

## **Title**

Ice detection on aircrafts using surface acoustic wave based sensor

## **Authors**

Nikolaj A. Feidenhans'l, Konstantin Astafiev, Rasmus Lou-Møller

## **Abstract**

Ice accretion on aircraft structures seriously affect flight operations and can compromise safety. This is due to the ice accretion significantly changing the airflow around the wing, leading to a decrease in the lift performance while also increasing the drag, especially for large angles of attack. Therefore, an Ice Protection System (IPS) is a critical system for ensuring safe flying conditions in all weather conditions. In conjunction to the IPS, an Ice Detection System (IDS) is needed to evaluate when and to what extent the IPS should be activated. Current IDS are often small probes vibrating with a specific frequency that change when ice forms on the probe. Naturally, such probe has to protrude the airframe, which results in a non-negligible effect on the aerodynamics and limits the number of probes that can be installed.

The present work is focused on developing an alternative IPS based on surface acoustic waves (SAW) generated by piezoelectric transducers. Such sensors can be positioned on the interior of the airframe, hence not affecting the aerodynamics of the aircraft. This allows sensing at more locations and with a higher sensor density, thus providing a more accurate evaluation of the icing level on all parts of the aircraft compared to the vibrating probes in a few selected places. Since IDS generally are mainly intended to alarm the pilot and aid in deciding the appropriate de-icing action, the increased number of detectors made possible by SAW based IDS will provide the pilot with more detailed information on the current icing conditions of the aircraft, to aid in applying the optimal de-icing measures. A prototype of SAW based IDS is demonstrated, showing a high sensitivity for detecting even single drops of accreted ice and being able to discriminate between different levels of ice accretion. The SAW devices are based on inter-digitated electrodes printed on a piezoelectric substrate that is bonded to a 1 mm thick aluminium plate, hence mimicking the bonding to the interior of the airframe. As ice accretes in the active area between two SAW devices (one sending and the other receiving the waves) the wave transmission efficiency is reduced, thus providing information on the amount of ice accretion. By comparing the joint response of several sensors, the system will also be able to provide information on the type of icing conditions, including supercooled large droplet (SLD) conditions.