC for the eco-efficient GTF engine, which MTU developed jointly with Pratt & Whitney.

MTU has also been involved in turbine technology for decades. The company is the world’s technology leader when it comes to low-pressure turbines (LPTs) that operate at maximum efficiency and minimum weight. The breadth of its expertise ranges from conventional models for business jet engines and power turbines for heavy-lift transport helicopter engines all the way to large conventional low-pressure turbines for turbofan engines powering medium- and long-haul airliners. MTU’s masterpiece is the high-speed low-pressure turbine, a key component of the GTF™ engine—technology unparalleled in the world.

Turbine center frames (TCF) are another of MTU’s core competencies. MTU develops and manufactures turbine center frames (TCFs) for engines that power long-haul airliners. The company’s Munich site and MTU Aero Engines Polska produce TCFs for the GP7000 (Airbus A380), the GEnx (Boeing 787 Dreamliner and Boeing 747-8), and the GE9X (the exclusive engine for the Boeing 777X). The GE9X TCF is MTU’s most technologically sophisticated turbine center frame.



High-pressure compressor (HPC)

The high-pressure compressor performs the main compression of the air drawn in by the fan and entering the core engine. It has a very high efficiency.

Low-pressure turbine (LPT)

The low-pressure turbine drives the low-pressure compressor and the fan, which in turn generates the bulk of the thrust.

Turbine center frame (TCF)

Turbine center frames serve as a duct for the hot gas flowing from the high-pressure turbine into the low-pressure turbine. They have to fulfill a variety of tasks.

CORE COMPETENCE 01:

High-pressure compressor (HPC)

The GTF's eight-stage transonic HPC has a pressure ratio of 15:1 and is characterized by extremely robust operating behavior with outstanding efficiency.

The GTF HPC is built on the blisk principle—and for the first time this includes the rear stages. To this end, MTU manufactures nickel blisks on behalf of Pratt & Whitney using the precision electrochemical machining (PECM) process. Other HPC highlights include new construction methods, such as casing treatment, a new rotor tie shaft design concept, the axially undivided inner ring, new materials, and the novel ERCoat® erosion protection layer, which is an innovative multilayer coating for airfoils.

Two brush seals are also installed in the GTF compressor area. These innovative MTU seals replace conventional labyrinth seals and significantly reduce any remaining leakage flow.

A brief guide:
High-pressure compressor

www.aeroreport.de/en

CORE COMPETENCE 02:

Low-pressure turbine (LPT)

MTU's high-speed low-pressure turbine is a key component of the innovative geared turbofan and is exclusively mastered by MTU for this application.

The GTF LPT achieves significantly higher circumferential speeds, which reduces the aerodynamic load and means the stages can work both harder and with higher stage efficiencies. This allows the stage count to be reduced by almost half.

The high-speed LPT features a new type of aerodynamically optimized 3D airfoil. Opting to have the high-pressure and low-pressure shafts rotate in opposite directions made it possible to integrate the previously standard first guide-vane stage of the LPT into the turbine center frame. Other highlights include a new housing concept for better shielding from hot gas as well as lighter materials for the rotor disks. MTU brush seals reduce cooling and leakage air, and borescope bosses are the first components to be produced on an industrial scale using the additive manufacturing technique of laser powder bed fusion.

A brief guide:
Low-pressure turbine

www.aeroreport.de/en

CORE COMPETENCE 03:

Turbine center frame (TCF)

During operation, TCFs are exposed to extreme stresses such as high mechanical loads and high temperatures.

Their function is to route the flow of hot gases exiting the high-pressure turbine at a temperature of more than 1,000 degrees Celsius to the low-pressure turbine while keeping aerodynamic losses to a minimum. Both turbines need to be provided with cooling air, which is supplied through the turbine center frame. As the supporting structure, the TCF accommodates the rear bearing of the high-pressure spool, thus playing a major part in maintaining the clearances in the high-pressure turbine. At the same time, it is essential to ensure seamless delivery and return of oil through the hot structure.

Building on the basic architecture of the GEnx TCF, the GE9X TCF features extensive optimizations that further improve its weight, service life, and manufacturability. It also features MTU's first fully bionically designed components: brackets for oil lines. These achieve a weight reduction of 35 percent.

A brief guide:
Turbine center frame

www.aeroreport.de/en

Tank systems in aircraft: More than just containers

*Before takeoff, aircraft must be refueled. But where is the kerosene actually stored? How does the distribution of the tanks affect performance? And how do the requirements differ for alternative fuels? **AERO**REPORT provides answers to the most important questions.*

Text: *Monika Weiner*

Where does the fuel go? Cavities become tanks

During aircraft refueling, up to 800 kilograms of kerosene—that's almost 1,000 liters—flow into the tanks every minute. Commercial aircraft can hold numerous metric tons of fuel: the Airbus A380 can carry some 254,760 kilograms. If this fuel were stored exclusively in the fuselage, as is normal in small propellor aircraft, it would eat up an enormous amount of storage space. And it would make the aircraft structure heavier: during flight, the force of gravity pulls the fuselage downward, while the force of lift pushes the wings upward.

