AirTN-NextGen Workshop

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AirTN-NextGen Workshop on Virtual testing, towards virtual certification

Icing research roadmap and certified codes

Icing research roadmap and certified codes
Content

- **Context**
- **Icing R&D Roadmap**
- **Conclusion & Way Forward**

Icing research roadmap and certified codes
Content

- **Context**

- *Icing R&D Roadmap*
- *Conclusion & Way Forward*

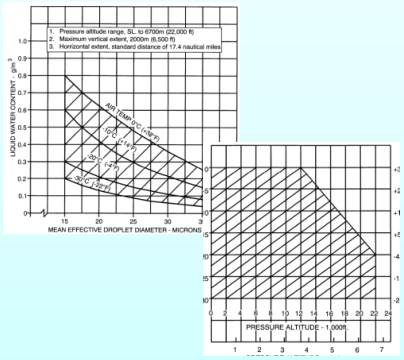
Icing research roadmap and certified codes
Context

- Current Ice & Protection Functions

Wing (Slats 3 4 5) **Handling Quality** protection: bleed anti-ice

ATA30 cockpit systems
Probes protection
Advisory Ice Detection System

App. C



Nacelle inlet cowl **Foreign Object Damage** protection: bleed anti-ice

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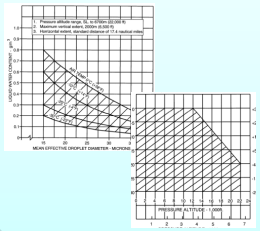
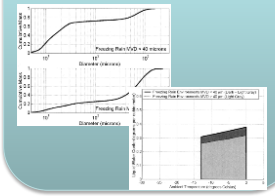
Context

- Future A/C Ice & Protection Functions

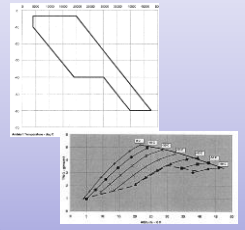
App. C



App. O **(SLD)**



App. P (Crystals)



HTP/VTP
Handling Quality (HQ)
protection TBC

ATA30 Cockpit systems
Probes protection
Primary detection system
Weather on-board

Pylon & Nacelle
FOD protection

Radome ice shedding

Inboard Wing
Engine **Foreign Object Damage** protection TBC

Outboard Wing
Handling Quality protection

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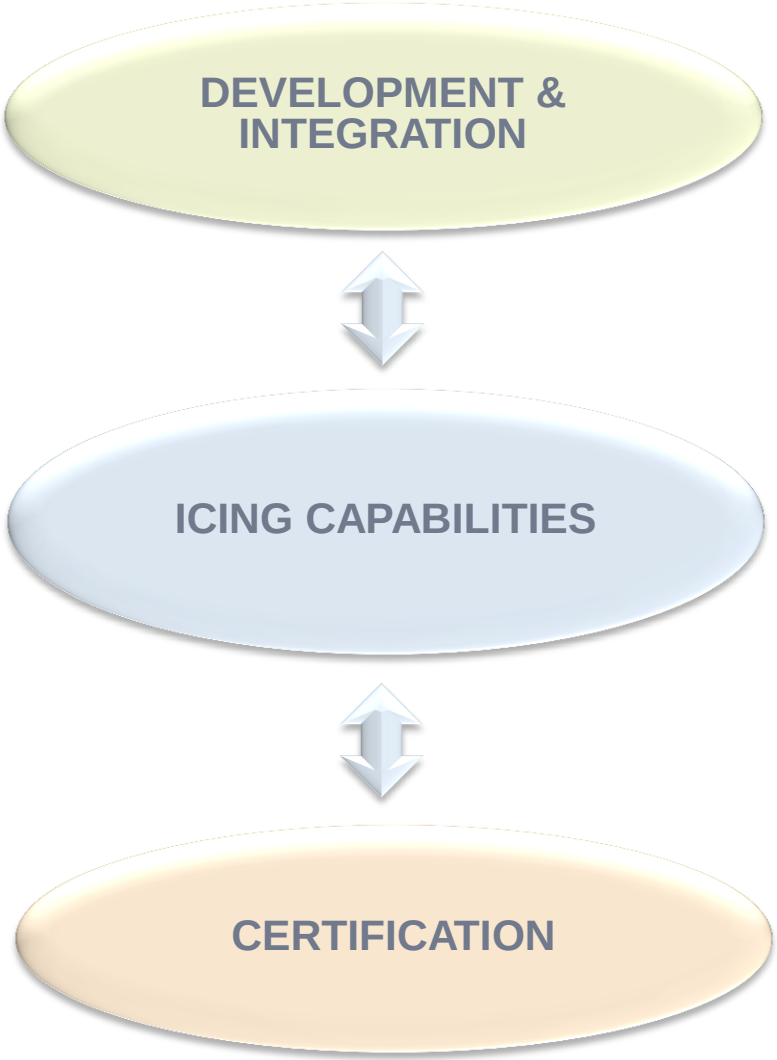
Context

