AIRCRAFT ICING RESEARCH ALLIANCE (AIRA)

RESEARCH STRATEGY

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Executive Summary

The Aircraft Icing Research Alliance (AIRA) was formed in 1999 to play an international leadership role in formulating and developing collaborative research programs in the area of aircraft icing. The signatory agencies of the AIRA protocol document have agreed to encourage research collaborations and the exchange of technical information, and to work together to facilitate the development of aircraft icing technologies, emphasizing those that are of a pre competitive nature . The AIRA Research Strategy described in this document is the cornerstone of this effort.

The aim of this research strategy is to influence the AIRA member organizations regarding the most appropriate areas for research focus over the next 3-5 years, and to provide a framework and a process for proposing, selecting and initiating collaborative research that will involve some of the AIRA members as well as organizations that are not members of AIRA (e.g. academia and industrial as well as other government agencies). Research collaborations among the AIRA members will ideally focus on the highest research priorities that are identified within this document. This document describes an approach to actively involving the international icing community in regularly re evaluating and updating (as appropriate) these research priorities that will in turn permit this strategy to be updated.

An initial version of this document (version 1.0) was published in December, 2002. This document is the first update (version 2.0) to that document.

Introduction

Aircraft icing is the most critical natural hazard affecting the safe operation of aircraft in the northern hemisphere. While some aircraft are certified for flight into icing conditions (described as light, moderate or severe), and aircraft operate in icing conditions routinely, there are a number of outstanding challenges in the understanding of aircraft icing that need to be addressed. These concern, for example, the atmospheric conditions leading to aircraft icing, the variability of natural icing conditions, aircraft performance in icing conditions, modeling of icing accretion and their aerodynamic effects and icing forecasts. Like many other complex problems in science and technology a multi-disciplinary approach is well suited to effectively addressing these problems.

North American and European countries are continuing to invest in research to increase the safety of aircraft with respect to icing, with the shared common purpose of improving air transportation safety overall. In addition a number of universities have active programs in icing research with core competencies in various aspects of the icing research problem while a number of industrial organizations are conducting applied research and development efforts focused on specific problems of interest.
The Aircraft Icing Research Alliance (AIRA) was created in 1999 by Canadian and US partners with the purpose of increasing the degree of coordination and collaboration in aircraft icing research, especially research collaborations among the government agencies.
The current AIRA members are:

National Aeronautics and Space Administration (NASA)
National Oceanic and Atmospheric Administration (NOAA)
Federal Aviation Administration (FAA)
Transport Canada (TC)
Environment Canada (EC)
Canadian Department of National Defence
National Research Council of Canada (NRC)
Defence Science and Technology Laboratory-UK (dstl)

Specifically the mission of AIRA is:

To coordinate among the parties, the conduct of collaborative aircraft icing research activities that improve the safety of aircraft operations in icing conditions.

The major goals established for AIRA to support the organization's mission are:

1. Develop and maintain a integrated aircraft icing research strategic plan that balances short-term and long-term research needs
2. Implement an integrated aircraft icing research strategic plan through research collaboration among the AIRA members
3. Strengthen and foster long-term aircraft icing research expertise
4. Exchange appropriate technical and scientific information
5. Encourage the development of critical aircraft icing technologies
6. Provide a framework for collaboration between AIRA members as well as with external organizations

The following sections of this document directly addresses these goals through descriptions of:

- The organizational structure of AIRA.
- The current list of strategic research focus areas (RFA's) that will have immediate and longer term relevance to the needs of the aircraft icing community and the shorter list of priority RFA's for AIRA's shorter term emphasis in conducting collaborative research.
- The process by which the AIRA RFA's are reviewed with the icing community and updated.
- The process for developing collaborative research projects among the AIRA partners and involving wherever appropriate external organizations.
- An approach by which collaborative research projects initiated by research groups other than the AIRA members could result in AIRA endorsement and involvement.

The underlying theme of AIRA is to prioritize and focus research efforts and foster research collaborations of appropriate participants as a means of most efficiently improving the safety of all classes of aircraft operating in icing conditions.

The Structure of AIRA

The current structure of AIRA is based on the protocol document that was written during the first year (!999) of the organization's creation. An Executive Steering Committee (ESC) with a single voting representative from each of the agencies, which have signed the protocol document, is responsible for providing the executive leadership for AIRA. The individuals serving on the ESC are appointed by their respective government organizations. As individual projects are formulated by AIRA, Standing Subcommittees (SSC's) are formed to plan and conduct the individual collaborative research efforts. The ESC desires that to the greatest extent possible the leader of each AIRA sponsored/supported project (and therefore the SSC) will be "self appointed" but when that does not occur, the ESC will take the appropriate steps to ensure a project leader is identified. The make up of the various SSC's can include not only individuals representing AIRA signatories but also individuals representing external organizations who have committed to being risk-sharing partners in any specific research effort.

