One of the constants in the aviation industry is change. Global warming as well as the conversion of aviation in the course of the corona crisis are now demanding this from airlines more than ever before. What developments will shape the industry in the future?
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In ancient mythology, flying was considered a privilege of the gods. Before pandemic outbreak, very earthly airlines worldwide carried more than four billion passengers a year. Since the corona crisis represents a turning point, the aviation industry concentrates on these major challenges in the future: Despite annual average fuel savings of 1.5 percent, even greater efforts are needed to further offset the environmental impact of global air traffic from its expected development after pandemic. The industry has set itself the goal of reducing CO₂ emissions of the global fleet by 50 percent by 2050. Ideas and concepts to achieve this have long been in existence and under development: They range from climate-neutral fuels to alternative propulsion systems using electric motors, batteries or fuel cells, new design and production possibilities through increased digitization, more efficient forms of air traffic, and new means of air transport using small electrically powered aircraft. How will these innovations change aviation and the MRO industry? We venture a look at the trends and technologies of the next 25 years.

When and where will flying taxis take off?

Reports appear almost daily about start-ups and companies claiming to have developed in most cases a fully electric, autonomous air taxi that is on the verge of a breakthrough. Experts currently count far more than 100 projects worldwide. And indeed, prototypes by Volocopter, Lilium, Ehang or Kitty Hawk have already taken off - at least briefly. “A great achievement,” says Rolf Henke, Executive Board member of the German Aerospace Center (DLR). Nevertheless, the expert considers a mass deployment over major European cities to remain unlikely in the next 10 to 15 years. “Getting a single flying taxi airborne is no problem – but having hundreds or thousands of them hovering all over the city autonomously is a completely different matter.” The already extensive safety requirements increase with scaling, and along with the demands such a scenario is shifted ever further into the future. In Germany, Klaas Klasen, who heads the Center of Competence for Unmanned Aerial Systems of the Lufthansa Group, and works on predictive maintenance solutions for air taxis among other things, sees another hurdle: “Flying taxes make sense where traveling by air saves a lot of time. If public transport is well developed, the question arises as to whether the willingness to pay for the use of a faster air taxi is there, and whether it is worth the effort”. In addition, the aircraft must be really well integrated into the mobility chain, says Kay Plötner from the Bauhaus Luftfahrt (aviation) research institute in Munich. Long distances to the take-off and landing platforms would take time and create additional traffic on the ground. As a replacement for taxis, buses, and trains, however, air taxis are not only too expensive but also ecologically at a disadvantage: “Vertical take-offs and landings always require a lot of energy,” says Plötner. In addition to individual feeder services for wealthy business travelers who, for example, want to get from Manhattan to JFK Airport quickly, experts hold on to the possibility of a future market as long as mobility will normalize against the background of the pandemic where there is no viable alternative: for example in the megacities of Asia or Africa with poorly developed infrastructure such as Manila, Jakarta or Luanda, as well as in areas with numerous islands or mountains. In any case, it is worth being prepared: According to analysts at Morgan Stanley Research, business with autonomous air taxis could grow to a total addressable market volume equivalent to 1.36 trillion euros by 2040.
Alternatives to conventional turbine technology

As yet, only a few smaller research aircraft or air taxi prototypes fly with electric motors and batteries or even fuel cells. But in future, larger machines with such alternative drives are also likely set to take off. Four years ago, the US start-up Wright Electric already announced aircraft for around 150 passengers, which are due to fly exclusively with electricity from 2027. By a good ten years later, the Norwegian state-owned airport operator Avinor even plans to have converted all domestic flights to zero-emission electric drives. DLR Executive Board member Rolf Henke is somewhat skeptical about this: “The batteries will still be large, heavy and expensive in ten years’ time,” says the expert. Smaller aircraft will soon be able to fly short distances in the air. For aircraft with more than twenty seats, however, he believes a hybrid drive would be more suitable. In this case, fuel cells or a turbine in the fuselage that runs on alternative fuels and drives a generator produce the electricity for electric engines. The high energy requirement at take-off is supported by additional smaller batteries. The advantage: “The gas turbine can operate continuously at its optimum operating point, making it very efficient and allowing it to be optimally dimensioned,” says Robert Heigl, innovation manager at Lufthansa Technik, who specializes in sustainability. Airbus is currently working on such an engine in the E-Fan X research project. CEO Guillaume Faury considers it conceivable to have a hybrid-electric, 150-seat passenger aircraft in the air by 2035. Since the middle of last year, Wright Electric, too, has stopped talking about purely electric propulsion systems and now refers to plug-in hybrid aircraft - which is probably attributable to their new cooperation with Airbus. However, the hybrid drive still has to show whether it really offers an economically relevant advantage. Since each new generation of aircraft already consumes an average of 15 percent less kerosene than the previous one, it needs to offer fuel savings of at least 20 percent, or ideally more. One challenge: The weight disadvantages of electric motors, batteries, and the gas turbine with generator have to be compensated by efficient operation and the aerodynamic advantages of distributed electric drives. But long-haul aircraft will still be flying with conventional engines in 25 years’ time: “That is why today’s engine technology must also become even more efficient,” insists Lufthansa Technik expert Heigl.

