Greater safety in aviation – detecting turbulence in advance

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Many aircraft passengers are familiar with the phenomenon; the sky is clear and blue, the aircraft is cruising calmly, but suddenly everything is disrupted by temporary turbulence. Passengers frequently experience this as a kind of 'hole in the air'. The reason for this unpleasant change in flight altitude is something known as 'clear-air turbulence' (CAT) – turbulence that occurs independently of cloud cover, is invisible and cannot be accurately predicted. For both passengers and crew, strong turbulence can mean an increased risk of falls and accidents. Recent results in atmospheric research indicate that such turbulence will occur more frequently due to climate change and will become even more of a problem for aircraft. However, a method of detecting turbulence has now been developed for the first time, under a European joint project called DELICAT (Demonstration of LIDAR based Clear Air Turbulence detection). The new technology is currently being tested by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and the project partners. The current measurement flight campaign will take place until the end of August. The flight route starts in Amsterdam and continues throughout Europe.

Origin of turbulence

Wind shear often occurs along the jet stream. This involves extended layers of air that move against each other horizontally at different speeds. Particularly strong wind shear can create waves that ultimately break, like waves on water. When a wave breaks, it either causes vortices in the air, or turbulence – specifically CAT.

When an aircraft encounters this turbulence, it alters the angle of the airflow over the wings; this leads to the familiar changes in lift. CAT has long been an unavoidable phenomenon in aviation, as these swirling air masses in the clear sky are neither visible to the eye nor measurable with sensors.

A solution is on the horizon; in future it might be possible to calculate where air turbulence is, using laser measurements to generate the required data. The idea is to identify, in advance, any minor changes in the density and speed of the air along the flight path and use this to detect and predict CAT from a distance.

Measurement by laser

Researchers at the DLR Institute of Atmospheric Physics have developed a laser-based measurement device to do this. A LIDAR (Light Detection and Ranging) instrument can be installed on board an aircraft and emits short-wave ultraviolet laser radiation along the direction of flight. The density of the air is determined from the backscatter value measured for the air molecules, oxygen and nitrogen. Fluctuations in this density then provide information about the turbulence there. This indirectly acquired information enables analysis of the air in the region the aircraft is about to fly through. In other words, clear air turbulence is made visible in advance along the route.

Specially developed measuring instrument

The project DELICAT test flights currently taking place are being used to demonstrate the measurement process and the functioning of the new technology. The PH-LAB research aircraft, a modified Cessna Citation operated by Dutch partner 'National Aerospace Laboratory' (Nationaal Lucht- en Ruimtevaartlaboratorium; NLR), is being used for this. The UV-

LIDAR system, which was specially developed by the DLR Institute of Atmospheric Physics, has been installed for the laser measurements.

After the measurement flight campaign has been successfully concluded, the data will be analysed. Thanks to the comprehensive measurement results on CAT, the researchers will not only be able to demonstrate their new technology – the unique data set will also provide them with important information on the formation mechanisms and on complex atmospheric processes. The long-term goal is to develop an integrated detection system for avoiding air turbulence. In future, pilots might then be able to put out a message in the aircraft cabin asking passengers to return to their seats and fasten their seat belts, or even fly around the affected region.

About the project

DELICAT is a joint project sponsored by the European Union. It was launched in 2009 and will end in March 2014. In total 12 partners from seven EU countries are participating in the joint project: project coordinator THALES, the German Aerospace Center (DLR), Centre National de la Recherche Scientifique (CNRS), Hovemere, Météo France, Nationaal Lucht- en Ruimtevaartlaboratorium (NLR), Office National d'Etudes et de Recherches Aérospatiales (ONERA, the French Aerospace Lab), National Institute of Research and Development in Optoelectronics (INOE), A. M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences, Laser Diagnostic Instruments, Interdisciplinary Centre for Mathematical and Computational Modelling/Warsaw University, and EADS Deutschland GmbH.

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Contacts

Bernadette Jung
German Aerospace Center (DLR)
Public Affairs and Communications: Oberpaffenhofen, Weilheim, Augsburg
Tel.: +49 8153 28-2251
Fax: +49 8153 28-1243
Bernadette.Jung@dlr.de

Dr Patrick Vrancken
German Aerospace Center (DLR)
DLR Institute of Atmospheric Physics
Tel.: +49 8153 28-1538
Patrick.Vrancken@dlr.de

