SENS4ICE

SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES
FOR SAFER AVIATION IN ICING ENVIRONMENT

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Project public abstract

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SENS4ICE - SENSORS AND CERTIFIABLE HYBRID ARCHITECTURES FOR SAFER AVIATION IN ICING ENVIRONMENT

Modern airplanes are well equipped to cope with the most common icing conditions, which are defined Appendix C of FAR Part 25 / CS-25. However, some conditions containing Supercooled Large Droplets (SLD) have been the cause of severe accidents over the last three decades. It has become clear that improving safety is of high importance for these icing conditions as ice can form on unprotected areas of the lifting surfaces. Consequently, authorities addressed these safety concerns by issuing new certification rules under Appendix O of FAR Part 25 / CS-25 to ensure that future airplanes remain controllable in these conditions and can exit safely upon detection. Hence, the key to increasing overall aviation icing safety is the early and reliable detection of icing conditions to allow the necessary actions to be taken by the flight crew. The EU-funded project SENS4ICE (SENSors and certifiable hybrid architectures for safer aviation in ICing Environment) directly addresses this need for reliable detection and discrimination of icing conditions.

Although much progress has been made on icing detection, there are considerable gaps which still exist, specifically regarding the newly introduced icing conditions of Appendix O. This is the focus of the novel approach of the SENS4ICE project which seeks to intelligently cope with the complex problem of ice detection through the hybridisation of different detection techniques. In the proposed hybrid system, the direct sensing of atmospheric conditions and/or ice accretion on the airframe is combined with an indirect detection of ice accretion on the airframe by monitoring the change of aircraft's characteristics. SENS4ICE will address the development, test, validation, and maturation of the different detection principles, the hybridisation - in close cooperation with regulators to develop acceptable means of compliance - and the final airborne demonstration of technology capabilities in relevant natural icing conditions.

SENS4ICE will address this challenge with a unique layered safety approach (see Figure 1) of:

- **Strategic and tactical icing assessment**: Improved ice condition predictions before entering an area using new more reliable forecasting methods and a "nowcasting" with high spatial and temporal resolution based on satellite data, weather radar data and data from other aircraft that have flown in the same area. A better understanding of atmospheric conditions producing SLD will be gained through a dedicated atmospheric characterization effort leading to better prediction models. This will assist in both timely avoidance of true icing threats and prevention of false identification of an icing threat. Thus, helping to both improve safety and reduce fuel consumption through unnecessary diversions.
- **In-situ ice detection:** A robust and hybrid ice detection system based on a range of sensors with different physical principles to reliably detect all icing conditions during both entry and flight through SLD conditions. Besides direct measurement of atmospheric properties and ice accretion, indirect detection of ice accretion through changes of the aircraft characteristics will be investigated. Pilots will obtain better situational awareness and ice protection systems will be activated only if a true icing hazard exists, reducing the overall energy consumption and emissions to ensure greener aviation.

For the hybrid ice detection system, various technologies utilizing different physical principles can be combined in order to use each individual technologies' advantages and mitigate individual sensor limitations. For example, a combination of technologies to detect icing conditions in the atmosphere, ice accretion on the aircraft's surfaces, or the change of aircraft characteristics due to ice accretion can be part of the hybrid solution. All in all, the hybrid system will combine several individual technologies with the aim of providing a more robust and reliable detection.

- **Contingency**: Prevention of icing-induced loss of control events as a contingency to safely exit icing conditions. Complementary to the increased situational awareness of icing conditions, the detection of a reduced aircraft flight envelope provides the necessary information to alert the crew to the reduced aircraft capabilities as ice forms on the airframe.

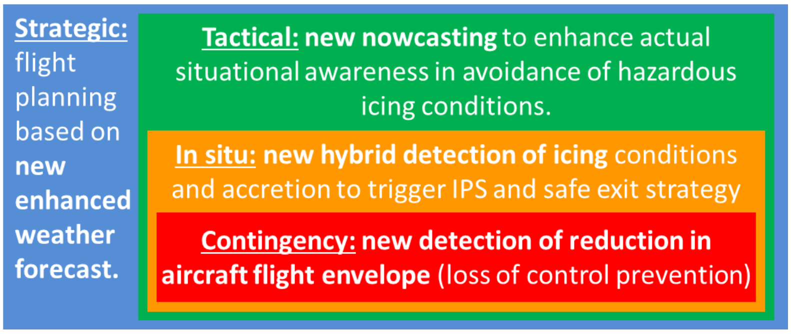

Figure 1: SENS4ICE layered safety concept for liquid water icing.

