This project has received funding from European Union's Horizon 2020 research and innovation programme under grant agreement n° 824253
SENS4ICE Project Overview
SENSors and certifiable hybrid architectures for safer aviation in ICing Environment

- JAN 2019 - DEC 2022 (project extension expected)
- Coordinator: DLR

**Budget:**
- max. EU contribution: 6.6 M EUR
- total estimated eligible costs: 11.9 M EUR
- project effort in person-months approx.: 1100 PM

[https://www.sens4ice-project.eu](https://www.sens4ice-project.eu)
#sens4iceproject on LinkedIn
SENS4ICE Consortium Partners

1) DEUTSCHES ZENTRUM FUER LUFT - UND RAUMFAHRT e.V. (DLR)
2) AVIONS DE TRANSPORT REGIONAL (ATR)
3) AEROTEX UK LLP
4) CENTRAL AEROLOGICAL OBSERVATORY
5) CENTRO ITALIANO RICERCHE AEROSPAZIALI SCPA (CIRA)
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 (INTA)
11) LEONARDO - SOCIETA PER AZIONI
12) L-UP SAS
13) OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES (ONERA)
14) FEDERAL STATE UNITARY ENTERPRISE THE CENTRAL AEROHYDRODYNAMIC INSTITUTE NAMED AFTER PROF. N.E. ZHUKOVSKY (TsAGI)
15) TECHNISCHE UNIVERSITAT BRAUNSCHWEIG
16) RAYTHEON TECHNOLOGIES RESEARCH CENTER
17) SAFRAN AEROTECHNICS
18) HONEYWELL INTERNATIONAL INC
19) COLLINS AEROSPACE
20) NATIONAL RESEARCH COUNCIL CANADA

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March 2021
InCo – international cooperation flagship: Aviation International Cooperation Flagship "Safer and Greener Aviation in a Smaller World"

20 project parties (11 countries)
- 13 European/7 international
- 9 research centers, 1 university, 9 industrial partners (OEMs and system developers), 1 consultancy partner

Advisory Board (9 members)
- aviation certification authorities (EASA, FAA, ANAC)
- manufacturing (Bombardier, Gulfstream, Airbus DS, DAHER)
- research (ITA, NLR)
- operations (VC - Vereinigung Cockpit, German Pilot’s Association)

Coordination with EU icing projects ICE GENESIS and MUSIC-haic
SENS4ICE Goal/ Impact

Problem

- Detect icing conditions (including App. O/ SLD icing) – detection very challenging

Solution

- Hybrid approach – fusion of input data: sensor(s) and indirect detection

Benefits

- Operational benefits: activate anti-/de-icing, avoid/ leave icing conditions
- Certification process benefits – flights in App. O/ SLD icing
  - safety risk due to severe and unknown aircraft icing
  - online evaluation of safety margins during flight tests/ certification flights
SENS4ICE
Scope and positioning

- SENS4ICE fills the gap of SLD icing detection (App. 0)
  - hybridisation of different detection techniques
- Technology development, test, validation and maturation
  with specific regards to integration of hybrid system architectures
  - TRL 5 of hybrid system at the end of SENS4ICE
- Technology demonstration in relevant icing conditions:
  - testing facilities
  - flight test
  - SENS4ICE will provide large data base of icing conditions
- Close cooperation with regulation authorities
  for development of new certifiable hybrid ice detection system
  - SENS4ICE will provide an acceptable means of compliance

- SENS4ICE contributes to increase aviation safety in SLD icing conditions
Expected impact

- Contribute to **increased flight safety** by fewer accidents and less in-flight events worldwide
- Contribute to **reduce costs** for all stakeholders by improved and internationally accepted certification rules, standards and means of compliance, covering all types of icing hazards
- Contribute to **decrease delays** in operations thanks to more efficient avoidance of icing hazards and to fewer damages in need of inspection and repair
Layered Approach on Ice Detection

SENS4ICE will address this challenge of reliably detecting and avoiding App. O SLD conditions with a unique layered safety approach:

- **Strategic**: flight planning based on new enhanced weather forecast.
- **Tactical**: new nowcasting to enhance actual situational awareness in avoidance of hazardous icing conditions.
- **In situ**: new hybrid detection of icing conditions and accretion to trigger IPS and safe exit strategy.
- **Contingency**: new detection of reduction in aircraft flight envelope (loss of control prevention)

→ **Hybrid ice detection** is central technology and key to this approach
SENSors and certifiable hybrid architectures for safer aviation in Icing Environment

**SENS4ICE**

**WP 1**
Direct and indirect ice detection for App. O

- Task 1.1 Direct ice detection sensors
- Task 1.2 Icing wind tunnel testing and evaluation of direct ice detection sensors
- Task 1.3 Selection of sensor technology for hybridization & airborne demonstration
- Task 1.4 Indirect ice detection
- Task 1.5 Remote detection of icing conditions
- Task 1.6 Maturation of sensor technologies for airborne demonstration

**WP 2**
Hybrid ice detection architectures

- Task 2.1 Hybrid ice detection system specification & requirements
- Task 2.2 Means of compliance for certification
- Task 2.3 Ice detection system implementation