The heavier the fuselage and the lighter the wings, the greater are the stresses that the connecting components, the wing roots, must withstand. The only way to minimize these stresses is to shift as much weight as possible to the wings. That makes the wings an ideal place to transport kerosene.

How much fuel is pumped into the tanks depends on the planned flight route. The on-board computer calculates the required quantity, always in accordance with this rule: as much as necessary and as little as possible. To avoid unnecessary weight, the quantity of fuel carried is exactly enough to get the aircraft to its destination plus a safety reserve in case the flight takes longer, for example because congestion at the destination airport delays the landing.

What tanks are there?

To save weight, the designers of large commercial aircraft have dispensed with steel or plastic tanks and instead use the cavities in the wings. Because these tank systems are integrated into the structure, they are called integral tanks. Depending on the wing design, an aircraft will feature several such tanks, which are sealed with a special sealant and interconnected via a system of pumps and fuel lines. A basic distinction is made between inner tanks, which are located close to the fuselage, and outer tanks, which are located close to the wingtips. Fighter jets follow the same principle of integral tanks, with inner tanks often also used as ballistic protection in the wing.

Some aircraft, for example the Boeing 747, also have a fuselage tank located between the wings under the floor of the passenger cabin. The new Airbus A321XLR, a narrowbody with a record range of 8,700 kilometers, will also be equipped with a fuselage tank: this "rear center tank" is an integral part of the aircraft structure and has a capacity of 12,900 liters.

Long-haul aircraft usually also have an additional trim tank in the tail assembly. This helps stabilize horizontal position during flight: as the fill level and thus the weight of the wing tanks decreases, the aircraft's center of gravity shifts to the rear; fuel can be pumped forward from the trim tank to compensate.

Challenges in operation: Avoiding damage

During the flight, kerosene is pumped from the tanks to the engines. Commercial aircraft are equipped with a tank ventilation system to avoid a build-up of negative pressure, as this would block the further supply of kerosene. The flight speed forces air through the system's air intakes to form an air cushion on the fuel in the tank. This not only reduces the evaporation of the fuel, but also supports the work of the pumps.

Water can condense out of the air entering the tanks, and microbes can colonize and multiply in the moist environment that this creates. The result is biofilms that can penetrate the smallest cracks, attack aluminum alloys, and cause corrosion damage. The biomass of such films can also enter the pumps and valves, leading to faults. Biocide additives in kerosene prevent the growth of such microorganisms. The latter nonetheless become a problem especially when an aircraft is stationary for a longer period of time—as was often the case during the coronavirus pandemic. As a result, some tanks had to be specially cleaned before the resumption of flight operations.

How will we fly tomorrow? New fuels sometimes require new designs

Alternative fuels are set to help make the aviation of the future climate-neutral. At engine and aircraft manufacturers, airport operators and airlines, researchers are working on new solutions for propulsion systems, aircraft designs, and infrastructure.

Sustainable aviation fuels, or SAF for short, are an alternative to kerosene, which is derived from fossil fuels. These fuels can be produced from renewable raw materials or with the help of renewable energy sources, carbon dioxide, and hydrogen. Initial tests show that flight operations and infrastructure can be converted to SAF without a problem if certification for the respective aircraft type is available. Using 100 percent SAF without aromatics will probably require adjustments to tank systems, for instance the seals.

Switching to hydrogen would require completely new refueling systems: gaseous hydrogen is rather unsuitable for aviation because it requires extremely large and heavy pressure vessels, which must withstand several hundred bar. Cooling the hydrogen and transporting it in liquid form is a better option. This cryogenic fuel requires special tanks with thermal insulation designed for relatively low pressures of between two and ten bar. Technically, cylindrical or round shapes are best for meeting these requirements, but these are difficult to integrate into the wings. That's why engineers are already working on new aircraft designs. And the maintenance processes and infrastructure at the airport, including the logistics of making the fuel available, would also have to be redesigned to accommodate hydrogen supply.

A fuel system for liquid hydrogen

MTU Aero Engines is working with aerospace company MT Aerospace to develop a complete liquid-hydrogen fuel system for commercial aviation. The system consists of tanks, sensors, heat exchangers, valves, safety systems, and controls. The first system is to be tested at MT Aerospace in Augsburg, Germany, before the end of the year. The aerospace company's experts are responsible for the cryogenic hydrogen storage and supply system, additively manufactured heat exchangers, the sensors, and system integration. The safety system, the control system, and the valve technology are part of MTU's work package. In terms of system technology, the LH_2 *fuel system could, with slight modifications, also be used for direct hydrogen combustion in aircraft gas turbines.*

The first application is to be MTU's Flying Fuel Cell™ (FFC). In the FFC, hydrogen reacts with oxygen from the air to form water, thereby releasing electrical energy. A highly efficient electric motor then uses this energy to drive the propellor via a gearbox. The FFC does not produce any emissions of CO_2 *or* NO_X *or particulates—its only emission is water. It thus reduces the climate impact of aviation by as much as 95 percent—i.e., to virtually zero. And since the propellor is then the sole source of propulsion noise, the FFC will also help achieve massive noise reductions.*

ABOUT THE AUTHOR:

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.

