1. PUBLISHABLE SUMMARY

1.1. SUMMARY DESCRIPTION OF THE PROJECT CONTEXT AND THE MAIN OBJECTIVES

Commercial aircraft have been experiencing in-service events while flying in the vicinity of deep convective clouds since at least the early 1990s. Heated probes and engines are the areas of aircraft most prone to mixed phase and glaciated icing threat. In anticipation of regulation changes according to mixed phase and glaciated icing conditions, the HAIC project will provide the necessary Acceptable Means of Compliance (numerical and test capabilities) and appropriate ice particle detection/awareness technologies to the European Aeronautical industry for use on-board commercial aircraft in order to enhance safety when an aircraft is flying in such weather conditions.

HAIC will also develop international cooperation and collaboration thanks to the involvement of key international organisations and companies as partners of the project or through the advisory board.

The main objectives of the HAIC project are to allow the European aeronautical industry to face challenges related to the evolution of regulation regarding mixed phase and glaciated icing conditions by characterising high ice water content environments and developing the Acceptable Means of Compliance (test facilities and numerical tools) to improve aircraft operation in such weather conditions by developing appropriate detection and awareness technologies to be fitted on aircraft and being able to alert the flight crew, thus continuously enhancing international flight safety.

This can be broken down into the following scientific, technical and dissemination objectives:

1.1.1. Scientific and Technical Objectives

- Characterise, optimise, enhance and select the most sophisticated cloud microphysics probes to measure mixed phase and glaciated icing conditions during flight tests and to calibrate icing wind tunnels
- Measure and characterise the microphysical properties of core or near-core regions of deep convective clouds, including cloud liquid and ice water contents, particle size distributions and particle shapes and provide 99th percentile total water content statistics as a function of distance scale to assess Appendix D and P diagrams representativeness vs real atmosphere
- Upgrade European icing wind tunnels to allow reproduction of mixed phase and glaciated icing conditions to allow the European Aeronautical industry to perform equipment qualification and generate a detailed experimental database to validate numerical tools
- Understand and model involved physical phenomena and develop numerical tools to simulate the impact of mixed phase and glaciated icing conditions on aircraft components (mainly engines and probes) for supporting both design and certification phases and perform an integrated cross-validation between in-flight measurements, wind-tunnel measurements and model predictions
- Develop and validate mixed phase and glaciated icing conditions awareness and detection technologies to alert the crew of flight in these particular icing conditions or to adapt the flight path well in advance in order to avoid such weather conditions

1.1.2. Dissemination Objectives

- Assess the proposed mixed phase and glaciated icing environment as defined in Appendix D and P in light of the analysis of the research flight tests performed as part of the HAIC project and provide recommendations to the regulatory bodies (EASA and FAA).
- Develop international cooperation and collaboration thanks to the involvement of key international organisations and companies as partners of the project or through the Advisory Board.

1.2. WORK PERFORMED SINCE THE BEGINNING OF THE PROJECT AND THE MAIN RESULTS ACHIEVED SO FAR

HAIC has achieved most of the objectives planned during the second year of the project.

As part of SP1 Instrumentation, the final selection of the most sophisticated probes to achieve the objectives of the 1st HAIC/HIWC international field campaign out of Darwin in January-March 2014 was achieved (including the mini-IKP from HIWC, 2D-S, PIP, CDP & Robust and alternative sondes). These probes were integrated on the SAFIRE Falcon 20 research aircraft. In addition, the instruments to support the calibration of the test facilities developed as part of the SP5 were also selected and their performances are being currently assessed through tests in a small scale icing wind tunnel.

In SP2 High IWC Flight tests Campaigns, the 1st HAIC/HIWC field campaign, aiming at providing the 99th percentile total water content statistics as a function of distance scale to industry and regulators, was conducted out of Darwin, Australia from 16th January 2014 to 07th March 2014, representing a total of 76,6F/H on site. This campaign is the results of an efficient and fruitfull international collaboration with the US lead HIWC project and the EASA-HighIWC project. However, some data are still missing to achieve the rulemaking objective and a 2nd HAIC/HIWC field campaign is thus planned in April/May 2015 out of Cayenne, French Guyana to complete the database. The post-treatment of collected data is on-going and the release of the validated database should be achieved on time.

Regarding SP3 Space-borne Observation & Nowcasting of High IWC Regions, the capability to retrieve specific signature of high IWC regions from geostationary and polar orbiting satellites was assessed based on the in-service events database and flight test dataset provided by Airbus. The MET-FR RDT product (Rapidly Developing Thunderstorm), capable to detect and characterise convection, was also deployed at Darwin, Australia to support the 1st HAIC/HIWC international field campaign in January-March 2014. These activities enabled to validate TRL3 maturity (proof of concept) for these technostreams.