- Evolution of **icing regulation** (SLD, Glaciated & mixed phase icing conditions,…)
- Development and integration of **new and disruptive technologies** (eWIPS, PFIDS,…) to enable new A/C configuration, bleedless A/C,…
- Development and validation of **capabilities** to support technologies development, integration and certification (Test facilities, M&T, processes,…)
- Improvement of **A/C operations** through availability of enhanced weather information
- Continuous development and securisation of **icing expertise** in Europe

…While maintening the highest level of **safety**

Icing research roadmap and certified codes
Context

- On time and in quality availability of **validated capabilities** is key to support
  - **Development** of new A/C products
    - New features to support sizing and integration of new technologies
    - Develop trade capability
    - Reduce cost thanks to less tests
    - Improve efficiency thanks to lead time reduction
  - **Certification** of new A/C products
    - Availability of Means of Compliance (MoC) to deal with new regulation (e.g. SLD, Ice Crystals,…)
    - Pave the way to virtual certification



Icing research roadmap and certified codes
Content

- *Context*

- **Icing R&D Roadmap**
  - **Rulemaking**
  - **Capabilities**
  - **Technologies**

- *Conclusion & Way Forward*

Icing research roadmap and certified codes
Icing R&D Roadmap / Rulemaking

Status

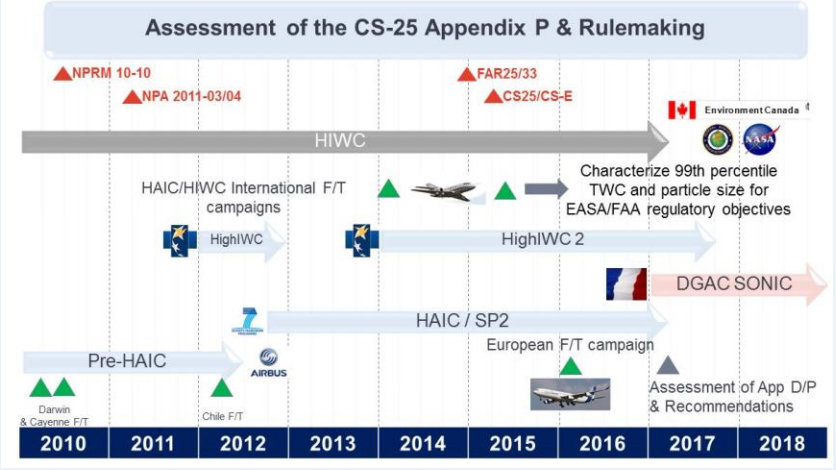
- **International HAIC/HIWC field campaigns** held in Darwin in Q1 2014 and in Cayenne in Q2 2015
- Primary objective is to provide **99th percentile total water content statistics**, as a function of distance scale, to industry and regulators for assessment of CS25 Appendix P
- **Two types of convection** for sampling :
  - Oceanic convection (primary focus)
  - Continental convection (secondary focus)
- **Three flight levels** for sampling:
  - -50°C: a typical cruise altitude for commercial jet aircraft ; -30°C and -10°C