**WP 3**
Airborne demonstration and atmosphere characterization

- Task 3.1 Specification for sensor integration
- Task 3.2 HW and SW integration on ATR platform + flight test preparation
- Task 3.3 HW and SW integration on EBM platform + flight test preparation
- Task 3.4 Airborne demonstration in natural icing with ATR platform
- Task 3.5 Airborne demonstration in natural icing with Embraer platform
- Task 3.6 Flight test in natural icing with Yak-42 D platform
- Task 3.7 Atmosphere characterization

**WP 4**
Technology evaluation

- Task 4.1 Individual technology evaluation and roadmap for future developments
- Task 4.2 Evaluation of hybrid ice detection
- Task 4.3 Overall evaluation of flight test campaigns
- Task 4.4 Evaluation of project developments and results

**WP 5**
Project management and international cooperation

- Task 5.1 Project progress monitoring and interfacing with international partners
- Task 5.2 Administrative, financial and quality management
- Task 6.1 Dissemination activities and Action Plan
- Task 6.2 Communication
- Task 6.3 IPR, exploitation and certification

**WP 6**
Communication, dissemination and exploitation

March 2021
Technical Work Packages interrelation

WP 1
Direct and indirect ice detection for App. O

WP 2
Hybrid ice detection architectures

WP 3
Airborne demonstration and atmosphere characterization

WP 4
Technology evaluation

WP 5
Project management and international cooperation

WP 6
Communication, dissemination and exploitation

Ice detection technology
Hybrid ice detection system
Flight test results

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WP1: Direct and indirect ice detection for App. O

High Level Objectives

Main Objective: Develop technologies capable of detecting App. O icing conditions using a three-pronged approach:

- **Direct detection**: development of *in situ* sensors capable of ice detection
  - 11 technologies under development representing a variety of physical detection principles
  - Evaluation in icing wind tunnel tests under simulated App. O conditions – three tunnels/total of 26 weeks testing time
  - Two-stage evaluation/selection process to ensure most promising sensors advance to flight test (WP3)

- **Indirect detection**: utilising existing sensor information and aircraft performance reference data for early detection of airframe icing

- **Remote detection**: development of methods to detect App. O conditions before the aircraft enters the hazard area
  - Detection and Nowcasting: development of algorithms that combine meteorological factors retrieved from satellite data to detect and forecast (very short-term range) icing threats in App. O conditions
  - Polarimetric weather radar: development of algorithms to classify icing threats and identify App. O conditions

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March 2021
SENS4ICE research facilities: Icing Wind Tunnels

- TU Braunschweig
  - SLD capabilities available and enhanced during SENS4ICE
- TsAGI AHT SD and EU-1:
  - SLD capabilities developed during SENS4ICE
- Collins Aerospace
  - SLD capabilities available and enhanced during SENS4ICE
- National Research Council Canada
  - SLD capabilities available during SENS4ICE

- Total testing time: 28 weeks
- Planned time frame: NOV 2020 – MAR 2021
WP2: Hybrid Ice Detection

Development, test, validation and maturation of different technologies for

- direct ice detection
- indirect ice detection

Objectives for hybrid ice detection

1. Hybrid ice detection system specification
2. Certification programme for hybrid ice detection system
3. Hybrid ice detection system modelling
4. Hybrid ice detection design, build & assembly (+ TRL 5 review)

in close cooperation with OEMs and certification authorities during SENS4ICE

Robust Hybrid Ice Detection:

- different techniques for direct sensing of atmospheric conditions and/or ice accretion
- indirect techniques to detect change of aircraft characteristics with ice accretion on airframe
Hybrid Ice Detection: Development Workflow

WP1: Direct & indirect ice detection
- selected direct sensors

WP1 sensor requirements

Icing Wind Tunnel Tests

Laboratory Tests

Hybrid high-level specifications

Certifiability demonstration

Modelling/Simulation

Direct detection

Indirect detection

WP2: Hybrid Ice Detection Development
- Hybrid demonstrator model
- Hybrid demonstrator assembly
- aircraft sensors

WP3: Airborne demonstration
- Flight Test
WP3: Airborne demonstration and atmosphere characterisation
dedicated to airborne technology demonstration in relevant icing conditions

Objectives

- Issue main requirements and constraints for integration of sensors and probes on flight test platforms
- Release flight test program for testing new individual and hybrid technologies in distinct icing conditions
- Perform airborne demonstration in natural icing conditions:
  - in Europe with CNRS/SAFIRE ATR-42
  - in North America with Embraer Phenom 300
  - in Russia with Yak-42D “Roshydromet”
- Characterisation of atmosphere from flight test campaigns in App. O conditions

Guidance by special Flight Test Committee (FTC) formed by platform providers and leaders of WP1, WP2 and WP4 to ensure harmonised preparation and execution of individual flight test campaigns
SENS4ICE research facilities: Flight Test Platforms

- total flight test time: 125h in natural icing conditions
- planned main time frame: Q1/2022 (delays expected due to Covid-19)

**SAFIRE**
ATR-42

**Embraer**
Phenom 300

**CAO Yak-42D**
Roshydromet

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