Andreas Klöckner coordinates research into electric flight at DLR

CHANGE IS IN THE AIR

The vision of the quiet and climate-friendly aviation of the future is at the heart of DLR's aeronautics research. Andreas Klöckner sees electric propulsion as a vital part of this change – hardly surprising, given that the aeronautical engineer coordinates research on electric flight at DLR. Hybrid-electric commercial aircraft have the potential to bring about a mobility revolution that is now within reach. In this interview, Klöckner explains the research challenges still to be addressed by DLR scientists, and the innovations needed before e-mobility can really take off.

An interview with Andreas Klöckner on electric flight

Electric cars are now part of the cityscape in many places. When will electric mobility manage a similar feat in the air?

: Efforts towards developing increasingly electrified aircraft are a step in the right direction and they are important, because today's aviation is facing huge challenges. Electric propulsion can provide part of the solution. Air traffic is already responsible for around five percent of the global climate impact, yet the demand for mobility in the air continues to rise steadily. The International Air Transport Association estimates that air traffic will double every 20 years. If we want to achieve the targets set by the European Commission to reduce carbon dioxide emissions by 75 percent by 2050, we have to start thinking about making radical changes to our air transport system now.

Is aviation on the threshold of sweeping change?

: Yes. Electric propulsion marks a radical shift. Imagine using an electric motor to drive the propeller or fan, instead of using a conventional gas turbine. This change, while ostensibly simple, entails numerous changes. For one thing, we have to provide the electrical energy somehow. Ideally, we would do that with batteries or fuel cells, or use an electric generator on a power turbine. In all likelihood, however, we will need a hybrid solution with several energy sources that can, for example, be used for different flight phases. We have to make similar decisions about the distribution of power within the aircraft. The focus here is on the technical constraints dictated by the voltage level and current, so we also have to think about superconductive solutions. Last but not least, power needs to be converted into motion. Alongside the usual aircraft configurations, electric propulsion also opens up the possibility of distributed propulsion, boundary layer ingestion or air taxis with vertical take-off.

Is electric flight no longer just a pipe dream?

: Over the last few years, there has been a growing interest in this area, which has been reflected in increasing investment in research. To give some examples, Airbus and Siemens have taken on 200 employees at their new site in Ottobrunn, near Munich, for this very purpose. One of the six programme lines within the German Federal government's aviation research programme is explicitly dedicated to electric flight, and the European Union is also providing funding for electric aviation projects to the tune of several million euro. That kind of investment is vital because if electric aviation succeeds, it will have a huge impact on the supplier pyramid in the aviation industry. The two principal components of the aircraft – namely the airframe and the engine – will no longer be considered separately, as they are today. As a result, engine manufacturers will increasingly be on an equal footing with aircraft manufacturers. Some people are already predicting that the airframe will be built around the propulsion system.

What is driving the increase in research relating to electric flight, and large-scale investment by aircraft manufacturers?

: Essentially, there are three advantages to electric flight. Firstly, flying powered by electricity alone is locally emission-free. This means that the aircraft itself does not emit any pollutants. Noise pollution – whether at the airport or inside the cabin – could also be significantly reduced. Secondly, electrical systems are expected to incur fewer production and maintenance costs due to the lower number of moving parts. That said, we still face major challenges in terms of the mass production, ageing and maintenance of key components, such as the batteries. The third benefit is that electric engines enable completely new aircraft configurations, which should further reduce fuel consumption, and thus emissions. All in all, electric flight brings completely new transport services into the realm of the possible. A quiet, clean and cost-effective mode of transport – perhaps with vertical take-off – could mean, for instance, that flying shuttle services from the city centre to the nearest big airport are quite conceivable. It is a scenario to which a whole series of start-ups have already committed themselves ...

Successful interaction between all these components would therefore pave the way for completely new mobility concepts. How will electric aircraft change the face of aviation?