- **Challenges / Next steps:**
  - **Data processing and analysis**
  - **Assessment of the CS25 Appendix P**

- **Projects**: HAIC, HIWC, EASA-HighIWC
- **Funding:** FP7, FAA, EASA, ICC

Illustration

Roadmap



HAIC: High Altitude Ice Crystals ; HIWC: High Ice Water Content : F/T: Flight Test

Icing research roadmap and certified codes
Icing R&D Roadmap – Capabilities / Performance Degradations

Status

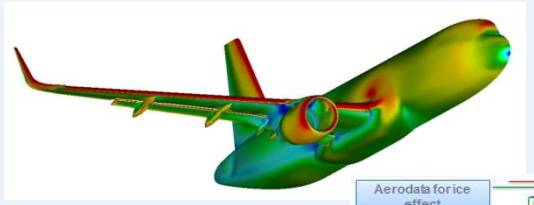
• **Goal:** Develop **CFD capability** for prediction of perfomance degradations due to ice & Improve **Aerodata process for icing** which today rely on past aircraft experience, engineering judgement and low Reynolds number testing.

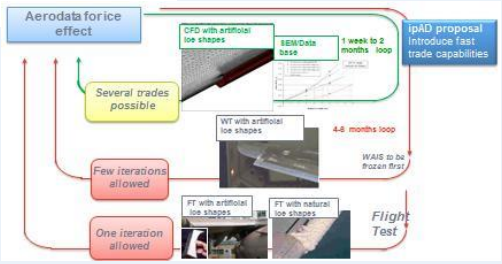
• **Key Results**
- Turbulence modeling
- Advanced, modular and robust mesh generation concept
- RANS CFD capability assessment

•**Challenges / Next steps:**
- **3D experimental database** for CFD capability assessment/validation (ONERA/NASA SUNSET2)
- **Advanced modeling eg DES, LBM**
- Implementation into **Aerodata Process for icing**

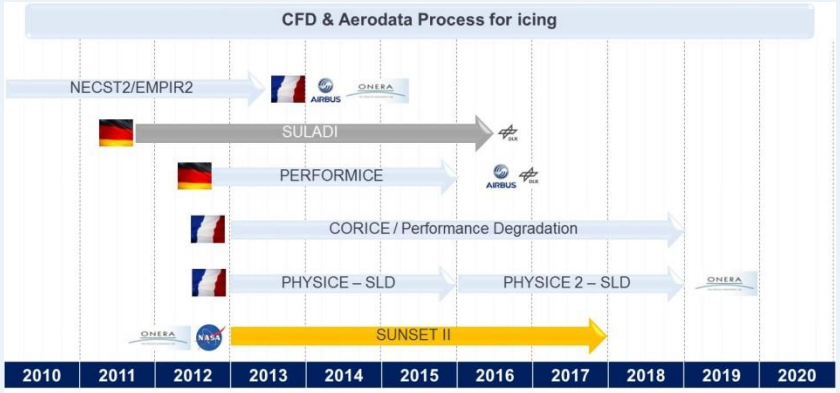
•**Project:** NECST1/2, SULADI, PERFORMICE, CORICE, PHYSICE, SUNSET2, Cleansky
•**Funding:** DGAC, LUFO, Cleansky, ONERA, NASA, FAA

Illustration





Roadmap



CFD: Computational Fluid Dynamics

Icing research roadmap and certified codes
Icing R&D Roadmap – Capabilities / SLD

