Ice detection technologies to enable aviation safety

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Aircraft icing, caused by soaring altitudes and high concentrations of ice crystal laden clouds, continues to be a concern for the aviation industry. While build-up of these tiny crystals can cause damage to an aircraft engine or worse, researchers at the National Research Council of Canada (NRC) are addressing an industry-wide gap with the development of two new technologies designed to enhance ice particle detection – an ultrasound ice detection sensor, and a particle ice probe.

The ultrasound ice accretion sensor is a non-intrusive device that uses ultrasound technology to send out acoustic waves that provide data about conditions on the inside of an aircraft's engine. What's particularly innovative about the ultrasound senor is that it does not have to be placed within the environment being measured, ultimately eliminating the risk of damage caused by ice and debris.

The sensor uses ultrasound to act as both a microphone and a speaker, sending out an acoustic wave that is reflected back, and providing data about conditions on the other side of the 'skin.' The reflected acoustic signal is analyzed using methods developed at NRC.

Over three years, the sensor was put through rigorous testing for ice crystal icing investigation. Modifications to enhance the technology included improving performance and durability through changes to materials, cabling and fabrication, and the development and testing of installation procedures. The sensor was ready to move to a definitive high altitude ice crystal icing engine test in November 2015. Through NRC's Memorandum of Understanding (MOU) with NASA to collaboratively advance icing research and improve flight safety, the sensor was tested at the NASA Propulsion Systems Laboratory. In partnership with Honeywell Engines and the Ice Crystal Consortium, which provided a test engine known to roll back to idle in certain icing conditions, the sensor was tested at 30,000 feet in a real icing environment.

"We have been able to detect ice accretion in an actual engine icing environment, and have also seen that this sensor has sufficient sensitivity to distinguish between severe and light accretions and in effect, to measure the accretion intensity," said Dan Fuleki, a project manager at NRC.

Like the ultrasound ice accretion sensor, the NRC's particle ice probe is a small, lightweight device mounted to aircraft or engine surfaces and has no effect on fuel consumption or aerodynamics. The probe detects particles in the atmosphere around the aircraft by measuring changes in the electrical characteristics when flying in a high-altitude and ice crystal environment.

Why is this important? Aircraft icing resulting from liquid water in clouds has been a concern of the aviation industry for decades. More recently though, research and technology development has been focused on the risks related to ice crystals in clouds. Even when present in high concentrations, these ice crystals remain invisible to airborne weather radar. Ice crystals can clog or damage engines and block or foul pitot tubes – used to measure aircraft speed – initiating a dangerous sequence of events that at least once ended tragically.

Recently implemented regulations in Europe and North America require aircraft manufacturers to address the issue of ice crystal icing environments. An initial understanding of this problem and its many factors prompted the European Commission to fund the High Altitude Ice Crystal (HAIC) project created by Airbus in 2012. Since preventing aircraft icing is a broad industry necessity, the project engaged many research organizations and industries with the common goal of allowing aircraft to operate safely in these atmospheric conditions. The National Research Council of Canada, one of 34 partners from 15 countries, had the key task to provide and enhance ice particle detection and awareness technologies for use onboard commercial aircraft.

The ice probe, a small, lightweight device flush-mounted to aircraft or engine inlet surfaces, has no deleterious effects on fuel consumption or aerodynamics. In addition, the commercial version is expected to require no more power than a cellphone.

It detects particles in the atmosphere around the aircraft by measuring changes in the electrical characteristics of the local atmosphere when in an ice crystal environment. It uses this capability to detect and measure the concentration of ice particles in ice crystal laden clouds. How this information is then used is up to the aircraft manufacturer: to detect and continue, or to detect and react (change route).

The development of these two industry-leading ice particle detection technologies for high-altitude aircrafts are both ready to leave the laboratories for the commercial market. This will help deliver an important objective for the aviation industry related to the improvement of the aircraft operation and the enhancement of international flight safety when flying in mixed phase and glaciated icing conditions. The availability of appropriate detection and awareness technologies fitted on aircraft will be an important outcome of this innovation, providing the ability to alert flight crew or enable the adaptation of the flight path well in advance so as to avoid flying in such weather conditions.