AIRA Priority Research Focus Areas

The AIRA Executive Steering Committee recently completed a lengthy process of reviewing and updating the overall list of Research Focus Areas (RFA's) and from this list the highest priority RFA's. These two lists that were reviewed were developed during the start up phase of AIRA (calendar year 2000-2002 time frame) and represented the inputs of not only the AIRA membership of the time but also the more general aircraft icing community. The overall list of RFA's was developed using a taxonomy of theme/sub themes/ RFA's.

Not too surprisingly, some changes occurred from the original list developed and the current list of highest priority RFA's for the five theme areas are as follows:

Theme	Sub Theme	Research Focus Area
In-Flight Icing	Aerodynamic Performance and Handling Qualities	1. Aerodynamic Performance and Handling Qualities in icing- Appendix C, SLD, ZR
	Atmospheric Characterization	2. High ice water content
	Weather and Forecasting	3. Nowcasting development and validation
		4. Dissemination of weather information
		5. Forecasting development and validation
		6. Remote sensing systems for icing detection
	Facilities, Simulators, and Instrumentation Systems	7. Comparison of tools, techniques and facilities and the establishment of standards
	Fundamental Ice Physics	8. Ice formation mechanics
		9. Scaling
	Ice Shedding	10. Ice shedding mechanisms
	Propulsion and Power plant icing	11. High ice water ingestion
Aircraft Icing While on the Ground		12. Fluid integrity detection system
		13. Performance effects of limited contamination
Runway Winter Contamination		None
Operations, Human Factors and Training		14. Flight crew training module for operations in icing conditions
Safety and Economic Analysis		None
Emerging Technologies		None

For documentation, the complete list of RFA's (87 total) is given in Appendix A.

AIRA Collaborative Research Process

In order to realize the mission of AIRA it is necessary to establish agreed upon priorities for icing research and then to actively foster collaboration in the planning and conduct of research projects that address these priorities. AIRA highly values collaborative involvement from outside groups and encourages research collaborations that involve not only the AIRA signatories but external organizations as well. In this section , the processes are described that AIRA is employing to communicate with external organizations to seek involvement in AIRA led efforts as well as a process where investigators from organizations outside of AIRA can present initiatives and seek collaborative involvement from AIRA members as well as from non - AIRA groups.

Annually the AIRA Executive Steering Committee (ESC) will organize an Icing Research Implementation Forum (RIF). This event will normally be held in conjunction with a scientific/engineering conference that would normally attract a large portion of the icing research community Currently, AIRA is partnering with the AIAA Aerospace Sciences Meeting and Exhibit to conduct the annual RIF events. The specific agenda for the RIF event is somewhat variable but the general structure is as follows:

1. Overview of AIRA by chair person of AIRA ESC
2. One (or more)invited lectures by leaders in the icing community on topics of general interest
3. Presentation and discussion of AIRA Research Focus Areas (RFA's)
4. Presentations on selected AIRA sponsored/supported research projects
5. Open discussion involving all RIF attendees

The individual RIF agendas are structured so as to emphasize open communication and dialogue among all session participants so as to:

1. seek input on current AIRA Research Focus Areas (RFA's)
2. seek input in the formulation phase of new AIRA led research projects,
3 provide updates on status of AIRA led research efforts underway
4 provide opportunities for investigators from external organizations to present opportunities for collaborative research projects

The RIF sessions are structured to emphasize and encourage open communication and dialogue among all those who can attend the session, but communication should be an ongoing rather than episodic process so that research collaborations can be actively encouraged and fostered. To this end, the AIRA web site serves as the centerpiece of the organization's approach to encouraging and fostering ongoing communication and interaction between interested organizations and individuals. The URL for the AIRA web site is:

http://icingalliance.org/

Some of the key features of the AIRA web site include:

1. A news section to provide updates on AIRA overall activities
2. A section that provides quarterly updates on all AIRA sponsored/supported research projects (**Collaborations**)
3. A section that contains all the governing documentation for AIRA (**About AIRA**)
4. A calendar section that displays meetings related to the AIRA mission (**Calendar**)

5. A communication link that allows readers to communicate directly with AIRA and receive timely communication and feedback (**Contact AIRA**)

The ESC of AIRA encourages all individuals to access and utilize the web site and provide recommendations for upgrade/improvement. These suggestions can be sent directly to AIRA through the website contact link (**Contact AIRA**)

In addition, AIRA will look for opportunities at other scientific/engineering conferences to highlight specific AIRA research projects that should be of interest to participants in that particular meeting.

The ESC also has a one-two day meeting midway through the year to assess progress towards AIRA objectives and begin to develop the agenda for the following year's RIF. Typically these meetings are hosted by one of the AIRA member organizations.

As already indicated, AIRA is very open to exploring collaborative opportunities which are initiated by individuals from organizations external to AIRA. The annual RIF as well as the AIRA web site provide two different venues for opportunities to be brought forward for consideration. Regardless of the approach followed, it will be the responsibility of the ESC to consider each opportunity and decide as a group whether or not it is appropriate for AIRA to become involved.

