Unseen danger – Frank Holzäpfel investigates the propagation of wake turbulence

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Is it actually true that migrating birds sometimes fly in a V-formation because they can take advantage of the wake flow generated by the bird in front? Frank Holzäpfel laughs. "Yes that's correct. There have even been scientific studies into this subject. The wings of birds generate similar vortical flows to the wings of an aeroplane – wake vortices. The bird flying behind can make enormous use of the updraft region of this vortex. It saves energy!" Aircraft create such turbulence behind them as well, but on a larger scale and with consequences for following aircraft. Fluid dynamics expert Frank Holzäpfel is working on understanding and predicting the behaviour of these vortices – and he can accelerate their decay.

From combustion chambers to the open atmosphere

When Frank Holzäpfel completed his doctorate in mechanical engineering at the Karlsruhe Institute of Technology in 1996, there was already a job waiting for him at Daimler in Stuttgart-Möhringen; his career path would have started as a trainee. But his direction changed while he was still at university: "While I was doing my doctorate, I came to associate the name 'Schumann' with authority in the area of fluid dynamics," says Holzäpfel, recalling the former director of the DLR Institute of Atmospherics Physics, Professor Ulrich Schumann. A job advertisement appeared in the weekly journal 'Zeit' at just the right time. According to the advertisement, a scientist was needed in the DLR Department of Cloud Physics and Transport Meteorology to "develop an effective mathematical and physical model for calculating the lifetime of wake turbulence behind aircraft". The newly fledged doctor saw an opportunity for applying the knowledge from his doctoral work on highly turbulent vortex flows in combustion chambers to aircraft wake flows in aviation. "The subject matter was more important to me than material rewards at the time," recalls Holzäpfel – and it was the subject matter for the vacant position that took him to Oberpfaffenhofen. Holzäpfel, who was the fastest at his institution to get his doctoral qualification with distinction, immediately got along with Professor Schumann, so he resigned from Daimler and joined DLR.

Wake turbulence – a challenge in aviation

"If you say to somebody, at a party for example, that you work on turbulence in combustion chambers or that your dissertation had the title 'Turbulence Structure in Free and Confined Swirl Flows', you can be sure that the conversation will be over in two minutes," the 51-year-old scientist says, raising his eyebrows. But the subject of wake turbulence is much more interesting, and it has moved him from combustion chambers to the open atmosphere: "It is a tangible subject that concerns everyone, as it involves the safety of human life in air travel." This is because wake turbulence presents a safety problem in aviation. A very specific safety distance must be maintained when aircraft take off and land. This is because the air behind the wings experiences strong coherent rotation, and this can cause the following aircraft to experience a powerful roll moment and rotate around its longitudinal axis. Therefore, trailing aircraft must wait until the air has calmed down again during take-off and landing at an airport. The fact that the scope of his activity stretches from basic research to the application of this in and around aircraft is what still appeals to the DLR scientist about this research area.

Well connected

Holzäpfel used his first years at DLR – until 2005 – to obtain his postdoctoral lecture qualification in Fluid Mechanics at the Technische Universität München. In collaborating with other DLR institutes, his expertise has created synergies in the area of wake turbulence

research. "You cannot make progress in research without good internal contacts," says Holzäpfel. "This is because we have to keep the entire system in view – everyone must be involved, from experts in fluid dynamics, flight dynamics and flight guidance to users such as airports, air traffic control and pilots, as well as aviation authorities and manufacturers." As a scientific advisor, Holzäpfel has also had the support of external partners during the most spectacular wake turbulence flights; in 2006, the first wake turbulence tests for the new Airbus A380 took place at the Oberpfaffenhofen research airport. Following this successful research into wake turbulence and advice from Frank Holzäpfel, Airbus announced that recommendations for suitable safety distances to other aircraft could be made available.

Fascination for the media

Armed with six white boards of painted plywood measuring 2.2 metres by 4 metres, Holzäpfel and his team set off for the runway at the Oberpfaffenhofen research airport in April 2013, which was pleased to assist with the latest experiment relating to wake turbulence. The DLR team aims to use this new technique to reduce dangerous vortices from landing aircraft. Wake turbulence is formed as a result of the difference in pressure between the top and undersides of aircraft wings. It is particularly dangerous for lighter aircraft landing behind heavier airplanes. The already patented technique for reducing this wake turbulence has now been tested by DLR researchers under real flight conditions for the first time. A camera team from the BBC accompanied the scientist that day. "I hadn't expected that I would be filmed from every possible angle," confesses Holzäpfel, who had come into such close contact with the media for the first time as part of the research project. DLR test pilots guided the HALO research aircraft through artificially generated smoke, which made the invisible spiralling of the vortices behind the wings visible. The DLR HALO research aircraft flew over the white board construction at 250 kilometres an hour and at an altitude of 22 metres. "This is about having barriers on the ground to disrupt the wake turbulence," explains Holzäpfel. The boards, which are placed parallel to the direction of approach, create small vortices themselves, and so accelerate the decay of the aircraft's wake turbulence.