Status

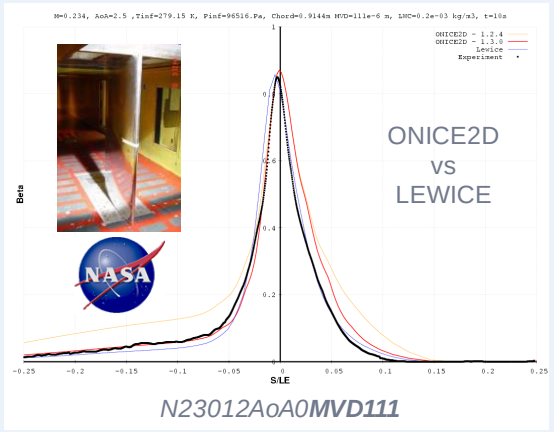
•**Goal:** Develop **Acceptable Means of Compliance (AMC)** wrt the new SLD certification requirements (CS25 Appendix O),

•**Key Results:**
- **Understanding and modeling of physical phenomena** related to SLD such as break-up, splashing and bouncing
- **IWT** capability development & 2D and 3D EXTICE **SLD experimental database for FZDZ**
- **Assessment** of 2D and 3D numerical tools

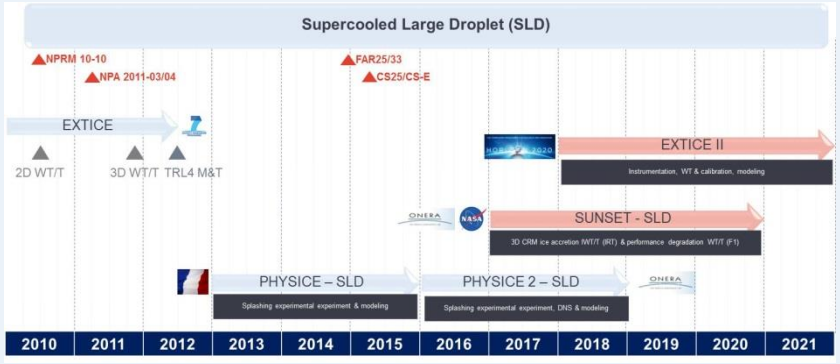
•**Challenges / Next Steps: EXTICE2**
- **Icing Wind Tunnel** improvement & calibration and standardization
- **Accurate SLD experimental database**
- **Numerical tools** improvement (splashing)
- **International Collaboration**

• **Projects**: EXTICE, PHYSICE
• **Funding:** FP7, DGAC

Illustration



Roadmap



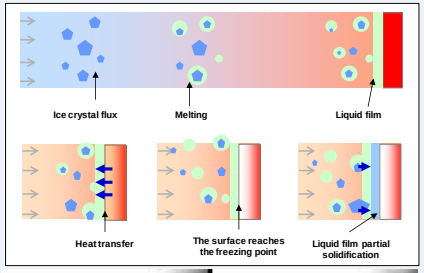
SLD: Supercooled Large Droplet ; FZDZ: Freezing Drizzle ; FZRA: Freezing Rain ; IWT: Icing Wind Tunnel

Icing research roadmap and certified codes
Icing R&D Roadmap – Capabilities / Ice Crystals

