NASA and DLR: joint research flights using biofuel

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Biofuels provide an opportunity to lower the carbon dioxide footprint of air travel and to reduce the potential climatic effects of particle emissions and enhanced cloudiness by aviation. The United States National Aeronautics and Space Administration NASA, the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) and the Canadian National Research Council (NRC) are tackling this globally topical research area in joint test flights in California from 7 to 16 May 2014. The emissions of a biofuel-kerosene mixture and its effects on the formation and properties of condensation trails are being measured at typical commercial flight altitudes. The flight campaign, which are being led by NASA, involve more than 100 scientists and technicians. Four research aircraft are being used, including DLR's Falcon 20-E. The campaign base is NASA's Armstrong Flight Research Center in Palmdale, California.

//www.youtube.com/embed/TtcUqlWmTBM

Video – DLR Falcon test flight in the exhaust plume of the NASA DC-8

"Measurements in aircraft exhaust plumes and condensation trails require a great deal of experience and proven measuring equipment," says DLR mission head Hans Schlager from the Institute of Atmospheric Physics."In recent years, DLR has built up this expertise and measurement instrumentation in airborne sampling experiments in the wake of aircraft." The DLR Falcon has been used in various measurement campaigns involving the investigation of emissions and condensation trails left behind by commercial aircraft since 2000.

Research in formation flight

The current research flights are taking place under the ACCESS-II project (Alternative Fuel Effects on Contrails and Cruise Emissions). The four research aircraft being used are flying in formation at typical commercial flight altitudes of between nine and 12 kilometres, headed by NASA's four-engine DC-8. Behind the DC-8, the scientists on board the DLR Falcon and the NASA Falcon measure the composition of the exhaust gas at a distance of 100 metres to 20 kilometres. In addition, a Canadian National Research Council (NRC) T-33 is investigating the dynamics of the DC-8's wake turbulence.

"Our Falcon is an extraordinarily robust research aircraft and ideal for taking measurements in the exhaust plume and in condensation trails," says DLR test pilot Philipp Weber. "Heavy structure loads that not all aircraft are designed for can occur in aircraft wake turbulence." In addition, there are numerous in situ trace gas and aerosol measurement instruments for the Falcon that have been designed for the harsh conditions in an aircraft trail. The DLR Falcon became famous in the Spring of 2010 when, as the Volcano Ash Hunter, it carried out measurements over Germany in the ash cloud from Icelandic volcano Eyjafiallajökull.

The scientific teams and research aircraft complement each other well in the test flights in California. NASA project leader Bruce Anderson from NASA Langley Research Center welcomes the international support: "DLR's expertise and measurement capabilities are making an important contribution to the ACCESS-II campaign." DLR researchers have been working with NASA in the area of atmospheric research for 15 years, laying the foundations for the current joint flight campaigns in California. "For the DLR scientists, working with NASA on this research mission is a real benefit," says Hans Schlager.

Alternative fuel emissions

During the research flights, the four CFM56 engines on the DC-8 are alternately powered by regular JP-8 aviation fuel and a one-to-one mixture of HEFA (Hydroprocessed Esters and Fatty Acids) biofuel. HEFA comes from the oil of Camelina plants. In their measurements of biofuel exhaust gases, the DLR researchers are concentrating on the emissions of soot particles and sulphur compounds, and the size and shape of the ice crystals in the condensation trails. It is expected that the combustion of biofuels, in addition to a better carbon dioxide balance, will lead to significantly fewer soot and sulphur particles. Hence, a lower level of soot emissions may lead to larger ice crystals in the condensation trails, which may reduce the impact of aviation on the climate by additional cloudiness.

The results of the NASA, DLR and NRC joint flight tests will also be discussed at the next meeting of the International Forum for Aviation Research (IFAR). An international consortium of 23 IFAR member states will have access to the results of the research programme. IFAR is the active forum for the internationally leading aviation research actors. DLR and NASA play a leading role in IFAR.

In future, DLR will be focusing on the area of alternative fuels under the ECLIF (Emission and Climate Impact of Alternative Fuels) project. "Under ECLIF our research focus is on various types of alternative fuels, and we will investigate both the combustion in the engine and the resulting emissions," says Patrick Le Clercq from the DLR Institute of Combustion Technology. Initial research flights for Project ECLIF with the DLR's A320 ATRA and Falcon are planned for 2015.

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Exhaust measurements in formation flight

Behind the DC-8, the scientists on board the DLR Falcon measured the exhaust gas composition.

Credit: NASA.

NASA DC-8 and Falcon

The research aircraft flew at altitudes of between nine and 12 kilometres during the experiments.

Credit: NASA.

T-33 of the Canadian National Research Counsel (NRC)

The T-33 of the Canadian National Research Council (NRC) examined the dynamics of the DC-8's wake vortices.

Credit: NASA.

NASA DC-8 before a test flight

During the research flights, the four CFM56 engines of the DC-8 alternated between regular JP-8 jet fuel and a one-to-one mixture of JP-8 and the biofuel HEFA (Hydroprocessed Esters and Fatty Acids). HEFA is obtained from the oil of Camelina plants.

Credit: DLR (CC-BY 3.0).

Rollout

In the morning, the DLR Falcon is towed onto the apron at the Armstrong Flight Research Center in Palmdale, California, before a research flight. The Falcon was housed in the same hangar as the SOFIA airborne observatory during the research mission with NASA.

Credit: DLR (CC-BY 3.0).

The NASA Falcon

The NASA Falcon was housed together with other research aircraft in a hangar at Palmdale, California for the measurement campaign.

Credit: DLR (CC-BY 3.0).

Inside the cabin of the DLR Falcon

DLR researchers focus on measurements of the biofuel exhaust emissions of soot and sulphur particles, as well as the size and shape of the ice crystals in the condensation trails.

Credit: DLR (CC-BY 3.0).

Rendezvous with SOFIA in Palmdale, California

After a research flight, the Falcon is towed past the SOFIA airborne observatory on the way to its parking position.

Credit: DLR (CC-BY 3.0).

Measurements in the exhaust gas plume of an engine

The DLR Falcon flies with its measuring inlets in the upper part of an engine exhaust gas plume.

Credit: NASA.

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