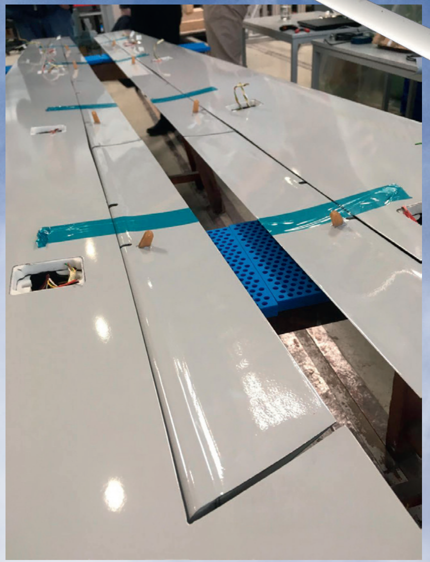
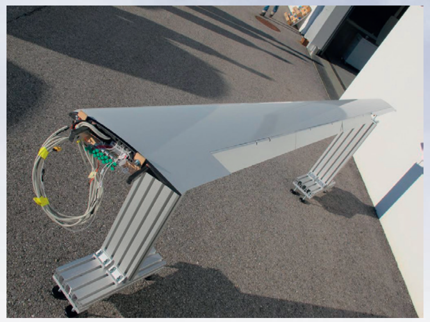
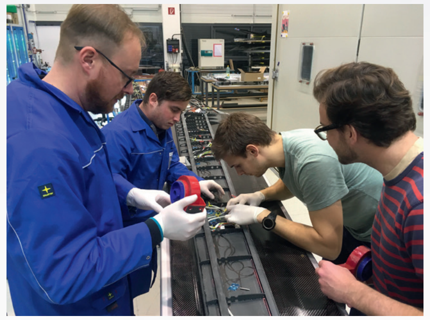
A new approach to flutter in flight

Flutter can break an aircraft's wings, so it's an important consideration in design. Researchers in the Flexop project are developing new tools to both model flutter and to control it during flight, which could open up new possibilities in design and boost the competitiveness of European industry, as Dr Bálint Vanek explains.







A phenomenon which occurs when aerodynamics and structures couple in an unstable way, flutter can cause aircraft wings to break, and so is a correspondingly important consideration in design and development. Based at the Institute for Computer Science and Control Hungarian Academy of Sciences (MTA SZTAKI) in Budapest, Dr Balint Vanek is the coordinator of Flexop, a project which brings together academic and commercial partners to develop multidisciplinary aircraft design capabilities. "We are developing methods to actively control aeroelastic deformation," he explains. Researchers in the project are developing active control methods to get the flutter phenomenon under control, and to ensure that it doesn't have adverse consequences."We are developing methods and tools to model aero-servo-elastic behaviour, while we are also developing methods and tools to get it under control," continues Dr Vanek.

This could open up new possibilities in aircraft design and development. Currently, aircraft are designed to be free from flutter under all flying conditions, but with sophisticated active control methods, it would potentially be possible to control flutter during flight. "We are looking at whether this flutter phenomenon could be brought closer to the normal operating range in future, where there's always an active control method in place which keeps it under control," says Dr Vanek. This means that designs previously considered unviable could be looked at afresh, while also opening up new possibilities. "For example, an airframe which is very flexible and prone to flutter may be allowed to fly in future. This is because flutter will not occur, given that you have a smart control system in place which is able to suppress the oscillations caused by flutter," explains Dr Vanek. "It would be like an additional layer of the fly-by-wire system.

Aeroelastic behaviour

A deep understanding of flutter and the behaviour of aircraft wings during flight is central to this wider goal. An aircraft wing can be thought of as a kind of flexible beam; researchers are exploring new methods of controlling its behaviour in terms of bending, torsion and certain other axes. "With both active and passive feedback mechanisms, it's possible to reduce the loads on the wing. Very sophisticated mathematical models and tools are required to model the aeroelastic behaviour and design the feedback controls," outlines Dr Vanek. Within the project, researchers have access to large volumes of data on how wings behave during flight. "We have developed a complete unmanned demonstrator aircraft to validate our tools, and we have put a large number of sensors on the wings of this aircraft. Each wing has hundreds of measurement points to monitor wing stress and deformation with fibrebrags, in addition to the six accelerometers and 12 rate gyros, which are used for onboard the flight control computer in the development of the active control mechanisms," says Dr Vanek.