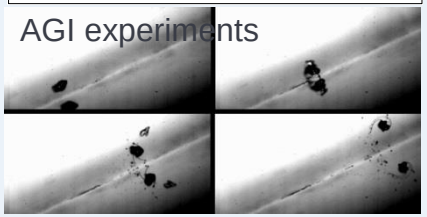
Status

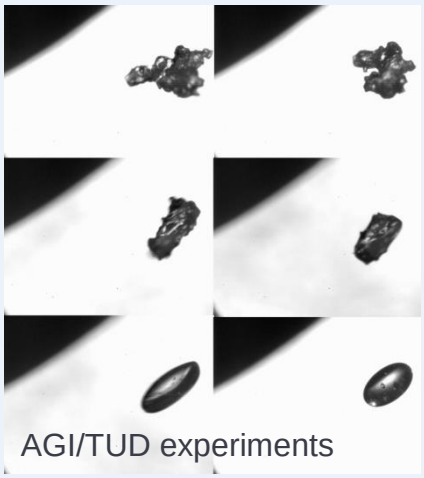
- **Goal:** Develop **Acceptable Means of Compliance (AMC)** wrt the new glaciated and mixed phase icing conditions certification requirements (CS25 Appendix P),
- **Key Results:**
  - **Calibration** (TRL5) for icing test facilities
  - **Performance assessment** (TRL4) for numerical capability
- **Challenges / Next Steps:**
  - **Upscaling of icing test facilities** & convergence on calibration / instrumentation
  - **Improvement of particle / wall interaction modeling and development of 3D capability**
  - **International collaboration & <u>Need for further action of research beyond HAIC</u>**
- **Projects**: HAIC, Future Sky Safety
- **Funding:** FP7, H2020

Illustration



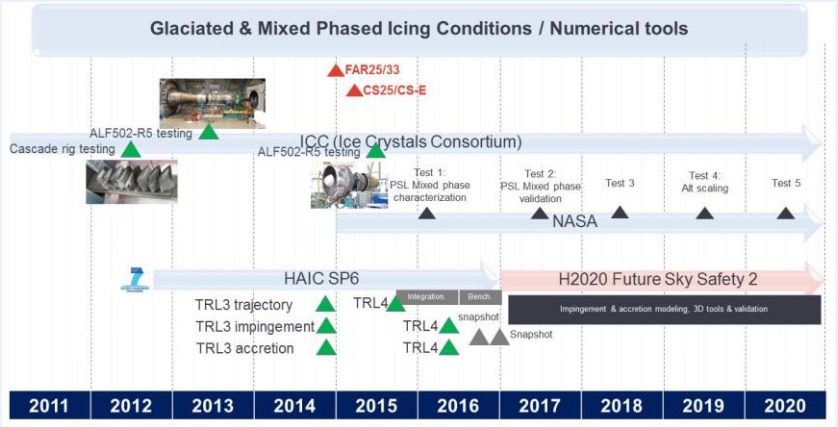
AGI experiments





AGI/TUD experiments

Roadmap



Icing research roadmap and certified codes
Icing R&D Roadmap – Capabilities / Ice Accretion

Status

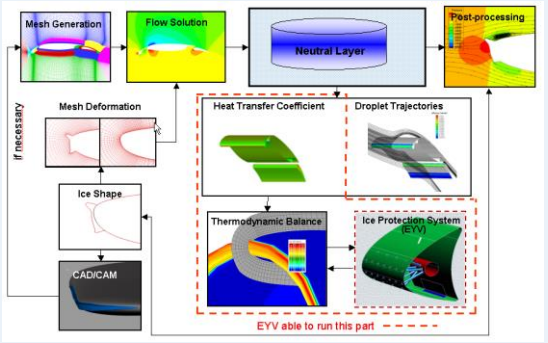
•**Goal: 2D and 3D Ice accretion prediction capability** to support design and certification of future products**.** The changes to be delivered by the current activities are:
- Enhanced 2D ice accretion capability (High-lift)
- 3D ice accretion capability & methodology

•**Key Results:**
- 2D ice accretion capability improvement (High-lift, RANS)
- 3D capability development (IGLOO3D, ICECREMO)
- Preliminary 3D capability integration (e.g. AIT)
- Preliminary 3D Capability Assessment