The SENS4ICE project is pursuing two main high-level objectives which are fully in line with the FlightPath 2050 and the ACARE Strategic Research and Innovation Agenda (SRIA). These two objectives are subdivided into five more specific, measurable and timed objectives. They contribute clearly to the high-level objectives from which they were derived.

High-level objective A: Increase the flight safety in icing conditions and especially for SLD conditions.

The first objective is to mature individual direct and indirect detection technologies to detect Appendix O conditions or ice accretion due to encountering Appendix O conditions and improve Appendix C sensor reliability. The second objective, based upon generic and aircraft-specific requirements and the technologies developed in the first objective, is to develop a hybrid ice detection system able to reliably detect all liquid water icing conditions and reliably discriminate icing conditions corresponding to Appendix C and O. This system will not specifically address Appendix D/P ice crystal conditions but some technologies may contribute to detection of these environments. The final objective is to increase pilot awareness of remote icing threats through the development of nowcasting and/or weather radar. Consequently, the objective is to develop a certifiable detection system architecture suited for use as an automatic primary ice detection system (i.e. with no pilot action required).

High-level objective B: Contribute to increasing the knowledge base on the formation and occurrence of Appendix O conditions.

The objective is to provide and analyse data in Appendix O icing conditions and in conditions close to Appendix O. The observation and characterization of relevant icing conditions will facilitate an enhanced physical understanding of their formation and appearance. The flight demonstration of the hybrid system and the reference sensors will provide a very rare possibility to gather a significant amount of data in these conditions.

The consortium unites European and international aircraft manufacturers, equipment suppliers and research/academia with a large variety of technologies that have emerged in recent years. The most promising and mature of these technologies will be selected for flight testing, while several other less mature but promising technologies will be advanced in a laboratory environment. Since icing is a global hazard, SENS4ICE will address this challenge with a global consortium including participants from Brazil, USA, and Russia. By aligning the EU-funded activity with nationally and internally funded programmes of those countries, a harmonised global perspective on Acceptable Means of Compliance can be achieved, and technological progress can be further advanced by ensuring the coordination of research efforts and avoiding overlap.

The expected impact of the project is to contribute to the smart, green and integrated transport while addressing the challenges of the transport competitiveness, performance and sustainability. SENS4ICE will tackle these challenges by contributing to increased passenger safety, decreased cost by improving certification rules, and increasing aviation efficiency by avoidance of icing hazards, reducing unnecessary diversions due to false identification of icing hazards and lowering inspection and MRO operations.

SENS4ICE in a nutshell

Project title: SENSors and certifiable hybrid architectures for safer aviation in ICing Environment

Project duration: 48 months (January 2019 – December 2022)

Coordinated by: DLR – Deutsches Zentrum für Luft- und Raumfahrt e.V., Germany

EU contribution: 6.6M EUR

Total estimated eligible costs: 11.9M EUR

EU Grant Agreement No: 824253

Project public website: www.sens4ice-project.eu

Project public profile on Cordis: https://cordis.europa.eu/project/rcn/219208

Consortium: 20 European and international partners

1. DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT e.V.
2. AVIONS DE TRANSPORT REGIONAL
3. AEROTEX UK LLP
4. CENTRAL AEROLOGICAL OBSERVATORY
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6. CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS
7. EMBRAER SA
8. STATE RESEARCH INSTITUTE OF AVIATION SYSTEMS
9. HONEYWELL INTERNATIONAL SRO
10. INSTITUTO NACIONAL DE TECNICA AEROESPACIAL ESTEBAN TERRADAS
11. LEONARDO - SOCIETA PER AZIONI
12. L-UP SAS
13. OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES,
14. FEDERAL STATE UNITARY ENTERPRISE THE CENTRAL AEROHYDRODYNAMIC INSTITUTE NAMED AFTER PROF. N.E. ZHUKOVSKY
15. TECHNISCHE UNIVERSITAET BRAUNSCHWEIG
16. UNITED TECHNOLOGIES RESEARCH CENTRE IRELAND, LIMITED
17. ZODIAC AEROTECHNICS SAS (SAFRAN)
18. HONEYWELL INTERNATIONAL INC
19. GOODRICH DE-ICING AND SPECIALTY SYSTEMS (COLLINS AEROSPACE)
20. NATIONAL RESEARCH COUNCIL CANADA