AIRA Areas of Future Emphasis

One of the main areas of responsibility for the Executive Steering Committee (ESC) is to develop and communicate to all stakeholders/interested parties the areas of future emphasis for AIRA. Through a series of interactions (meetings and telecons) over the past 18 months, the ESC has determined that the following will be the areas of emphasis for AIRA for the near term :

1. Increase involvement of European organizations in AIRA.

2. Formulate and conduct an AIRA sponsored/supported effort related to propulsion system icing and in particular to performance in mixed icing conditions (i.e. super cooled water droplets and ice crystals)

3. Formulate and conduct an AIRA sponsored/supported research effort related to ice adhesion/shedding from rotating surfaces emphasizing a physics based approach.

4. Investigate the icing research needs of UAV ‘s and determine the requirements/needs/opportunities for future AIRA sponsored/supported research efforts.

The ESC would welcome any comments, recommendations, etc on these areas of emphasis. Organizations wishing to provide inputs are asked to do so by using the AIRA website.

Appendix A-Complete List of AIRA Research Focus Areas

Theme	Sub Theme	Research Focus Area
In-Flight Icing	Aerodynamic Performance and Handling Qualities	1. Aerodynamic Performance and Handling Qualities in icing- Appendix C, SLD, ZR
		2. Effects due to minor ice accretion or roughness on airfoils and finite wings
		3. Aircraft anti/de-icing systems and loss of effectiveness under severe conditions
		4. Ice detection systems
		5. Detection of minor ice accretion and icing near the freezing point
		6. Low adhesion materials
		7. Advanced icing protection systems
		8. Propeller and rotor efficiency in icing
		9. Systems for real time performance modeling, monitoring and flight control in ice accretion
	Atmospheric Characterization	10. Climatology of in-flight icing environments
		11. All liquid, mixed phase, all ice phase characterization
		12. Clustering, variability and extent of icing conditions
		13. Appropriate statistical descriptors of cloud and icing properties
		14. Frequency of occurrence
		15. Modeling of icing environments for icing simulations
		16. SLD formation mechanisms
		17. Measurement and analysis practices
		18. High ice water content
	Weather and Forecasting	19. Nowcasting development and validation
		20. Numerical forecast models of icing conditions
		21. Terminology/symbology of icing conditions
		22. Dissemination of weather

		information
		23. Diagnostic models of icing conditions
		24. Forecasting development and validation
		25. Remote sensing systems for icing detection
		26. Meteorological definitions for icing potential
	Facilities, Simulators, and Instrumentation Systems	27. Integrated instrumentation for in-flight icing research
		28. Instrumentation standards for in-flight icing research, tunnel measurements and certification flight test
		29. Airborne and ground-based remote sensing systems for cloud properties characterization
		30. Calibration facilities and methods development
		31. Remote sensing systems for ice shape measurement in tunnels and on aircraft
		32. Code development (ice prediction and protection)
		33. Ice feature sensitivity studies
		34. Validation data base
		35. Advanced simulator capabilities (large droplet, low liquid water, small droplet, ice particles)
		36. Advanced icing tankers
		37. Code validation and inter-code performance and validation
		38. Tunnel and code validation in atmospheric conditions
		39. Comparison of tools, techniques and facilities and the establishment of standards
	Fundamental Ice Physics	40. Roughness enhanced heat transfer
		41. Improved turbulence modeling in icing codes
		42. Ice formation mechanics
		43 Warm temperature ice growth physics
		44. Mixed phase ice growth physics
		45. Large droplet dynamics
		46. Ice phase dynamics

		47. Scaling
		48. Accretion of wet snow
	Ice Shedding	49. Ice shedding mechanisms
		50. Trajectories of shed ice
		51. Aerodynamic break-up
		52. Impact assessment
	Propulsion and Power plant icing	53. Turbojet - engine icing physics and hazards
		54. Turboprop - induction system icing physics and hazards
		55. High ice water ingestion
		56. Shed ice ingestion
		57. Propeller icing
		58. Engine Performance in icing conditions
Aircraft icing While on the Ground		59. Aerodynamic effects of de/anti icing fluids
		60. Fluid performance and behavior
		61. Improved atmospheric icing simulation facilities
		62. Nowcasting airport winter weather
		63. Fluid integrity detection system
		64. Aerodynamic effects of surfaces contaminated by frozen precipitation
		65. Fast response precipitation type and rate sensors
		66. Rotorcraft deicing
		67. Advanced de/anti-icing, including environmentally friendly methods
		68. Performance effects of limited contamination
Runway Winter Contamination		69. Runway de-icing
		70. Runway de-icing
		71. Surface traction (runway, taxiway and ramps)
		72. Advanced condition detection
Operations, Human Factors and Training		73. Flight training devices for operations in icing conditions
		74. Weather forecast training modules
		75. Advanced control systems

		- masking of icing effects
		76. Flight crew awareness in icing conditions
		77. Flight crew decision making in icing conditions
		78. Flight crew training module for operations in icing conditions
		79. Safe Wing versus Clean Wing
		80. Avoidance and escape
Safety and Economic Analysis		81. Analysis methodology and parameter values
		82. Development of an incident/accident data base
		83. Sensitivity analysis of the data base
		84. Cost benefit analysis
		85. Research effectiveness analysis
Emerging Technologies		86. Nanotechnology
		87. MEMS