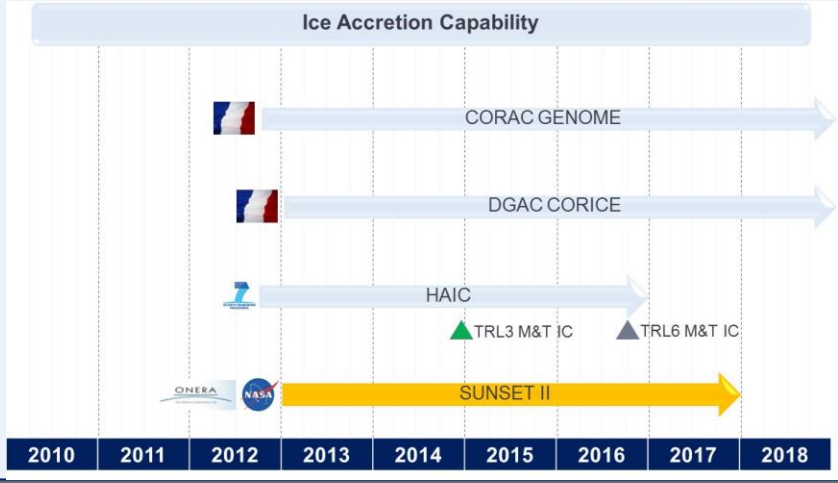
•**Challenges / Next Steps:**
- Capability improvement & **Integration into industrial environment**
- **3D experimental database** & Capability assessment/validation (SUNSET2)

• **Projects**: GENOME, SUNSET2
• **Funding:** CORAC, ONERA, NASA, FAA

Illustration



Roadmap



Icing research roadmap and certified codes
Icing R&D Roadmap – Capabilities / Ice Protection System

Status

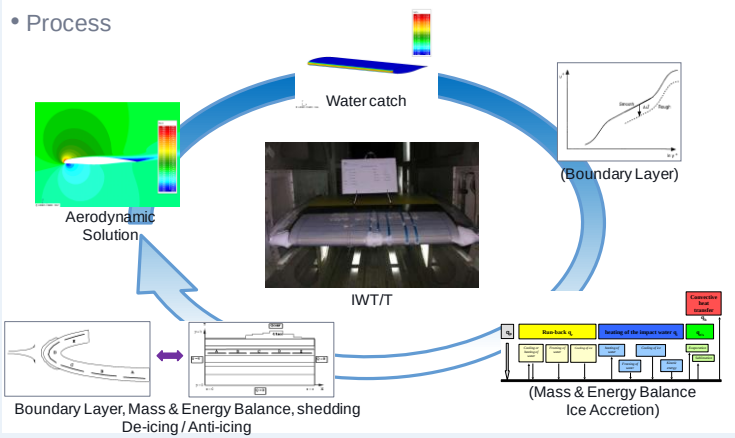
•**Goal:** To develop **advanced capabilities for prediction of performances of e**lectrical **I**ce **P**rotection **S**ystem (ETIPS, EMIPS) as enabler for More Electrical Aircraft

•**Key Results:**
- **Experimental databases** (Cleansky, AEROMUCO) for assessment/validation of the capability
- Preliminary capability assessment

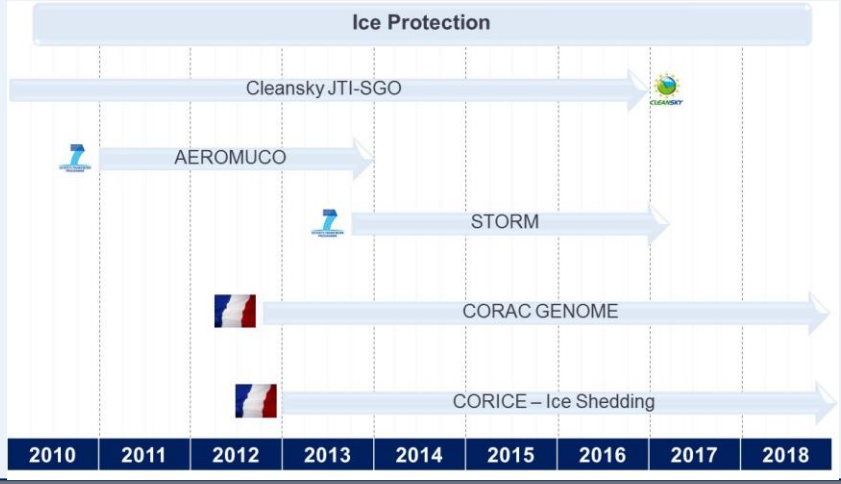
•**Challenges / Next Steps:**
- **Runback**
- **Ice shedding, ice mechanical properties** and ice block trajectory incl coatings
- Capability **validation**

