Wake turbulence - DLR tests warning system in flight experiments

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When in flight, aircraft generate turbulence behind them known as wake vortices, which can affect the air traffic that follows. The German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) is currently testing a wake turbulence warning system in flight experiments using its ATRA and Falcon research aircraft. The system can predict potentially dangerous wake turbulence using just the positional data and weather information from a preceding aircraft.

Making turbulence visible

In a total of three research flights, the Falcon acted as a vortex generator, making repeated passes across the flight path of the ATRA (Advanced Technology Research Aircraft). "In the system we have developed, precise information on the position and speed of the preceding aircraft is received by conventional flight safety systems on board ATRA," explains Fethi Abdelmoula of the DLR Institute of Flight Systems. "The computer can use this data to compute where wake turbulence, which is invisible in the absence of condensation trails, exists in the airspace." The pilots see these predictions on a display. The calculations take into consideration the wind and atmospheric conditions, using software developed by the DLR Institute of Atmospheric Physics. The researchers tested the accuracy of the wake turbulence predictions with flights directed into the turbulence.

Precise coordination

"A particular challenge in these flight tests is the precise coordination of the flight of the two aircraft into the wake turbulence," says flight test engineer Adrian Müller from the DLR Flight Experiments Facility. The scientists use the condensation trails from the Falcon to detect the otherwise invisible turbulence during the flight. As ATRA, an Airbus A320 converted into a research aircraft, is significantly larger than the Falcon, the amount of vibration experienced when flying into the turbulence is comparatively small. The manoeuvres were flown in the airspace above Mecklenburg-Vorpommern and Brandenburg. The research aircraft took off and landed at DLR's Braunschweig site.

Rolling over the wingtips

Wake turbulence, which is also referred to as wingtip vortices, consists of counter-rotating trails of turbulent air streaming behind an aircraft in flight. Their intensity depends on the size and weight of the aircraft. Consequently, the wake turbulence of large jets such as the Airbus A380 or Boeing 747 is particularly powerful, so smaller aircraft must maintain an increased safety distance of up to 15 kilometres behind these giants of the skies. The lifetime of wake turbulence is influenced by the wind conditions, turbulence and temperature stratification in the atmosphere. Generally, the wake turbulence slowly decays before dissipating entirely. Wake turbulence originates from the aerodynamics of the wingtips. The reduced pressure of the upper side of the wing combines with the increased pressure on the underside of the wing, causing the air to roll over the wingtip and form a vortex.

DLR wake turbulence projects

DLR scientists have been working on the basic functionality of the DLR Wake Encounter Avoidance and Advisory system (WEAA) since 2012, in the Weather-Optimised Air Traffic (Wetteroptimierter Flugverkehr; WOLV) and Land-Based and Onboard Wake Systems (L-bows) projects. Under the guidance of the DLR Institute of Flight Systems, a technology is gradually

being developed that predicts wake turbulence along the flight path, estimates its effects and recommends a suitable avoidance manoeuvre – or carries it out automatically if necessary. The DLR Institute of Atmospheric Physics is contributing the wake turbulence prediction software. Part of the work was conducted under a contract with Airbus. A complete demonstration model of the warning system is expected to be ready by 2017.

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DLR ATRA research aircraft

The Airbus A320-232 'D-ATRA' (Advanced Technology Research Aircraft) is the largest member of the DLR research fleet.

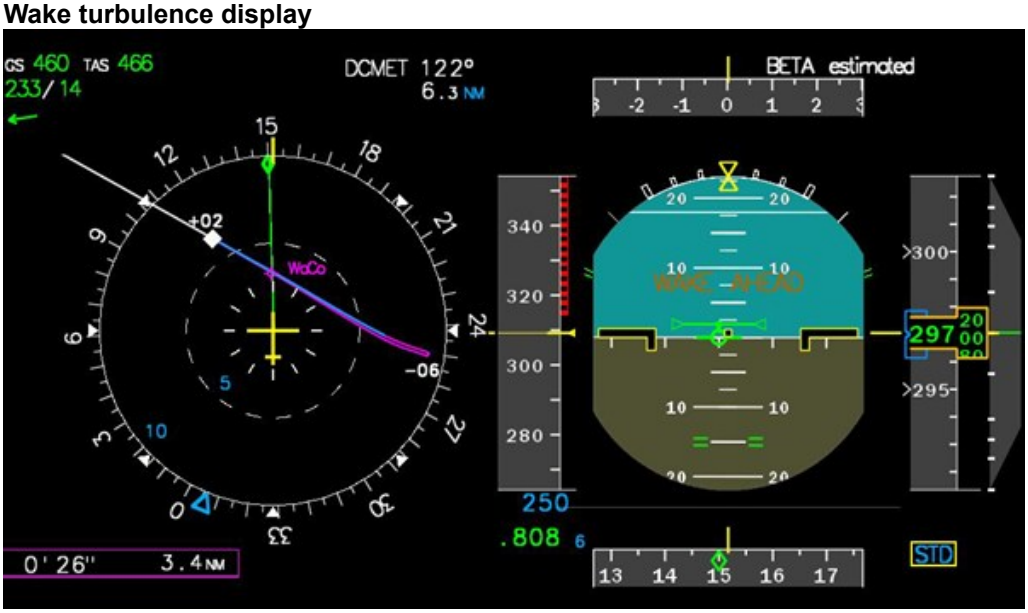
Credit: DLR/Evi Blink (CC-BY 3.0).

Falcon and ATRA outside the hangar at DLR Braunschweig

The DLR research aircraft ATRA (Advanced Technology Research Aircraft) and Falcon started their joint flight tests from the Braunschweig research airport.

Credit: DLR (CC-BY 3.0).

Wake turbulence display



Navigation display – a magenta line indicates the area of the wake. The 'WaCo' symbol shows the predicted position of conflict with the wake turbulence.

Credit: DLR (CC-BY 3.0).

DLR Falcon research aircraft

The DLR Falcon can fly higher than most commercial aircraft and is extremely robust and agile.

Credit: DLR (CC-BY 3.0).

Condensation trails are well suited for the visualisation of wake turbulence

Since they constitute an appropriate technique for visualising the two individual components of a wake, good visibility of contrails in the cruise range above 10,000 metres is a prerequisite for carrying out the experiments. Experts from the DLR Institute of Atmospheric Physics predicted condensation trail formation using the Schmidt-Appleman criterion.

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