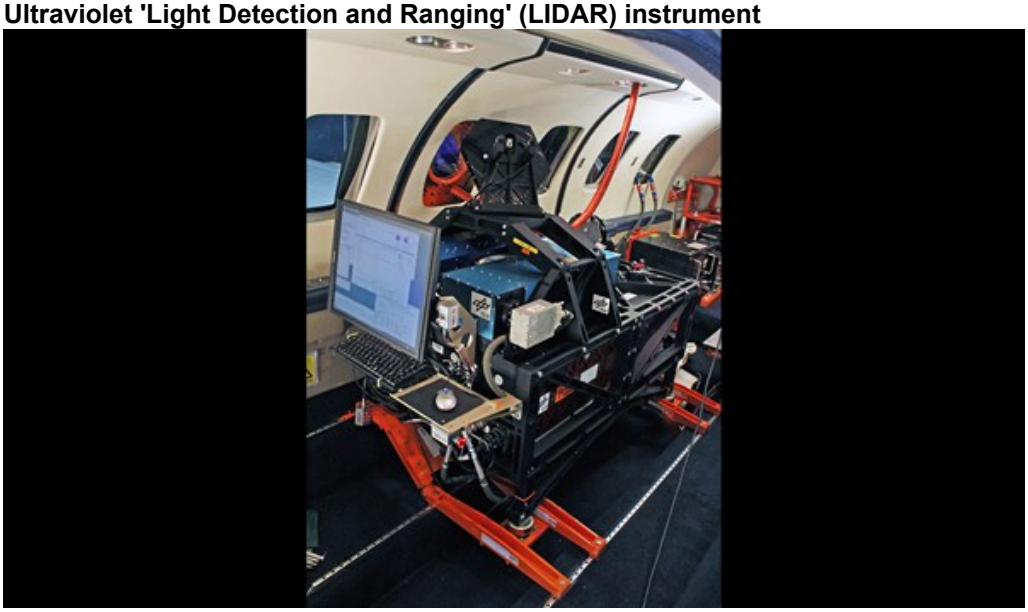
Kelvin-Helmholtz clouds caused by turbulence in the air

Wind shear often occurs along the jet stream. This involves extended layers of air that move against each other horizontally at different speeds. Particularly strong wind shear can create

waves that ultimately break, like waves on water. When a wave breaks, it causes vortices in the air or turbulence – specifically 'clear-air turbulence' (CAT).

Credit: Astronautilus.

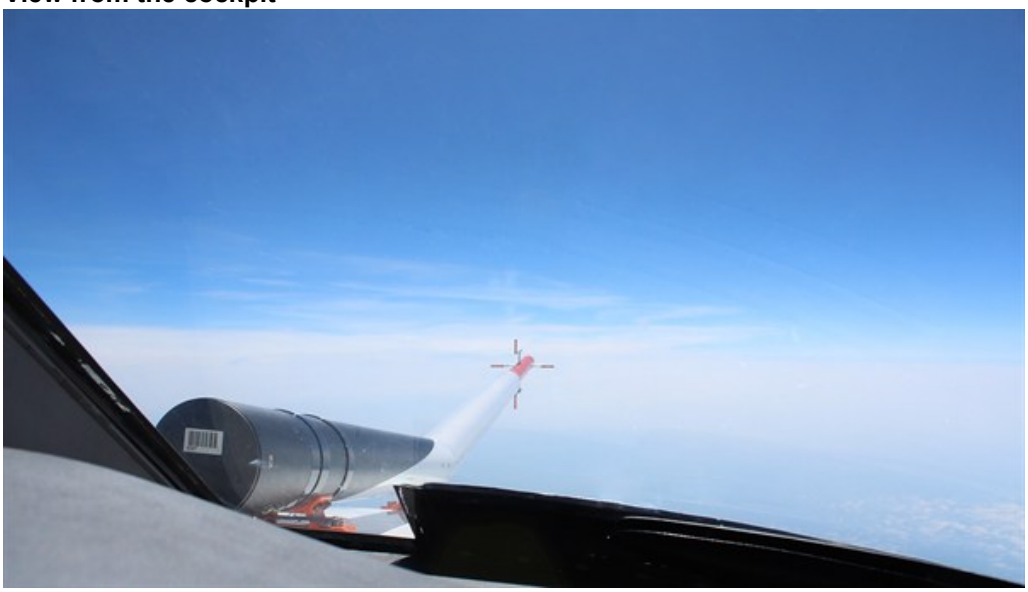
Ultraviolet 'Light Detection and Ranging' (LIDAR) instrument



Researchers at the DLR Institute of Atmospheric Physics have developed a laser-based instrument to detect and predict 'clear air turbulence' (CAT) from a distance. Under a European joint project called DELICAT (Demonstration of LIDAR based Clear Air Turbulence detection) the new technology is currently being tested by the German Aerospace Center (DLR) and its project partners.

Credit: DLR (CC-BY 3.0).

View from the cockpit



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