• **Projects**: Cleansky, AEROMUCO, STORM, GENOME, CORICE
• **Funding:** Cleansky, FP7, CORAC, DGAC

Illustration



Roadmap



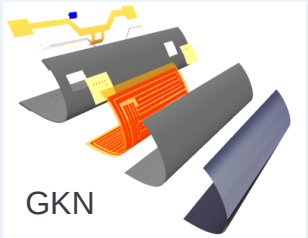
eIPS: electrical Ice Protection System ; MEA: More Electrical Aircraft ; ETIPS: electro-thermal Ice Protection System ; EMIPS: electro-mechanical Ice Protection System

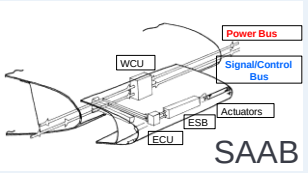
Icing research roadmap and certified codes
Icing R&D Roadmap – Technologies / Ice Protection System

Status

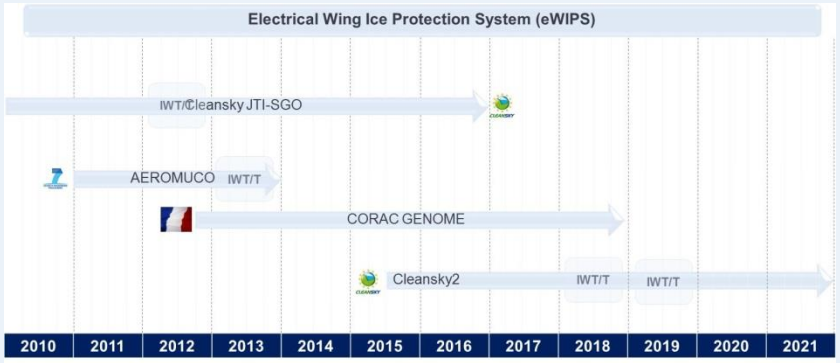
- **Goal:** To develop **e**lectrical **W**ing **I**ce **P**rotection **S**ystem (ETIPS, EMIPS) as enabler for More Electrical Aircraft (MEA) : Power consumption reduction and optimization, icephobic and hydrophobic coatings, change from anti-ice to de-ice, integration
- **Key Results:**
  - **ETIPS/EMIPS technology**
  - **Experimental databases** (Cleansky, AEROMUCO) for assessment/validation of the eWIPS performances (TRL4)
- **Challenges / Next Steps:**
  - **ETIPS/EMIPS technology improvement**
  - **Icephobic and hydrophobic coatings** for performance optimisation
  - **Integration & F/T**
- **Projects**: Cleansky, AEROMUCO, STORM, GENOME, INTEQ/AIWO/WIST
- **Funding:** Cleansky, FP7, CORAC, DTI

Illustration





Roadmap



eIPS: electrical Ice Protection System ; MEA: More Electrical Aircraft ; ETIPS: electro-thermal Ice Protection System ; EMIPS: electro-mechanical Ice Protection System ; HYLIPS: Hybrid Low power Ice Protection System, F/T: Flight Tests

Icing research roadmap and certified codes
Icing R&D Roadmap – Technologies / Icing Detection System

Status

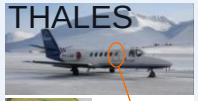
•**Goal:** Develop **Detection & Awareness technologies**, including primary mode, able to detect, discriminate and characterise icing conditions (CS25 Appendices C, O, P)