This data is then used to validate the mathematical models, while also helping researchers gain deeper insights into the behaviour of the wing during flight. Research into wing aeroelasticity is coupled with investigations into the flight control system during the design process, representing a new approach. "Aeroelastic analysis and flight control have traditionally been done separately," explains Dr Vanek. However, researchers in the FLEXOP project are now trying to couple these two areas in the design process, which could help improve efficiency and reduce the costs of aircraft development. "As it's in the design stage the feedback loop is closed earlier, so potentially the design changes are less costly," he explains. "It's a very multi-disciplinary project, yet traditionally flight control and aeroelasticity people did not work together that closely."

The two groups may not always interpret an aeroelasticity model in the same way, so methods and tools have been developed in the project to effectively bridge the gap. Alongside the tools and methods that are being developed, an aircraft itself is being built within the project, which Dr Vanek says is an important feedback mechanism. "It effectively helps to get both groups on the same page, both the aeroelasticity people and the flight control people," he says. The aircraft itself is nearing completion, and different experimental wing-sets have been developed. "The aircraft will be flying at some point over the next few months, and we will start gathering data, while in parallel we are also going to work on the scale-up," continues Dr Vanek. "In the scale-up we want to essentially extrapolate all the tools and methodologies to a full-sized commercial aircraft."

our preliminary results at the CleanSky 2 meetings, and there was a lot of interest in the technologies that have been developed in the project," says Dr Vanek.

The wider goal in the project is to help improve the efficiency of the aircraft design cycle, and also the performance of aircraft in terms of issues like fuel efficiency and their overall payload, or their carrying capacity. One major objective in the field is to design a lighter airframe, which would have knock-on effects. "If the airframe is lighter, then less fuel is required. So in principle, if you don't have that much structural reinforcement in the wing, then you can use that to either fly further or to carry a greater payload," says Dr Vanek. Improved aeroelastic tailoring and optimisation of the aircraft structure could lead to further weight reductions, an important consideration for industry. "For example, aerocomposites company FACC is a tier-one supplier to several aerospace companies. It's very important for them to see how aircraft wings will be built in future," stresses Dr Vanek.

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This could provide a significant boost to the European aircraft industry at a time when it faces increasingly intense competition from emerging markets. A number of different scale-up configurations have been identified, now Dr Vanek is looking to explore the likely impact on aircraft performance. "We want to look at the trade-offs in terms of payload and fuel efficiency in those new configurations, trade-offs which are enabled by the technologies and methodologies which we have developed in the project," he outlines. These are of course important considerations for manufacturers, and so there is a lot of interest from the commercial sector in the project's research. "I presented

FLEXOP

Flutter free flight envelope expansion for economical performance improvement

Project Objectives

The FLEXOP project is about developing multidisciplinary aircraft design capabilities for Europe that will increase competitiveness with emerging markets - particularly in terms of aircraft development costs. A closer coupling of wing aeroelasticity and flight control systems in the design process opens new opportunities to explore previously unviable designs. Common methods and tools across the disciplines also provide a way to rapidly adapt existing designs into derivative aircraft, at a reduced technological risk.

Project Funding

Horizon 2020. https://flexop.eu/facts

Project Partners

• https://flexop.eu/partners

Contact Details

Virág Bodor, Project Manager
MTA-SZTAKI
Hungarian Academy of Sciences
Institute for Computer Science and Control
H-1111 Budapest,
Kende u. 13-17.
Hungary
T: +36 1 279 6220
E: bodor.virag@sztaki.mta.hu
W: https://flexop.eu

Dr Bálint Vanek

Dr Bálint Vanek's research interest includes safety aspects of both manned and unmanned aerial vehicles (UAV), which includes areas of aeroservoelasticity, fault detection and reconfigurable control of aerospace systems, mainly using the linear parameter-varying (LPV) framework. UAVs and their insertion into the common airspace is another research topic I am interested in. I am working on developing a safety critical avionics architecture for small UAVs and also providing them a vision based sense-and-avoid capability. I am the coordinator of the H2020 Research Project FLEXOP, working on flexible aircraft control technologies, to mitigate the effects of flutter, and also the PI of EU H2020 VISION.