In SP4 High IWC Detection & Awareness Technology, evidence of feasibility was provided for both detection systems and weather radar thanks to the availability of a complete set of requirements, technology description and partial validation of the performances through laboratory experimentations and icing wind tunnel tests. Indeed, major milestones were achieved with the successful conduction of Key and Strategic TRL3 gate reviews for the technologies investigated as part of the project. 5 out of 8 technologies were selected to proceed towards TRL4 level and flight tests in accordance with the downselection process agreed in the DoW.

In SP5 High IWC Test Capability Enhancement, new ice crystals generator devices, able to generate ice crystals with various median sizes, aspect ratios and crystal densities, were developed and are being currently implemented in GKN, DGA, ESTERLINE and TUBS wind tunnels. The commissioning tests to be completed by end 2014 will allow demonstrating TRL3 maturity. Also, calibration methodology was defined and shared with international ice crystals community and is expected to be the baseline for a future update of the SAE Aerospace Recommended Practice (ARP) for Calibration and Acceptance of Icing Wind Tunnels.

Finally, SP6 High IWC Tools & Simulation Development completed the laboratory tests at AGI, Darmstadt University and TSAGI aiming at better understanding and characterising ice particle trajectory, impingement and accretion physical phenomena. Based on these experiments, preliminary models were derived and implemented into numerical tools. The capability and performances were also assessed by comparing numerical results to NASA/NRC experiments whose results are publicly available. This technostream is now well on track to demonstrate TRL3 maturity by end 2014.

1.3. EXPECTED FINAL RESULTS AND THEIR POTENTIAL IMPACTS AND USE (INCLUDING SOCIO-ECONOMIC IMPACT AND THE WIDER SOCIETAL IMPLICATIONS OF THE PROJECT SO FAR)

Operational safety related research activities are a major research topic which has been dominant throughout the ACARE Strategic Research Agendas 1 and 2 which provides the Aeronautics Research agenda up to 2020. “Flight path 2050” also emphasis the importance of safety and the mastering of all aeronautical aspects (Aircraft & operational safety, ATM, Infrastructures, Test and simulation facilities and certification) related to weather hazards.

The HAIC project will significantly contribute to this objective through the delivery of the following expected results:

- A characterisation of the microphysical properties of core or near-core regions of deep convective clouds based on a unique flight test dataset in deep oceanic convective storms

- A set of experimental and numerical capabilities as Acceptable Means of Compliance (AMC) for the qualification and certification of future aircraft products (mainly probes and engines)
    - Four complementary upgraded European icing test facilities (TRL6) with improved representativeness of simulated mixed phase and glaciated icing conditions and covering the whole flight and icing envelope
    - A unique European numerical model for ice particle trajectory, impingement and accretion and mature research and industrial simulation tools (TRL6)
- A set of awareness and detection technologies to be fitted on aircraft and able to alert the flight crew when an aircraft is flying in such weather conditions
    - A pre-operational space-borne remote detection and nowcasting application of glaciated icing conditions (TRL6) based on imagery of geostationary MSG-SEVIRI satellite observations, validated with space-borne active and passive cloud observations from LEO and GEO missions and integrated into a pre-operational application for detection of Rapidly Developing Thunderstorm (RDT) over the Tropical Atlantic
    - An upgraded on-board weather radar (TRL6), based on current state-of-the-art X-band airborne weather radar equipment, to raise awareness to the flight crew of the encounter of glaciated icing conditions
    - Two to four mixed phase and glaciated icing conditions detectors (TRL6) to alert the flight crew in these particular icing conditions
- An assessment of the representativeness of the proposed mixed phase and glaciated icing environment as defined in Appendix D and P and a set of recommendations to regulatory bodies (EASA/FAA) in light of the atmosphere characterisation performed as part of the project

Indeed, HAIC will provide aircraft manufacturers with enhanced understanding, measurement and modelling capacities of near icing or icing conditions at high altitude. All these capacities will in turn permit the effective industrialization and integration of appropriate detection and awareness technologies on new aircraft products and possibly on existing aircraft fleet and the effective development and qualification of new air data probes and engines.

HAIC will also cover standardisation at international and European level through SAE or EUROCAE regarding pitot probes qualification requirements (SAE AS8006, EUROCAE ETSO C16a), test facility calibration methodology (SAE ARP5905) or operational performance for inflight icing detection systems (SAE AS5498).

These contributions will allow improving aircraft operation in such icing conditions and thus to enhance international flight safety

Finally, HAIC is promoting cooperation with international working groups and international collaboration. HAIC and many of its partners, as members of several dominant international working groups, will disseminate much of the HAIC results to working groups such as the EIWG, EUROCAE WG89 or SAE AC-9C. Also, on top of the HAIC/HIWC international collaboration to collect cloud data in deep convective clouds, five partners from Australia, Canada and the United States are directly involved in the project. Lastly, several other US based organisations (FAA, Boeing, NASA, GE, Goodrich, etc) have accepted to join the HAIC advisory board.