Return of the giant flying cigars

Huge new cargo airships are poised to revolutionize logistics in remote areas. The builders of the latest generation have learned their lessons from history.

It's barely 50 kilometers from Berlin Brandenburg Airport on Germany's A13 highway before drivers see the world's largest free-standing hall towering above the flat landscape on their left. It was built in the 1990s to house construction of the CargoLifter, the largest airship in the world by far, measuring 260 meters from nose to tail—15 meters longer than the legendary Hindenburg zeppelin, the LZ 129 from the 1930s. But by 2002, the company was bankrupt. Nevertheless, Germany remains the home of these enormous "flying cigars." For example, the only place in the world today where you can regularly book a passenger flight in an airship is the town of Friedrichshafen on Lake Constance in southern Germany.

Airships vanished from the aviation scene when their heyday ended decades ago. But now that's changing, as this environmentally friendly mode of transportation is being rediscovered in the pursuit of sustainability. For instance, an airship of the latest generation is being built in Sunnyvale, California: the 122-meter-long Pathfinder 1 hovered a few centimeters above the ground for the first time in May 2023. Thanks to a high-tech structure made of carbon fiber that uses non-flammable helium as a lifting gas, and will eventually incorporate solar cells, batteries, and electric motors, Pathfinder 1 will be a "green" airship flying humanitarian missions.

The Graf Zeppelin is considered the most successful airship of its time.

Even today, the Zeppelin flies sightseeing tours.

The new generation of "flying cigars" doesn't have conventional engines, but instead features electric or hybrid-electric propulsion, powered by fuel cells or solar cells on the outside of the shell.

Airship flights from Madrid to Barcelona

In Europe, the British company Hybrid Air Vehicles (HAV) is currently the furthest along. Its Airlander 10 is a blimp—a non-rigid airship that does not have a rigid internal weight. Shaped like a person's rear end, the hull is the container for both the lifting gas and the load-bearing system. In addition to freight transport, the vehicle will primarily be used for commercial passenger transport. The Spanish regional airline Air Nostrum has pre-ordered 20 Airlander 10s and hopes to operate the airships between Barcelona and Mallorca as early as 2026. Work is also already underway on the much larger successor model, the Airlander 50, which will be able to carry up to 200 passengers or a payload of 50 metric tons.

Purportedly able to fly much further and much faster is the H2 Clipper, which is currently being developed by the California company of the same name. By 2029, this airship is expected to travel nearly 10,000 kilometers at a speed of 280 km/h, powered by hydrogen fuel-cell electric motors. Its payload is expected to be up to 154 metric tons—

Flying Whales ___ *The French company plans to use its LCA60T airship to transport heavy loads such as logs or special equipment like wind turbine blades. The airships would also be suitable for use as high-altitude platforms for, say, earth observation or mobile communications.*

Airlander ___ *The airship project by British company Hybrid Air Vehicles is a blimp–a non-rigid airship with no internal structural framework. In addition to freight transport, the vehicle will primarily be used for commercial passenger transport.*

A COMPARISON OF AIRSHIP PROJECTS

Name	Origin	Length	Payload	Range	Lifting gas	Purpose	Introduction
Zeppelin NT	DE	75.10m	17 people + crew	1,000 km	Helium	Tourism	2001
Cargolifter CL160	DE	260m	160 metric tons	10,000 km	Helium	Cargo	Bankruptcy in 2002
LTA Pathfinder 1	USA	122m	28 metric tons	3,700 km	Helium	Humanit. aid	unknown
LTA Pathfinder 3	USA	185m	96 metric tons	16,000 km	Helium	Humanit. aid	unknown
Airlander 10	UK	92m	14 t or 100 pers.	3,700 km	Helium	Logistics, tourism	2025
Airlander 50	UK	119m	50 t or 200 pers.	2,200 km	Helium	Logistics, tourism	2033
H2 Clipper	USA	n. a.	150 metric tons	9,656 km	Hydrogen	Hydrogen freighter	2029
Flying Whales LCA60T	FR	200m	60 metric tons	n. a.	Helium	Logistics	2027
To compare:							
Boeing 747-8F	USA	76m	134 metric tons	8,130 km	n. a.	Aviation	2011

about one-third more than conventional freighters. The H2 Clipper would be the first airship since the Hindenburg disaster in 1939 to use hydrogen as a lifting gas. The European Union Aviation Safety Agency (EASA) has allowed this since 2022, but approval in the U.S. is still pending. One player looking to the exceptionally large cargo segment as a market is French project Flying Whales. Its 200-meter airship LCA60T would be able to unload wind turbine rotors directly at the most remote construction sites.

ABOUT THE AUTHOR:

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

YOU CAN FIND THE FULL ARTICLE ONLINE:

Green and economical – The promise of the new airships
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