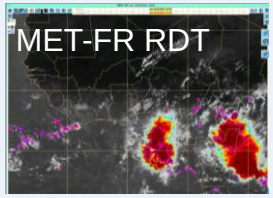
•**Key Results:**
- TRL5 achieved for **IDS** / CS25 App C (Cleansky)
- TRL3/4 achieved for **IDS** and **WXR** / CS25 App O, P (HAIC, GENOME)
- TRL5 achieved for **satellite based detection products** (1st generation) / CS25 App P (HAIC)
- HAIC A340 MSN1 **Flight Tests** early 2016
- Initiation of standardisation process for IDS and WXR as part of **EUROCAE WG95**

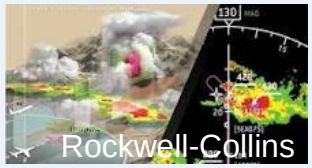
•**Challenges / Next Steps:**
- **Mature and integrate Detection & Awareness tehnologies**

• **Projects**: DANIELA, NESLIE, Cleansky, ON-WINGS, HAIC, CORICE, GENOME
• **Funding:** Cleansky, FP7, DGAC, CORAC

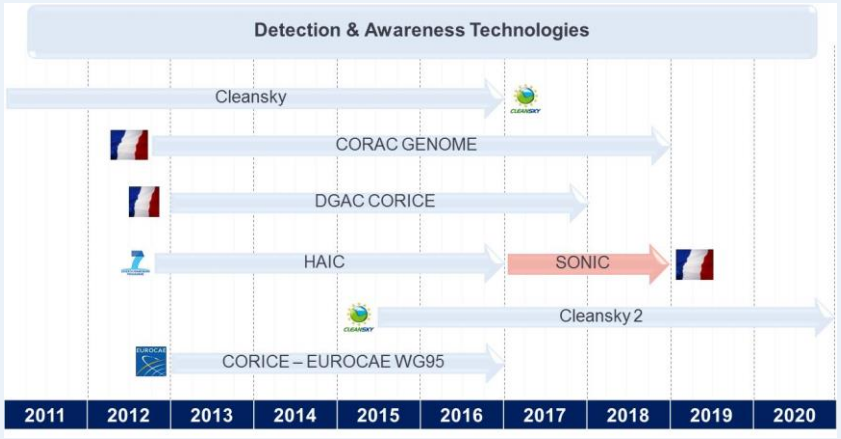
Illustration





Roadmap



IDS: Ice or Icing Conditions Detection System : WXR: Weather Radar ; F/T: Flight Tests

Icing research roadmap and certified codes
Content

- *Context*
- *Icing R&D Roadmap*

- **Conclusion & Way Forward**

Icing research roadmap and certified codes
Conclusion

- An **interdisciplinary and cross-sectoral network**

- An effort to **streamline icing R&D activities** through the definition of an integrated R&D roadmap including identification of the gaps in the available knowledge and prioritization of areas for improvement
  - To face challenges related to regulation evolution (SLD, Ice Crystals,…)
  - To enable development, integration and certification of new technologies and new aircraft configurations
  - To bring value through the improvement of efficiency and the reduction of the costs

- A successful **international collaboration** on glaciated and mixed phase icing topic in the framework of HAIC

- However, some major gaps remain…

Icing research roadmap and certified codes
Way Forward

- Pursue the effort to develop the **engineering tools** to face challenges related to the evolution of regulation
  - Glaciated and mixed phase icing conditions
  - Supercooled Large Droplet
- **Networking & Coordination at European level** has to be re-enforced to ensure alignment with the needs, avoid gaps and/or overlap and maximize efficiency
- **International Collaboration** has to be promoted. The complexity and costs of current research greatly benefits from international partnerships and coordination of resources
  - Common need for operational safety
  - Expertise required across multiple disciplines, doesn't reside in a single organization
  - Facilities and test assets operated by multiple organizations across national boundaries
  - Reduce duplication of effort / develop complementary research strategies