Taking to the skies with sustainable fuels

If an Airbus A320 were equipped with standard lithium-ion batteries weighing as much as the kerosene in full tanks, the jet could fly for just 20 minutes instead of seven hours. This sample calculation from the US online education portal brilliant.org highlights the importance that alternative fuels will gain. For more than ten years now, airlines have been testing kerosene that is no longer produced from fossil oil, but can be filled and used in the same way. For a long time, biofuels were considered a favorite. “Compared to other methods, they are easier to produce, but the cultivation of energy crops would require far too large an area to sustainably supply the global aircraft fleet,” Heigl notes. What’s more, energy crops compete with food production, and could even lead to the additional destruction of natural rainforest. He sees such fuels, however, as a necessary bridging technology on the way to a greater proportion of synthetic fuels. They are produced, for example, by means of renewable electricity from sunlight, or wind power from water and carbon dioxide. In aircraft engines, the so-called e-Kerosene is burned again and generates CO₂. “e-Kerosene is therefore only truly CO₂-neutral when the carbon dioxide for its production is taken from the atmosphere. So-called direct-air capture technologies are currently under development, so we are beginning with CO₂ from cement plants, among other things, and will then switch over later,” says Philipp Engelkamp, co-founder of Ineratec. The Karlsruhe-based start-up constructs the production facilities for e-Kerosene so compactly that individual modules fit into a standard container. “This enables us to flexibly produce synthetic fuels anywhere and grow step by step with a wind farm or solar field, for example,” says Engelkamp. In the next two decades, the young company aims to attain a substantial double-digit share of the global production of sustainable fuels. Innovation manager Heigl estimates that achieving the relevant volume for aviation is not a foregone conclusion: “Just to supply the Lufthansa fleet with synthetic fuels for one year alone would require about one third of Germany’s annual electricity consumption. Nevertheless, e-Kerosene, along with alternative propulsion systems, biofuels, and more efficient conventional engine technology, is an enormously important element on the path to climate-neutral air travel,” says Heigl: “Only the interplay of all these options will significantly reduce aviation’s CO₂ footprint.
Managing growth with Industry 4.0

What should result at the end of the increasing digitization of manufacturing processes in aviation is clear: the intelligent factory, which can act autonomously by means of artificial intelligence, cameras, sensors, smart algorithms, and robotics - in other words, function without human intervention. It should reduce production costs, shorten development cycles, and improve quality - while at the same time enabling higher production volumes. “The big challenge here is that the aviation industry already achieves 99.9 percent reliability in its processes,” says Sven Taubert, Head of Corporate Market Intelligence & Foresight at Lufthansa Technik. “As a consequence, all new technologies have to be at least as good or better”. Since very high requirements for the quality and safety of products and processes also apply, Industry 4.0 projects in aviation are not only expensive, but above all take time. According to Taubert, this applies to areas such as predictive maintenance and 3D printing just as much as it does to big-data analyses and simulation by digital twin. “Industry 4.0 will certainly revolutionize production in aviation, but step by step and over the course of the coming decades,” says Thomas Belitz of the German Aerospace Industries Association (BDLI). This is evident in the case of 3D printing: although the sector is a cross-industry leader in this field, “even today, less than one percent of aircraft parts come from additive manufacturing processes,” explains Taubert’s colleague Gerrit Rexhausen, innovation manager for Industry 4.0 projects. One of the reasons for this is the time-consuming certification processes. “You can’t just quickly install a software update on a 3D printing machine or move it a meter to the side. After every tiny change, we have to demonstrate that the process and component quality is still perfect,” says Rexhausen. From now on, therefore, the proportion of 3D-printed components in aircraft will increase gradually but slowly. The vision of the intelligent factory will be implemented in the same evolutionary way. Until it is one day capable of autonomous production, humans and robots will continue to work side by side for a long time to come. However, Taubert is convinced that the topic of cyber security will develop more rapidly. “The standards are already very high today - but as the amount of data in all areas is rising sharply, in five years’ time we will see an increasing number of aviation companies with their own cyber-security departments.”