Natural science meets social skills

The scientist lives with his wife Marcela Sebesta-Holzäpfel and four children among the greenery of Utting am Ammersee. "This is another reason why I decided to join DLR," the scientist says with a smile. Being born in Heilbronn, he wanted to live as close to water as possible. With a house 200 metres from the Ammersee coast, he has managed this. While his everyday work involves scientific subjects, he and his wife have developed a secondary line in social education. During his doctorate, the two worked with other committed individuals to develop emergency fostering for children in Karlsruhe. For the Holzäpfel family, this means taking in foster children for a transition period lasting from a few weeks to several years. The family has now taken in 17 children for various periods of time. Besides two children of their own, they have permanently integrated two of these children into their family. "For us, the time during which we took in children for emergency fostering was a tremendous experience," says Holzäpfel. He and his wife have been studying many aspects in the area of social work and social skills through this commitment for the past 20 years. "What I have learned I can apply in all sorts of wonderful ways in my private life and my daily work as a researcher."

Contacts

Miriam Kamin
Deutsches Zentrum für Luft- und Raumfahrt (DLR) - German Aerospace Center
Tel.: +49 8153 28-2297
Fax: +49 8153 28-1243
Miriam.Kamin@dlr.de

Frank Holzäpfel
German Aerospace Center (DLR)
Cloud Physics and Traffic Meteorology
Tel.: +49 8153 28-2529
frank.holzaepfel@dlr.de

Frank Holzäpfel

Frank Holzäpfel has been working at the DLR Institute of Atmospheric Physics in Oberpfaffenhofen since 1996. The researcher is working on understanding and predicting the behaviour of these vortices - and he can accelerate their decay.

Credit: DLR (CC-BY 3.0).

DLR Patent - 'Plate Line'

Secondary vortices form on the approximately four-metre-long plates, which causes the primary wake turbulence to dissipate significantly faster.

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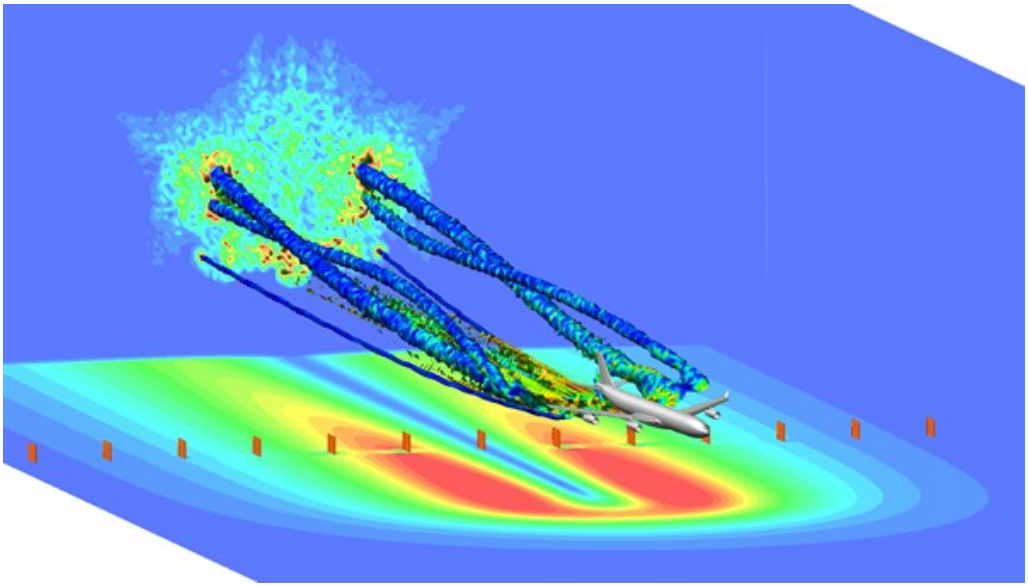
Wake vortices in a simulation



Wake turbulence simulation for an Airbus A340 on final approach, just before touchdown. Below the aircraft, a 'Plate Line' can be seen. DLR has developed a globally unique method to simulate the flow around the aircraft with the creation of vortices, their further development and eventual dissipation. Here, the vortices are shown during their formation – prior to decay.

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