: Plenty of small electric aircraft are already being flown by amateur enthusiasts. Gliders with electric auxiliary engines have also been around for years. Electric aircraft will start to conquer new niches, starting with the general aviation sector. In a few years, we might indeed see the first electric air taxis carrying well-off customers across megacities like São Paulo or Mexico City. Over time, electric engines will reach a larger customer base and also find their way into larger commercial aircraft. Initially, we are likely to see the greatest changes at the regional and national levels: I am thinking of shuttle services that might be set up at small airports, or a further expanding air transport network. This would be particularly useful for business-people who do a lot of travelling. However, we are still very far from being able to fly with electric power across the ocean – and when it happens it will be with hybrid propulsion systems.

Norway aims for all short-haul flights to be on electric aircraft by 2040. How feasible do you think this is?

: It is ambitious, but completely achievable. We are already managing to transport two to four people several hundred kilometres using e-power. Our fuel cell research is looking at ranges of up to 1500 kilometres. That would make it possible to fly almost the entire length of Norway, but most routes are much shorter than that – usually around 500 kilometres. The challenge is to scale the systems up to passenger numbers of 50 to 80, as is normal for aircraft flying regional routes. We will probably not be able to do this on battery power alone in the near future, due to the weight. With the same energy content, batteries are around 60 times heavier than kerosene. However, hybrid transitional solutions could allow us to

View of a national electric flight test facility planned by DLR.
It will be used for test flights with an electrically powered commercial passenger aircraft.

combine the energy density of kerosene or hydrogen with the emission-free properties of batteries. Of course, this still leaves a lot of questions up in the air – from optimal configuration to infrastructure such as charging facilities, not to mention the renewable generation of the electrical energy required, or even just the hydrogen. At DLR, we are addressing all of these issues.

The need for individual mobility is a driving factor in road transport. Does this also apply to aviation?

: A large number of start-ups and research groups are dedicated to pursuing the dream of individual aviation. These days, it is possible to rent your own helicopter in the world's biggest cities, but that is still unaffordable for most people, and it is likely to remain this way for the time being. The sheer effort of coordinating thousands of individual air taxis in urban areas using the procedures required today effectively prohibits any widespread rollout of such solutions. Nonetheless, extensive research is being carried out into automated, unmanned aircraft. For example, we are working on a comprehensive, automatic and, most importantly, scalable solution for air traffic management. These solutions could certainly be applied to individual air transport, including automated aircraft, in the future.

What do you consider to be the biggest obstacles to electric aviation?

: For one thing, there is the propulsion system. At DLR we are investigating different propulsion technologies – from concepts, simulations and laboratory set-ups through to integration into new aircraft configurations. The impact on the overall aviation sector is another concern. In this area, we are looking at the consequences for travellers, airlines, regulatory authorities, other airspace users, airports and even local residents. In doing so, we have to consider the scaling aspects: bigger aircraft, more travellers, more frequent flight movements, and so on.

In everything that we do, it is important to understand and develop the basic technology, but also to think ahead and keep looking at the big picture. We have already achieved huge success with technology demonstrators such as the HY4, which is being used to test pioneering fuel cell technologies in flight. The next step is to think about aircraft in the next size class – and we are not the only ones who will be doing so.

How is Germany, and Europe as a whole, positioned for the market launch of electric aircraft?

: In Europe, and Germany in particular, we are in an excellent position. DLR is the only large-scale research institution in Europe with the capability to study all aspects of electric flight at the required level of detail, and to follow it through in actual demonstrations. There are only a handful of comparable research institutions around the world. We collaborate with universities that are outstanding in this field, as well as with innovative industrial companies. Clearly, the boundaries between traditional aviation and other sectors of industry are becoming increasingly blurred. When it comes to electric flight, it is important not only to have the big names of the industry on board, but also electrical engineering companies, which have not traditionally been closely associated with aviation. In addition, an ever-growing number of small businesses and start-ups are injecting the necessary agility into the system. What we really need next is a research aircraft that allows us to test all of the technology required for electric flight, and which is accessible to all of the parties involved. DLR should play an integrative role here, and we are ready to do that.

