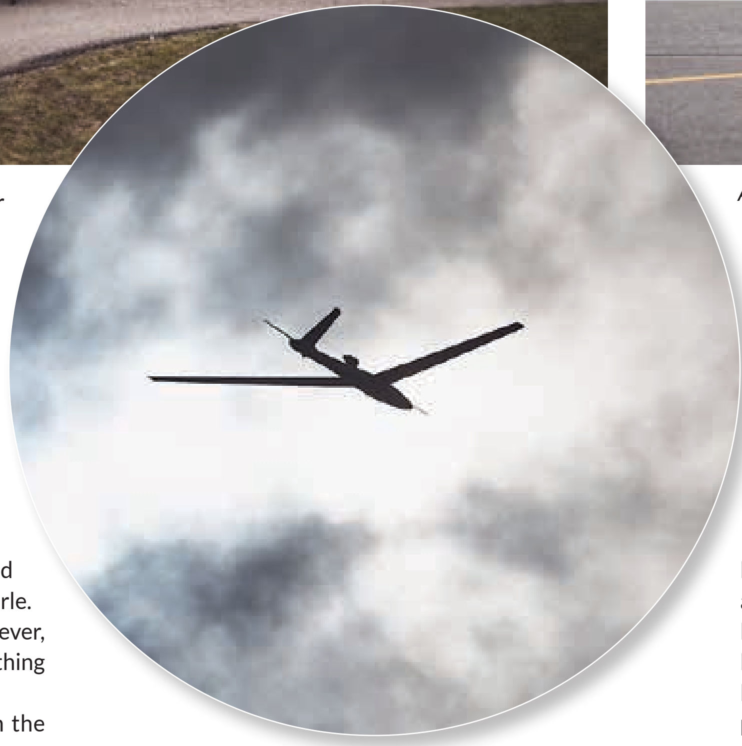
First flight for super-efficient aeroelastic wing

In a joint effort by the Technical University of Munich (TUM) and the German Aerospace Centre (DLR), researchers have successfully developed and tested technologies for lighter aircraft wings that are still extremely stable. These innovative wings could soon make flying both greener and more cost-efficient. Known as aeroelastic wings, a successful first flight was completed at an airfield in Oberpfaffenhofen, Germany late last year.



Above right: *The unmanned flying demonstrator with 7.0 m wingspan takes off at the Oberpfaffenhofen airfield. This demonstrator uses the aeroelastic carbon fibre wing developed by DLR in collaboration with Delft University of Technology. Systematic alignment of the fibres when making the wing has allowed researchers to optimise the wing's flexural and torsional behaviour.*

Above left: *FLEXOP aims to develop and validate new methods for designing active and passive systems for flutter suppression of very light and more flexible wing structures. Partners from industry and academia are working on control algorithms, actuators, design optimisation as well as the development of an unmanned flying demonstrator with a 7.0 m wingspan and engine propulsion system for testing these innovative approaches.*

Left: *The demonstrator flying at an estimated height of 130 m. Maximum altitude is not actually of great interest and the test flights are generally conducted at below 300 m.* Photos: ©Fabian Vogl; TUM.

Wings with a wider wingspan and less weight also have less air resistance and better energy-efficiency. Optimised lift behaviour could save fuel and thus reduce both emissions and costs. The limiting factor for building wings such as these is the aerodynamic phenomenon known as flutter. Aerodynamic drag and wind gusts result in continuously increasing wing vibration, similar to a flag fluttering in the wind.

"Flutter leads to material fatigue and can even go as far as ripping off the wing," explains Sebastian Köberle, research associate at the TUM Professorship for Aircraft Design. Although every wing begins to flutter at a certain speed, shorter and thicker wings have higher structural rigidity and thus higher stability. Making wings that have a wider wing-span that are still exactly as stable will add much more weight.

The European project FLEXOP (Flutter Free FLight Envelope eXpansion for ecOnomical Performance improvement) involves scientists from six countries working on new technologies that can bring flutter under control and, at the same time, make it possible to build and use lighter wings.

FLEXOP aims to develop and validate new methods for designing active and passive systems for flutter suppression of very light and thus flexible wing structures. Under the guidance of the Horizon2020 research and innovation program, partners from industry and academia from the six countries are working on control algorithms, actuators, design optimisation as well as an unmanned flying demonstrator with 7.0 m wingspan and engine propulsion system for testing these innovative approaches.

Test flights demonstrate behaviour of innovative wings

The TUM researchers are responsible for the conceptual design and execution of the test flights. The tests aim to demonstrate the actual behaviour of the two innovative wing designs developed in the project: The aeroelastic wing and the flutter wing.

Here the TUM scientists first built a three-and-a-half metre long, seven meter wide flight demonstrator in which they integrated the systems provided by their European partners. Using reference wings configured especially for this purpose, the researchers then worked to make the flight demonstrator automatically fly a predefined test flight path. They figured out the optimum settings and developed manuals and checklists for the test flights. "The flight demonstrator is supposed to fly so fast with the new wings that they would theoretically have to flutter," says Köberle. "When flying at such high speeds, however, we have to be absolutely sure that nothing goes wrong."

The aircraft has to be visible from the ground at all times so that the researchers can intervene in case of an emergency. This means that flight manoeuvres have to be performed within a tight radius of only one kilometre.

Sebastian Köberle, research associate at the TUM Professorship for Aircraft Design, along with Daniel Teubl and Dr. Christian Rößler, transport the demonstrator from the DLR apron to the runway. Photo: ©Fabian Vogl; TUM.

Successful first flight of the aeroelastic wing

After completion of the complex preliminary work, a test flight with the innovative wing could be conducted for the first time. "Up to now everything has worked out just as we expected it to," says Köberle. "Now the data evaluation starts."

The wing, which took off for the first time at the Oberpfaffenhofen airfield, is the aeroelastic optimised wing developed by DLR in collaboration with Delft University of Technology and is made from a carbon fibre composite. A special alignment of the fibres when making the wing allowed the researchers influence its flexural and torsional behaviour. "If the wing is bent by the force of the air, it turns at the same time, avoiding the force of the wind," says Wolf-Reiner Krüger from the DLR Institute of Aeroelasticity in Götting.

Active flap control on the flutter wing

The second super-efficient wing developed in the project is referred to as the flutter wing, designed by TUM and made of fibreglass. When flutter occurs, the outermost flaps are deployed, functioning as dampers. "The integrated active flap controls developed at DLR significantly increase possibilities for a significantly lighter design," says Gertjan Looye from the DLR Institute of System Dynamics and Control in Oberpfaffenhofen. Looye is responsible for coordinating the DLR portion of the project.

A second flight control system is being developed by the Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA SZTAKI). The project director Bálint Vanek of MTA SZTAKI adds: "A wing like this could make it possible to transport 20% more freight or to use 7.0% less fuel." Since the technology involved is very complex, the tests on this wing have not yet been conducted.

From demonstrator to passenger aircraft

The wing is intended to do more than just take off on the flight demonstrator: In a further step the results of the project are to be transferred to the design of transport and passenger aircraft. ❑

The computer workplace of the Ground Control Station. The middle computer screen shows the map and the heads up display used for guiding the demonstrator. Photo: ©Fabian Vogl; TUM.