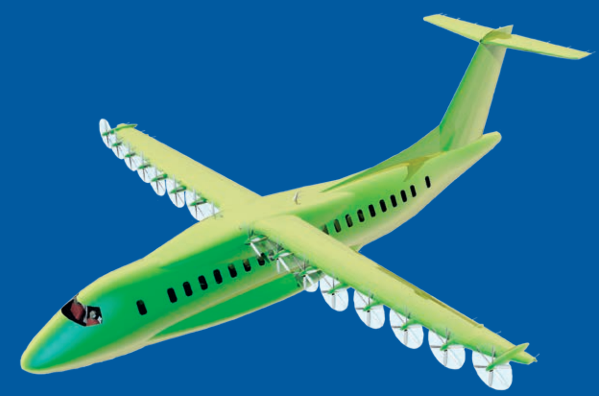
What about the certification procedures? There are bound to be a lot of issues to address there ...

: Yes, indeed. Some are obvious. For instance, how do we deal with large, flammable batteries? Others are more entrenched in the system: the current approval requirements simply do not cater for any type of drive systems other than piston engines and turbines. Nevertheless, we are working under the assumption that electric engines will be used in aircraft sooner or later. The regulatory authorities are also starting to cooperate with research, industry and standardisation bodies. We are benefiting from the fact that aviation certification is also having to address other challenges at the moment. Unmanned systems may be far more difficult to certify than electric engines. The European Aviation Safety Agency (EASA) has already developed much more flexible regulations in conjunction with its sister organisations around the world. Previously, these bodies prescribed specific tests, but now they only stipulate the overarching criteria. Aviation authorities are working closely with standardisation bodies to devise specific and appropriate inspection methods. These are mostly based in the United States, though, so we could do more work on this in Europe. In any case, DLR will continue to bring its expertise to bear on all these issues, as stated in a recently signed framework agreement with EASA.

Mr Klöckner, could you sum up the current state of electric flight in one sentence?

: Electromobility is already in the air, and research is still required before it can enter the commercial market, but as far as DLR is concerned, the aviation Energy Transition is already under way.

The interview was conducted by **Annabel Brückmann** of the Aeronautics Programme Strategy Department at DLR.

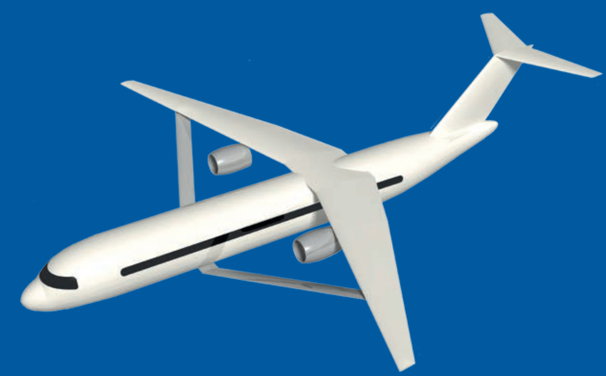


Regional Hybrid Demonstrator-MH

Concept for a regional airliner with distributed engines. By arranging many power units along the wing, the lift can be increased and the propulsion efficiency improved. The increased lift can be used to reduce the required wing area and thus to reduce weight and drag. In addition, control of the aircraft can be performed in part by individual control of the propulsion motors. This means that the tailplane and horizontal stabiliser can be of a smaller design and thus also lighter and offering lower drag. This concept was considered in the context of the Clean Sky 2 project ADEC.

ADEC BLI Canard 01

Concept for a short- and medium-range aircraft with a hybrid electric propulsion system. An electrically driven fan at the rear draws in the fuselage boundary layer and thus improves the propulsion efficiency. This research is being carried out as part of the ADEC W.P.-1.6.1.4 project (Advanced Engine and Aircraft Configurations), which, in turn, is part of the European Clean Sky 2 programme. In addition to DLR, research facilities from France (ONERA) and the Netherlands (TU Delft, NLR), and the industrial partners Airbus and Rolls-Royce are involved.



NACOR SBFSW-WE

Concept for a short- and medium-range aircraft with a forward-swept, strut-supported wing. The braced wing has a lower mass than a self-supporting design. The negative sweep enables natural laminar flow in some areas, which significantly reduces drag. The research work is ongoing in the NACOR TS A-1.3 project (Novel High-Efficiency Configurations) as part of the European Clean Sky 2 programme. In addition to DLR, research institutions from France (ONERA) and the industrial partners Dassault Aviation and Airbus are involved.